

The GNU Modula-2 Compiler

For GCC version 13.2.0

(GCC)

Gaius Mulley

Published by the Free Software Foundation
51 Franklin Street, Fifth Floor
Boston, MA 02110-1301, USA

Copyright © 1999-2023 Free Software Foundation, Inc.

Permission is granted to copy, distribute and/or modify this document under the terms of the GNU Free Documentation License, Version 1.3 or any later version published by the Free Software Foundation; with no Invariant Sections, no Front-Cover Texts, and no Back-Cover Texts. A copy of the license is included in the section entitled “GNU Free Documentation License”.

Table of Contents

1	Overview of GNU Modula-2	1
1.1	What is GNU Modula-2	1
1.2	Why use GNU Modula-2	1
1.3	How to get source code using git	1
1.4	GNU Modula-2 Features	2
2	Using GNU Modula-2	3
2.1	Example compile and link	3
2.2	Compiler options	3
2.3	Elementary data types	9
2.4	Permanently accessible base procedures	10
2.4.1	Standard procedures and functions common to PIM and ISO	10
2.4.2	ISO specific standard procedures and functions	15
2.5	GNU Modula-2 supported dialects	16
2.5.1	Integer division, remainder and modulus	16
2.6	Exception implementation	17
2.7	How to detect run time problems at compile time	17
2.8	GNU Modula-2 language extensions	18
2.8.1	Optional procedure parameter	20
2.9	Type compatibility	21
2.9.1	Expression compatibility	23
2.9.2	Assignment compatibility	23
2.9.3	Parameter compatibility	23
2.10	Unbounded by reference	24
2.11	Building a shared library	25
2.12	How to produce swig interface files	26
2.12.1	Limitations of automatic generated of Swig files	27
2.13	How to produce a Python module	28
2.14	Interfacing GNU Modula-2 to C	31
2.15	Interface to assembly language	33
2.16	Data type alignment	33
2.17	Packing data types	35
2.18	Accessing GNU Modula-2 Built-ins	37
2.19	The PIM system module	42
2.20	The ISO system module	46
2.21	Release map	51
2.22	Documentation	52
2.23	Regression tests for gm2 in the repository	52
2.24	Limitations	52
2.25	Objectives	52
2.26	FAQ	52
2.26.1	Why use the C++ exception mechanism in GCC, rather than a bespoke Modula-2 mechanism?	52

2.27	Community	52
2.28	Other languages for GCC.....	53
2.29	License of GNU Modula-2	53
GNU General Public License		54
	Contributing to GNU Modula-2.....	64
3	EBNF of GNU Modula-2.....	66
4	PIM and ISO library definitions.....	75
4.1	Base libraries.....	75
4.1.1	gm2-libs/ASCII	75
4.1.2	gm2-libs/Args	76
4.1.3	gm2-libs/Assertion.....	77
4.1.4	gm2-libs/Break	78
4.1.5	gm2-libs/Builtins	79
4.1.6	gm2-libs/COROUTINES	84
4.1.7	gm2-libs/CmdArgs	85
4.1.8	gm2-libs/Debug	86
4.1.9	gm2-libs/DynamicStrings.....	87
4.1.10	gm2-libs/Environment	95
4.1.11	gm2-libs/FIO.....	96
4.1.12	gm2-libs/FormatStrings	103
4.1.13	gm2-libs/FpuIO	105
4.1.14	gm2-libs/GetOpt	106
4.1.15	gm2-libs/IO	109
4.1.16	gm2-libs/Indexing.....	111
4.1.17	gm2-libs/LMathLib0	114
4.1.18	gm2-libs/LegacyReal	115
4.1.19	gm2-libs/M2Dependent	116
4.1.20	gm2-libs/M2EXCEPTION	117
4.1.21	gm2-libs/M2LINK.....	118
4.1.22	gm2-libs/M2RTS	119
4.1.23	gm2-libs/MathLib0.....	123
4.1.24	gm2-libs/MemUtils.....	124
4.1.25	gm2-libs/NumberIO	125
4.1.26	gm2-libs/OptLib	127
4.1.27	gm2-libs/PushBackInput	129
4.1.28	gm2-libs/RTExceptions.....	132
4.1.29	gm2-libs/RTint	136
4.1.30	gm2-libs/SArgs.....	139
4.1.31	gm2-libs/SCmdArgs	140
4.1.32	gm2-libs/SEnvironment.....	141
4.1.33	gm2-libs/SFIO	142
4.1.34	gm2-libs/SMathLib0.....	144

4.1.35	gm2-libs/SYSTEM	145
4.1.36	gm2-libs/Scan	149
4.1.37	gm2-libs/Selective	151
4.1.38	gm2-libs/StdIO	153
4.1.39	gm2-libs/Storage	155
4.1.40	gm2-libs/StrCase	156
4.1.41	gm2-libs/StrIO	157
4.1.42	gm2-libs/StrLib	158
4.1.43	gm2-libs/StringConvert	160
4.1.44	gm2-libs/SysExceptions	167
4.1.45	gm2-libs/SysStorage	168
4.1.46	gm2-libs/TimeString	170
4.1.47	gm2-libs/UnixArgs	171
4.1.48	gm2-libs/cbuiltin	172
4.1.49	gm2-libs/cgetopt	176
4.1.50	gm2-libs/cxxabi	178
4.1.51	gm2-libs/dtoa	179
4.1.52	gm2-libs/errno	180
4.1.53	gm2-libs/gdbif	181
4.1.54	gm2-libs/ldtoa	182
4.1.55	gm2-libs/libc	183
4.1.56	gm2-libs/libm	193
4.1.57	gm2-libs/sckt	195
4.1.58	gm2-libs/termios	198
4.1.59	gm2-libs/wrapc	203
4.2	PIM and Logitech 3.0 Compatible	206
4.2.1	gm2-libs-log/BitBlockOps	206
4.2.2	gm2-libs-log/BitByteOps	209
4.2.3	gm2-libs-log/BitWordOps	212
4.2.4	gm2-libs-log/BlockOps	215
4.2.5	gm2-libs-log/Break	217
4.2.6	gm2-libs-log/CardinalIO	218
4.2.7	gm2-libs-log/Conversions	221
4.2.8	gm2-libs-log/DebugPMD	222
4.2.9	gm2-libs-log/DebugTrace	223
4.2.10	gm2-libs-log/Delay	224
4.2.11	gm2-libs-log/Display	225
4.2.12	gm2-libs-log/ErrorCode	226
4.2.13	gm2-libs-log/FileSystem	227
4.2.14	gm2-libs-log/FloatingUtilities	233
4.2.15	gm2-libs-log/InOut	235
4.2.16	gm2-libs-log/Keyboard	239
4.2.17	gm2-libs-log/LongIO	240
4.2.18	gm2-libs-log/NumberConversion	241
4.2.19	gm2-libs-log/Random	242
4.2.20	gm2-libs-log/RealConversions	244
4.2.21	gm2-libs-log/RealInOut	247

4.2.22	gm2-libs-log/Strings	250
4.2.23	gm2-libs-log/Termbase	252
4.2.24	gm2-libs-log/Terminal	254
4.2.25	gm2-libs-log/TimeDate	256
4.3	PIM coroutine support	258
4.3.1	gm2-libs-coroutines/Executive	258
4.3.2	gm2-libs-coroutines/KeyBoardLEDs	261
4.3.3	gm2-libs-coroutines/SYSTEM	262
4.3.4	gm2-libs-coroutines/TimerHandler	268
4.4	M2 ISO Libraries	270
4.4.1	gm2-libs-iso/COROUTINES	271
4.4.2	gm2-libs-iso/ChanConsts	274
4.4.3	gm2-libs-iso/CharClass	276
4.4.4	gm2-libs-iso/ClientSocket	277
4.4.5	gm2-libs-iso/ComplexMath	278
4.4.6	gm2-libs-iso/ConvStringLong	280
4.4.7	gm2-libs-iso/ConvStringReal	281
4.4.8	gm2-libs-iso/ConvTypes	282
4.4.9	gm2-libs-iso/EXCEPTIONS	283
4.4.10	gm2-libs-iso/ErrnoCategory	285
4.4.11	gm2-libs-iso/GeneralUserExceptions	287
4.4.12	gm2-libs-iso/IOChan	288
4.4.13	gm2-libs-iso/IOConsts	292
4.4.14	gm2-libs-iso/IOLink	293
4.4.15	gm2-libs-iso/IOResult	296
4.4.16	gm2-libs-iso/LongComplexMath	297
4.4.17	gm2-libs-iso/LongConv	299
4.4.18	gm2-libs-iso/LongIO	301
4.4.19	gm2-libs-iso/LongMath	303
4.4.20	gm2-libs-iso/LongStr	305
4.4.21	gm2-libs-iso/LongWholeIO	307
4.4.22	gm2-libs-iso/LowLong	308
4.4.23	gm2-libs-iso/LowReal	310
4.4.24	gm2-libs-iso/LowShort	312
4.4.25	gm2-libs-iso/M2EXCEPTION	314
4.4.26	gm2-libs-iso/M2RTS	315
4.4.27	gm2-libs-iso/MemStream	319
4.4.28	gm2-libs-iso/Preemptive	321
4.4.29	gm2-libs-iso/Processes	322
4.4.30	gm2-libs-iso/ProgramArgs	326
4.4.31	gm2-libs-iso/RTco	327
4.4.32	gm2-libs-iso/RTdata	329
4.4.33	gm2-libs-iso/RTentity	331
4.4.34	gm2-libs-iso/RTfio	332
4.4.35	gm2-libs-iso/RTgen	334
4.4.36	gm2-libs-iso/RTgenif	337
4.4.37	gm2-libs-iso/RTio	340

4.4.38	gm2-libs-iso/RandomNumber	342
4.4.39	gm2-libs-iso/RawIO	345
4.4.40	gm2-libs-iso/RealConv	346
4.4.41	gm2-libs-iso/RealIO	348
4.4.42	gm2-libs-iso/RealMath	350
4.4.43	gm2-libs-iso/RealStr	352
4.4.44	gm2-libs-iso/RndFile	354
4.4.45	gm2-libs-iso/SIOResult	357
4.4.46	gm2-libs-iso/SLongIO	358
4.4.47	gm2-libs-iso/SLongWholeIO	360
4.4.48	gm2-libs-iso/SRawIO	361
4.4.49	gm2-libs-iso/SRealIO	362
4.4.50	gm2-libs-iso/SShortIO	364
4.4.51	gm2-libs-iso/SShortWholeIO	366
4.4.52	gm2-libs-iso/STextIO	367
4.4.53	gm2-libs-iso/SWholeIO	369
4.4.54	gm2-libs-iso/SYSTEM	370
4.4.55	gm2-libs-iso/Semaphores	375
4.4.56	gm2-libs-iso/SeqFile	376
4.4.57	gm2-libs-iso/ShortComplexMath	379
4.4.58	gm2-libs-iso/ShortIO	381
4.4.59	gm2-libs-iso/ShortWholeIO	383
4.4.60	gm2-libs-iso/SimpleCipher	384
4.4.61	gm2-libs-iso/StdChans	385
4.4.62	gm2-libs-iso/Storage	387
4.4.63	gm2-libs-iso/StreamFile	389
4.4.64	gm2-libs-iso/StringChan	390
4.4.65	gm2-libs-iso/Strings	391
4.4.66	gm2-libs-iso/SysClock	395
4.4.67	gm2-libs-iso/TERMINATION	397
4.4.68	gm2-libs-iso/TermFile	398
4.4.69	gm2-libs-iso/TextIO	400
4.4.70	gm2-libs-iso/WholeConv	402
4.4.71	gm2-libs-iso/WholeIO	404
4.4.72	gm2-libs-iso/WholeStr	405
4.4.73	gm2-libs-iso/wrapsock	406
4.4.74	gm2-libs-iso/wraptime	409
4.5	Indices	413

1 Overview of GNU Modula-2

1.1 What is GNU Modula-2

GNU Modula-2 is a front end (<http://gcc.gnu.org/frontends.html>) for the GNU Compiler Collection (GCC (<http://gcc.gnu.org/>)). The GNU Modula-2 compiler is compliant with the PIM2, PIM3, PIM4 and ISO dialects. Also implemented are a complete set of free ISO libraries and PIM libraries.

1

1.2 Why use GNU Modula-2

There are a number of advantages of using GNU Modula-2 rather than translate an existing project into another language.

The first advantage is of maintainability of the original sources and the ability to debug the original project source code using a combination of gm2 and gdb.

The second advantage is that gcc runs on many processors and platforms. gm2 builds and runs on powerpc64le, amd64, i386, aarch64 to name but a few processors.

gm2 can produce swig interface headers to allow access from Python and other scripting languages. It can also be used with C/C++ and generate shared libraries.

The compiler provides semantic analysis and run time checking (full ISO Modula-2 checking is implemented) and there is a plugin which can, under certain conditions, detect run time errors at compile time.

The compiler supports PIM2, PIM3, PIM4 and ISO dialects of Modula-2, work is under-way to implement M2R10. Many of the GCC builtins are available and access to assembly programming is achieved using the same syntax as that used by GCC.

The gm2 driver allows third party libraries to be installed alongside gm2 libraries. For example if the user specifies library `foo` using `-flibs=foo` the driver will check the standard GCC install directory for a sub directory `foo` containing the library contents. The library module search path is altered accordingly for compile and link.

1.3 How to get source code using git

GNU Modula-2 is now in the GCC git tree (<https://gcc.gnu.org/git.html>).

¹ The four Modula-2 dialects supported are defined in the following references:

PIM2: 'Programming in Modula-2', 2nd Edition, Springer Verlag, 1982, 1983 by Niklaus Wirth (PIM2).

PIM3: 'Programming in Modula-2', 3rd Corrected Edition, Springer Verlag, 1985 (PIM3).

PIM4: 'Programming in Modula-2', 4th Edition, Springer Verlag, 1988 (PIM4 (<http://freepages.modula2.org/report4/modula-2.html>)).

ISO: the ISO Modula-2 language as defined in 'ISO/IEC Information technology - programming languages - part 1: Modula-2 Language, ISO/IEC 10514-1 (1996)'

1.4 GNU Modula-2 Features

- the compiler currently complies with Programming in Modula-2 Edition 2, 3, 4 and ISO Modula-2. Users can switch on specific language features by using: `'-fpim'`, `'-fpim2'`, `'-fpim3'`, `'-fpim4'` or `'-fiso'`.
- the option `'-fswig'` will automatically create a swig interface file which corresponds to the definition module of the file being compiled.
- exception handling is compatible with C++ and swig. Modula-2 code can be used with C or C++ code.
- Python can call GNU Modula-2 modules via swig.
- shared libraries can be built.
- fixed sized types are now available from `'SYSTEM'`.
- variables can be declared at addresses.
- much better dwarf-2 debugging support and when used with `'gdb'` the programmer can display `RECORDs`, `ARRAYs`, `SETs`, subranges and constant char literals in Modula-2 syntax.
- supports sets of any ordinal size (memory permitting).
- easy interface to C, and varargs can be passed to C routines.
- many Logitech libraries have been implemented and can be accessed via: `'-flibs=m2log,m2pim,m2iso'`.
- coroutines have been implemented in the PIM style and these are accessible from `SYSTEM`. A number of supporting libraries (executive and file descriptor mapping to interrupt vector libraries are available through the `'-flibs=m2iso,m2pim'` switch).
- can be built as a cross compiler (for embedded microprocessors such as the AVR and the ARM).

2 Using GNU Modula-2

This document contains the user and design issues relevant to the Modula-2 front end to gcc.

2.1 Example compile and link

The `gm2` command is the GNU compiler for the Modula-2 language and supports many of the same options as `gcc`. See Section “Option Summary” in *Using the GNU Compiler Collection (GCC)*. This manual only documents the options specific to `gm2`.

This section describes how to compile and link a simple hello world program. It provides a few examples of using the different options mentioned in see Section “Compiler options” in `gm2`. Assuming that you have a file called `hello.mod` in your current directory which contains:

```
MODULE hello ;

FROM StrIO IMPORT WriteString, WriteLn ;

BEGIN
  WriteString ('hello world') ; WriteLn
END hello.
```

You can compile and link it by: `'gm2 -g hello.mod'`. The result will be an `'a.out'` file created in your directory.

You can split this command into two steps if you prefer. The compile step can be achieved by: `'gm2 -g -c -fscaffold-main hello.mod'` and the link via: `'gm2 -g hello.o'`.

1

2.2 Compiler options

This section describes the compiler options specific to GNU Modula-2 for generic flags details See Section “Invoking GCC” in `gcc`.

For any given input file, the file name suffix determines what kind of compilation is done. The following kinds of input file names are supported:

- `file.mod` Modula-2 implementation or program source files. See the `'-fmod='` option if you wish to compile a project which uses a different source file extension.
- `file.def` Modula-2 definition module source files. Definition modules are not compiled separately, in GNU Modula-2 definition modules are parsed as required when program or implementation modules are compiled. See the `'-fdef='` option if you wish to compile a project which uses a different source file extension.

¹ To see all the compile actions taken by `'gm2'` users can also add the `'-v'` flag at the command line, for example:

```
'gm2 -v -g -I. hello.mod'
```

This displays the sub processes initiated by `'gm2'` which can be useful when trouble shooting.

You can specify more than one input file on the `gm2` command line,

- `-g` create debugging information so that debuggers such as `gdb` can inspect and control executable.
- `-I` used to specify the search path for definition and implementation modules. An example is: `gm2 -g -c -I:.././libs foo.mod`. If this option is not specified then the default path is added which consists of the current directory followed by the appropriate language dialect library directories.
- `-fauto-init` turns on auto initialization of pointers to NIL. Whenever a block is created all pointers declared within this scope will have their addresses assigned to NIL.
- `-fbounds` turns on run time subrange, array index and indirection via NIL pointer checking.
- `-fcase` turns on compile time checking to check whether a `CASE` statement requires an `ELSE` clause when one was not specified.
- `-fcpp` preprocess the source with `'cpp -lang-asm -traditional-cpp'`. For further details about these options See Section "Invocation" in `cpp`. If `'-fcpp'` is supplied then all definition modules and implementation modules which are parsed will be preprocessed by `'cpp'`.
- `-fdebug-builtins` call a real function, rather than the builtin equivalent. This can be useful for debugging parameter values to a builtin function as it allows users to single step code into a real function.
- `-fdef=` recognize the specified suffix as a definition module filename. The default implementation and module filename suffix is `.def`. If this option is used GNU Modula-2 will still fall back to this default if a requested definition module is not found.
- `-fdump-system-exports` display all inbuilt system items. This is an internal command line option.
- `-fexceptions` turn on exception handling code. By default this option is on. Exception handling can be disabled by `'-fno-exceptions'` and no references are made to the run time exception libraries.
- `-fextended-opaque` allows opaque types to be implemented as any type. This is a GNU Modula-2 extension and it requires that the implementation module defining the opaque type is available so that it can be resolved when compiling the module which imports the opaque type.
- `-ffloatvalue` turns on run time checking to check whether a floating point number is about to exceed range.

- fgen-module-list=filename**
attempt to find all modules when linking and generate a module list. If the `filename` is `'-'` then the contents are not written and only used to force the linking of all module ctors. This option cannot be used if `'-fuse-list='` is enabled.
- findex** generate code to check whether array index values are out of bounds. Array index checking can be disabled via `'-fno-index'`.
- fiso** turn on ISO standard features. Currently this enables the ISO `SYSTEM` module and alters the default library search path so that the ISO libraries are searched before the PIM libraries. It also effects the behavior of `DIV` and `MOD` operators. See Section “Dialect” in `gm2`.
- flibs=** modifies the default library search path. The libraries supplied are: `m2pim`, `m2iso`, `m2min`, `m2log` and `m2cor`. These map onto the Programming in Modula-2 base libraries, ISO standard libraries, minimal library support, Logitech compatible library and Programming in Modula-2 with coroutines. Multiple libraries can be specified and are comma separated with precedence going to the first in the list. It is not necessary to use `-flibs=m2pim` or `-flibs=m2iso` if you also specify `-fpim`, `-fpim2`, `-fpim3`, `-fpim4` or `-fiso`. Unless you are using `-flibs=m2min` you should include `m2pim` as they provide the base modules which all other dialects utilize. The option `'-fno-libs=-'` disables the `'gm2'` driver from modifying the search and library paths.
- static-libgm2**
On systems that provide the `m2` runtimes as both shared and static libraries, this option forces the use of the static version.
- fm2-g** improve the debugging experience for new programmers at the expense of generating `nop` instructions if necessary to ensure single stepping precision over all code related keywords. An example of this is in termination of a list of nested `IF` statements where multiple `END` keywords are mapped onto a sequence of `nop` instructions.
- fm2-lower-case**
render keywords in error messages using lower case.
- fm2-pathname=**
specify the module mangled prefix name for all modules in the following include paths.
- fm2-pathnameI**
for internal use only: used by the driver to copy the user facing `-I` option.
- fm2-plugin**
insert plugin to identify run time errors at compile time (default on).
- fm2-prefix=**
specify the module mangled prefix name. All exported symbols from a definition module will have the prefix name.

- fm2-statistics**
generates quadruple information: number of quadruples generated, number of quadruples remaining after optimization and number of source lines compiled.
- fm2-strict-type**
experimental flag to turn on the new strict type checker.
- fm2-whole-program**
compile all implementation modules and program module at once. Notice that you need to take care if you are compiling different dialect modules (particularly with the negative operands to modulus). But this option, when coupled together with `-O3`, can deliver huge performance improvements.
- fmod=**
recognize the specified suffix as implementation and module filenames. The default implementation and module filename suffix is `.mod`. If this option is used GNU Modula-2 will still fall back to this default if it needs to read an implementation module and the specified suffixed filename does not exist.
- fnil**
generate code to detect accessing data through a NIL value pointer. Dereferencing checking through a NIL pointer can be disabled by `'-fno-nil'`.
- fpim**
turn on PIM standard features. Currently this enables the PIM `SYSTEM` module and determines which identifiers are pervasive (declared in the base module). If no other `'-fpim[234]'` switch is used then division and modulus operators behave as defined in PIM4. See Section "Dialect" in `gm2`.
- fpim2**
turn on PIM-2 standard features. Currently this removes `SIZE` from being a pervasive identifier (declared in the base module). It places `SIZE` in the `SYSTEM` module. It also effects the behavior of `DIV` and `MOD` operators. See Section "Dialect" in `gm2`.
- fpim3**
turn on PIM-3 standard features. Currently this only effects the behavior of `DIV` and `MOD` operators. See Section "Dialect" in `gm2`.
- fpim4**
turn on PIM-4 standard features. Currently this only effects the behavior of `DIV` and `MOD` operators. See Section "Dialect" in `gm2`.
- fpositive-mod-floor-div**
forces the `DIV` and `MOD` operators to behave as defined by PIM4. All modulus results are positive and the results from the division are rounded to the floor. See Section "Dialect" in `gm2`.
- fpthread**
link against the pthread library. By default this option is on. It can be disabled by `'-fno-pthread'`. GNU Modula-2 uses the GCC pthread libraries to implement coroutines (see the `SYSTEM` implementation module).
- frange**
generate code to check the assignment range, return value range set range and constructor range. Range checking can be disabled via `'-fno-range'`.
- freturn**
generate code to check that functions always exit with a `RETURN` and do not fall out at the end. Return checking can be disabled via `'-fno-return'`.

- fruntime-modules=**
specify, using a comma separated list, the run time modules and their order. These modules will be initialized first before any other modules in the application dependency. By default the run time modules list is set to `m2iso:RTentity,m2iso:Storage,m2iso:SYSTEM,m2iso:M2RTS,m2iso:RTEExceptions,m2iso:IOLink`. Note that these modules will only be linked into your executable if they are required. Adding a long list of dependent modules will not effect the size of the executable it merely states the initialization order should they be required.
- fscaffold-dynamic**
the option ensures that 'gm2' will generate a dynamic scaffold infrastructure when compiling implementation and program modules. By default this option is on. Use '`-fno-scaffold-dynamic`' to turn it off or select '`-fno-scaffold-static`'.
- fscaffold-c**
generate a C source scaffold for the current module being compiled.
- fscaffold-c++**
generate a C++ source scaffold for the current module being compiled.
- fscaffold-main**
force the generation of the 'main' function. This is not necessary if the '-c' is omitted.
- fscaffold-static**
the option ensures that 'gm2' will generate a static scaffold within the program module. The static scaffold consists of sequences of calls to all dependent module initialization and finalization procedures. The static scaffold is useful for debugging and single stepping the initialization blocks of implementation modules.
- fshared** generate a shared library from the module.
- fsoft-check-all**
turns on all run time checks. This is the same as invoking GNU Modula-2 using the command options `-fnil -frange -findex -fwholevalue -fwholediv -fcase -freturn`.
- fsources**
displays the path to the source of each module. This option can be used at compile time to check the correct definition module is being used.
- fswig** generate a swig interface file.
- funbounded-by-reference**
enable optimization of unbounded parameters by attempting to pass non VAR unbounded parameters by reference. This optimization avoids the implicit copy inside the callee procedure. GNU Modula-2 will only allow unbounded parameters to be passed by reference if, inside the callee procedure, they are not written to, no address is calculated on the array and it is not passed as a VAR

parameter. Note that it is possible to write code to break this optimization, therefore this option should be used carefully. For example it would be possible to take the address of an array, pass the address and the array to a procedure, read from the array in the procedure and write to the location using the address parameter.

Due to the dangerous nature of this option it is not enabled when the `'-O'` option is specified.

`-fuse-list=filename`

if `'-fscaffold-static'` is enabled then use the file `filename` for the initialization order of modules. Whereas if `'-fscaffold-dynamic'` is enabled then use this file to force linking of all module ctors. This option cannot be used if `'-fgen-module-list='` is enabled.

`-fwholediv`

generate code to detect whole number division by zero or modulus by zero.

`-fwholevalue`

generate code to detect whole number overflow and underflow.

This section describes the linking related options. There are three linking strategies available which are dynamic scaffold, static scaffold and user defined. The dynamic scaffold is enabled by default and each module will register itself to the run time `'M2RTS'` via a constructor. The static scaffold mechanism will invoke each modules `'_init'` and `'_finish'` function in turn via a sequence of calls from within `'main'`. Lastly the user defined strategy can be implemented by turning off the dynamic and static options via `'-fno-scaffold-dynamic'` and `'-fno-scaffold-static'`.

In the simple test below:

```
$ gm2 hello.mod
```

the driver will add the options `'-fscaffold-dynamic'` and `'-fgen-module-list=-'` which generate a list of application modules and also creates the `'main'` function with calls to `'M2RTS'`. It can be useful to add the option `'-fsources'` which displays the source files as they are parsed and summarizes whether the source file is required for compilation or linking.

If you wish to split the above command line into a compile and link then you could use these steps:

```
$ gm2 -c -fscaffold-main hello.mod
$ gm2 hello.o
```

The `'-fscaffold-main'` informs the compiler to generate the `'main'` function and scaffold. You can enable the environment variable `'GCC_M2LINK_RTFLAG'` to trace the construction and destruction of the application. The values for `'GCC_M2LINK_RTFLAG'` are shown in the table below:

value	meaning
=====	
all	turn on all flags below
module	trace modules as they register themselves
hex	display the hex address of the init/fini functions

```

warning | show any warnings
pre      | generate module list prior to dependency resolution
dep      | trace module dependency resolution
post     | generate module list after dependency resolution
force    | generate a module list after dependency and forced
          | ordering is complete

```

The values can be combined using a comma separated list.

One of the advantages of the dynamic scaffold is that the driver behaves in a similar way to the other front end drivers. For example consider a small project consisting of 4 definition implementation modules ('a.def', 'a.mod', 'b.def', 'b.mod', 'c.def', 'c.mod', 'd.def', 'd.mod') and a program module 'program.mod'.

To link this project we could:

```

$ gm2 -g -c a.mod
$ gm2 -g -c b.mod
$ gm2 -g -c c.mod
$ gm2 -g -c d.mod
$ gm2 -g program.mod a.o b.o c.o d.o

```

The module initialization sequence is defined by the ISO standard to follow the import graph traversal. The initialization order is the order in which the corresponding separate modules finish the processing of their import lists.

However, if required, you can override this using '-fruntime-modules=a,b,c,d' for example which forces the initialization sequence to 'a', 'b', 'c' and 'd'.

2.3 Elementary data types

This section describes the elementary data types supported by GNU Modula-2. It also describes the relationship between these data types and the equivalent C data types.

The following data types are supported: INTEGER, LONGINT, SHORTINT, CARDINAL, LONGCARD, SHORTCARD, BOOLEAN, REAL, LONGREAL, SHORTREAL, COMPLEX, LONGCOMPLEX, SHORTCOMPLEX and CHAR.

An equivalence table is given below:

GNU Modula-2	GNU C
=====	=====
INTEGER	int
LONGINT	long long int
SHORTINT	short int
CARDINAL	unsigned int
LONGCARD	long long unsigned int
SHORTCARD	short unsigned int
BOOLEAN	bool
REAL	double
LONGREAL	long double
SHORTREAL	float
CHAR	char
SHORTCOMPLEX	complex float

COMPLEX	complex double
LONGCOMPLEX	complex long double

Note that GNU Modula-2 also supports fixed sized data types which are exported from the SYSTEM module. See Section “The PIM system module” in gm2. See Section “The ISO system module” in gm2.

2.4 Permanently accessible base procedures.

This section describes the procedures and functions which are always visible.

2.4.1 Standard procedures and functions common to PIM and ISO

The following procedures are implemented and conform with Programming in Modula-2 and ISO Modula-2: NEW, DISPOSE, INC, DEC, INCL, EXCL and HALT. The standard functions are: ABS, CAP, CHR, FLOAT, HIGH, LFLOAT, LTRUNC, MIN, MAX, ODD, SFLOAT, STRUNC TRUNC and VAL. All these functions and procedures (except HALT, NEW, DISPOSE and, under non constant conditions, LENGTH) generate in-line code for efficiency.

```
(*
  ABS - returns the positive value of i.
*)
```

```
PROCEDURE ABS (i: <any signed type>) : <any signed type> ;
```

```
(*
  CAP - returns the capital of character ch providing
        ch lies within the range 'a'..'z'. Otherwise ch
        is returned unaltered.
*)
```

```
PROCEDURE CAP (ch: CHAR) : CHAR ;
```

```
(*
  CHR - converts a value of a <whole number type> into a CHAR.
        CHR(x) is shorthand for VAL(CHAR, x).
*)
```

```
PROCEDURE CHR (x: <whole number type>) : CHAR ;
```

```
(*
  DISPOSE - the procedure DISPOSE is replaced by:
             DEALLOCATE(p, TSIZE(p^)) ;
             The user is expected to import the procedure DEALLOCATE
```

(normally found in the module, Storage.)

In: a variable p: of any pointer type which has been initialized by a call to NEW.

Out: the area of memory

holding p[^] is returned to the system.

Note that the underlying procedure DEALLOCATE procedure in module Storage will assign p to NIL.

*)

```
PROCEDURE DISPOSE (VAR p:<any pointer type>) ;
```

(*

DEC - can either take one or two parameters. If supplied with one parameter then on the completion of the call to DEC, v will have its predecessor value. If two parameters are supplied then the value v will have its n'th predecessor. For these reasons the value of n must be >=0.

*)

```
PROCEDURE DEC (VAR v: <any base type>; [n: <any base type> = 1]) ;
```

(*

EXCL - excludes bit element e from a set type s.

*)

```
PROCEDURE EXCL (VAR s: <any set type>; e: <element of set type s>) ;
```

(*

FLOAT - will return a REAL number whose value is the same as o.

*)

```
PROCEDURE FLOAT (o: <any whole number type>) : REAL ;
```

(*

FLOATS - will return a SHORTREAL number whose value is the same as o.

*)

```
PROCEDURE FLOATS (o: <any whole number type>) : REAL ;
```

(*

FLOATL - will return a LONGREAL number whose value is the same as o.

*)

```
PROCEDURE FLOATL (o: <any whole number type>) : REAL ;
```

```
(*
  HALT - will call the HALT procedure inside the module M2RTS.
         Users can replace M2RTS.
*)

PROCEDURE HALT ;

(*
  HIGH - returns the last accessible index of an parameter declared as
         ARRAY OF CHAR. Thus

         PROCEDURE foo (a: ARRAY OF CHAR) ;
         VAR
           c: CARDINAL ;
         BEGIN
           c := HIGH(a)
         END foo ;

         BEGIN
           foo('hello')
         END

         will cause the local variable c to contain the value 4
*)

PROCEDURE HIGH (a: ARRAY OF CHAR) : CARDINAL ;

(*
  INC - can either take one or two parameters. If supplied
        with one parameter then on the completion of the call to
        INC, v will have its successor value. If two
        parameters are supplied then the value v will have its
        n'th successor. For these reasons the value of n
        must be >=0.
*)

PROCEDURE INC (VAR v: <any base type>; [n: <any base type> = 1]) ;

(*
  INCL - includes bit element e to a set type s.
*)

PROCEDURE INCL (VAR s: <any set type>; e: <element of set type s>) ;

(*
```

LFLOAT - will return a LONGREAL number whose value is the same as o.
*)

```
PROCEDURE LFLOAT (o: <any whole number type>) : LONGREAL ;
```

(*
LTRUNC - will return a LONG<type> number whose value is the
same as o. PIM2, PIM3 and ISO Modula-2 will return
a LONGCARD whereas PIM4 returns LONGINT.
*)

```
PROCEDURE LTRUNC (o: <any floating point type>) : LONG<type> ;
```

(*
MIN - returns the lowest legal value of an ordinal type.
*)

```
PROCEDURE MIN (t: <ordinal type>) : <ordinal type> ;
```

(*
MAX - returns the largest legal value of an ordinal type.
*)

```
PROCEDURE MAX (t: <ordinal type>) : <ordinal type> ;
```

(*
NEW - the procedure NEW is replaced by:
ALLOCATE(p, TSIZE(p[^])) ;
The user is expected to import the procedure ALLOCATE
(normally found in the module, Storage.)

In: a variable p: of any pointer type.
Out: variable p is set to some allocated memory
which is large enough to hold all the contents of p[^].
*)

```
PROCEDURE NEW (VAR p:<any pointer type>) ;
```

(*
ODD - returns TRUE if the value is not divisible by 2.
*)

```
PROCEDURE ODD (x: <whole number type>) : BOOLEAN ;
```

```
(*
  SFLOAT - will return a SHORTREAL number whose value is the same
           as o.
*)

PROCEDURE SFLOAT (o: <any whole number type>) : SHORTREAL ;

(*
  STRUNC - will return a SHORT<type> number whose value is the same
           as o. PIM2, PIM3 and ISO Modula-2 will return a
           SHORTCARD whereas PIM4 returns SHORTINT.
*)

PROCEDURE STRUNC (o: <any floating point type>) : SHORT<type> ;

(*
  TRUNC - will return a <type> number whose value is the same as o.
          PIM2, PIM3 and ISO Modula-2 will return a CARDINAL
          whereas PIM4 returns INTEGER.
*)

PROCEDURE TRUNC (o: <any floating point type>) : <type> ;

(*
  TRUNCS - will return a <type> number whose value is the same
           as o. PIM2, PIM3 and ISO Modula-2 will return a
           SHORTCARD whereas PIM4 returns SHORTINT.
*)

PROCEDURE TRUNCS (o: <any floating point type>) : <type> ;

(*
  TRUNCL - will return a <type> number whose value is the same
           as o. PIM2, PIM3 and ISO Modula-2 will return a
           LONGCARD whereas PIM4 returns LONGINT.
*)

PROCEDURE TRUNCL (o: <any floating point type>) : <type> ;

(*
  VAL - converts data i of <any simple data type 2> to
        <any simple data type 1> and returns this value.
        No range checking is performed during this conversion.
*)
```

```
PROCEDURE VAL (<any simple data type 1>,
              i: <any simple data type 2>) : <any simple data type 1> ;
```

2.4.2 ISO specific standard procedures and functions

The standard function LENGTH is specific to ISO Modula-2 and is defined as:

```
(*
  IM - returns the imaginary component of a complex type.
       The return value will the same type as the imaginary field
       within the complex type.
*)
```

```
PROCEDURE IM (c: <any complex type>) : <floating point type> ;
```

```
(*
  INT - returns an INTEGER value which has the same value as v.
        This function is equivalent to: VAL(INTEGER, v).
*)
```

```
PROCEDURE INT (v: <any ordinal type>) : INTEGER ;
```

```
(*
  LENGTH - returns the length of string a.
*)
```

```
PROCEDURE LENGTH (a: ARRAY OF CHAR) : CARDINAL ;
```

This function is evaluated at compile time, providing that string a is a constant. If a cannot be evaluated then a call is made to M2RTS.Length.

```
(*
  ODD - returns a BOOLEAN indicating whether the whole number
        value, v, is odd.
*)
```

```
PROCEDURE ODD (v: <any whole number type>) : BOOLEAN ;
```

```
(*
  RE - returns the real component of a complex type.
       The return value will the same type as the real field
       within the complex type.
*)
```

```
PROCEDURE RE (c: <any complex type>) : <floating point type> ;
```

2.5 GNU Modula-2 supported dialects

This section describes the dialects understood by GNU Modula-2. It also describes the differences between the dialects and any command line switches which determine dialect behaviour.

The GNU Modula-2 compiler is compliant with four dialects of Modula-2. The language as defined in 'Programming in Modula-2' 2nd Edition, Springer Verlag, 1982, 1983 by Niklaus Wirth (PIM2), 'Programming in Modula-2', 3rd Corrected Edition, Springer Verlag, 1985 (PIM3) and 'Programming in Modula-2', 4th Edition, Springer Verlag, 1988 (PIM4) <http://freepages.modula2.org/report4/modula-2.html> and the ISO Modula-2 language as defined in ISO/IEC Information technology - programming languages - part 1: Modula-2 Language, ISO/IEC 10514-1 (1996) (ISO).

The command line switches '-fpim2', '-fpim3', '-fpim4' and '-fiso' can be used to force mutually exclusive features. However by default the compiler will not aggressively fail if a non mutually exclusive feature is used from another dialect. For example it is possible to specify '-fpim2' and still utilize 'DEFINITION' 'MODULES' which have no export list.

Some dialect differences will force a compile time error, for example in PIM2 the user must `IMPORT SIZE` from the module `SYSTEM`, whereas in PIM3 and PIM4 `SIZE` is a pervasive function. Thus compiling PIM4 source code with the '-fpim2' switch will cause a compile time error. This can be fixed quickly with an additional `IMPORT` or alternatively by compiling with the '-fpim4' switch.

However there are some very important differences between the dialects which are mutually exclusive and therefore it is vital that users choose the dialects with care when these language features are used.

2.5.1 Integer division, remainder and modulus

The most dangerous set of mutually exclusive features found in the four dialects supported by GNU Modula-2 are the `INTEGER` division, remainder and modulus arithmetic operators. It is important to note that the same source code can be compiled to give different run time results depending upon these switches! The reference manual for the various dialects of Modula-2 are quite clear about this behavior and sadly there are three distinct definitions.

The table below illustrates the problem when a negative operand is used.

		Pim2/3		Pim4		ISO			
		-----	-----	-----	-----	-----	-----	-----	-----
lval	rval	DIV	MOD	DIV	MOD	DIV	MOD	/	REM
31	10	3	1	3	1	3	1	3	1
-31	10	-3	-1	-4	9	-4	9	-3	-1
31	-10	-3	1	-3	1	Exception		-3	1
-31	-10	3	-1	4	9	Exception		3	-1

See also P24 of PIM2, P27 of PIM3, P29 of PIM4 and P201 of the ISO Standard. At present all dialect division, remainder and modulus are implemented as above, apart from the exception calling in the ISO dialect. Instead of exception handling the results are the same as the PIM4 dialect. This is a temporary implementation situation.

2.6 Exception implementation

This section describes how exceptions are implemented in GNU Modula-2 and how command line switches affect their behavior. The option ‘`-fsoft-check-all`’ enables all software checking of nil dereferences, division by zero etc. Additional code is produced to check these conditions and exception handlers are invoked if the conditions prevail.

Without ‘`-fsoft-check-all`’ these exceptions will be caught by hardware (assuming the hardware support exists) and a signal handler is invoked. The signal handler will in turn `THROW` an exception which will be caught by the appropriate Modula-2 handler. However the action of throwing an exception from within a signal handler is implementation defined (according to the C++ documentation). For example on the `x86_64` architecture this works whereas on the `i686` architecture it does not. Therefore to ensure portability it is recommended to use ‘`-fsoft-check-all`’.

2

2.7 How to detect run time problems at compile time

Consider the following program:

```
MODULE assignvalue ; (*!m2iso+gm2*)

PROCEDURE bad () : INTEGER ;
VAR
  i: INTEGER ;
BEGIN
  i := -1 ;
  RETURN i
END bad ;

VAR
  foo: CARDINAL ;
BEGIN
  (* The m2rte plugin will detect this as an error, post
  optimization. *)
  foo := bad ()
END assignvalue.
```

here we see that the programmer has overlooked that the return value from ‘`bad`’ will cause an overflow to ‘`foo`’. If we compile the code with the following options:

```
$ gm2 -g -fsoft-check-all -O2 -c assignvalue.mod
assignvalue.mod:16:0:inevitable that this error will occur at run time,
assignment will result in an overflow
```

The `gm2` semantic plugin is automatically run and will generate a warning message for every exception call which is known as reachable. It is highly advised to run the optimizer (‘`-O2`’ or ‘`-O3`’) with ‘`-fsoft-check-all`’ so that the compiler is able to run the optimizer and perform variable and flow analysis before the semantic plugin is invoked.

² ‘`-fsoft-check-all`’ can be effectively combined with ‘`-O2`’ to semantically analyze source code for possible run time errors at compile time.

2.8 GNU Modula-2 language extensions

This section introduces the GNU Modula-2 language extensions. The GNU Modula-2 compiler allows abstract data types to be any type, not just restricted to a pointer type providing the `-fextended-opaque` option is supplied See Section “Compiler options” in gm2.

Declarations can be made in any order, whether they are types, constants, procedures, nested modules or variables.

GNU Modula-2 also allows programmers to interface to C and assembly language.

GNU Modula-2 provides support for the special tokens `__LINE__`, `__FILE__`, `__FUNCTION__` and `__DATE__`. Support for these tokens will occur even if the `-fcpp` option is not supplied. A table of these identifiers and their data type and values is given below:

Scope	GNU Modula-2 token	Data type and example value
anywhere	<code>__LINE__</code>	Constant Literal compatible with <code>CARDINAL</code> , <code>INTEGER</code> and <code>WORD</code> . Example 1234
anywhere	<code>__FILE__</code>	Constant string compatible with parameter <code>ARRAY OF CHAR</code> or an <code>ARRAY</code> whose <code>SIZE</code> is <code>>=</code> string length. Example "hello.mod"
procedure	<code>__FUNCTION__</code>	Constant string compatible with parameter <code>ARRAY OF CHAR</code> or an <code>ARRAY</code> whose <code>SIZE</code> is <code>>=</code> string length. Example "calc"
module	<code>__FUNCTION__</code>	Example "module hello initialization"
anywhere	<code>__DATE__</code>	Constant string compatible with parameter <code>ARRAY OF CHAR</code> or an <code>ARRAY</code> whose <code>SIZE</code> is <code>>=</code> string length. Example "Thu Apr 29 10:07:16 BST 2004"
anywhere	<code>__COLUMN__</code>	Gives a constant literal number determining the left hand column where the first <code>_</code> appears in <code>__COLUMN__</code> . The left most column is 1.

The preprocessor 'cpp' can be invoked via the '-fcpp' command line option. This in turn invokes 'cpp' with the following arguments '-traditional -lang-asm'. These options preserve comments and all quotations. 'gm2' treats a '#' character in the first column as a preprocessor directive.

For example here is a module which calls FatalError via the macro ERROR.

```

MODULE cpp ;

FROM SYSTEM IMPORT ADR, SIZE ;
FROM libc IMPORT exit, printf, malloc ;

PROCEDURE FatalError (a, file: ARRAY OF CHAR;
                     line: CARDINAL;
                     func: ARRAY OF CHAR) ;
BEGIN
  printf ("%s:%d:fatal error, %s, in %s\n",
          ADR (file), line, ADR (a), ADR (func)) ;
  exit (1)
END FatalError ;

#define ERROR(X) FatalError(X, __FILE__, __LINE__, __FUNCTION__)

VAR
  pc: POINTER TO CARDINAL;
BEGIN
  pc := malloc (SIZE (CARDINAL)) ;
  IF pc = NIL
  THEN
    ERROR ('out of memory')
  END
END cpp.

```

Another use for the C preprocessor in Modula-2 might be to turn on debugging code. For example the library module FormatStrings.mod uses procedures from DynamicStrings.mod and to track down memory leaks it was useful to track the source file and line where each string was created. Here is a section of FormatStrings.mod which shows how the debugging code was enabled and disabled by adding -fcpp to the command line.

```

FROM DynamicStrings IMPORT String, InitString, InitStringChar, Mark,
                          ConCat, Slice, Index, char,
                          Assign, Length, Mult, Dup, ConCatChar,
                          PushAllocation, PopAllocationExemption,
                          InitStringDB, InitStringCharStarDB,
                          InitStringCharDB, MultDB, DupDB, SliceDB ;

(*
#define InitString(X) InitStringDB(X, __FILE__, __LINE__)
#define InitStringCharStar(X) InitStringCharStarDB(X, __FILE__, \

```

```

__LINE__)
#define InitStringChar(X) InitStringCharDB(X, __FILE__, __LINE__)
#define Mult(X,Y) MultDB(X, Y, __FILE__, __LINE__)
#define Dup(X) DupDB(X, __FILE__, __LINE__)
#define Slice(X,Y,Z) SliceDB(X, Y, Z, __FILE__, __LINE__)
*)

PROCEDURE doDSdbEnter ;
BEGIN
    PushAllocation
END doDSdbEnter ;

PROCEDURE doDSdbExit (s: String) ;
BEGIN
    s := PopAllocationExemption (TRUE, s)
END doDSdbExit ;

PROCEDURE DSdbEnter ;
BEGIN
END DSdbEnter ;

PROCEDURE DSdbExit (s: String) ;
BEGIN
END DSdbExit ;

(*
#define DBsbEnter doDBsbEnter
#define DBsbExit doDBsbExit
*)

PROCEDURE Sprintf1 (s: String; w: ARRAY OF BYTE) : String ;
BEGIN
    DSdbEnter ;
    s := FormatString (HandleEscape (s), w) ;
    DSdbExit (s) ;
    RETURN s
END Sprintf1 ;

```

It is worth noting that the overhead of this code once `-fcpp` is not present and `-O2` is used will be zero since the local empty procedures `DSdbEnter` and `DSdbExit` will be thrown away by the optimization passes of the GCC backend.

2.8.1 Optional procedure parameter

GNU Modula-2 allows the last parameter to a procedure or function parameter to be optional. For example in the ISO library `COROUTINES.def` the procedure `NEWCOROUTINE` is defined as having an optional fifth argument (`initProtection`) which, if absent, is automatically replaced by `NIL`.

```
PROCEDURE NEWCOROUTINE (procBody: PROC; workspace: SYSTEM.ADDRESS;
                        size: CARDINAL; VAR cr: COROUTINE;
                        [initProtection: PROTECTION = NIL]);
```

(* Creates a new coroutine whose body is given by procBody, and returns the identity of the coroutine in cr. workspace is a pointer to the work space allocated to the coroutine; size specifies the size of this workspace in terms of SYSTEM.LOC.

The optional fifth argument may contain a single parameter which specifies the initial protection level of the coroutine.

*)

The implementation module COROUTINES.mod implements this procedure using the following syntax:

```
PROCEDURE NEWCOROUTINE (procBody: PROC; workspace: SYSTEM.ADDRESS;
                        size: CARDINAL; VAR cr: COROUTINE;
                        [initProtection: PROTECTION]);
BEGIN
END NEWCOROUTINE ;
```

Note that it is illegal for this declaration to contain an initializer value for `initProtection`. However it is necessary to surround this parameter with the brackets [and]. This serves to remind the programmer that the last parameter was declared as optional in the definition module.

Local procedures can be declared to have an optional final parameter in which case the initializer is mandatory in the implementation or program module.

GNU Modula-2 also provides additional fixed sized data types which are all exported from the `SYSTEM` module. See Section “The PIM system module” in `gm2`. See Section “The ISO system module” in `gm2`.

2.9 Type compatibility

This section discuss the issues surrounding assignment, expression and parameter compatibility, their effect of the additional fixed sized datatypes and also their effect of run time checking. The data types supported by the compiler are:

GNU Modula-2	scope	switches
=====		
INTEGER	pervasive	
LONGINT	pervasive	
SHORTINT	pervasive	
CARDINAL	pervasive	
LONGCARD	pervasive	
SHORTCARD	pervasive	
BOOLEAN	pervasive	
BITSET	pervasive	

REAL	pervasive	
LONGREAL	pervasive	
SHORTREAL	pervasive	
CHAR	pervasive	
SHORTCOMPLEX	pervasive	
COMPLEX	pervasive	
LONGCOMPLEX	pervasive	
LOC	SYSTEM	-fiso
BYTE	SYSTEM	
WORD	SYSTEM	
ADDRESS	SYSTEM	

The following extensions are supported for most architectures (please check SYSTEM.def).

```
=====
INTEGER8          SYSTEM
INTEGER16         SYSTEM
INTEGER32         SYSTEM
INTEGER64         SYSTEM
CARDINAL8         SYSTEM
CARDINAL16        SYSTEM
CARDINAL32        SYSTEM
CARDINAL64        SYSTEM
BITSET8           SYSTEM
BITSET16          SYSTEM
BITSET32          SYSTEM
WORD16            SYSTEM
WORD32            SYSTEM
WORD64            SYSTEM
REAL32            SYSTEM
REAL64            SYSTEM
REAL96            SYSTEM
REAL128           SYSTEM
COMPLEX32         SYSTEM
COMPLEX64         SYSTEM
COMPLEX96         SYSTEM
COMPLEX128        SYSTEM
```

The Modula-2 language categorizes compatibility between entities of possibly differing types into three sub components: expressions, assignments, and parameters. Parameter compatibility is further divided into two sections for pass by reference and pass by value compatibility.

For more detail on the Modula-2 type compatibility see the Modula-2 ISO standard BS ISO/IEC 10514-1:1996 page 121-125. For detail on the PIM type compatibility see Programming in Modula-2 Edition 4 page 29, (Elementary Data Types).

2.9.1 Expression compatibility

Modula-2 restricts the types of expressions to the same type. Expression compatibility is a symmetric relation.

For example two sub expressions of `INTEGER` and `CARDINAL` are not expression compatible (<http://freepages.modula2.org/report4/modula-2.html> and ISO Modula-2).

In GNU Modula-2 this rule is also extended across all fixed sized data types (imported from `SYSTEM`).

2.9.2 Assignment compatibility

This section discusses the assignment issues surrounding assignment compatibility of elementary types (`INTEGER`, `CARDINAL`, `REAL` and `CHAR` for example). The information here is found in more detail in the Modula-2 ISO standard BS ISO/IEC 10514-1:1996 page 122.

Assignment compatibility exists between the same sized elementary types.

Same type family of different sizes are also compatible as long as the `MAX(type)` and `MIN(type)` is known. So for example this includes the `INTEGER` family, `CARDINAL` family and the `REAL` family.

The reason for this is that when the assignment is performed the compiler will check to see that the expression (on the right of the `:=`) lies within the range of the designator type (on the left hand side of the `:=`). Thus these ordinal types can be assignment compatible. However it does mean that `WORD32` is not compatible with `WORD16` as `WORD32` does not have a minimum or maximum value and therefore cannot be checked. The compiler does not know which of the two bytes from `WORD32` should be copied into `WORD16` and which two should be ignored. Currently the types `BITSET8`, `BITSET16` and `BITSET32` are assignment incompatible. However this restriction maybe lifted when further run time checking is achieved.

Modula-2 does allow `INTEGER` to be assignment compatible with `WORD` as they are the same size. Likewise GNU Modula-2 allows `INTEGER16` to be compatible with `WORD16` and the same for the other fixed sized types and their sized equivalent in either `WORDn`, `BYTE` or `LOC` types. However it prohibits assignment between `WORD` and `WORD32` even though on many systems these sizes will be the same. The reasoning behind this rule is that the extended fixed sized types are meant to be used by applications requiring fixed sized data types and it is more portable to forbid the blurring of the boundaries between fixed sized and machine dependent sized types.

Intermediate code run time checking is always generated by the front end. However this intermediate code is only translated into actual code if the appropriate command line switches are specified. This allows the compiler to perform limited range checking at compile time. In the future it will allow the extensive GCC optimizations to propagate constant values through to the range checks which if they are found to exceed the type range will result in a compile time error message.

2.9.3 Parameter compatibility

Parameter compatibility is divided into two areas, pass by value and pass by reference (`VAR`). In the case of pass by value the rules are exactly the same as assignment. However in the second case, pass by reference, the actual parameter and formal parameter must be the

same size and family. Furthermore `INTEGER` and `CARDINALs` are not treated as compatible in the pass by reference case.

The types `BYTE`, `LOC`, `WORD` and `WORDn` derivatives are assignment and parameter compatible with any data type of the same size.

2.10 Unbounded by reference

This section documents a GNU Modula-2 compiler switch which implements a language optimization surrounding the implementation of unbounded arrays. In GNU Modula-2 the unbounded array is implemented by utilizing an internal structure `struct {dataType *address, unsigned int high}`. So given the Modula-2 procedure declaration:

```
PROCEDURE foo (VAR a: ARRAY OF dataType) ;
BEGIN
  IF a[2]= (* etc *)
END foo ;
```

it is translated into GCC trees, which can be represented in their C form thus:

```
void foo (struct {dataType *address, unsigned int high} a)
{
  if (a.address[2] == /* etc */)
}
```

Whereas if the procedure `foo` was declared as:

```
PROCEDURE foo (a: ARRAY OF dataType) ;
BEGIN
  IF a[2]= (* etc *)
END foo ;
```

then it is implemented by being translated into the following GCC trees, which can be represented in their C form thus:

```
void foo (struct {dataType *address, unsigned int high} a)
{
  dataType *copyContents = (dataType *)alloca (a.high+1);
  memcpy(copyContents, a.address, a.high+1);
  a.address = copyContents;

  if (a.address[2] == /* etc */)
}
```

This implementation works, but it makes a copy of each non `VAR` unbounded array when a procedure is entered. If the unbounded array is not changed during procedure `foo` then this implementation will be very inefficient. In effect Modula-2 lacks the `REF` keyword of Ada. Consequently the programmer maybe tempted to sacrifice semantic clarity for greater efficiency by declaring the parameter using the `VAR` keyword in place of `REF`.

The `-funbounded-by-reference` switch instructs the compiler to check and see if the programmer is modifying the content of any unbounded array. If it is modified then a copy will be made upon entry into the procedure. Conversely if the content is only read and never modified then this non `VAR` unbounded array is a candidate for being passed by reference.

It is only a candidate as it is still possible that passing this parameter by reference could alter the meaning of the source code. For example consider the following case:

```

PROCEDURE StrConCat (VAR a: ARRAY OF CHAR; b, c: ARRAY OF CHAR) ;
BEGIN
    (* code which performs string a := b + c *)
END StrConCat ;

PROCEDURE foo ;
VAR
    a: ARRAY [0..3] OF CHAR ;
BEGIN
    a := 'q' ;
    StrConCat(a, a, a)
END foo ;

```

In the code above we see that the same parameter, `a`, is being passed three times to `StrConCat`. Clearly even though parameters `b` and `c` are never modified it would be incorrect to implement them as pass by reference. Therefore the compiler checks to see if any non `VAR` parameter is type compatible with any `VAR` parameter and if so it generates run time procedure entry checks to determine whether the contents of parameters `b` or `c` matches the contents of `a`. If a match is detected then a copy is made and the **address** in the unbounded **structure** is modified.

The compiler will check the address range of each candidate against the address range of any `VAR` parameter, providing they are type compatible. For example consider:

```

PROCEDURE foo (a: ARRAY OF BYTE; VAR f: REAL) ;
BEGIN
    f := 3.14 ;
    IF a[0]=BYTE(0)
    THEN
        (* etc *)
    END
END foo ;

PROCEDURE bar ;
BEGIN
    r := 2.0 ;
    foo(r, r)
END bar ;

```

Here we see that although parameter, `a`, is a candidate for the passing by reference, it would be incorrect to use this transformation. Thus the compiler detects that parameters, `a` and `f` are type compatible and will produce run time checking code to test whether the address range of their respective contents intersect.

2.11 Building a shared library

This section describes building a tiny shared library implemented in Modula-2 and built with `libtool`. Suppose a project consists of two definition modules and two implementation

modules and a program module `a.def`, `a.mod`, `b.def`, `b.mod` and `c.mod`. The first step is to compile the modules using position independent code. This can be achieved by the following three commands:

```
libtool --tag=CC --mode=compile gm2 -g -c a.mod -o a.lo
libtool --tag=CC --mode=compile gm2 -g -c b.mod -o b.lo
libtool --tag=CC --mode=compile gm2 -g -c c.mod -o c.lo
```

The second step is to generate the shared library initialization and finalization routines. We can do this by asking `gm2` to generate a list of dependent modules and then use this to generate the scaffold. We also must compile the scaffold.

```
gm2 -c -g -fmakelist c.mod
gm2 -c -g -fmakeinit -fshared c.mod
libtool --tag=CC --mode=compile g++ -g -c c_m2.cpp -o c_m2.lo
```

The third step is to link all these `.lo` files.

```
libtool --mode=link gcc -g c_m2.lo a.lo b.lo c.lo \
-L$(prefix)/lib64 \
-rpath `pwd` -lgm2 -lstdc++ -lm -o libabc.la
```

At this point the shared library `libabc.so` will have been created inside the directory `.libs`.

2.12 How to produce swig interface files

This section describes how Modula-2 implementation modules can be called from Python (and other scripting languages such as TCL and Perl). GNU Modula-2 can be instructed to create a swig interface when it is compiling an implementation module. Swig then uses the interface file to generate all the necessary wrapping so that the desired scripting language may access the implementation module.

Here is an example of how you might call upon the services of the Modula-2 library module `NumberIO` from Python3.

The following commands can be used to generate the Python3 module:

```
export src='directory to the sources'
export prefix='directory to where the compiler is installed'
gm2 -I${src} -c -g -fswig ${src}/../../../../gm2-libs/NumberIO.mod
gm2 -I${src} -c -g -fmakelist ${src}/../../../../gm2-libs/NumberIO.mod

gm2 -I${src} -c -g -fmakeinit -fshared \
  ${src}/../../../../gm2-libs/NumberIO.mod

swig -c++ -python3 NumberIO.i

libtool --mode=compile g++ -g -c -I${src} NumberIO_m2.cpp \
  -o NumberIO_m2.lo

libtool --tag=CC --mode=compile gm2 -g -c \
  -I${src}/../../../../gm2-libs \
  ${src}/../../../../gm2-libs/NumberIO.mod -o NumberIO.lo
```

```

libtool --tag=CC --mode=compile g++ -g -c NumberIO_wrap.cxx \
-I/usr/include/python3 -o NumberIO_wrap.lo

libtool --mode=link gcc -g NumberIO_m2.lo NumberIO_wrap.lo \
-L${prefix}/lib64 \
-rpath `pwd` -lgm2 -lstdc++ -lm -o libNumberIO.la

cp .libs/libNumberIO.so _NumberIO.so

```

The first four commands, generate the swig interface file `NumberIO.i` and python wrap files `NumberIO_wrap.cxx` and `NumberIO.py`. The next three `libtool` commands compile the C++ and Modula-2 source code into `.lo` objects. The last `libtool` command links all the `.lo` files into a `.la` file and includes all shared library dependencies.

Now it is possible to run the following Python script (called `testnum.py`):

```

import NumberIO

print ("1234 x 2 =", NumberIO.NumberIO_StrToInt("1234")*2)

```

like this:

```

$ python3 testnum.py
1234 x 2 = 2468

```

See Section “Producing a Python module” in `gm2` for another example which uses the `UNQUALIFIED` keyword to reduce the module name clutter from the viewport of Python3.

2.12.1 Limitations of automatic generated of Swig files

This section discusses the limitations of automatically generating swig files. From the previous example we see that the module `NumberIO` had a swig interface file `NumberIO.i` automatically generated by the compiler. If we consider three of the procedure definitions in `NumberIO.def` we can see the success and limitations of the automatic interface generation.

```

PROCEDURE StrToHex (a: ARRAY OF CHAR; VAR x: CARDINAL) ;
PROCEDURE StrToInt (a: ARRAY OF CHAR; VAR x: INTEGER) ;
PROCEDURE ReadInt (VAR x: CARDINAL) ;

```

Below are the swig interface prototypes:

```

extern void NumberIO_StrToHex (char *_m2_address_a,
                               int _m2_high_a, unsigned int *OUTPUT);
/* parameters: x is known to be an OUTPUT */
extern void NumberIO_StrToInt (char *_m2_address_a,
                               int _m2_high_a, int *OUTPUT);
/* parameters: x is guessed to be an OUTPUT */
extern void NumberIO_ReadInt (int *x);
/* parameters: x is unknown */

```

In the case of `StrToHex` it can be seen that the compiler detects that the last parameter is an output. It explicitly tells swig this by using the parameter name `OUTPUT` and in the following comment it informs the user that it knows this to be an output parameter. In the second procedure `StrToInt` it marks the final parameter as an output, but it tells the

user that this is only a guess. Finally in `ReadInt` it informs the user that it does not know whether the parameter, `x`, is an output, input or an inout parameter.

The compiler decides whether to mark a parameter as either: `INPUT`, `OUTPUT` or `INOUT` if it is read before written or visa versa in the first basic block. At this point it will write output that the parameter is known. If it is not read or written in the first basic block then subsequent basic blocks are searched and the result is commented as a guess. Finally if no read or write occurs then the parameter is commented as unknown. However, clearly it is possible to fool this mechanism. Nevertheless automatic generation of implementation module into swig interface files was thought sufficiently useful despite these limitations.

In conclusion it would be wise to check all parameters in any automatically generated swig interface file. Furthermore you can force the automatic mechanism to generate correct interface files by reading or writing to the `VAR` parameter in the first basic block of a procedure.

2.13 How to produce a Python module

This section describes how it is possible to produce a Python module from Modula-2 code. There are a number of advantages to this approach, it ensures your code reaches a wider audience, maybe it is easier to initialize your application in Python.

The example application here is a pedagogical two dimensional gravity next event simulation. The Python module needs to have a clear API which should be placed in a single definition module. Furthermore the API should only use fundamental pervasive data types and strings. Below the API is contained in the file `twoDsim.def`:

```
DEFINITION MODULE twoDsim ;

EXPORT UNQUALIFIED gravity, box, poly3, poly5, poly6, mass,
                    fix, circle, pivot, velocity, accel, fps,
                    replayRate, simulateFor ;

(*
  gravity - turn on gravity at: g m^2
*)

PROCEDURE gravity (g: REAL) ;

(*
  box - place a box in the world at (x0,y0),(x0+i,y0+j)
*)

PROCEDURE box (x0, y0, i, j: REAL) : CARDINAL ;

(*
  poly3 - place a triangle in the world at:
          (x0,y0),(x1,y1),(x2,y2)
*)
```

```
PROCEDURE poly3 (x0, y0, x1, y1, x2, y2: REAL) : CARDINAL ;
```

```
(*  
  poly5 - place a pentagon in the world at:  
          (x0,y0),(x1,y1),(x2,y2),(x3,y3),(x4,y4)  
*)
```

```
PROCEDURE poly5 (x0, y0, x1, y1,  
                x2, y2, x3, y3, x4, y4: REAL) : CARDINAL ;
```

```
(*  
  poly6 - place a hexagon in the world at:  
          (x0,y0),(x1,y1),(x2,y2),(x3,y3),(x4,y4),(x5,y5)  
*)
```

```
PROCEDURE poly6 (x0, y0, x1, y1,  
                x2, y2, x3, y3,  
                x4, y4, x5, y5: REAL) : CARDINAL ;
```

```
(*  
  mass - specify the mass of an object and return the, id.  
*)
```

```
PROCEDURE mass (id: CARDINAL; m: REAL) : CARDINAL ;
```

```
(*  
  fix - fix the object to the world.  
*)
```

```
PROCEDURE fix (id: CARDINAL) : CARDINAL ;
```

```
(*  
  circle - adds a circle to the world. Center  
           defined by: x0, y0 radius, r.  
*)
```

```
PROCEDURE circle (x0, y0, r: REAL) : CARDINAL ;
```

```
(*  
  velocity - give an object, id, a velocity, vx, vy.
```

```

*)

PROCEDURE velocity (id: CARDINAL; vx, vy: REAL) : CARDINAL ;

(*
  accel - give an object, id, an acceleration, ax, ay.
*)

PROCEDURE accel (id: CARDINAL; ax, ay: REAL) : CARDINAL ;

(*
  fps - set frames per second.
*)

PROCEDURE fps (f: REAL) ;

(*
  replayRate - set frames per second during replay.
*)

PROCEDURE replayRate (f: REAL) ;

(*
  simulateFor - render for, t, seconds.
*)

PROCEDURE simulateFor (t: REAL) ;

END twoDsim.

```

The keyword `UNQUALIFIED` can be used to ensure that the compiler will provide externally accessible functions `gravity`, `box`, `poly3`, `poly5`, `poly6`, `mass`, `fix`, `circle`, `pivot`, `velocity`, `accel`, `fps`, `replayRate`, `simulateFor` rather than name mangled alternatives. Hence in our Python3 application we could write:

```

#!/usr/bin/env python3

from twoDsim import *

b = box (0.0, 0.0, 1.0, 1.0)
b = fix (b)
c1 = circle (0.7, 0.7, 0.05)
c1 = mass (c1, 0.01)

```

```

c2 = circle (0.7, 0.1, 0.05)
c2 = mass (c2, 0.01)
c2 = fix (c2)
gravity (-9.81)
fps (24.0*4.0)
replayRate (24.0)
print ("creating frames")
try:
    simulateFor (1.0)
    print ("all done")
except:
    print ("exception raised")

```

which accesses the various functions defined and implemented by the module `twoDsim`. The Modula-2 source code is compiled via:

```

$ gm2 -g -fiso -c -fswig twoDsim.mod
$ gm2 -g -fiso -c -fmakelist twoDsim.mod
$ gm2 -g -fiso -c -fmakeinit twoDsim.mod

```

The first command both compiles the source file creating `twoDsim.o` and produces a swig interface file `swig.i`. We now use `swig` and `g++` to produce and compile the interface wrappers:

```

$ libtool --mode=compile g++ -g -c twoDsim_m2.cpp -o twoDsim_m2.lo
$ swig -c++ -python3 twoDsim.i
$ libtool --mode=compile g++ -c -fPIC twoDsim_wrap.cxx \
  -I/usr/include/python3 -o twoDsim_wrap.lo
$ libtool --mode=compile gm2 -g -fPIC -fiso -c deviceGnuPic.mod
$ libtool --mode=compile gm2 -g -fPIC -fiso -c roots.mod
$ libtool --mode=compile gm2 -g -fPIC -fiso -c -fswig \
  twoDsim.mod -o twoDsim.lo

```

Finally the application is linked into a shared library:

```

$ libtool --mode=link gcc -g twoDsim_m2.lo twoDsim_wrap.lo \
  roots.lo deviceGnuPic.lo \
  -L${prefix}/lib64 \
  -rpath `pwd` -lgm2 -lstc++ -lm -o libtwoDsim.la
cp .libs/libtwoDsim.so _twoDsim.so

```

The library name must start with `_` to comply with the Python3 module naming scheme.

2.14 Interfacing GNU Modula-2 to C

The GNU Modula-2 compiler tries to use the C calling convention wherever possible however some parameters have no C equivalent and thus a language specific method is used. For example unbounded arrays are passed as a `struct {void *address, unsigned int high}` and the contents of these arrays are copied by callee functions when they are declared as non `VAR` parameters. The `VAR` equivalent unbounded array parameters need no copy, but still use the `struct` representation.

The recommended method of interfacing GNU Modula-2 to C is by telling the definition module that the implementation is in the C language. This is achieved by using the tokens `DEFINITION MODULE FOR "C"`. Here is an example `libprintf.def`.

```
DEFINITION MODULE FOR "C" libprintf ;

EXPORT UNQUALIFIED printf ;

PROCEDURE printf (a: ARRAY OF CHAR; ...) : [ INTEGER ] ;

END libprintf.
```

the `UNQUALIFIED` keyword in the definition module informs GNU Modula-2 not to prefix the module name to exported references in the object file.

The `printf` declaration states that the first parameter semantically matches `ARRAY OF CHAR` but since the module is for the C language it will be mapped onto `char *`. The token `...` indicates a variable number of arguments (varargs) and all parameters passed here are mapped onto their C equivalents. Arrays and constant strings are passed as pointers. Lastly `[INTEGER]` states that the caller can ignore the function return result if desired.

The hello world program can be rewritten as:

```
MODULE hello ;

FROM libprintf IMPORT printf ;

BEGIN
  printf ("hello world\n")
END hello.
```

and it can be compiled by:

```
'gm2 -g hello.mod -lc'
```

In reality the `-lc` is redundant as `libc` is always included in the linking process. It is shown here to emphasize that the C library or object file containing `printf` must be present. The search path for modules can be changed by using `-I`.

If a procedure function is declared using varargs then some parameter values are converted. The table below summarizes the default conversions and default types used.

Actual Parameter	Default conversion	Type of actual value passed
123	none	long long int
"hello world"	none	const char *
a: ARRAY OF CHAR	ADR (a)	char *
a: ARRAY [0..5] OF CHAR	ADR (a)	char *
3.14	none	long double

If you wish to pass `int` values then you should explicitly convert the constants using one of the conversion mechanisms. For example: `INTEGER(10)` or `VAL(INTEGER, 10)` or `CAST(INTEGER, 10)`.

2.15 Interface to assembly language

The interface for GNU Modula-2 to assembly language is almost identical to GNU C. The only alterations are that the keywords `asm` and `volatile` are in capitals, following the Modula-2 convention.

A simple, but highly non optimal, example is given below. Here we want to add the two `CARDINAL`s `foo` and `bar` together and return the result. The target processor is assumed to be executing the x86_64 instruction set.

```
PROCEDURE Example (foo, bar: CARDINAL) : CARDINAL ;
VAR
  myout: CARDINAL ;
BEGIN
  ASM VOLATILE ("movq %1,%%rax; addq %2,%%rax; movq %%rax,%0"
    : "=rm" (myout)           (* outputs *)
    : "rm" (foo), "rm" (bar)  (* inputs *)
    : "rax");                 (* we trash *)
  RETURN( myout )
END Example ;
```

For a full description of this interface we refer the reader to the GNU C manual.

See Section “Extensions to the C Language Family” in `gcc`.

The same example can be written using the newer extensions of naming the operands rather than using numbered arguments.

```
PROCEDURE Example (foo, bar: CARDINAL) : CARDINAL ;
VAR
  myout: CARDINAL ;
BEGIN
  ASM VOLATILE (
    "movq %[left],%%rax; addq %[right],%%rax; movq %%rax,%[output]"
    : [output] "=rm" (myout)           (* outputs *)
    : [left] "rm" (foo), [right] "rm" (bar) (* inputs *)
    : "rax");                           (* we trash *)
  RETURN( myout )
END Example ;
```

Both examples generate exactly the same code. It is worth noting that the specifier “`rm`” indicates that the operand can be either a register or memory. Of course you must choose an instruction which can take either, but this allows the compiler to take more efficient choices depending upon the optimization level given to the compiler.

2.16 Data type alignment

GNU Modula-2 allows you to specify alignment for types and variables. The syntax for alignment is to use the ISO pragma directives `<* bytealignment (expression)` and `>*`. These directives can be used after type and variable declarations.

The ebnf of the alignment production is:

```
Alignment := [ ByteAlignment ] =:
ByteAlignment := '<*' AttributeExpression '*>' =:
```



```
AlignmentExpression := "(" ConstExpression ")" =:
```

The `Alignment` ebnf statement may be used during construction of types, records, record fields, arrays, pointers and variables. Below is an example of aligning a type so that the variable `bar` is aligned on a 1024 address.

```
MODULE align ;

TYPE
  foo = INTEGER <* bytealignment(1024) *> ;

VAR
  z : INTEGER ;
  bar: foo ;
BEGIN
END align.
```

The next example aligns a variable on a 1024 byte boundary.

```
MODULE align2 ;

VAR
  x : CHAR ;
  z : ARRAY [0..255] OF INTEGER <* bytealignment(1024) *> ;
BEGIN
END align2.
```

Here the example aligns a pointer on a 1024 byte boundary.

```
MODULE align4 ;

FROM SYSTEM IMPORT ADR ;
FROM libc IMPORT exit ;

VAR
  x : CHAR ;
  z : POINTER TO INTEGER <* bytealignment(1024) *> ;
BEGIN
  IF ADR(z) MOD 1024=0
  THEN
    exit(0)
  ELSE
    exit(1)
  END
END align4.
```

In example `align5` record field `y` is aligned on a 1024 byte boundary.

```
MODULE align5 ;

FROM SYSTEM IMPORT ADR ;
FROM libc IMPORT exit ;
```

```

TYPE
  rec = RECORD
    x: CHAR ;
    y: CHAR <* bytealignment(1024) *> ;
  END ;
VAR
  r: rec ;
BEGIN
  IF ADR(r.y) MOD 1024=0
  THEN
    exit(0)
  ELSE
    exit(1)
  END
END align5.

```

In the example below module `align6` declares `foo` as an array of 256 INTEGERS. The array `foo` is aligned on a 1024 byte boundary.

```

MODULE align6 ;

FROM SYSTEM IMPORT ADR ;
FROM libc IMPORT exit ;

TYPE
  foo = ARRAY [0..255] OF INTEGER <* bytealignment(1024) *> ;

VAR
  x : CHAR ;
  z : foo ;
BEGIN
  IF ADR(z) MOD 1024=0
  THEN
    exit(0)
  ELSE
    exit(1)
  END
END align6.

```

2.17 Packing data types

The pragma `<* bytealignment(0) *>` can be used to specify that the fields within a `RECORD` are to be packed. Currently this only applies to fields which are declared as subranges, ordinal types and enumerated types. Here is an example of how two subranges might be packed into a byte.

```

TYPE
  bits3c = [0..7] ;
  bits3i = [-4..3] ;

```

```

byte = RECORD
    <* bytealignment(0) *>
    x: bits3c ;
    <* bitsunused(2) *>
    y: bits3i ;
END ;

```

Notice that the user has specified that in between fields `x` and `y` there are two bits unused.

Now the user wishes to create a record with byte numbers zero and one occupied and then an `INTEGER32` field which is four byte aligned. In this case byte numbers two and three will be unused. The pragma `bytealignment` can be issued at the start of the record indicating the default alignment for the whole record and this can be overridden by individual fields if necessary.

```

rec = RECORD
    <* bytealignment (1) *> ;
    a, b: byte ;
    x: INTEGER32 <* bytealignment(4) *> ;
END ;

```

In the following example the user has specified that a record has two fields `p` and `q` but that there are three bytes unused between these fields.

```

header = RECORD
    <* bytealignment(1) *>
    p: byte ;
    <* bytesunused(3) *>
    q: byte ;
END ;

```

The pragma `<* bytesunused(x) *>` can only be used if the current field is on a byte boundary. There is also a `SYSTEM` pseudo procedure function `TBITSIZE(T)` which returns the minimum number of bits necessary to represent type `T`.

Another example of packing record bit fields is given below:

```

MODULE align21 ;

FROM libc IMPORT exit ;

TYPE
    colour = (red, blue, green, purple, white, black) ;

    soc = PACKEDSET OF colour ;

    rec = RECORD
        <* bytealignment(0) *>
        x: soc ;
        y: [-1..1] ;
    END ;

```

```

VAR
  r: rec ;
  v: CARDINAL ;
BEGIN
  v := SIZE(r) ;
  IF SIZE(r)#1
  THEN
    exit(1)
  END ;
  r.x := soc{blue} ;
  IF r.x#soc{blue}
  THEN
    exit(2)
  END
END align21.

```

Here we see that the total size of this record is one byte and consists of a six bit set type followed by a 2 bit integer subrange.

2.18 Accessing GNU Modula-2 Built-ins

This section describes the built-in constants and functions defined in GNU Modula-2. The following compiler constants can be accessed using the `__ATTRIBUTE__` `__BUILTIN__` keywords. These are not part of the Modula-2 language and they may differ depending upon the target architecture but they provide a method whereby common libraries can interface to a different underlying architecture.

The built-in constants are: `BITS_PER_UNIT`, `BITS_PER_WORD`, `BITS_PER_CHAR` and `UNITS_PER_WORD`. They are integrated into GNU Modula-2 by an extension to the `ConstFactor` rule:

```

ConstFactor := ConstQualidentOrSet | Number | ConstString |
  "(" ConstExpression ")" | "NOT" ConstFactor |
  ConstAttribute =:

```

```

ConstAttribute := "__ATTRIBUTE__" "__BUILTIN__" "(" "(" Ident ")" ")" =:

```

Here is an example taken from the ISO library `SYSTEM.def`:

```

CONST
  BITS_PERLOC    = __ATTRIBUTE__ __BUILTIN__ ((BITS_PER_UNIT)) ;
  LOCS_PERWORD  = __ATTRIBUTE__ __BUILTIN__ ((UNITS_PER_WORD)) ;

```

Built-in functions are transparent to the end user. All built-in functions are declared in `DEFINITION MODULEs` and are imported as and when required. Built-in functions are declared in definition modules by using the `__BUILTIN__` keyword. Here is a section of the ISO library `LongMath.def` which demonstrates this feature.

```

PROCEDURE __BUILTIN__ sqrt (x: LONGREAL): LONGREAL;
  (* Returns the square root of x *)

```

This indicates that the function `sqrt` will be implemented using the gcc built-in maths library. If gcc cannot utilize the built-in function (for example if the programmer requested

the address of `sqrt`) then code is generated to call the alternative function implemented in the IMPLEMENTATION MODULE.

Sometimes a function exported from the DEFINITION MODULE will have a different name from the built-in function within gcc. In such cases the mapping between the GNU Modula-2 function name and the gcc name is expressed using the keywords `__ATTRIBUTE__` `__BUILTIN__` (`(Ident)`). For example the function `sqrt` in `LongMath.def` maps onto the gcc built-in function `sqrtl` and this is expressed as:

```
PROCEDURE __ATTRIBUTE__ __BUILTIN__ ((sqrtl)) sqrt
                                     (x: LONGREAL) : LONGREAL;
    (* Returns the positive square root of x *)
```

The following module `Builtins.def` enumerates the list of built-in functions which can be accessed in GNU Modula-2. It also serves to define the parameter and return value for each function:

```
DEFINITION MODULE Builtins ;

FROM SYSTEM IMPORT ADDRESS ;

(* floating point intrinsic procedure functions *)

PROCEDURE __BUILTIN__ isfinitef (x: SHORTREAL) : INTEGER ;
PROCEDURE __BUILTIN__ isfinite (x: REAL) : INTEGER ;
PROCEDURE __BUILTIN__ isfinitel (x: LONGREAL) : INTEGER ;

PROCEDURE __BUILTIN__ sinf (x: SHORTREAL) : SHORTREAL ;
PROCEDURE __BUILTIN__ sin (x: REAL) : REAL ;
PROCEDURE __BUILTIN__ sinl (x: LONGREAL) : LONGREAL ;

PROCEDURE __BUILTIN__ cosf (x: SHORTREAL) : SHORTREAL ;
PROCEDURE __BUILTIN__ cos (x: REAL) : REAL ;
PROCEDURE __BUILTIN__ cosl (x: LONGREAL) : LONGREAL ;

PROCEDURE __BUILTIN__ sqrtf (x: SHORTREAL) : SHORTREAL ;
PROCEDURE __BUILTIN__ sqrt (x: REAL) : REAL ;
PROCEDURE __BUILTIN__ sqrtl (x: LONGREAL) : LONGREAL ;

PROCEDURE __BUILTIN__ atan2f (x, y: SHORTREAL) : SHORTREAL ;
PROCEDURE __BUILTIN__ atan2 (x, y: REAL) : REAL ;
PROCEDURE __BUILTIN__ atan2l (x, y: LONGREAL) : LONGREAL ;

PROCEDURE __BUILTIN__ fabsf (x: SHORTREAL) : SHORTREAL ;
PROCEDURE __BUILTIN__ fabs (x: REAL) : REAL ;
PROCEDURE __BUILTIN__ fabsl (x: LONGREAL) : LONGREAL ;

PROCEDURE __BUILTIN__ logf (x: SHORTREAL) : SHORTREAL ;
PROCEDURE __BUILTIN__ log (x: REAL) : REAL ;
PROCEDURE __BUILTIN__ logl (x: LONGREAL) : LONGREAL ;
```

```

PROCEDURE __BUILTIN__ expf (x: SHORTREAL) : SHORTREAL ;
PROCEDURE __BUILTIN__ exp (x: REAL) : REAL ;
PROCEDURE __BUILTIN__ expl (x: LONGREAL) : LONGREAL ;

PROCEDURE __BUILTIN__ log10f (x: SHORTREAL) : SHORTREAL ;
PROCEDURE __BUILTIN__ log10 (x: REAL) : REAL ;
PROCEDURE __BUILTIN__ log10l (x: LONGREAL) : LONGREAL ;

PROCEDURE __BUILTIN__ exp10f (x: SHORTREAL) : SHORTREAL ;
PROCEDURE __BUILTIN__ exp10 (x: REAL) : REAL ;
PROCEDURE __BUILTIN__ exp10l (x: LONGREAL) : LONGREAL ;

PROCEDURE __BUILTIN__ ilogbf (x: SHORTREAL) : INTEGER ;
PROCEDURE __BUILTIN__ ilogb (x: REAL) : INTEGER ;
PROCEDURE __BUILTIN__ ilogbl (x: LONGREAL) : INTEGER ;

PROCEDURE __BUILTIN__ huge_val () : REAL ;
PROCEDURE __BUILTIN__ huge_valf () : SHORTREAL ;
PROCEDURE __BUILTIN__ huge_vall () : LONGREAL ;

PROCEDURE __BUILTIN__ modf (x: REAL; VAR y: REAL) : REAL ;
PROCEDURE __BUILTIN__ modff (x: SHORTREAL;
                             VAR y: SHORTREAL) : SHORTREAL ;
PROCEDURE __BUILTIN__ modfl (x: LONGREAL; VAR y: LONGREAL) : LONGREAL ;

PROCEDURE __BUILTIN__ signbit (r: REAL) : INTEGER ;
PROCEDURE __BUILTIN__ signbitf (s: SHORTREAL) : INTEGER ;
PROCEDURE __BUILTIN__ signbitl (l: LONGREAL) : INTEGER ;

PROCEDURE __BUILTIN__ nextafter (x, y: REAL) : REAL ;
PROCEDURE __BUILTIN__ nextafterf (x, y: SHORTREAL) : SHORTREAL ;
PROCEDURE __BUILTIN__ nextafterl (x, y: LONGREAL) : LONGREAL ;

PROCEDURE __BUILTIN__ nexttoward (x, y: REAL) : LONGREAL ;
PROCEDURE __BUILTIN__ nexttowardf (x, y: SHORTREAL) : LONGREAL ;
PROCEDURE __BUILTIN__ nexttowardl (x, y: LONGREAL) : LONGREAL ;

PROCEDURE __BUILTIN__ scalbln (x: REAL; n: LONGINT) : REAL ;
PROCEDURE __BUILTIN__ scalblnf (x: SHORTREAL; n: LONGINT) : SHORTREAL ;
PROCEDURE __BUILTIN__ scalblnl (x: LONGREAL; n: LONGINT) : LONGREAL ;

PROCEDURE __BUILTIN__ scalbn (x: REAL; n: INTEGER) : REAL ;
PROCEDURE __BUILTIN__ scalbnf (x: SHORTREAL; n: INTEGER) : SHORTREAL ;
PROCEDURE __BUILTIN__ scalbnl (x: LONGREAL; n: INTEGER) : LONGREAL ;

(* complex arithmetic intrinsic procedure functions *)

```

```
PROCEDURE __BUILTIN__ cabsf (z: SHORTCOMPLEX) : SHORTREAL ;
PROCEDURE __BUILTIN__ cabs (z: COMPLEX) : REAL ;
PROCEDURE __BUILTIN__ cabsl (z: LONGCOMPLEX) : LONGREAL ;

PROCEDURE __BUILTIN__ cargf (z: SHORTCOMPLEX) : SHORTREAL ;
PROCEDURE __BUILTIN__ carg (z: COMPLEX) : REAL ;
PROCEDURE __BUILTIN__ cargl (z: LONGCOMPLEX) : LONGREAL ;

PROCEDURE __BUILTIN__ conjf (z: SHORTCOMPLEX) : SHORTCOMPLEX ;
PROCEDURE __BUILTIN__ conj (z: COMPLEX) : COMPLEX ;
PROCEDURE __BUILTIN__ conjl (z: LONGCOMPLEX) : LONGCOMPLEX ;

PROCEDURE __BUILTIN__ cpowerf (base: SHORTCOMPLEX;
                               exp: SHORTREAL) : SHORTCOMPLEX ;
PROCEDURE __BUILTIN__ cpower (base: COMPLEX; exp: REAL) : COMPLEX ;
PROCEDURE __BUILTIN__ cpowerl (base: LONGCOMPLEX;
                               exp: LONGREAL) : LONGCOMPLEX ;

PROCEDURE __BUILTIN__ csqrtf (z: SHORTCOMPLEX) : SHORTCOMPLEX ;
PROCEDURE __BUILTIN__ csqrt (z: COMPLEX) : COMPLEX ;
PROCEDURE __BUILTIN__ csqrtl (z: LONGCOMPLEX) : LONGCOMPLEX ;

PROCEDURE __BUILTIN__ cexpf (z: SHORTCOMPLEX) : SHORTCOMPLEX ;
PROCEDURE __BUILTIN__ cexp (z: COMPLEX) : COMPLEX ;
PROCEDURE __BUILTIN__ cexpl (z: LONGCOMPLEX) : LONGCOMPLEX ;

PROCEDURE __BUILTIN__ clnf (z: SHORTCOMPLEX) : SHORTCOMPLEX ;
PROCEDURE __BUILTIN__ cln (z: COMPLEX) : COMPLEX ;
PROCEDURE __BUILTIN__ clnl (z: LONGCOMPLEX) : LONGCOMPLEX ;

PROCEDURE __BUILTIN__ csinf (z: SHORTCOMPLEX) : SHORTCOMPLEX ;
PROCEDURE __BUILTIN__ csin (z: COMPLEX) : COMPLEX ;
PROCEDURE __BUILTIN__ csinl (z: LONGCOMPLEX) : LONGCOMPLEX ;

PROCEDURE __BUILTIN__ ccosf (z: SHORTCOMPLEX) : SHORTCOMPLEX ;
PROCEDURE __BUILTIN__ ccos (z: COMPLEX) : COMPLEX ;
PROCEDURE __BUILTIN__ ccosl (z: LONGCOMPLEX) : LONGCOMPLEX ;

PROCEDURE __BUILTIN__ ctanf (z: SHORTCOMPLEX) : SHORTCOMPLEX ;
PROCEDURE __BUILTIN__ ctan (z: COMPLEX) : COMPLEX ;
PROCEDURE __BUILTIN__ ctanl (z: LONGCOMPLEX) : LONGCOMPLEX ;

PROCEDURE __BUILTIN__ carcsinf (z: SHORTCOMPLEX) : SHORTCOMPLEX ;
PROCEDURE __BUILTIN__ carcsin (z: COMPLEX) : COMPLEX ;
PROCEDURE __BUILTIN__ carcsinl (z: LONGCOMPLEX) : LONGCOMPLEX ;
```

```

PROCEDURE __BUILTIN__ carccosf (z: SHORTCOMPLEX) : SHORTCOMPLEX ;
PROCEDURE __BUILTIN__ carccos (z: COMPLEX) : COMPLEX ;
PROCEDURE __BUILTIN__ carccosl (z: LONGCOMPLEX) : LONGCOMPLEX ;

PROCEDURE __BUILTIN__ carctanf (z: SHORTCOMPLEX) : SHORTCOMPLEX ;
PROCEDURE __BUILTIN__ carctan (z: COMPLEX) : COMPLEX ;
PROCEDURE __BUILTIN__ carctanl (z: LONGCOMPLEX) : LONGCOMPLEX ;

(* memory and string intrinsic procedure functions *)

PROCEDURE __BUILTIN__ alloca (i: CARDINAL) : ADDRESS ;
PROCEDURE __BUILTIN__ memcpy (dest, src: ADDRESS;
                               nbytes: CARDINAL) : ADDRESS ;
PROCEDURE __BUILTIN__ index (s: ADDRESS; c: INTEGER) : ADDRESS ;
PROCEDURE __BUILTIN__ rindex (s: ADDRESS; c: INTEGER) : ADDRESS ;
PROCEDURE __BUILTIN__ memcmp (s1, s2: ADDRESS;
                               nbytes: CARDINAL) : INTEGER ;
PROCEDURE __BUILTIN__ memset (s: ADDRESS; c: INTEGER;
                               nbytes: CARDINAL) : ADDRESS ;
PROCEDURE __BUILTIN__ memmove (s1, s2: ADDRESS;
                               nbytes: CARDINAL) : ADDRESS ;
PROCEDURE __BUILTIN__ strcat (dest, src: ADDRESS) : ADDRESS ;
PROCEDURE __BUILTIN__ strncat (dest, src: ADDRESS;
                               nbytes: CARDINAL) : ADDRESS ;
PROCEDURE __BUILTIN__ strcpy (dest, src: ADDRESS) : ADDRESS ;
PROCEDURE __BUILTIN__ strncpy (dest, src: ADDRESS;
                               nbytes: CARDINAL) : ADDRESS ;
PROCEDURE __BUILTIN__ strcmp (s1, s2: ADDRESS) : INTEGER ;
PROCEDURE __BUILTIN__ strncmp (s1, s2: ADDRESS;
                               nbytes: CARDINAL) : INTEGER ;
PROCEDURE __BUILTIN__ strlen (s: ADDRESS) : INTEGER ;
PROCEDURE __BUILTIN__ strstr (haystack, needle: ADDRESS) : ADDRESS ;
PROCEDURE __BUILTIN__ strpbrk (s, accept: ADDRESS) : ADDRESS ;
PROCEDURE __BUILTIN__ strspn (s, accept: ADDRESS) : CARDINAL ;
PROCEDURE __BUILTIN__ strcspn (s, accept: ADDRESS) : CARDINAL ;
PROCEDURE __BUILTIN__ strchr (s: ADDRESS; c: INTEGER) : ADDRESS ;
PROCEDURE __BUILTIN__ strrchr (s: ADDRESS; c: INTEGER) : ADDRESS ;

(*
  longjmp - this GCC builtin restricts the val to always 1.
*)
(* do not use these two builtins, as gcc, only really
   anticipates that the Ada front end should use them
   and it only uses them in its runtime exception handling.
   We leave them here in the hope that someday they will
   behave more like their libc counterparts. *)

```



```

PROCEDURE __BUILTIN__ longjmp (env: ADDRESS; val: INTEGER) ;
PROCEDURE __BUILTIN__ setjmp (env: ADDRESS) : INTEGER ;

(*
  frame_address - returns the address of the frame.
                  The current frame is obtained if level is 0,
                  the next level up if level is 1 etc.
*)

PROCEDURE __BUILTIN__ frame_address (level: CARDINAL) : ADDRESS ;

(*
  return_address - returns the return address of function.
                  The current function return address is
                  obtained if level is 0,
                  the next level up if level is 1 etc.
*)

PROCEDURE __BUILTIN__ return_address (level: CARDINAL) : ADDRESS ;

(*
  alloca_trace - this is a no-op which is used for internal debugging.
*)

PROCEDURE alloca_trace (returned: ADDRESS; nBytes: CARDINAL) : ADDRESS ;

END Builtin.

```

Although this module exists and will result in the generation of in-line code if optimization flags are passed to GNU Modula-2, users are advised to utilize the same functions from more generic libraries. The built-in mechanism will be applied to these generic libraries where appropriate. Note for the mathematical routines to be in-lined you need to specify the ‘-ffast-math -O’ options.

2.19 The PIM system module

```

DEFINITION MODULE SYSTEM ;

EXPORT QUALIFIED BITS PER BYTE, BYTES PER WORD,
                ADDRESS, WORD, BYTE, CSIZE_T, CSSIZE_T, (*
                Target specific data types. *)
                ADR, TSIZE, ROTATE, SHIFT, THROW, TBITSIZE ;
                (* SIZE is also exported if -fpim2 is used. *)

```

```

CONST
  BITS_PER_BYTE = __ATTRIBUTE__ __BUILTIN__ ((BITS_PER_UNIT)) ;
  BYTES_PER_WORD = __ATTRIBUTE__ __BUILTIN__ ((UNITS_PER_WORD)) ;

(* Note that the full list of system and sized datatypes include:
   LOC, WORD, BYTE, ADDRESS,

   (and the non language standard target types)

   INTEGER8, INTEGER16, INTEGER32, INTEGER64,
   CARDINAL8, CARDINAL16, CARDINAL32, CARDINAL64,
   WORD16, WORD32, WORD64, BITSET8, BITSET16,
   BITSET32, REAL32, REAL64, REAL128, COMPLEX32,
   COMPLEX64, COMPLEX128, C_SIZE_T, C_SIZE_T.

   Also note that the non-standard data types will
   move into another module in the future. *)

(* The following types are supported on this target:
TYPE
  (* Target specific data types. *)
*)

(*
   all the functions below are declared internally to gm2
   =====
PROCEDURE ADR (VAR v: <anytype>): ADDRESS;
  (* Returns the address of variable v. *)

PROCEDURE SIZE (v: <type>) : ZType;
  (* Returns the number of BYTES used to store a v of
   any specified <type>. Only available if -fpim2 is used.
  *)

PROCEDURE TSIZE (<type>) : CARDINAL;
  (* Returns the number of BYTES used to store a value of the
   specified <type>.
  *)

PROCEDURE ROTATE (val: <a set type>;
                 num: INTEGER): <type of first parameter>;
  (* Returns a bit sequence obtained from val by rotating up/right
   or down/right by the absolute value of num. The direction is
   down/right if the sign of num is negative, otherwise the direction

```

is up/left.

*)

PROCEDURE SHIFT (val: <a set type>;

num: INTEGER): <type of first parameter>;

(* Returns a bit sequence obtained from val by shifting up/left or down/right by the absolute value of num, introducing zeros as necessary. The direction is down/right if the sign of num is negative, otherwise the direction is up/left.

*)

PROCEDURE THROW (i: INTEGER) <* noreturn *> ;

(*

THROW is a GNU extension and was not part of the PIM or ISO standards. It throws an exception which will be caught by the EXCEPT block (assuming it exists). This is a compiler builtin function which interfaces to the GCC exception handling runtime system.

GCC uses the term throw, hence the naming distinction between the GCC builtin and the Modula-2 runtime library procedure Raise. The later library procedure Raise will call SYSTEM.THROW after performing various housekeeping activities.

*)

PROCEDURE TBITSIZE (<type>) : CARDINAL ;

(* Returns the minimum number of bits necessary to represent <type>. This procedure function is only useful for determining the number of bits used for any type field within a packed RECORD. It is not particularly useful elsewhere since <type> might be optimized for speed, for example a BOOLEAN could occupy a WORD.

*)

*)

(* The following procedures are invoked by GNU Modula-2 to shift non word sized set types. They are not strictly part of the core PIM Modula-2, however they are used to implement the SHIFT procedure defined above, which are in turn used by the Logitech compatible libraries.

Users will access these procedures by using the procedure SHIFT above and GNU Modula-2 will map SHIFT onto one of the following procedures.

*)

(*

ShiftVal - is a runtime procedure whose job is to implement the SHIFT procedure of ISO SYSTEM. GNU Modula-2 will

inline a SHIFT of a single WORD sized set and will only call this routine for larger sets.

*)

```
PROCEDURE ShiftVal (VAR s, d: ARRAY OF BITSET;
                   SetSizeInBits: CARDINAL;
                   ShiftCount: INTEGER) ;
```

(*

ShiftLeft - performs the shift left for a multi word set.
This procedure might be called by the back end of GNU Modula-2 depending whether amount is known at compile time.

*)

```
PROCEDURE ShiftLeft (VAR s, d: ARRAY OF BITSET;
                    SetSizeInBits: CARDINAL;
                    ShiftCount: CARDINAL) ;
```

(*

ShiftRight - performs the shift left for a multi word set.
This procedure might be called by the back end of GNU Modula-2 depending whether amount is known at compile time.

*)

```
PROCEDURE ShiftRight (VAR s, d: ARRAY OF BITSET;
                     SetSizeInBits: CARDINAL;
                     ShiftCount: CARDINAL) ;
```

(*

RotateVal - is a runtime procedure whose job is to implement the ROTATE procedure of ISO SYSTEM. GNU Modula-2 will inline a ROTATE of a single WORD (or less) sized set and will only call this routine for larger sets.

*)

```
PROCEDURE RotateVal (VAR s, d: ARRAY OF BITSET;
                    SetSizeInBits: CARDINAL;
                    RotateCount: INTEGER) ;
```

(*

RotateLeft - performs the rotate left for a multi word set.

This procedure might be called by the back end of GNU Modula-2 depending whether amount is known at compile time.

*)

```
PROCEDURE RotateLeft (VAR s, d: ARRAY OF BITSET;
                     SetSizeInBits: CARDINAL;
                     RotateCount: CARDINAL) ;
```

(*

RotateRight - performs the rotate right for a multi word set.
This procedure might be called by the back end of GNU Modula-2 depending whether amount is known at compile time.

*)

```
PROCEDURE RotateRight (VAR s, d: ARRAY OF BITSET;
                      SetSizeInBits: CARDINAL;
                      RotateCount: CARDINAL) ;
```

END SYSTEM.

The different dialects of Modula-2 PIM-[234] and ISO Modula-2 declare the function `SIZE` in different places. PIM-[34] and ISO Modula-2 declare `SIZE` as a pervasive function (declared in the base module). PIM-2 defined `SIZE` in the `SYSTEM` module (as shown above).

GNU Modula-2 allows users to specify the dialect of Modula-2 by using the `-fiso` and `-fpim2` command line switches.

The data types `CSIZE_T` and `CSSIZE_T` are also exported from the `SYSTEM` module. The type `CSIZE_T` is unsigned and is mapped onto the target C data type `size_t` whereas the type `CSSIZE_T` is mapped onto the signed C data type `ssize_t`.

It is anticipated that these should only be used to provide cross platform definition modules for C libraries.

There are also a variety of fixed sized `INTEGER` and `CARDINAL` types. The variety of the fixed sized types will depend upon the target architecture.

2.20 The ISO system module

```
DEFINITION MODULE SYSTEM;
```

```
(* Gives access to system programming facilities that are probably
   non portable. *)
```

```
(* The constants and types define underlying properties of storage *)
```

```
EXPORT QUALIFIED BITSPERLOC, LOCSPERWORD,
```

```

        LOC, BYTE, WORD, ADDRESS, CSIZE_T, CSSIZE_T, (*
        Target specific data types. *)
        ADDADR, SUBADR, DIFADR, MAKEADR, ADR, ROTATE,
        SHIFT, CAST, TSIZE,

        (* Internal GM2 compiler functions *)
        ShiftVal, ShiftLeft, ShiftRight,
        RotateVal, RotateLeft, RotateRight,
        THROW, TBITSIZE ;

CONST
        (* <implementation-defined constant> ; *)
        BITSPERLOC   = __ATTRIBUTE__ __BUILTIN__ ((BITS_PER_UNIT)) ;
        (* <implementation-defined constant> ; *)
        LOCSPERWORD  = __ATTRIBUTE__ __BUILTIN__ ((UNITS_PER_WORD)) ;
        (* <implementation-defined constant> ; *)
        LOCSPERBYTE  = 8 DIV BITSPERLOC ;

(* Note that the full list of system and sized datatypes include:
   LOC, WORD, BYTE, ADDRESS,

   (and the non language standard target types)

   INTEGER8, INTEGER16, INTEGER32, INTEGER64,
   CARDINAL8, CARDINAL16, CARDINAL32, CARDINAL64,
   WORD16, WORD32, WORD64, BITSET8, BITSET16,
   BITSET32, REAL32, REAL64, REAL128, COMPLEX32,
   COMPLEX64, COMPLEX128, CSIZE_T, CSSIZE_T.

   Also note that the non-standard data types will
   move into another module in the future. *)

(*
   All the data types and procedures below are declared internally.
   =====
TYPE
        (* Target specific data types. *)

TYPE
        LOC; (* A system basic type. Values are the uninterpreted
              contents of the smallest addressable unit of storage *)
        ADDRESS = POINTER TO LOC;
        WORD = ARRAY [0 .. LOCSPERWORD-1] OF LOC;

        (* BYTE and LOCSPERBYTE are provided if appropriate for machine *)

```

TYPE

```
  BYTE = ARRAY [0 .. LOCSPERBYTE-1] OF LOC;
```

```
PROCEDURE ADDADR (addr: ADDRESS; offset: CARDINAL): ADDRESS;
```

```
  (* Returns address given by (addr + offset), or may raise
     an exception if this address is not valid.
```

```
  *)
```

```
PROCEDURE SUBADR (addr: ADDRESS; offset: CARDINAL): ADDRESS;
```

```
  (* Returns address given by (addr - offset), or may raise an
     exception if this address is not valid.
```

```
  *)
```

```
PROCEDURE DIFADR (addr1, addr2: ADDRESS): INTEGER;
```

```
  (* Returns the difference between addresses (addr1 - addr2),
     or may raise an exception if the arguments are invalid
     or address space is non-contiguous.
```

```
  *)
```

```
PROCEDURE MAKEADR (high: <some type>; ...): ADDRESS;
```

```
  (* Returns an address constructed from a list of values whose
     types are implementation-defined, or may raise an
     exception if this address is not valid.
```

In GNU Modula-2, MAKEADR can take any number of arguments which are mapped onto the type ADDRESS. The first parameter maps onto the high address bits and subsequent parameters map onto lower address bits. For example:

```
a := MAKEADR(BYTE(OFEH), BYTE(ODCH), BYTE(OBAH), BYTE(O98H),
             BYTE(O76H), BYTE(O54H), BYTE(O32H), BYTE(O10H)) ;
```

then the value of, a, on a 64 bit machine is: OFEDCBA9876543210H

The parameters do not have to be the same type, but constants must be typed.

```
  *)
```

```
PROCEDURE ADR (VAR v: <anytype>): ADDRESS;
```

```
  (* Returns the address of variable v. *)
```

```
PROCEDURE ROTATE (val: <a packedset type>;
```

```
                 num: INTEGER): <type of first parameter>;
```

```
  (* Returns a bit sequence obtained from val by rotating up/right
     or down/right by the absolute value of num. The direction is
     down/right if the sign of num is negative, otherwise the direction
     is up/left.
```

*)

```
PROCEDURE SHIFT (val: <a packedset type>;
                num: INTEGER): <type of first parameter>;
(* Returns a bit sequence obtained from val by shifting up/left
   or down/right by the absolute value of num, introducing
   zeros as necessary. The direction is down/right if the sign of
   num is negative, otherwise the direction is up/left.
```

*)

```
PROCEDURE CAST (<targettype>; val: <anytype>): <targettype>;
(* CAST is a type transfer function. Given the expression
   denoted by val, it returns a value of the type <targettype>.
   An invalid value for the target value or a
   physical address alignment problem may raise an exception.
```

*)

```
PROCEDURE TSIZE (<type>; ... ): CARDINAL;
(* Returns the number of LOCS used to store a value of the
   specified <type>. The extra parameters, if present,
   are used to distinguish variants in a variant record.
```

*)

```
PROCEDURE THROW (i: INTEGER) <* noreturn *> ;
(*
   THROW is a GNU extension and was not part of the PIM or ISO
   standards. It throws an exception which will be caught by the
   EXCEPT block (assuming it exists). This is a compiler builtin
   function which interfaces to the GCC exception handling runtime
   system.
   GCC uses the term throw, hence the naming distinction between
   the GCC builtin and the Modula-2 runtime library procedure Raise.
   The later library procedure Raise will call SYSTEM.THROW after
   performing various housekeeping activities.
```

*)

```
PROCEDURE TBITSIZE (<type>) : CARDINAL ;
(* Returns the minimum number of bits necessary to represent
   <type>. This procedure function is only useful for determining
   the number of bits used for any type field within a packed RECORD.
   It is not particularly useful elsewhere since <type> might be
   optimized for speed, for example a BOOLEAN could occupy a WORD.
```

*)

*)

(* The following procedures are invoked by GNU Modula-2 to

shift non word set types. They are not part of ISO Modula-2 but are used to implement the SHIFT procedure defined above. *)

```
(*
  ShiftVal - is a runtime procedure whose job is to implement
             the SHIFT procedure of ISO SYSTEM. GNU Modula-2 will
             inline a SHIFT of a single WORD sized set and will only
             call this routine for larger sets.
*)
```

```
PROCEDURE ShiftVal (VAR s, d: ARRAY OF BITSET;
                   SetSizeInBits: CARDINAL;
                   ShiftCount: INTEGER) ;
```

```
(*
  ShiftLeft - performs the shift left for a multi word set.
             This procedure might be called by the back end of
             GNU Modula-2 depending whether amount is known at
             compile time.
*)
```

```
PROCEDURE ShiftLeft (VAR s, d: ARRAY OF BITSET;
                    SetSizeInBits: CARDINAL;
                    ShiftCount: CARDINAL) ;
```

```
(*
  ShiftRight - performs the shift left for a multi word set.
             This procedure might be called by the back end of
             GNU Modula-2 depending whether amount is known at
             compile time.
*)
```

```
PROCEDURE ShiftRight (VAR s, d: ARRAY OF BITSET;
                     SetSizeInBits: CARDINAL;
                     ShiftCount: CARDINAL) ;
```

```
(*
  RotateVal - is a runtime procedure whose job is to implement
             the ROTATE procedure of ISO SYSTEM. GNU Modula-2 will
             inline a ROTATE of a single WORD (or less)
             sized set and will only call this routine for larger
             sets.
*)
```

```
PROCEDURE RotateVal (VAR s, d: ARRAY OF BITSET;
```

```

        SetSizeInBits: CARDINAL;
        RotateCount: INTEGER) ;

(*
  RotateLeft - performs the rotate left for a multi word set.
               This procedure might be called by the back end of
               GNU Modula-2 depending whether amount is known at
               compile time.
*)

PROCEDURE RotateLeft (VAR s, d: ARRAY OF BITSET;
                     SetSizeInBits: CARDINAL;
                     RotateCount: CARDINAL) ;

(*
  RotateRight - performs the rotate right for a multi word set.
               This procedure might be called by the back end of
               GNU Modula-2 depending whether amount is known at
               compile time.
*)

PROCEDURE RotateRight (VAR s, d: ARRAY OF BITSET;
                      SetSizeInBits: CARDINAL;
                      RotateCount: CARDINAL) ;

END SYSTEM.
```

The data types `CSIZE_T` and `CSSIZE_T` are also exported from the `SYSTEM` module. The type `CSIZE_T` is unsigned and is mapped onto the target C data type `size_t` whereas the type `CSSIZE_T` is mapped onto the signed C data type `ssize_t`.

It is anticipated that these should only be used to provide cross platform definition modules for C libraries.

There are also a variety of fixed sized `INTEGER` and `CARDINAL` types. The variety of the fixed sized types will depend upon the target architecture.

2.21 Release map

GNU Modula-2 is now part of GCC and therefore will adopt the GCC release schedule. It is intended that GNU Modula-2 implement more of the GCC builtins (vararg access) and GCC features.

There is an intention to implement the ISO generics and the M2R10 dialect of Modula-2. It will also implement all language changes. If you wish to see something different please email gm2@nongnu.org with your ideas.

2.22 Documentation

The GNU Modula-2 documentation is available on line <https://gcc.gnu.org/onlinedocs> or in the pdf, info, html file format.

2.23 Regression tests for gm2 in the repository

The regression testsuite can be run from the gcc build directory:

```
$ cd build-gcc
$ make check -j 24
```

which runs the complete testsuite for all compilers using 24 parallel invocations of the compiler. Individual language testsuites can be run by specifying the language, for example the Modula-2 testsuite can be run using:

```
$ cd build-gcc
$ make check-m2 -j 24
```

Finally the results of the testsuite can be emailed to the gcc-testresults (<https://gcc.gnu.org/lists.html>) list using the `test_summary` script found in the gcc source tree:

```
$ 'directory to the sources'/contrib/test_summary
```

2.24 Limitations

Logitech compatibility library is incomplete. The principle modules for this platform exist however for a comprehensive list of completed modules please check the documentation `gm2.html`.

2.25 Objectives

- The intention of GNU Modula-2 is to provide a production Modula-2 front end to GCC.
- It should support all Niklaus Wirth PIM Dialects [234] and also ISO Modula-2 including a re-implementation of all the ISO modules.
- There should be an easy interface to C.
- Exploit the features of GCC.
- Listen to the requests of the users.

2.26 FAQ

2.26.1 Why use the C++ exception mechanism in GCC, rather than a bespoke Modula-2 mechanism?

The C++ mechanism is tried and tested, it also provides GNU Modula-2 with the ability to link with C++ modules and via swig it can raise Python exceptions.

2.27 Community

You can subscribe to the GNU Modula-2 mailing by sending an email to: `gm2-subscribe@nongnu.org` or by <http://lists.nongnu.org/mailman/listinfo/gm2>. The mailing list contents can be viewed <http://lists.gnu.org/archive/html/gm2>.

2.28 Other languages for GCC

These exist and can be found on the frontends web page on the gcc web site (<http://gcc.gnu.org/frontends.html>).

2.29 License of GNU Modula-2

GNU Modula-2 is free software, the compiler is held under the GPL v3 <http://www.gnu.org/licenses/gpl.txt>, its libraries (pim, iso and Logitech compatible) are under the GPL v3 with the GCC run time library exception clause.

Under Section 7 of GPL version 3, you are granted additional permissions described in the GCC Runtime Library Exception, version 3.1, as published by the Free Software Foundation.

You should have received a copy of the GNU General Public License and a copy of the GCC Runtime Library Exception along with this program; see the files COPYING3 and COPYING.RUNTIME respectively. If not, see <http://www.gnu.org/licenses/>.

More information on how these licenses work is available <http://www.gnu.org/licenses/licenses.html> on the GNU web site.

GNU General Public License

Version 3, 29 June 2007

Copyright © 2007 Free Software Foundation, Inc. <https://www.fsf.org>

Everyone is permitted to copy and distribute verbatim copies of this license document, but changing it is not allowed.

Preamble

The GNU General Public License is a free, copyleft license for software and other kinds of works.

The licenses for most software and other practical works are designed to take away your freedom to share and change the works. By contrast, the GNU General Public License is intended to guarantee your freedom to share and change all versions of a program—to make sure it remains free software for all its users. We, the Free Software Foundation, use the GNU General Public License for most of our software; it applies also to any other work released this way by its authors. You can apply it to your programs, too.

When we speak of free software, we are referring to freedom, not price. Our General Public Licenses are designed to make sure that you have the freedom to distribute copies of free software (and charge for them if you wish), that you receive source code or can get it if you want it, that you can change the software or use pieces of it in new free programs, and that you know you can do these things.

To protect your rights, we need to prevent others from denying you these rights or asking you to surrender the rights. Therefore, you have certain responsibilities if you distribute copies of the software, or if you modify it: responsibilities to respect the freedom of others.

For example, if you distribute copies of such a program, whether gratis or for a fee, you must pass on to the recipients the same freedoms that you received. You must make sure that they, too, receive or can get the source code. And you must show them these terms so they know their rights.

Developers that use the GNU GPL protect your rights with two steps: (1) assert copyright on the software, and (2) offer you this License giving you legal permission to copy, distribute and/or modify it.

For the developers' and authors' protection, the GPL clearly explains that there is no warranty for this free software. For both users' and authors' sake, the GPL requires that modified versions be marked as changed, so that their problems will not be attributed erroneously to authors of previous versions.

Some devices are designed to deny users access to install or run modified versions of the software inside them, although the manufacturer can do so. This is fundamentally incompatible with the aim of protecting users' freedom to change the software. The systematic pattern of such abuse occurs in the area of products for individuals to use, which is precisely where it is most unacceptable. Therefore, we have designed this version of the GPL to prohibit the practice for those products. If such problems arise substantially in other domains, we stand ready to extend this provision to those domains in future versions of the GPL, as needed to protect the freedom of users.

Finally, every program is threatened constantly by software patents. States should not allow patents to restrict development and use of software on general-purpose computers, but in those that do, we wish to avoid the special danger that patents applied to a free program could make it effectively proprietary. To prevent this, the GPL assures that patents cannot be used to render the program non-free.

The precise terms and conditions for copying, distribution and modification follow.

TERMS AND CONDITIONS

0. Definitions.

“This License” refers to version 3 of the GNU General Public License.

“Copyright” also means copyright-like laws that apply to other kinds of works, such as semiconductor masks.

“The Program” refers to any copyrightable work licensed under this License. Each licensee is addressed as “you”. “Licensees” and “recipients” may be individuals or organizations.

To “modify” a work means to copy from or adapt all or part of the work in a fashion requiring copyright permission, other than the making of an exact copy. The resulting work is called a “modified version” of the earlier work or a work “based on” the earlier work.

A “covered work” means either the unmodified Program or a work based on the Program.

To “propagate” a work means to do anything with it that, without permission, would make you directly or secondarily liable for infringement under applicable copyright law, except executing it on a computer or modifying a private copy. Propagation includes copying, distribution (with or without modification), making available to the public, and in some countries other activities as well.

To “convey” a work means any kind of propagation that enables other parties to make or receive copies. Mere interaction with a user through a computer network, with no transfer of a copy, is not conveying.

An interactive user interface displays “Appropriate Legal Notices” to the extent that it includes a convenient and prominently visible feature that (1) displays an appropriate copyright notice, and (2) tells the user that there is no warranty for the work (except to the extent that warranties are provided), that licensees may convey the work under this License, and how to view a copy of this License. If the interface presents a list of user commands or options, such as a menu, a prominent item in the list meets this criterion.

1. Source Code.

The “source code” for a work means the preferred form of the work for making modifications to it. “Object code” means any non-source form of a work.

A “Standard Interface” means an interface that either is an official standard defined by a recognized standards body, or, in the case of interfaces specified for a particular programming language, one that is widely used among developers working in that language.

The “System Libraries” of an executable work include anything, other than the work as a whole, that (a) is included in the normal form of packaging a Major Component, but which is not part of that Major Component, and (b) serves only to enable use of the work with that Major Component, or to implement a Standard Interface for which an implementation is available to the public in source code form. A “Major Component”, in this context, means a major essential component (kernel, window system, and so on) of the specific operating system (if any) on which the executable work runs, or a compiler used to produce the work, or an object code interpreter used to run it.

The “Corresponding Source” for a work in object code form means all the source code needed to generate, install, and (for an executable work) run the object code and to modify the work, including scripts to control those activities. However, it does not include the work’s System Libraries, or general-purpose tools or generally available free programs which are used unmodified in performing those activities but which are not part of the work. For example, Corresponding Source includes interface definition files associated with source files for the work, and the source code for shared libraries and dynamically linked subprograms that the work is specifically designed to require, such as by intimate data communication or control flow between those subprograms and other parts of the work.

The Corresponding Source need not include anything that users can regenerate automatically from other parts of the Corresponding Source.

The Corresponding Source for a work in source code form is that same work.

2. Basic Permissions.

All rights granted under this License are granted for the term of copyright on the Program, and are irrevocable provided the stated conditions are met. This License explicitly affirms your unlimited permission to run the unmodified Program. The output from running a covered work is covered by this License only if the output, given its content, constitutes a covered work. This License acknowledges your rights of fair use or other equivalent, as provided by copyright law.

You may make, run and propagate covered works that you do not convey, without conditions so long as your license otherwise remains in force. You may convey covered works to others for the sole purpose of having them make modifications exclusively for you, or provide you with facilities for running those works, provided that you comply with the terms of this License in conveying all material for which you do not control copyright. Those thus making or running the covered works for you must do so exclusively on your behalf, under your direction and control, on terms that prohibit them from making any copies of your copyrighted material outside their relationship with you.

Conveying under any other circumstances is permitted solely under the conditions stated below. Sublicensing is not allowed; section 10 makes it unnecessary.

3. Protecting Users’ Legal Rights From Anti-Circumvention Law.

No covered work shall be deemed part of an effective technological measure under any applicable law fulfilling obligations under article 11 of the WIPO copyright treaty adopted on 20 December 1996, or similar laws prohibiting or restricting circumvention of such measures.

When you convey a covered work, you waive any legal power to forbid circumvention of technological measures to the extent such circumvention is effected by exercising rights under this License with respect to the covered work, and you disclaim any intention to limit operation or modification of the work as a means of enforcing, against the work's users, your or third parties' legal rights to forbid circumvention of technological measures.

4. Conveying Verbatim Copies.

You may convey verbatim copies of the Program's source code as you receive it, in any medium, provided that you conspicuously and appropriately publish on each copy an appropriate copyright notice; keep intact all notices stating that this License and any non-permissive terms added in accord with section 7 apply to the code; keep intact all notices of the absence of any warranty; and give all recipients a copy of this License along with the Program.

You may charge any price or no price for each copy that you convey, and you may offer support or warranty protection for a fee.

5. Conveying Modified Source Versions.

You may convey a work based on the Program, or the modifications to produce it from the Program, in the form of source code under the terms of section 4, provided that you also meet all of these conditions:

- a. The work must carry prominent notices stating that you modified it, and giving a relevant date.
- b. The work must carry prominent notices stating that it is released under this License and any conditions added under section 7. This requirement modifies the requirement in section 4 to "keep intact all notices".
- c. You must license the entire work, as a whole, under this License to anyone who comes into possession of a copy. This License will therefore apply, along with any applicable section 7 additional terms, to the whole of the work, and all its parts, regardless of how they are packaged. This License gives no permission to license the work in any other way, but it does not invalidate such permission if you have separately received it.
- d. If the work has interactive user interfaces, each must display Appropriate Legal Notices; however, if the Program has interactive interfaces that do not display Appropriate Legal Notices, your work need not make them do so.

A compilation of a covered work with other separate and independent works, which are not by their nature extensions of the covered work, and which are not combined with it such as to form a larger program, in or on a volume of a storage or distribution medium, is called an "aggregate" if the compilation and its resulting copyright are not used to limit the access or legal rights of the compilation's users beyond what the individual works permit. Inclusion of a covered work in an aggregate does not cause this License to apply to the other parts of the aggregate.

6. Conveying Non-Source Forms.

You may convey a covered work in object code form under the terms of sections 4 and 5, provided that you also convey the machine-readable Corresponding Source under the terms of this License, in one of these ways:

- a. Convey the object code in, or embodied in, a physical product (including a physical distribution medium), accompanied by the Corresponding Source fixed on a durable physical medium customarily used for software interchange.
- b. Convey the object code in, or embodied in, a physical product (including a physical distribution medium), accompanied by a written offer, valid for at least three years and valid for as long as you offer spare parts or customer support for that product model, to give anyone who possesses the object code either (1) a copy of the Corresponding Source for all the software in the product that is covered by this License, on a durable physical medium customarily used for software interchange, for a price no more than your reasonable cost of physically performing this conveying of source, or (2) access to copy the Corresponding Source from a network server at no charge.
- c. Convey individual copies of the object code with a copy of the written offer to provide the Corresponding Source. This alternative is allowed only occasionally and noncommercially, and only if you received the object code with such an offer, in accord with subsection 6b.
- d. Convey the object code by offering access from a designated place (gratis or for a charge), and offer equivalent access to the Corresponding Source in the same way through the same place at no further charge. You need not require recipients to copy the Corresponding Source along with the object code. If the place to copy the object code is a network server, the Corresponding Source may be on a different server (operated by you or a third party) that supports equivalent copying facilities, provided you maintain clear directions next to the object code saying where to find the Corresponding Source. Regardless of what server hosts the Corresponding Source, you remain obligated to ensure that it is available for as long as needed to satisfy these requirements.
- e. Convey the object code using peer-to-peer transmission, provided you inform other peers where the object code and Corresponding Source of the work are being offered to the general public at no charge under subsection 6d.

A separable portion of the object code, whose source code is excluded from the Corresponding Source as a System Library, need not be included in conveying the object code work.

A “User Product” is either (1) a “consumer product”, which means any tangible personal property which is normally used for personal, family, or household purposes, or (2) anything designed or sold for incorporation into a dwelling. In determining whether a product is a consumer product, doubtful cases shall be resolved in favor of coverage. For a particular product received by a particular user, “normally used” refers to a typical or common use of that class of product, regardless of the status of the particular user or of the way in which the particular user actually uses, or expects or is expected to use, the product. A product is a consumer product regardless of whether the product has substantial commercial, industrial or non-consumer uses, unless such uses represent the only significant mode of use of the product.

“Installation Information” for a User Product means any methods, procedures, authorization keys, or other information required to install and execute modified versions of a covered work in that User Product from a modified version of its Corresponding Source.

The information must suffice to ensure that the continued functioning of the modified object code is in no case prevented or interfered with solely because modification has been made.

If you convey an object code work under this section in, or with, or specifically for use in, a User Product, and the conveying occurs as part of a transaction in which the right of possession and use of the User Product is transferred to the recipient in perpetuity or for a fixed term (regardless of how the transaction is characterized), the Corresponding Source conveyed under this section must be accompanied by the Installation Information. But this requirement does not apply if neither you nor any third party retains the ability to install modified object code on the User Product (for example, the work has been installed in ROM).

The requirement to provide Installation Information does not include a requirement to continue to provide support service, warranty, or updates for a work that has been modified or installed by the recipient, or for the User Product in which it has been modified or installed. Access to a network may be denied when the modification itself materially and adversely affects the operation of the network or violates the rules and protocols for communication across the network.

Corresponding Source conveyed, and Installation Information provided, in accord with this section must be in a format that is publicly documented (and with an implementation available to the public in source code form), and must require no special password or key for unpacking, reading or copying.

7. Additional Terms.

“Additional permissions” are terms that supplement the terms of this License by making exceptions from one or more of its conditions. Additional permissions that are applicable to the entire Program shall be treated as though they were included in this License, to the extent that they are valid under applicable law. If additional permissions apply only to part of the Program, that part may be used separately under those permissions, but the entire Program remains governed by this License without regard to the additional permissions.

When you convey a copy of a covered work, you may at your option remove any additional permissions from that copy, or from any part of it. (Additional permissions may be written to require their own removal in certain cases when you modify the work.) You may place additional permissions on material, added by you to a covered work, for which you have or can give appropriate copyright permission.

Notwithstanding any other provision of this License, for material you add to a covered work, you may (if authorized by the copyright holders of that material) supplement the terms of this License with terms:

- a. Disclaiming warranty or limiting liability differently from the terms of sections 15 and 16 of this License; or
- b. Requiring preservation of specified reasonable legal notices or author attributions in that material or in the Appropriate Legal Notices displayed by works containing it; or
- c. Prohibiting misrepresentation of the origin of that material, or requiring that modified versions of such material be marked in reasonable ways as different from the original version; or

- d. Limiting the use for publicity purposes of names of licensors or authors of the material; or
- e. Declining to grant rights under trademark law for use of some trade names, trademarks, or service marks; or
- f. Requiring indemnification of licensors and authors of that material by anyone who conveys the material (or modified versions of it) with contractual assumptions of liability to the recipient, for any liability that these contractual assumptions directly impose on those licensors and authors.

All other non-permissive additional terms are considered “further restrictions” within the meaning of section 10. If the Program as you received it, or any part of it, contains a notice stating that it is governed by this License along with a term that is a further restriction, you may remove that term. If a license document contains a further restriction but permits relicensing or conveying under this License, you may add to a covered work material governed by the terms of that license document, provided that the further restriction does not survive such relicensing or conveying.

If you add terms to a covered work in accord with this section, you must place, in the relevant source files, a statement of the additional terms that apply to those files, or a notice indicating where to find the applicable terms.

Additional terms, permissive or non-permissive, may be stated in the form of a separately written license, or stated as exceptions; the above requirements apply either way.

8. Termination.

You may not propagate or modify a covered work except as expressly provided under this License. Any attempt otherwise to propagate or modify it is void, and will automatically terminate your rights under this License (including any patent licenses granted under the third paragraph of section 11).

However, if you cease all violation of this License, then your license from a particular copyright holder is reinstated (a) provisionally, unless and until the copyright holder explicitly and finally terminates your license, and (b) permanently, if the copyright holder fails to notify you of the violation by some reasonable means prior to 60 days after the cessation.

Moreover, your license from a particular copyright holder is reinstated permanently if the copyright holder notifies you of the violation by some reasonable means, this is the first time you have received notice of violation of this License (for any work) from that copyright holder, and you cure the violation prior to 30 days after your receipt of the notice.

Termination of your rights under this section does not terminate the licenses of parties who have received copies or rights from you under this License. If your rights have been terminated and not permanently reinstated, you do not qualify to receive new licenses for the same material under section 10.

9. Acceptance Not Required for Having Copies.

You are not required to accept this License in order to receive or run a copy of the Program. Ancillary propagation of a covered work occurring solely as a consequence of using peer-to-peer transmission to receive a copy likewise does not require acceptance.

However, nothing other than this License grants you permission to propagate or modify any covered work. These actions infringe copyright if you do not accept this License. Therefore, by modifying or propagating a covered work, you indicate your acceptance of this License to do so.

10. Automatic Licensing of Downstream Recipients.

Each time you convey a covered work, the recipient automatically receives a license from the original licensors, to run, modify and propagate that work, subject to this License. You are not responsible for enforcing compliance by third parties with this License.

An “entity transaction” is a transaction transferring control of an organization, or substantially all assets of one, or subdividing an organization, or merging organizations. If propagation of a covered work results from an entity transaction, each party to that transaction who receives a copy of the work also receives whatever licenses to the work the party’s predecessor in interest had or could give under the previous paragraph, plus a right to possession of the Corresponding Source of the work from the predecessor in interest, if the predecessor has it or can get it with reasonable efforts.

You may not impose any further restrictions on the exercise of the rights granted or affirmed under this License. For example, you may not impose a license fee, royalty, or other charge for exercise of rights granted under this License, and you may not initiate litigation (including a cross-claim or counterclaim in a lawsuit) alleging that any patent claim is infringed by making, using, selling, offering for sale, or importing the Program or any portion of it.

11. Patents.

A “contributor” is a copyright holder who authorizes use under this License of the Program or a work on which the Program is based. The work thus licensed is called the contributor’s “contributor version”.

A contributor’s “essential patent claims” are all patent claims owned or controlled by the contributor, whether already acquired or hereafter acquired, that would be infringed by some manner, permitted by this License, of making, using, or selling its contributor version, but do not include claims that would be infringed only as a consequence of further modification of the contributor version. For purposes of this definition, “control” includes the right to grant patent sublicenses in a manner consistent with the requirements of this License.

Each contributor grants you a non-exclusive, worldwide, royalty-free patent license under the contributor’s essential patent claims, to make, use, sell, offer for sale, import and otherwise run, modify and propagate the contents of its contributor version.

In the following three paragraphs, a “patent license” is any express agreement or commitment, however denominated, not to enforce a patent (such as an express permission to practice a patent or covenant not to sue for patent infringement). To “grant” such a patent license to a party means to make such an agreement or commitment not to enforce a patent against the party.

If you convey a covered work, knowingly relying on a patent license, and the Corresponding Source of the work is not available for anyone to copy, free of charge and under the terms of this License, through a publicly available network server or other readily accessible means, then you must either (1) cause the Corresponding Source to be so

available, or (2) arrange to deprive yourself of the benefit of the patent license for this particular work, or (3) arrange, in a manner consistent with the requirements of this License, to extend the patent license to downstream recipients. “Knowingly relying” means you have actual knowledge that, but for the patent license, your conveying the covered work in a country, or your recipient’s use of the covered work in a country, would infringe one or more identifiable patents in that country that you have reason to believe are valid.

If, pursuant to or in connection with a single transaction or arrangement, you convey, or propagate by procuring conveyance of, a covered work, and grant a patent license to some of the parties receiving the covered work authorizing them to use, propagate, modify or convey a specific copy of the covered work, then the patent license you grant is automatically extended to all recipients of the covered work and works based on it.

A patent license is “discriminatory” if it does not include within the scope of its coverage, prohibits the exercise of, or is conditioned on the non-exercise of one or more of the rights that are specifically granted under this License. You may not convey a covered work if you are a party to an arrangement with a third party that is in the business of distributing software, under which you make payment to the third party based on the extent of your activity of conveying the work, and under which the third party grants, to any of the parties who would receive the covered work from you, a discriminatory patent license (a) in connection with copies of the covered work conveyed by you (or copies made from those copies), or (b) primarily for and in connection with specific products or compilations that contain the covered work, unless you entered into that arrangement, or that patent license was granted, prior to 28 March 2007.

Nothing in this License shall be construed as excluding or limiting any implied license or other defenses to infringement that may otherwise be available to you under applicable patent law.

12. No Surrender of Others’ Freedom.

If conditions are imposed on you (whether by court order, agreement or otherwise) that contradict the conditions of this License, they do not excuse you from the conditions of this License. If you cannot convey a covered work so as to satisfy simultaneously your obligations under this License and any other pertinent obligations, then as a consequence you may not convey it at all. For example, if you agree to terms that obligate you to collect a royalty for further conveying from those to whom you convey the Program, the only way you could satisfy both those terms and this License would be to refrain entirely from conveying the Program.

13. Use with the GNU Affero General Public License.

Notwithstanding any other provision of this License, you have permission to link or combine any covered work with a work licensed under version 3 of the GNU Affero General Public License into a single combined work, and to convey the resulting work. The terms of this License will continue to apply to the part which is the covered work, but the special requirements of the GNU Affero General Public License, section 13, concerning interaction through a network will apply to the combination as such.

14. Revised Versions of this License.

The Free Software Foundation may publish revised and/or new versions of the GNU General Public License from time to time. Such new versions will be similar in spirit to the present version, but may differ in detail to address new problems or concerns.

Each version is given a distinguishing version number. If the Program specifies that a certain numbered version of the GNU General Public License “or any later version” applies to it, you have the option of following the terms and conditions either of that numbered version or of any later version published by the Free Software Foundation. If the Program does not specify a version number of the GNU General Public License, you may choose any version ever published by the Free Software Foundation.

If the Program specifies that a proxy can decide which future versions of the GNU General Public License can be used, that proxy’s public statement of acceptance of a version permanently authorizes you to choose that version for the Program.

Later license versions may give you additional or different permissions. However, no additional obligations are imposed on any author or copyright holder as a result of your choosing to follow a later version.

15. Disclaimer of Warranty.

THERE IS NO WARRANTY FOR THE PROGRAM, TO THE EXTENT PERMITTED BY APPLICABLE LAW. EXCEPT WHEN OTHERWISE STATED IN WRITING THE COPYRIGHT HOLDERS AND/OR OTHER PARTIES PROVIDE THE PROGRAM “AS IS” WITHOUT WARRANTY OF ANY KIND, EITHER EXPRESSED OR IMPLIED, INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE. THE ENTIRE RISK AS TO THE QUALITY AND PERFORMANCE OF THE PROGRAM IS WITH YOU. SHOULD THE PROGRAM PROVE DEFECTIVE, YOU ASSUME THE COST OF ALL NECESSARY SERVICING, REPAIR OR CORRECTION.

16. Limitation of Liability.

IN NO EVENT UNLESS REQUIRED BY APPLICABLE LAW OR AGREED TO IN WRITING WILL ANY COPYRIGHT HOLDER, OR ANY OTHER PARTY WHO MODIFIES AND/OR CONVEYS THE PROGRAM AS PERMITTED ABOVE, BE LIABLE TO YOU FOR DAMAGES, INCLUDING ANY GENERAL, SPECIAL, INCIDENTAL OR CONSEQUENTIAL DAMAGES ARISING OUT OF THE USE OR INABILITY TO USE THE PROGRAM (INCLUDING BUT NOT LIMITED TO LOSS OF DATA OR DATA BEING RENDERED INACCURATE OR LOSSES SUSTAINED BY YOU OR THIRD PARTIES OR A FAILURE OF THE PROGRAM TO OPERATE WITH ANY OTHER PROGRAMS), EVEN IF SUCH HOLDER OR OTHER PARTY HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES.

17. Interpretation of Sections 15 and 16.

If the disclaimer of warranty and limitation of liability provided above cannot be given local legal effect according to their terms, reviewing courts shall apply local law that most closely approximates an absolute waiver of all civil liability in connection with the Program, unless a warranty or assumption of liability accompanies a copy of the Program in return for a fee.

END OF TERMS AND CONDITIONS

How to Apply These Terms to Your New Programs

If you develop a new program, and you want it to be of the greatest possible use to the public, the best way to achieve this is to make it free software which everyone can redistribute and change under these terms.

To do so, attach the following notices to the program. It is safest to attach them to the start of each source file to most effectively state the exclusion of warranty; and each file should have at least the “copyright” line and a pointer to where the full notice is found.

```
one line to give the program's name and a brief idea of what it does.
Copyright (C) year name of author
```

```
This program is free software: you can redistribute it and/or modify
it under the terms of the GNU General Public License as published by
the Free Software Foundation, either version 3 of the License, or (at
your option) any later version.
```

```
This program is distributed in the hope that it will be useful, but
WITHOUT ANY WARRANTY; without even the implied warranty of
MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE. See the GNU
General Public License for more details.
```

```
You should have received a copy of the GNU General Public License
along with this program. If not, see https://www.gnu.org/licenses/.
```

Also add information on how to contact you by electronic and paper mail.

If the program does terminal interaction, make it output a short notice like this when it starts in an interactive mode:

```
program Copyright (C) year name of author
This program comes with ABSOLUTELY NO WARRANTY; for details type 'show w'.
This is free software, and you are welcome to redistribute it
under certain conditions; type 'show c' for details.
```

The hypothetical commands ‘show w’ and ‘show c’ should show the appropriate parts of the General Public License. Of course, your program’s commands might be different; for a GUI interface, you would use an “about box”.

You should also get your employer (if you work as a programmer) or school, if any, to sign a “copyright disclaimer” for the program, if necessary. For more information on this, and how to apply and follow the GNU GPL, see <https://www.gnu.org/licenses/>.

The GNU General Public License does not permit incorporating your program into proprietary programs. If your program is a subroutine library, you may consider it more useful to permit linking proprietary applications with the library. If this is what you want to do, use the GNU Lesser General Public License instead of this License. But first, please read <https://www.gnu.org/licenses/why-not-lgpl.html>.

Contributing to GNU Modula-2

Please do and please read the GNU Emacs info under

- * Standards: (standards). GNU coding standards.
- * Intellectual Property:: Keeping Free Software Free

- * Reading Non-Free Code:: Referring to Proprietary Programs
- * Contributions:: Accepting Contributions

You might consider joining the GM2 Mailing list before you start coding. The mailing list may be subscribed via a web interface <http://lists.nongnu.org/mailman/listinfo/gm2> or via email gm2-subscribe@nongnu.org.

Many thanks and enjoy your coding!

3 EBNF of GNU Modula-2

This chapter contains the EBNF of GNU Modula-2. This grammar currently supports both PIM and ISO dialects. The rules here are automatically extracted from the crammer files in GNU Modula-2 and serve to document the syntax of the extensions described earlier and how they fit in with the base language.

Note that the first six productions are built into the lexical analysis phase.

```

Ident := is a builtin and checks for an identifier
      =:

Integer := is a builtin and checks for an integer
        =:

Real := is a builtin and checks for an real constant
      =:

string := is a builtin and checks for an string constant
       =:

FileUnit := ( DefinitionModule |
             ImplementationOrProgramModule )
          =:

ProgramModule := 'MODULE' Ident [ Priority ] ';' {
               Import } Block Ident '.'
              =:

ImplementationModule := 'IMPLEMENTATION' 'MODULE' Ident
                    [ Priority ] ';' { Import
                                   } Block
                    Ident '.'
                    =:

ImplementationOrProgramModule := ImplementationModule |
                               ProgramModule
                               =:

Number := Integer | Real
        =:

Qualident := Ident { '.' Ident }
          =:

ConstantDeclaration := Ident '=' ConstExpression
                    =:

ConstExpression := SimpleConstExpr [ Relation SimpleConstExpr ]
                 =:

Relation := '=' | '#' | '<>' | '<' | '<=' |
           '>' | '>=' | 'IN'
          =:

SimpleConstExpr := UnaryOrConstTerm { AddOperator
                                   ConstTerm }
                =:

UnaryOrConstTerm := '+' ConstTerm |

```

```

        '-' ConstTerm |
        ConstTerm
    =:
AddOperator := '+' | '-' | 'OR'
    =:
ConstTerm := ConstFactor { MulOperator ConstFactor }
    =:
MulOperator := '*' | '/' | 'DIV' | 'MOD' |
    'REM' | 'AND' | '&'
    =:
ConstFactor := Number | ConstString |
    ConstSetOrQualidentOrFunction |
    '(' ConstExpression ')' |
    'NOT' ConstFactor |
    ConstAttribute
    =:
ConstString := string
    =:
ComponentElement := ConstExpression [ '..' ConstExpression ]
    =:
ComponentValue := ComponentElement [ 'BY' ConstExpression ]
    =:
ArraySetRecordValue := ComponentValue { ',' ComponentValue }
    =:
Constructor := '{' [ ArraySetRecordValue ] '}'
    =:
ConstSetOrQualidentOrFunction := Constructor |
    Qualident [ Constructor |
    ConstActualParameters ]
    =:
ConstActualParameters := '(' [ ExpList ] ')'
    =:
ConstAttribute := '__ATTRIBUTE__' '__BUILTIN__' '('
    '(' ConstAttributeExpression ')'
    ')'
    =:
ConstAttributeExpression := Ident | '<' Qualident
    ',' Ident '>'
    =:
ByteAlignment := '<*' AttributeExpression '*>'
    =:
Alignment := [ ByteAlignment ]
    =:
TypeDeclaration := Ident '=' Type Alignment

```

```

=:
Type := SimpleType | ArrayType | RecordType |
      SetType | PointerType | ProcedureType
=:
SimpleType := Qualident [ SubrangeType ] |
            Enumeration | SubrangeType
=:
Enumeration := '(' IdentList ')'
=:
IdentList := Ident { ',' Ident }
=:
SubrangeType := '[' ConstExpression '..' ConstExpression
              ']'
=:
ArrayType := 'ARRAY' SimpleType { ',' SimpleType }
           'OF' Type
=:
RecordType := 'RECORD' [ DefaultRecordAttributes ]
            FieldListSequence 'END'
=:
DefaultRecordAttributes := '<*' AttributeExpression
                        '*>'
=:
RecordFieldPragma := [ '<*' FieldPragmaExpression {
                      ',' FieldPragmaExpression } '*>' ]
=:
FieldPragmaExpression := Ident [ '(' ConstExpression
                               ')' ]
=:
AttributeExpression := Ident '(' ConstExpression ')'
=:
FieldListSequence := FieldListStatement { ';' FieldListStatement }
=:
FieldListStatement := [ FieldList ]
=:
FieldList := IdentList ':' Type RecordFieldPragma |
            'CASE' CaseTag 'OF' Varients { '|' Varients }
            [ 'ELSE' FieldListSequence ] 'END'
=:
TagIdent := [ Ident ]
=:
CaseTag := TagIdent [ ':' Qualident ]

```

```

=:
Variant := [ VariantCaseLabelList ':' FieldListSequence ]
=:
VariantCaseLabelList := VariantCaseLabels { ',' VariantCaseLabels }
=:
VariantCaseLabels := ConstExpression [ '..' ConstExpression ]
=:
CaseLabelList := CaseLabels { ',' CaseLabels }
=:
CaseLabels := ConstExpression [ '..' ConstExpression ]
=:
SetType := ( 'SET' | 'PACKEDSET' ) 'OF' SimpleType
=:
PointerType := 'POINTER' 'TO' Type
=:
ProcedureType := 'PROCEDURE' [ FormalTypeList ]
=:
FormalTypeList := '(' ( '(' FormalReturn |
                        ProcedureParameters ')' FormalReturn )
=:
FormalReturn := [ ':' OptReturnType ]
=:
OptReturnType := '[' Qualident ']' |
                Qualident
=:
ProcedureParameters := ProcedureParameter { ',' ProcedureParameter }
=:
ProcedureParameter := '...' | 'VAR' FormalType |
                       FormalType
=:
VarIdent := Ident [ '[' ConstExpression ']' ]
=:
VariableDeclaration := VarIdentList ':' Type Alignment
=:
VarIdentList := VarIdent { ',' VarIdent }
=:
Designator := Qualident { SubDesignator }
=:
SubDesignator := '.' Ident | '[' ExpList ']' |
                '^'
=:
ExpList := Expression { ',' Expression }

```



```

                [ 'ELSE' StatementSequence ] 'END'
            =:
Case := [ CaseLabellist ':' StatementSequence ]
      =:
WhileStatement := 'WHILE' Expression 'DO' StatementSequence
                'END'
            =:
RepeatStatement := 'REPEAT' StatementSequence 'UNTIL'
                 Expression
            =:
ForStatement := 'FOR' Ident ':=' Expression 'TO' Expression
               [ 'BY' ConstExpression ] 'DO' StatementSequence
               'END'
            =:
LoopStatement := 'LOOP' StatementSequence 'END'
            =:
WithStatement := 'WITH' Designator 'DO' StatementSequence
                'END'
            =:
ProcedureDeclaration := ProcedureHeading ';' ( ProcedureBlock
                                                Ident
                                                )
            =:
DefineBuiltinProcedure := [ '__ATTRIBUTE__' '__BUILTIN__'
                           '(' '(' Ident ')' ')' |
                           '__INLINE__' ]
            =:
ProcedureHeading := 'PROCEDURE' DefineBuiltinProcedure
                  ( Ident [ FormalParameters ] AttributeNoReturn )
            =:
AttributeNoReturn := [ '<*' Ident '*>' ]
            =:
AttributeUnused := [ '<*' Ident '*>' ]
            =:
Builtin := [ '__BUILTIN__' | '__INLINE__' ]
            =:
DefProcedureHeading := 'PROCEDURE' Builtin ( Ident
                                             [ DefFormalParameters ]
                                             AttributeNoReturn )
            =:
ProcedureBlock := { Declaration } [ 'BEGIN' BlockBody ]
                'END'

```

```

=:
Block := { Declaration } InitialBlock FinalBlock
      'END'
=:
InitialBlock := [ 'BEGIN' BlockBody ]
=:
FinalBlock := [ 'FINALLY' BlockBody ]
=:
BlockBody := NormalPart [ 'EXCEPT' ExceptionalPart ]
=:
NormalPart := StatementSequence
=:
ExceptionalPart := StatementSequence
=:
Declaration := 'CONST' { ConstantDeclaration ';' } |
              'TYPE' { TypeDeclaration ';' } |
              'VAR' { VariableDeclaration ';' } |
              ProcedureDeclaration ';' |
              ModuleDeclaration ';'
=:
DefFormalParameters := '(' [ DefMultiFPSection ] ')'
                    FormalReturn
=:
DefMultiFPSection := DefExtendedFP |
                    FPSection [ ';' DefMultiFPSection ]
=:
FormalParameters := '(' [ MultiFPSection ] ')' FormalReturn
=:
MultiFPSection := ExtendedFP | FPSection [ ';' MultiFPSection ]
=:
FPSection := NonVarFPSection | VarFPSection
=:
DefExtendedFP := DefOptArg | '...'
=:
ExtendedFP := OptArg | '...'
=:
VarFPSection := 'VAR' IdentList ':' FormalType [ AttributeUnused ]
=:
NonVarFPSection := IdentList ':' FormalType [ AttributeUnused ]
=:
OptArg := '[' Ident ':' FormalType [ '=' ConstExpression ]
        ']'

```

```

=:
DefOptArg := '[' Ident ':' FormalType '=' ConstExpression
            ']'
=:
FormalType := { 'ARRAY' 'OF' } Qualident
=:
ModuleDeclaration := 'MODULE' Ident [ Priority ] ';'
                  { Import } [ Export ] Block
                  Ident
=:
Priority := '[' ConstExpression ']'
=:
Export := 'EXPORT' ( 'QUALIFIED' IdentList |
                    'UNQUALIFIED' IdentList |
                    IdentList ) ';'
=:
Import := 'FROM' Ident 'IMPORT' IdentList ';' |
         'IMPORT' IdentList ';'
=:
DefinitionModule := 'DEFINITION' 'MODULE' [ 'FOR' string
                                           ] Ident
                  ';' { Import } [ Export ] {
    Definition } 'END' Ident '.'
=:
Definition := 'CONST' { ConstantDeclaration ';' } |
             'TYPE' { Ident ( ';' | '=' Type Alignment
                             ';' ) } |
             'VAR' { VariableDeclaration ';' } |
             DefProcedureHeading ';'
=:
AsmStatement := 'ASM' [ 'VOLATILE' ] '(' AsmOperands
              ')'
=:
NamedOperand := '[' Ident ']'
=:
AsmOperandName := [ NamedOperand ]
=:
AsmOperands := string [ ':' AsmList [ ':' AsmList [
    ':' TrashList ] ] ]
=:
AsmList := [ AsmElement ] { ',' AsmElement }
=:
AsmElement := AsmOperandName string '(' Expression
            ')'

```



```
      =:  
TrashList := [ string ] { ',' string }  
      =:
```

4 PIM and ISO library definitions

This chapter contains M2F, PIM and ISO libraries.

4.1 Base libraries

These are the base libraries for the GNU Modula-2 compiler. These modules originally came from the M2F compiler and have been cleaned up and extended. They provide a basic interface to the underlying operating system via `libc`. They also include a number of libraries to allow access to compiler built-ins. Perhaps the largest difference to PIM and ISO libraries is the `DynamicString` module which declares the type `String`. The heavy use of this opaque data type results in a number of equivalent modules that can either handle `ARRAY OF CHAR` or `String`.

These modules have been extensively tested and are used throughout building the GNU Modula-2 compiler.

4.1.1 gm2-libs/ASCII

```

DEFINITION MODULE ASCII ;

EXPORT QUALIFIED
    nul, soh, stx, etx, eot, enq, ack, bel,
    bs , ht , nl , vt , np , cr , so , si ,
    dle, dc1, dc2, dc3, dc4, nak, syn, etb,
    can, em , sub, esc, fs , gs , rs , us ,
    sp , (* All the above are in order *)
    lf, ff, eof, del, tab, EOL ;

(*
    Note that lf, eof and EOL are added.
*)

CONST
    nul=000C; soh=001C; stx=002C; etx=003C;
    eot=004C; enq=005C; ack=006C; bel=007C;
    bs =010C; ht =011C; nl =012C; vt =013C;
    np =014C; cr =015C; so =016C; si =017C;
    dle=020C; dc1=021C; dc2=022C; dc3=023C;
    dc4=024C; nak=025C; syn=026C; etb=027C;
    can=030C; em =031C; sub=032C; esc=033C;
    fs =034C; gs =035C; rs =036C; us =037C;
    sp =040C; (* All the above are in order *)
    lf =nl ; ff =np ; eof=eot ; tab=ht ;
    del=177C; EOL=nl ;

END ASCII.
```

4.1.2 gm2-libs/Args

```
DEFINITION MODULE Args ;
```

```
EXPORT QUALIFIED GetArg, Narg ;
```

```
(*  
  GetArg - returns the nth argument from the command line.  
           The success of the operation is returned.  
*)
```

```
PROCEDURE GetArg (VAR a: ARRAY OF CHAR; n: CARDINAL) : BOOLEAN ;
```

```
(*  
  Narg - returns the number of arguments available from  
         command line.  
*)
```

```
PROCEDURE Narg () : CARDINAL ;
```

```
END Args.
```

4.1.3 gm2-libs/Assertion

```
DEFINITION MODULE Assertion ;
```

```
EXPORT QUALIFIED Assert ;
```

```
(*  
  Assert - tests the boolean Condition, if it fails then HALT  
           is called.  
*)
```

```
PROCEDURE Assert (Condition: BOOLEAN) ;
```

```
END Assertion.
```

4.1.4 gm2-libs/Break

```
DEFINITION MODULE Break ;
```

```
END Break.
```

4.1.5 gm2-libs/Builtins

```

DEFINITION MODULE Builtins ;

FROM SYSTEM IMPORT ADDRESS ;

(* floating point intrinsic procedure functions *)

PROCEDURE __BUILTIN__ isfinitef (x: SHORTREAL) : INTEGER ;
PROCEDURE __BUILTIN__ isfinite (x: REAL) : INTEGER ;
PROCEDURE __BUILTIN__ isfinitel (x: LONGREAL) : INTEGER ;

PROCEDURE __BUILTIN__ sinf (x: SHORTREAL) : SHORTREAL ;
PROCEDURE __BUILTIN__ sin (x: REAL) : REAL ;
PROCEDURE __BUILTIN__ sinl (x: LONGREAL) : LONGREAL ;

PROCEDURE __BUILTIN__ cosf (x: SHORTREAL) : SHORTREAL ;
PROCEDURE __BUILTIN__ cos (x: REAL) : REAL ;
PROCEDURE __BUILTIN__ cosl (x: LONGREAL) : LONGREAL ;

PROCEDURE __BUILTIN__ sqrtf (x: SHORTREAL) : SHORTREAL ;
PROCEDURE __BUILTIN__ sqrt (x: REAL) : REAL ;
PROCEDURE __BUILTIN__ sqrtl (x: LONGREAL) : LONGREAL ;

PROCEDURE __BUILTIN__ atan2f (x, y: SHORTREAL) : SHORTREAL ;
PROCEDURE __BUILTIN__ atan2 (x, y: REAL) : REAL ;
PROCEDURE __BUILTIN__ atan2l (x, y: LONGREAL) : LONGREAL ;

PROCEDURE __BUILTIN__ fabsf (x: SHORTREAL) : SHORTREAL ;
PROCEDURE __BUILTIN__ fabs (x: REAL) : REAL ;
PROCEDURE __BUILTIN__ fabsl (x: LONGREAL) : LONGREAL ;

PROCEDURE __BUILTIN__ logf (x: SHORTREAL) : SHORTREAL ;
PROCEDURE __BUILTIN__ log (x: REAL) : REAL ;
PROCEDURE __BUILTIN__ logl (x: LONGREAL) : LONGREAL ;

PROCEDURE __BUILTIN__ expf (x: SHORTREAL) : SHORTREAL ;
PROCEDURE __BUILTIN__ exp (x: REAL) : REAL ;
PROCEDURE __BUILTIN__ expl (x: LONGREAL) : LONGREAL ;

PROCEDURE __BUILTIN__ log10f (x: SHORTREAL) : SHORTREAL ;
PROCEDURE __BUILTIN__ log10 (x: REAL) : REAL ;
PROCEDURE __BUILTIN__ log10l (x: LONGREAL) : LONGREAL ;

PROCEDURE __BUILTIN__ exp10f (x: SHORTREAL) : SHORTREAL ;
PROCEDURE __BUILTIN__ exp10 (x: REAL) : REAL ;
PROCEDURE __BUILTIN__ exp10l (x: LONGREAL) : LONGREAL ;

```

```

PROCEDURE __BUILTIN__ ilogbf (x: SHORTREAL) : INTEGER ;
PROCEDURE __BUILTIN__ ilogb (x: REAL) : INTEGER ;
PROCEDURE __BUILTIN__ ilogbl (x: LONGREAL) : INTEGER ;

PROCEDURE __BUILTIN__ huge_val () : REAL ;
PROCEDURE __BUILTIN__ huge_valf () : SHORTREAL ;
PROCEDURE __BUILTIN__ huge_vall () : LONGREAL ;

PROCEDURE __BUILTIN__ modf (x: REAL; VAR y: REAL) : REAL ;
PROCEDURE __BUILTIN__ modff (x: SHORTREAL;
                             VAR y: SHORTREAL) : SHORTREAL ;
PROCEDURE __BUILTIN__ modfl (x: LONGREAL; VAR y: LONGREAL) : LONGREAL ;

PROCEDURE __BUILTIN__ signbit (r: REAL) : INTEGER ;
PROCEDURE __BUILTIN__ signbitf (s: SHORTREAL) : INTEGER ;
PROCEDURE __BUILTIN__ signbitl (l: LONGREAL) : INTEGER ;

PROCEDURE __BUILTIN__ nextafter (x, y: REAL) : REAL ;
PROCEDURE __BUILTIN__ nextafterf (x, y: SHORTREAL) : SHORTREAL ;
PROCEDURE __BUILTIN__ nextafterl (x, y: LONGREAL) : LONGREAL ;

PROCEDURE __BUILTIN__ nexttoward (x, y: REAL) : LONGREAL ;
PROCEDURE __BUILTIN__ nexttowardf (x, y: SHORTREAL) : LONGREAL ;
PROCEDURE __BUILTIN__ nexttowardl (x, y: LONGREAL) : LONGREAL ;

PROCEDURE __BUILTIN__ scalbln (x: REAL; n: LONGINT) : REAL ;
PROCEDURE __BUILTIN__ scalblnf (x: SHORTREAL; n: LONGINT) : SHORTREAL ;
PROCEDURE __BUILTIN__ scalblnl (x: LONGREAL; n: LONGINT) : LONGREAL ;

PROCEDURE __BUILTIN__ scalbn (x: REAL; n: INTEGER) : REAL ;
PROCEDURE __BUILTIN__ scalbnf (x: SHORTREAL; n: INTEGER) : SHORTREAL ;
PROCEDURE __BUILTIN__ scalbnl (x: LONGREAL; n: INTEGER) : LONGREAL ;

(* complex arithmetic intrinsic procedure functions *)

PROCEDURE __BUILTIN__ cabsf (z: SHORTCOMPLEX) : SHORTREAL ;
PROCEDURE __BUILTIN__ cabs (z: COMPLEX) : REAL ;
PROCEDURE __BUILTIN__ cabsl (z: LONGCOMPLEX) : LONGREAL ;

PROCEDURE __BUILTIN__ cargf (z: SHORTCOMPLEX) : SHORTREAL ;
PROCEDURE __BUILTIN__ carg (z: COMPLEX) : REAL ;
PROCEDURE __BUILTIN__ cargl (z: LONGCOMPLEX) : LONGREAL ;

PROCEDURE __BUILTIN__ conjf (z: SHORTCOMPLEX) : SHORTCOMPLEX ;
PROCEDURE __BUILTIN__ conj (z: COMPLEX) : COMPLEX ;
PROCEDURE __BUILTIN__ conjl (z: LONGCOMPLEX) : LONGCOMPLEX ;

```

```

PROCEDURE __BUILTIN__ cpowerf (base: SHORTCOMPLEX;
                               exp: SHORTREAL) : SHORTCOMPLEX ;
PROCEDURE __BUILTIN__ cpower (base: COMPLEX; exp: REAL) : COMPLEX ;
PROCEDURE __BUILTIN__ cpowerl (base: LONGCOMPLEX;
                               exp: LONGREAL) : LONGCOMPLEX ;

PROCEDURE __BUILTIN__ csqrtf (z: SHORTCOMPLEX) : SHORTCOMPLEX ;
PROCEDURE __BUILTIN__ csqrt (z: COMPLEX) : COMPLEX ;
PROCEDURE __BUILTIN__ csqrtl (z: LONGCOMPLEX) : LONGCOMPLEX ;

PROCEDURE __BUILTIN__ cexpf (z: SHORTCOMPLEX) : SHORTCOMPLEX ;
PROCEDURE __BUILTIN__ cexp (z: COMPLEX) : COMPLEX ;
PROCEDURE __BUILTIN__ cexpl (z: LONGCOMPLEX) : LONGCOMPLEX ;

PROCEDURE __BUILTIN__ clnf (z: SHORTCOMPLEX) : SHORTCOMPLEX ;
PROCEDURE __BUILTIN__ cln (z: COMPLEX) : COMPLEX ;
PROCEDURE __BUILTIN__ clnl (z: LONGCOMPLEX) : LONGCOMPLEX ;

PROCEDURE __BUILTIN__ csinf (z: SHORTCOMPLEX) : SHORTCOMPLEX ;
PROCEDURE __BUILTIN__ csin (z: COMPLEX) : COMPLEX ;
PROCEDURE __BUILTIN__ csinl (z: LONGCOMPLEX) : LONGCOMPLEX ;

PROCEDURE __BUILTIN__ ccosf (z: SHORTCOMPLEX) : SHORTCOMPLEX ;
PROCEDURE __BUILTIN__ ccos (z: COMPLEX) : COMPLEX ;
PROCEDURE __BUILTIN__ ccosl (z: LONGCOMPLEX) : LONGCOMPLEX ;

PROCEDURE __BUILTIN__ ctanf (z: SHORTCOMPLEX) : SHORTCOMPLEX ;
PROCEDURE __BUILTIN__ ctan (z: COMPLEX) : COMPLEX ;
PROCEDURE __BUILTIN__ ctanl (z: LONGCOMPLEX) : LONGCOMPLEX ;

PROCEDURE __BUILTIN__ carcsinf (z: SHORTCOMPLEX) : SHORTCOMPLEX ;
PROCEDURE __BUILTIN__ carcsin (z: COMPLEX) : COMPLEX ;
PROCEDURE __BUILTIN__ carcsinl (z: LONGCOMPLEX) : LONGCOMPLEX ;

PROCEDURE __BUILTIN__ carccosf (z: SHORTCOMPLEX) : SHORTCOMPLEX ;
PROCEDURE __BUILTIN__ carccos (z: COMPLEX) : COMPLEX ;
PROCEDURE __BUILTIN__ carccosl (z: LONGCOMPLEX) : LONGCOMPLEX ;

PROCEDURE __BUILTIN__ carctanf (z: SHORTCOMPLEX) : SHORTCOMPLEX ;
PROCEDURE __BUILTIN__ carctan (z: COMPLEX) : COMPLEX ;
PROCEDURE __BUILTIN__ carctanl (z: LONGCOMPLEX) : LONGCOMPLEX ;

(* memory and string intrinsic procedure functions *)

PROCEDURE __BUILTIN__ alloca (i: CARDINAL) : ADDRESS ;
PROCEDURE __BUILTIN__ memcpy (dest, src: ADDRESS;

```



```

                                nbytes: CARDINAL) : ADDRESS ;
PROCEDURE __BUILTIN__ index (s: ADDRESS; c: INTEGER) : ADDRESS ;
PROCEDURE __BUILTIN__ rindex (s: ADDRESS; c: INTEGER) : ADDRESS ;
PROCEDURE __BUILTIN__ memcmp (s1, s2: ADDRESS;
                                nbytes: CARDINAL) : INTEGER ;
PROCEDURE __BUILTIN__ memset (s: ADDRESS; c: INTEGER;
                                nbytes: CARDINAL) : ADDRESS ;
PROCEDURE __BUILTIN__ memmove (s1, s2: ADDRESS;
                                nbytes: CARDINAL) : ADDRESS ;
PROCEDURE __BUILTIN__ strcat (dest, src: ADDRESS) : ADDRESS ;
PROCEDURE __BUILTIN__ strncat (dest, src: ADDRESS;
                                nbytes: CARDINAL) : ADDRESS ;
PROCEDURE __BUILTIN__ strcpy (dest, src: ADDRESS) : ADDRESS ;
PROCEDURE __BUILTIN__ strncpy (dest, src: ADDRESS;
                                nbytes: CARDINAL) : ADDRESS ;
PROCEDURE __BUILTIN__ strcmp (s1, s2: ADDRESS) : INTEGER ;
PROCEDURE __BUILTIN__ strncmp (s1, s2: ADDRESS;
                                nbytes: CARDINAL) : INTEGER ;
PROCEDURE __BUILTIN__ strlen (s: ADDRESS) : INTEGER ;
PROCEDURE __BUILTIN__ strstr (haystack, needle: ADDRESS) : ADDRESS ;
PROCEDURE __BUILTIN__ strpbrk (s, accept: ADDRESS) : ADDRESS ;
PROCEDURE __BUILTIN__ strspn (s, accept: ADDRESS) : CARDINAL ;
PROCEDURE __BUILTIN__ strcspn (s, accept: ADDRESS) : CARDINAL ;
PROCEDURE __BUILTIN__ strchr (s: ADDRESS; c: INTEGER) : ADDRESS ;
PROCEDURE __BUILTIN__ strrchr (s: ADDRESS; c: INTEGER) : ADDRESS ;

(*)
    longjmp - this GCC builtin restricts the val to always 1.
*)
(*) do not use these two builtins, as gcc, only really
    anticipates that the Ada front end should use them
    and it only uses them in its runtime exception handling.
    We leave them here in the hope that someday they will
    behave more like their libc counterparts. *)

PROCEDURE __BUILTIN__ longjmp (env: ADDRESS; val: INTEGER) ;
PROCEDURE __BUILTIN__ setjmp (env: ADDRESS) : INTEGER ;

(*)
    frame_address - returns the address of the frame.
                    The current frame is obtained if level is 0,
                    the next level up if level is 1 etc.
*)

PROCEDURE __BUILTIN__ frame_address (level: CARDINAL) : ADDRESS ;

```

```
(*
  return_address - returns the return address of function.
                  The current function return address is
                  obtained if level is 0,
                  the next level up if level is 1 etc.
*)

PROCEDURE __BUILTIN__ return_address (level: CARDINAL) : ADDRESS ;

(*
  alloca_trace - this is a no-op which is used for internal debugging.
*)

PROCEDURE alloca_trace (returned: ADDRESS; nBytes: CARDINAL) : ADDRESS ;

END Builtins.
```

4.1.6 gm2-libs/COROUTINES

```
DEFINITION MODULE FOR "C" COROUTINES ;

CONST
    UnassignedPriority = 0 ;

TYPE
    INTERRUPTSOURCE = CARDINAL ;
    PROTECTION = [UnassignedPriority..7] ;

END COROUTINES.
```

4.1.7 gm2-libs/CmdArgs

```
DEFINITION MODULE CmdArgs ;

EXPORT QUALIFIED GetArg, Narg ;

(*
  GetArg - returns the nth argument from the command line, CmdLine
           the success of the operation is returned.
*)

PROCEDURE GetArg (CmdLine: ARRAY OF CHAR;
                 n: CARDINAL; VAR Argi: ARRAY OF CHAR) : BOOLEAN ;

(*
  Narg - returns the number of arguments available from
         command line, CmdLine.
*)

PROCEDURE Narg (CmdLine: ARRAY OF CHAR) : CARDINAL ;

END CmdArgs.
```

4.1.8 gm2-libs/Debug

```
DEFINITION MODULE Debug ;

(*
  Description: provides some simple debugging routines.
*)

EXPORT QUALIFIED Halt, DebugString ;

(*
  Halt - writes a message in the format:
          Module:Function:Line:Message

          It then terminates by calling HALT.
*)

PROCEDURE Halt (Message,
                Module,
                Function: ARRAY OF CHAR ;
                LineNo : CARDINAL) ;

(*
  DebugString - writes a string to the debugging device (Scn.Write).
                It interprets \n as carriage return, linefeed.
*)

PROCEDURE DebugString (a: ARRAY OF CHAR) ;

END Debug.
```

4.1.9 gm2-libs/DynamicStrings

```

DEFINITION MODULE DynamicStrings ;

FROM SYSTEM IMPORT ADDRESS ;
EXPORT QUALIFIED String,
    InitString, KillString, Fin, InitStringCharStar,
    InitStringChar, Index, RIndex,
    Mark, Length, ConCat, ConCatChar, Assign, Dup, Add,
    Equal, EqualCharStar, EqualArray, ToUpper, ToLower,
    CopyOut, Mult, Slice,
    RemoveWhitePrefix, RemoveWhitePostfix, RemoveComment,
    char, string,
    InitStringDB, InitStringCharStarDB, InitStringCharDB,
    MultDB, DupDB, SliceDB,
    PushAllocation, PopAllocation, PopAllocationExemption ;

TYPE
    String ;

(*
    InitString - creates and returns a String type object.
                 Initial contents are, a.
*)

PROCEDURE InitString (a: ARRAY OF CHAR) : String ;

(*
    KillString - frees String, s, and its contents.
                 NIL is returned.
*)

PROCEDURE KillString (s: String) : String ;

(*
    Fin - finishes with a string, it calls KillString with, s.
          The purpose of the procedure is to provide a short cut
          to calling KillString and then testing the return result.
*)

PROCEDURE Fin (s: String) ;

(*

```

```
        InitStringCharStar - initializes and returns a String to contain
                           the C string.
*)

PROCEDURE InitStringCharStar (a: ADDRESS) : String ;

(*
    InitStringChar - initializes and returns a String to contain the
                   single character, ch.
*)

PROCEDURE InitStringChar (ch: CHAR) : String ;

(*
    Mark - marks String, s, ready for garbage collection.
*)

PROCEDURE Mark (s: String) : String ;

(*
    Length - returns the length of the String, s.
*)

PROCEDURE Length (s: String) : CARDINAL ;

(*
    ConCat - returns String, a, after the contents of, b,
            have been appended.
*)

PROCEDURE ConCat (a, b: String) : String ;

(*
    ConCatChar - returns String, a, after character, ch,
                has been appended.
*)

PROCEDURE ConCatChar (a: String; ch: CHAR) : String ;

(*
    Assign - assigns the contents of, b, into, a.
*)
```

```
        String, a, is returned.
*)

PROCEDURE Assign (a, b: String) : String ;

(*
  Dup - duplicate a String, s, returning the copy of s.
*)

PROCEDURE Dup (s: String) : String ;

(*
  Add - returns a new String which contains the contents of a and b.
*)

PROCEDURE Add (a, b: String) : String ;

(*
  Equal - returns TRUE if String, a, and, b, are equal.
*)

PROCEDURE Equal (a, b: String) : BOOLEAN ;

(*
  EqualCharStar - returns TRUE if contents of String, s, is
                  the same as the string, a.
*)

PROCEDURE EqualCharStar (s: String; a: ADDRESS) : BOOLEAN ;

(*
  EqualArray - returns TRUE if contents of String, s, is the
               same as the string, a.
*)

PROCEDURE EqualArray (s: String; a: ARRAY OF CHAR) : BOOLEAN ;

(*
  Mult - returns a new string which is n concatenations of String, s.
         If n<=0 then an empty string is returned.
*)
```



```
PROCEDURE Mult (s: String; n: CARDINAL) : String ;
```

```
(*  
  Slice - returns a new string which contains the elements  
          low..high-1  
  
          strings start at element 0  
          Slice(s, 0, 2) will return elements 0, 1 but not 2  
          Slice(s, 1, 3) will return elements 1, 2 but not 3  
          Slice(s, 2, 0) will return elements 2..max  
          Slice(s, 3, -1) will return elements 3..max-1  
          Slice(s, 4, -2) will return elements 4..max-2  
*)
```

```
PROCEDURE Slice (s: String; low, high: INTEGER) : String ;
```

```
(*  
  Index - returns the indice of the first occurrence of, ch, in  
          String, s. -1 is returned if, ch, does not exist.  
          The search starts at position, o.  
*)
```

```
PROCEDURE Index (s: String; ch: CHAR; o: CARDINAL) : INTEGER ;
```

```
(*  
  RIndex - returns the indice of the last occurrence of, ch,  
           in String, s. The search starts at position, o.  
           -1 is returned if, ch, is not found.  
*)
```

```
PROCEDURE RIndex (s: String; ch: CHAR; o: CARDINAL) : INTEGER ;
```

```
(*  
  RemoveComment - assuming that, comment, is a comment delimiter  
                 which indicates anything to its right is a comment  
                 then strip off the comment and also any white space  
                 on the remaining right hand side.  
                 It leaves any white space on the left hand side  
                 alone.  
*)
```

```
PROCEDURE RemoveComment (s: String; comment: CHAR) : String ;
```

```
(*  
  RemoveWhitePrefix - removes any leading white space from String, s.  
                    A new string is returned.  
*)
```

```
PROCEDURE RemoveWhitePrefix (s: String) : String ;
```

```
(*  
  RemoveWhitePostfix - removes any leading white space from String, s.  
                    A new string is returned.  
*)
```

```
PROCEDURE RemoveWhitePostfix (s: String) : String ;
```

```
(*  
  ToUpper - returns string, s, after it has had its lower case  
           characters replaced by upper case characters.  
           The string, s, is not duplicated.  
*)
```

```
PROCEDURE ToUpper (s: String) : String ;
```

```
(*  
  ToLower - returns string, s, after it has had its upper case  
           characters replaced by lower case characters.  
           The string, s, is not duplicated.  
*)
```

```
PROCEDURE ToLower (s: String) : String ;
```

```
(*  
  CopyOut - copies string, s, to a.  
*)
```

```
PROCEDURE CopyOut (VAR a: ARRAY OF CHAR; s: String) ;
```

```
(*  
  char - returns the character, ch, at position, i, in String, s.  
        As Slice the index can be negative so:
```

```

char(s, 0) will return the first character
char(s, 1) will return the second character
char(s, -1) will return the last character
char(s, -2) will return the penultimate character

```

a nul character is returned if the index is out of range.

*)

```
PROCEDURE char (s: String; i: INTEGER) : CHAR ;
```

(*

string - returns the C style char * of String, s.

*)

```
PROCEDURE string (s: String) : ADDRESS ;
```

(*

to easily debug an application using this library one could use
use the following macro processing defines:

```

#define InitString(X) InitStringDB(X, __FILE__, __LINE__)
#define InitStringCharStar(X) InitStringCharStarDB(X, \
  __FILE__, __LINE__)
#define InitStringChar(X) InitStringCharDB(X, __FILE__, __LINE__)
#define Mult(X,Y) MultDB(X, Y, __FILE__, __LINE__)
#define Dup(X) DupDB(X, __FILE__, __LINE__)
#define Slice(X,Y,Z) SliceDB(X, Y, Z, __FILE__, __LINE__)

```

and then invoke gm2 with the -fcpp flag.

*)

(*

InitStringDB - the debug version of InitString.

*)

```
PROCEDURE InitStringDB (a: ARRAY OF CHAR;
  file: ARRAY OF CHAR; line: CARDINAL) : String ;
```

(*

InitStringCharStarDB - the debug version of InitStringCharStar.

*)

```
PROCEDURE InitStringCharStarDB (a: ADDRESS;
```

```

                                file: ARRAY OF CHAR;
                                line: CARDINAL) : String ;

(*
  InitStringCharDB - the debug version of InitStringChar.
*)

PROCEDURE InitStringCharDB (ch: CHAR;
                            file: ARRAY OF CHAR;
                            line: CARDINAL) : String ;

(*
  MultDB - the debug version of MultDB.
*)

PROCEDURE MultDB (s: String; n: CARDINAL;
                 file: ARRAY OF CHAR; line: CARDINAL) : String ;

(*
  DupDB - the debug version of Dup.
*)

PROCEDURE DupDB (s: String;
                file: ARRAY OF CHAR; line: CARDINAL) : String ;

(*
  SliceDB - debug version of Slice.
*)

PROCEDURE SliceDB (s: String; low, high: INTEGER;
                  file: ARRAY OF CHAR; line: CARDINAL) : String ;

(*
  PushAllocation - pushes the current allocation/deallocation lists.
*)

PROCEDURE PushAllocation ;

(*
  PopAllocation - test to see that all strings are deallocated since
                 the last push. Then it pops to the previous
                 allocation/deallocation lists.
*)
```

```

        If halt is true then the application terminates
        with an exit code of 1.
*)

PROCEDURE PopAllocation (halt: BOOLEAN) ;

(*
    PopAllocationExemption - test to see that all strings are
    deallocated, except string e since
    the last push.
    Post-condition: it pops to the previous
    allocation/deallocation lists.

    If halt is true then the application
    terminates with an exit code of 1.

    The string, e, is returned unmodified,
*)

PROCEDURE PopAllocationExemption (halt: BOOLEAN; e: String) : String ;

END DynamicStrings.
```

4.1.10 gm2-libs/Environment

```
DEFINITION MODULE Environment ;

EXPORT QUALIFIED GetEnvironment, PutEnvironment ;

(*
  GetEnvironment - gets the environment variable Env and places
                  a copy of its value into string, dest.
                  It returns TRUE if the string Env was found in
                  the processes environment.
*)

PROCEDURE GetEnvironment (Env: ARRAY OF CHAR;
                        VAR dest: ARRAY OF CHAR) : BOOLEAN ;

(*
  PutEnvironment - change or add an environment variable definition
                  EnvDef.
                  TRUE is returned if the environment variable was
                  set or changed successfully.
*)

PROCEDURE PutEnvironment (EnvDef: ARRAY OF CHAR) : BOOLEAN ;

END Environment.
```

4.1.11 gm2-libs/FIO

```
DEFINITION MODULE FIO ;

(* Provides a simple buffered file input/output library. *)

FROM SYSTEM IMPORT ADDRESS, BYTE ;

EXPORT QUALIFIED (* types *)
  File,
  (* procedures *)
  OpenToRead, OpenToWrite, OpenForRandom, Close,
  EOF, EOLN, WasEOLN, IsNoError, Exists, IsActive,
  exists, openToRead, openToWrite, openForRandom,
  SetPositionFromBeginning,
  SetPositionFromEnd,
  FindPosition,
  ReadChar, ReadString,
  WriteChar, WriteString, WriteLine,
  WriteCardinal, ReadCardinal,
  UnReadChar,
  WriteNBytes, ReadNBytes,
  FlushBuffer,
  GetUnixFileDescriptor,
  GetFileName, getFileName, getFileNameLength,
  FlushOutErr,
  (* variables *)
  StdIn, StdOut, StdErr ;

TYPE
  File = CARDINAL ;

(* the following variables are initialized to their UNIX equivalents *)
VAR
  StdIn, StdOut, StdErr: File ;

(*
  IsNoError - returns a TRUE if no error has occurred on file, f.
*)

PROCEDURE IsNoError (f: File) : BOOLEAN ;

(*
```

```
    IsActive - returns TRUE if the file, f, is still active.
*)

PROCEDURE IsActive (f: File) : BOOLEAN ;

(*
    Exists - returns TRUE if a file named, fname exists for reading.
*)

PROCEDURE Exists (fname: ARRAY OF CHAR) : BOOLEAN ;

(*
    OpenToRead - attempts to open a file, fname, for reading and
                 it returns this file.
                 The success of this operation can be checked by
                 calling IsNoError.
*)

PROCEDURE OpenToRead (fname: ARRAY OF CHAR) : File ;

(*
    OpenToWrite - attempts to open a file, fname, for write and
                 it returns this file.
                 The success of this operation can be checked by
                 calling IsNoError.
*)

PROCEDURE OpenToWrite (fname: ARRAY OF CHAR) : File ;

(*
    OpenForRandom - attempts to open a file, fname, for random access
                   read or write and it returns this file.
                   The success of this operation can be checked by
                   calling IsNoError.
                   towrite, determines whether the file should be
                   opened for writing or reading.
                   newfile, determines whether a file should be
                   created if towrite is TRUE or whether the
                   previous file should be left alone,
                   allowing this descriptor to seek
                   and modify an existing file.
*)
```



```
PROCEDURE OpenForRandom (fname: ARRAY OF CHAR;
                        towrite, newfile: BOOLEAN) : File ;

(*
  Close - close a file which has been previously opened using:
  OpenToRead, OpenToWrite, OpenForRandom.
  It is correct to close a file which has an error status.
*)

PROCEDURE Close (f: File) ;

(* the following functions are functionally equivalent to the above
  except they allow C style names.
*)

PROCEDURE exists      (fname: ADDRESS; flength: CARDINAL) : BOOLEAN ;
PROCEDURE openToRead  (fname: ADDRESS; flength: CARDINAL) : File ;
PROCEDURE openToWrite (fname: ADDRESS; flength: CARDINAL) : File ;
PROCEDURE openForRandom (fname: ADDRESS; flength: CARDINAL;
                        towrite, newfile: BOOLEAN) : File ;

(*
  FlushBuffer - flush contents of the FIO file, f, to libc.
*)

PROCEDURE FlushBuffer (f: File) ;

(*
  ReadNBytes - reads nBytes of a file into memory area, dest, returning
  the number of bytes actually read.
  This function will consume from the buffer and then
  perform direct libc reads. It is ideal for large reads.
*)

PROCEDURE ReadNBytes (f: File; nBytes: CARDINAL;
                    dest: ADDRESS) : CARDINAL ;

(*
  ReadAny - reads HIGH(a) bytes into, a. All input
  is fully buffered, unlike ReadNBytes and thus is more
  suited to small reads.
*)
```

```
PROCEDURE ReadAny (f: File; VAR a: ARRAY OF BYTE) ;
```

```
(*  
  WriteNBytes - writes nBytes from memory area src to a file  
                returning the number of bytes actually written.  
                This function will flush the buffer and then  
                write the nBytes using a direct write from libc.  
                It is ideal for large writes.  
*)
```

```
PROCEDURE WriteNBytes (f: File; nBytes: CARDINAL;  
                      src: ADDRESS) : CARDINAL ;
```

```
(*  
  WriteAny - writes HIGH(a) bytes onto, file, f. All output  
            is fully buffered, unlike WriteNBytes and thus is more  
            suited to small writes.  
*)
```

```
PROCEDURE WriteAny (f: File; VAR a: ARRAY OF BYTE) ;
```

```
(*  
  WriteChar - writes a single character to file, f.  
*)
```

```
PROCEDURE WriteChar (f: File; ch: CHAR) ;
```

```
(*  
  EOF - tests to see whether a file, f, has reached end of file.  
*)
```

```
PROCEDURE EOF (f: File) : BOOLEAN ;
```

```
(*  
  EOLN - tests to see whether a file, f, is about to read a newline.  
         It does NOT consume the newline. It reads the next character  
         and then immediately unreads the character.  
*)
```

```
PROCEDURE EOLN (f: File) : BOOLEAN ;
```

```
(*
  WasEOLN - tests to see whether a file, f, has just read a newline
            character.
*)
```

```
PROCEDURE WasEOLN (f: File) : BOOLEAN ;
```

```
(*
  ReadChar - returns a character read from file, f.
             Sensible to check with IsNoError or EOF after calling
             this function.
*)
```

```
PROCEDURE ReadChar (f: File) : CHAR ;
```

```
(*
  UnReadChar - replaces a character, ch, back into file, f.
               This character must have been read by ReadChar
               and it does not allow successive calls. It may
               only be called if the previous read was successful,
               end of file or end of line seen.
*)
```

```
PROCEDURE UnReadChar (f: File ; ch: CHAR) ;
```

```
(*
  WriteLine - writes out a linefeed to file, f.
*)
```

```
PROCEDURE WriteLine (f: File) ;
```

```
(*
  WriteString - writes a string to file, f.
*)
```

```
PROCEDURE WriteString (f: File; a: ARRAY OF CHAR) ;
```

```
(*
  ReadString - reads a string from file, f, into string, a.
              It terminates the string if HIGH is reached or
              if a newline is seen or an error occurs.
*)
```

```
*)

PROCEDURE ReadString (f: File; VAR a: ARRAY OF CHAR) ;

(*
  WriteCardinal - writes a CARDINAL to file, f.
                  It writes the binary image of the CARDINAL.
                  to file, f.
*)

PROCEDURE WriteCardinal (f: File; c: CARDINAL) ;

(*
  ReadCardinal - reads a CARDINAL from file, f.
                 It reads a bit image of a CARDINAL
                 from file, f.
*)

PROCEDURE ReadCardinal (f: File) : CARDINAL ;

(*
  GetUnixFileDescriptor - returns the UNIX file descriptor of a file.
                         Useful when combining FIO.mod with select
                         (in Selective.def - but note the comments in
                         Selective about using read/write primitives)
*)

PROCEDURE GetUnixFileDescriptor (f: File) : INTEGER ;

(*
  SetPositionFromBeginning - sets the position from the beginning
                            of the file.
*)

PROCEDURE SetPositionFromBeginning (f: File; pos: LONGINT) ;

(*
  SetPositionFromEnd - sets the position from the end of the file.
*)

PROCEDURE SetPositionFromEnd (f: File; pos: LONGINT) ;
```

```
(*
  FindPosition - returns the current absolute position in file, f.
*)

PROCEDURE FindPosition (f: File) : LONGINT ;

(*
  GetFileName - assigns, a, with the filename associated with, f.
*)

PROCEDURE GetFileName (f: File; VAR a: ARRAY OF CHAR) ;

(*
  getFileName - returns the address of the filename associated with, f.
*)

PROCEDURE getFileName (f: File) : ADDRESS ;

(*
  getFileNameLength - returns the number of characters associated with
                      filename, f.
*)

PROCEDURE getFileNameLength (f: File) : CARDINAL ;

(*
  FlushOutErr - flushes, StdOut, and, StdErr.
*)

PROCEDURE FlushOutErr ;

END FIO.
```

4.1.12 gm2-libs/FormatStrings

```
DEFINITION MODULE FormatStrings ;

FROM SYSTEM IMPORT BYTE ;
FROM DynamicStrings IMPORT String ;
EXPORT QUALIFIED Sprintf0, Sprintf1, Sprintf2, Sprintf3, Sprintf4,
                HandleEscape ;

(*
  Sprintf0 - returns a String containing, fmt, after it has had its
            escape sequences translated.
*)

PROCEDURE Sprintf0 (fmt: String) : String ;

(*
  Sprintf1 - returns a String containing, fmt, together with
            encapsulated entity, w. It only formats the
            first %s or %d with n.
*)

PROCEDURE Sprintf1 (fmt: String; w: ARRAY OF BYTE) : String ;

(*
  Sprintf2 - returns a string, fmt, which has been formatted.
*)

PROCEDURE Sprintf2 (fmt: String; w1, w2: ARRAY OF BYTE) : String ;

(*
  Sprintf3 - returns a string, fmt, which has been formatted.
*)

PROCEDURE Sprintf3 (fmt: String; w1, w2, w3: ARRAY OF BYTE) : String ;

(*
  Sprintf4 - returns a string, fmt, which has been formatted.
*)

PROCEDURE Sprintf4 (fmt: String;
                  w1, w2, w3, w4: ARRAY OF BYTE) : String ;
```

```
(*
  HandleEscape - translates \a, \b, \e, \f, \n, \r, \x[hex] \[octal]
                 into their respective ascii codes. It also converts
                 \[any] into a single [any] character.
*)

PROCEDURE HandleEscape (s: String) : String ;

END FormatStrings.
```

4.1.13 gm2-libs/FpuIO

```
DEFINITION MODULE FpuIO ;

EXPORT QUALIFIED ReadReal, WriteReal, StrToReal, RealToStr,
                  ReadLongReal, WriteLongReal, StrToLongReal,
                  LongRealToStr,
                  ReadLongInt, WriteLongInt, StrToLongInt,
                  LongIntToStr ;

PROCEDURE ReadReal (VAR x: REAL) ;
PROCEDURE WriteReal (x: REAL; TotalWidth, FractionWidth: CARDINAL) ;
PROCEDURE StrToReal (a: ARRAY OF CHAR ; VAR x: REAL) ;
PROCEDURE RealToStr (x: REAL; TotalWidth, FractionWidth: CARDINAL;
                    VAR a: ARRAY OF CHAR) ;

PROCEDURE ReadLongReal (VAR x: LONGREAL) ;
PROCEDURE WriteLongReal (x: LONGREAL;
                        TotalWidth, FractionWidth: CARDINAL) ;
PROCEDURE StrToLongReal (a: ARRAY OF CHAR ; VAR x: LONGREAL) ;
PROCEDURE LongRealToStr (x: LONGREAL;
                        TotalWidth, FractionWidth: CARDINAL;
                        VAR a: ARRAY OF CHAR) ;

PROCEDURE ReadLongInt (VAR x: LONGINT) ;
PROCEDURE WriteLongInt (x: LONGINT; n: CARDINAL) ;
PROCEDURE StrToLongInt (a: ARRAY OF CHAR ; VAR x: LONGINT) ;
PROCEDURE LongIntToStr (x: LONGINT; n: CARDINAL; VAR a: ARRAY OF CHAR) ;

END FpuIO.
```


4.1.14 gm2-libs/GetOpt

```

DEFINITION MODULE GetOpt ;

FROM SYSTEM IMPORT ADDRESS ;
FROM DynamicStrings IMPORT String ;

CONST
  no_argument = 0 ;
  required_argument = 1 ;
  optional_argument = 2 ;

TYPE
  LongOptions ;
  PtrToInteger = POINTER TO INTEGER ;

(*
  GetOpt - call C getopt and fill in the parameters:
           optarg, optind, opterr and optop.
*)

PROCEDURE GetOpt (argc: INTEGER; argv: ADDRESS; optstring: String;
                 VAR optarg: String;
                 VAR optind, opterr, optopt: INTEGER) : CHAR ;

(*
  InitLongOptions - creates and returns a LongOptions empty array.
*)

PROCEDURE InitLongOptions () : LongOptions ;

(*
  AddLongOption - appends long option {name, has_arg, flag, val} to the
                 array of options and new long options array is
                 returned.
                 The old array, lo, should no longer be used.

  (from man 3 getopt)
  The meanings of the different fields are:

  name   is the name of the long option.

  has_arg
  is: no_argument (or 0) if the option does not take an
      argument; required_argument (or 1) if the option

```

requires an argument; or optional_argument (or 2) if the option takes an optional argument.

flag specifies how results are returned for a long option. If flag is NULL, then getopt_long() returns val. (For example, the calling program may set val to the equivalent short option character). Otherwise, getopt_long() returns 0, and flag points to a variable which is set to val if the option is found, but left unchanged if the option is not found.

val is the value to return, or to load into the variable pointed to by flag.

The last element of the array has to be filled with zeros.

*)

```
PROCEDURE AddLongOption (lo: LongOptions;
                        name: String; has_arg: INTEGER;
                        flag: PtrToInteger;
                        val: INTEGER) : LongOptions ;
```

(*

KillLongOptions - returns NIL and also frees up memory associated with, lo.

*)

```
PROCEDURE KillLongOptions (lo: LongOptions) : LongOptions ;
```

(*

GetOptLong - works like GetOpt but will accept long options (using two dashes). If the program only accepts long options then optstring should be an empty string, not NIL.

*)

```
PROCEDURE GetOptLong (argc: INTEGER; argv: ADDRESS; optstring: String;
                    longopts: LongOptions;
                    VAR longindex: INTEGER) : INTEGER ;
```

(*

GetOptLongOnly - works like GetOptLong except that a single dash can be used for a long option.

*)

```
PROCEDURE GetOptLongOnly (argc: INTEGER; argv: ADDRESS;  
                          optstring: String; longopts: LongOptions;  
                          VAR longindex: INTEGER) : INTEGER ;  
  
END GetOpt.
```

4.1.15 gm2-libs/IO

```
DEFINITION MODULE IO ;

(*
  Description: provides Read, Write, Errors procedures that map onto UNIX
  file descriptors 0, 1 and 2. This is achieved by using
  FIO if we are in buffered mode and using libc.write
  if not.
*)

EXPORT QUALIFIED Read, Write, Error,
                  UnBufferedMode, BufferedMode,
                  EchoOn, EchoOff ;

PROCEDURE Read (VAR ch: CHAR) ;
PROCEDURE Write (ch: CHAR) ;
PROCEDURE Error (ch: CHAR) ;

(*
  UnBufferedMode - places file descriptor, fd, into an unbuffered mode.
*)

PROCEDURE UnBufferedMode (fd: INTEGER; input: BOOLEAN) ;

(*
  BufferedMode - places file descriptor, fd, into a buffered mode.
*)

PROCEDURE BufferedMode (fd: INTEGER; input: BOOLEAN) ;

(*
  EchoOn - turns on echoing for file descriptor, fd. This
  only really makes sence for a file descriptor opened
  for terminal input or maybe some specific file descriptor
  which is attached to a particular piece of hardware.
*)

PROCEDURE EchoOn (fd: INTEGER; input: BOOLEAN) ;

(*
  EchoOff - turns off echoing for file descriptor, fd. This
```

only really makes sense for a file descriptor opened
for terminal input or maybe some specific file descriptor
which is attached to a particular piece of hardware.

*)

```
PROCEDURE EchoOff (fd: INTEGER; input: BOOLEAN) ;
```

```
END IO.
```

4.1.16 gm2-libs/Indexing

```
DEFINITION MODULE Indexing ;

FROM SYSTEM IMPORT ADDRESS ;
EXPORT QUALIFIED Index, InitIndex, KillIndex, GetIndice, PutIndice,
                HighIndice, LowIndice, InBounds, IsIndiceInIndex,
                RemoveIndiceFromIndex, IncludeIndiceIntoIndex,
                ForeachIndiceInIndexDo, DeleteIndice, DebugIndex ;

TYPE
    Index ;
    IndexProcedure = PROCEDURE (ADDRESS) ;

(*
    InitIndex - creates and returns an Index.
*)

PROCEDURE InitIndex (low: CARDINAL) : Index ;

(*
    KillIndex - returns Index to free storage.
*)

PROCEDURE KillIndex (i: Index) : Index ;

(*
    DebugIndex - turns on debugging within an index.
*)

PROCEDURE DebugIndex (i: Index) : Index ;

(*
    InBounds - returns TRUE if indice, n, is within the bounds
                of the dynamic array.
*)

PROCEDURE InBounds (i: Index; n: CARDINAL) : BOOLEAN ;

(*
    HighIndice - returns the last legally accessible indice of this array.■
*)
```

```
PROCEDURE HighIndice (i: Index) : CARDINAL ;
```

```
(*  
  LowIndice - returns the first legally accessible indice of this array.■  
*)
```

```
PROCEDURE LowIndice (i: Index) : CARDINAL ;
```

```
(*  
  PutIndice - places, a, into the dynamic array at position i[n]  
*)
```

```
PROCEDURE PutIndice (i: Index; n: CARDINAL; a: ADDRESS) ;
```

```
(*  
  GetIndice - retrieves, element i[n] from the dynamic array.  
*)
```

```
PROCEDURE GetIndice (i: Index; n: CARDINAL) : ADDRESS ;
```

```
(*  
  IsIndiceInIndex - returns TRUE if, a, is in the index, i.  
*)
```

```
PROCEDURE IsIndiceInIndex (i: Index; a: ADDRESS) : BOOLEAN ;
```

```
(*  
  RemoveIndiceFromIndex - removes, a, from Index, i.  
*)
```

```
PROCEDURE RemoveIndiceFromIndex (i: Index; a: ADDRESS) ;
```

```
(*  
  DeleteIndice - delete i[j] from the array.  
*)
```

```
PROCEDURE DeleteIndice (i: Index; j: CARDINAL) ;
```

```
(*
```

```
        IncludeIndicesIntoIndex - if the indice is not in the index, then
                                add it at the end.
*)

PROCEDURE IncludeIndicesIntoIndex (i: Index; a: ADDRESS) ;

(*
  ForeachIndicesInIndexDo - for each j indice of i, call procedure p(i[j])
*)

PROCEDURE ForeachIndicesInIndexDo (i: Index; p: IndexProcedure) ;

END Indexing.
```


4.1.17 gm2-libs/LMathLib0

```
DEFINITION MODULE LMathLib0 ;

CONST
  pi    = 3.1415926535897932384626433832795028841972;
  exp1  = 2.7182818284590452353602874713526624977572;

PROCEDURE __BUILTIN__ sqrt (x: LONGREAL) : LONGREAL ;
PROCEDURE exp (x: LONGREAL) : LONGREAL ;
PROCEDURE ln (x: LONGREAL) : LONGREAL ;
PROCEDURE __BUILTIN__ sin (x: LONGREAL) : LONGREAL ;
PROCEDURE __BUILTIN__ cos (x: LONGREAL) : LONGREAL ;
PROCEDURE tan (x: LONGREAL) : LONGREAL ;
PROCEDURE arctan (x: LONGREAL) : LONGREAL ;
PROCEDURE entier (x: LONGREAL) : INTEGER ;

END LMathLib0.
```

4.1.18 gm2-libs/LegacyReal

```
DEFINITION MODULE LegacyReal ;
```

```
TYPE
```

```
  REAL = SHORTREAL ;
```

```
END LegacyReal.
```

4.1.19 gm2-libs/M2Dependent

```
DEFINITION MODULE M2Dependent ;

FROM SYSTEM IMPORT ADDRESS ;

TYPE
  ArgCEnvP = PROCEDURE (INTEGER, ADDRESS, ADDRESS) ;

PROCEDURE ConstructModules (applicationmodule, libname: ADDRESS;
                           argc: INTEGER; argv, envp: ADDRESS) ;

PROCEDURE DeconstructModules (applicationmodule, libname: ADDRESS;
                              argc: INTEGER; argv, envp: ADDRESS) ;

(*
  RegisterModule - adds module name to the list of outstanding
                  modules which need to have their dependencies
                  explored to determine initialization order.
*)

PROCEDURE RegisterModule (modulename, libname: ADDRESS;
                          init, fini: ArgCEnvP;
                          dependencies: PROC) ;

(*
  RequestDependant - used to specify that modulename:libname
                    is dependant upon
                    module dependantmodule:dependantlibname
*)

PROCEDURE RequestDependant (modulename, libname,
                            dependantmodule, dependantlibname: ADDRESS) ;

END M2Dependent.
```

4.1.20 gm2-libs/M2EXCEPTION

```
DEFINITION MODULE M2EXCEPTION;
```

```
(* This enumerated list of exceptions must match the exceptions in gm2-libs-iso to
   allow mixed module dialect projects. *)
```

```
TYPE
```

```
  M2Exceptions =
```

```
    (indexException,      rangeException,      caseSelectException,  invalidLocation
     functionException,   wholeValueException,  wholeDivException,   realValueExcept
     realDivException,   complexValueException, complexDivException,  protException,
     sysException,       coException,          exException
    );
```

```
(* If the program or coroutine is in the exception state then return the enumeration
   value representing the exception cause.  If it is not in the exception state then
   raises and exception (exException). *)
```

```
PROCEDURE M2Exception () : M2Exceptions;
```

```
(* Returns TRUE if the program or coroutine is in the exception state.
   Returns FALSE if the program or coroutine is not in the exception state. *)
```

```
PROCEDURE IsM2Exception () : BOOLEAN;
```

```
END M2EXCEPTION.
```

4.1.21 gm2-libs/M2LINK

```
DEFINITION MODULE FOR "C" M2LINK ;
```

```
TYPE
```

```
  PtrToChar = POINTER TO CHAR ;
```

```
(* These variables are set by the compiler in the program module  
   according to linking command line options. *)
```

```
VAR
```

```
  ForcedModuleInitOrder: PtrToChar ;
```

```
  StaticInitialization : BOOLEAN ;
```

```
END M2LINK.
```

4.1.22 gm2-libs/M2RTS

```

DEFINITION MODULE M2RTS ;

FROM SYSTEM IMPORT ADDRESS ;

TYPE
  ArgCEnvP = PROCEDURE (INTEGER, ADDRESS, ADDRESS) ;

PROCEDURE ConstructModules (applicationmodule, libname: ADDRESS;
                           argc: INTEGER; argv, envp: ADDRESS) ;

PROCEDURE DeconstructModules (applicationmodule, libname: ADDRESS;
                              argc: INTEGER; argv, envp: ADDRESS) ;

(*
  RegisterModule - adds module name to the list of outstanding
                  modules which need to have their dependencies
                  explored to determine initialization order.
*)

PROCEDURE RegisterModule (name, libname: ADDRESS;
                          init, fini: ArgCEnvP;
                          dependencies: PROC) ;

(*
  RequestDependant - used to specify that modulename is dependant upon
                    module dependantmodule.
*)

PROCEDURE RequestDependant (modulename, libname,
                            dependantmodule, dependantlibname: ADDRESS) ;■

(*
  InstallTerminationProcedure - installs a procedure, p, which will
                                be called when the procedure
                                ExecuteTerminationProcedures
                                is invoked. It returns TRUE is the
                                procedure is installed.
*)

PROCEDURE InstallTerminationProcedure (p: PROC) : BOOLEAN ;

```

```
(*
  ExecuteInitialProcedures - executes the initial procedures installed
                           by InstallInitialProcedure.
*)

PROCEDURE ExecuteInitialProcedures ;

(*
  InstallInitialProcedure - installs a procedure to be executed just
                           before the BEGIN code section of the main
                           program module.
*)

PROCEDURE InstallInitialProcedure (p: PROC) : BOOLEAN ;

(*
  ExecuteTerminationProcedures - calls each installed termination procedure
                               in reverse order.
*)

PROCEDURE ExecuteTerminationProcedures ;

(*
  Terminate - provides compatibility for pim. It call exit with
              the exitcode provided in a prior call to ExitOnHalt
              (or zero if ExitOnHalt was never called). It does
              not call ExecuteTerminationProcedures.
*)

PROCEDURE Terminate <* noreturn *> ;

(*
  HALT - terminate the current program. The procedure Terminate
         is called before the program is stopped. The parameter
         exitcode is optional. If the parameter is not supplied
         HALT will call libc 'abort', otherwise it will exit with
         the code supplied. Supplying a parameter to HALT has the
         same effect as calling ExitOnHalt with the same code and
         then calling HALT with no parameter.
*)
```

```
PROCEDURE HALT ([exitcode: INTEGER = -1]) <* noreturn *> ;
```

```
(*  
  Halt - provides a more user friendly version of HALT, which takes  
         four parameters to aid debugging.  It writes an error message  
         to stderr and calls exit (1).  
*)
```

```
PROCEDURE Halt (description, filename, function: ARRAY OF CHAR;  
               line: CARDINAL) <* noreturn *> ;
```

```
(*  
  HaltC - provides a more user friendly version of HALT, which takes  
          four parameters to aid debugging.  It writes an error message  
          to stderr and calls exit (1).  
*)
```

```
PROCEDURE HaltC (description, filename, function: ADDRESS;  
                line: CARDINAL) <* noreturn *> ;
```

```
(*  
  ExitOnHalt - if HALT is executed then call exit with the exit code, e.█  
*)
```

```
PROCEDURE ExitOnHalt (e: INTEGER) ;
```

```
(*  
  ErrorMessage - emits an error message to stderr and then calls exit (1).█  
*)
```

```
PROCEDURE ErrorMessage (message: ARRAY OF CHAR;  
                       filename: ARRAY OF CHAR;  
                       line: CARDINAL;  
                       function: ARRAY OF CHAR) <* noreturn *> ;
```

```
(*  
  Length - returns the length of a string, a. This is called whenever  
           the user calls LENGTH and the parameter cannot be calculated  
           at compile time.  
*)
```

```
PROCEDURE Length (a: ARRAY OF CHAR) : CARDINAL ;
```



```
(*  
  The following are the runtime exception handler routines.  
*)
```

```
PROCEDURE AssignmentException (filename: ADDRESS; line, column: CARDINAL; scope, messa  
PROCEDURE ReturnException (filename: ADDRESS; line, column: CARDINAL; scope, message: .  
PROCEDURE IncException (filename: ADDRESS; line, column: CARDINAL; scope, message: ADD  
PROCEDURE DecException (filename: ADDRESS; line, column: CARDINAL; scope, message: ADD  
PROCEDURE InclException (filename: ADDRESS; line, column: CARDINAL; scope, message: AD  
PROCEDURE ExclException (filename: ADDRESS; line, column: CARDINAL; scope, message: AD  
PROCEDURE ShiftException (filename: ADDRESS; line, column: CARDINAL; scope, message: A  
PROCEDURE RotateException (filename: ADDRESS; line, column: CARDINAL; scope, message: .  
PROCEDURE StaticArraySubscriptException (filename: ADDRESS; line, column: CARDINAL; sc  
PROCEDURE DynamicArraySubscriptException (filename: ADDRESS; line, column: CARDINAL; s  
PROCEDURE ForLoopBeginException (filename: ADDRESS; line, column: CARDINAL; scope, mes  
PROCEDURE ForLoopToException (filename: ADDRESS; line, column: CARDINAL; scope, messag  
PROCEDURE ForLoopEndException (filename: ADDRESS; line, column: CARDINAL; scope, messa  
PROCEDURE PointerNilException (filename: ADDRESS; line, column: CARDINAL; scope, messa  
PROCEDURE NoReturnException (filename: ADDRESS; line, column: CARDINAL; scope, message  
PROCEDURE CaseException (filename: ADDRESS; line, column: CARDINAL; scope, message: AD  
PROCEDURE WholeNonPosDivException (filename: ADDRESS; line, column: CARDINAL; scope, m  
PROCEDURE WholeNonPosModException (filename: ADDRESS; line, column: CARDINAL; scope, m  
PROCEDURE WholeZeroDivException (filename: ADDRESS; line, column: CARDINAL; scope, mes  
PROCEDURE WholeZeroRemException (filename: ADDRESS; line, column: CARDINAL; scope, mes  
PROCEDURE WholeValueException (filename: ADDRESS; line, column: CARDINAL; scope, messa  
PROCEDURE RealValueException (filename: ADDRESS; line, column: CARDINAL; scope, messag  
PROCEDURE ParameterException (filename: ADDRESS; line, column: CARDINAL; scope, messag  
PROCEDURE NoException (filename: ADDRESS; line, column: CARDINAL; scope, message: ADDR
```

```
END M2RTS.
```

4.1.23 gm2-libs/MathLib0

```
DEFINITION MODULE MathLib0 ;

CONST
  pi    = 3.1415926535897932384626433832795028841972;
  exp1  = 2.7182818284590452353602874713526624977572;

PROCEDURE __BUILTIN__ sqrt (x: REAL) : REAL ;
PROCEDURE exp (x: REAL) : REAL ;
PROCEDURE ln (x: REAL) : REAL ;
PROCEDURE __BUILTIN__ sin (x: REAL) : REAL ;
PROCEDURE __BUILTIN__ cos (x: REAL) : REAL ;
PROCEDURE tan (x: REAL) : REAL ;
PROCEDURE arctan (x: REAL) : REAL ;
PROCEDURE entier (x: REAL) : INTEGER ;

END MathLib0.
```

4.1.24 gm2-libs/MemUtils

```
DEFINITION MODULE MemUtils ;

FROM SYSTEM IMPORT ADDRESS ;
EXPORT QUALIFIED MemCopy, MemZero ;

(*
  MemCopy - copys a region of memory to the required destination.
*)

PROCEDURE MemCopy (from: ADDRESS; length: CARDINAL; to: ADDRESS) ;

(*
  MemZero - sets a region of memory: a..a+length to zero.
*)

PROCEDURE MemZero (a: ADDRESS; length: CARDINAL) ;

END MemUtils.
```

4.1.25 gm2-libs/NumberIO

```
DEFINITION MODULE NumberIO ;

EXPORT QUALIFIED ReadCard, WriteCard, ReadHex, WriteHex, ReadInt, WriteInt,
    CardToStr, StrToCard, StrToHex, HexToStr, StrToInt, IntToStr,
    ReadOct, WriteOct, OctToStr, StrToOct,
    ReadBin, WriteBin, BinToStr, StrToBin,
    StrToBinInt, StrToHexInt, StrToOctInt ;

PROCEDURE ReadCard (VAR x: CARDINAL) ;

PROCEDURE WriteCard (x, n: CARDINAL) ;

PROCEDURE ReadHex (VAR x: CARDINAL) ;

PROCEDURE WriteHex (x, n: CARDINAL) ;

PROCEDURE ReadInt (VAR x: INTEGER) ;

PROCEDURE WriteInt (x: INTEGER ; n: CARDINAL) ;

PROCEDURE CardToStr (x, n: CARDINAL ; VAR a: ARRAY OF CHAR) ;

PROCEDURE StrToCard (a: ARRAY OF CHAR ; VAR x: CARDINAL) ;

PROCEDURE HexToStr (x, n: CARDINAL ; VAR a: ARRAY OF CHAR) ;

PROCEDURE StrToHex (a: ARRAY OF CHAR ; VAR x: CARDINAL) ;

PROCEDURE IntToStr (x: INTEGER ; n: CARDINAL ; VAR a: ARRAY OF CHAR) ;

PROCEDURE StrToInt (a: ARRAY OF CHAR ; VAR x: INTEGER) ;

PROCEDURE ReadOct (VAR x: CARDINAL) ;

PROCEDURE WriteOct (x, n: CARDINAL) ;

PROCEDURE OctToStr (x, n: CARDINAL ; VAR a: ARRAY OF CHAR) ;

PROCEDURE StrToOct (a: ARRAY OF CHAR ; VAR x: CARDINAL) ;

PROCEDURE ReadBin (VAR x: CARDINAL) ;

PROCEDURE WriteBin (x, n: CARDINAL) ;
```

```
PROCEDURE BinToStr (x, n: CARDINAL ; VAR a: ARRAY OF CHAR) ;  
PROCEDURE StrToBin (a: ARRAY OF CHAR ; VAR x: CARDINAL) ;  
PROCEDURE StrToBinInt (a: ARRAY OF CHAR ; VAR x: INTEGER) ;  
PROCEDURE StrToHexInt (a: ARRAY OF CHAR ; VAR x: INTEGER) ;  
PROCEDURE StrToOctInt (a: ARRAY OF CHAR ; VAR x: INTEGER) ;  
  
END NumberIO.
```

4.1.26 gm2-libs/OptLib

```
DEFINITION MODULE OptLib ;

FROM SYSTEM IMPORT ADDRESS ;
FROM DynamicStrings IMPORT String ;

TYPE
    Option ;

(*
    InitOption - constructor for Option.
*)

PROCEDURE InitOption (argc: INTEGER; argv: ADDRESS) : Option ;

(*
    KillOption - deconstructor for Option.
*)

PROCEDURE KillOption (o: Option) : Option ;

(*
    Dup - duplicate the option array inside, o.
    Notice that this does not duplicate all the contents
    (strings) of argv.
    Shallow copy of the top level indices.
*)

PROCEDURE Dup (o: Option) : Option ;

(*
    Slice - return a new option which has elements [low:high] from the
    options, o.
*)

PROCEDURE Slice (o: Option; low, high: INTEGER) : Option ;

(*
    IndexStrCmp - returns the index in the argv array which matches
    string, s. -1 is returned if the string is not found.
*)
```

```
PROCEDURE IndexStrCmp (o: Option; s: String) : INTEGER ;

(*
  IndexStrNCmp - returns the index in the argv array where the first
                 characters are matched by string, s.
                 -1 is returned if the string is not found.
*)

PROCEDURE IndexStrNCmp (o: Option; s: String) : INTEGER ;

(*
  ConCat - returns the concatenation of a and b.
*)

PROCEDURE ConCat (a, b: Option) : Option ;

(*
  GetArgv - return the argv component of option.
*)

PROCEDURE GetArgv (o: Option) : ADDRESS ;

(*
  GetArgc - return the argc component of option.
*)

PROCEDURE GetArgc (o: Option) : INTEGER ;

END OptLib.
```

4.1.27 gm2-libs/PushBackInput

```
DEFINITION MODULE PushBackInput ;

FROM FIO IMPORT File ;
FROM DynamicStrings IMPORT String ;

EXPORT QUALIFIED Open, PutCh, GetCh, Error, WarnError, WarnString,
                  Close, SetDebug, GetExitStatus, PutStr,
                  PutString, GetColumnPosition, GetCurrentLine ;

(*
  Open - opens a file for reading.
*)

PROCEDURE Open (a: ARRAY OF CHAR) : File ;

(*
  GetCh - gets a character from either the push back stack or
          from file, f.
*)

PROCEDURE GetCh (f: File) : CHAR ;

(*
  PutCh - pushes a character onto the push back stack, it also
          returns the character which has been pushed.
*)

PROCEDURE PutCh (ch: CHAR) : CHAR ;

(*
  PutString - pushes a string onto the push back stack.
*)

PROCEDURE PutString (a: ARRAY OF CHAR) ;

(*
  PutStr - pushes a dynamic string onto the push back stack.
           The string, s, is not deallocated.
*)
```



```
PROCEDURE PutStr (s: String) ;
```

```
(*  
  Error - emits an error message with the appropriate file, line combination.█  
*)
```

```
PROCEDURE Error (a: ARRAY OF CHAR) ;
```

```
(*  
  WarnError - emits an error message with the appropriate file, line combination.█  
              It does not terminate but when the program finishes an exit status of█  
              1 will be issued.  
*)
```

```
PROCEDURE WarnError (a: ARRAY OF CHAR) ;
```

```
(*  
  WarnString - emits an error message with the appropriate file, line combination.█  
              It does not terminate but when the program finishes an exit status of█  
              1 will be issued.  
*)
```

```
PROCEDURE WarnString (s: String) ;
```

```
(*  
  Close - closes the opened file.  
*)
```

```
PROCEDURE Close (f: File) ;
```

```
(*  
  GetExitStatus - returns the exit status which will be 1 if any warnings were issued█  
*)
```

```
PROCEDURE GetExitStatus () : CARDINAL ;
```

```
(*  
  SetDebug - sets the debug flag on or off.  
*)
```

```
PROCEDURE SetDebug (d: BOOLEAN) ;
```

```
(*
  GetColumnPosition - returns the column position of the current character.
*)
PROCEDURE GetColumnPosition () : CARDINAL ;

(*
  GetCurrentLine - returns the current line number.
*)
PROCEDURE GetCurrentLine () : CARDINAL ;

END PushBackInput.
```

4.1.28 gm2-libs/RTExceptions

```

DEFINITION MODULE RTExceptions ;

(* Runtime exception handler routines.  This should
   be considered as a system module for GNU Modula-2
   and allow the compiler to interface with exception
   handling.  *)

FROM SYSTEM IMPORT ADDRESS ;
EXPORT QUALIFIED EHBlock,
               Raise, SetExceptionBlock, GetExceptionBlock,
               GetTextBuffer, GetTextBufferSize, GetNumber,
               InitExceptionBlock, KillExceptionBlock,
               PushHandler, PopHandler,
               BaseExceptionsThrow, DefaultErrorCatch,
               IsInExceptionState, SetExceptionState,
               SwitchExceptionState, GetBaseExceptionBlock,
               SetExceptionSource, GetExceptionSource ;

TYPE
  EHBlock ;
  ProcedureHandler = PROCEDURE ;

(*
   Raise - invoke the exception handler associated with, number,
           in the active EHBlock.  It keeps a record of the number
           and message in the EHBlock for later use.
   *)

PROCEDURE Raise (number: CARDINAL;
                file: ADDRESS; line: CARDINAL;
                column: CARDINAL; function: ADDRESS;
                message: ADDRESS) <* noreturn *> ;

(*
   SetExceptionBlock - sets, source, as the active EHB.
   *)

PROCEDURE SetExceptionBlock (source: EHBlock) ;

(*
   GetExceptionBlock - returns the active EHB.
   *)

```

```
PROCEDURE GetExceptionBlock () : EHBlock ;
```

```
(*  
  GetTextBuffer - returns the address of the EHB buffer.  
*)
```

```
PROCEDURE GetTextBuffer (e: EHBlock) : ADDRESS ;
```

```
(*  
  GetTextBufferSize - return the size of the EHB text buffer.  
*)
```

```
PROCEDURE GetTextBufferSize (e: EHBlock) : CARDINAL ;
```

```
(*  
  GetNumber - return the exception number associated with,  
              source.  
*)
```

```
PROCEDURE GetNumber (source: EHBlock) : CARDINAL ;
```

```
(*  
  InitExceptionBlock - creates and returns a new exception block.  
*)
```

```
PROCEDURE InitExceptionBlock () : EHBlock ;
```

```
(*  
  KillExceptionBlock - destroys the EHB, e, and all its handlers.  
*)
```

```
PROCEDURE KillExceptionBlock (e: EHBlock) : EHBlock ;
```

```
(*  
  PushHandler - install a handler in EHB, e.  
*)
```

```
PROCEDURE PushHandler (e: EHBlock; number: CARDINAL; p: ProcedureHandler) ;■
```

```
(*
  PopHandler - removes the handler associated with, number, from
              EHB, e.
*)

PROCEDURE PopHandler (e: EHBlock; number: CARDINAL) ;

(*
  DefaultErrorCatch - displays the current error message in
                    the current exception block and then
                    calls HALT.
*)

PROCEDURE DefaultErrorCatch ;

(*
  BaseExceptionsThrow - configures the Modula-2 exceptions to call
                      THROW which in turn can be caught by an
                      exception block.  If this is not called then
                      a Modula-2 exception will simply call an
                      error message routine and then HALT.
*)

PROCEDURE BaseExceptionsThrow ;

(*
  IsInExceptionState - returns TRUE if the program is currently
                    in the exception state.
*)

PROCEDURE IsInExceptionState () : BOOLEAN ;

(*
  SetExceptionState - returns the current exception state and
                    then sets the current exception state to,
                    to.
*)

PROCEDURE SetExceptionState (to: BOOLEAN) : BOOLEAN ;

(*
  SwitchExceptionState - assigns, from, with the current exception
```

```

                                state and then assigns the current exception
                                to, to.
*)

PROCEDURE SwitchExceptionState (VAR from: BOOLEAN; to: BOOLEAN) ;

(*
  GetBaseExceptionBlock - returns the initial language exception block
                        created.
*)

PROCEDURE GetBaseExceptionBlock () : EHBlock ;

(*
  SetExceptionSource - sets the current exception source to, source.
*)

PROCEDURE SetExceptionSource (source: ADDRESS) ;

(*
  GetExceptionSource - returns the current exception source.
*)

PROCEDURE GetExceptionSource () : ADDRESS ;

END RTEExceptions.
```

4.1.29 gm2-libs/RTint

```
DEFINITION MODULE RTint ;

(* Provides users of the COROUTINES library with the
   ability to create interrupt sources based on
   file descriptors and timeouts. *)

FROM SYSTEM IMPORT ADDRESS ;

TYPE
  DispatchVector = PROCEDURE (CARDINAL, CARDINAL, ADDRESS) ;

(*
   InitInputVector - returns an interrupt vector which is associated
                   with the file descriptor, fd.
*)

PROCEDURE InitInputVector (fd: INTEGER; pri: CARDINAL) : CARDINAL ;

(*
   InitOutputVector - returns an interrupt vector which is associated
                    with the file descriptor, fd.
*)

PROCEDURE InitOutputVector (fd: INTEGER; pri: CARDINAL) : CARDINAL ;

(*
   InitTimeVector - returns an interrupt vector associated with
                  the relative time.
*)

PROCEDURE InitTimeVector (micro, secs: CARDINAL; pri: CARDINAL) : CARDINAL ;

(*
   ReArmTimeVector - reprimes the vector, vec, to deliver an interrupt
                   at the new relative time.
*)

PROCEDURE ReArmTimeVector (vec: CARDINAL; micro, secs: CARDINAL) ;

(*
```

```
    GetTimeVector - assigns, micro, and, secs, with the remaining
                    time before this interrupt will expire.
                    This value is only updated when a Listen
                    occurs.
*)

PROCEDURE GetTimeVector (vec: CARDINAL; VAR micro, secs: CARDINAL) ;

(*
    AttachVector - adds the pointer, p, to be associated with the interrupt
                    vector. It returns the previous value attached to this
                    vector.
*)

PROCEDURE AttachVector (vec: CARDINAL; ptr: ADDRESS) : ADDRESS ;

(*
    IncludeVector - includes, vec, into the dispatcher list of
                    possible interrupt causes.
*)

PROCEDURE IncludeVector (vec: CARDINAL) ;

(*
    ExcludeVector - excludes, vec, from the dispatcher list of
                    possible interrupt causes.
*)

PROCEDURE ExcludeVector (vec: CARDINAL) ;

(*
    Listen - will either block indefinitely (until an interrupt)
             or alternatively will test to see whether any interrupts
             are pending.
             If a pending interrupt was found then, call, is called
             and then this procedure returns.
             It only listens for interrupts > pri.
*)

PROCEDURE Listen (untilInterrupt: BOOLEAN;
                 call: DispatchVector;
                 pri: CARDINAL) ;
```



```
(*  
  Init - allows the user to force the initialize order.  
*)  
  
PROCEDURE Init ;  
  
END RTint.
```

4.1.30 gm2-libs/SArgs

```
DEFINITION MODULE SArgs ;

FROM DynamicStrings IMPORT String ;
EXPORT QUALIFIED GetArg, Narg ;

(*
  GetArg - returns the nth argument from the command line.
           The success of the operation is returned.
           If TRUE is returned then the string, s, contains a
           new string, otherwise s is set to NIL.
*)

PROCEDURE GetArg (VAR s: String ; n: CARDINAL) : BOOLEAN ;

(*
  Narg - returns the number of arguments available from
         command line.
*)

PROCEDURE Narg() : CARDINAL ;

END SArgs.
```

4.1.31 gm2-libs/SCmdArgs

```
DEFINITION MODULE SCmdArgs ;

FROM DynamicStrings IMPORT String ;

EXPORT QUALIFIED GetArg, Narg ;

(*
  GetArg - returns the nth argument from the command line, CmdLine
           the success of the operation is returned.
*)

PROCEDURE GetArg (CmdLine: String;
                 n: CARDINAL; VAR Argi: String) : BOOLEAN ;

(*
  Narg - returns the number of arguments available from
         command line, CmdLine.
*)

PROCEDURE Narg (CmdLine: String) : CARDINAL ;

END SCmdArgs.
```

4.1.32 gm2-libs/SEnvironment

```
DEFINITION MODULE SEnvironment ;

FROM DynamicStrings IMPORT String ;
EXPORT QUALIFIED GetEnvironment ;

(*
  GetEnvironment - gets the environment variable Env and places
                  a copy of its value into String, dest.
                  It returns TRUE if the string Env was found in
                  the processes environment.
*)

PROCEDURE GetEnvironment (Env: String;
                        VAR dest: String) : BOOLEAN ;

(*
  PutEnvironment - change or add an environment variable definition EnvDef.
                  TRUE is returned if the environment variable was
                  set or changed successfully.
*)

PROCEDURE PutEnvironment (EnvDef: String) : BOOLEAN ;

END SEnvironment.
```

4.1.33 gm2-libs/SFIO

```
DEFINITION MODULE SFIO ;

FROM DynamicStrings IMPORT String ;
FROM FIO IMPORT File ;

EXPORT QUALIFIED OpenToRead, OpenToWrite, OpenForRandom, Exists, WriteS, ReadS ;

(*
  Exists - returns TRUE if a file named, fname exists for reading.
*)

PROCEDURE Exists (fname: String) : BOOLEAN ;

(*
  OpenToRead - attempts to open a file, fname, for reading and
               it returns this file.
               The success of this operation can be checked by
               calling IsNoError.
*)

PROCEDURE OpenToRead (fname: String) : File ;

(*
  OpenToWrite - attempts to open a file, fname, for write and
                it returns this file.
                The success of this operation can be checked by
                calling IsNoError.
*)

PROCEDURE OpenToWrite (fname: String) : File ;

(*
  OpenForRandom - attempts to open a file, fname, for random access
                  read or write and it returns this file.
                  The success of this operation can be checked by
                  calling IsNoError.
                  towrite, determines whether the file should be
                  opened for writing or reading.
                  if towrite is TRUE or whether the previous file should
                  be left alone, allowing this descriptor to seek
                  and modify an existing file.
*)
```

```
*)

PROCEDURE OpenForRandom (fname: String; towrite, newfile: BOOLEAN) : File ;

(*
  WriteS - writes a string, s, to, file. It returns the String, s.
*)

PROCEDURE WriteS (file: File; s: String) : String ;

(*
  ReadS - reads a string, s, from, file. It returns the String, s.
          It stops reading the string at the end of line or end of file.
          It consumes the newline at the end of line but does not place
          this into the returned string.
*)

PROCEDURE ReadS (file: File) : String ;

END SFIO.
```

4.1.34 gm2-libs/SMathLib0

```
DEFINITION MODULE SMathLib0 ;

CONST
  pi    = 3.1415926535897932384626433832795028841972;
  exp1  = 2.7182818284590452353602874713526624977572;

PROCEDURE __BUILTIN__ sqrt (x: SHORTREAL) : SHORTREAL ;
PROCEDURE exp (x: SHORTREAL) : SHORTREAL ;
PROCEDURE ln (x: SHORTREAL) : SHORTREAL ;
PROCEDURE __BUILTIN__ sin (x: SHORTREAL) : SHORTREAL ;
PROCEDURE __BUILTIN__ cos (x: SHORTREAL) : SHORTREAL ;
PROCEDURE tan (x: SHORTREAL) : SHORTREAL ;
PROCEDURE arctan (x: SHORTREAL) : SHORTREAL ;
PROCEDURE entier (x: SHORTREAL) : INTEGER ;

END SMathLib0.
```

4.1.35 gm2-libs/SYSTEM

```
DEFINITION MODULE SYSTEM ;
```

```
EXPORT QUALIFIED BITS_PER_BYTE, BYTES_PER_WORD,
    ADDRESS, WORD, BYTE, C_SIZE_T, C_SIZE_T, (*
    Target specific data types. *)
    ADR, T_SIZE, ROTATE, SHIFT, THROW, T_BIT_SIZE ;
    (* SIZE is also exported if -fpim2 is used. *)
```

```
CONST
```

```
    BITS_PER_BYTE = __ATTRIBUTE__ __BUILTIN__ ((BITS_PER_UNIT)) ;
    BYTES_PER_WORD = __ATTRIBUTE__ __BUILTIN__ ((UNITS_PER_WORD)) ;
```

```
(* Note that the full list of system and sized datatypes include:
    LOC, WORD, BYTE, ADDRESS,
```

```
(and the non language standard target types)
```

```
    INTEGER8, INTEGER16, INTEGER32, INTEGER64,
    CARDINAL8, CARDINAL16, CARDINAL32, CARDINAL64,
    WORD16, WORD32, WORD64, BITSET8, BITSET16,
    BITSET32, REAL32, REAL64, REAL128, COMPLEX32,
    COMPLEX64, COMPLEX128, C_SIZE_T, C_SIZE_T.
```

```
Also note that the non-standard data types will
move into another module in the future. *)
```

```
(* The following types are supported on this target:
TYPE
```

```
(* Target specific data types. *)
*)
```

```
(*
```

```
all the functions below are declared internally to gm2
```

```
=====
```

```
PROCEDURE ADR (VAR v: <anytype>): ADDRESS;
```

```
(* Returns the address of variable v. *)
```

```
PROCEDURE SIZE (v: <type>) : ZType;
```

```
(* Returns the number of BYTES used to store a v of
any specified <type>. Only available if -fpim2 is used.
```

```
*)
```



```
PROCEDURE TSIZE (<type>) : CARDINAL;
  (* Returns the number of BYTES used to store a value of the
  specified <type>.
  *)

PROCEDURE ROTATE (val: <a set type>;
                 num: INTEGER): <type of first parameter>;
  (* Returns a bit sequence obtained from val by rotating up/right
  or down/right by the absolute value of num. The direction is
  down/right if the sign of num is negative, otherwise the direction
  is up/left.
  *)

PROCEDURE SHIFT (val: <a set type>;
                num: INTEGER): <type of first parameter>;
  (* Returns a bit sequence obtained from val by shifting up/left
  or down/right by the absolute value of num, introducing
  zeros as necessary. The direction is down/right if the sign of
  num is negative, otherwise the direction is up/left.
  *)

PROCEDURE THROW (i: INTEGER) <* noreturn *> ;
  (*
  THROW is a GNU extension and was not part of the PIM or ISO
  standards. It throws an exception which will be caught by the
  EXCEPT block (assuming it exists). This is a compiler builtin
  function which interfaces to the GCC exception handling runtime
  system.
  GCC uses the term throw, hence the naming distinction between
  the GCC builtin and the Modula-2 runtime library procedure Raise.
  The later library procedure Raise will call SYSTEM.THROW after
  performing various housekeeping activities.
  *)

PROCEDURE TBITSIZE (<type>) : CARDINAL ;
  (* Returns the minimum number of bits necessary to represent
  <type>. This procedure function is only useful for determining
  the number of bits used for any type field within a packed RECORD.
  It is not particularly useful elsewhere since <type> might be
  optimized for speed, for example a BOOLEAN could occupy a WORD.
  *)
*)

(* The following procedures are invoked by GNU Modula-2 to
  shift non word sized set types. They are not strictly part
  of the core PIM Modula-2, however they are used
  to implement the SHIFT procedure defined above,
```

which are in turn used by the Logitech compatible libraries.

Users will access these procedures by using the procedure SHIFT above and GNU Modula-2 will map SHIFT onto one of the following procedures.

*)

(*

ShiftVal - is a runtime procedure whose job is to implement the SHIFT procedure of ISO SYSTEM. GNU Modula-2 will inline a SHIFT of a single WORD sized set and will only call this routine for larger sets.

*)

```
PROCEDURE ShiftVal (VAR s, d: ARRAY OF BITSET;
                   SetSizeInBits: CARDINAL;
                   ShiftCount: INTEGER) ;
```

(*

ShiftLeft - performs the shift left for a multi word set. This procedure might be called by the back end of GNU Modula-2 depending whether amount is known at compile time.

*)

```
PROCEDURE ShiftLeft (VAR s, d: ARRAY OF BITSET;
                    SetSizeInBits: CARDINAL;
                    ShiftCount: CARDINAL) ;
```

(*

ShiftRight - performs the shift left for a multi word set. This procedure might be called by the back end of GNU Modula-2 depending whether amount is known at compile time.

*)

```
PROCEDURE ShiftRight (VAR s, d: ARRAY OF BITSET;
                     SetSizeInBits: CARDINAL;
                     ShiftCount: CARDINAL) ;
```

(*

RotateVal - is a runtime procedure whose job is to implement the ROTATE procedure of ISO SYSTEM. GNU Modula-2 will inline a ROTATE of a single WORD (or less) sized set and will only call this routine for larger

4.1.36 gm2-libs/Scan

```
DEFINITION MODULE Scan ;

(* Provides a primitive symbol fetching from input.
   Symbols are delimited by spaces and tabs.
   Limitation only allows one source file at
   a time to deliver symbols. *)

EXPORT QUALIFIED GetNextSymbol, WriteError,
                  OpenSource, CloseSource,
                  TerminateOnError, DefineComments ;

(* OpenSource - opens a source file for reading. *)

PROCEDURE OpenSource (a: ARRAY OF CHAR) : BOOLEAN ;

(* CloseSource - closes the current source file from reading. *)

PROCEDURE CloseSource ;

(* GetNextSymbol gets the next source symbol and returns it in a. *)

PROCEDURE GetNextSymbol (VAR a: ARRAY OF CHAR) ;

(* WriteError writes a message, a, under the source line, which
   * attempts to pinpoint the Symbol at fault. *)

PROCEDURE WriteError (a: ARRAY OF CHAR) ;

(*
   TerminateOnError - exits with status 1 if we call WriteError.
   *)

PROCEDURE TerminateOnError ;

(*
   DefineComments - defines the start of comments within the source
   file.
   *)
```

The characters in Start define the comment start and characters in End define the end.
The BOOLEAN eoln determine whether the comment is terminated by end of line. If eoln is TRUE then End is ignored.

If this procedure is never called then no comments are allowed.

*)

```
PROCEDURE DefineComments (Start, End: ARRAY OF CHAR; eoln: BOOLEAN) ;
```

```
END Scan.
```

4.1.37 gm2-libs/Selective

```

DEFINITION MODULE Selective ;

FROM SYSTEM IMPORT ADDRESS ;

EXPORT QUALIFIED SetOfFd, Timeval,
                 InitSet, KillSet, InitTime, KillTime,
                 GetTime, SetTime,
                 FdZero, FdSet, FdClr, FdIsSet, Select,
                 MaxFdsPlusOne, WriteCharRaw, ReadCharRaw,
                 GetTimeOfDay ;

TYPE
  SetOfFd = ADDRESS ;      (* Hidden type in Selective.c *)
  Timeval = ADDRESS ;     (* Hidden type in Selective.c *)

PROCEDURE Select (nooffds: CARDINAL;
                 readfds, writefds, exceptfds: SetOfFd;
                 timeout: Timeval) : INTEGER ;

PROCEDURE InitTime (sec, usec: CARDINAL) : Timeval ;
PROCEDURE KillTime (t: Timeval) : Timeval ;
PROCEDURE GetTime (t: Timeval; VAR sec, usec: CARDINAL) ;
PROCEDURE SetTime (t: Timeval; sec, usec: CARDINAL) ;
PROCEDURE InitSet () : SetOfFd ;
PROCEDURE KillSet (s: SetOfFd) : SetOfFd ;
PROCEDURE FdZero (s: SetOfFd) ;
PROCEDURE FdSet (fd: INTEGER; s: SetOfFd) ;
PROCEDURE FdClr (fd: INTEGER; s: SetOfFd) ;
PROCEDURE FdIsSet (fd: INTEGER; s: SetOfFd) : BOOLEAN ;
PROCEDURE MaxFdsPlusOne (a, b: INTEGER) : INTEGER ;

(* you must use the raw routines with select - not the FIO buffered routines *)
PROCEDURE WriteCharRaw (fd: INTEGER; ch: CHAR) ;
PROCEDURE ReadCharRaw (fd: INTEGER) : CHAR ;

(*
  GetTimeOfDay - fills in a record, Timeval, filled in with the
                 current system time in seconds and microseconds.
                 It returns zero (see man 3p gettimeofday)
*)

PROCEDURE GetTimeOfDay (tv: Timeval) : INTEGER ;

```

END Selective.

4.1.38 gm2-libs/StdIO

```
DEFINITION MODULE StdIO ;

EXPORT QUALIFIED ProcRead, ProcWrite,
                 Read, Write,
                 PushOutput, PopOutput, GetCurrentOutput,
                 PushInput, PopInput, GetCurrentInput ;

TYPE
  ProcWrite = PROCEDURE (CHAR) ;
  ProcRead  = PROCEDURE (VAR CHAR) ;

(*
  Read - is the generic procedure that all higher application layers
        should use to receive a character.
*)

PROCEDURE Read (VAR ch: CHAR) ;

(*
  Write - is the generic procedure that all higher application layers
        should use to emit a character.
*)

PROCEDURE Write (ch: CHAR) ;

(*
  PushOutput - pushes the current Write procedure onto a stack,
              any future references to Write will actually invoke
              procedure, p.
*)

PROCEDURE PushOutput (p: ProcWrite) ;

(*
  PopOutput - restores Write to use the previous output procedure.
*)

PROCEDURE PopOutput ;
```



```
(*
  GetCurrentOutput - returns the current output procedure.
*)

PROCEDURE GetCurrentOutput () : ProcWrite ;

(*
  PushInput - pushes the current Read procedure onto a stack,
              any future references to Read will actually invoke
              procedure, p.
*)

PROCEDURE PushInput (p: ProcRead) ;

(*
  PopInput - restores Write to use the previous output procedure.
*)

PROCEDURE PopInput ;

(*
  GetCurrentInput - returns the current input procedure.
*)

PROCEDURE GetCurrentInput () : ProcRead ;

END StdIO.
```

4.1.39 gm2-libs/Storage

```
DEFINITION MODULE Storage ;

FROM SYSTEM IMPORT ADDRESS ;

EXPORT QUALIFIED ALLOCATE, DEALLOCATE, REALLOCATE, Available ;

(*
  ALLOCATE - attempt to allocate memory from the heap.
             NIL is returned in, a, if ALLOCATE fails.
*)

PROCEDURE ALLOCATE (VAR a: ADDRESS ; Size: CARDINAL) ;

(*
  DEALLOCATE - return, Size, bytes to the heap.
              The variable, a, is set to NIL.
*)

PROCEDURE DEALLOCATE (VAR a: ADDRESS ; Size: CARDINAL) ;

(*
  REALLOCATE - attempts to reallocate storage. The address,
              a, should either be NIL in which case ALLOCATE
              is called, or alternatively it should have already
              been initialized by ALLOCATE. The allocated storage
              is resized accordingly.
*)

PROCEDURE REALLOCATE (VAR a: ADDRESS; Size: CARDINAL) ;

(*
  Available - returns TRUE if, Size, bytes can be allocated.
*)

PROCEDURE Available (Size: CARDINAL) : BOOLEAN ;

END Storage.
```

4.1.40 gm2-libs/StrCase

```
DEFINITION MODULE StrCase ;

EXPORT QUALIFIED StrToUpperCase, StrToLowerCase, Cap, Lower ;

(*
  StrToUpperCase - converts string, a, to uppercase returning the
                  result in, b.
*)

PROCEDURE StrToUpperCase (a: ARRAY OF CHAR ; VAR b: ARRAY OF CHAR) ;

(*
  StrToLowerCase - converts string, a, to lowercase returning the
                  result in, b.
*)

PROCEDURE StrToLowerCase (a: ARRAY OF CHAR ; VAR b: ARRAY OF CHAR) ;

(*
  Cap - converts a lower case character into a capital character.
        If the character is not a lower case character 'a'..'z'
        then the character is simply returned unaltered.
*)

PROCEDURE Cap (ch: CHAR) : CHAR ;

(*
  Lower - converts an upper case character into a lower case character.
          If the character is not an upper case character 'A'..'Z'
          then the character is simply returned unaltered.
*)

PROCEDURE Lower (ch: CHAR) : CHAR ;

END StrCase.
```

4.1.41 gm2-libs/StrIO

```
DEFINITION MODULE StrIO ;

EXPORT QUALIFIED ReadString, WriteString,
                  WriteLn ;

(*
   WriteLn - writes a carriage return and a newline
             character.
*)

PROCEDURE WriteLn ;

(*
   ReadString - reads a sequence of characters into a string.
                Line editing accepts Del, Ctrl H, Ctrl W and
                Ctrl U.
*)

PROCEDURE ReadString (VAR a: ARRAY OF CHAR) ;

(*
   WriteString - writes a string to the default output.
*)

PROCEDURE WriteString (a: ARRAY OF CHAR) ;

END StrIO.
```

4.1.42 gm2-libs/StrLib

```
DEFINITION MODULE StrLib ;
```

```
EXPORT QUALIFIED StrConcat, StrLen, StrCopy, StrEqual, StrLess,  
                 IsSubString, StrRemoveWhitePrefix ;
```

```
(*  
  StrConcat - combines a and b into c.  
*)
```

```
PROCEDURE StrConcat (a, b: ARRAY OF CHAR; VAR c: ARRAY OF CHAR) ;
```

```
(*  
  StrLess - returns TRUE if string, a, alphabetically occurs before  
            string, b.  
*)
```

```
PROCEDURE StrLess (a, b: ARRAY OF CHAR) : BOOLEAN ;
```

```
(*  
  StrEqual - performs a = b on two strings.  
*)
```

```
PROCEDURE StrEqual (a, b: ARRAY OF CHAR) : BOOLEAN ;
```

```
(*  
  StrLen - returns the length of string, a.  
*)
```

```
PROCEDURE StrLen (a: ARRAY OF CHAR) : CARDINAL ;
```

```
(*  
  StrCopy - copy string src into string dest providing dest is large enough.■  
            If dest is smaller than a then src then the string is truncated when■  
            dest is full. Add a nul character if there is room in dest.■  
*)
```

```
PROCEDURE StrCopy (src: ARRAY OF CHAR ; VAR dest: ARRAY OF CHAR) ;
```

```
(*
```

```
    IsSubString - returns true if b is a subcomponent of a.
*)

PROCEDURE IsSubString (a, b: ARRAY OF CHAR) : BOOLEAN ;

(*
    StrRemoveWhitePrefix - copies string, into string, b, excluding any white
                           space in front of a.
*)

PROCEDURE StrRemoveWhitePrefix (a: ARRAY OF CHAR; VAR b: ARRAY OF CHAR) ;

END StrLib.
```

4.1.43 gm2-libs/StringConvert

```
DEFINITION MODULE StringConvert ;
```

```
FROM DynamicStrings IMPORT String ;
EXPORT QUALIFIED IntegerToString, StringToInteger,
StringToLongInteger, LongIntegerToString,
StringToCardinal, CardinalToString,
StringToLongCardinal, LongCardinalToString,
StringToShortCardinal, ShortCardinalToString,
StringToLongreal, LongrealToString,
ToSigFig,
stoi, itos, ctos, stoc, hstoi, ostoi, bstoi,
hstoc, ostoc, bstoc,
stor, stolr ;
```

```
(*
IntegerToString - converts INTEGER, i, into a String. The field width
can be specified if non zero. Leading characters
are defined by padding and this function will
prepend a + if sign is set to TRUE.
The base allows the caller to generate binary,
octal, decimal, hexadecimal numbers.
The value of lower is only used when hexadecimal
numbers are generated and if TRUE then digits
abcdef are used, and if FALSE then ABCDEF are used.
*)
```

```
PROCEDURE IntegerToString (i: INTEGER; width: CARDINAL; padding: CHAR; sign: BOOLEAN;
base: CARDINAL; lower: BOOLEAN) : String ;
```

```
(*
CardinalToString - converts CARDINAL, c, into a String. The field
width can be specified if non zero. Leading
characters are defined by padding.
The base allows the caller to generate binary,
octal, decimal, hexadecimal numbers.
The value of lower is only used when hexadecimal
numbers are generated and if TRUE then digits
abcdef are used, and if FALSE then ABCDEF are used.
*)
```

```
PROCEDURE CardinalToString (c: CARDINAL; width: CARDINAL; padding: CHAR;
base: CARDINAL; lower: BOOLEAN) : String ;
```

```
(*
  StringToInteger - converts a string, s, of, base, into an INTEGER.
                   Leading white space is ignored. It stops converting
                   when either the string is exhausted or if an illegal
                   numeral is found.
                   The parameter found is set TRUE if a number was found.
*)

PROCEDURE StringToInteger (s: String; base: CARDINAL; VAR found: BOOLEAN) : INTEGER ;

(*
  StringToCardinal - converts a string, s, of, base, into a CARDINAL.
                   Leading white space is ignored. It stops converting
                   when either the string is exhausted or if an illegal
                   numeral is found.
                   The parameter found is set TRUE if a number was found.
*)

PROCEDURE StringToCardinal (s: String; base: CARDINAL; VAR found: BOOLEAN) : CARDINAL

(*
  LongIntegerToString - converts LONGINT, i, into a String. The field width
                   can be specified if non zero. Leading characters
                   are defined by padding and this function will
                   prepend a + if sign is set to TRUE.
                   The base allows the caller to generate binary,
                   octal, decimal, hexadecimal numbers.
                   The value of lower is only used when hexadecimal
                   numbers are generated and if TRUE then digits
                   abcdef are used, and if FALSE then ABCDEF are used.
*)

PROCEDURE LongIntegerToString (i: LONGINT; width: CARDINAL; padding: CHAR;
                               sign: BOOLEAN; base: CARDINAL; lower: BOOLEAN) : String

(*
  StringToLongInteger - converts a string, s, of, base, into an LONGINT.
                   Leading white space is ignored. It stops converting
                   when either the string is exhausted or if an illegal
                   numeral is found.
                   The parameter found is set TRUE if a number was found.
*)
```



```
PROCEDURE StringToLongInteger (s: String; base: CARDINAL; VAR found: BOOLEAN) : LONGIN
```

```
(*
```

```
  LongCardinalToString - converts LONGCARD, c, into a String. The field
                        width can be specified if non zero. Leading
                        characters are defined by padding.
                        The base allows the caller to generate binary,
                        octal, decimal, hexadecimal numbers.
                        The value of lower is only used when hexadecimal
                        numbers are generated and if TRUE then digits
                        abcdef are used, and if FALSE then ABCDEF are used.
*)
```

```
PROCEDURE LongCardinalToString (c: LONGCARD; width: CARDINAL; padding: CHAR;
                                base: CARDINAL; lower: BOOLEAN) : String ;
```

```
(*
```

```
  StringToLongCardinal - converts a string, s, of, base, into a LONGCARD.
                        Leading white space is ignored. It stops converting
                        when either the string is exhausted or if an illegal
                        numeral is found.
                        The parameter found is set TRUE if a number was found.
*)
```

```
PROCEDURE StringToLongCardinal (s: String; base: CARDINAL; VAR found: BOOLEAN) : LONGC
```

```
(*
```

```
  ShortCardinalToString - converts SHORTCARD, c, into a String. The field
                        width can be specified if non zero. Leading
                        characters are defined by padding.
                        The base allows the caller to generate binary,
                        octal, decimal, hexadecimal numbers.
                        The value of lower is only used when hexadecimal
                        numbers are generated and if TRUE then digits
                        abcdef are used, and if FALSE then ABCDEF are used.
*)
```

```
PROCEDURE ShortCardinalToString (c: SHORTCARD; width: CARDINAL; padding: CHAR;
                                base: CARDINAL; lower: BOOLEAN) : String ;
```

```
(*
```

```
  StringToShortCardinal - converts a string, s, of, base, into a SHORTCARD.
```

Leading white space is ignored. It stops converting when either the string is exhausted or if an illegal numeral is found.

The parameter found is set TRUE if a number was found.

*)

```
PROCEDURE StringToShortCardinal (s: String; base: CARDINAL;
                                VAR found: BOOLEAN) : SHORTCARD ;
```

(*
stoi - decimal string to INTEGER
*)

```
PROCEDURE stoi (s: String) : INTEGER ;
```

(*
itos - integer to decimal string.
*)

```
PROCEDURE itos (i: INTEGER; width: CARDINAL; padding: CHAR; sign: BOOLEAN) : String ;
```

(*
ctos - cardinal to decimal string.
*)

```
PROCEDURE ctos (c: CARDINAL; width: CARDINAL; padding: CHAR) : String ;
```

(*
stoc - decimal string to CARDINAL
*)

```
PROCEDURE stoc (s: String) : CARDINAL ;
```

(*
hstoi - hexadecimal string to INTEGER
*)

```
PROCEDURE hstoi (s: String) : INTEGER ;
```

(*
ostoi - octal string to INTEGER

```
*)

PROCEDURE ostoi (s: String) : INTEGER ;

(*
  bstoi - binary string to INTEGER
*)

PROCEDURE bstoi (s: String) : INTEGER ;

(*
  hstoc - hexadecimal string to CARDINAL
*)

PROCEDURE hstoc (s: String) : CARDINAL ;

(*
  ostoc - octal string to CARDINAL
*)

PROCEDURE ostoc (s: String) : CARDINAL ;

(*
  bstoc - binary string to CARDINAL
*)

PROCEDURE bstoc (s: String) : CARDINAL ;

(*
  StringToLongreal - returns a LONGREAL and sets found to TRUE
                    if a legal number is seen.
*)

PROCEDURE StringToLongreal (s: String; VAR found: BOOLEAN) : LONGREAL ;

(*
  LongrealToString - converts a LONGREAL number, Real, which has,
                    TotalWidth, and FractionWidth into a string.

                    So for example:
```

```

LongrealToString(1.0, 4, 2) -> '1.00'
LongrealToString(12.3, 5, 2) -> '12.30'
LongrealToString(12.3, 6, 2) -> ' 12.30'
LongrealToString(12.3, 6, 3) -> '12.300'

```

if total width is too small then the fraction becomes truncated.

```

LongrealToString(12.3, 5, 3) -> '12.30'

```

If TotalWidth is 0 then the function will return the value of x which is converted into as a fixed point number with exhaustive precision.

*)

```

PROCEDURE LongrealToString (x: LONGREAL;
                             TotalWidth, FractionWidth: CARDINAL) : String ;

```

```

(*
  stor - returns a REAL given a string.
*)

```

```

PROCEDURE stor (s: String) : REAL ;

```

```

(*
  stolr - returns a LONGREAL given a string.
*)

```

```

PROCEDURE stolr (s: String) : LONGREAL ;

```

```

(*
  ToSigFig - returns a floating point or base 10 integer
             string which is accurate to, n, significant
             figures. It will return a new String
             and, s, will be destroyed.

```

So: 12.345

rounded to the following significant figures yields

5	12.345
4	12.34

```

        3      12.3
        2      12
        1      10
*)

PROCEDURE ToSigFig (s: String; n: CARDINAL) : String ;

(*
  ToDecimalPlaces - returns a floating point or base 10 integer
                    string which is accurate to, n, decimal
                    places. It will return a new String
                    and, s, will be destroyed.
                    Decimal places yields, n, digits after
                    the .

                    So: 12.345

                    rounded to the following decimal places yields

                    5      12.34500
                    4      12.3450
                    3      12.345
                    2      12.34
                    1      12.3
*)

PROCEDURE ToDecimalPlaces (s: String; n: CARDINAL) : String ;

END StringConvert.
```

4.1.44 gm2-libs/SysExceptions

```
DEFINITION MODULE SysExceptions ;

(* Provides a mechanism for the underlying libraries to
   configure the exception routines. This mechanism
   is used by both the ISO and PIM libraries.
   It is written to be ISO compliant and this also
   allows for mixed dialect projects. *)

FROM SYSTEM IMPORT ADDRESS ;

TYPE
  PROCEXCEPTION = PROCEDURE (ADDRESS) ;

PROCEDURE InitExceptionHandler (indexf, range, casef, invalidloc,
                                function, wholevalue, wholediv,
                                realvalue, realdiv, complexvalue,
                                complexdiv, protection, systemf,
                                coroutine, exception: PROCEXCEPTION) ;

END SysExceptions.
```

4.1.45 gm2-libs/SysStorage

```
DEFINITION MODULE SysStorage ;

(* Provides dynamic allocation for the system components.
   This allows the application to use the traditional Storage module
   which can be handled differently. *)

FROM SYSTEM IMPORT ADDRESS ;
EXPORT QUALIFIED ALLOCATE, DEALLOCATE, REALLOCATE, Available, Init ;

(*
   ALLOCATE - attempt to allocate memory from the heap.
             NIL is returned in, a, if ALLOCATE fails.
*)

PROCEDURE ALLOCATE (VAR a: ADDRESS ; size: CARDINAL) ;

(*
   DEALLOCATE - return, size, bytes to the heap.
               The variable, a, is set to NIL.
*)

PROCEDURE DEALLOCATE (VAR a: ADDRESS ; size: CARDINAL) ;

(*
   REALLOCATE - attempts to reallocate storage. The address,
               a, should either be NIL in which case ALLOCATE
               is called, or alternatively it should have already
               been initialized by ALLOCATE. The allocated storage
               is resized accordingly.
*)

PROCEDURE REALLOCATE (VAR a: ADDRESS; size: CARDINAL) ;

(*
   Available - returns TRUE if, size, bytes can be allocated.
*)

PROCEDURE Available (size: CARDINAL) : BOOLEAN;

(*
```

```
Init - initializes the heap.  
      This does nothing on a GNU/Linux system.  
      But it remains here since it might be used in an  
      embedded system.
```

```
*)
```

```
PROCEDURE Init ;
```

```
END SysStorage.
```


4.1.46 gm2-libs/TimeString

```
DEFINITION MODULE TimeString ;
```

```
EXPORT QUALIFIED GetTimeString ;
```

```
(*  
  GetTimeString - places the time in ascii format into array, a.
```

```
*)
```

```
PROCEDURE GetTimeString (VAR a: ARRAY OF CHAR) ;
```

```
END TimeString.
```

4.1.47 gm2-libs/UnixArgs

```
DEFINITION MODULE UnixArgs ;  
  
FROM SYSTEM IMPORT ADDRESS ;  
  
EXPORT QUALIFIED GetArgC, GetArgV, GetEnvV ;  
  
PROCEDURE GetArgC () : INTEGER ;  
PROCEDURE GetArgV () : ADDRESS ;  
PROCEDURE GetEnvV () : ADDRESS ;  
  
END UnixArgs.
```

4.1.48 gm2-libs/cbuiltin

```

DEFINITION MODULE FOR "C" cbuiltin ;

FROM SYSTEM IMPORT ADDRESS ;
EXPORT UNQUALIFIED alloca, memcpy,
  isfinite, isfinitef, isfinitel,
  isinf_sign, isinf_signf, isinf_signl,
  sinf, sinl, sin,
  cosf, cosl, cos,
  atan2f, atan2l, atan2,
  sqrtf, sqrtl, sqrt,
  fabsf, fabsl, fabs,
  logf, logl, log,
  expf, expl, exp,
  log10f, log10l, log10,
  exp10f, exp10l, exp10,
  ilogbf, ilogbl, ilogb,
  significand, significandf, significandl,
  modf, modff, modfl,
  nextafter, nextafterf, nextafterl,
  nexttoward, nexttowardf, nexttowardl,
  scalb, scalbf, scalbl,
  scalbn, scalbnf, scalbnl,
  scalbln, scalblnf, scalblnl,

  cabsf, cabsl, cabs,
  cargf, carg, cargl,
  conjf, conj, conjl,
  cpowf, cpow, cpowl,
  csqrtf, csqrt, csqrtl,
  cexpf, cexp, cexpl,
  clogf, clog, clogl,
  csinf, csin, csinl,
  ccosf, ccos, ccosl,
  ctanf, ctan, ctanl,
  casin, casin, casinl,
  cacosf, cacos, cacosl,
  catanf, catan, catanl,

  index, rindex,
  memcmp, memset, memmove,
  strcat, strncat, strcpy, strncpy, strcmp, strncmp,
  strlen, strstr, strpbrk, strspn, strcspn, strchr, strrchr ;■

PROCEDURE alloca (i: CARDINAL) : ADDRESS ;
PROCEDURE memcpy (dest, src: ADDRESS; n: CARDINAL) : ADDRESS ;

```

```
PROCEDURE isfinite (x: REAL) : BOOLEAN ;
PROCEDURE isfinitel (x: LONGREAL) : BOOLEAN ;
PROCEDURE isfinitef (x: SHORTREAL) : BOOLEAN ;
PROCEDURE isinf_sign (x: REAL) : BOOLEAN ;
PROCEDURE isinf_signl (x: LONGREAL) : BOOLEAN ;
PROCEDURE isinf_signf (x: SHORTREAL) : BOOLEAN ;
PROCEDURE sinf (x: SHORTREAL) : SHORTREAL ;
PROCEDURE sin (x: REAL) : REAL ;
PROCEDURE sinl (x: LONGREAL) : LONGREAL ;
PROCEDURE cosf (x: SHORTREAL) : SHORTREAL ;
PROCEDURE cos (x: REAL) : REAL ;
PROCEDURE cosl (x: LONGREAL) : LONGREAL ;
PROCEDURE atan2f (x, y: SHORTREAL) : SHORTREAL ;
PROCEDURE atan2 (x, y: REAL) : REAL ;
PROCEDURE atan2l (x, y: LONGREAL) : LONGREAL ;
PROCEDURE sqrtf (x: SHORTREAL) : SHORTREAL ;
PROCEDURE sqrt (x: REAL) : REAL ;
PROCEDURE sqrtl (x: LONGREAL) : LONGREAL ;
PROCEDURE fabsf (x: SHORTREAL) : SHORTREAL ;
PROCEDURE fabs (x: REAL) : REAL ;
PROCEDURE fabsl (x: LONGREAL) : LONGREAL ;
PROCEDURE logf (x: SHORTREAL) : SHORTREAL ;
PROCEDURE log (x: REAL) : REAL ;
PROCEDURE logl (x: LONGREAL) : LONGREAL ;
PROCEDURE expf (x: SHORTREAL) : SHORTREAL ;
PROCEDURE exp (x: REAL) : REAL ;
PROCEDURE expl (x: LONGREAL) : LONGREAL ;
PROCEDURE log10f (x: SHORTREAL) : SHORTREAL ;
PROCEDURE log10 (x: REAL) : REAL ;
PROCEDURE log10l (x: LONGREAL) : LONGREAL ;
PROCEDURE exp10f (x: SHORTREAL) : SHORTREAL ;
PROCEDURE exp10 (x: REAL) : REAL ;
PROCEDURE exp10l (x: LONGREAL) : LONGREAL ;
PROCEDURE ilogbf (x: SHORTREAL) : INTEGER ;
PROCEDURE ilogb (x: REAL) : INTEGER ;
PROCEDURE ilogbl (x: LONGREAL) : INTEGER ;

PROCEDURE significand (r: REAL) : REAL ;
PROCEDURE significandf (s: SHORTREAL) : SHORTREAL ;
PROCEDURE significandl (l: LONGREAL) : LONGREAL ;

PROCEDURE modf (x: REAL; VAR y: REAL) : REAL ;
PROCEDURE modff (x: SHORTREAL; VAR y: SHORTREAL) : SHORTREAL ;
PROCEDURE modfl (x: LONGREAL; VAR y: LONGREAL) : LONGREAL ;

PROCEDURE nextafter (x, y: REAL) : REAL ;
PROCEDURE nextafterf (x, y: SHORTREAL) : SHORTREAL ;
```

```
PROCEDURE nextafterl (x, y: LONGREAL) : LONGREAL ;

PROCEDURE nexttoward (x, y: REAL) : REAL ;
PROCEDURE nexttowardf (x, y: SHORTREAL) : SHORTREAL ;
PROCEDURE nexttowardl (x, y: LONGREAL) : LONGREAL ;

PROCEDURE scalb (x, n: REAL) : REAL ;
PROCEDURE scalbf (x, n: SHORTREAL) : SHORTREAL ;
PROCEDURE scalbl (x, n: LONGREAL) : LONGREAL ;

PROCEDURE scalbn (x: REAL; n: INTEGER) : REAL ;
PROCEDURE scalbnf (x: SHORTREAL; n: INTEGER) : SHORTREAL ;
PROCEDURE scalbnl (x: LONGREAL; n: INTEGER) : LONGREAL ;

PROCEDURE scalbln (x: REAL; n: LONGINT) : REAL ;
PROCEDURE scalblnf (x: SHORTREAL; n: LONGINT) : SHORTREAL ;
PROCEDURE scalblnl (x: LONGREAL; n: LONGINT) : LONGREAL ;

PROCEDURE cabsf (z: SHORTCOMPLEX) : SHORTREAL ;
PROCEDURE cabs (z: COMPLEX) : REAL ;
PROCEDURE cabsl (z: LONGCOMPLEX) : LONGREAL ;

PROCEDURE cargf (z: SHORTCOMPLEX) : SHORTREAL ;
PROCEDURE carg (z: COMPLEX) : REAL ;
PROCEDURE cargl (z: LONGCOMPLEX) : LONGREAL ;

PROCEDURE conjf (z: SHORTCOMPLEX) : SHORTCOMPLEX ;
PROCEDURE conj (z: COMPLEX) : COMPLEX ;
PROCEDURE conjl (z: LONGCOMPLEX) : LONGCOMPLEX ;

PROCEDURE cpowf (base: SHORTCOMPLEX; exp: SHORTREAL) : SHORTCOMPLEX ;
PROCEDURE cpow (base: COMPLEX; exp: REAL) : COMPLEX ;
PROCEDURE cpowl (base: LONGCOMPLEX; exp: LONGREAL) : LONGCOMPLEX ;

PROCEDURE csqrtf (z: SHORTCOMPLEX) : SHORTCOMPLEX ;
PROCEDURE csqrt (z: COMPLEX) : COMPLEX ;
PROCEDURE csqrtl (z: LONGCOMPLEX) : LONGCOMPLEX ;

PROCEDURE cexpf (z: SHORTCOMPLEX) : SHORTCOMPLEX ;
PROCEDURE cexp (z: COMPLEX) : COMPLEX ;
PROCEDURE cexpl (z: LONGCOMPLEX) : LONGCOMPLEX ;

PROCEDURE clogf (z: SHORTCOMPLEX) : SHORTCOMPLEX ;
PROCEDURE clog (z: COMPLEX) : COMPLEX ;
PROCEDURE clogl (z: LONGCOMPLEX) : LONGCOMPLEX ;

PROCEDURE csinf (z: SHORTCOMPLEX) : SHORTCOMPLEX ;
```

```
PROCEDURE csin (z: COMPLEX) : COMPLEX ;
PROCEDURE csinl (z: LONGCOMPLEX) : LONGCOMPLEX ;

PROCEDURE ccosf (z: SHORTCOMPLEX) : SHORTCOMPLEX ;
PROCEDURE ccos (z: COMPLEX) : COMPLEX ;
PROCEDURE ccosl (z: LONGCOMPLEX) : LONGCOMPLEX ;

PROCEDURE ctanf (z: SHORTCOMPLEX) : SHORTCOMPLEX ;
PROCEDURE ctan (z: COMPLEX) : COMPLEX ;
PROCEDURE ctanl (z: LONGCOMPLEX) : LONGCOMPLEX ;

PROCEDURE casinf (z: SHORTCOMPLEX) : SHORTCOMPLEX ;
PROCEDURE casin (z: COMPLEX) : COMPLEX ;
PROCEDURE casinl (z: LONGCOMPLEX) : LONGCOMPLEX ;

PROCEDURE cacosf (z: SHORTCOMPLEX) : SHORTCOMPLEX ;
PROCEDURE cacos (z: COMPLEX) : COMPLEX ;
PROCEDURE cacosl (z: LONGCOMPLEX) : LONGCOMPLEX ;

PROCEDURE catanf (z: SHORTCOMPLEX) : SHORTCOMPLEX ;
PROCEDURE catan (z: COMPLEX) : COMPLEX ;
PROCEDURE catanl (z: LONGCOMPLEX) : LONGCOMPLEX ;

PROCEDURE index (s: ADDRESS; c: INTEGER) : ADDRESS ;
PROCEDURE rindex (s: ADDRESS; c: INTEGER) : ADDRESS ;
PROCEDURE memcmp (s1, s2: ADDRESS; n: CARDINAL) : INTEGER ;
PROCEDURE memmove (s1, s2: ADDRESS; n: CARDINAL) : ADDRESS ;
PROCEDURE memset (s: ADDRESS; c: INTEGER; n: CARDINAL) : ADDRESS ;
PROCEDURE strcat (dest, src: ADDRESS) : ADDRESS ;
PROCEDURE strncat (dest, src: ADDRESS; n: CARDINAL) : ADDRESS ;
PROCEDURE strcpy (dest, src: ADDRESS) : ADDRESS ;
PROCEDURE strncpy (dest, src: ADDRESS; n: CARDINAL) : ADDRESS ;
PROCEDURE strcmp (s1, s2: ADDRESS) : INTEGER ;
PROCEDURE strncmp (s1, s2: ADDRESS; n: CARDINAL) : INTEGER ;
PROCEDURE strlen (s: ADDRESS) : INTEGER ;
PROCEDURE strstr (haystack, needle: ADDRESS) : ADDRESS ;
PROCEDURE strpbrk (s, accept: ADDRESS) : ADDRESS ;
PROCEDURE strspn (s, accept: ADDRESS) : CARDINAL ;
PROCEDURE strcspn (s, accept: ADDRESS) : CARDINAL ;
PROCEDURE strchr (s: ADDRESS; c: INTEGER) : ADDRESS ;
PROCEDURE strrchr (s: ADDRESS; c: INTEGER) : ADDRESS ;

END cbuiltin.
```

4.1.49 gm2-libs/cgetopt

```
DEFINITION MODULE cgetopt ;
```

```
FROM SYSTEM IMPORT ADDRESS ;
```

```
TYPE
```

```
  Options = ADDRESS ;
```

```
VAR
```

```
  optarg          : ADDRESS ;
```

```
  optind, opterr, optopt: INTEGER ;
```

```
(*
```

```
  getopt - the getopt() function parses the command-line arguments.
```

```
  Its arguments argc and argv are the argument count and array as
  passed to the main() function on program invocation. An element of
  argv that starts with '-' (and is not exactly "-" or "--") is an
  option element. The characters of this element (aside from the
  initial '-') are option characters. If getopt() is called
  repeatedly, it returns successively each of the option characters
  from each of the option elements.
```

```
*)
```

```
PROCEDURE getopt (argc: INTEGER; argv: ADDRESS; optstring: ADDRESS) : CHAR ;
```

```
(*
```

```
  getopt_long - works like getopt() except that it also accepts long options,
  started with two dashes. (If the program accepts only long
  options, then optstring should be specified as an empty string (""),
  not NULL.) Long option names may be abbreviated if the abbreviation
  is unique or is an exact match for some defined option. A
  long option may take a parameter, of the form --arg=param or
  --arg param.
```

```
*)
```

```
PROCEDURE getopt_long (argc: INTEGER; argv: ADDRESS; optstring: ADDRESS;
                      longopts: ADDRESS; VAR longindex: INTEGER) : INTEGER ;
```

```
(*
```

```
  getopt_long_only - a wrapper for the C getopt_long_only.
```

```
*)
```

```
PROCEDURE getopt_long_only (argc: INTEGER; argv: ADDRESS; optstring: ADDRESS;
                           longopts: ADDRESS; VAR longindex: INTEGER) : INTEGER ;

(*
  InitOptions - constructor for empty Options.
*)

PROCEDURE InitOptions () : Options ;

(*
  KillOptions - deconstructor for empty Options.
*)

PROCEDURE KillOptions (o: Options) : Options ;

(*
  SetOption - set option[index] with {name, has_arg, flag, val}.
*)

PROCEDURE SetOption (o: Options; index: CARDINAL;
                   name: ADDRESS; has_arg: BOOLEAN;
                   VAR flag: INTEGER; val: INTEGER) ;

(*
  GetLongOptionArray - return a pointer to the C array containing all
                      long options.
*)

PROCEDURE GetLongOptionArray (o: Options) : ADDRESS ;

END cgetopt.
```


4.1.50 gm2-libs/cxxabi

```
DEFINITION MODULE FOR "C" cxxabi ;

(* This should only be used by the compiler and it matches the
   g++ implementation. *)

FROM SYSTEM IMPORT ADDRESS ;
EXPORT UNQUALIFIED __cxa_begin_catch, __cxa_end_catch, __cxa_rethrow ;

PROCEDURE __cxa_begin_catch (a: ADDRESS) : ADDRESS ;
PROCEDURE __cxa_end_catch ;
PROCEDURE __cxa_rethrow ;

END cxxabi.
```

4.1.51 gm2-libs/dtoa

```
DEFINITION MODULE dtoa ;

FROM SYSTEM IMPORT ADDRESS ;

TYPE
  Mode = (maxsignificant, decimaldigits) ;

(*
  strtod - returns a REAL given a string, s. It will set
           error to TRUE if the number is too large.
*)

PROCEDURE strtod (s: ADDRESS; VAR error: BOOLEAN) : REAL ;

(*
  dtoa - converts a REAL, d, into a string. The address of the
         string is returned.
         mode      indicates the type of conversion required.
         ndigits   determines the number of digits according to mode.
         decpt     the position of the decimal point.
         sign      does the string have a sign?
*)

PROCEDURE dtoa (d          : REAL;
               mode       : Mode;
               ndigits    : INTEGER;
               VAR decpt  : INTEGER;
               VAR sign   : BOOLEAN) : ADDRESS ;

END dtoa.
```

4.1.52 gm2-libs/errno

```
DEFINITION MODULE errno ;

CONST
    EINTR = 4 ; (* system call interrupted *)
    ERANGE = 34 ; (* result is too large *)
    EAGAIN = 11 ; (* retry the system call *)

PROCEDURE geterrno () : INTEGER ;

END errno.
```

4.1.53 gm2-libs/gdbif

```
DEFINITION MODULE gdbif ;

(* Provides interactive connectivity with gdb useful for debugging
   Modula-2 shared libraries. *)

EXPORT UNQUALIFIED sleepSpin, finishSpin, connectSpin ;

(*
   finishSpin - sets boolean mustWait to FALSE.
*)

PROCEDURE finishSpin ;

(*
   sleepSpin - waits for the boolean variable mustWait to become FALSE.
               It sleeps for a second between each test of the variable.
*)

PROCEDURE sleepSpin ;

(*
   connectSpin - breakpoint placeholder. Its only purpose is to allow users
                 to set a breakpoint. This procedure is called once
                 sleepSpin is released from its spin (via a call from
                 finishSpin).
*)

PROCEDURE connectSpin ;

END gdbif.
```

4.1.54 gm2-libs/ldtoa

```
DEFINITION MODULE ldtoa ;

FROM SYSTEM IMPORT ADDRESS ;

TYPE
  Mode = (maxsignificant, decimaldigits) ;

(*
  strtold - returns a LONGREAL given a C string, s. It will set
           error to TRUE if the number is too large or badly formed.
*)

PROCEDURE strtold (s: ADDRESS; VAR error: BOOLEAN) : LONGREAL ;

(*
  ldtoa - converts a LONGREAL, d, into a string. The address of the
         string is returned.
         mode      indicates the type of conversion required.
         ndigits   determines the number of digits according to mode.
         decpt     the position of the decimal point.
         sign      does the string have a sign?
*)

PROCEDURE ldtoa (d          : LONGREAL;
                mode       : Mode;
                ndigits    : INTEGER;
                VAR decpt  : INTEGER;
                VAR sign   : BOOLEAN) : ADDRESS ;

END ldtoa.
```

4.1.55 gm2-libs/libc

```

DEFINITION MODULE FOR "C" libc ;

FROM SYSTEM IMPORT ADDRESS, CSIZE_T, CSSIZE_T ;

EXPORT UNQUALIFIED time_t, timeb, tm, ptrToTM,
    write, read,
    system, abort,
    malloc, free,
    exit, isatty,
    getenv, putenv, getpid,
    dup, close, open, lseek,
    readv, writev,
    perror, creat,
    getcwd, chown, strlen, strcpy, strncpy,
    unlink, setenv,
    memcpy, memset, memmove, printf, realloc,
    rand, srand,
    time, localtime, ftime,
    shutdown, snprintf,
    rename, setjmp, longjmp, atexit,
    ttyname, sleep, execv ;

TYPE
    time_t = LONGINT ;

    ptrToTM = POINTER TO tm ;
    tm = RECORD
        tm_sec: INTEGER ;      (* Seconds.      [0-60] (1 leap second) *)
        tm_min: INTEGER ;      (* Minutes.    [0-59]  *)
        tm_hour: INTEGER ;     (* Hours.      [0-23]  *)
        tm_mday: INTEGER ;     (* Day.        [1-31]  *)
        tm_mon: INTEGER ;      (* Month.      [0-11]  *)
        tm_year: INTEGER ;     (* Year - 1900. *)
        tm_wday: INTEGER ;     (* Day of week. [0-6]  *)
        tm_yday: INTEGER ;     (* Days in year. [0-365] *)
        tm_isdst: INTEGER ;    (* DST.        [-1/0/1] *)
        tm_gmtoff: LONGINT ;   (* Seconds east of UTC. *)
        tm_zone: ADDRESS ;     (* char * zone name *)
    END ;

    timeb = RECORD
        time      : time_t ;
        millitm   : SHORTCARD ;
        timezone  : SHORTCARD ;

```

```
        dstflag : SHORTCARD ;
    END ;

    exitP = PROCEDURE () : INTEGER ;

    (*
        ssize_t write (int d, void *buf, size_t nbytes)
    *)
    PROCEDURE write (d: INTEGER; buf: ADDRESS; nbytes: CSIZE_T) : [ CSSIZE_T ] ;■

    (*
        ssize_t read (int d, void *buf, size_t nbytes)
    *)
    PROCEDURE read (d: INTEGER; buf: ADDRESS; nbytes: CSIZE_T) : [ CSSIZE_T ] ;■

    (*
        int system(string)
        char *string;
    *)
    PROCEDURE system (a: ADDRESS) : [ INTEGER ] ;

    (*
        abort - generate a fault

        abort() first closes all open files if possible, then sends
        an IOT signal to the process. This signal usually results
        in termination with a core dump, which may be used for
        debugging.

        It is possible for abort() to return control if is caught or
        ignored, in which case the value returned is that of the
        kill(2V) system call.
    *)
    PROCEDURE abort <* noreturn *> ;

    (*
        malloc - memory allocator.
```

```
void *malloc(size_t size);
```

malloc() returns a pointer to a block of at least size bytes, which is appropriately aligned. If size is zero, malloc() returns a non-NULL pointer, but this pointer should not be dereferenced.

*)

```
PROCEDURE malloc (size: CSIZE_T) : ADDRESS ;
```

(*

free - memory deallocator.

```
free (void *ptr);
```

free() releases a previously allocated block. Its argument is a pointer to a block previously allocated by malloc, calloc, realloc, malloc, or memalign.

*)

```
PROCEDURE free (ptr: ADDRESS) ;
```

(*

```
void *realloc (void *ptr, size_t size);
```

realloc changes the size of the memory block pointed to by ptr to size bytes. The contents will be unchanged to the minimum of the old and new sizes; newly allocated memory will be uninitialized. If ptr is NIL, the call is equivalent to malloc(size); if size is equal to zero, the call is equivalent to free(ptr). Unless ptr is NIL, it must have been returned by an earlier call to malloc(), realloc.

*)

```
PROCEDURE realloc (ptr: ADDRESS; size: CSIZE_T) : ADDRESS ;
```

(*

isatty - does this descriptor refer to a terminal.

*)

```
PROCEDURE isatty (fd: INTEGER) : INTEGER ;
```



```
(*
  exit - returns control to the invoking process. Result, r, is
        returned.
*)

PROCEDURE exit (r: INTEGER) <* noreturn *> ;

(*
  getenv - returns the C string for the equivalent C environment
          variable.
*)

PROCEDURE getenv (s: ADDRESS) : ADDRESS ;

(*
  putenv - change or add an environment variable.
*)

PROCEDURE putenv (s: ADDRESS) : INTEGER ;

(*
  getpid - returns the UNIX process identification number.
*)

PROCEDURE getpid () : INTEGER ;

(*
  dup - duplicates the file descriptor, d.
*)

PROCEDURE dup (d: INTEGER) : INTEGER ;

(*
  close - closes the file descriptor, d.
*)

PROCEDURE close (d: INTEGER) : [ INTEGER ] ;

(*
  open - open the file, filename with flag and mode.
*)
```

```
PROCEDURE open (filename: ADDRESS; oflag: INTEGER; ...) : INTEGER ;

(*
  creat - creates a new file
*)

PROCEDURE creat (filename: ADDRESS; mode: CARDINAL) : INTEGER;

(*
  lseek - calls unix lseek:

          off_t lseek(int fildes, off_t offset, int whence);
*)

PROCEDURE lseek (fd: INTEGER; offset: LONGINT; whence: INTEGER) : LONGINT ;■

(*
  perror - writes errno and string. (ARRAY OF CHAR is translated onto ADDRESS).■
*)

PROCEDURE perror (string: ARRAY OF CHAR);

(*
  readv - reads an io vector of bytes.
*)

PROCEDURE readv (fd: INTEGER; v: ADDRESS; n: INTEGER) : [ INTEGER ] ;

(*
  writev - writes an io vector of bytes.
*)

PROCEDURE writev (fd: INTEGER; v: ADDRESS; n: INTEGER) : [ INTEGER ] ;

(*
  getcwd - copies the absolute pathname of the
           current working directory to the array pointed to by buf,
           which is of length size.

           If the current absolute path name would require a buffer
```

longer than size elements, NULL is returned, and errno is set to ERANGE; an application should check for this error, and allocate a larger buffer if necessary.

*)

```
PROCEDURE getcwd (buf: ADDRESS; size: CSIZE_T) : ADDRESS ;
```

(*

chown - The owner of the file specified by path or by fd is changed. Only the super-user may change the owner of a file. The owner of a file may change the group of the file to any group of which that owner is a member. The super-user may change the group arbitrarily.

If the owner or group is specified as -1, then that ID is not changed.

On success, zero is returned. On error, -1 is returned, and errno is set appropriately.

*)

```
PROCEDURE chown (filename: ADDRESS; uid, gid: INTEGER) : [ INTEGER ] ;
```

(*

strlen - returns the length of string, a.

*)

```
PROCEDURE strlen (a: ADDRESS) : CSIZE_T ;
```

(*

strcpy - copies string, src, into, dest.
It returns dest.

*)

```
PROCEDURE strcpy (dest, src: ADDRESS) : [ ADDRESS ] ;
```

(*

strncpy - copies string, src, into, dest, copying at most, n, bytes.
It returns dest.

*)

```
PROCEDURE strncpy (dest, src: ADDRESS; n: CARDINAL) : [ ADDRESS ] ;
```

```
(*  
  unlink - removes file and returns 0 if successful.  
*)
```

```
PROCEDURE unlink (file: ADDRESS) : [ INTEGER ] ;
```

```
(*  
  memcpy - copy memory area
```

```
  SYNOPSIS
```

```
  #include <string.h>
```

```
  void *memcpy(void *dest, const void *src, size_t n);  
  It returns dest.
```

```
*)
```

```
PROCEDURE memcpy (dest, src: ADDRESS; size: CSIZE_T) : [ ADDRESS ] ;
```

```
(*  
  memset - fill memory with a constant byte
```

```
  SYNOPSIS
```

```
  #include <string.h>
```

```
  void *memset(void *s, int c, size_t n);  
  It returns s.
```

```
*)
```

```
PROCEDURE memset (s: ADDRESS; c: INTEGER; size: CSIZE_T) : [ ADDRESS ] ;
```

```
(*  
  memmove - copy memory areas which may overlap
```

```
  SYNOPSIS
```

```
  #include <string.h>
```

```
  void *memmove(void *dest, const void *src, size_t n);  
  It returns dest.
```

```
*)
```

```
PROCEDURE memmove (dest, src: ADDRESS; size: CSIZE_T) : [ ADDRESS ] ;

(*
  int printf(const char *format, ...);
*)

PROCEDURE printf (format: ARRAY OF CHAR; ...) : [ INTEGER ] ;

(*
  int snprintf(char *str, size_t size, const char *format, ...);
*)

PROCEDURE snprintf (dest: ADDRESS; size: CSIZE_T;
                   format: ARRAY OF CHAR; ...) : [ INTEGER ] ;

(*
  setenv - sets environment variable, name, to value.
          It will overwrite an existing value if, overwrite,
          is true. It returns 0 on success and -1 for an error.
*)

PROCEDURE setenv (name: ADDRESS; value: ADDRESS; overwrite: INTEGER) : [ INTEGER ] ;■

(*
  srand - initialize the random number seed.
*)

PROCEDURE srand (seed: INTEGER) ;

(*
  rand - return a random integer.
*)

PROCEDURE rand () : INTEGER ;

(*
  time - returns a pointer to the time_t value. If, a,
         is not NIL then the libc value is copied into
         memory at address, a.
*)

PROCEDURE time (a: ADDRESS) : time_t ;
```

```
(*
  localtime - returns a pointer to the libc copy of the tm
              structure.
*)

PROCEDURE localtime (VAR t: time_t) : ADDRESS ;

(*
  ftime - return date and time.
*)

PROCEDURE ftime (VAR t: timeb) : [ INTEGER ] ;

(*
  shutdown - shutdown a socket, s.
             if how = 0, then no more reads are allowed.
             if how = 1, then no more writes are allowed.
             if how = 2, then no more reads or writes are allowed.
*)

PROCEDURE shutdown (s: INTEGER; how: INTEGER) : [ INTEGER ] ;

(*
  rename - change the name or location of a file
*)

PROCEDURE rename (oldpath, newpath: ADDRESS) : [ INTEGER ] ;

(*
  setjmp - returns 0 if returning directly, and non-zero
           when returning from longjmp using the saved
           context.
*)

PROCEDURE setjmp (env: ADDRESS) : INTEGER ;

(*
  longjmp - restores the environment saved by the last call
           of setjmp with the corresponding env argument.
           After longjmp is completed, program execution
```

```
        continues as if the corresponding call of setjmp
        had just returned the value val. The value of
        val must not be zero.
*)

PROCEDURE longjmp (env: ADDRESS; val: INTEGER) ;

(*
  atexit - execute, proc, when the function exit is called.
*)

PROCEDURE atexit (proc: exitP) : [ INTEGER ] ;

(*
  ttyname - returns a pointer to a string determining the ttyname.
*)

PROCEDURE ttyname (filedes: INTEGER) : ADDRESS ;

(*
  sleep - calling thread sleeps for seconds.
*)

PROCEDURE sleep (seconds: CARDINAL) : [ CARDINAL ] ;

(*
  execv - execute a file.
*)

PROCEDURE execv (pathname: ADDRESS; argv: ADDRESS) : [ INTEGER ] ;

END libc.
```

4.1.56 gm2-libs/libm

```
DEFINITION MODULE FOR "C" libm ;
```

```
(* Users are strongly advised to use MathLib0 or RealMath as calls
   to functions within these modules will generate inline code.
   This module is used by MathLib0 and RealMath when inline code cannot
   be generated. *)
```

```
EXPORT UNQUALIFIED sin, sinl, sinf,
                   cos, cosl, cosf,
                   tan, tanl, tanf,
                   sqrt, sqrtl, sqrtf,
                   asin, asinl, asinf,
                   acos, acosl, acosf,
                   atan, atanl, atanf,
                   atan2, atan2l, atan2f,
                   exp, expl, expf,
                   log, logl, logf,
                   exp10, exp10l, exp10f,
                   pow, powl, powf,
                   floor, floorl, floorf,
                   ceil, ceill, ceilf ;
```

```
PROCEDURE sin (x: REAL) : REAL ;
PROCEDURE sinl (x: LONGREAL) : LONGREAL ;
PROCEDURE sinf (x: SHORTREAL) : SHORTREAL ;
PROCEDURE cos (x: REAL) : REAL ;
PROCEDURE cosl (x: LONGREAL) : LONGREAL ;
PROCEDURE cosf (x: SHORTREAL) : SHORTREAL ;
PROCEDURE tan (x: REAL) : REAL ;
PROCEDURE tanl (x: LONGREAL) : LONGREAL ;
PROCEDURE tanf (x: SHORTREAL) : SHORTREAL ;
PROCEDURE sqrt (x: REAL) : REAL ;
PROCEDURE sqrtl (x: LONGREAL) : LONGREAL ;
PROCEDURE sqrtf (x: SHORTREAL) : SHORTREAL ;
PROCEDURE asin (x: REAL) : REAL ;
PROCEDURE asinl (x: LONGREAL) : LONGREAL ;
PROCEDURE asinf (x: SHORTREAL) : SHORTREAL ;
PROCEDURE acos (x: REAL) : REAL ;
PROCEDURE acosl (x: LONGREAL) : LONGREAL ;
PROCEDURE acosf (x: SHORTREAL) : SHORTREAL ;
PROCEDURE atan (x: REAL) : REAL ;
PROCEDURE atanl (x: LONGREAL) : LONGREAL ;
PROCEDURE atanf (x: SHORTREAL) : SHORTREAL ;
PROCEDURE atan2 (x, y: REAL) : REAL ;
PROCEDURE atan2l (x, y: LONGREAL) : LONGREAL ;
```



```
PROCEDURE atan2f (x, y: SHORTREAL) : SHORTREAL ;
PROCEDURE exp (x: REAL) : REAL ;
PROCEDURE expl (x: LONGREAL) : LONGREAL ;
PROCEDURE expf (x: SHORTREAL) : SHORTREAL ;
PROCEDURE log (x: REAL) : REAL ;
PROCEDURE logl (x: LONGREAL) : LONGREAL ;
PROCEDURE logf (x: SHORTREAL) : SHORTREAL ;
PROCEDURE exp10 (x: REAL) : REAL ;
PROCEDURE exp10l (x: LONGREAL) : LONGREAL ;
PROCEDURE exp10f (x: SHORTREAL) : SHORTREAL ;
PROCEDURE pow (x, y: REAL) : REAL ;
PROCEDURE powl (x, y: LONGREAL) : LONGREAL ;
PROCEDURE powf (x, y: SHORTREAL) : SHORTREAL ;
PROCEDURE floor (x: REAL) : REAL ;
PROCEDURE floorl (x: LONGREAL) : LONGREAL ;
PROCEDURE floorf (x: SHORTREAL) : SHORTREAL ;
PROCEDURE ceil (x: REAL) : REAL ;
PROCEDURE ceill (x: LONGREAL) : LONGREAL ;
PROCEDURE ceilf (x: SHORTREAL) : SHORTREAL ;
```

```
END libm.
```

4.1.57 gm2-libs/sckt

```

DEFINITION MODULE sckt ;

FROM SYSTEM IMPORT ADDRESS ;
EXPORT QUALIFIED tcpServerState,
                 tcpServerEstablish, tcpServerEstablishPort,
                 tcpServerAccept, getLocalIP,
                 tcpServerPortNo, tcpServerIP, tcpServerSocketFd,
                 tcpServerClientIP, tcpServerClientPortNo,
                 tcpClientState,
                 tcpClientSocket, tcpClientSocketIP, tcpClientConnect,
                 tcpClientPortNo, tcpClientIP, tcpClientSocketFd ;

TYPE
  tcpServerState = ADDRESS ;
  tcpClientState = ADDRESS ;

(*
  tcpServerEstablish - returns a tcpState containing the relevant
                    information about a socket declared to receive
                    tcp connections.
*)

PROCEDURE tcpServerEstablish () : tcpServerState ;

(*
  tcpServerEstablishPort - returns a tcpState containing the relevant
                    information about a socket declared to receive
                    tcp connections. This method attempts to use
                    the port specified by the parameter.
*)

PROCEDURE tcpServerEstablishPort (port: CARDINAL) : tcpServerState ;

(*
  tcpServerAccept - returns a file descriptor once a client has connected and
                    been accepted.
*)

PROCEDURE tcpServerAccept (s: tcpServerState) : INTEGER ;

(*

```



```
PROCEDURE tcpClientSocket (serverName: ADDRESS; portNo: CARDINAL) : tcpClientState ;  
  
(*  
  tcpClientSocketIP - returns a file descriptor (socket) which has  
    connected to, ip:portNo.  
*)  
  
PROCEDURE tcpClientSocketIP (ip: CARDINAL; portNo: CARDINAL) : tcpClientState ;  
  
(*  
  tcpClientConnect - returns the file descriptor associated with, s,  
    once a connect has been performed.  
*)  
  
PROCEDURE tcpClientConnect (s: tcpClientState) : INTEGER ;  
  
(*  
  tcpClientPortNo - returns the portNo from structure, s.  
*)  
  
PROCEDURE tcpClientPortNo (s: tcpClientState) : INTEGER ;  
  
(*  
  tcpClientSocketFd - returns the sockFd from structure, s.  
*)  
  
PROCEDURE tcpClientSocketFd (s: tcpClientState) : INTEGER ;  
  
(*  
  tcpClientIP - returns the IP address from structure, s.  
*)  
  
PROCEDURE tcpClientIP (s: tcpClientState) : CARDINAL ;  
  
END sckt.
```

4.1.58 gm2-libs/termios

```

DEFINITION MODULE termios ;

FROM SYSTEM IMPORT ADDRESS ;

TYPE
  TERMIOS = ADDRESS ;

  ControlChar = (vintr, vquit, verase, vkill, veof, vtime, vmin,
                 vswtc, vstart, vstop, vsusp, veol, vreprint, vdiscard,
                 vwerase, vlnext, veol2) ;

  Flag = (
    (* input flag bits *)
    ignbrk, ibrkint, ignpar, iparmrk, inpck, istrip, inlcr,
    igncr, icrnl, iuclc, ixon, ixany, ixoff, imaxbel,
    (* output flag bits *)
    opost, olcuc, onlcr, ocrnl, onocr, onlret, ofill, ofdel,
    onl0, onl1, ocr0, ocr1, ocr2, ocr3,
    otab0, otab1, otab2, otab3, obs0, obs1, off0, off1, ovt0, ovt1,
    (* baud rate *)
    b0, b50, b75, b110, b135, b150, b200, b300, b600, b1200,
    b1800, b2400, b4800, b9600, b19200, b38400,
    b57600, b115200, b240400, b460800, b500000, b576000,
    b921600, b1000000, b1152000, b1500000, b2000000, b2500000,
    b3000000, b3500000, b4000000, maxbaud, crtscts,
    (* character size *)
    cs5, cs6, cs7, cs8, cstopb, cread, parenb, parodd, hupcl, clocal,
    (* local flags *)
    lisig, licanon, lxcase, lecho, lechoe, lechok, lechonl, lnoflsh,
    ltopstop, lechoctl, lechopr, lechoke, lflusho, lpendin, liexten) ;

  (*
  InitTermios - new data structure.
  *)

PROCEDURE InitTermios () : TERMIOS ;

  (*
  KillTermios - delete data structure.
  *)

PROCEDURE KillTermios (t: TERMIOS) : TERMIOS ;

```

```
(*
  cfgetospeed - return output baud rate.
*)

PROCEDURE cfgetospeed (t: TERMIOS) : INTEGER ;

(*
  cfgetispeed - return input baud rate.
*)

PROCEDURE cfgetispeed (t: TERMIOS) : INTEGER ;

(*
  cfsetospeed - set output baud rate.
*)

PROCEDURE cfsetospeed (t: TERMIOS; b: CARDINAL) : INTEGER ;

(*
  cfsetispeed - set input baud rate.
*)

PROCEDURE cfsetispeed (t: TERMIOS; b: CARDINAL) : INTEGER ;

(*
  cfsetspeed - set input and output baud rate.
*)

PROCEDURE cfsetspeed (t: TERMIOS; b: CARDINAL) : INTEGER ;

(*
  tcgetattr - get state of, fd, into, t.
*)

PROCEDURE tcgetattr (fd: INTEGER; t: TERMIOS) : INTEGER ;

(*
  The following three functions return the different option values.
*)
```

```
PROCEDURE tcsnow () : INTEGER ; (* alter fd now *)
PROCEDURE tc drain () : INTEGER ; (* alter when all output has been sent *)
PROCEDURE tc flush () : INTEGER ; (* like drain, except discard any pending input *)

(*
   tcsetattr - set state of, fd, to, t, using option.
*)

PROCEDURE tcsetattr (fd: INTEGER; option: INTEGER; t: TERMIOS) : INTEGER ;

(*
   cfmakeraw - sets, t, to raw mode.
*)

PROCEDURE cfmakeraw (t: TERMIOS) ;

(*
   tc sendbreak - send zero bits for duration.
*)

PROCEDURE tc sendbreak (fd: INTEGER; duration: INTEGER) : INTEGER ;

(*
   tc drain - waits for pending output to be written on, fd.
*)

PROCEDURE tc drain (fd: INTEGER) : INTEGER ;

(*
   tc flushi - flush input.
*)

PROCEDURE tc flushi (fd: INTEGER) : INTEGER ;

(*
   tc flusho - flush output.
*)

PROCEDURE tc flusho (fd: INTEGER) : INTEGER ;
```

```
(*
  tcflushio - flush input and output.
*)

PROCEDURE tcflushio (fd: INTEGER) : INTEGER ;

(*
  tcflowoni - restart input on, fd.
*)

PROCEDURE tcflowoni (fd: INTEGER) : INTEGER ;

(*
  tcflowoffi - stop input on, fd.
*)

PROCEDURE tcflowoffi (fd: INTEGER) : INTEGER ;

(*
  tcflowono - restart output on, fd.
*)

PROCEDURE tcflowono (fd: INTEGER) : INTEGER ;

(*
  tcflowoffo - stop output on, fd.
*)

PROCEDURE tcflowoffo (fd: INTEGER) : INTEGER ;

(*
  GetFlag - sets a flag value from, t, in, b, and returns TRUE
            if, t, supports, f.
*)

PROCEDURE GetFlag (t: TERMIOS; f: Flag; VAR b: BOOLEAN) : BOOLEAN ;

(*
  SetFlag - sets a flag value in, t, to, b, and returns TRUE if
            this flag value is supported.
*)
```



```
PROCEDURE SetFlag (t: TERMIOS; f: Flag; b: BOOLEAN) : BOOLEAN ;

(*
  GetChar - sets a CHAR, ch, value from, t, and returns TRUE if
            this value is supported.
*)

PROCEDURE GetChar (t: TERMIOS; c: ControlChar; VAR ch: CHAR) : BOOLEAN ;

(*
  SetChar - sets a CHAR value in, t, and returns TRUE if, c,
            is supported.
*)

PROCEDURE SetChar (t: TERMIOS; c: ControlChar; ch: CHAR) : BOOLEAN ;

END termios.
```

4.1.59 gm2-libs/wrapc

```
DEFINITION MODULE wrapc ;

FROM SYSTEM IMPORT ADDRESS ;

EXPORT QUALIFIED strtime, filesize, fileinode,
                 getrand, getusername, filemtime,
                 getnameuidgid, signbit, signbitf, signbitl,
                 isfinite, isfinitel, isfinitef ;

(*
   strtime - returns the C string for the equivalent C asctime
            function.
*)

PROCEDURE strtime () : ADDRESS ;

(*
   filesize - assigns the size of a file, f, into low, high and
            returns zero if successful.
*)

PROCEDURE filesize (f: INTEGER; VAR low, high: CARDINAL) : INTEGER ;

(*
   fileinode - return the inode associated with file, f.
*)

PROCEDURE fileinode (f: INTEGER; VAR low, high: CARDINAL) : INTEGER ;

(*
   filemtime - returns the mtime of a file, f.
*)

PROCEDURE filemtime (f: INTEGER) : INTEGER ;

(*
   getrand - returns a random number between 0..n-1
*)

PROCEDURE getrand (n: INTEGER) : INTEGER ;
```

```
(*
  getusername - returns a C string describing the current user.
*)

PROCEDURE getusername () : ADDRESS ;

(*
  getnameuidgid - fills in the, uid, and, gid, which represents
                  user, name.
*)

PROCEDURE getnameuidgid (name: ADDRESS; VAR uid, gid: INTEGER) ;

(*
  in C these procedure functions are really macros, so we provide
  real C functions and let gm2 call these if the builtins
  are unavailable.
*)

PROCEDURE signbit (r: REAL) : INTEGER ;
PROCEDURE signbitf (s: SHORTREAL) : INTEGER ;
PROCEDURE signbitl (l: LONGREAL) : INTEGER ;

(*
  isfinite - provide non builtin alternative to the gcc builtin isfinite.
            Returns 1 if x is finite and 0 if it is not.
*)

PROCEDURE isfinite (x: REAL) : INTEGER ;

(*
  isfinitef - provide non builtin alternative to the gcc builtin isfinite.
            Returns 1 if x is finite and 0 if it is not.
*)

PROCEDURE isfinitef (x: SHORTREAL) : INTEGER ;

(*
  isfinitel - provide non builtin alternative to the gcc builtin isfinite.
            Returns 1 if x is finite and 0 if it is not.
*)
```

*)

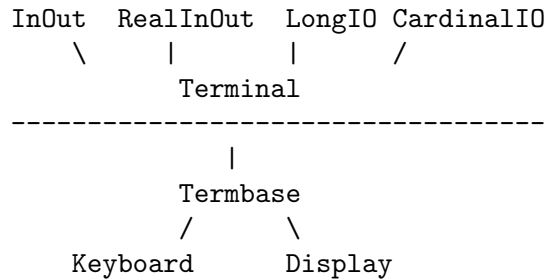
```
PROCEDURE isfinitel (x: LONGREAL) : INTEGER ;
```

```
END wrapc.
```

4.2 PIM and Logitech 3.0 Compatible

These modules are provided to enable legacy Modula-2 applications to build with GNU Modula-2. It is advised that these module should not be used for new projects, maybe the ISO libraries or the native compiler PIM libraries (FIO) should be used instead.

Here is an outline of the module layering:



Above the line are user level PIM [234] and Logitech 3.0 compatible modules. Below the line Logitech 3.0 advised that these modules should be considered part of the runtime system. The libraries do not provide all the features found in the Logitech libraries as a number of these features were MS-DOS related. Essentially the basic input/output, file system, string manipulation and conversion routines are provided. Access to DOSCALL, graphics, time and date are not as these were constrained by the limitations of MS-DOS.

The following libraries are contained within the base GNU Modula-2 libraries and are also Logitech-3.0 compatible: See Section 4.1.1 [gm2-libs/ASCII], page 75, See Section 4.1.39 [gm2-libs/Storage], page 155, and See Section 4.1.23 [gm2-libs/MathLib0], page 123. These libraries are always available for any dialect of the language (although their implementation and behaviour might differ, for example Storage ISO and PIM).

The following libraries are Logitech-3.0 compatible but fall outside the base GNU Modula-2 libraries.

4.2.1 gm2-libs-log/BitBlockOps

```
DEFINITION MODULE BitBlockOps ;
```

```
FROM SYSTEM IMPORT ADDRESS ;
```

```
(*
```

```
  BlockAnd - performs a bitwise AND on blocks
              [dest..dest+size-1] := [dest..dest+size-1] AND
                                      [src..src+size-1]
```

```
*)
```

```
PROCEDURE BlockAnd (dest, src: ADDRESS; size: CARDINAL) ;
```

```
(*
  BlockOr - performs a bitwise OR on blocks
           [dest..dest+size-1] := [dest..dest+size-1] OR
                               [src..src+size-1]
*)

PROCEDURE BlockOr (dest, src: ADDRESS; size: CARDINAL) ;

(*
  BlockXor - performs a bitwise XOR on blocks
           [dest..dest+size-1] := [dest..dest+size-1] XOR
                               [src..src+size-1]
*)

PROCEDURE BlockXor (dest, src: ADDRESS; size: CARDINAL) ;

(*
  BlockNot - performs a bitsize NOT on the block as defined
            by: [dest..dest+size-1]
*)

PROCEDURE BlockNot (dest: ADDRESS; size: CARDINAL) ;

(*
  BlockShr - performs a block shift right of, count, bits.
            Where the block is defined as:
            [dest..dest+size-1].
            The block is considered to be an ARRAY OF BYTES
            which is shifted, bit at a time over each byte in
            turn. The left most byte is considered the byte
            located at the lowest address.
            If you require an endianness SHIFT use
            the SYSTEM.SHIFT procedure and declare the
            block as a POINTER TO set type.
*)

PROCEDURE BlockShr (dest: ADDRESS; size, count: CARDINAL) ;

(*
  BlockShl - performs a block shift left of, count, bits.
            Where the block is defined as:
            [dest..dest+size-1].
            The block is considered to be an ARRAY OF BYTES
```

which is shifted, bit at a time over each byte in turn. The left most byte is considered the byte located at the lowest address.

If you require an endianness SHIFT use the SYSTEM.SHIFT procedure and declare the block as a POINTER TO set type.

*)

```
PROCEDURE BlockShl (dest: ADDRESS; size, count: CARDINAL) ;
```

(*

BlockRor - performs a block rotate right of, count, bits.

Where the block is defined as:

[dest..dest+size-1].

The block is considered to be an ARRAY OF BYTES which is rotated, bit at a time over each byte in turn. The left most byte is considered the byte located at the lowest address.

If you require an endianness ROTATE use the SYSTEM.ROTATE procedure and declare the block as a POINTER TO set type.

*)

```
PROCEDURE BlockRor (dest: ADDRESS; size, count: CARDINAL) ;
```

(*

BlockRol - performs a block rotate left of, count, bits.

Where the block is defined as:

[dest..dest+size-1].

The block is considered to be an ARRAY OF BYTES which is rotated, bit at a time over each byte in turn. The left most byte is considered the byte located at the lowest address.

If you require an endianness ROTATE use the SYSTEM.ROTATE procedure and declare the block as a POINTER TO set type.

*)

```
PROCEDURE BlockRol (dest: ADDRESS; size, count: CARDINAL) ;
```

```
END BitBlockOps.
```

4.2.2 gm2-libs-log/BitByteOps

```
DEFINITION MODULE BitByteOps ;

FROM SYSTEM IMPORT BYTE ;

(*
  GetBits - returns the bits firstBit..lastBit from source.
            Bit 0 of byte maps onto the firstBit of source.
*)

PROCEDURE GetBits (source: BYTE; firstBit, lastBit: CARDINAL) : BYTE ;

(*
  SetBits - sets bits in, byte, starting at, firstBit, and ending at,
            lastBit, with, pattern.  The bit zero of, pattern, will
            be placed into, byte, at position, firstBit.
*)

PROCEDURE SetBits (VAR byte: BYTE; firstBit, lastBit: CARDINAL;
                  pattern: BYTE) ;

(*
  ByteAnd - returns a bitwise (left AND right)
*)

PROCEDURE ByteAnd (left, right: BYTE) : BYTE ;

(*
  ByteOr - returns a bitwise (left OR right)
*)

PROCEDURE ByteOr (left, right: BYTE) : BYTE ;

(*
  ByteXor - returns a bitwise (left XOR right)
*)

PROCEDURE ByteXor (left, right: BYTE) : BYTE ;

(*
```



```
    ByteNot - returns a byte with all bits inverted.
*)

PROCEDURE ByteNot (byte: BYTE) : BYTE ;

(*
    ByteShr - returns a, byte, which has been shifted, count
              bits to the right.
*)

PROCEDURE ByteShr (byte: BYTE; count: CARDINAL) : BYTE ;

(*
    ByteShl - returns a, byte, which has been shifted, count
              bits to the left.
*)

PROCEDURE ByteShl (byte: BYTE; count: CARDINAL) : BYTE ;

(*
    ByteSar - shift byte arithmetic right. Preserves the top
              end bit and as the value is shifted right.
*)

PROCEDURE ByteSar (byte: BYTE; count: CARDINAL) : BYTE ;

(*
    ByteRor - returns a, byte, which has been rotated, count
              bits to the right.
*)

PROCEDURE ByteRor (byte: BYTE; count: CARDINAL) : BYTE ;

(*
    ByteRol - returns a, byte, which has been rotated, count
              bits to the left.
*)

PROCEDURE ByteRol (byte: BYTE; count: CARDINAL) : BYTE ;

(*
```

```
    HighNibble - returns the top nibble only from, byte.
                The top nibble of, byte, is extracted and
                returned in the bottom nibble of the return
                value.
*)

PROCEDURE HighNibble (byte: BYTE) : BYTE ;

(*
    LowNibble - returns the low nibble only from, byte.
                The top nibble is replaced by zeros.
*)

PROCEDURE LowNibble (byte: BYTE) : BYTE ;

(*
    Swap - swaps the low and high nibbles in the, byte.
*)

PROCEDURE Swap (byte: BYTE) : BYTE ;

END BitByteOps.
```

4.2.3 gm2-libs-log/BitWordOps

```
DEFINITION MODULE BitWordOps ;

FROM SYSTEM IMPORT WORD ;

(*
  GetBits - returns the bits firstBit..lastBit from source.
            Bit 0 of word maps onto the firstBit of source.
*)

PROCEDURE GetBits (source: WORD; firstBit, lastBit: CARDINAL) : WORD ;

(*
  SetBits - sets bits in, word, starting at, firstBit, and ending at,
            lastBit, with, pattern.  The bit zero of, pattern, will
            be placed into, word, at position, firstBit.
*)

PROCEDURE SetBits (VAR word: WORD; firstBit, lastBit: CARDINAL;
                  pattern: WORD) ;

(*
  WordAnd - returns a bitwise (left AND right)
*)

PROCEDURE WordAnd (left, right: WORD) : WORD ;

(*
  WordOr - returns a bitwise (left OR right)
*)

PROCEDURE WordOr (left, right: WORD) : WORD ;

(*
  WordXor - returns a bitwise (left XOR right)
*)

PROCEDURE WordXor (left, right: WORD) : WORD ;

(*
```

```
    WordNot - returns a word with all bits inverted.
*)

PROCEDURE WordNot (word: WORD) : WORD ;

(*
    WordShr - returns a, word, which has been shifted, count
              bits to the right.
*)

PROCEDURE WordShr (word: WORD; count: CARDINAL) : WORD ;

(*
    WordShl - returns a, word, which has been shifted, count
              bits to the left.
*)

PROCEDURE WordShl (word: WORD; count: CARDINAL) : WORD ;

(*
    WordSar - shift word arithmetic right. Preserves the top
              end bit and as the value is shifted right.
*)

PROCEDURE WordSar (word: WORD; count: CARDINAL) : WORD ;

(*
    WordRor - returns a, word, which has been rotated, count
              bits to the right.
*)

PROCEDURE WordRor (word: WORD; count: CARDINAL) : WORD ;

(*
    WordRol - returns a, word, which has been rotated, count
              bits to the left.
*)

PROCEDURE WordRol (word: WORD; count: CARDINAL) : WORD ;

(*
```

```
    HighByte - returns the top byte only from, word.
               The byte is returned in the bottom byte
               in the return value.
*)

PROCEDURE HighByte (word: WORD) : WORD ;

(*
    LowByte - returns the low byte only from, word.
               The byte is returned in the bottom byte
               in the return value.
*)

PROCEDURE LowByte (word: WORD) : WORD ;

(*
    Swap - byte flips the contents of word.
*)

PROCEDURE Swap (word: WORD) : WORD ;

END BitWordOps.
```

4.2.4 gm2-libs-log/BlockOps

```
DEFINITION MODULE BlockOps ;

FROM SYSTEM IMPORT ADDRESS ;

(*
  MoveBlockForward - moves, n, bytes from, src, to, dest.
                    Starts copying from src and keep copying
                    until, n, bytes have been copied.
*)

PROCEDURE BlockMoveForward (dest, src: ADDRESS; n: CARDINAL) ;

(*
  MoveBlockBackward - moves, n, bytes from, src, to, dest.
                    Starts copying from src+n and keeps copying
                    until, n, bytes have been copied.
                    The last datum to be copied will be the byte
                    at address, src.
*)

PROCEDURE BlockMoveBackward (dest, src: ADDRESS; n: CARDINAL) ;

(*
  BlockClear - fills, block..block+n-1, with zero's.
*)

PROCEDURE BlockClear (block: ADDRESS; n: CARDINAL) ;

(*
  BlockSet - fills, n, bytes starting at, block, with a pattern
            defined at address pattern..pattern+patternSize-1.
*)

PROCEDURE BlockSet (block: ADDRESS; n: CARDINAL;
                  pattern: ADDRESS; patternSize: CARDINAL) ;

(*
  BlockEqual - returns TRUE if the blocks defined, a..a+n-1, and,
              b..b+n-1 contain the same bytes.
*)
```

```
PROCEDURE BlockEqual (a, b: ADDRESS; n: CARDINAL) : BOOLEAN ;
```

```
(*
```

```
  BlockPosition - searches for a pattern as defined by  
                  pattern..patternSize-1 in the block,  
                  block..block+blockSize-1. It returns  
                  the offset from block indicating the  
                  first occurrence of, pattern.  
                  MAX(CARDINAL) is returned if no match  
                  is detected.
```

```
*)
```

```
PROCEDURE BlockPosition (block: ADDRESS; blockSize: CARDINAL;  
                        pattern: ADDRESS; patternSize: CARDINAL) : CARDINAL ;■
```

```
END BlockOps.
```

4.2.5 gm2-libs-log/Break

```
DEFINITION MODULE Break ;
```

```
EXPORT QUALIFIED EnableBreak, DisableBreak, InstallBreak, UnInstallBreak ;■
```

```
(*  
  EnableBreak - enable the current break handler.  
*)
```

```
PROCEDURE EnableBreak ;
```

```
(*  
  DisableBreak - disable the current break handler (and all  
                 installed handlers).  
*)
```

```
PROCEDURE DisableBreak ;
```

```
(*  
  InstallBreak - installs a procedure, p, to be invoked when  
                 a ctrl-c is caught. Any number of these  
                 procedures may be stacked. Only the top  
                 procedure is run when ctrl-c is caught.  
*)
```

```
PROCEDURE InstallBreak (p: PROC) ;
```

```
(*  
  UnInstallBreak - pops the break handler stack.  
*)
```

```
PROCEDURE UnInstallBreak ;
```

```
END Break.
```


4.2.6 gm2-libs-log/CardinalIO

```
DEFINITION MODULE CardinalIO ;

EXPORT QUALIFIED Done,
    ReadCardinal, WriteCardinal, ReadHex, WriteHex,
    ReadLongCardinal, WriteLongCardinal, ReadLongHex,
    WriteLongHex,
    ReadShortCardinal, WriteShortCardinal, ReadShortHex,
    WriteShortHex ;

VAR
    Done: BOOLEAN ;

(*
    ReadCardinal - read an unsigned decimal number from the terminal.
                  The read continues until a space, newline, esc or
                  end of file is reached.
*)

PROCEDURE ReadCardinal (VAR c: CARDINAL) ;

(*
    WriteCardinal - writes the value, c, to the terminal and ensures
                  that at least, n, characters are written. The number
                  will be padded out by preceding spaces if necessary.
*)

PROCEDURE WriteCardinal (c: CARDINAL; n: CARDINAL) ;

(*
    ReadHex - reads in an unsigned hexadecimal number from the terminal.
             The read continues until a space, newline, esc or
             end of file is reached.
*)

PROCEDURE ReadHex (VAR c: CARDINAL) ;

(*
    WriteHex - writes out a CARDINAL, c, in hexadecimal format padding
             with, n, characters (leading with '0')
*)
```

```
PROCEDURE WriteHex (c: CARDINAL; n: CARDINAL) ;
```

```
(*  
  ReadLongCardinal - read an unsigned decimal number from the terminal.  
                    The read continues until a space, newline, esc or  
                    end of file is reached.  
*)
```

```
PROCEDURE ReadLongCardinal (VAR c: LONGCARD) ;
```

```
(*  
  WriteLongCardinal - writes the value, c, to the terminal and ensures  
                    that at least, n, characters are written. The number  
                    will be padded out by preceding spaces if necessary.  
*)
```

```
PROCEDURE WriteLongCardinal (c: LONGCARD; n: CARDINAL) ;
```

```
(*  
  ReadLongHex - reads in an unsigned hexadecimal number from the terminal.  
               The read continues until a space, newline, esc or  
               end of file is reached.  
*)
```

```
PROCEDURE ReadLongHex (VAR c: LONGCARD) ;
```

```
(*  
  WriteLongHex - writes out a LONGCARD, c, in hexadecimal format padding  
               with, n, characters (leading with '0')  
*)
```

```
PROCEDURE WriteLongHex (c: LONGCARD; n: CARDINAL) ;
```

```
(*  
  WriteShortCardinal - writes the value, c, to the terminal and ensures  
                    that at least, n, characters are written. The number  
                    will be padded out by preceding spaces if necessary.  
*)
```

```
PROCEDURE WriteShortCardinal (c: SHORTCARD; n: CARDINAL) ;
```

```
(*
  ReadShortCardinal - read an unsigned decimal number from the terminal.
                    The read continues until a space, newline, esc or
                    end of file is reached.
*)

PROCEDURE ReadShortCardinal (VAR c: SHORTCARD) ;

(*
  ReadShortHex - reads in an unsigned hexadecimal number from the terminal.
                The read continues until a space, newline, esc or
                end of file is reached.
*)

PROCEDURE ReadShortHex (VAR c: SHORTCARD) ;

(*
  WriteShortHex - writes out a SHORTCARD, c, in hexadecimal format padding
                 with, n, characters (leading with '0')
*)

PROCEDURE WriteShortHex (c: SHORTCARD; n: CARDINAL) ;

END CardinalIO.
```

4.2.7 gm2-libs-log/Conversions

```
DEFINITION MODULE Conversions ;
```

```
EXPORT QUALIFIED ConvertOctal, ConvertHex, ConvertCardinal,
                  ConvertInteger, ConvertLongInt, ConvertShortInt ;
```

```
(*
  ConvertOctal - converts a CARDINAL, num, into an octal/hex/decimal
                 string and right justifies the string. It adds
                 spaces rather than '0' to pad out the string
                 to len characters.
```

```
                If the length of str is < num then the number is
                truncated on the right.
```

```
*)
```

```
PROCEDURE ConvertOctal (num, len: CARDINAL; VAR str: ARRAY OF CHAR) ;
PROCEDURE ConvertHex   (num, len: CARDINAL; VAR str: ARRAY OF CHAR) ;
PROCEDURE ConvertCardinal (num, len: CARDINAL; VAR str: ARRAY OF CHAR) ;
```

```
(*
  The INTEGER counterparts will add a '-' if, num, is <0
```

```
*)
```

```
PROCEDURE ConvertInteger (num: INTEGER; len: CARDINAL; VAR str: ARRAY OF CHAR) ;
PROCEDURE ConvertLongInt (num: LONGINT; len: CARDINAL; VAR str: ARRAY OF CHAR) ;
PROCEDURE ConvertShortInt (num: SHORTINT; len: CARDINAL; VAR str: ARRAY OF CHAR) ;
```

```
END Conversions.
```

4.2.8 gm2-libs-log/DebugPMD

```
DEFINITION MODULE DebugPMD ;
```

```
END DebugPMD.
```

4.2.9 gm2-libs-log/DebugTrace

```
DEFINITION MODULE DebugTrace ;
```

```
END DebugTrace.
```

4.2.10 gm2-libs-log/Delay

```
DEFINITION MODULE Delay ;
```

```
EXPORT QUALIFIED Delay ;
```

```
(*  
  milliSec - delays the program by approximately, milliSec, milliseconds.■  
*)
```

```
PROCEDURE Delay (milliSec: INTEGER) ;
```

```
END Delay.
```

4.2.11 gm2-libs-log/Display

```
DEFINITION MODULE Display ;
```

```
EXPORT QUALIFIED Write ;
```

```
(*
```

```
  Write - display a character to the stdout.
```

```
    ASCII.EOL moves to the beginning of the next line.
```

```
    ASCII.del erases the character to the left of the cursor.
```

```
*)
```

```
PROCEDURE Write (ch: CHAR) ;
```

```
END Display.
```


4.2.12 gm2-libs-log/ErrorCode

```
DEFINITION MODULE ErrorCode ;

EXPORT QUALIFIED SetErrorCode, GetErrorCode, ExitToOS ;

(*
  SetErrorCode - sets the exit value which will be used if
                 the application terminates normally.
*)

PROCEDURE SetErrorCode (value: INTEGER) ;

(*
  GetErrorCode - returns the current value to be used upon
                 application termination.
*)

PROCEDURE GetErrorCode (VAR value: INTEGER) ;

(*
  ExitToOS - terminate the application and exit returning
             the last value set by SetErrorCode to the OS.
*)

PROCEDURE ExitToOS ;

END ErrorCode.
```

4.2.13 gm2-libs-log/FileSystem

```

DEFINITION MODULE FileSystem ;

(* Use this module sparingly, FIO or the ISO file modules have a
   much cleaner interface. *)

FROM SYSTEM IMPORT WORD, BYTE, ADDRESS ;
IMPORT FIO ;
FROM DynamicStrings IMPORT String ;

EXPORT QUALIFIED File, Response, Flag, FlagSet,

        Create, Close, Lookup, Rename, Delete,
        SetRead, SetWrite, SetModify, SetOpen,
        Doio, SetPos, GetPos, Length, Reset,

        ReadWord, ReadChar, ReadByte, ReadNBytes,
        WriteWord, WriteChar, WriteByte, WriteNBytes ;

TYPE
  File = RECORD
    res      : Response ;
    flags    : FlagSet ;
    eof      : BOOLEAN ;
    lastWord: WORD ;
    lastByte: BYTE ;
    fio      : FIO.File ;
    highpos,
    lowpos   : CARDINAL ;
    name     : String ;
  END ;

  Flag = (
    read,      (* read access mode *)
    write,     (* write access mode *)
    modify,
    truncate,  (* truncate file when closed *)
    again,     (* reread the last character *)
    temporary, (* file is temporary *)
    opened     (* file has been opened *)
  );

  FlagSet = SET OF Flag;

  Response = (done, notdone, notsupported, callerror,
              unknownfile, paramerror, toomanyfiles,

```

```
        userdeverror) ;

    Command = (create, close, lookup, rename, delete,
              setread, setwrite, setmodify, setopen,
              doio, setpos, getpos, length) ;

    (*
     Create - creates a temporary file. To make the file perminant
              the file must be renamed.
    *)

PROCEDURE Create (VAR f: File) ;

    (*
     Close - closes an open file.
    *)

PROCEDURE Close (f: File) ;

    (*
     Lookup - looks for a file, filename. If the file is found
              then, f, is opened. If it is not found and, newFile,
              is TRUE then a new file is created and attached to, f.
              If, newFile, is FALSE and no file was found then f.res
              is set to notdone.
    *)

PROCEDURE Lookup (VAR f: File; filename: ARRAY OF CHAR; newFile: BOOLEAN) ;

    (*
     Rename - rename a file and change a temporary file to a permanent
              file. f.res is set appropriately.
    *)

PROCEDURE Rename (VAR f: File; newname: ARRAY OF CHAR) ;

    (*
     Delete - deletes a file, name, and sets the f.res field.
              f.res is set appropriately.
    *)

PROCEDURE Delete (name: ARRAY OF CHAR; VAR f: File) ;
```

```
(*
  ReadWord - reads a WORD, w, from file, f.
             f.res is set appropriately.
*)

PROCEDURE ReadWord (VAR f: File; VAR w: WORD) ;

(*
  WriteWord - writes one word to a file, f.
             f.res is set appropriately.
*)

PROCEDURE WriteWord (VAR f: File; w: WORD) ;

(*
  ReadChar - reads one character from a file, f.
*)

PROCEDURE ReadChar (VAR f: File; VAR ch: CHAR) ;

(*
  WriteChar - writes a character, ch, to a file, f.
             f.res is set appropriately.
*)

PROCEDURE WriteChar (VAR f: File; ch: CHAR) ;

(*
  ReadByte - reads a BYTE, b, from file, f.
            f.res is set appropriately.
*)

PROCEDURE ReadByte (VAR f: File; VAR b: BYTE) ;

(*
  WriteByte - writes one BYTE, b, to a file, f.
            f.res is set appropriately.
*)

PROCEDURE WriteByte (VAR f: File; b: BYTE) ;
```

```
(*
  ReadNBytes - reads a sequence of bytes from a file, f.
*)

PROCEDURE ReadNBytes (VAR f: File; a: ADDRESS; amount: CARDINAL;
                    VAR actuallyRead: CARDINAL) ;

(*
  WriteNBytes - writes a sequence of bytes to file, f.
*)

PROCEDURE WriteNBytes (VAR f: File; a: ADDRESS; amount: CARDINAL;
                    VAR actuallyWritten: CARDINAL) ;

(*
  Again - returns the last character read to the internal buffer
         so that it can be read again.
*)

PROCEDURE Again (VAR f: File) ;

(*
  SetRead - puts the file, f, into the read state.
           The file position is unchanged.
*)

PROCEDURE SetRead (VAR f: File) ;

(*
  SetWrite - puts the file, f, into the write state.
           The file position is unchanged.
*)

PROCEDURE SetWrite (VAR f: File) ;

(*
  SetModify - puts the file, f, into the modify state.
            The file position is unchanged but the file can be
            read and written.
*)
```

```
PROCEDURE SetModify (VAR f: File) ;
```

```
(*  
  SetOpen - places a file, f, into the open state. The file may  
            have been in the read/write/modify state before and  
            in which case the previous buffer contents are flushed  
            and the file state is reset to open. The position is  
            unaltered.  
*)
```

```
PROCEDURE SetOpen (VAR f: File) ;
```

```
(*  
  Reset - places a file, f, into the open state and reset the  
          position to the start of the file.  
*)
```

```
PROCEDURE Reset (VAR f: File) ;
```

```
(*  
  SetPos - lseek to a position within a file.  
*)
```

```
PROCEDURE SetPos (VAR f: File; high, low: CARDINAL) ;
```

```
(*  
  GetPos - return the position within a file.  
*)
```

```
PROCEDURE GetPos (VAR f: File; VAR high, low: CARDINAL) ;
```

```
(*  
  Length - returns the length of file, in, high, and, low.  
*)
```

```
PROCEDURE Length (VAR f: File; VAR high, low: CARDINAL) ;
```

```
(*  
  Doio - effectively flushes a file in write mode, rereads the  
         current buffer from disk if in read mode and writes
```

```
        and rereads the buffer if in modify mode.
*)

PROCEDURE Doio (VAR f: File) ;

(*
  FileNameChar - checks to see whether the character, ch, is
                 legal in a filename. nul is returned if the
                 character was illegal.
*)

PROCEDURE FileNameChar (ch: CHAR) ;

END FileSystem.
```

4.2.14 gm2-libs-log/FloatingUtilities

```
DEFINITION MODULE FloatingUtilities ;
```

```
EXPORT QUALIFIED Frac, Round, Float, Trunc,  
                  Fracl, Roundl, Floatl, Truncl ;
```

```
(*  
  Frac - returns the fractional component of, r.  
*)
```

```
PROCEDURE Frac (r: REAL) : REAL ;
```

```
(*  
  Int - returns the integer part of r. It rounds the value towards zero.█  
*)
```

```
PROCEDURE Int (r: REAL) : INTEGER ;
```

```
(*  
  Round - returns the number rounded to the nearest integer.  
*)
```

```
PROCEDURE Round (r: REAL) : INTEGER ;
```

```
(*  
  Float - returns a REAL value corresponding to, i.  
*)
```

```
PROCEDURE Float (i: INTEGER) : REAL ;
```

```
(*  
  Trunc - round to the nearest integer not larger in absolute  
         value.  
*)
```

```
PROCEDURE Trunc (r: REAL) : INTEGER ;
```

```
(*  
  Fracl - returns the fractional component of, r.  
*)
```



```
PROCEDURE Fracl (r: LONGREAL) : LONGREAL ;
```

```
(*  
  Intl - returns the integer part of r. It rounds the value towards zero.■  
*)
```

```
PROCEDURE Intl (r: LONGREAL) : LONGINT ;
```

```
(*  
  Roundl - returns the number rounded to the nearest integer.  
*)
```

```
PROCEDURE Roundl (r: LONGREAL) : LONGINT ;
```

```
(*  
  Floatl - returns a REAL value corresponding to, i.  
*)
```

```
PROCEDURE Floatl (i: INTEGER) : LONGREAL ;
```

```
(*  
  Truncl - round to the nearest integer not larger in absolute  
          value.  
*)
```

```
PROCEDURE Truncl (r: LONGREAL) : LONGINT ;
```

```
END FloatingUtilities.
```

4.2.15 gm2-libs-log/InOut

```
DEFINITION MODULE InOut ;

IMPORT ASCII ;
FROM DynamicStrings IMPORT String ;
EXPORT QUALIFIED EOL, Done, termCH, OpenInput, OpenOutput,
             CloseInput, CloseOutput,
             Read, ReadString, ReadInt, ReadCard,
             Write, WriteLn, WriteString, WriteInt, WriteCard,
             WriteOct, WriteHex,
             ReadS, WriteS ;

CONST
    EOL = ASCII.EOL ;

VAR
    Done : BOOLEAN ;
    termCH: CHAR ;

(*
    OpenInput - reads a string from stdin as the filename for reading.
                If the filename ends with `.' then it appends the defext
                extension. The global variable Done is set if all
                was successful.
*)

PROCEDURE OpenInput (defext: ARRAY OF CHAR) ;

(*
    CloseInput - closes an opened input file and returns input back to
                StdIn.
*)

PROCEDURE CloseInput ;

(*
    OpenOutput - reads a string from stdin as the filename for writing.
                If the filename ends with `.' then it appends the defext
                extension. The global variable Done is set if all
                was successful.
*)

PROCEDURE OpenOutput (defext: ARRAY OF CHAR) ;
```

```
(*
  CloseOutput - closes an opened output file and returns output back to
                StdOut.
*)
```

```
PROCEDURE CloseOutput ;
```

```
(*
  Read - reads a single character from the current input file.
        Done is set to FALSE if end of file is reached or an
        error occurs.
*)
```

```
PROCEDURE Read (VAR ch: CHAR) ;
```

```
(*
  ReadString - reads a sequence of characters. Leading white space
              is ignored and the string is terminated with a character
              <= ' '
*)
```

```
PROCEDURE ReadString (VAR s: ARRAY OF CHAR) ;
```

```
(*
  WriteString - writes a string to the output file.
*)
```

```
PROCEDURE WriteString (s: ARRAY OF CHAR) ;
```

```
(*
  Write - writes out a single character, ch, to the current output file.■
*)
```

```
PROCEDURE Write (ch: CHAR) ;
```

```
(*
  WriteLn - writes a newline to the output file.
*)
```

```
PROCEDURE WriteLn ;
```

```
(*
  ReadInt - reads a string and converts it into an INTEGER, x.
           Done is set if an INTEGER is read.
*)

PROCEDURE ReadInt (VAR x: INTEGER) ;

(*
  ReadInt - reads a string and converts it into an INTEGER, x.
           Done is set if an INTEGER is read.
*)

PROCEDURE ReadCard (VAR x: CARDINAL) ;

(*
  WriteCard - writes the CARDINAL, x, to the output file. It ensures
             that the number occupies, n, characters. Leading spaces
             are added if required.
*)

PROCEDURE WriteCard (x, n: CARDINAL) ;

(*
  WriteInt - writes the INTEGER, x, to the output file. It ensures
            that the number occupies, n, characters. Leading spaces
            are added if required.
*)

PROCEDURE WriteInt (x: INTEGER; n: CARDINAL) ;

(*
  WriteOct - writes the CARDINAL, x, to the output file in octal.
            It ensures that the number occupies, n, characters.
            Leading spaces are added if required.
*)

PROCEDURE WriteOct (x, n: CARDINAL) ;

(*
  WriteHex - writes the CARDINAL, x, to the output file in hexadecimal.
```

```
        It ensures that the number occupies, n, characters.
        Leading spaces are added if required.
*)

PROCEDURE WriteHex (x, n: CARDINAL) ;

(*
  ReadS - returns a string which has is a sequence of characters.
         Leading white space is ignored and string is terminated
         with a character <= ' '.
*)

PROCEDURE ReadS () : String ;

(*
  WriteS - writes a String to the output device.
          It returns the string, s.
*)

PROCEDURE WriteS (s: String) : String ;

END InOut.
```

4.2.16 gm2-libs-log/Keyboard

```
DEFINITION MODULE Keyboard ;
```

```
EXPORT QUALIFIED Read, KeyPressed ;
```

```
(*  
  Read - reads a character from StdIn. If necessary it will wait  
         for a key to become present on StdIn.  
*)
```

```
PROCEDURE Read (VAR ch: CHAR) ;
```

```
(*  
  KeyPressed - returns TRUE if a character can be read from StdIn  
               without blocking the caller.  
*)
```

```
PROCEDURE KeyPressed () : BOOLEAN ;
```

```
END Keyboard.
```

4.2.17 gm2-libs-log/LongIO

```
DEFINITION MODULE LongIO ;

EXPORT QUALIFIED Done, ReadLongInt, WriteLongInt ;

VAR
  Done: BOOLEAN ;

PROCEDURE ReadLongInt (VAR i: LONGINT) ;
PROCEDURE WriteLongInt (i: LONGINT; n: CARDINAL) ;

END LongIO.
```

4.2.18 gm2-libs-log/NumberConversion

```
DEFINITION MODULE NumberConversion ;
```

```
(* --fixme-- finish this. *)
```

```
END NumberConversion.
```


4.2.19 gm2-libs-log/Random

```
DEFINITION MODULE Random ;

FROM SYSTEM IMPORT BYTE ;
EXPORT QUALIFIED Randomize, RandomInit, RandomBytes, RandomCard, RandomInt, RandomReal

(*
  Randomize - initialize the random number generator with a seed
              based on the microseconds.
*)

PROCEDURE Randomize ;

(*
  RandomInit - initialize the random number generator with value, seed.
*)

PROCEDURE RandomInit (seed: CARDINAL) ;

(*
  RandomBytes - fills in an array with random values.
*)

PROCEDURE RandomBytes (VAR a: ARRAY OF BYTE) ;

(*
  RandomInt - return an INTEGER in the range 0..bound-1
*)

PROCEDURE RandomInt (bound: INTEGER) : INTEGER ;

(*
  RandomCard - return a CARDINAL in the range 0..bound-1
*)

PROCEDURE RandomCard (bound: CARDINAL) : CARDINAL ;

(*
  RandomReal - return a REAL number in the range 0.0..1.0
*)
```

```
PROCEDURE RandomReal () : REAL ;

(*
  RandomLongReal - return a LONGREAL number in the range 0.0..1.0
*)

PROCEDURE RandomLongReal () : LONGREAL ;

END Random.
```

4.2.20 gm2-libs-log/RealConversions

```
DEFINITION MODULE RealConversions ;
```

```
EXPORT QUALIFIED SetNoOfExponentDigits,
                  RealToString, StringToReal,
                  LongRealToString, StringToLongReal ;
```

```
(*
  SetNoOfExponentDigits - sets the number of exponent digits to be
                        used during future calls of LongRealToString
                        and RealToString providing that the width
                        is sufficient.
                        If this value is set to 0 (the default) then
                        the number digits used is the minimum necessary.
*)
```

```
PROCEDURE SetNoOfExponentDigits (places: CARDINAL) ;
```

```
(*
  RealToString - converts a real, r, into a right justified string, str.
                The number of digits to the right of the decimal point
                is given in, digits. The value, width, represents the
                maximum number of characters to be used in the string,
                str.
```

If digits is negative then exponent notation is used whereas if digits is positive then fixed point notation is used.

If, r, is less than 0.0 then a '-' precedes the value, str. However, if, r, is ≥ 0.0 a '+' is not added.

If the conversion of, r, to a string requires more than, width, characters then the string, str, is set to a nul string and, ok is assigned FALSE.

For fixed point notation the minimum width required is $\text{ABS}(\text{width})+8$

For exponent notation the minimum width required is $\text{ABS}(\text{digits})+2+\log_{10}(\text{magnitude})$.

if r is a NaN then the string 'nan' is returned formatted and ok will be FALSE.

*)

```
PROCEDURE RealToString (r: REAL; digits, width: INTEGER;
    VAR str: ARRAY OF CHAR; VAR ok: BOOLEAN) ;
```

(*

LongRealToString - converts a real, r, into a right justified string, str. The number of digits to the right of the decimal point is given in, digits. The value, width, represents the maximum number of characters to be used in the string, str.

If digits is negative then exponent notation is used whereas if digits is positive then fixed point notation is used.

If, r, is less than 0.0 then a '-' preceeds the value, str. However, if, r, is ≥ 0.0 a '+' is not added.

If the conversion of, r, to a string requires more than, width, characters then the string, str, is set to a nul string and, ok is assigned FALSE.

For fixed point notation the minimum width required is $ABS(width)+8$

For exponent notation the minimum width required is $ABS(digits)+2+\log_{10}(\text{magnitude})$.

Examples:

```
RealToString(100.0, 10, 10, a, ok)      -> '100.000000'
```

```
RealToString(100.0, -5, 12, a, ok)     -> ' 1.00000E+2'
```

```
RealToString(123.456789, 10, 10, a, ok) -> '123.456789'
```

```
RealToString(123.456789, -5, 13, a, ok) -> ' 1.23456E+2'
```

```
RealToString(123.456789, -2, 15, a, ok) -> '          1.23E+2'
```

if r is a NaN then the string 'nan' is returned formatted and ok will be FALSE.

*)

```
PROCEDURE LongRealToString (r: LONGREAL; digits, width: INTEGER;
    VAR str: ARRAY OF CHAR; VAR ok: BOOLEAN) ;
```

```
(*
  StringToReal - converts, str, into a REAL, r. The parameter, ok, is
                 set to TRUE if the conversion was successful.
*)

PROCEDURE StringToReal (str: ARRAY OF CHAR; VAR r: REAL; VAR ok: BOOLEAN) ;█

(*
  StringToLongReal - converts, str, into a LONGREAL, r. The parameter, ok, is█
                    set to TRUE if the conversion was successful.
*)

PROCEDURE StringToLongReal (str: ARRAY OF CHAR; VAR r: LONGREAL; VAR ok: BOOLEAN) ;█

END RealConversions.
```

4.2.21 gm2-libs-log/RealInOut

```
DEFINITION MODULE RealInOut ;

EXPORT QUALIFIED SetNoOfDecimalPlaces,
                 ReadReal, WriteReal, WriteRealOct,
                 ReadLongReal, WriteLongReal, WriteLongRealOct,
                 ReadShortReal, WriteShortReal, WriteShortRealOct,
                 Done ;

CONST
  DefaultDecimalPlaces = 6 ;

VAR
  Done: BOOLEAN ;

(*
  SetNoOfDecimalPlaces - number of decimal places WriteReal and
                       WriteLongReal should emit. This procedure
                       can be used to override the default
                       DefaultDecimalPlaces constant.
*)

PROCEDURE SetNoOfDecimalPlaces (places: CARDINAL) ;

(*
  ReadReal - reads a real number, legal syntaxes include:
             100, 100.0, 100e0, 100E0, 100E-1, E2, +1E+2, 1e+2
*)

PROCEDURE ReadReal (VAR x: REAL) ;

(*
  WriteReal - writes a real to the terminal. The real number
             is right justified and, n, is the minimum field
             width.
*)

PROCEDURE WriteReal (x: REAL; n: CARDINAL) ;

(*
  WriteRealOct - writes the real to terminal in octal words.
*)
```

```
PROCEDURE WriteRealOct (x: REAL) ;

(*
  ReadLongReal - reads a LONGREAL number, legal syntaxes include:
                  100, 100.0, 100e0, 100E0, 100E-1, E2, +1E+2, 1e+2
*)

PROCEDURE ReadLongReal (VAR x: LONGREAL) ;

(*
  WriteLongReal - writes a LONGREAL to the terminal. The real number
                  is right justified and, n, is the minimum field
                  width.
*)

PROCEDURE WriteLongReal (x: LONGREAL; n: CARDINAL) ;

(*
  WriteLongRealOct - writes the LONGREAL to terminal in octal words.
*)

PROCEDURE WriteLongRealOct (x: LONGREAL) ;

(*
  ReadShortReal - reads a SHORTREAL number, legal syntaxes include:
                  100, 100.0, 100e0, 100E0, 100E-1, E2, +1E+2, 1e+2
*)

PROCEDURE ReadShortReal (VAR x: SHORTREAL) ;

(*
  WriteShortReal - writes a SHORTREAL to the terminal. The real number
                  is right justified and, n, is the minimum field
                  width.
*)

PROCEDURE WriteShortReal (x: SHORTREAL; n: CARDINAL) ;

(*
  WriteShortRealOct - writes the SHORTREAL to terminal in octal words.
```

*)

```
PROCEDURE WriteShortRealOct (x: SHORTREAL) ;
```

```
END RealInOut.
```


4.2.22 gm2-libs-log/Strings

```
DEFINITION MODULE Strings ;

EXPORT QUALIFIED Assign, Insert, Delete, Pos, Copy, ConCat, Length,
                  CompareStr ;

(*
  Assign - dest := source.
*)

PROCEDURE Assign (VAR dest: ARRAY OF CHAR; source: ARRAY OF CHAR) ;

(*
  Insert - insert the string, substr, into str at position, index.
          substr, is added to the end of, str, if, index >= length(str)
*)

PROCEDURE Insert (substr: ARRAY OF CHAR; VAR str: ARRAY OF CHAR;
                 index: CARDINAL) ;

(*
  Delete - delete len characters from, str, starting at, index.
*)

PROCEDURE Delete (VAR str: ARRAY OF CHAR; index: CARDINAL; length: CARDINAL) ;

(*
  Pos - return the first position of, substr, in, str.
*)

PROCEDURE Pos (substr, str: ARRAY OF CHAR) : CARDINAL ;

(*
  Copy - copy at most, length, characters in, substr, to, str,
        starting at position, index.
*)

PROCEDURE Copy (str: ARRAY OF CHAR;
               index, length: CARDINAL; VAR result: ARRAY OF CHAR) ;

(*
  ConCat - concatenates two strings, s1, and, s2
```

```
        and places the result into, dest.
*)

PROCEDURE ConCat (s1, s2: ARRAY OF CHAR; VAR dest: ARRAY OF CHAR) ;

(*
  Length - return the length of string, s.
*)

PROCEDURE Length (s: ARRAY OF CHAR) : CARDINAL ;

(*
  CompareStr - compare two strings, left, and, right.
*)

PROCEDURE CompareStr (left, right: ARRAY OF CHAR) : INTEGER ;

END Strings.
```

4.2.23 gm2-libs-log/Termbase

```
DEFINITION MODULE Termbase ;
```

```
(*
```

```
Initially the read routines from Keyboard and the
write routine from Display is assigned to the Read,
KeyPressed and Write procedures.
```

```
*)
```

```
EXPORT QUALIFIED ReadProcedure, StatusProcedure, WriteProcedure,
AssignRead, AssignWrite, UnAssignRead, UnAssignWrite,
Read, KeyPressed, Write ;
```

```
TYPE
```

```
ReadProcedure = PROCEDURE (VAR CHAR) ;
WriteProcedure = PROCEDURE (CHAR) ;
StatusProcedure = PROCEDURE () : BOOLEAN ;
```

```
(*
```

```
AssignRead - assigns a read procedure and status procedure for terminal
input. Done is set to TRUE if successful. Subsequent
Read and KeyPressed calls are mapped onto the user supplied
procedures. The previous read and status procedures are
uncovered and reused after UnAssignRead is called.
```

```
*)
```

```
PROCEDURE AssignRead (rp: ReadProcedure; sp: StatusProcedure;
VAR Done: BOOLEAN) ;
```

```
(*
```

```
UnAssignRead - undo the last call to AssignRead and set Done to TRUE
on success.
```

```
*)
```

```
PROCEDURE UnAssignRead (VAR Done: BOOLEAN) ;
```

```
(*
```

```
Read - reads a single character using the currently active read
procedure.
```

```
*)
```

```
PROCEDURE Read (VAR ch: CHAR) ;
```

```
(*
  KeyPressed - returns TRUE if a character is available to be read.
*)
```

```
PROCEDURE KeyPressed () : BOOLEAN ;
```

```
(*
  AssignWrite - assigns a write procedure for terminal output.
                Done is set to TRUE if successful. Subsequent
                Write calls are mapped onto the user supplied
                procedure. The previous write procedure is
                uncovered and reused after UnAssignWrite is called.
*)
```

```
PROCEDURE AssignWrite (wp: WriteProcedure; VAR Done: BOOLEAN) ;
```

```
(*
  UnAssignWrite - undo the last call to AssignWrite and set Done to TRUE
                 on success.
*)
```

```
PROCEDURE UnAssignWrite (VAR Done: BOOLEAN) ;
```

```
(*
  Write - writes a single character using the currently active write
          procedure.
*)
```

```
PROCEDURE Write (VAR ch: CHAR) ;
```

```
END Termbase.
```

4.2.24 gm2-libs-log/Terminal

```
DEFINITION MODULE Terminal ;
```

```
(*  
  It provides simple terminal input output  
  routines which all utilize the TermBase module.  
*)
```

```
EXPORT QUALIFIED Read, KeyPressed, ReadAgain, ReadString, Write,  
  WriteString, WriteLn ;
```

```
(*  
  Read - reads a single character.  
*)
```

```
PROCEDURE Read (VAR ch: CHAR) ;
```

```
(*  
  KeyPressed - returns TRUE if a character can be read without blocking  
  the caller.  
*)
```

```
PROCEDURE KeyPressed () : BOOLEAN ;
```

```
(*  
  ReadString - reads a sequence of characters.  
  Tabs are expanded into 8 spaces and <cr> or <lf> terminates  
  the string.  
*)
```

```
PROCEDURE ReadString (VAR s: ARRAY OF CHAR) ;
```

```
(*  
  ReadAgain - makes the last character readable again.  
*)
```

```
PROCEDURE ReadAgain ;
```

```
(*  
  Write - writes a single character to the Termbase module.  
*)
```

```
PROCEDURE Write (ch: CHAR) ;

(*
  WriteString - writes out a string which is terminated by a <nul>
                character or the end of string HIGH(s).
*)

PROCEDURE WriteString (s: ARRAY OF CHAR) ;

(*
  WriteLn - writes a lf character.
*)

PROCEDURE WriteLn ;

END Terminal.
```

4.2.25 gm2-libs-log/TimeDate

```

DEFINITION MODULE TimeDate ;

(*
  Legacy compatibility - you are advised to use cleaner
  designed modules based on 'man 3 strptime'
  and friends for new projects as the day value here is ugly.
  [it was mapped onto MSDOS pre 2000].
*)

EXPORT QUALIFIED Time, GetTime, SetTime, CompareTime, TimeToZero,
                  TimeToString ;

TYPE
(*
  day holds:  bits 0..4 = day of month (1..31)
                5..8 = month of year (1..12)
                9..  = year - 1900
  minute holds:  hours * 60 + minutes
  millisec holds: seconds * 1000 + millisec
                  which is reset to 0 every minute
*)

  Time = RECORD
    day, minute, millisec: CARDINAL ;
  END ;

(*
  GetTime - returns the current date and time.
*)

PROCEDURE GetTime (VAR curTime: Time) ;

(*
  SetTime - does nothing, but provides compatibility with
            the Logitech-3.0 library.
*)

PROCEDURE SetTime (curTime: Time) ;

(*
  CompareTime - compare two dates and time which returns:

```

```
        -1 if t1 < t2
         0 if t1 = t2
         1 if t1 > t2
*)

PROCEDURE CompareTime (t1, t2: Time) : INTEGER ;

(*
  TimeToZero - initializes, t, to zero.
*)

PROCEDURE TimeToZero (VAR t: Time) ;

(*
  TimeToString - convert time, t, to a string.
                 The string, s, should be at least 19 characters
                 long and the returned string will be

                 yyyy-mm-dd hh:mm:ss
*)

PROCEDURE TimeToString (t: Time; VAR s: ARRAY OF CHAR) ;

END TimeDate.
```


4.3 PIM coroutine support

This directory contains a PIM SYSTEM containing the PROCESS primitives built on top of gthreads.

4.3.1 gm2-libs-coroutines/Executive

```

DEFINITION MODULE Executive ;

EXPORT QUALIFIED SEMAPHORE, DESCRIPTOR,
    InitProcess, KillProcess, Resume, Suspend, InitSemaphore,
    Wait, Signal, WaitForIO, Ps, GetCurrentProcess,
    RotateRunQueue, ProcessName, DebugProcess ;

TYPE
    SEMAPHORE ;          (* defines Dijkstra's semaphores *)
    DESCRIPTOR ;        (* handle onto a process          *)

(*
    InitProcess - initializes a process which is held in the suspended
                  state. When the process is resumed it will start executing
                  procedure, p. The process has a maximum stack size of,
                  StackSize, bytes and its textual name is, Name.
                  The StackSize should be at least 5000 bytes.
*)

PROCEDURE InitProcess (p: PROC; StackSize: CARDINAL;
                      Name: ARRAY OF CHAR) : DESCRIPTOR ;

(*
    KillProcess - kills the current process. Notice that if InitProcess
                  is called again, it might reuse the DESCRIPTOR of the
                  killed process. It is the responsibility of the caller
                  to ensure all other processes understand this process
                  is different.
*)

PROCEDURE KillProcess ;

(*
    Resume - resumes a suspended process. If all is successful then the process, p,
             is returned. If it fails then NIL is returned.
*)

PROCEDURE Resume (d: DESCRIPTOR) : DESCRIPTOR ;

```

```
(*
  Suspend - suspend the calling process.
           The process can only continue running if another process
           Resumes it.
*)

PROCEDURE Suspend ;

(*
  InitSemaphore - creates a semaphore whose initial value is, v, and
                 whose name is, Name.
*)

PROCEDURE InitSemaphore (v: CARDINAL; Name: ARRAY OF CHAR) : SEMAPHORE ;

(*
  Wait - performs dijkstra's P operation on a semaphore.
        A process which calls this procedure will
        wait until the value of the semaphore is > 0
        and then it will decrement this value.
*)

PROCEDURE Wait (s: SEMAPHORE) ;

(*
  Signal - performs dijkstra's V operation on a semaphore.
          A process which calls the procedure will increment
          the semaphores value.
*)

PROCEDURE Signal (s: SEMAPHORE) ;

(*
  WaitForIO - waits for an interrupt to occur on vector, VectorNo.
*)

PROCEDURE WaitForIO (VectorNo: CARDINAL) ;

(*
  Ps - displays a process list together with process status.
```

```
*)  
  
PROCEDURE Ps ;  
  
(*  
    GetCurrentProcess - returns the descriptor of the current running  
                        process.  
*)  
  
PROCEDURE GetCurrentProcess () : DESCRIPTOR ;  
  
(*  
    RotateRunQueue - rotates the process run queue.  
                    It does not call the scheduler.  
*)  
  
PROCEDURE RotateRunQueue ;  
  
(*  
    ProcessName - displays the name of process, d, through  
                 DebugString.  
*)  
  
PROCEDURE ProcessName (d: DESCRIPTOR) ;  
  
(*  
    DebugProcess - gdb debug handle to enable users to debug deadlocked  
                 semaphore processes.  
*)  
  
PROCEDURE DebugProcess (d: DESCRIPTOR) ;  
  
END Executive.
```

4.3.2 gm2-libs-coroutines/KeyBoardLEDs

```
DEFINITION MODULE KeyBoardLEDs ;

EXPORT QUALIFIED SwitchLeds,
                  SwitchScroll, SwitchNum, SwitchCaps ;

(*
  SwitchLeds - switch the keyboard LEDs to the state defined
              by the BOOLEAN variables. TRUE = ON.
*)

PROCEDURE SwitchLeds (NumLock, CapsLock, ScrollLock: BOOLEAN) ;

(*
  SwitchScroll - switches the scroll LED on or off.
*)

PROCEDURE SwitchScroll (Scroll: BOOLEAN) ;

(*
  SwitchNum - switches the Num LED on or off.
*)

PROCEDURE SwitchNum (Num: BOOLEAN) ;

(*
  SwitchCaps - switches the Caps LED on or off.
*)

PROCEDURE SwitchCaps (Caps: BOOLEAN) ;

END KeyBoardLEDs.
```

4.3.3 gm2-libs-coroutines/SYSTEM

```

DEFINITION MODULE SYSTEM ;

(* This module is designed to be used on a native operating system
   rather than an embedded system as it implements the coroutine
   primitives TRANSFER, IOTRANSFER and
   NEWPROCESS through the GNU Pthread library. *)

FROM COROUTINES IMPORT PROTECTION ;

EXPORT QUALIFIED (* the following are built into the compiler: *)
  ADDRESS, WORD, BYTE, CSIZE_T, CSSIZE_T, (*
  Target specific data types. *)
  ADR, TSIZE, ROTATE, SHIFT, THROW, TBITSIZE,
  (* SIZE is exported depending upon -fpim2 and
     -fpedantic. *)
  (* The rest are implemented in SYSTEM.mod. *)
  PROCESS, TRANSFER, NEWPROCESS, IOTRANSFER,
  LISTEN,
  ListenLoop, TurnInterrupts,
  (* Internal GM2 compiler functions. *)
  ShiftVal, ShiftLeft, ShiftRight,
  RotateVal, RotateLeft, RotateRight ;

TYPE
  PROCESS = RECORD
    context: INTEGER ;
  END ;

(* Note that the full list of system and sized datatypes include:
   LOC, WORD, BYTE, ADDRESS,

   (and the non language standard target types)

   INTEGER8, INTEGER16, INTEGER32, INTEGER64,
   CARDINAL8, CARDINAL16, CARDINAL32, CARDINAL64,
   WORD16, WORD32, WORD64, BITSET8, BITSET16,
   BITSET32, REAL32, REAL64, REAL128, COMPLEX32,
   COMPLEX64, COMPLEX128, CSIZE_T, CSSIZE_T.

   Also note that the non-standard data types will
   move into another module in the future. *)

(* The following types are supported on this target:
   (* Target specific data types. *)

```

*)

(*
TRANSFER - save the current volatile environment into, p1.
Restore the volatile environment from, p2.

*)

PROCEDURE TRANSFER (VAR p1: PROCESS; p2: PROCESS) ;

(*
NEWPROCESS - p is a parameterless procedure, a, is the origin of
the workspace used for the process stack and containing
the volatile environment of the process. StackSize, is
the maximum size of the stack in bytes which can be used
by this process. new, is the new process.

*)

PROCEDURE NEWPROCESS (p: PROC; a: ADDRESS; StackSize: CARDINAL; VAR new: PROCESS) ;■

(*
IOTRANSFER - saves the current volatile environment into, First,
and restores volatile environment, Second.
When an interrupt, InterruptNo, is encountered then
the reverse takes place. (The then current volatile
environment is shelved onto Second and First is resumed).■

NOTE: that upon interrupt the Second might not be the
same process as that before the original call to
IOTRANSFER.

*)

PROCEDURE IOTRANSFER (VAR First, Second: PROCESS; InterruptNo: CARDINAL) ;■

(*
LISTEN - briefly listen for any interrupts.

*)

PROCEDURE LISTEN ;

(*
ListenLoop - should be called instead of users writing:

```

LOOP
    LISTEN
END

```

It performs the same function but yields control back to the underlying operating system via a call to `pth_select`. It also checks for deadlock. This function returns when an interrupt occurs ie a file descriptor becomes ready or a time event expires. See the module `RTint`.

*)

```
PROCEDURE ListenLoop ;
```

```

(*)
    TurnInterrupts - switches processor interrupts to the protection
                    level, to. It returns the old value.
*)

```

```
PROCEDURE TurnInterrupts (to: PROTECTION) : PROTECTION ;
```

```

(*)
    all the functions below are declared internally to gm2
    =====

```

```

PROCEDURE ADR (VAR v: <anytype>): ADDRESS;
    (* Returns the address of variable v. *)

```

```

PROCEDURE SIZE (v: <type>) : ZType;
    (* Returns the number of BYTES used to store a v of
       any specified <type>. Only available if -fpim2 is used.
    *)

```

```

PROCEDURE TSIZE (<type>) : CARDINAL;
    (* Returns the number of BYTES used to store a value of the
       specified <type>.
    *)

```

```

PROCEDURE ROTATE (val: <a set type>;
                 num: INTEGER): <type of first parameter>;
    (* Returns a bit sequence obtained from val by rotating up or down
       (left or right) by the absolute value of num. The direction is
       down if the sign of num is negative, otherwise the direction is up.
    *)

```

```

PROCEDURE SHIFT (val: <a set type>;
                 num: INTEGER): <type of first parameter>;
(* Returns a bit sequence obtained from val by shifting up or down
   (left or right) by the absolute value of num, introducing
   zeros as necessary. The direction is down if the sign of
   num is negative, otherwise the direction is up.
*)

PROCEDURE THROW (i: INTEGER) <* noreturn *> ;
(*
   THROW is a GNU extension and was not part of the PIM or ISO
   standards. It throws an exception which will be caught by the EXCEPT
   block (assuming it exists). This is a compiler builtin function which
   interfaces to the GCC exception handling runtime system.
   GCC uses the term throw, hence the naming distinction between
   the GCC builtin and the Modula-2 runtime library procedure Raise.
   The later library procedure Raise will call SYSTEM.THROW after
   performing various housekeeping activities.
*)

PROCEDURE TBITSIZE (<type>) : CARDINAL ;
(* Returns the minimum number of bits necessary to represent
   <type>. This procedure function is only useful for determining
   the number of bits used for any type field within a packed RECORD.
   It is not particularly useful elsewhere since <type> might be
   optimized for speed, for example a BOOLEAN could occupy a WORD.
*)

(* The following procedures are invoked by GNU Modula-2 to
   shift non word sized set types. They are not strictly part
   of the core PIM Modula-2, however they are used
   to implement the SHIFT procedure defined above,
   which are in turn used by the Logitech compatible libraries.

   Users will access these procedures by using the procedure
   SHIFT above and GNU Modula-2 will map SHIFT onto one of
   the following procedures.

   ShiftVal - is a runtime procedure whose job is to implement
   the SHIFT procedure of ISO SYSTEM. GNU Modula-2 will
   inline a SHIFT of a single WORD sized set and will
   only call this routine for larger sets.
*)

```



```
PROCEDURE ShiftVal (VAR s, d: ARRAY OF BITSET;
                   SetSizeInBits: CARDINAL;
                   ShiftCount: INTEGER) ;

(*
  ShiftLeft - performs the shift left for a multi word set.
              This procedure might be called by the back end of
              GNU Modula-2 depending whether amount is known at
              compile time.
*)

PROCEDURE ShiftLeft (VAR s, d: ARRAY OF BITSET;
                    SetSizeInBits: CARDINAL;
                    ShiftCount: CARDINAL) ;

(*
  ShiftRight - performs the shift left for a multi word set.
              This procedure might be called by the back end of
              GNU Modula-2 depending whether amount is known at
              compile time.
*)

PROCEDURE ShiftRight (VAR s, d: ARRAY OF BITSET;
                     SetSizeInBits: CARDINAL;
                     ShiftCount: CARDINAL) ;

(*
  RotateVal - is a runtime procedure whose job is to implement
              the ROTATE procedure of ISO SYSTEM. GNU Modula-2 will
              inline a ROTATE of a single WORD (or less)
              sized set and will only call this routine for
              larger sets.
*)

PROCEDURE RotateVal (VAR s, d: ARRAY OF BITSET;
                    SetSizeInBits: CARDINAL;
                    RotateCount: INTEGER) ;

(*
  RotateLeft - performs the rotate left for a multi word set.
              This procedure might be called by the back end of
              GNU Modula-2 depending whether amount is known
              at compile time.
*)
```

*)

```
PROCEDURE RotateLeft (VAR s, d: ARRAY OF BITSET;  
    SetSizeInBits: CARDINAL;  
    RotateCount: CARDINAL) ;
```

(*

RotateRight - performs the rotate right for a multi word set.
This procedure might be called by the back end of
GNU Modula-2 depending whether amount is known at
compile time.

*)

```
PROCEDURE RotateRight (VAR s, d: ARRAY OF BITSET;  
    SetSizeInBits: CARDINAL;  
    RotateCount: CARDINAL) ;
```

```
END SYSTEM.
```

4.3.4 gm2-libs-coroutines/TimerHandler

```

DEFINITION MODULE TimerHandler ;

(* It also provides the Executive with a basic round robin scheduler. *)

EXPORT QUALIFIED TicksPerSecond, GetTicks,
                 EVENT,
                 Sleep, ArmEvent, WaitOn, Cancel, ReArmEvent ;

CONST
  TicksPerSecond = 25 ; (* Number of ticks per second. *)

TYPE
  EVENT ;

(*
  GetTicks - returns the number of ticks since boottime.
*)

PROCEDURE GetTicks () : CARDINAL ;

(*
  Sleep - suspends the current process for a time, t.
          The time is measured in ticks.
*)

PROCEDURE Sleep (t: CARDINAL) ;

(*
  ArmEvent - initializes an event, e, to occur at time, t.
             The time, t, is measured in ticks.
             The event is NOT placed onto the event queue.
*)

PROCEDURE ArmEvent (t: CARDINAL) : EVENT ;

(*
  WaitOn - places event, e, onto the event queue and then the calling
           process suspends. It is resumed up by either the event
           expiring or the event, e, being cancelled.
           TRUE is returned if the event was cancelled
*)

```

```
FALSE is returned if the event expires.
The event, e, is always assigned to NIL when the function
finishes.

*)

PROCEDURE WaitOn (VAR e: EVENT) : BOOLEAN ;

(*
  Cancel - cancels the event, e, on the event queue and makes
  the appropriate process runnable again.
  TRUE is returned if the event was cancelled and
  FALSE is returned if the event was not found or
  no process was waiting on this event.
*)

PROCEDURE Cancel (e: EVENT) : BOOLEAN ;

(*
  ReArmEvent - removes an event, e, from the event queue. A new time
  is given to this event and it is then re-inserted onto the
  event queue in the correct place.
  TRUE is returned if this occurred
  FALSE is returned if the event was not found.
*)

PROCEDURE ReArmEvent (e: EVENT; t: CARDINAL) : BOOLEAN ;

END TimerHandler.
```

4.4 M2 ISO Libraries

This directory contains the ISO definition modules and some corresponding implementation modules. The definition files: `ChanConsts.def`, `CharClass.def`, `ComplexMath.def`, `ConvStringLong.def`, `ConvStringReal.def`, `ConvTypes.def`, `COROUTINES.def`, `EXCEPTIONS.def`, `GeneralUserExceptions.def`, `IOChan.def`, `IOConsts.def`, `IOLink.def`, `IOLink.def`, `IOResult.def`, `LongComplexMath.def`, `LongConv.def`, `LongIO.def`, `LongMath.def`, `LongStr.def`, `LowLong.def`, `LowReal.def`, `M2EXCEPTION.def`, `Processes.def`, `ProgramArgs.def`, `RawIO.def`, `RealConv.def`, `RealIO.def`, `RealMath.def`, `RealStr.def`, `RndFile.def`, `Semaphores.def`, `SeqFile.def`, `SIOResult.def`, `SLongIO.def`, `SRawIO.def`, `SRealIO.def`, `StdChans.def`, `STextIO.def`, `Storage.def`, `StreamFile.def`, `Strings.def`, `SWholeIO.def`, `SysClock.def`, `SYSTEM.def`, `TERMINATION.def`, `TextIO.def`, `WholeConv.def`, `WholeIO.def` and `WholeStr.def` were defined by the International Standard Information technology - programming languages BS ISO/IEC 10514-1:1996E Part 1: Modula-2, Base Language.

The Copyright to the definition files `ChanConsts.def`, `CharClass.def`, `ComplexMath.def`, `ConvStringLong.def`, `ConvStringReal.def`, `ConvTypes.def`, `COROUTINES.def`, `EXCEPTIONS.def`, `GeneralUserExceptions.def`, `IOChan.def`, `IOConsts.def`, `IOLink.def`, `IOLink.def`, `IOResult.def`, `LongComplexMath.def`, `LongConv.def`, `LongIO.def`, `LongMath.def`, `LongStr.def`, `LowLong.def`, `LowReal.def`, `M2EXCEPTION.def`, `Processes.def`, `ProgramArgs.def`, `RawIO.def`, `RealConv.def`, `RealIO.def`, `RealMath.def`, `RealStr.def`, `RndFile.def`, `Semaphores.def`, `SeqFile.def`, `SIOResult.def`, `SLongIO.def`, `SRawIO.def`, `SRealIO.def`, `StdChans.def`, `STextIO.def`, `Storage.def`, `StreamFile.def`, `Strings.def`, `SWholeIO.def`, `SysClock.def`, `SYSTEM.def`, `TERMINATION.def`, `TextIO.def`, `WholeConv.def`, `WholeIO.def` and `WholeStr.def` belong to ISO/IEC (International Organization for Standardization and International Electrotechnical Commission). The licence allows them to be distributed with the compiler (as described on page 707 of the Information technology - Programming languages Part 1: Modula-2, Base Language. BS ISO/IEC 10514-1:1996).

All implementation modules and `ClientSocket.def`, `LongWholeIO.def`, `M2RTS.def`, `MemStream.def`, `pth.def`, `RandomNumber.def`, `RTdata.def`, `RTentity.def`, `RTfio.def`, `RTio.def`, `ShortComplexMath.def`, `ShortIO.def`, `ShortWholeIO.def`, `SimpleCipher.def`, `SLongWholeIO.def`, `SShortIO.def`, `SShortWholeIO.def`, `StringChan.def` and `wraptime.def` are Copyright of the FSF and are held under the GPLv3 with runtime exceptions.

Under Section 7 of GPL version 3, you are granted additional permissions described in the GCC Runtime Library Exception, version 3.1, as published by the Free Software Foundation.

You should have received a copy of the GNU General Public License and a copy of the GCC Runtime Library Exception along with this program; see the files `COPYING3` and `COPYING.RUNTIME` respectively. If not, see <http://www.gnu.org/licenses/>.

Notice that GNU Modula-2 contains additional libraries for input/output of `SHORTREAL`, `SHORTCARD`, `SHORTINT`, `LONGCARD`, `LONGINT` data types. It also provides a `RandomNumber`, `SimpleCipher` and `ClientSocket` modules as well as low level modules which allow the IO libraries to coexist with their PIM counterparts.

4.4.1 gm2-libs-iso/COROUTINES

```

DEFINITION MODULE COROUTINES;

(* Facilities for coroutines and the handling of interrupts *)

IMPORT SYSTEM ;

CONST
  UnassignedPriority = 0 ;

TYPE
  COROUTINE ; (* Values of this type are created dynamically by NEWCOROUTINE
               and identify the coroutine in subsequent operations *)
  INTERRUPTSOURCE = CARDINAL ;
  PROTECTION = [UnassignedPriority..7] ;

PROCEDURE NEWCOROUTINE (procBody: PROC;
                       workspace: SYSTEM.ADDRESS;
                       size: CARDINAL;
                       VAR cr: COROUTINE;
                       [initProtection: PROTECTION = UnassignedPriority]);
  (* Creates a new coroutine whose body is given by procBody, and
   returns the identity of the coroutine in cr. workspace is a
   pointer to the work space allocated to the coroutine; size
   specifies the size of this workspace in terms of SYSTEM.LOC.

   The optarg, initProtection, may contain a single parameter which
   specifies the initial protection level of the coroutine.
  *)

PROCEDURE TRANSFER (VAR from: COROUTINE; to: COROUTINE);
  (* Returns the identity of the calling coroutine in from, and
   transfers control to the coroutine specified by to.
  *)

PROCEDURE IOTRANSFER (VAR from: COROUTINE; to: COROUTINE);
  (* Returns the identity of the calling coroutine in from and
   transfers control to the coroutine specified by to. On
   occurrence of an interrupt, associated with the caller, control
   is transferred back to the caller, and the identity of the
   interrupted coroutine is returned in from. The calling coroutine
   must be associated with a source of interrupts.
  *)

```

```
PROCEDURE ATTACH (source: INTERRUPTSOURCE);
  (* Associates the specified source of interrupts with the calling
  coroutine. *)

PROCEDURE DETACH (source: INTERRUPTSOURCE);
  (* Dissociates the specified source of interrupts from the calling
  coroutine. *)

PROCEDURE IsATTACHED (source: INTERRUPTSOURCE): BOOLEAN;
  (* Returns TRUE if and only if the specified source of interrupts is
  currently associated with a coroutine; otherwise returns FALSE.
  *)

PROCEDURE HANDLER (source: INTERRUPTSOURCE): COROUTINE;
  (* Returns the coroutine, if any, that is associated with the source
  of interrupts. The result is undefined if IsATTACHED(source) =
  FALSE.
  *)

PROCEDURE CURRENT (): COROUTINE;
  (* Returns the identity of the calling coroutine. *)

PROCEDURE LISTEN (p: PROTECTION);
  (* Momentarily changes the protection of the calling coroutine to
  p. *)

PROCEDURE PROT (): PROTECTION;
  (* Returns the protection of the calling coroutine. *)

(*
  TurnInterrupts - switches processor interrupts to the protection
  level, to. It returns the old value.
*)

PROCEDURE TurnInterrupts (to: PROTECTION) : PROTECTION ;

(*
  ListenLoop - should be called instead of users writing:

      LOOP
        LISTEN
      END

  It performs the same function but yields
  control back to the underlying operating system.
*)
```

It also checks for deadlock.

Note that this function does return when an interrupt occurs.■

(File descriptor becomes ready or time event expires).

*)

```
PROCEDURE ListenLoop ;
```

```
END COROUTINES.
```


4.4.2 gm2-libs-iso/ChanConsts

```
DEFINITION MODULE ChanConsts;
```

```
(* Common types and values for channel open requests and results *)
```

```
TYPE
```

```
ChanFlags =          (* Request flags possibly given when a channel is opened *)
( readFlag,          (* input operations are requested/available *)
  writeFlag,         (* output operations are requested/available *)
  oldFlag,           (* a file may/must/did exist before the channel is opened *)
  textFlag,          (* text operations are requested/available *)
  rawFlag,           (* raw operations are requested/available *)
  interactiveFlag,  (* interactive use is requested/applies *)
  echoFlag           (* echoing by interactive device on removal of characters from in
                    stream requested/applies *)
);
```

```
FlagSet = SET OF ChanFlags;
```

```
(* Singleton values of FlagSet, to allow for example, read + write *)
```

```
CONST
```

```
read = FlagSet{readFlag};  (* input operations are requested/available *)
write = FlagSet{writeFlag}; (* output operations are requested/available *)
old = FlagSet{oldFlag};    (* a file may/must/did exist before the channel is opened *)
text = FlagSet{textFlag};  (* text operations are requested/available *)
raw = FlagSet{rawFlag};    (* raw operations are requested/available *)
interactive = FlagSet{interactiveFlag}; (* interactive use is requested/applies *)
echo = FlagSet{echoFlag};  (* echoing by interactive device on removal of character
                    input stream requested/applies *)
```

```
TYPE
```

```
OpenResults =          (* Possible results of open requests *)
( opened,              (* the open succeeded as requested *)
  wrongNameFormat,    (* given name is in the wrong format for the implementation *)
  wrongFlags,         (* given flags include a value that does not apply to the device *)
  tooManyOpen,       (* this device cannot support any more open channels *)
  outOfChans,        (* no more channels can be allocated *)
  wrongPermissions,  (* file or directory permissions do not allow request *)
  noRoomOnDevice,    (* storage limits on the device prevent the open *)
  noSuchFile,        (* a needed file does not exist *)
  fileExists,        (* a file of the given name already exists when a new one is requested *)
  wrongFileType,     (* the file is of the wrong type to support the required operations *)
  noTextOperations,  (* text operations have been requested, but are not supported *)
  noRawOperations,   (* raw operations have been requested, but are not supported *)
  noMixedOperations, (* text and raw operations have been requested, but they are not supported *)
```

```
                                are not supported in combination *)
alreadyOpen,                    (* the source/destination is already open for operations not su
                                in combination with the requested operations *)■
otherProblem                    (* open failed for some other reason *)
);

END ChanConsts.
```

4.4.3 gm2-libs-iso/CharClass

```
DEFINITION MODULE CharClass;

    (* Classification of values of the type CHAR *)

PROCEDURE IsNumeric (ch: CHAR): BOOLEAN;
    (* Returns TRUE if and only if ch is classified as a numeric character *)■

PROCEDURE IsLetter (ch: CHAR): BOOLEAN;
    (* Returns TRUE if and only if ch is classified as a letter *)

PROCEDURE IsUpper (ch: CHAR): BOOLEAN;
    (* Returns TRUE if and only if ch is classified as an upper case letter *)■

PROCEDURE IsLower (ch: CHAR): BOOLEAN;
    (* Returns TRUE if and only if ch is classified as a lower case letter *)■

PROCEDURE IsControl (ch: CHAR): BOOLEAN;
    (* Returns TRUE if and only if ch represents a control function *)

PROCEDURE IsWhiteSpace (ch: CHAR): BOOLEAN;
    (* Returns TRUE if and only if ch represents a space character or a format effector *)

END CharClass.
```

4.4.4 gm2-libs-iso/ClientSocket

```
DEFINITION MODULE ClientSocket ;

FROM IOChan IMPORT ChanId ;
FROM ChanConsts IMPORT FlagSet, OpenResults ;

(*
  OpenSocket - opens a TCP client connection to host:port.
*)

PROCEDURE OpenSocket (VAR cid: ChanId;
                     host: ARRAY OF CHAR; port: CARDINAL;
                     f: FlagSet; VAR res: OpenResults) ;

(*
  Close - if the channel identified by cid is not open to
          a socket stream, the exception wrongDevice is
          raised; otherwise closes the channel, and assigns
          the value identifying the invalid channel to cid.
*)

PROCEDURE Close (VAR cid: ChanId) ;

(*
  IsSocket - tests if the channel identified by cid is open as
             a client socket stream.
*)

PROCEDURE IsSocket (cid: ChanId) : BOOLEAN ;

END ClientSocket.
```

4.4.5 gm2-libs-iso/ComplexMath

```

DEFINITION MODULE ComplexMath;

    (* Mathematical functions for the type COMPLEX *)

CONST
    i =      CMLPX (0.0, 1.0);
    one =    CMLPX (1.0, 0.0);
    zero =   CMLPX (0.0, 0.0);

PROCEDURE __BUILTIN__ abs (z: COMPLEX): REAL;
    (* Returns the length of z *)

PROCEDURE __BUILTIN__ arg (z: COMPLEX): REAL;
    (* Returns the angle that z subtends to the positive real axis *)

PROCEDURE __BUILTIN__ conj (z: COMPLEX): COMPLEX;
    (* Returns the complex conjugate of z *)

PROCEDURE __BUILTIN__ power (base: COMPLEX; exponent: REAL): COMPLEX;
    (* Returns the value of the number base raised to the power exponent *)

PROCEDURE __BUILTIN__ sqrt (z: COMPLEX): COMPLEX;
    (* Returns the principal square root of z *)

PROCEDURE __BUILTIN__ exp (z: COMPLEX): COMPLEX;
    (* Returns the complex exponential of z *)

PROCEDURE __BUILTIN__ ln (z: COMPLEX): COMPLEX;
    (* Returns the principal value of the natural logarithm of z *)

PROCEDURE __BUILTIN__ sin (z: COMPLEX): COMPLEX;
    (* Returns the sine of z *)

PROCEDURE __BUILTIN__ cos (z: COMPLEX): COMPLEX;
    (* Returns the cosine of z *)

PROCEDURE __BUILTIN__ tan (z: COMPLEX): COMPLEX;
    (* Returns the tangent of z *)

PROCEDURE __BUILTIN__ arcsin (z: COMPLEX): COMPLEX;
    (* Returns the arcsine of z *)

PROCEDURE __BUILTIN__ arccos (z: COMPLEX): COMPLEX;
    (* Returns the arccosine of z *)

```

```
PROCEDURE __BUILTIN__ arctan (z: COMPLEX): COMPLEX;
    (* Returns the arctangent of z *)

PROCEDURE polarToComplex (abs, arg: REAL): COMPLEX;
    (* Returns the complex number with the specified polar coordinates *)

PROCEDURE scalarMult (scalar: REAL; z: COMPLEX): COMPLEX;
    (* Returns the scalar product of scalar with z *)

PROCEDURE IsCMathException (): BOOLEAN;
    (* Returns TRUE if the current coroutine is in the exceptional
       execution state because of the raising of an exception in a
       routine from this module; otherwise returns FALSE.
    *)

END ComplexMath.
```

4.4.6 gm2-libs-iso/ConvStringLong

```
DEFINITION MODULE ConvStringLong ;
```

```
FROM DynamicStrings IMPORT String ;
```

```
(*  
  RealToFloatString - converts a real with, sigFigs, into a string  
                    and returns the result as a string.  
*)
```

```
PROCEDURE RealToFloatString (real: LONGREAL; sigFigs: CARDINAL) : String ;■
```

```
(*  
  RealToEngString - converts the value of real to floating-point  
                  string form, with sigFigs significant figures.  
                  The number is scaled with one to three digits  
                  in the whole number part and with an exponent  
                  that is a multiple of three.  
*)
```

```
PROCEDURE RealToEngString (real: LONGREAL; sigFigs: CARDINAL) : String ;
```

```
(*  
  RealToFixedString - returns the number of characters in the fixed-point  
                    string representation of real rounded to the given  
                    place relative to the decimal point.  
*)
```

```
PROCEDURE RealToFixedString (real: LONGREAL; place: INTEGER) : String ;
```

```
END ConvStringLong.
```

4.4.7 gm2-libs-iso/ConvStringReal

```
DEFINITION MODULE ConvStringReal ;
```

```
FROM DynamicStrings IMPORT String ;
```

```
(*  
  RealToFloatString - converts a real with, sigFigs, into a string  
                    and returns the result as a string.  
*)
```

```
PROCEDURE RealToFloatString (real: REAL; sigFigs: CARDINAL) : String ;
```

```
(*  
  RealToEngString - converts the value of real to floating-point  
                  string form, with sigFigs significant figures.  
                  The number is scaled with one to three digits  
                  in the whole number part and with an exponent  
                  that is a multiple of three.  
*)
```

```
PROCEDURE RealToEngString (real: REAL; sigFigs: CARDINAL) : String ;
```

```
(*  
  RealToFixedString - returns the number of characters in the fixed-point  
                    string representation of real rounded to the given  
                    place relative to the decimal point.  
*)
```

```
PROCEDURE RealToFixedString (real: REAL; place: INTEGER) : String ;
```

```
END ConvStringReal.
```


4.4.8 gm2-libs-iso/ConvTypes

```
DEFINITION MODULE ConvTypes;
```

```
  (* Common types used in the string conversion modules *)
```

```
TYPE
```

```
ConvResults =      (* Values of this type are used to express the format of a string
  (
    strAllRight,    (* the string format is correct for the corresponding conversion *)
    strOutOfRange, (* the string is well-formed but the value cannot be represented *)
    strWrongFormat, (* the string is in the wrong format for the conversion *)
    strEmpty        (* the given string is empty *)
  );
```

```
ScanClass = (* Values of this type are used to classify input to finite state scanner
  (
    padding, (* a leading or padding character at this point in the scan - ignore it *)
    valid,   (* a valid character at this point in the scan - accept it *)
    invalid, (* an invalid character at this point in the scan - reject it *)
    terminator (* a terminating character at this point in the scan (not part of token)
  );
```

```
ScanState = (* The type of lexical scanning control procedures *)
  PROCEDURE (CHAR, VAR ScanClass, VAR ScanState);
```

```
END ConvTypes.
```

4.4.9 gm2-libs-iso/EXCEPTIONS

```
DEFINITION MODULE EXCEPTIONS;

(* Provides facilities for raising user exceptions
   and for making enquiries concerning the current execution state.
*)

TYPE
  ExceptionSource;    (* values of this type are used within library
                       modules to identify the source of raised
                       exceptions *)
  ExceptionNumber = CARDINAL;

PROCEDURE AllocateSource(VAR newSource: ExceptionSource);
  (* Allocates a unique value of type ExceptionSource *)

PROCEDURE RAISE (source: ExceptionSource;
                 number: ExceptionNumber; message: ARRAY OF CHAR)
  <* noreturn *> ;
  (* Associates the given values of source, number and message with
   the current context and raises an exception.
*)

PROCEDURE CurrentNumber (source: ExceptionSource): ExceptionNumber;
  (* If the current coroutine is in the exceptional execution state
   because of the raising of an exception from source, returns
   the corresponding number, and otherwise raises an exception.
*)

PROCEDURE GetMessage (VAR text: ARRAY OF CHAR);
  (* If the current coroutine is in the exceptional execution state,
   returns the possibly truncated string associated with the
   current context. Otherwise, in normal execution state,
   returns the empty string.
*)

PROCEDURE IsCurrentSource (source: ExceptionSource): BOOLEAN;
  (* If the current coroutine is in the exceptional execution state
   because of the raising of an exception from source, returns
   TRUE, and otherwise returns FALSE.
*)

PROCEDURE IsExceptionalExecution (): BOOLEAN;
  (* If the current coroutine is in the exceptional execution state
   because of the raising of an exception, returns TRUE, and
   otherwise returns FALSE.
*)
```

*)

END EXCEPTIONS.

4.4.10 gm2-libs-iso/ErrnoCategory

```
DEFINITION MODULE ErrnoCategory ;

(*
  provides an interface to errno (if the system
  supports it) which determines whether the current
  errno is a hard or soft error.  These distinctions
  are needed by the ISO Modula-2 libraries.  Not all
  errno values are tested, only those which could be
  related to a device.
*)

IMPORT ChanConsts ;

(*
  IsErrnoHard - returns TRUE if the value of errno is associated with
  a hard device error.
*)

PROCEDURE IsErrnoHard (e: INTEGER) : BOOLEAN ;

(*
  IsErrnoSoft - returns TRUE if the value of errno is associated with
  a soft device error.
*)

PROCEDURE IsErrnoSoft (e: INTEGER) : BOOLEAN ;

(*
  UnAvailable - returns TRUE if the value of errno indicates that
  the resource or device is unavailable for some
  reason.
*)

PROCEDURE UnAvailable (e: INTEGER) : BOOLEAN ;

(*
  GetOpenResults - maps errno onto the ISO Modula-2 enumerated
  type, OpenResults.
*)

PROCEDURE GetOpenResults (e: INTEGER) : ChanConsts.OpenResults ;
```

END ErrnoCategory.

4.4.11 gm2-libs-iso/GeneralUserExceptions

```
DEFINITION MODULE GeneralUserExceptions;

(* Provides facilities for general user-defined exceptions *)

TYPE
  GeneralExceptions = (problem, disaster);

PROCEDURE RaiseGeneralException (exception: GeneralExceptions;
                                text: ARRAY OF CHAR);
  (* Raises exception using text as the associated message *)

PROCEDURE IsGeneralException (): BOOLEAN;
  (* Returns TRUE if the current coroutine is in the exceptional
     execution state because of the raising of an exception from
     GeneralExceptions; otherwise returns FALSE.
  *)

PROCEDURE GeneralException(): GeneralExceptions;
  (* If the current coroutine is in the exceptional execution
     state because of the raising of an exception from
     GeneralExceptions, returns the corresponding enumeration value,
     and otherwise raises an exception.
  *)

END GeneralUserExceptions.
```

4.4.12 gm2-libs-iso/IOChan

```
DEFINITION MODULE IOChan;
```

```
  (* Types and procedures forming the interface to channels for
     device-independent data transfer modules
  *)
```

```
IMPORT IOConsts, ChanConsts, SYSTEM;
```

```
TYPE
```

```
  ChanId; (* Values of this type are used to identify channels *)
```

```
  (* There is one pre-defined value identifying an invalid channel
     on which no data transfer operations are available. It may
     be used to initialize variables of type ChanId.
  *)
```

```
PROCEDURE InvalidChan (): ChanId;
```

```
  (* Returns the value identifying the invalid channel. *)
```

```
  (* For each of the following operations, if the device supports
     the operation on the channel, the behaviour of the procedure
     conforms with the description below. The full behaviour is
     defined for each device module. If the device does not
     support the operation on the channel, the behaviour of the
     procedure is to raise the exception notAvailable.
  *)
```

```
  (* Text operations - these perform any required translation between the
     internal and external representation of text.
  *)
```

```
PROCEDURE Look (cid: ChanId; VAR ch: CHAR; VAR res: IOConsts.ReadResults);
```

```
  (* If there is a character as the next item in the input stream
     cid, assigns its value to ch without removing it from the stream;
     otherwise the value of ch is not defined. res (and the stored
     read result) are set to the value allRight, endOfLine, or endOfInput.
  *)
```

```
PROCEDURE Skip (cid: ChanId);
```

```
  (* If the input stream cid has ended, the exception skipAtEnd
     is raised; otherwise the next character or line mark in cid is
     removed, and the stored read result is set to the value
     allRight.
  *)
```

```
PROCEDURE SkipLook (cid: ChanId; VAR ch: CHAR; VAR res: IOConsts.ReadResults);  
  (* If the input stream cid has ended, the exception skipAtEnd is  
    raised; otherwise the next character or line mark in cid is  
    removed. If there is a character as the next item in cid  
    stream, assigns its value to ch without removing it from the  
    stream. Otherwise, the value of ch is not defined. res  
    (and the stored read result) are set to the value allRight,  
    endOfLine, or endOfInput.  
  *)  
  
PROCEDURE WriteLn (cid: ChanId);  
  (* Writes a line mark over the channel cid. *)  
  
PROCEDURE TextRead (cid: ChanId; to: SYSTEM.ADDRESS; maxChars: CARDINAL;  
  VAR charsRead: CARDINAL);  
  (* Reads at most maxChars characters from the current line in cid,  
    and assigns corresponding values to successive components of  
    an ARRAY OF CHAR variable for which the address of the first  
    component is to. The number of characters read is assigned to charsRead.  
    The stored read result is set to allRight, endOfLine, or endOfInput.  
  *)  
  
PROCEDURE TextWrite (cid: ChanId; from: SYSTEM.ADDRESS;  
  charsToWrite: CARDINAL);  
  (* Writes a number of characters given by the value of charsToWrite,  
    from successive components of an ARRAY OF CHAR variable for which  
    the address of the first component is from, to the channel cid.  
  *)  
  
  (* Direct raw operations - these do not effect translation between  
    the internal and external representation of data  
  *)  
  
PROCEDURE RawRead (cid: ChanId; to: SYSTEM.ADDRESS; maxLocs: CARDINAL;  
  VAR locsRead: CARDINAL);  
  (* Reads at most maxLocs items from cid, and assigns corresponding  
    values to successive components of an ARRAY OF LOC variable for  
    which the address of the first component is to. The number of  
    characters read is assigned to charsRead. The stored read result  
    is set to the value allRight, or endOfInput.  
  *)  
  
PROCEDURE RawWrite (cid: ChanId; from: SYSTEM.ADDRESS; locsToWrite: CARDINAL);  
  (* Writes a number of items given by the value of charsToWrite,  
    from successive components of an ARRAY OF LOC variable for  
    which the address of the first component is from, to the channel cid.  
  *)
```



```

(* Common operations *)

PROCEDURE GetName (cid: ChanId; VAR s: ARRAY OF CHAR);
  (* Copies to s a name associated with the channel cid, possibly truncated
  (depending on the capacity of s).
  *)

PROCEDURE Reset (cid: ChanId);
  (* Resets the channel cid to a state defined by the device module. *)

PROCEDURE Flush (cid: ChanId);
  (* Flushes any data buffered by the device module out to the channel cid. *)

  (* Access to read results *)

PROCEDURE SetReadResult (cid: ChanId; res: IOConsts.ReadResults);
  (* Sets the read result value for the channel cid to the value res. *)

PROCEDURE ReadResult (cid: ChanId): IOConsts.ReadResults;
  (* Returns the stored read result value for the channel cid.
  (This is initially the value notKnown).
  *)

  (* Users can discover which flags actually apply to a channel *)

PROCEDURE CurrentFlags (cid: ChanId): ChanConsts.FlagSet;
  (* Returns the set of flags that currently apply to the channel cid. *)

  (* The following exceptions are defined for this module and its clients *)

TYPE
  ChanExceptions =
    (wrongDevice,      (* device specific operation on wrong device *)
     notAvailable,    (* operation attempted that is not available on that
                       channel *)
     skipAtEnd,       (* attempt to skip data from a stream that has ended *)
     softDeviceError, (* device specific recoverable error *)
     hardDeviceError, (* device specific non-recoverable error *)
     textParseError, (* input data does not correspond to a character or
                       line mark - optional detection *)
     notAChannel      (* given value does not identify a channel -
                       optional detection *)
    );

PROCEDURE IsChanException (): BOOLEAN;
  (* Returns TRUE if the current coroutine is in the exceptional

```

```
        execution state because of the raising of an exception from
        ChanExceptions; otherwise returns FALSE.
    *)

PROCEDURE ChanException (): ChanExceptions;
    (* If the current coroutine is in the exceptional execution state
       because of the raising of an exception from ChanExceptions,
       returns the corresponding enumeration value, and otherwise
       raises an exception.
    *)

    (* When a device procedure detects a device error, it raises the
       exception softDeviceError or hardDeviceError. If these
       exceptions are handled, the following facilities may be
       used to discover an implementation-defined error number for
       the channel.
    *)

TYPE
    DeviceErrNum = INTEGER;

PROCEDURE DeviceError (cid: ChanId): DeviceErrNum;
    (* If a device error exception has been raised for the channel cid,
       returns the error number stored by the device module.
    *)

END IOChan.
```

4.4.13 gm2-libs-iso/IOConsts

```
DEFINITION MODULE IOConsts;
```

```
    (* Types and constants for input/output modules *)
```

```
TYPE
```

```
  ReadResults = (* This type is used to classify the result of an input operation *)
  (
    notKnown,      (* no read result is set *)
    allRight,      (* data is as expected or as required *)
    outOfRange,    (* data cannot be represented *)
    wrongFormat,   (* data not in expected format *)
    endOfLine,     (* end of line seen before expected data *)
    endOfInput     (* end of input seen before expected data *)
  );
```

```
END IOConsts.
```

4.4.14 gm2-libs-iso/IOLink

```
DEFINITION MODULE IOLink;
```

```
(* Types and procedures for the standard implementation of channels *)
```

```
IMPORT IOChan, IOConsts, ChanConsts, SYSTEM;
```

```
TYPE
```

```
  DeviceId;
```

```
  (* Values of this type are used to identify new device modules,
     and are normally obtained by them during their initialization.
  *)
```

```
PROCEDURE AllocateDeviceId (VAR did: DeviceId);
```

```
(* Allocates a unique value of type DeviceId, and assigns this
   value to did. *)
```

```
PROCEDURE MakeChan (did: DeviceId; VAR cid: IOChan.ChanId);
```

```
(* Attempts to make a new channel for the device module identified
   by did. If no more channels can be made, the identity of
   the invalid channel is assigned to cid. Otherwise, the identity
   of a new channel is assigned to cid.
*)
```

```
PROCEDURE UnMakeChan (did: DeviceId; VAR cid: IOChan.ChanId);
```

```
(* If the device module identified by did is not the module that
   made the channel identified by cid, the exception wrongDevice is
   raised; otherwise the channel is deallocated, and the value
   identifying the invalid channel is assigned to cid.
*)
```

```
TYPE
```

```
  DeviceTablePtr = POINTER TO DeviceTable;
```

```
  (* Values of this type are used to refer to device tables *)
```

```
TYPE
```

```
  LookProc      = PROCEDURE (DeviceTablePtr, VAR CHAR, VAR IOConsts.ReadResults) ;■
```

```
  SkipProc      = PROCEDURE (DeviceTablePtr) ;
```

```
  SkipLookProc  = PROCEDURE (DeviceTablePtr, VAR CHAR, VAR IOConsts.ReadResults) ;■
```

```
  WriteLnProc   = PROCEDURE (DeviceTablePtr) ;
```

```
  TextReadProc  = PROCEDURE (DeviceTablePtr, SYSTEM.ADDRESS, CARDINAL, VAR CARDINAL) ;
```

```
  TextWriteProc = PROCEDURE (DeviceTablePtr, SYSTEM.ADDRESS, CARDINAL) ;
```

```
  RawReadProc   = PROCEDURE (DeviceTablePtr, SYSTEM.ADDRESS, CARDINAL, VAR CARDINAL) ;
```

```
  RawWriteProc  = PROCEDURE (DeviceTablePtr, SYSTEM.ADDRESS, CARDINAL) ;
```

```
  GetNameProc   = PROCEDURE (DeviceTablePtr, VAR ARRAY OF CHAR) ;
```

```
  ResetProc     = PROCEDURE (DeviceTablePtr) ;
```

```

FlushProc      = PROCEDURE (DeviceTablePtr) ;
FreeProc       = PROCEDURE (DeviceTablePtr) ;
  (* Carry out the operations involved in closing the corresponding
    channel, including flushing buffers, but do not unmake the
    channel.
  *)

```

TYPE

```
DeviceData = SYSTEM.ADDRESS;
```

```
DeviceTable =
```

```

RECORD          (* Initialized by MakeChan to: *)
  cd: DeviceData;      (* the value NIL *)
  did: DeviceId;      (* the value given in the call of MakeChan *)
  cid: IOChan.ChanId;  (* the identity of the channel *)
  result: IOConsts.ReadResults; (* the value notKnown *)
  errNum: IOChan.DeviceErrNum; (* undefined *)
  flags: ChanConsts.FlagSet; (* ChanConsts.FlagSet{} *)
  doLook: LookProc;    (* raise exception notAvailable *)
  doSkip: SkipProc;    (* raise exception notAvailable *)
  doSkipLook: SkipLookProc; (* raise exception notAvailable *)
  doLnWrite: WriteLnProc; (* raise exception notAvailable *)
  doTextRead: TextReadProc; (* raise exception notAvailable *)
  doTextWrite: TextWriteProc; (* raise exception notAvailable *)
  doRawRead: RawReadProc; (* raise exception notAvailable *)
  doRawWrite: RawWriteProc; (* raise exception notAvailable *)
  doGetName: GetNameProc; (* return the empty string *)
  doReset: ResetProc;   (* do nothing *)
  doFlush: FlushProc;   (* do nothing *)
  doFree: FreeProc;     (* do nothing *)
END;

```

```
(* The pointer to the device table for a channel is obtained using the
following procedure: *)
```

```
(*
  If the device module identified by did is not the module that made
  the channel identified by cid, the exception wrongDevice is raised.
*)
```

```
PROCEDURE DeviceTablePtrValue (cid: IOChan.ChanId; did: DeviceId): DeviceTablePtr;
```

```
(*
  Tests if the device module identified by did is the module

```

```

        that made the channel identified by cid.
    *)

PROCEDURE IsDevice (cid: IOChan.ChanId; did: DeviceId) : BOOLEAN;

TYPE
    DevExceptionRange = IOChan.ChanExceptions;

    (*
    ISO standard states defines

    DevExceptionRange = [IOChan.notAvailable .. IOChan.textParseError];

    however this must be a bug as other modules need to raise
    IOChan.wrongDevice exceptions.
    *)

PROCEDURE RAISEdevException (cid: IOChan.ChanId; did: DeviceId;
                             x: DevExceptionRange; s: ARRAY OF CHAR) <* noreturn *> ;

    (* If the device module identified by did is not the module that made the channel
       identified by cid, the exception wrongDevice is raised; otherwise the given excep
       is raised, and the string value in s is included in the exception message.
    *)

PROCEDURE IsIOException () : BOOLEAN;
    (* Returns TRUE if the current coroutine is in the exceptional execution state
       because of the raising of an exception from ChanExceptions;
       otherwise FALSE.
    *)

PROCEDURE IOException () : IOChan.ChanExceptions;
    (* If the current coroutine is in the exceptional execution state because of the
       raising of an exception from ChanExceptions, returns the corresponding
       enumeration value, and otherwise raises an exception.
    *)

END IOLink.
```

4.4.15 gm2-libs-iso/IOResult

```
DEFINITION MODULE IOResult;
```

```
    (* Read results for specified channels *)
```

```
IMPORT IOConsts, IOChan;
```

```
TYPE
```

```
    ReadResults = IOConsts.ReadResults;
```

```
    (*
```

```
    ReadResults = (* This type is used to classify the result of an input operation *
```

```
    (
```

```
        notKnown,    (* no read result is set *)
```

```
        allRight,    (* data is as expected or as required *)
```

```
        outOfRange,  (* data cannot be represented *)
```

```
        wrongFormat, (* data not in expected format *)
```

```
        endOfLine,   (* end of line seen before expected data *)
```

```
        endOfInput   (* end of input seen before expected data *)
```

```
    );
```

```
    *)
```

```
PROCEDURE ReadResult (cid: IOChan.ChanId): ReadResults;
```

```
    (* Returns the result for the last read operation on the channel cid. *)■
```

```
END IOResult.
```

4.4.16 gm2-libs-iso/LongComplexMath

```
DEFINITION MODULE LongComplexMath;

    (* Mathematical functions for the type LONGCOMPLEX *)

CONST
    i =      CMLPX (0.0, 1.0);
    one =    CMLPX (1.0, 0.0);
    zero =   CMLPX (0.0, 0.0);

PROCEDURE abs (z: LONGCOMPLEX): LONGREAL;
    (* Returns the length of z *)

PROCEDURE arg (z: LONGCOMPLEX): LONGREAL;
    (* Returns the angle that z subtends to the positive real axis *)

PROCEDURE conj (z: LONGCOMPLEX): LONGCOMPLEX;
    (* Returns the complex conjugate of z *)

PROCEDURE power (base: LONGCOMPLEX; exponent: LONGREAL): LONGCOMPLEX;
    (* Returns the value of the number base raised to the power exponent *)

PROCEDURE sqrt (z: LONGCOMPLEX): LONGCOMPLEX;
    (* Returns the principal square root of z *)

PROCEDURE exp (z: LONGCOMPLEX): LONGCOMPLEX;
    (* Returns the complex exponential of z *)

PROCEDURE ln (z: LONGCOMPLEX): LONGCOMPLEX;
    (* Returns the principal value of the natural logarithm of z *)

PROCEDURE sin (z: LONGCOMPLEX): LONGCOMPLEX;
    (* Returns the sine of z *)

PROCEDURE cos (z: LONGCOMPLEX): LONGCOMPLEX;
    (* Returns the cosine of z *)

PROCEDURE tan (z: LONGCOMPLEX): LONGCOMPLEX;
    (* Returns the tangent of z *)

PROCEDURE arcsin (z: LONGCOMPLEX): LONGCOMPLEX;
    (* Returns the arcsine of z *)

PROCEDURE arccos (z: LONGCOMPLEX): LONGCOMPLEX;
    (* Returns the arccosine of z *)
```



```
PROCEDURE arctan (z: LONGCOMPLEX): LONGCOMPLEX;
    (* Returns the arctangent of z *)

PROCEDURE polarToComplex (abs, arg: LONGREAL): LONGCOMPLEX;
    (* Returns the complex number with the specified polar coordinates *)

PROCEDURE scalarMult (scalar: LONGREAL; z: LONGCOMPLEX): LONGCOMPLEX;
    (* Returns the scalar product of scalar with z *)

PROCEDURE IsCMathException (): BOOLEAN;
    (* Returns TRUE if the current coroutine is in the exceptional execution state
       because of the raising of an exception in a routine from this module; otherwise
       returns FALSE.
    *)

END LongComplexMath.
```

4.4.17 gm2-libs-iso/LongConv

```

DEFINITION MODULE LongConv;

    (* Low-level LONGREAL/string conversions *)

IMPORT
    ConvTypes;

TYPE
    ConvResults = ConvTypes.ConvResults; (* strAllRight, strOutOfRange,
                                          strWrongFormat, strEmpty *)

PROCEDURE ScanReal (inputCh: CHAR; VAR chClass: ConvTypes.ScanClass;
                   VAR nextState: ConvTypes.ScanState);
    (* Represents the start state of a finite state scanner for real
       numbers - assigns class of inputCh to chClass and a procedure
       representing the next state to nextState.
    *)

PROCEDURE FormatReal (str: ARRAY OF CHAR): ConvResults;
    (* Returns the format of the string value for conversion to LONGREAL. *)

PROCEDURE ValueReal (str: ARRAY OF CHAR): LONGREAL;
    (* Returns the value corresponding to the real number string value
       str if str is well-formed; otherwise raises the LongConv exception.
    *)

PROCEDURE LengthFloatReal (real: LONGREAL; sigFigs: CARDINAL): CARDINAL;
    (* Returns the number of characters in the floating-point string
       representation of real with sigFigs significant figures.
    *)

PROCEDURE LengthEngReal (real: LONGREAL; sigFigs: CARDINAL): CARDINAL;
    (* Returns the number of characters in the floating-point engineering
       string representation of real with sigFigs significant figures.
    *)

PROCEDURE LengthFixedReal (real: LONGREAL; place: INTEGER): CARDINAL;
    (* Returns the number of characters in the fixed-point string
       representation of real rounded to the given place relative to the
       decimal point.
    *)

PROCEDURE IsRConvException (): BOOLEAN;
    (* Returns TRUE if the current coroutine is in the exceptional
       execution state because of the raising of an exception in a

```

```
        routine from this module; otherwise returns FALSE.  
*)  
  
END LongConv.
```

4.4.18 gm2-libs-iso/LongIO

```
DEFINITION MODULE LongIO;
```

```
  (* Input and output of long real numbers in decimal text form
     over specified channels. The read result is of the type
     IOConsts.ReadResults.
  *)
```

```
IMPORT IOChan;
```

```
  (* The text form of a signed fixed-point real number is
     ["+" | "-"], decimal digit, {decimal digit}, [".",
     {decimal digit}]
```

```
  The text form of a signed floating-point real number is
  signed fixed-point real number,
  "E", ["+" | "-"], decimal digit, {decimal digit}
  *)
```

```
PROCEDURE ReadReal (cid: IOChan.ChanId; VAR real: LONGREAL);
```

```
  (* Skips leading spaces, and removes any remaining characters
     from cid that form part of a signed fixed or floating
     point number. The value of this number is assigned to real.
     The read result is set to the value allRight, outOfRange,
     wrongFormat, endOfLine, or endOfInput.
  *)
```

```
PROCEDURE WriteFloat (cid: IOChan.ChanId; real: LONGREAL;
                     sigFigs: CARDINAL; width: CARDINAL);
```

```
  (* Writes the value of real to cid in floating-point text form,
     with sigFigs significant figures, in a field of the given
     minimum width.
  *)
```

```
PROCEDURE WriteEng (cid: IOChan.ChanId; real: LONGREAL;
                   sigFigs: CARDINAL; width: CARDINAL);
```

```
  (* As for WriteFloat, except that the number is scaled with
     one to three digits in the whole number part, and with an
     exponent that is a multiple of three.
  *)
```

```
PROCEDURE WriteFixed (cid: IOChan.ChanId; real: LONGREAL;
                     place: INTEGER; width: CARDINAL);
```

```
  (* Writes the value of real to cid in fixed-point text form,
     rounded to the given place relative to the decimal point,
     in a field of the given minimum width.
```

```
*)  
  
PROCEDURE WriteReal (cid: IOChan.ChanId; real: LONGREAL;  
                    width: CARDINAL);  
  (* Writes the value of real to cid, as WriteFixed if the  
    sign and magnitude can be shown in the given width, or  
    otherwise as WriteFloat. The number of places or  
    significant digits depends on the given width.  
  *)  
  
END LongIO.
```

4.4.19 gm2-libs-iso/LongMath

```

DEFINITION MODULE LongMath;

    (* Mathematical functions for the type LONGREAL *)

CONST
    pi    = 3.1415926535897932384626433832795028841972;
    exp1  = 2.7182818284590452353602874713526624977572;

PROCEDURE __BUILTIN__ sqrt (x: LONGREAL): LONGREAL;
    (* Returns the positive square root of x *)

PROCEDURE __BUILTIN__ exp (x: LONGREAL): LONGREAL;
    (* Returns the exponential of x *)

PROCEDURE __BUILTIN__ ln (x: LONGREAL): LONGREAL;
    (* Returns the natural logarithm of x *)

    (* The angle in all trigonometric functions is measured in radians *)

PROCEDURE __BUILTIN__ sin (x: LONGREAL): LONGREAL;
    (* Returns the sine of x *)

PROCEDURE __BUILTIN__ cos (x: LONGREAL): LONGREAL;
    (* Returns the cosine of x *)

PROCEDURE tan (x: LONGREAL): LONGREAL;
    (* Returns the tangent of x *)

PROCEDURE arcsin (x: LONGREAL): LONGREAL;
    (* Returns the arcsine of x *)

PROCEDURE arccos (x: LONGREAL): LONGREAL;
    (* Returns the arccosine of x *)

PROCEDURE arctan (x: LONGREAL): LONGREAL;
    (* Returns the arctangent of x *)

PROCEDURE power (base, exponent: LONGREAL): LONGREAL;
    (* Returns the value of the number base raised to the power exponent *)

PROCEDURE round (x: LONGREAL): INTEGER;
    (* Returns the value of x rounded to the nearest integer *)

PROCEDURE IsRMathException (): BOOLEAN;
    (* Returns TRUE if the current coroutine is in the exceptional

```

```
execution state because of the raising of an exception in a  
routine from this module; otherwise returns FALSE.
```

```
*)
```

```
END LongMath.
```

4.4.20 gm2-libs-iso/LongStr

```

DEFINITION MODULE LongStr;

    (* LONGREAL/string conversions *)

IMPORT
    ConvTypes;

TYPE
    (* strAllRight, strOutOfRange, strWrongFormat, strEmpty *)
    ConvResults = ConvTypes.ConvResults;

    (* the string form of a signed fixed-point real number is
       ["+" | "-"], decimal digit, {decimal digit}, [".",
       {decimal digit}]
    *)

    (* the string form of a signed floating-point real number is
       signed fixed-point real number, "E", ["+" | "-"],
       decimal digit, {decimal digit}
    *)

PROCEDURE StrToReal (str: ARRAY OF CHAR; VAR real: LONGREAL;
                    VAR res: ConvResults);
    (* Ignores any leading spaces in str. If the subsequent characters
       in str are in the format of a signed real number, assigns a
       corresponding value to real. Assigns a value indicating the
       format of str to res.
    *)

PROCEDURE RealToFloat (real: LONGREAL; sigFigs: CARDINAL;
                      VAR str: ARRAY OF CHAR);
    (* Converts the value of real to floating-point string form, with
       sigFigs significant figures, and copies the possibly truncated
       result to str.
    *)

PROCEDURE RealToEng (real: LONGREAL; sigFigs: CARDINAL;
                    VAR str: ARRAY OF CHAR);
    (* Converts the value of real to floating-point string form, with
       sigFigs significant figures, and copies the possibly truncated
       result to str. The number is scaled with one to three digits
       in the whole number part and with an exponent that is a
       multiple of three.
    *)

```



```
PROCEDURE RealToFixed (real: LONGREAL; place: INTEGER;
                      VAR str: ARRAY OF CHAR);
  (* Converts the value of real to fixed-point string form, rounded
     to the given place relative to the decimal point, and copies
     the possibly truncated result to str.
  *)

PROCEDURE RealToStr (real: LONGREAL; VAR str: ARRAY OF CHAR);
  (* Converts the value of real as RealToFixed if the sign and
     magnitude can be shown within the capacity of str, or
     otherwise as RealToFloat, and copies the possibly truncated
     result to str. The number of places or significant digits
     depend on the capacity of str.
  *)

END LongStr.
```

4.4.21 gm2-libs-iso/LongWholeIO

```
DEFINITION MODULE LongWholeIO;

  (* Input and output of whole numbers in decimal text form
     over specified channels. The read result is of the
     type IOConsts.ReadResults.
  *)

IMPORT IOChan;

  (* The text form of a signed whole number is
     ["+" | "-"], decimal digit, {decimal digit}

     The text form of an unsigned whole number is
     decimal digit, {decimal digit}
  *)

PROCEDURE ReadInt (cid: IOChan.ChanId; VAR int: LONGINT);
  (* Skips leading spaces, and removes any remaining characters
     from cid that form part of a signed whole number. The
     value of this number is assigned to int. The read result
     is set to the value allRight, outOfRange, wrongFormat,
     endOfLine, or endOfInput.
  *)

PROCEDURE WriteInt (cid: IOChan.ChanId; int: LONGINT;
                   width: CARDINAL);
  (* Writes the value of int to cid in text form, in a field of
     the given minimum width. *)

PROCEDURE ReadCard (cid: IOChan.ChanId; VAR card: LONGCARD);
  (* Skips leading spaces, and removes any remaining characters
     from cid that form part of an unsigned whole number. The
     value of this number is assigned to card. The read result
     is set to the value allRight, outOfRange, wrongFormat,
     endOfLine, or endOfInput.
  *)

PROCEDURE WriteCard (cid: IOChan.ChanId; card: LONGCARD;
                    width: CARDINAL);
  (* Writes the value of card to cid in text form, in a field
     of the given minimum width. *)

END LongWholeIO.
```

4.4.22 gm2-libs-iso/LowLong

```
DEFINITION MODULE LowLong;
```

```
    (* Access to underlying properties of the type LONGREAL *)
```

```
CONST
```

```
radix      = __ATTRIBUTE__ __BUILTIN__ (( <LONGREAL, radix> )) ;      (* ZType *)
places     = __ATTRIBUTE__ __BUILTIN__ (( <LONGREAL, places> )) ;    (* ZType *)
expoMin    = __ATTRIBUTE__ __BUILTIN__ (( <LONGREAL, expoMin> )) ;   (* ZType *)
expoMax    = __ATTRIBUTE__ __BUILTIN__ (( <LONGREAL, expoMax> )) ;   (* ZType *)
large      = __ATTRIBUTE__ __BUILTIN__ (( <LONGREAL, large> )) ;     (* RType *)
small      = __ATTRIBUTE__ __BUILTIN__ (( <LONGREAL, small> )) ;     (* RType *)
IEC559     = __ATTRIBUTE__ __BUILTIN__ (( <LONGREAL, IEC559> )) ;    (* BOOLEAN *)
LIA1       = __ATTRIBUTE__ __BUILTIN__ (( <LONGREAL, LIA1> )) ;     (* BOOLEAN *)
ISO        = __ATTRIBUTE__ __BUILTIN__ (( <LONGREAL, ISO> )) ;      (* BOOLEAN *)
IEEE       = __ATTRIBUTE__ __BUILTIN__ (( <LONGREAL, IEEE> )) ;    (* BOOLEAN *)
rounds     = __ATTRIBUTE__ __BUILTIN__ (( <LONGREAL, rounds> )) ;    (* BOOLEAN *)
gUnderflow = __ATTRIBUTE__ __BUILTIN__ (( <LONGREAL, gUnderflow> )) ; (* BOOLEAN *)
exception  = __ATTRIBUTE__ __BUILTIN__ (( <LONGREAL, exception> )) ; (* BOOLEAN *)
extend     = __ATTRIBUTE__ __BUILTIN__ (( <LONGREAL, extend> )) ;    (* BOOLEAN *)
nModes     = __ATTRIBUTE__ __BUILTIN__ (( <LONGREAL, nModes> )) ;   (* ZType *)
```

```
TYPE
```

```
    Modes = PACKEDSET OF [0 .. nModes-1];
```

```
PROCEDURE exponent (x: LONGREAL): INTEGER;
```

```
    (* Returns the exponent value of x *)
```

```
PROCEDURE fraction (x: LONGREAL): LONGREAL;
```

```
    (* Returns the significand (or significant part) of x *)
```

```
PROCEDURE sign (x: LONGREAL): LONGREAL;
```

```
    (* Returns the signum of x *)
```

```
PROCEDURE succ (x: LONGREAL): LONGREAL;
```

```
    (* Returns the next value of the type LONGREAL greater than x *)
```

```
PROCEDURE ulp (x: LONGREAL): LONGREAL;
```

```
    (* Returns the value of a unit in the last place of x *)
```

```
PROCEDURE pred (x: LONGREAL): LONGREAL;
```

```
    (* Returns the previous value of the type LONGREAL less than x *)
```

```
PROCEDURE intpart (x: LONGREAL): LONGREAL;
```

```
    (* Returns the integer part of x *)
```

```
PROCEDURE fractpart (x: LONGREAL): LONGREAL;
  (* Returns the fractional part of x *)

PROCEDURE scale (x: LONGREAL; n: INTEGER): LONGREAL;
  (* Returns the value of x * radix ** n *)

PROCEDURE trunc (x: LONGREAL; n: INTEGER): LONGREAL;
  (* Returns the value of the first n places of x *)

PROCEDURE round (x: LONGREAL; n: INTEGER): LONGREAL;
  (* Returns the value of x rounded to the first n places *)

PROCEDURE synthesize (expart: INTEGER; frapart: LONGREAL): LONGREAL;
  (* Returns a value of the type LONGREAL constructed from the given expart and frapar

PROCEDURE setMode (m: Modes);
  (* Sets status flags appropriate to the underlying implementation of the type LONGRE

PROCEDURE currentMode (): Modes;
  (* Returns the current status flags in the form set by setMode *)

PROCEDURE IsLowException (): BOOLEAN;
  (* Returns TRUE if the current coroutine is in the exceptional execution state
    because of the raising of an exception in a routine from this module; otherwise
    returns FALSE.
  *)

END LowLong.
```

4.4.23 gm2-libs-iso/LowReal

```
DEFINITION MODULE LowReal;
```

```
    (* Access to underlying properties of the type REAL *)
```

```
CONST
```

```

radix      = __ATTRIBUTE__ __BUILTIN__ (( <REAL, radix> )) ;      (* ZType *)
places     = __ATTRIBUTE__ __BUILTIN__ (( <REAL, places> )) ;    (* ZType *)
expoMin    = __ATTRIBUTE__ __BUILTIN__ (( <REAL, expoMin> )) ;   (* ZType *)
expoMax    = __ATTRIBUTE__ __BUILTIN__ (( <REAL, expoMax> )) ;   (* ZType *)
large      = __ATTRIBUTE__ __BUILTIN__ (( <REAL, large> )) ;     (* RType *)
small      = __ATTRIBUTE__ __BUILTIN__ (( <REAL, small> )) ;     (* RType *)
IEC559     = __ATTRIBUTE__ __BUILTIN__ (( <REAL, IEC559> )) ;    (* BOOLEAN *)
LIA1       = __ATTRIBUTE__ __BUILTIN__ (( <REAL, LIA1> )) ;      (* BOOLEAN *)
ISO        = __ATTRIBUTE__ __BUILTIN__ (( <REAL, ISO> )) ;       (* BOOLEAN *)
IEEE       = __ATTRIBUTE__ __BUILTIN__ (( <REAL, IEEE> )) ;      (* BOOLEAN *)
rounds     = __ATTRIBUTE__ __BUILTIN__ (( <REAL, rounds> )) ;    (* BOOLEAN *)
gUnderflow = __ATTRIBUTE__ __BUILTIN__ (( <REAL, gUnderflow> )) ; (* BOOLEAN *)
exception  = __ATTRIBUTE__ __BUILTIN__ (( <REAL, exception> )) ; (* BOOLEAN *)
extend     = __ATTRIBUTE__ __BUILTIN__ (( <REAL, extend> )) ;    (* BOOLEAN *)
nModes     = __ATTRIBUTE__ __BUILTIN__ (( <REAL, nModes> )) ;    (* ZType *)

```

```
TYPE
```

```
    Modes = PACKEDSET OF [0..nModes-1];
```

```
PROCEDURE exponent (x: REAL): INTEGER;
    (* Returns the exponent value of x *)
```

```
PROCEDURE fraction (x: REAL): REAL;
    (* Returns the significand (or significant part) of x *)
```

```
PROCEDURE sign (x: REAL): REAL;
    (* Returns the signum of x *)
```

```
PROCEDURE succ (x: REAL): REAL;
    (* Returns the next value of the type REAL greater than x *)
```

```
PROCEDURE ulp (x: REAL): REAL;
    (* Returns the value of a unit in the last place of x *)
```

```
PROCEDURE pred (x: REAL): REAL;
    (* Returns the previous value of the type REAL less than x *)
```

```
PROCEDURE intpart (x: REAL): REAL;
    (* Returns the integer part of x *)
```

```
PROCEDURE fractpart (x: REAL): REAL;
  (* Returns the fractional part of x *)

PROCEDURE scale (x: REAL; n: INTEGER): REAL;
  (* Returns the value of x * radix ** n *)

PROCEDURE trunc (x: REAL; n: INTEGER): REAL;
  (* Returns the value of the first n places of x *)

PROCEDURE round (x: REAL; n: INTEGER): REAL;
  (* Returns the value of x rounded to the first n places *)

PROCEDURE synthesize (expart: INTEGER; frapart: REAL): REAL;
  (* Returns a value of the type REAL constructed from the given expart and frapart *)

PROCEDURE setMode (m: Modes);
  (* Sets status flags appropriate to the underlying implementation of the type REAL *)

PROCEDURE currentMode (): Modes;
  (* Returns the current status flags in the form set by setMode *)

PROCEDURE IsLowException (): BOOLEAN;
  (* Returns TRUE if the current coroutine is in the exceptional execution state
     because of the raising of an exception in a routine from this module; otherwise
     returns FALSE.
  *)

END LowReal.
```

4.4.24 gm2-libs-iso/LowShort

```
DEFINITION MODULE LowShort;
```

```
  (* Access to underlying properties of the type SHORTREAL *)
```

```
CONST
```

```

radix      = __ATTRIBUTE__ __BUILTIN__ (( <SHORTREAL, radix> )) ;      (* ZType *)
places     = __ATTRIBUTE__ __BUILTIN__ (( <SHORTREAL, places> )) ;    (* ZType *)
expoMin    = __ATTRIBUTE__ __BUILTIN__ (( <SHORTREAL, expoMin> )) ;   (* ZType *)
expoMax    = __ATTRIBUTE__ __BUILTIN__ (( <SHORTREAL, expoMax> )) ;   (* ZType *)
large      = __ATTRIBUTE__ __BUILTIN__ (( <SHORTREAL, large> )) ;     (* RType *)
small      = __ATTRIBUTE__ __BUILTIN__ (( <SHORTREAL, small> )) ;     (* RType *)
IEC559     = __ATTRIBUTE__ __BUILTIN__ (( <SHORTREAL, IEC559> )) ;    (* BOOLEAN *)
LIA1       = __ATTRIBUTE__ __BUILTIN__ (( <SHORTREAL, LIA1> )) ;      (* BOOLEAN *)
ISO        = __ATTRIBUTE__ __BUILTIN__ (( <SHORTREAL, ISO> )) ;       (* BOOLEAN *)
IEEE       = __ATTRIBUTE__ __BUILTIN__ (( <SHORTREAL, IEEE> )) ;     (* BOOLEAN *)
rounds     = __ATTRIBUTE__ __BUILTIN__ (( <SHORTREAL, rounds> )) ;    (* BOOLEAN *)
gUnderflow = __ATTRIBUTE__ __BUILTIN__ (( <SHORTREAL, gUnderflow> )) ; (* BOOLEAN *)
exception  = __ATTRIBUTE__ __BUILTIN__ (( <SHORTREAL, exception> )) ; (* BOOLEAN *)
extend     = __ATTRIBUTE__ __BUILTIN__ (( <SHORTREAL, extend> )) ;    (* BOOLEAN *)
nModes     = __ATTRIBUTE__ __BUILTIN__ (( <SHORTREAL, nModes> )) ;    (* ZType *)

```

```
TYPE
```

```
  Modes = PACKEDSET OF [0 .. nModes-1];
```

```
PROCEDURE exponent (x: SHORTREAL): INTEGER;
```

```
  (* Returns the exponent value of x *)
```

```
PROCEDURE fraction (x: SHORTREAL): SHORTREAL;
```

```
  (* Returns the significand (or significant part) of x *)
```

```
PROCEDURE sign (x: SHORTREAL): SHORTREAL;
```

```
  (* Returns the signum of x *)
```

```
PROCEDURE succ (x: SHORTREAL): SHORTREAL;
```

```
  (* Returns the next value of the type SHORTREAL greater than x *)
```

```
PROCEDURE ulp (x: SHORTREAL): SHORTREAL;
```

```
  (* Returns the value of a unit in the last place of x *)
```

```
PROCEDURE pred (x: SHORTREAL): SHORTREAL;
```

```
  (* Returns the previous value of the type SHORTREAL less than x *)
```

```
PROCEDURE intpart (x: SHORTREAL): SHORTREAL;
```

```
  (* Returns the integer part of x *)
```

```
PROCEDURE fractpart (x: SHORTREAL): SHORTREAL;
  (* Returns the fractional part of x *)

PROCEDURE scale (x: SHORTREAL; n: INTEGER): SHORTREAL;
  (* Returns the value of x * radix ** n *)

PROCEDURE trunc (x: SHORTREAL; n: INTEGER): SHORTREAL;
  (* Returns the value of the first n places of x *)

PROCEDURE round (x: SHORTREAL; n: INTEGER): SHORTREAL;
  (* Returns the value of x rounded to the first n places *)

PROCEDURE synthesize (expart: INTEGER; frapart: SHORTREAL): SHORTREAL;
  (* Returns a value of the type SHORTREAL constructed from the given expart and frapart *)

PROCEDURE setMode (m: Modes);
  (* Sets status flags appropriate to the underlying implementation of the type SHORTREAL *)

PROCEDURE currentMode (): Modes;
  (* Returns the current status flags in the form set by setMode *)

PROCEDURE IsLowException (): BOOLEAN;
  (* Returns TRUE if the current coroutine is in the exceptional execution state
   because of the raising of an exception in a routine from this module; otherwise
   returns FALSE.
  *)

END LowShort.
```


4.4.25 gm2-libs-iso/M2EXCEPTION

```
DEFINITION MODULE M2EXCEPTION;
```

```
(* Provides facilities for identifying language exceptions *)
```

```
TYPE
```

```
  M2Exceptions =
```

```
  (indexException,      rangeException,      caseSelectException,  invalidLocation
   functionException,   wholeValueException, wholeDivException,    realValueExcept
   realDivException,   complexValueException, complexDivException,  protException,
   sysException,       coException,          exException
  );
```

```
PROCEDURE M2Exception (): M2Exceptions;
```

```
(* If the current coroutine is in the exceptional execution state because of the raising
   of a language exception, returns the corresponding enumeration value, and otherwise
   raises an exception.
*)
```

```
PROCEDURE IsM2Exception (): BOOLEAN;
```

```
(* If the current coroutine is in the exceptional execution state because of the raising
   of a language exception, returns TRUE, and otherwise returns FALSE.
*)
```

```
END M2EXCEPTION.
```

4.4.26 gm2-libs-iso/M2RTS

```

DEFINITION MODULE M2RTS ;

FROM SYSTEM IMPORT ADDRESS ;

TYPE
  ArgCEnvP = PROCEDURE (INTEGER, ADDRESS, ADDRESS) ;

PROCEDURE ConstructModules (applicationmodule, libname: ADDRESS;
                           argc: INTEGER; argv, envp: ADDRESS) ;

PROCEDURE DeconstructModules (applicationmodule, libname: ADDRESS;
                              argc: INTEGER; argv, envp: ADDRESS) ;

(*
  RegisterModule - adds module name to the list of outstanding
                  modules which need to have their dependencies
                  explored to determine initialization order.
*)

PROCEDURE RegisterModule (name, libname: ADDRESS;
                          init, fini: ArgCEnvP;
                          dependencies: PROC) ;

(*
  RequestDependant - used to specify that modulename is dependant upon
                    module dependantmodule.
*)

PROCEDURE RequestDependant (modulename, libname,
                            dependantmodule, dependantlibname: ADDRESS) ;■

(*
  ExecuteTerminationProcedures - calls each installed termination
                                 procedure in reverse order.
*)

PROCEDURE ExecuteTerminationProcedures ;

(*

```

```
    InstallTerminationProcedure - installs a procedure, p, which will
                                be called when the procedure
                                ExecuteTerminationProcedures
                                is invoked. It returns TRUE if the
                                procedure is installed.
*)

PROCEDURE InstallTerminationProcedure (p: PROC) : BOOLEAN ;

(*
    ExecuteInitialProcedures - executes the initial procedures installed
                                by InstallInitialProcedure.
*)

PROCEDURE ExecuteInitialProcedures ;

(*
    InstallInitialProcedure - installs a procedure to be executed just
                                before the BEGIN code section of the main
                                program module.
*)

PROCEDURE InstallInitialProcedure (p: PROC) : BOOLEAN ;

(*
    HALT - terminate the current program. The procedure
            ExecuteTerminationProcedures
            is called before the program is stopped. The parameter
            exitcode is optional. If the parameter is not supplied
            HALT will call libc 'abort', otherwise it will exit with
            the code supplied. Supplying a parameter to HALT has the
            same effect as calling ExitOnHalt with the same code and
            then calling HALT with no parameter.
*)

PROCEDURE HALT ([exitcode: INTEGER = -1]) <* noreturn *> ;

(*
    Halt - provides a more user friendly version of HALT, which takes
            four parameters to aid debugging. It writes an error message
            to stderr and calls exit (1).
*)
```

```
PROCEDURE Halt (description, filename, function: ARRAY OF CHAR;
               line: CARDINAL) <* noreturn *> ;

(*
  HaltC - provides a more user friendly version of HALT, which takes
         four parameters to aid debugging. It writes an error message
         to stderr and calls exit (1).
*)

PROCEDURE HaltC (description, filename, function: ADDRESS;
               line: CARDINAL) <* noreturn *> ;

(*
  ExitOnHalt - if HALT is executed then call exit with the exit code, e.
*)

PROCEDURE ExitOnHalt (e: INTEGER) ;

(*
  ErrorMessage - emits an error message to stderr and then calls exit (1).
*)

PROCEDURE ErrorMessage (message: ARRAY OF CHAR;
                       filename: ARRAY OF CHAR;
                       line: CARDINAL;
                       function: ARRAY OF CHAR) <* noreturn *> ;

(*
  IsTerminating - Returns true if any coroutine has started program termination
                 and false otherwise.
*)

PROCEDURE IsTerminating () : BOOLEAN ;

(*
  HasHalted - Returns true if a call to HALT has been made and false
             otherwise.
*)

PROCEDURE HasHalted () : BOOLEAN ;
```

```
(*
  Length - returns the length of a string, a. This is called whenever
           the user calls LENGTH and the parameter cannot be calculated
           at compile time.
*)
```

```
PROCEDURE Length (a: ARRAY OF CHAR) : CARDINAL ;
```

```
(*
  The following are the runtime exception handler routines.
*)
```

```
PROCEDURE AssignmentException (filename: ADDRESS; line, column: CARDINAL; scope, message: ADDRESS);
PROCEDURE ReturnException (filename: ADDRESS; line, column: CARDINAL; scope, message: ADDRESS);
PROCEDURE IncException (filename: ADDRESS; line, column: CARDINAL; scope, message: ADDRESS);
PROCEDURE DecException (filename: ADDRESS; line, column: CARDINAL; scope, message: ADDRESS);
PROCEDURE InclException (filename: ADDRESS; line, column: CARDINAL; scope, message: ADDRESS);
PROCEDURE ExclException (filename: ADDRESS; line, column: CARDINAL; scope, message: ADDRESS);
PROCEDURE ShiftException (filename: ADDRESS; line, column: CARDINAL; scope, message: ADDRESS);
PROCEDURE RotateException (filename: ADDRESS; line, column: CARDINAL; scope, message: ADDRESS);
PROCEDURE StaticArraySubscriptException (filename: ADDRESS; line, column: CARDINAL; scope, message: ADDRESS);
PROCEDURE DynamicArraySubscriptException (filename: ADDRESS; line, column: CARDINAL; scope, message: ADDRESS);
PROCEDURE ForLoopBeginException (filename: ADDRESS; line, column: CARDINAL; scope, message: ADDRESS);
PROCEDURE ForLoopToException (filename: ADDRESS; line, column: CARDINAL; scope, message: ADDRESS);
PROCEDURE ForLoopEndException (filename: ADDRESS; line, column: CARDINAL; scope, message: ADDRESS);
PROCEDURE PointerNilException (filename: ADDRESS; line, column: CARDINAL; scope, message: ADDRESS);
PROCEDURE NoReturnException (filename: ADDRESS; line, column: CARDINAL; scope, message: ADDRESS);
PROCEDURE CaseException (filename: ADDRESS; line, column: CARDINAL; scope, message: ADDRESS);
PROCEDURE WholeNonPosDivException (filename: ADDRESS; line, column: CARDINAL; scope, message: ADDRESS);
PROCEDURE WholeNonPosModException (filename: ADDRESS; line, column: CARDINAL; scope, message: ADDRESS);
PROCEDURE WholeZeroDivException (filename: ADDRESS; line, column: CARDINAL; scope, message: ADDRESS);
PROCEDURE WholeZeroRemException (filename: ADDRESS; line, column: CARDINAL; scope, message: ADDRESS);
PROCEDURE WholeValueException (filename: ADDRESS; line, column: CARDINAL; scope, message: ADDRESS);
PROCEDURE RealValueException (filename: ADDRESS; line, column: CARDINAL; scope, message: ADDRESS);
PROCEDURE ParameterException (filename: ADDRESS; line, column: CARDINAL; scope, message: ADDRESS);
PROCEDURE NoException (filename: ADDRESS; line, column: CARDINAL; scope, message: ADDRESS);
```

```
END M2RTS.
```

4.4.27 gm2-libs-iso/MemStream

```
DEFINITION MODULE MemStream ;
```

```
(*
```

```
  Description: provides an ISO module which can write to a memory
                buffer or read from a memory buffer.
```

```
*)
```

```
FROM IOChan IMPORT ChanId ;
```

```
FROM ChanConsts IMPORT FlagSet, OpenResults ;
```

```
FROM SYSTEM IMPORT ADDRESS, LOC ;
```

```
(*
```

```
  Attempts to obtain and open a channel connected to a contiguous
  buffer in memory. The write flag is implied; without the raw
  flag, text is implied. If successful, assigns to cid the identity of
  the opened channel, assigns the value opened to res.
```

```
  If a channel cannot be opened as required,
  the value of res indicates the reason, and cid identifies the
  invalid channel.
```

```
  The parameters, buffer, length and used maybe updated as
  data is written. The buffer maybe reallocated
  and its address might alter, however the parameters will
  always reflect the current active buffer. When this
  channel is closed the buffer is deallocated and
  buffer will be set to NIL, length and used will be set to
  zero.
```

```
*)
```

```
PROCEDURE OpenWrite (VAR cid: ChanId; flags: FlagSet;
```

```
                    VAR res: OpenResults;
```

```
                    VAR buffer: ADDRESS;
```

```
                    VAR length: CARDINAL;
```

```
                    VAR used: CARDINAL;
```

```
                    deallocOnClose: BOOLEAN) ;
```

```
(*
```

```
  Attempts to obtain and open a channel connected to a contiguous
  buffer in memory. The read and old flags are implied; without
  the raw flag, text is implied. If successful, assigns to cid the
  identity of the opened channel, assigns the value opened to res, and
  selects input mode, with the read position corresponding to the start
  of the buffer. If a channel cannot be opened as required, the value of
```

```
    res indicates the reason, and cid identifies the invalid channel.  
*)
```

```
PROCEDURE OpenRead (VAR cid: ChanId; flags: FlagSet;  
                   VAR res: OpenResults;  
                   buffer: ADDRESS; length: CARDINAL;  
                   deallocOnClose: BOOLEAN) ;
```

```
(*  
  Close - if the channel identified by cid is not open to  
          a memory stream, the exception wrongDevice is  
          raised; otherwise closes the channel, and assigns  
          the value identifying the invalid channel to cid.  
*)
```

```
PROCEDURE Close (VAR cid: ChanId) ;
```

```
(*  
  Rewrite - assigns the buffer index to zero. Subsequent  
            writes will overwrite the previous buffer contents.  
*)
```

```
PROCEDURE Rewrite (cid: ChanId) ;
```

```
(*  
  Reread - assigns the buffer index to zero. Subsequent  
           reads will read the previous buffer contents.  
*)
```

```
PROCEDURE Reread (cid: ChanId) ;
```

```
(*  
  IsMem - tests if the channel identified by cid is open as  
          a memory stream.  
*)
```

```
PROCEDURE IsMem (cid: ChanId) : BOOLEAN ;
```

```
END MemStream.
```

4.4.28 gm2-libs-iso/Preemptive

```
DEFINITION MODULE Preemptive ;
```

```
(*  
  initPreemptive - if microsecs > 0 then turn on preemptive scheduling.  
                  if microsecs = 0 then preemptive scheduling is turned off.■  
*)
```

```
PROCEDURE initPreemptive (seconds, microsecs: CARDINAL) ;
```

```
END Preemptive.
```


4.4.29 gm2-libs-iso/Processes

```
DEFINITION MODULE Processes;
```

```
  (* This module allows concurrent algorithms to be expressed using
     processes. A process is a unit of a program that has the
     potential to run in parallel with other processes.
  *)
```

```
IMPORT SYSTEM;
```

```
TYPE
```

```
  ProcessId; (* Used to identify processes *)
  Parameter = SYSTEM.ADDRESS; (* Used to pass data between processes *)
  Body = PROC; (* Used as the type of a process body *)
  Urgency = INTEGER; (* Used by the internal scheduler *)
  Sources = CARDINAL; (* Used to identify event sources *)
  ProcessesExceptions = (* Exceptions raised by this module *)
    (passiveProgram, processError);
```

```
(* The following procedures create processes and switch control between
   them. *)
```

```
PROCEDURE Create (procBody: Body; extraSpace: CARDINAL; procUrg: Urgency;
                 procParams: Parameter; VAR procId: ProcessId);
```

```
  (* Creates a new process with procBody as its body, and with urgency
     and parameters given by procUrg and procParams. At least as
     much workspace (in units of SYSTEM.LOC) as is specified by
     extraSpace is allocated to the process.
     An identity for the new process is returned in procId.
     The process is created in the passive state; it will not run
     until activated.
  *)
```

```
PROCEDURE Start (procBody: Body; extraSpace: CARDINAL; procUrg: Urgency;
                 procParams: Parameter; VAR procId: ProcessId);
```

```
  (* Creates a new process, with parameters as for Create.
     The process is created in the ready state; it is eligible to
     run immediately.
  *)
```

```
PROCEDURE StopMe ();
```

```
  (* Terminates the calling process.
     The process must not be associated with a source of events.
  *)
```

```
PROCEDURE SuspendMe ();
```

(* Causes the calling process to enter the passive state. The procedure only returns when the calling process is again activated by another process.

*)

PROCEDURE Activate (procId: ProcessId);

(* Causes the process identified by procId to enter the ready state, and thus to become eligible to run again.

*)

PROCEDURE SuspendMeAndActivate (procId: ProcessId);

(* Executes an atomic sequence of SuspendMe() and Activate(procId). *)

PROCEDURE Switch (procId: ProcessId; VAR info: Parameter);

(* Causes the calling process to enter the passive state; the process identified by procId becomes the currently executing process. info is used to pass parameter information from the calling to the activated process. On return, info will contain information from the process that chooses to switch back to this one (or will be NIL if Activate or SuspendMeAndActivate are used instead of Switch).

*)

PROCEDURE Wait ();

(* Causes the calling process to enter the waiting state. The procedure will return when the calling process is activated by another process, or when one of its associated eventSources has generated an event.

*)

(* The following procedures allow the association of processes with sources of external events.

*)

PROCEDURE Attach (eventSource: Sources);

(* Associates the specified eventSource with the calling process. *)

PROCEDURE Detach (eventSource: Sources);

(* Dissociates the specified eventSource from the program. *)

PROCEDURE IsAttached (eventSource: Sources): BOOLEAN;

(* Returns TRUE if and only if the specified eventSource is currently associated with one of the processes of the program.

*)

```
PROCEDURE Handler (eventSource: Sources): ProcessId;
  (* Returns the identity of the process, if any, that is
   associated with the specified eventSource.
  *)

(* The following procedures allow processes to obtain their
  identity, parameters, and urgency.
  *)

PROCEDURE Me (): ProcessId;
  (* Returns the identity of the calling process (as assigned
   when the process was first created).
  *)

PROCEDURE MyParam (): Parameter;
  (* Returns the value specified as procParams when the calling
   process was created. *)

PROCEDURE UrgencyOf (procId: ProcessId): Urgency;
  (* Returns the urgency established when the process identified
   by procId was first created.
  *)

(* The following procedure provides facilities for exception
  handlers. *)

PROCEDURE ProcessesException (): ProcessesExceptions;
  (* If the current coroutine is in the exceptional execution state
   because of the raising of a language exception, returns the
   corresponding enumeration value, and otherwise raises an
   exception.
  *)

PROCEDURE IsProcessesException (): BOOLEAN;
  (* Returns TRUE if the current coroutine is in the exceptional
   execution state because of the raising of an exception in
   a routine from this module; otherwise returns FALSE.
  *)

(*
  Reschedule - rotates the ready queue and transfers to the process
  with the highest run priority.
  *)

PROCEDURE Reschedule ;
```

```
(*  
  displayProcesses -  
*)  
  
PROCEDURE displayProcesses (message: ARRAY OF CHAR) ;  
  
END Processes.
```

4.4.30 gm2-libs-iso/ProgramArgs

```
DEFINITION MODULE ProgramArgs;

    (* Access to program arguments *)

IMPORT IOChan;

TYPE
    ChanId = IOChan.ChanId;

PROCEDURE ArgChan (): ChanId;
    (* Returns a value that identifies a channel for reading
       program arguments *)

PROCEDURE IsArgPresent (): BOOLEAN;
    (* Tests if there is a current argument to read from.  If not,
       read <= IOChan.CurrentFlags() will be FALSE, and attempting
       to read from the argument channel will raise the exception
       notAvailable.
    *)

PROCEDURE NextArg ();
    (* If there is another argument, causes subsequent input from the
       argument device to come from the start of the next argument.
       Otherwise there is no argument to read from, and a call of
       IsArgPresent will return FALSE.
    *)

END ProgramArgs.
```

4.4.31 gm2-libs-iso/RTco

```

DEFINITION MODULE FOR "C" RTco ;

FROM SYSTEM IMPORT ADDRESS ;

IMPORT RTentity ; (* Imported so the initialization call graph
                   understands that RTco.cc depends upon RTentity. *)

(* init initializes the module and allows the application to lazily invoke threads. *)

PROCEDURE init () : INTEGER ;

PROCEDURE initThread (p: PROC; stackSize: CARDINAL; interruptLevel: CARDINAL) : INTEGE

PROCEDURE initSemaphore (value: CARDINAL) : INTEGER ;

PROCEDURE wait (semaphore: INTEGER) ;

PROCEDURE signal (semaphore: INTEGER) ;

PROCEDURE transfer (VAR p1: INTEGER; p2: INTEGER) ;

PROCEDURE waitThread (tid: INTEGER) ;

PROCEDURE signalThread (tid: INTEGER) ;

PROCEDURE currentThread () : INTEGER ;

(* currentInterruptLevel returns the interrupt level of the current thread. *)

PROCEDURE currentInterruptLevel () : CARDINAL ;

(* turninterrupts returns the old interrupt level and assigns the interrupt level
   to newLevel. *)

PROCEDURE turnInterrupts (newLevel: CARDINAL) : CARDINAL ;

(*
   select access to the select system call which will be thread safe.
   This is typically called from the idle process to wait for an interrupt.
*)

PROCEDURE select (p1: INTEGER;

```

```
p2: ADDRESS;  
p3: ADDRESS;  
p4: ADDRESS;  
p5: ADDRESS) : INTEGER ;
```

```
END RTco.
```

4.4.32 gm2-libs-iso/RTdata

```
DEFINITION MODULE RTdata ;

(*
   Description: provides a mechanism whereby devices can store
                data attached to a device.
*)

FROM SYSTEM IMPORT ADDRESS ;
FROM IOLink IMPORT DeviceTablePtr ;

TYPE
  ModuleId ;
  FreeProcedure = PROCEDURE (ADDRESS) ;

(*
   MakeModuleId - creates a unique module Id.
*)

PROCEDURE MakeModuleId (VAR m: ModuleId) ;

(*
   InitData - adds, datum, to the device, d. The datum
              is associated with ModuleID, m.
*)

PROCEDURE InitData (d: DeviceTablePtr; m: ModuleId;
                  datum: ADDRESS; f: FreeProcedure) ;

(*
   GetData - returns the datum associated with ModuleId, m.
*)

PROCEDURE GetData (d: DeviceTablePtr; m: ModuleId) : ADDRESS ;

(*
   KillData - destroys the datum associated with ModuleId, m,
              in device, d. It invokes the free procedure
              given during InitData.
*)

PROCEDURE KillData (d: DeviceTablePtr; m: ModuleId) ;
```


END RTdata.

4.4.33 gm2-libs-iso/RTentity

```
DEFINITION MODULE RTentity ;
```

```
(*
```

```
  Description: provides a set of routines for maintaining an
               efficient mechanism to group opaque (or pointer)
               data structures together.  Internally the
               entities are grouped together using a binary
               tree.  It does not use Storage - and instead
               uses malloc, free from libc as Storage uses the
               module to detect erroneous deallocations.
```

```
*)
```

```
IMPORT SYSTEM ;
```

```
TYPE
```

```
  Group ;
```

```
PROCEDURE InitGroup () : Group ;
```

```
PROCEDURE KillGroup (g: Group) : Group ;
```

```
PROCEDURE GetKey (g: Group; a: SYSTEM.ADDRESS) : CARDINAL ;
```

```
PROCEDURE PutKey (g: Group; a: SYSTEM.ADDRESS; key: CARDINAL) ;
```

```
PROCEDURE DelKey (g: Group; a: SYSTEM.ADDRESS) ;
```

```
PROCEDURE IsIn (g: Group; a: SYSTEM.ADDRESS) : BOOLEAN ;
```

```
END RTentity.
```

4.4.34 gm2-libs-iso/RTfio

```
DEFINITION MODULE RTfio ;
```

```
(*
  Description: provides default FIO based methods for the RTgenif
               procedures. These will be used by StreamFile,
               SeqFile, StdChans, TermFile and RndFile.
*)
```

```
FROM SYSTEM IMPORT ADDRESS ;
FROM IOLink IMPORT DeviceTablePtr;
FROM RTgenif IMPORT GenDevIF ;
```

```
(*
  doreadchar - returns a CHAR from the file associated with, g.
*)
```

```
PROCEDURE doreadchar (g: GenDevIF; d: DeviceTablePtr) : CHAR ;
```

```
(*
  dounreadchar - pushes a CHAR back onto the file associated
                 with, g.
*)
```

```
PROCEDURE dounreadchar (g: GenDevIF; d: DeviceTablePtr; ch: CHAR) : CHAR ;■
```

```
(*
  dogeterrno - returns the errno relating to the generic device.
*)
```

```
PROCEDURE dogeterrno (g: GenDevIF; d: DeviceTablePtr) : INTEGER ;
```

```
(*
  dorbytes - reads upto, max, bytes setting, actual, and
             returning FALSE if an error (not due to eof)
             occurred.
*)
```

```
PROCEDURE dorbytes (g: GenDevIF;
                   d: DeviceTablePtr;
                   to: ADDRESS;
                   max: CARDINAL;
```

```
        VAR actual: CARDINAL) : BOOLEAN ;

(*
  dowbytes - writes up to, nBytes.  It returns FALSE
            if an error occurred and it sets actual
            to the amount of data written.
*)

PROCEDURE dowbytes (g: GenDevIF;
                   d: DeviceTablePtr;
                   from: ADDRESS;
                   nBytes: CARDINAL;
                   VAR actual: CARDINAL) : BOOLEAN ;

(*
  dowriteln - attempt to write an end of line marker to the
            file and returns TRUE if successful.
*)

PROCEDURE dowriteln (g: GenDevIF; d: DeviceTablePtr) : BOOLEAN ;

(*
  iseof - returns TRUE if end of file has been seen.
*)

PROCEDURE iseof (g: GenDevIF; d: DeviceTablePtr) : BOOLEAN ;

(*
  iseoln - returns TRUE if end of line has been seen.
*)

PROCEDURE iseoln (g: GenDevIF; d: DeviceTablePtr) : BOOLEAN ;

(*
  iserror - returns TRUE if an error was seen on the device.
            Note that reaching EOF is not classified as an
            error.
*)

PROCEDURE iserror (g: GenDevIF; d: DeviceTablePtr) : BOOLEAN ;

END RTfio.
```

4.4.35 gm2-libs-iso/RTgen

```
DEFINITION MODULE RTgen ;
```

```
(*
  Description: provides a generic device interface between
               ISO channels and the underlying PIM style
               FIO procedure calls.
*)
```

```
FROM RTgenif IMPORT GenDevIF ;
FROM IOLink IMPORT DeviceId, DeviceTablePtr;
FROM IOConsts IMPORT ReadResults ;
FROM SYSTEM IMPORT ADDRESS ;
```

```
TYPE
```

```
  ChanDev ;
  DeviceType = (seqfile, streamfile, programargs, stdchans, term, socket, rndfile) ;
```

```
(*
  InitChanDev - initialize and return a ChanDev.
*)
```

```
PROCEDURE InitChanDev (t: DeviceType; d: DeviceId; g: GenDevIF) : ChanDev ;
```

```
(*
  KillChanDev - deallocates, g.
*)
```

```
PROCEDURE KillChanDev (g: GenDevIF) : GenDevIF ;
```

```
(*
  RaiseEOFInLook - returns TRUE if the Look procedure
                  should raise an exception if it
                  sees end of file.
*)
```

```
PROCEDURE RaiseEOFInLook (g: ChanDev) : BOOLEAN ;
```

```
(*
  RaiseEOFInSkip - returns TRUE if the Skip procedure
                  should raise an exception if it

```

```
                sees end of file.

*)

PROCEDURE RaiseEOFInSkip (g: ChanDev) : BOOLEAN ;

PROCEDURE doLook (g: ChanDev;
                  d: DeviceTablePtr;
                  VAR ch: CHAR;
                  VAR r: ReadResults) ;

PROCEDURE doSkip (g: ChanDev;
                  d: DeviceTablePtr) ;

PROCEDURE doSkipLook (g: ChanDev;
                      d: DeviceTablePtr;
                      VAR ch: CHAR;
                      VAR r: ReadResults) ;

PROCEDURE doWriteLn (g: ChanDev;
                    d: DeviceTablePtr) ;

PROCEDURE doReadText (g: ChanDev;
                      d: DeviceTablePtr;
                      to: ADDRESS;
                      maxChars: CARDINAL;
                      VAR charsRead: CARDINAL) ;

PROCEDURE doWriteText (g: ChanDev;
                       d: DeviceTablePtr;
                       from: ADDRESS;
                       charsToWrite: CARDINAL) ;

PROCEDURE doReadLocs (g: ChanDev;
                      d: DeviceTablePtr;
                      to: ADDRESS;
                      maxLocs: CARDINAL;
                      VAR locsRead: CARDINAL) ;

PROCEDURE doWriteLocs (g: ChanDev;
                       d: DeviceTablePtr;
                       from: ADDRESS;
                       locsToWrite: CARDINAL) ;

(*
    checkErrno - checks a number of errno conditions and raises
                 appropriate ISO exceptions if they occur.
```

*)

```
PROCEDURE checkErrno (g: ChanDev; d: DeviceTablePtr) ;
```

```
END RTgen.
```

4.4.36 gm2-libs-iso/RTgenif

```

DEFINITION MODULE RTgenif ;

(*
  Description: provides a generic interface mechanism used
              by RTgen. This is not an ISO module but rather
              a runtime support module.
*)

FROM SYSTEM IMPORT ADDRESS ;
FROM IOLink IMPORT DeviceId, DeviceTablePtr ;

TYPE
  GenDevIF ;
  readchar   = PROCEDURE (GenDevIF, DeviceTablePtr) : CHAR ;
  unreadchar = PROCEDURE (GenDevIF, DeviceTablePtr, CHAR) : CHAR ;
  geterrno   = PROCEDURE (GenDevIF, DeviceTablePtr) : INTEGER ;
  readbytes  = PROCEDURE (GenDevIF, DeviceTablePtr, ADDRESS, CARDINAL, VAR CARDINAL)
  writebytes = PROCEDURE (GenDevIF, DeviceTablePtr, ADDRESS, CARDINAL, VAR CARDINAL)
  writeln    = PROCEDURE (GenDevIF, DeviceTablePtr) : BOOLEAN ;
  iseof      = PROCEDURE (GenDevIF, DeviceTablePtr) : BOOLEAN ;
  iseoln     = PROCEDURE (GenDevIF, DeviceTablePtr) : BOOLEAN ;
  iserror    = PROCEDURE (GenDevIF, DeviceTablePtr) : BOOLEAN ;

(*
  InitGenDevIF - initializes a generic device.
*)

PROCEDURE InitGenDevIF (d      : DeviceId;
                       rc      : readchar;
                       urc     : unreadchar;
                       geterr  : geterrno;
                       rbytes  : readbytes;
                       wbytes  : writebytes;
                       wl      : writeln;
                       eof     : iseof;
                       eoln    : iseoln;
                       iserr   : iserror) : GenDevIF ;

(*
  getDID - returns the device id this generic interface.
*)

PROCEDURE getDID (g: GenDevIF) : DeviceId ;

```



```
(*
  doReadChar - returns the next character from the generic
                device.
*)
```

```
PROCEDURE doReadChar (g: GenDevIF; d: DeviceTablePtr) : CHAR ;
```

```
(*
  doUnReadChar - pushes back a character to the generic device.
*)
```

```
PROCEDURE doUnReadChar (g: GenDevIF; d: DeviceTablePtr; ch: CHAR) : CHAR ;
```

```
(*
  doGetErrno - returns the errno relating to the generic device.
*)
```

```
PROCEDURE doGetErrno (g: GenDevIF; d: DeviceTablePtr) : INTEGER ;
```

```
(*
  doRBytes - attempts to read, n, bytes from the generic device.
             It set the actual amount read and returns a boolean
             to determine whether an error occurred.
*)
```

```
PROCEDURE doRBytes (g: GenDevIF; d: DeviceTablePtr;
                  to: ADDRESS; max: CARDINAL;
                  VAR actual: CARDINAL) : BOOLEAN ;
```

```
(*
  doWBytes - attempts to write, n, bytes to the generic device.
             It sets the actual amount written and returns a
             boolean to determine whether an error occurred.
*)
```

```
PROCEDURE doWBytes (g: GenDevIF; d: DeviceTablePtr;
                  from: ADDRESS; max: CARDINAL;
                  VAR actual: CARDINAL) : BOOLEAN ;
```

```
(*
```

```
    doWrLn - writes an end of line marker and returns
            TRUE if successful.
*)

PROCEDURE doWrLn (g: GenDevIF; d: DeviceTablePtr) : BOOLEAN ;

(*
    isEOF - returns true if the end of file was reached.
*)

PROCEDURE isEOF (g: GenDevIF; d: DeviceTablePtr) : BOOLEAN ;

(*
    isEOLN - returns true if the end of line was reached.
*)

PROCEDURE isEOLN (g: GenDevIF; d: DeviceTablePtr) : BOOLEAN ;

(*
    isError - returns true if an error was seen in the device.
*)

PROCEDURE isError (g: GenDevIF; d: DeviceTablePtr) : BOOLEAN ;

(*
    KillGenDevIF - deallocates a generic device.
*)

PROCEDURE KillGenDevIF (g: GenDevIF) : GenDevIF ;

END RTgenif.
```

4.4.37 gm2-libs-iso/RTio

```
DEFINITION MODULE RTio ;
```

```
(*
```

```
  Description: provides low level routines for creating and destroying  
              ChanIds. This is necessary to allow multiple modules  
              to create, ChanId values, where ChanId is an opaque  
              type.
```

```
*)
```

```
IMPORT FIO, IOLink ;
```

```
TYPE
```

```
  ChanId ;
```

```
(*
```

```
  InitChanId - return a new ChanId.
```

```
*)
```

```
PROCEDURE InitChanId () : ChanId ;
```

```
(*
```

```
  KillChanId - deallocate a ChanId.
```

```
*)
```

```
PROCEDURE KillChanId (c: ChanId) : ChanId ;
```

```
(*
```

```
  NilChanId - return a NIL pointer.
```

```
*)
```

```
PROCEDURE NilChanId () : ChanId ;
```

```
(*
```

```
  GetDeviceId - returns the device id, from, c.
```

```
*)
```

```
PROCEDURE GetDeviceId (c: ChanId) : IOLink.DeviceId ;
```

```
(*
```

```
  SetDeviceId - sets the device id in, c.
```

```
*)  
  
PROCEDURE SetDeviceId (c: ChanId; d: IOLink.DeviceId) ;  
  
(*  
  GetDevicePtr - returns the device table ptr, from, c.  
*)  
  
PROCEDURE GetDevicePtr (c: ChanId) : IOLink.DeviceTablePtr ;  
  
(*  
  SetDevicePtr - sets the device table ptr in, c.  
*)  
  
PROCEDURE SetDevicePtr (c: ChanId; p: IOLink.DeviceTablePtr) ;  
  
(*  
  GetFile - returns the file field from, c.  
*)  
  
PROCEDURE GetFile (c: ChanId) : FIO.File ;  
  
(*  
  SetFile - sets the file field in, c.  
*)  
  
PROCEDURE SetFile (c: ChanId; f: FIO.File) ;  
  
END RTio.
```

4.4.38 gm2-libs-iso/RandomNumber

```
DEFINITION MODULE RandomNumber ;

(*
  Description: provides primitives for obtaining random numbers on
  pervasive data types.
*)

FROM SYSTEM IMPORT BYTE ;
EXPORT QUALIFIED Randomize, RandomInit, RandomBytes,
  RandomCard, RandomShortCard, RandomLongCard,
  RandomInt, RandomShortInt, RandomLongInt,
  RandomReal, RandomLongReal, RandomShortReal ;

(*
  Randomize - initialize the random number generator with a seed
  based on the microseconds.
*)

PROCEDURE Randomize ;

(*
  RandomInit - initialize the random number generator with value, seed.
*)

PROCEDURE RandomInit (seed: CARDINAL) ;

(*
  RandomBytes - fills in an array with random values.
*)

PROCEDURE RandomBytes (VAR a: ARRAY OF BYTE) ;

(*
  RandomInt - return an INTEGER in the range [low .. high].
*)

PROCEDURE RandomInt (low, high: INTEGER) : INTEGER ;

(*
  RandomShortInt - return an SHORTINT in the range [low..high].
*)
```

```
*)

PROCEDURE RandomShortInt (low, high: SHORTINT) : SHORTINT ;

(*
  RandomLongInt - return an LONGINT in the range [low..high].
*)

PROCEDURE RandomLongInt (low, high: LONGINT) : LONGINT ;

(*
  RandomShortCard - return a SHORTCARD in the range [low..high].
*)

PROCEDURE RandomShortCard (low, high: CARDINAL) : CARDINAL ;

(*
  RandomCard - return a CARDINAL in the range [low..high].
*)

PROCEDURE RandomCard (low, high: CARDINAL) : CARDINAL ;

(*
  RandomLongCard - return an LONGCARD in the range [low..high].
*)

PROCEDURE RandomLongCard (low, high: LONGCARD) : LONGCARD ;

(*
  RandomReal - return a REAL number in the range 0.0..1.0
*)

PROCEDURE RandomReal () : REAL ;

(*
  RandomShortReal - return a SHORTREAL number in the range 0.0..1.0
*)

PROCEDURE RandomShortReal () : SHORTREAL ;
```

```
(*  
  RandomLongReal - return a LONGREAL number in the range 0.0..1.0  
*)  
  
PROCEDURE RandomLongReal () : LONGREAL ;  
  
END RandomNumber.
```

4.4.39 gm2-libs-iso/RawIO

```
DEFINITION MODULE RawIO;
```

```
    (* Reading and writing data over specified channels using raw
       operations, that is, with no conversion or interpretation.
       The read result is of the type IOConsts.ReadResults.
    *)
```

```
IMPORT IOChan, SYSTEM;
```

```
PROCEDURE Read (cid: IOChan.ChanId; VAR to: ARRAY OF SYSTEM.LOC);
    (* Reads storage units from cid, and assigns them to
       successive components of to. The read result is set
       to the value allRight, wrongFormat, or endOfInput.
    *)
```

```
PROCEDURE Write (cid: IOChan.ChanId; from: ARRAY OF SYSTEM.LOC);
    (* Writes storage units to cid from successive components
       of from. *)
```

```
END RawIO.
```


4.4.40 gm2-libs-iso/RealConv

```
DEFINITION MODULE RealConv;

    (* Low-level REAL/string conversions *)

IMPORT
    ConvTypes;

TYPE
    (* strAllRight, strOutOfRange, strWrongFormat, strEmpty *)
    ConvResults = ConvTypes.ConvResults;

PROCEDURE ScanReal (inputCh: CHAR; VAR chClass: ConvTypes.ScanClass;
                   VAR nextState: ConvTypes.ScanState);
    (* Represents the start state of a finite state scanner for real
       numbers - assigns class of inputCh to chClass and a procedure
       representing the next state to nextState.
    *)

PROCEDURE FormatReal (str: ARRAY OF CHAR): ConvResults;
    (* Returns the format of the string value for conversion to REAL. *)

PROCEDURE ValueReal (str: ARRAY OF CHAR): REAL;
    (* Returns the value corresponding to the real number string value
       str if str is well-formed; otherwise raises the RealConv
       exception.
    *)

PROCEDURE LengthFloatReal (real: REAL; sigFigs: CARDINAL): CARDINAL;
    (* Returns the number of characters in the floating-point string
       representation of real with sigFigs significant figures.
    *)

PROCEDURE LengthEngReal (real: REAL; sigFigs: CARDINAL): CARDINAL;
    (* Returns the number of characters in the floating-point engineering
       string representation of real with sigFigs significant figures.
    *)

PROCEDURE LengthFixedReal (real: REAL; place: INTEGER): CARDINAL;
    (* Returns the number of characters in the fixed-point string
       representation of real rounded to the given place relative to the
       decimal point.
    *)

PROCEDURE IsRConvException (): BOOLEAN;
    (* Returns TRUE if the current coroutine is in the exceptional
```

execution state because of the raising of an exception in a routine from this module; otherwise returns FALSE.

*)

END RealConv.

4.4.41 gm2-libs-iso/RealIO

```
DEFINITION MODULE RealIO;
```

```
(* Input and output of real numbers in decimal text form
   over specified channels. The read result is of the
   type IOConsts.ReadResults.
*)
```

```
IMPORT IOChan;
```

```
(* The text form of a signed fixed-point real number is
   ["+" | "-"], decimal digit, {decimal digit},
   [".", {decimal digit}]
```

```
The text form of a signed floating-point real number is
   signed fixed-point real number,
   "E", ["+" | "-"], decimal digit, {decimal digit}
*)
```

```
PROCEDURE ReadReal (cid: IOChan.ChanId; VAR real: REAL);
```

```
(* Skips leading spaces, and removes any remaining characters
   from cid that form part of a signed fixed or floating
   point number. The value of this number is assigned to real.
   The read result is set to the value allRight, outOfRange,
   wrongFormat, endOfLine, or endOfInput.
*)
```

```
PROCEDURE WriteFloat (cid: IOChan.ChanId; real: REAL;
                     sigFigs: CARDINAL; width: CARDINAL);
```

```
(* Writes the value of real to cid in floating-point text form,
   with sigFigs significant figures, in a field of the given
   minimum width.
*)
```

```
PROCEDURE WriteEng (cid: IOChan.ChanId; real: REAL;
                   sigFigs: CARDINAL; width: CARDINAL);
```

```
(* As for WriteFloat, except that the number is scaled with
   one to three digits in the whole number part, and with an
   exponent that is a multiple of three.
*)
```

```
PROCEDURE WriteFixed (cid: IOChan.ChanId; real: REAL;
                    place: INTEGER; width: CARDINAL);
```

```
(* Writes the value of real to cid in fixed-point text form,
   rounded to the given place relative to the decimal point,
   in a field of the given minimum width.
```

```
*)  
  
PROCEDURE WriteReal (cid: IOChan.ChanId;  
                    real: REAL; width: CARDINAL);  
  (* Writes the value of real to cid, as WriteFixed if the sign  
    and magnitude can be shown in the given width, or otherwise  
    as WriteFloat. The number of places or significant digits  
    depends on the given width.  
  *)  
  
END RealIO.
```

4.4.42 gm2-libs-iso/RealMath

```
DEFINITION MODULE RealMath;

    (* Mathematical functions for the type REAL *)

CONST
    pi    = 3.1415926535897932384626433832795028841972;
    exp1  = 2.7182818284590452353602874713526624977572;

PROCEDURE __BUILTIN__ sqrt (x: REAL): REAL;
    (* Returns the positive square root of x *)

PROCEDURE __BUILTIN__ exp (x: REAL): REAL;
    (* Returns the exponential of x *)

PROCEDURE __BUILTIN__ ln (x: REAL): REAL;
    (* Returns the natural logarithm of x *)

    (* The angle in all trigonometric functions is measured in radians *)

PROCEDURE __BUILTIN__ sin (x: REAL): REAL;
    (* Returns the sine of x *)

PROCEDURE __BUILTIN__ cos (x: REAL): REAL;
    (* Returns the cosine of x *)

PROCEDURE tan (x: REAL): REAL;
    (* Returns the tangent of x *)

PROCEDURE arcsin (x: REAL): REAL;
    (* Returns the arcsine of x *)

PROCEDURE arccos (x: REAL): REAL;
    (* Returns the arccosine of x *)

PROCEDURE arctan (x: REAL): REAL;
    (* Returns the arctangent of x *)

PROCEDURE power (base, exponent: REAL) : REAL;
    (* Returns the value of the number base raised to the power exponent *)

PROCEDURE round (x: REAL) : INTEGER;
    (* Returns the value of x rounded to the nearest integer *)

PROCEDURE IsRMathException () : BOOLEAN;
    (* Returns TRUE if the current coroutine is in the exceptional execution state
```

```
because of the raising of an exception in a routine from this module; otherwise  
returns FALSE.
```

```
*)
```

```
END RealMath.
```

4.4.43 gm2-libs-iso/RealStr

```

DEFINITION MODULE RealStr;

    (* REAL/string conversions *)

IMPORT
    ConvTypes;

TYPE
    (* strAllRight, strOutOfRange, strWrongFormat, strEmpty *)
    ConvResults = ConvTypes.ConvResults;

    (* the string form of a signed fixed-point real number is
       ["+" | "-"], decimal digit, {decimal digit}, [".",
       {decimal digit}]
    *)

    (* the string form of a signed floating-point real number is
       signed fixed-point real number, "E", ["+" | "-"],
       decimal digit, {decimal digit}
    *)

PROCEDURE StrToReal (str: ARRAY OF CHAR; VAR real: REAL;
                    VAR res: ConvResults);
    (* Ignores any leading spaces in str. If the subsequent characters
       in str are in the format of a signed real number, assigns a
       corresponding value to real. Assigns a value indicating the
       format of str to res.
    *)

PROCEDURE RealToFloat (real: REAL; sigFigs: CARDINAL;
                      VAR str: ARRAY OF CHAR);
    (* Converts the value of real to floating-point string form, with
       sigFigs significant figures, and copies the possibly truncated
       result to str.
    *)

PROCEDURE RealToEng (real: REAL; sigFigs: CARDINAL;
                    VAR str: ARRAY OF CHAR);
    (* Converts the value of real to floating-point string form, with
       sigFigs significant figures, and copies the possibly truncated
       result to str. The number is scaled with one to three digits
       in the whole number part and with an exponent that is a multiple
       of three.
    *)

```

```
PROCEDURE RealToFixed (real: REAL; place: INTEGER;
                      VAR str: ARRAY OF CHAR);
  (* Converts the value of real to fixed-point string form, rounded
     to the given place relative to the decimal point, and copies
     the possibly truncated result to str.
  *)

PROCEDURE RealToStr (real: REAL; VAR str: ARRAY OF CHAR);
  (* Converts the value of real as RealToFixed if the sign and
     magnitude can be shown within the capacity of str, or
     otherwise as RealToFloat, and copies the possibly truncated
     result to str. The number of places or significant digits are
     implementation-defined.
  *)

END RealStr.
```


4.4.44 gm2-libs-iso/RndFile

```

DEFINITION MODULE RndFile;

    (* Random access files *)

IMPORT IOChan, ChanConsts, SYSTEM;

TYPE
    ChanId = IOChan.ChanId;
    FlagSet = ChanConsts.FlagSet;
    OpenResults = ChanConsts.OpenResults;

    (* Accepted singleton values of FlagSet *)

CONST
    (* input operations are requested/available *)
    read = FlagSet{ChanConsts.readFlag};
    (* output operations are requested/available *)
    write = FlagSet{ChanConsts.writeFlag};
    (* a file may/must/did exist before the channel is opened *)
    old = FlagSet{ChanConsts.oldFlag};
    (* text operations are requested/available *)
    text = FlagSet{ChanConsts.textFlag};
    (* raw operations are requested/available *)
    raw = FlagSet{ChanConsts.rawFlag};

PROCEDURE OpenOld (VAR cid: ChanId; name: ARRAY OF CHAR; flags: FlagSet;
    VAR res: OpenResults);
    (* Attempts to obtain and open a channel connected to a stored random
    access file of the given name.
    The old flag is implied; without the write flag, read is implied;
    without the text flag, raw is implied.
    If successful, assigns to cid the identity of the opened channel,
    assigns the value opened to res, and sets the read/write position
    to the start of the file.
    If a channel cannot be opened as required, the value of res indicates
    the reason, and cid identifies the invalid channel.
    *)

PROCEDURE OpenClean (VAR cid: ChanId; name: ARRAY OF CHAR; flags: FlagSet;
    VAR res: OpenResults);
    (* Attempts to obtain and open a channel connected to a stored random
    access file of the given name.
    The write flag is implied; without the text flag, raw is implied.
    If successful, assigns to cid the identity of the opened channel,
    assigns the value opened to res, and truncates the file to zero length.

```

If a channel cannot be opened as required, the value of res indicates the reason, and cid identifies the invalid channel.

*)

```
PROCEDURE IsRndFile (cid: ChanId): BOOLEAN;
```

(* Tests if the channel identified by cid is open to a random access file. *)

```
PROCEDURE IsRndFileException (): BOOLEAN;
```

(* Returns TRUE if the current coroutine is in the exceptional execution state because of the raising of a RndFile exception; otherwise returns FALSE.

*)

```
CONST
```

```
FilePosSize = SIZE(LONGINT) ;
```

(* <implementation-defined whole number greater than zero>; *)

```
TYPE
```

```
FilePos = LONGINT ; (* ARRAY [1 .. FilePosSize] OF SYSTEM.LOC; *)
```

```
PROCEDURE StartPos (cid: ChanId): FilePos;
```

(* If the channel identified by cid is not open to a random access file, the exception wrongDevice is raised; otherwise returns the position of the start of the file.

*)

```
PROCEDURE CurrentPos (cid: ChanId): FilePos;
```

(* If the channel identified by cid is not open to a random access file, the exception wrongDevice is raised; otherwise returns the position of the current read/write position.

*)

```
PROCEDURE EndPos (cid: ChanId): FilePos;
```

(* If the channel identified by cid is not open to a random access file, the exception wrongDevice is raised; otherwise returns the first position after which there have been no writes.

*)

```
PROCEDURE NewPos (cid: ChanId; chunks: INTEGER; chunkSize: CARDINAL;
                 from: FilePos): FilePos;
```

(* If the channel identified by cid is not open to a random access file, the exception wrongDevice is raised; otherwise returns the position (chunks * chunkSize) relative to the position given by from, or raises the exception posRange if the required position cannot be represented as a value of type FilePos.

*)

```
PROCEDURE SetPos (cid: ChanId; pos: FilePos);
  (* If the channel identified by cid is not open to a random access file,
    the exception wrongDevice is raised; otherwise sets the read/write
    position to the value given by pos.
  *)

PROCEDURE Close (VAR cid: ChanId);
  (* If the channel identified by cid is not open to a random access file,
    the exception wrongDevice is raised; otherwise closes the channel,
    and assigns the value identifying the invalid channel to cid.
  *)

END RndFile.
```

4.4.45 gm2-libs-iso/SIOResult

```
DEFINITION MODULE SIOResult;

    (* Read results for the default input channel *)

IMPORT IOConsts;

TYPE
    ReadResults = IOConsts.ReadResults;

    (*
    ReadResults =    (* This type is used to classify the result of an input operation
    (
        notKnown,    (* no read result is set *)
        allRight,    (* data is as expected or as required *)
        outOfRange,  (* data cannot be represented *)
        wrongFormat, (* data not in expected format *)
        endOfLine,   (* end of line seen before expected data *)
        endOfInput   (* end of input seen before expected data *)
    );
    *)

PROCEDURE ReadResult (): ReadResults;
    (* Returns the result for the last read operation on the default input channel. *)

END SIOResult.
```

4.4.46 gm2-libs-iso/SLongIO

```
DEFINITION MODULE SLongIO;
```

```
(* Input and output of long real numbers in decimal text form
   using default channels. The read result is of the type
   IOConsts.ReadResults.
```

```
*)
```

```
(* The text form of a signed fixed-point real number is
   ["+" | "-"], decimal digit, {decimal digit},
   [".", {decimal digit}]
```

```
The text form of a signed floating-point real number is
signed fixed-point real number,
"E", ["+" | "-"], decimal digit, {decimal digit}
```

```
*)
```

```
PROCEDURE ReadReal (VAR real: LONGREAL);
```

```
(* Skips leading spaces, and removes any remaining characters
   from the default input channel that form part of a signed
   fixed or floating point number. The value of this number
   is assigned to real. The read result is set to the value
   allRight, outOfRange, wrongFormat, endOfLine, or endOfInput.
```

```
*)
```

```
PROCEDURE WriteFloat (real: LONGREAL; sigFigs: CARDINAL;
                     width: CARDINAL);
```

```
(* Writes the value of real to the default output channel in
   floating-point text form, with sigFigs significant figures,
   in a field of the given minimum width.
```

```
*)
```

```
PROCEDURE WriteEng (real: LONGREAL; sigFigs: CARDINAL;
                   width: CARDINAL);
```

```
(* As for WriteFloat, except that the number is scaled with
   one to three digits in the whole number part, and with an
   exponent that is a multiple of three.
```

```
*)
```

```
PROCEDURE WriteFixed (real: LONGREAL; place: INTEGER;
                    width: CARDINAL);
```

```
(* Writes the value of real to the default output channel in
   fixed-point text form, rounded to the given place relative
   to the decimal point, in a field of the given minimum width.
```

```
*)
```

```
PROCEDURE WriteReal (real: LONGREAL; width: CARDINAL);
  (* Writes the value of real to the default output channel, as
    WriteFixed if the sign and magnitude can be shown in the
    given width, or otherwise as WriteFloat. The number of
    places or significant digits depends on the given width.
  *)

END SLongIO.
```

4.4.47 gm2-libs-iso/SLongWholeIO

DEFINITION MODULE SLongWholeIO;

(* Input and output of whole numbers in decimal text form over default channels. The read result is of the type IOConsts.ReadResults.

*)

(* The text form of a signed whole number is
["+" | "-"], decimal digit, {decimal digit}

The text form of an unsigned whole number is
decimal digit, {decimal digit}

*)

PROCEDURE ReadInt (VAR int: LONGINT);

(* Skips leading spaces, and removes any remaining characters from the default input channel that form part of a signed whole number. The value of this number is assigned to int. The read result is set to the value allRight, outOfRange, wrongFormat, endOfLine, or endOfInput.

*)

PROCEDURE WriteInt (int: LONGINT; width: CARDINAL);

(* Writes the value of int to the default output channel in text form, in a field of the given minimum width.

*)

PROCEDURE ReadCard (VAR card: LONGCARD);

(* Skips leading spaces, and removes any remaining characters from the default input channel that form part of an unsigned whole number. The value of this number is assigned to card. The read result is set to the value allRight, outOfRange, wrongFormat, endOfLine, or endOfInput.

*)

PROCEDURE WriteCard (card: LONGCARD; width: CARDINAL);

(* Writes the value of card to the default output channel in text form, in a field of the given minimum width.

*)

END SLongWholeIO.

4.4.48 gm2-libs-iso/SRawIO

```
DEFINITION MODULE SRawIO;
```

```
    (* Reading and writing data over default channels using raw operations, that is, with  
    conversion or interpretation. The read result is of the type IOConsts.ReadResults  
    *)
```

```
IMPORT SYSTEM;
```

```
PROCEDURE Read (VAR to: ARRAY OF SYSTEM.LOC);
```

```
    (* Reads storage units from the default input channel, and assigns them to successive  
    components of to. The read result is set to the value allRight, wrongFormat, or  
    endOfInput.  
    *)
```

```
PROCEDURE Write (from: ARRAY OF SYSTEM.LOC);
```

```
    (* Writes storage units to the default output channel from successive components of  
    *)
```

```
END SRawIO.
```


4.4.49 gm2-libs-iso/SRealIO

DEFINITION MODULE SRealIO;

(* Input and output of real numbers in decimal text form over default channels. The read result is of the type IOConsts.ReadResults.

*)

(* The text form of a signed fixed-point real number is ["+" | "-"], decimal digit, {decimal digit}, [".", {decimal digit}]

The text form of a signed floating-point real number is signed fixed-point real number, "E", ["+" | "-"], decimal digit, {decimal digit}

*)

PROCEDURE ReadReal (VAR real: REAL);

(* Skips leading spaces, and removes any remaining characters from the default input channel that form part of a signed fixed or floating point number. The value of this number is assigned to real. The read result is set to the value allRight, outOfRange, wrongFormat, endOfLine, or endOfInput.

*)

PROCEDURE WriteFloat (real: REAL; sigFigs: CARDINAL; width: CARDINAL);

(* Writes the value of real to the default output channel in floating-point text form, with sigFigs significant figures, in a field of the given minimum width.

*)

PROCEDURE WriteEng (real: REAL; sigFigs: CARDINAL; width: CARDINAL);

(* As for WriteFloat, except that the number is scaled with one to three digits in the whole number part, and with an exponent that is a multiple of three.

*)

PROCEDURE WriteFixed (real: REAL; place: INTEGER; width: CARDINAL);

(* Writes the value of real to the default output channel in fixed-point text form, rounded to the given place relative to the decimal point, in a field of the given minimum width.

*)

PROCEDURE WriteReal (real: REAL; width: CARDINAL);

(* Writes the value of real to the default output channel, as WriteFixed if the sign and magnitude can be shown in the

given width, or otherwise as WriteFloat. The number of places or significant digits depends on the given width.
*)

END SRealIO.

4.4.50 gm2-libs-iso/SShortIO

DEFINITION MODULE SShortIO;

(* Input and output of short real numbers in decimal text form using default channels. The read result is of the type IOConsts.ReadResults.

*)

(* The text form of a signed fixed-point real number is ["+" | "-"], decimal digit, {decimal digit}, [".", {decimal digit}]

The text form of a signed floating-point real number is signed fixed-point real number, "E", ["+" | "-"], decimal digit, {decimal digit}

*)

PROCEDURE ReadReal (VAR real: SHORTREAL);

(* Skips leading spaces, and removes any remaining characters from the default input channel that form part of a signed fixed or floating point number. The value of this number is assigned to real. The read result is set to the value allRight, outOfRange, wrongFormat, endOfLine, or endOfInput.

*)

PROCEDURE WriteFloat (real: SHORTREAL; sigFigs: CARDINAL;
width: CARDINAL);

(* Writes the value of real to the default output channel in floating-point text form, with sigFigs significant figures, in a field of the given minimum width.

*)

PROCEDURE WriteEng (real: SHORTREAL; sigFigs: CARDINAL;
width: CARDINAL);

(* As for WriteFloat, except that the number is scaled with one to three digits in the whole number part, and with an exponent that is a multiple of three.

*)

PROCEDURE WriteFixed (real: SHORTREAL; place: INTEGER;
width: CARDINAL);

(* Writes the value of real to the default output channel in fixed-point text form, rounded to the given place relative to the decimal point, in a field of the given minimum width.

*)

```
PROCEDURE WriteReal (real: SHORTREAL; width: CARDINAL);
  (* Writes the value of real to the default output channel, as
    WriteFixed if the sign and magnitude can be shown in the
    given width, or otherwise as WriteFloat. The number of
    places or significant digits depends on the given width.
  *)

END SShortIO.
```

4.4.51 gm2-libs-iso/SShortWholeIO

DEFINITION MODULE SShortWholeIO;

(* Input and output of whole numbers in decimal text form over default channels. The read result is of the type IOConsts.ReadResults.

*)

(* The text form of a signed whole number is
["+" | "-"], decimal digit, {decimal digit}

The text form of an unsigned whole number is
decimal digit, {decimal digit}

*)

PROCEDURE ReadInt (VAR int: SHORTINT);

(* Skips leading spaces, and removes any remaining characters from the default input channel that form part of a signed whole number. The value of this number is assigned to int. The read result is set to the value allRight, outOfRange, wrongFormat, endOfLine, or endOfInput.

*)

PROCEDURE WriteInt (int: SHORTINT; width: CARDINAL);

(* Writes the value of int to the default output channel in text form, in a field of the given minimum width.

*)

PROCEDURE ReadCard (VAR card: SHORTCARD);

(* Skips leading spaces, and removes any remaining characters from the default input channel that form part of an unsigned whole number. The value of this number is assigned to card. The read result is set to the value allRight, outOfRange, wrongFormat, endOfLine, or endOfInput.

*)

PROCEDURE WriteCard (card: SHORTCARD; width: CARDINAL);

(* Writes the value of card to the default output channel in text form, in a field of the given minimum width.

*)

END SShortWholeIO.

4.4.52 gm2-libs-iso/STextIO

```
DEFINITION MODULE STextIO;
```

```
(* Input and output of character and string types over default channels. The read result
   is of the type IOConsts.ReadResults.
*)
```

```
(* The following procedures do not read past line marks *)
```

```
PROCEDURE ReadChar (VAR ch: CHAR);
```

```
(* If possible, removes a character from the default input stream, and assigns the
   corresponding value to ch. The read result is set to allRight, endOfLine or
   endOfInput.
*)
```

```
PROCEDURE ReadRestLine (VAR s: ARRAY OF CHAR);
```

```
(* Removes any remaining characters from the default input stream before the next line
   mark, copying to s as many as can be accommodated as a string value. The read result
   is set to the value allRight, outOfRange, endOfLine, or endOfInput.
*)
```

```
PROCEDURE ReadString (VAR s: ARRAY OF CHAR);
```

```
(* Removes only those characters from the default input stream before the next line
   mark that can be accommodated in s as a string value, and copies them to s. The read result
   is set to the value allRight, endOfLine, or endOfInput.
*)
```

```
PROCEDURE ReadToken (VAR s: ARRAY OF CHAR);
```

```
(* Skips leading spaces, and then removes characters from the default input stream before
   the next space or line mark, copying to s as many as can be accommodated as a string
   value. The read result is set to the value allRight, outOfRange, endOfLine, or
   endOfInput.
*)
```

```
(* The following procedure reads past the next line mark *)
```

```
PROCEDURE SkipLine;
```

```
(* Removes successive items from the default input stream up to and including the next
   line mark or until the end of input is reached. The read result is set to the value
   allRight, or endOfInput.
*)
```

```
(* Output procedures *)
```

```
PROCEDURE WriteChar (ch: CHAR);
```

```
    (* Writes the value of ch to the default output stream. *)  
  
PROCEDURE WriteLn;  
    (* Writes a line mark to the default output stream. *)  
  
PROCEDURE WriteString (s: ARRAY OF CHAR);  
    (* Writes the string value of s to the default output stream. *)  
  
END STextIO.
```

4.4.53 gm2-libs-iso/SWholeIO

```
DEFINITION MODULE SWholeIO;
```

```
(* Input and output of whole numbers in decimal text form over
   default channels. The read result is of the type
   IOConsts.ReadResults.
```

```
*)
```

```
(* The text form of a signed whole number is
   ["+" | "-"], decimal digit, {decimal digit}
```

```
   The text form of an unsigned whole number is
   decimal digit, {decimal digit}
```

```
*)
```

```
PROCEDURE ReadInt (VAR int: INTEGER);
```

```
(* Skips leading spaces, and removes any remaining characters
   from the default input channel that form part of a signed
   whole number. The value of this number is assigned
   to int. The read result is set to the value allRight,
   outOfRange, wrongFormat, endOfLine, or endOfInput.
```

```
*)
```

```
PROCEDURE WriteInt (int: INTEGER; width: CARDINAL);
```

```
(* Writes the value of int to the default output channel in
   text form, in a field of the given minimum width.
```

```
*)
```

```
PROCEDURE ReadCard (VAR card: CARDINAL);
```

```
(* Skips leading spaces, and removes any remaining characters
   from the default input channel that form part of an
   unsigned whole number. The value of this number is
   assigned to card. The read result is set to the value
   allRight, outOfRange, wrongFormat, endOfLine, or endOfInput.
```

```
*)
```

```
PROCEDURE WriteCard (card: CARDINAL; width: CARDINAL);
```

```
(* Writes the value of card to the default output channel in
   text form, in a field of the given minimum width.
```

```
*)
```

```
END SWholeIO.
```


4.4.54 gm2-libs-iso/SYSTEM

```

DEFINITION MODULE SYSTEM;

    (* Gives access to system programming facilities that are probably
       non portable. *)

    (* The constants and types define underlying properties of storage *)

EXPORT QUALIFIED BITS_PERLOC, LOCSPERWORD,
    LOC, BYTE, WORD, ADDRESS, CSIZE_T, CSSIZE_T, (*
    Target specific data types. *)
    ADDADR, SUBADR, DIFADR, MAKEADR, ADR, ROTATE,
    SHIFT, CAST, TSIZE,

    (* Internal GM2 compiler functions *)
    ShiftVal, ShiftLeft, ShiftRight,
    RotateVal, RotateLeft, RotateRight,
    THROW, TBITSIZE ;

CONST

    (* <implementation-defined constant> ; *)
    BITS_PERLOC    = __ATTRIBUTE__ __BUILTIN__ ((BITS_PER_UNIT)) ;
    (* <implementation-defined constant> ; *)
    LOCSPERWORD    = __ATTRIBUTE__ __BUILTIN__ ((UNITS_PER_WORD)) ;
    (* <implementation-defined constant> ; *)
    LOCSPERBYTE    = 8 DIV BITS_PERLOC ;

    (* Note that the full list of system and sized datatypes include:
       LOC, WORD, BYTE, ADDRESS,

       (and the non language standard target types)

       INTEGER8, INTEGER16, INTEGER32, INTEGER64,
       CARDINAL8, CARDINAL16, CARDINAL32, CARDINAL64,
       WORD16, WORD32, WORD64, BITSET8, BITSET16,
       BITSET32, REAL32, REAL64, REAL128, COMPLEX32,
       COMPLEX64, COMPLEX128, CSIZE_T, CSSIZE_T.

       Also note that the non-standard data types will
       move into another module in the future. *)

    (*
       All the data types and procedures below are declared internally.
       =====

```

```

TYPE

```

(* Target specific data types. *)

TYPE

```
LOC; (* A system basic type. Values are the uninterpreted
      contents of the smallest addressable unit of storage *)
ADDRESS = POINTER TO LOC;
WORD = ARRAY [0 .. LOCSPERWORD-1] OF LOC;
```

(* BYTE and LOCSPERBYTE are provided if appropriate for machine *)

TYPE

```
BYTE = ARRAY [0 .. LOCSPERBYTE-1] OF LOC;
```

```
PROCEDURE ADDADR (addr: ADDRESS; offset: CARDINAL): ADDRESS;
```

(* Returns address given by (addr + offset), or may raise an exception if this address is not valid.

*)

```
PROCEDURE SUBADR (addr: ADDRESS; offset: CARDINAL): ADDRESS;
```

(* Returns address given by (addr - offset), or may raise an exception if this address is not valid.

*)

```
PROCEDURE DIFADR (addr1, addr2: ADDRESS): INTEGER;
```

(* Returns the difference between addresses (addr1 - addr2), or may raise an exception if the arguments are invalid or address space is non-contiguous.

*)

```
PROCEDURE MAKEADR (high: <some type>; ...): ADDRESS;
```

(* Returns an address constructed from a list of values whose types are implementation-defined, or may raise an exception if this address is not valid.

In GNU Modula-2, MAKEADR can take any number of arguments which are mapped onto the type ADDRESS. The first parameter maps onto the high address bits and subsequent parameters map onto lower address bits. For example:

```
a := MAKEADR(BYTE(OFEH), BYTE(ODCH), BYTE(OBAH), BYTE(O98H),
             BYTE(O76H), BYTE(O54H), BYTE(O32H), BYTE(O10H)) ;
```

then the value of, a, on a 64 bit machine is: 0FEDCBA9876543210H

The parameters do not have to be the same type, but constants `_must_` be typed.

*)

```
PROCEDURE ADR (VAR v: <anytype>): ADDRESS;
  (* Returns the address of variable v. *)

PROCEDURE ROTATE (val: <a packedset type>;
                 num: INTEGER): <type of first parameter>;
  (* Returns a bit sequence obtained from val by rotating up/right
   or down/right by the absolute value of num. The direction is
   down/right if the sign of num is negative, otherwise the direction
   is up/left.
  *)

PROCEDURE SHIFT (val: <a packedset type>;
                num: INTEGER): <type of first parameter>;
  (* Returns a bit sequence obtained from val by shifting up/left
   or down/right by the absolute value of num, introducing
   zeros as necessary. The direction is down/right if the sign of
   num is negative, otherwise the direction is up/left.
  *)

PROCEDURE CAST (<targettype>; val: <anytype>): <targettype>;
  (* CAST is a type transfer function. Given the expression
   denoted by val, it returns a value of the type <targettype>.
   An invalid value for the target value or a
   physical address alignment problem may raise an exception.
  *)

PROCEDURE TSIZE (<type>; ... ): CARDINAL;
  (* Returns the number of LOCS used to store a value of the
   specified <type>. The extra parameters, if present,
   are used to distinguish variants in a variant record.
  *)

PROCEDURE THROW (i: INTEGER) <* noreturn *> ;
  (*
   THROW is a GNU extension and was not part of the PIM or ISO
   standards. It throws an exception which will be caught by the
   EXCEPT block (assuming it exists). This is a compiler builtin
   function which interfaces to the GCC exception handling runtime
   system.
   GCC uses the term throw, hence the naming distinction between
   the GCC builtin and the Modula-2 runtime library procedure Raise.
   The later library procedure Raise will call SYSTEM.THROW after
   performing various housekeeping activities.
  *)

PROCEDURE TBITSIZE (<type>) : CARDINAL ;
```

```

(* Returns the minimum number of bits necessary to represent
   <type>. This procedure function is only useful for determining
   the number of bits used for any type field within a packed RECORD.
   It is not particularly useful elsewhere since <type> might be
   optimized for speed, for example a BOOLEAN could occupy a WORD.
*)
*)

(* The following procedures are invoked by GNU Modula-2 to
   shift non word set types. They are not part of ISO Modula-2
   but are used to implement the SHIFT procedure defined above. *)

(*
   ShiftVal - is a runtime procedure whose job is to implement
   the SHIFT procedure of ISO SYSTEM. GNU Modula-2 will
   inline a SHIFT of a single WORD sized set and will only
   call this routine for larger sets.
*)

PROCEDURE ShiftVal (VAR s, d: ARRAY OF BITSET;
                   SetSizeInBits: CARDINAL;
                   ShiftCount: INTEGER) ;

(*
   ShiftLeft - performs the shift left for a multi word set.
   This procedure might be called by the back end of
   GNU Modula-2 depending whether amount is known at
   compile time.
*)

PROCEDURE ShiftLeft (VAR s, d: ARRAY OF BITSET;
                    SetSizeInBits: CARDINAL;
                    ShiftCount: CARDINAL) ;

(*
   ShiftRight - performs the shift left for a multi word set.
   This procedure might be called by the back end of
   GNU Modula-2 depending whether amount is known at
   compile time.
*)

PROCEDURE ShiftRight (VAR s, d: ARRAY OF BITSET;
                     SetSizeInBits: CARDINAL;
                     ShiftCount: CARDINAL) ;

```


4.4.55 gm2-libs-iso/Semaphores

```
DEFINITION MODULE Semaphores;
```

```
    (* Provides mutual exclusion facilities for use by processes. *)
```

```
TYPE
```

```
    SEMAPHORE;
```

```
PROCEDURE Create (VAR s: SEMAPHORE; initialCount: CARDINAL );
```

```
    (* Creates and returns s as the identity of a new semaphore that  
       has its associated count initialized to initialCount, and has  
       no processes yet waiting on it.
```

```
    *)
```

```
PROCEDURE Destroy (VAR s: SEMAPHORE);
```

```
    (* Recovers the resources used to implement the semaphore s,  
       provided that no process is waiting for s to become free.
```

```
    *)
```

```
PROCEDURE Claim (s: SEMAPHORE);
```

```
    (* If the count associated with the semaphore s is non-zero,  
       decrements this count and allows the calling process to  
       continue; otherwise suspends the calling process until  
       s is released.
```

```
    *)
```

```
PROCEDURE Release (s: SEMAPHORE);
```

```
    (* If there are any processes waiting on the semaphore s,  
       allows one of them to enter the ready state; otherwise  
       increments the count associated with s.
```

```
    *)
```

```
PROCEDURE CondClaim (s: SEMAPHORE): BOOLEAN;
```

```
    (* Returns FALSE if the call Claim(s) would cause the calling  
       process to be suspended; in this case the count associated  
       with s is not changed. Otherwise returns TRUE and the  
       associated count is decremented.
```

```
    *)
```

```
END Semaphores.
```

4.4.56 gm2-libs-iso/SeqFile

```

DEFINITION MODULE SeqFile;

    (* Rewindable sequential files *)

IMPORT IOChan, ChanConsts;

TYPE
    ChanId = IOChan.ChanId;
    FlagSet = ChanConsts.FlagSet;
    OpenResults = ChanConsts.OpenResults;

    (* Accepted singleton values of FlagSet *)

CONST
    (* input operations are requested/available *)
    read = FlagSet{ChanConsts.readFlag};

    (* output operations are requested/available *)
    write = FlagSet{ChanConsts.writeFlag};

    (* a file may/must/did exist before the channel is opened *)
    old = FlagSet{ChanConsts.oldFlag};

    (* text operations are requested/available *)
    text = FlagSet{ChanConsts.textFlag};

    (* raw operations are requested/available *)
    raw = FlagSet{ChanConsts.rawFlag};

PROCEDURE OpenWrite (VAR cid: ChanId; name: ARRAY OF CHAR;
                    flags: FlagSet; VAR res: OpenResults);
    (*
        Attempts to obtain and open a channel connected to a stored
        rewindable file of the given name.
        The write flag is implied; without the raw flag, text is
        implied. If successful, assigns to cid the identity of
        the opened channel, assigns the value opened to res, and
        selects output mode, with the write position at the start
        of the file (i.e. the file is of zero length).
        If a channel cannot be opened as required, the value of
        res indicates the reason, and cid identifies the invalid
        channel.
    *)

PROCEDURE OpenAppend (VAR cid: ChanId; name: ARRAY OF CHAR;

```

```
                flags: FlagSet; VAR res: OpenResults);
(*
  Attempts to obtain and open a channel connected to a stored
  rewindable file of the given name. The write and old flags
  are implied; without the raw flag, text is implied. If
  successful, assigns to cid the identity of the opened channel,
  assigns the value opened to res, and selects output mode,
  with the write position corresponding to the length of the
  file. If a channel cannot be opened as required, the value
  of res indicates the reason, and cid identifies the invalid
  channel.
*)

PROCEDURE OpenRead (VAR cid: ChanId; name: ARRAY OF CHAR;
                   flags: FlagSet; VAR res: OpenResults);
(* Attempts to obtain and open a channel connected to a stored
  rewindable file of the given name.
  The read and old flags are implied; without the raw flag,
  text is implied. If successful, assigns to cid the
  identity of the opened channel, assigns the value opened to
  res, and selects input mode, with the read position
  corresponding to the start of the file.
  If a channel cannot be opened as required, the value of
  res indicates the reason, and cid identifies the invalid
  channel.
*)

PROCEDURE IsSeqFile (cid: ChanId): BOOLEAN;
(* Tests if the channel identified by cid is open to a
  rewindable sequential file. *)

PROCEDURE Reread (cid: ChanId);
(* If the channel identified by cid is not open to a rewindable
  sequential file, the exception wrongDevice is raised;
  otherwise attempts to set the read position to the
  start of the file, and to select input mode.
  If the operation cannot be performed (perhaps because of
  insufficient permissions) neither input mode nor output
  mode is selected.
*)

PROCEDURE Rewrite (cid: ChanId);
(* If the channel identified by cid is not open to a
  rewindable sequential file, the exception wrongDevice is
  raised; otherwise, attempts to truncate the file to zero
  length, and to select output mode. If the operation
  cannot be performed (perhaps because of insufficient
```



```
permissions) neither input mode nor output mode is selected.
*)

PROCEDURE Close (VAR cid: ChanId);
(* If the channel identified by cid is not open to a rewindable
   sequential file, the exception wrongDevice is raised;
   otherwise closes the channel, and assigns the value
   identifying the invalid channel to cid.
*)

END SeqFile.
```

4.4.57 gm2-libs-iso/ShortComplexMath

```
DEFINITION MODULE ShortComplexMath;

    (* Mathematical functions for the type SHORTCOMPLEX *)

CONST
    i =      CMLX (0.0, 1.0);
    one =    CMLX (1.0, 0.0);
    zero =   CMLX (0.0, 0.0);

PROCEDURE abs (z: SHORTCOMPLEX): SHORTREAL;
    (* Returns the length of z *)

PROCEDURE arg (z: SHORTCOMPLEX): SHORTREAL;
    (* Returns the angle that z subtends to the positive real axis *)

PROCEDURE conj (z: SHORTCOMPLEX): SHORTCOMPLEX;
    (* Returns the complex conjugate of z *)

PROCEDURE power (base: SHORTCOMPLEX; exponent: SHORTREAL): SHORTCOMPLEX;
    (* Returns the value of the number base raised to the power exponent *)

PROCEDURE sqrt (z: SHORTCOMPLEX): SHORTCOMPLEX;
    (* Returns the principal square root of z *)

PROCEDURE exp (z: SHORTCOMPLEX): SHORTCOMPLEX;
    (* Returns the complex exponential of z *)

PROCEDURE ln (z: SHORTCOMPLEX): SHORTCOMPLEX;
    (* Returns the principal value of the natural logarithm of z *)

PROCEDURE sin (z: SHORTCOMPLEX): SHORTCOMPLEX;
    (* Returns the sine of z *)

PROCEDURE cos (z: SHORTCOMPLEX): SHORTCOMPLEX;
    (* Returns the cosine of z *)

PROCEDURE tan (z: SHORTCOMPLEX): SHORTCOMPLEX;
    (* Returns the tangent of z *)

PROCEDURE arcsin (z: SHORTCOMPLEX): SHORTCOMPLEX;
    (* Returns the arcsine of z *)

PROCEDURE arccos (z: SHORTCOMPLEX): SHORTCOMPLEX;
    (* Returns the arccosine of z *)
```

```
PROCEDURE arctan (z: SHORTCOMPLEX): SHORTCOMPLEX;
  (* Returns the arctangent of z *)

PROCEDURE polarToComplex (abs, arg: SHORTREAL): SHORTCOMPLEX;
  (* Returns the complex number with the specified polar coordinates *)

PROCEDURE scalarMult (scalar: SHORTREAL; z: SHORTCOMPLEX): SHORTCOMPLEX;
  (* Returns the scalar product of scalar with z *)

PROCEDURE IsCMathException (): BOOLEAN;
  (* Returns TRUE if the current coroutine is in the exceptional execution state
     because of the raising of an exception in a routine from this module; otherwise
     returns FALSE.
  *)

END ShortComplexMath.
```

4.4.58 gm2-libs-iso/ShortIO

```
DEFINITION MODULE ShortIO;
```

```
(* Input and output of short real numbers in decimal text form
   over specified channels. The read result is of the type
   IOConsts.ReadResults.
*)
```

```
IMPORT IOChan;
```

```
(* The text form of a signed fixed-point real number is
   ["+" | "-"], decimal digit, {decimal digit}, [".",
   {decimal digit}]
```

```
The text form of a signed floating-point real number is
   signed fixed-point real number,
   "E", ["+" | "-"], decimal digit, {decimal digit}
*)
```

```
PROCEDURE ReadReal (cid: IOChan.ChanId; VAR real: SHORTREAL);
```

```
(* Skips leading spaces, and removes any remaining characters
   from cid that form part of a signed fixed or floating
   point number. The value of this number is assigned to real.
   The read result is set to the value allRight, outOfRange,
   wrongFormat, endOfLine, or endOfInput.
*)
```

```
PROCEDURE WriteFloat (cid: IOChan.ChanId; real: SHORTREAL;
                     sigFigs: CARDINAL; width: CARDINAL);
```

```
(* Writes the value of real to cid in floating-point text form,
   with sigFigs significant figures, in a field of the given
   minimum width.
*)
```

```
PROCEDURE WriteEng (cid: IOChan.ChanId; real: SHORTREAL;
                   sigFigs: CARDINAL; width: CARDINAL);
```

```
(* As for WriteFloat, except that the number is scaled with
   one to three digits in the whole number part, and with an
   exponent that is a multiple of three.
*)
```

```
PROCEDURE WriteFixed (cid: IOChan.ChanId; real: SHORTREAL;
                    place: INTEGER; width: CARDINAL);
```

```
(* Writes the value of real to cid in fixed-point text form,
   rounded to the given place relative to the decimal point,
   in a field of the given minimum width.
```

*)

```
PROCEDURE WriteReal (cid: IOChan.ChanId; real: SHORTREAL;  
                    width: CARDINAL);  
  (* Writes the value of real to cid, as WriteFixed if the  
    sign and magnitude can be shown in the given width, or  
    otherwise as WriteFloat. The number of places or  
    significant digits depends on the given width.  
  *)
```

```
END ShortIO.
```

4.4.59 gm2-libs-iso/ShortWholeIO

```
DEFINITION MODULE ShortWholeIO;

  (* Input and output of whole numbers in decimal text form
     over specified channels. The read result is of the
     type IOConsts.ReadResults.
  *)

IMPORT IOChan;

  (* The text form of a signed whole number is
     ["+" | "-"], decimal digit, {decimal digit}

     The text form of an unsigned whole number is
     decimal digit, {decimal digit}
  *)

PROCEDURE ReadInt (cid: IOChan.ChanId; VAR int: SHORTINT);
  (* Skips leading spaces, and removes any remaining characters
     from cid that form part of a signed whole number. The
     value of this number is assigned to int. The read result
     is set to the value allRight, outOfRange, wrongFormat,
     endOfLine, or endOfInput.
  *)

PROCEDURE WriteInt (cid: IOChan.ChanId; int: SHORTINT;
                   width: CARDINAL);
  (* Writes the value of int to cid in text form, in a field of
     the given minimum width. *)

PROCEDURE ReadCard (cid: IOChan.ChanId; VAR card: SHORTCARD);
  (* Skips leading spaces, and removes any remaining characters
     from cid that form part of an unsigned whole number. The
     value of this number is assigned to card. The read result
     is set to the value allRight, outOfRange, wrongFormat,
     endOfLine, or endOfInput.
  *)

PROCEDURE WriteCard (cid: IOChan.ChanId; card: SHORTCARD;
                    width: CARDINAL);
  (* Writes the value of card to cid in text form, in a field
     of the given minimum width. *)

END ShortWholeIO.
```

4.4.60 gm2-libs-iso/SimpleCipher

```
DEFINITION MODULE SimpleCipher ;

(*
  Description: provides a simple Caesar cipher layer which
              can be attached to any channel device. This,
              pedagogical, module is designed to show how
              it is possible to add further layers underneath
              the channel devices.
*)

FROM IOChan IMPORT ChanId ;

(*
  InsertCipherLayer - inserts a caesar cipher below channel, cid.
                    The encryption, key, is specified.
*)

PROCEDURE InsertCipherLayer (cid: ChanId; key: INTEGER) ;

(*
  RemoveCipherLayer - removes a Caesar cipher below channel, cid.
*)

PROCEDURE RemoveCipherLayer (cid: ChanId) ;

END SimpleCipher.
```

4.4.61 gm2-libs-iso/StdChans

```
DEFINITION MODULE StdChans;

    (* Access to standard and default channels *)

IMPORT IOChan;

TYPE
    ChanId = IOChan.ChanId;
    (* Values of this type are used to identify channels *)

    (* The following functions return the standard channel values.
       These channels cannot be closed.
    *)

PROCEDURE StdInChan (): ChanId;
    (* Returns the identity of the implementation-defined standard source for
    program
       input.
    *)

PROCEDURE StdOutChan (): ChanId;
    (* Returns the identity of the implementation-defined standard source for program
       output.
    *)

PROCEDURE StdErrChan (): ChanId;
    (* Returns the identity of the implementation-defined standard destination for progr
       error messages.
    *)

PROCEDURE NullChan (): ChanId;
    (* Returns the identity of a channel open to the null device. *)

    (* The following functions return the default channel values *)

PROCEDURE InChan (): ChanId;
    (* Returns the identity of the current default input channel. *)

PROCEDURE OutChan (): ChanId;
    (* Returns the identity of the current default output channel. *)

PROCEDURE ErrChan (): ChanId;
    (* Returns the identity of the current default error message channel. *)

    (* The following procedures allow for redirection of the default channels *)
```



```
PROCEDURE SetInChan (cid: ChanId);
  (* Sets the current default input channel to that identified by cid. *)■

PROCEDURE SetOutChan (cid: ChanId);
  (* Sets the current default output channel to that identified by cid. *)■

PROCEDURE SetErrChan (cid: ChanId);
  (* Sets the current default error channel to that identified by cid. *)■

END StdChans.
```

4.4.62 gm2-libs-iso/Storage

```
DEFINITION MODULE Storage;
```

```
    (* Facilities for dynamically allocating and deallocating storage *)
```

```
IMPORT SYSTEM;
```

```
PROCEDURE ALLOCATE (VAR addr: SYSTEM.ADDRESS; amount: CARDINAL);
    (* Allocates storage for a variable of size amount and assigns
       the address of this variable to addr. If there is insufficient
       unallocated storage to do this, the value NIL is assigned to addr.
    *)
```

```
PROCEDURE DEALLOCATE (VAR addr: SYSTEM.ADDRESS; amount: CARDINAL);
    (* Deallocates amount locations allocated by ALLOCATE for
       the storage of the variable addressed by addr and assigns
       the value NIL to addr.
    *)
```

```
PROCEDURE REALLOCATE (VAR addr: SYSTEM.ADDRESS; amount: CARDINAL);
    (* Attempts to reallocate, amount of storage. Effectively it
       calls ALLOCATE, copies the amount of data pointed to by
       addr into the new space and DEALLOCATES the addr.
       This procedure is a GNU extension.
    *)
```

```
TYPE
```

```
    StorageExceptions = (
        nilDeallocation,           (* first argument to DEALLOCATE is NIL *)
        pointerToUnallocatedStorage, (* storage to deallocate not allocated by ALLOCATE *)
        wrongStorageToUnallocate   (* amount to deallocate is not amount allocated *)
    );
```

```
PROCEDURE IsStorageException (): BOOLEAN;
    (* Returns TRUE if the current coroutine is in the exceptional
       execution state because of the raising of an exception from
       StorageExceptions; otherwise returns FALSE.
    *)
```

```
PROCEDURE StorageException (): StorageExceptions;
    (* If the current coroutine is in the exceptional execution
       state because of the raising of an exception from
       StorageExceptions, returns the corresponding
       enumeration value, and otherwise raises an exception.
    *)
```

END Storage.

4.4.63 gm2-libs-iso/StreamFile

```

DEFINITION MODULE StreamFile;

    (* Independent sequential data streams *)

IMPORT IOChan, ChanConsts;

TYPE
    ChanId = IOChan.ChanId;
    FlagSet = ChanConsts.FlagSet;
    OpenResults = ChanConsts.OpenResults;

    (* Accepted singleton values of FlagSet *)

CONST
    read = FlagSet{ChanConsts.readFlag};    (* input operations are requested/available *)
    write = FlagSet{ChanConsts.writeFlag};  (* output operations are requested/available *)
    old = FlagSet{ChanConsts.oldFlag};      (* a file may/must/did exist before the channel
                                             opened *)
    text = FlagSet{ChanConsts.textFlag};    (* text operations are requested/available *)
    raw = FlagSet{ChanConsts.rawFlag};      (* raw operations are requested/available *)

PROCEDURE Open (VAR cid: ChanId; name: ARRAY OF CHAR;
               flags: FlagSet; VAR res: OpenResults);
    (* Attempts to obtain and open a channel connected to a
       sequential stream of the given name.
       The read flag implies old; without the raw flag, text is
       implied. If successful, assigns to cid the identity of
       the opened channel, and assigns the value opened to res.
       If a channel cannot be opened as required, the value of
       res indicates the reason, and cid identifies the invalid
       channel.
    *)

PROCEDURE IsStreamFile (cid: ChanId): BOOLEAN;
    (* Tests if the channel identified by cid is open to a sequential stream. *)

PROCEDURE Close (VAR cid: ChanId);
    (* If the channel identified by cid is not open to a sequential stream, the exception
       wrongDevice is raised; otherwise closes the channel, and assigns the value identified
       the invalid channel to cid.
    *)

END StreamFile.

```

4.4.64 gm2-libs-iso/StringChan

```
DEFINITION MODULE StringChan ;

  (*
    Description: provides a set of Channel and String
                input and output procedures.
  *)

  FROM DynamicStrings IMPORT String ;
  IMPORT IOChan;

  (*
    writeString - writes a string, s, to ChanId, cid.
                  The string, s, is not destroyed.
  *)

  PROCEDURE writeString (cid: IOChan.ChanId; s: String) ;

  (*
    writeFieldWidth - writes a string, s, to ChanId, cid.
                      The string, s, is not destroyed and it
                      is prefixed by spaces so that at least,
                      width, characters are written. If the
                      string, s, is longer than width then
                      no spaces are prefixed to the output
                      and the entire string is written.
  *)

  PROCEDURE writeFieldWidth (cid: IOChan.ChanId;
                             s: String; width: CARDINAL) ;

  END StringChan.
```

4.4.65 gm2-libs-iso/Strings

```
DEFINITION MODULE Strings;
```

```
  (* Facilities for manipulating strings *)
```

```
TYPE
```

```
  String1 = ARRAY [0..0] OF CHAR;
```

```
  (* String1 is provided for constructing a value of a single-character string type.
     single character value in order to pass CHAR values to ARRAY OF CHAR parameters
  *)
```

```
PROCEDURE Length (stringVal: ARRAY OF CHAR): CARDINAL;
```

```
  (* Returns the length of stringVal (the same value as would be returned by the
     pervasive function LENGTH).
  *)
```

```
  (* The following seven procedures construct a string value, and attempt to assign it to
     variable parameter. They all have the property that if the length of the constructed
     value exceeds the capacity of the variable parameter, a truncated value is assigned.
     if the length of the constructed string value is less than the capacity of the vari-
     parameter, a string terminator is appended before assignment is performed.
  *)
```

```
PROCEDURE Assign (source: ARRAY OF CHAR; VAR destination: ARRAY OF CHAR);
```

```
  (* Copies source to destination *)
```

```
PROCEDURE Extract (source: ARRAY OF CHAR; startIndex, numberToExtract: CARDINAL;
                  VAR destination: ARRAY OF CHAR);
```

```
  (* Copies at most numberToExtract characters from source to destination, starting at
     startIndex in source.
  *)
```

```
PROCEDURE Delete (VAR stringVar: ARRAY OF CHAR; startIndex, numberToDelete:
                 CARDINAL);
```

```
  (* Deletes at most numberToDelete characters from stringVar, starting at position
     startIndex.
  *)
```

```
PROCEDURE Insert (source: ARRAY OF CHAR; startIndex: CARDINAL;
                 VAR destination: ARRAY OF CHAR);
```

```
  (* Inserts source into destination at position startIndex *)
```

```
PROCEDURE Replace (source: ARRAY OF CHAR; startIndex: CARDINAL;
                  VAR destination: ARRAY OF CHAR);
```

```
  (* Copies source into destination, starting at position startIndex. Copying stops wh
```

all of source has been copied, or when the last character of the string value in destination has been replaced.

*)

```
PROCEDURE Append (source: ARRAY OF CHAR; VAR destination: ARRAY OF CHAR);
```

```
(* Appends source to destination. *)
```

```
PROCEDURE Concat (source1, source2: ARRAY OF CHAR; VAR destination: ARRAY OF CHAR);
```

```
(* Concatenates source2 onto source1 and copies the result into destination. *)
```

```
(* The following predicates provide for pre-testing of the operation-completion conditions for the procedures above.
```

```
*)
```

```
PROCEDURE CanAssignAll (sourceLength: CARDINAL; VAR destination: ARRAY OF CHAR): BOOLEAN;
```

```
(* Returns TRUE if a number of characters, indicated by sourceLength, will fit into destination; otherwise returns FALSE.
```

```
*)
```

```
PROCEDURE CanExtractAll (sourceLength, startIndex, numberToExtract: CARDINAL;
```

```
VAR destination: ARRAY OF CHAR): BOOLEAN;
```

```
(* Returns TRUE if there are numberToExtract characters starting at startIndex and within the sourceLength of some string, and if the capacity of destination is sufficient to hold numberToExtract characters; otherwise returns FALSE.
```

```
*)
```

```
PROCEDURE CanDeleteAll (stringLength, startIndex, numberToDelete: CARDINAL): BOOLEAN;
```

```
(* Returns TRUE if there are numberToDelete characters starting at startIndex and within the stringLength of some string; otherwise returns FALSE.
```

```
*)
```

```
PROCEDURE CanInsertAll (sourceLength, startIndex: CARDINAL;
```

```
VAR destination: ARRAY OF CHAR): BOOLEAN;
```

```
(* Returns TRUE if there is room for the insertion of sourceLength characters from some string into destination starting at startIndex; otherwise returns FALSE.
```

```
*)
```

```
PROCEDURE CanReplaceAll (sourceLength, startIndex: CARDINAL;
```

```
VAR destination: ARRAY OF CHAR): BOOLEAN;
```

```
(* Returns TRUE if there is room for the replacement of sourceLength characters in destination starting at startIndex; otherwise returns FALSE.
```

```
*)
```

```
PROCEDURE CanAppendAll (sourceLength: CARDINAL; VAR destination: ARRAY OF CHAR): BOOLEAN;
```

```
(* Returns TRUE if there is sufficient room in destination to append a string of length sourceLength to the string in destination; otherwise returns FALSE.
```

```
*)
```

```

PROCEDURE CanConcatAll (source1Length, source2Length: CARDINAL;
                       VAR destination: ARRAY OF CHAR): BOOLEAN;
    (* Returns TRUE if there is sufficient room in destination for a two strings of
       lengths source1Length and source2Length; otherwise returns FALSE.
    *)

(* The following type and procedures provide for the comparison of string values, and
   location of substrings within strings.
*)

TYPE
    CompareResults = (less, equal, greater);

PROCEDURE Compare (stringVal1, stringVal2: ARRAY OF CHAR): CompareResults;
    (* Returns less, equal, or greater, according as stringVal1 is lexically less than,
       equal to, or greater than stringVal2.
    *)

PROCEDURE Equal (stringVal1, stringVal2: ARRAY OF CHAR): BOOLEAN;
    (* Returns Strings.Compare(stringVal1, stringVal2) = Strings.equal *)

PROCEDURE FindNext (pattern, stringToSearch: ARRAY OF CHAR; startIndex: CARDINAL;
                   VAR patternFound: BOOLEAN; VAR posOfPattern: CARDINAL);
    (* Looks forward for next occurrence of pattern in stringToSearch, starting the search
       position startIndex. If startIndex < LENGTH(stringToSearch) and pattern is found,
       patternFound is returned as TRUE, and posOfPattern contains the start position in
       stringToSearch of pattern. Otherwise patternFound is returned as FALSE, and posOfPattern
       is unchanged.
    *)

PROCEDURE FindPrev (pattern, stringToSearch: ARRAY OF CHAR; startIndex: CARDINAL;
                   VAR patternFound: BOOLEAN; VAR posOfPattern: CARDINAL);
    (* Looks backward for the previous occurrence of pattern in stringToSearch and returns
       position of the first character of the pattern if found. The search for the pattern
       begins at startIndex. If pattern is found, patternFound is returned as TRUE, and
       posOfPattern contains the start position in stringToSearch of pattern in the range
       [0..startIndex]. Otherwise patternFound is returned as FALSE, and posOfPattern is
       unchanged.
    *)

PROCEDURE FindDiff (stringVal1, stringVal2: ARRAY OF CHAR;
                   VAR differenceFound: BOOLEAN; VAR posOfDifference: CARDINAL);
    (* Compares the string values in stringVal1 and stringVal2 for differences. If they
       are equal, differenceFound is returned as FALSE, and TRUE otherwise. If
       differenceFound is TRUE, posOfDifference is set to the position of the first
       difference; otherwise posOfDifference is unchanged.
    *)

```



```
PROCEDURE Capitalize (VAR stringVar: ARRAY OF CHAR);  
  (* Applies the function CAP to each character of the string value in stringVar. *)  
  
END Strings.
```

4.4.66 gm2-libs-iso/SysClock

```

DEFINITION MODULE SysClock;

(* Facilities for accessing a system clock that records the date
   and time of day *)

CONST
  maxSecondParts = 1000000 ;

TYPE
  Month    = [1 .. 12];
  Day      = [1 .. 31];
  Hour     = [0 .. 23];
  Min      = [0 .. 59];
  Sec      = [0 .. 59];
  Fraction = [0 .. maxSecondParts];
  UTCDiff  = [-780 .. 720];
  DateTime =
    RECORD
      year:      CARDINAL;
      month:     Month;
      day:       Day;
      hour:      Hour;
      minute:    Min;
      second:    Sec;
      fractions: Fraction; (* parts of a second *)
      zone:      UTCDiff;  (* Time zone differential
                             factor which is the number
                             of minutes to add to local
                             time to obtain UTC. *)
      summerTimeFlag: BOOLEAN; (* Interpretation of flag
                                 depends on local usage. *)
    END;

PROCEDURE CanGetClock(): BOOLEAN;
(* Tests if the clock can be read *)

PROCEDURE CanSetClock(): BOOLEAN;
(* Tests if the clock can be set *)

PROCEDURE IsValidDateTime(userData: DateTime): BOOLEAN;
(* Tests if the value of userData is a valid *)

PROCEDURE GetClock(VAR userData: DateTime);
(* Assigns local date and time of the day to userData *)

```

```
PROCEDURE SetClock(userData: DateTime);  
(* Sets the system time clock to the given local date and  
   time *)  
  
END SysClock.
```

4.4.67 gm2-libs-iso/TERMINATION

```
DEFINITION MODULE TERMINATION;
```

```
(* Provides facilities for enquiries concerning the occurrence of termination events.
```

```
PROCEDURE IsTerminating (): BOOLEAN ;
```

```
(* Returns true if any coroutine has started program termination and false otherwise
```

```
PROCEDURE HasHalted (): BOOLEAN ;
```

```
(* Returns true if a call to HALT has been made and false otherwise. *)■
```

```
END TERMINATION.
```

4.4.68 gm2-libs-iso/TermFile

```

DEFINITION MODULE TermFile;

    (* Access to the terminal device *)

    (* Channels opened by this module are connected to a single
       terminal device; typed characters are distributed between
       channels according to the sequence of read requests.
    *)

IMPORT IOChan, ChanConsts;

TYPE
    ChanId = IOChan.ChanId;
    FlagSet = ChanConsts.FlagSet;
    OpenResults = ChanConsts.OpenResults;

    (* Accepted singleton values of FlagSet *)

CONST
    read = FlagSet{ChanConsts.readFlag};
    (* input operations are requested/available *)
    write = FlagSet{ChanConsts.writeFlag};
    (* output operations are requested/available *)
    text = FlagSet{ChanConsts.textFlag};
    (* text operations are requested/available *)
    raw = FlagSet{ChanConsts.rawFlag};
    (* raw operations are requested/available *)
    echo = FlagSet{ChanConsts.echoFlag};
    (* echoing by interactive device on reading of
       characters from input stream requested/applies
    *)

PROCEDURE Open (VAR cid: ChanId; flagset: FlagSet; VAR res: OpenResults);
    (* Attempts to obtain and open a channel connected to
       the terminal. Without the raw flag, text is implied.
       Without the echo flag, line mode is requested,
       otherwise single character mode is requested.
       If successful, assigns to cid the identity of
       the opened channel, and assigns the value opened to res.
       If a channel cannot be opened as required, the value of
       res indicates the reason, and cid identifies the
       invalid channel.
    *)

PROCEDURE IsTermFile (cid: ChanId): BOOLEAN;

```

```
(* Tests if the channel identified by cid is open to
   the terminal. *)

PROCEDURE Close (VAR cid: ChanId);
  (* If the channel identified by cid is not open to the terminal,
     the exception wrongDevice is raised; otherwise closes the
     channel and assigns the value identifying the invalid channel
     to cid.
  *)

END TermFile.
```

4.4.69 gm2-libs-iso/TextIO

```
DEFINITION MODULE TextIO;

  (* Input and output of character and string types over
     specified channels. The read result is of the type
     IOConsts.ReadResults.
  *)

IMPORT IOChan;

  (* The following procedures do not read past line marks *)

PROCEDURE ReadChar (cid: IOChan.ChanId; VAR ch: CHAR);
  (* If possible, removes a character from the input stream
     cid and assigns the corresponding value to ch. The
     read result is set to the value allRight, endOfLine, or
     endOfInput.
  *)

PROCEDURE ReadRestLine (cid: IOChan.ChanId; VAR s: ARRAY OF CHAR);
  (* Removes any remaining characters from the input stream
     cid before the next line mark, copying to s as many as
     can be accommodated as a string value. The read result is
     set to the value allRight, outOfRange, endOfLine, or
     endOfInput.
  *)

PROCEDURE ReadString (cid: IOChan.ChanId; VAR s: ARRAY OF CHAR);
  (* Removes only those characters from the input stream cid
     before the next line mark that can be accommodated in s
     as a string value, and copies them to s. The read result
     is set to the value allRight, endOfLine, or endOfInput.
  *)

PROCEDURE ReadToken (cid: IOChan.ChanId; VAR s: ARRAY OF CHAR);
  (* Skips leading spaces, and then removes characters from
     the input stream cid before the next space or line mark,
     copying to s as many as can be accommodated as a string
     value. The read result is set to the value allRight,
     outOfRange, endOfLine, or endOfInput.
  *)

  (* The following procedure reads past the next line mark *)

PROCEDURE SkipLine (cid: IOChan.ChanId);
  (* Removes successive items from the input stream cid up
```

to and including the next line mark, or until the end of input is reached. The read result is set to the value allRight, or endOfInput.

*)

(* Output procedures *)

PROCEDURE WriteChar (cid: IOChan.ChanId; ch: CHAR);

(* Writes the value of ch to the output stream cid. *)

PROCEDURE WriteLn (cid: IOChan.ChanId);

(* Writes a line mark to the output stream cid. *)

PROCEDURE WriteString (cid: IOChan.ChanId; s: ARRAY OF CHAR);

(* Writes the string value in s to the output stream cid. *)

END TextIO.

4.4.70 gm2-libs-iso/WholeConv

```

DEFINITION MODULE WholeConv;

    (* Low-level whole-number/string conversions *)

IMPORT
    ConvTypes;

TYPE
    ConvResults = ConvTypes.ConvResults;
                (* strAllRight, strOutOfRange, strWrongFormat, strEmpty *)

PROCEDURE ScanInt (inputCh: CHAR;
                  VAR chClass: ConvTypes.ScanClass;
                  VAR nextState: ConvTypes.ScanState) ;
    (* Represents the start state of a finite state scanner for signed
       whole numbers - assigns class of inputCh to chClass and a
       procedure representing the next state to nextState.
    *)

PROCEDURE FormatInt (str: ARRAY OF CHAR): ConvResults;
    (* Returns the format of the string value for conversion to INTEGER. *)

PROCEDURE ValueInt (str: ARRAY OF CHAR): INTEGER;
    (* Returns the value corresponding to the signed whole number string
       value str if str is well-formed; otherwise raises the WholeConv
       exception.
    *)

PROCEDURE LengthInt (int: INTEGER): CARDINAL;
    (* Returns the number of characters in the string representation of
       int.
    *)

PROCEDURE ScanCard (inputCh: CHAR; VAR chClass: ConvTypes.ScanClass;
                  VAR nextState: ConvTypes.ScanState);
    (* Represents the start state of a finite state scanner for unsigned
       whole numbers - assigns class of inputCh to chClass and a procedure
       representing the next state to nextState.
    *)

PROCEDURE FormatCard (str: ARRAY OF CHAR): ConvResults;
    (* Returns the format of the string value for conversion to CARDINAL.
    *)

PROCEDURE ValueCard (str: ARRAY OF CHAR): CARDINAL;

```

```
(* Returns the value corresponding to the unsigned whole number string
   value str if str is well-formed; otherwise raises the WholeConv
   exception.
*)

PROCEDURE LengthCard (card: CARDINAL): CARDINAL;
(* Returns the number of characters in the string representation of
   card.
*)

PROCEDURE IsWholeConvException (): BOOLEAN;
(* Returns TRUE if the current coroutine is in the exceptional execution
   state because of the raising of an exception in a routine from this
   module; otherwise returns FALSE.
*)

END WholeConv.
```

4.4.71 gm2-libs-iso/WholeIO

```
DEFINITION MODULE WholeIO;

  (* Input and output of whole numbers in decimal text form
     over specified channels. The read result is of the
     type IOConsts.ReadResults.
  *)

IMPORT IOChan;

  (* The text form of a signed whole number is
     ["+" | "-"], decimal digit, {decimal digit}

     The text form of an unsigned whole number is
     decimal digit, {decimal digit}
  *)

PROCEDURE ReadInt (cid: IOChan.ChanId; VAR int: INTEGER);
  (* Skips leading spaces, and removes any remaining characters
     from cid that form part of a signed whole number. The
     value of this number is assigned to int. The read result
     is set to the value allRight, outOfRange, wrongFormat,
     endOfLine, or endOfInput.
  *)

PROCEDURE WriteInt (cid: IOChan.ChanId; int: INTEGER;
                   width: CARDINAL);
  (* Writes the value of int to cid in text form, in a field of
     the given minimum width. *)

PROCEDURE ReadCard (cid: IOChan.ChanId; VAR card: CARDINAL);
  (* Skips leading spaces, and removes any remaining characters
     from cid that form part of an unsigned whole number. The
     value of this number is assigned to card. The read result
     is set to the value allRight, outOfRange, wrongFormat,
     endOfLine, or endOfInput.
  *)

PROCEDURE WriteCard (cid: IOChan.ChanId; card: CARDINAL;
                    width: CARDINAL);
  (* Writes the value of card to cid in text form, in a field
     of the given minimum width. *)

END WholeIO.
```

4.4.72 gm2-libs-iso/WholeStr

```
DEFINITION MODULE WholeStr;

    (* Whole-number/string conversions *)

IMPORT
    ConvTypes;

TYPE
    ConvResults = ConvTypes.ConvResults;
    (* strAllRight, strOutOfRange, strWrongFormat, strEmpty *)

    (* the string form of a signed whole number is
       ["+" | "-"], decimal digit, {decimal digit}
    *)

PROCEDURE StrToInt (str: ARRAY OF CHAR; VAR int: INTEGER;
                   VAR res: ConvResults);
    (* Ignores any leading spaces in str. If the subsequent
       characters in str are in the format of a signed whole
       number, assigns a corresponding value to int. Assigns
       a value indicating the format of str to res.
    *)

PROCEDURE IntToStr (int: INTEGER; VAR str: ARRAY OF CHAR);
    (* Converts the value of int to string form and copies the
       possibly truncated result to str. *)

    (* the string form of an unsigned whole number is
       decimal digit, {decimal digit}
    *)

PROCEDURE StrToCard (str: ARRAY OF CHAR;
                    VAR card: CARDINAL;
                    VAR res: ConvResults);
    (* Ignores any leading spaces in str. If the subsequent
       characters in str are in the format of an unsigned
       whole number, assigns a corresponding value to card.
       Assigns a value indicating the format of str to res.
    *)

PROCEDURE CardToStr (card: CARDINAL; VAR str: ARRAY OF CHAR);
    (* Converts the value of card to string form and copies the
       possibly truncated result to str. *)

END WholeStr.
```

4.4.73 gm2-libs-iso/wrapsock

```
DEFINITION MODULE wrapsock ;
```

```
(*  
  Description: provides a set of wrappers to some client side  
              tcp socket primitives.  
*)
```

```
FROM SYSTEM IMPORT ADDRESS ;  
FROM ChanConsts IMPORT OpenResults ;
```

```
TYPE  
  clientInfo = ADDRESS ;
```

```
(*  
  clientOpen - returns an ISO Modula-2 OpenResult.  
              It attempts to connect to: hostname:portNo.  
              If successful then the data structure, c,  
              will have its fields initialized.  
*)
```

```
PROCEDURE clientOpen (c: clientInfo;  
                    hostname: ADDRESS;  
                    length: CARDINAL;  
                    portNo: CARDINAL) : OpenResults ;
```

```
(*  
  clientOpenIP - returns an ISO Modula-2 OpenResult.  
                It attempts to connect to: ipaddress:portNo.  
                If successful then the data structure, c,  
                will have its fields initialized.  
*)
```

```
PROCEDURE clientOpenIP (c: clientInfo;  
                      ip: CARDINAL;  
                      portNo: CARDINAL) : OpenResults ;
```

```
(*  
  getClientPortNo - returns the portNo from structure, c.  
*)
```

```
PROCEDURE getClientPortNo (c: clientInfo) : CARDINAL ;
```

```
(*
  getClientHostname - fills in the hostname of the server
                    the to which the client is connecting.
*)

PROCEDURE getClientHostname (c: clientInfo;
                           hostname: ADDRESS; high: CARDINAL) ;

(*
  getClientSocketFd - returns the sockFd from structure, c.
*)

PROCEDURE getClientSocketFd (c: clientInfo) : INTEGER ;

(*
  getClientIP - returns the sockFd from structure, s.
*)

PROCEDURE getClientIP (c: clientInfo) : CARDINAL ;

(*
  getPushBackChar - returns TRUE if a pushed back character
                  is available.
*)

PROCEDURE getPushBackChar (c: clientInfo; VAR ch: CHAR) : BOOLEAN ;

(*
  setPushBackChar - returns TRUE if it is able to push back a
                  character.
*)

PROCEDURE setPushBackChar (c: clientInfo; ch: CHAR) : BOOLEAN ;

(*
  getSizeOfClientInfo - returns the sizeof (opaque data type).
*)

PROCEDURE getSizeOfClientInfo () : CARDINAL ;
```

END wrapsock.

4.4.74 gm2-libs-iso/wraptime

```
DEFINITION MODULE wraptime ;

(*
   Description: provides an interface to various time related
                entities on the underlying host operating system.
                It provides access to the glibc/libc functions:
                gettimeofday, settimeofday and localtime_r.
*)

FROM SYSTEM IMPORT ADDRESS ;

TYPE
    timeval = ADDRESS ;
    timezone = ADDRESS ;
    tm      = ADDRESS ;

(*
   InitTimeval - returns a newly created opaque type.
*)

PROCEDURE InitTimeval () : timeval ;

(*
   KillTimeval - deallocates the memory associated with an
                opaque type.
*)

PROCEDURE KillTimeval (tv: timeval) : timeval ;

(*
   InitTimezone - returns a newly created opaque type.
*)

PROCEDURE InitTimezone () : timezone ;

(*
   KillTimezone - deallocates the memory associated with an
                opaque type.
*)

PROCEDURE KillTimezone (tv: timezone) : timezone ;
```



```
(*  
  InitTM - returns a newly created opaque type.  
*)
```

```
PROCEDURE InitTM () : tm ;
```

```
(*  
  KillTM - deallocates the memory associated with an  
           opaque type.  
*)
```

```
PROCEDURE KillTM (tv: tm) : tm ;
```

```
(*  
  gettimeofday - calls gettimeofday(2) with the same parameters, tv,  
                and, tz. It returns 0 on success.  
*)
```

```
PROCEDURE gettimeofday (tv: timeval; tz: timezone) : INTEGER ;
```

```
(*  
  settimeofday - calls settimeofday(2) with the same parameters, tv,  
                and, tz. It returns 0 on success.  
*)
```

```
PROCEDURE settimeofday (tv: timeval; tz: timezone) : INTEGER ;
```

```
(*  
  GetFractions - returns the tv_usec field inside the timeval structure  
                as a CARDINAL.  
*)
```

```
PROCEDURE GetFractions (tv: timeval) : CARDINAL ;
```

```
(*  
  localtime_r - returns the tm parameter, m, after it has been assigned with  
                appropriate contents determined by, tv. Notice that  
                this procedure function expects, timeval, as its first  
                parameter and not a time_t (as expected by the posix  
                equivalent). This avoids having to expose a time_t
```

system dependant definition.

*)

```
PROCEDURE localtime_r (tv: timeval; m: tm) : tm ;
```

(*

 GetYear - returns the year from the structure, m.

*)

```
PROCEDURE GetYear (m: tm) : CARDINAL ;
```

(*

 GetMonth - returns the month from the structure, m.

*)

```
PROCEDURE GetMonth (m: tm) : CARDINAL ;
```

(*

 GetDay - returns the day of the month from the structure, m.

*)

```
PROCEDURE GetDay (m: tm) : CARDINAL ;
```

(*

 GetHour - returns the hour of the day from the structure, m.

*)

```
PROCEDURE GetHour (m: tm) : CARDINAL ;
```

(*

 GetMinute - returns the minute within the hour from the structure, m.

*)

```
PROCEDURE GetMinute (m: tm) : CARDINAL ;
```

(*

 GetSecond - returns the seconds in the minute from the structure, m.

 The return value will always be in the range 0..59.

 A leap minute of value 60 will be truncated to 59.

*)

```
PROCEDURE GetSecond (m: tm) : CARDINAL ;

(*
  GetSummerTime - returns a boolean indicating whether summer time is
                  set.
*)

PROCEDURE GetSummerTime (tz: timezone) : BOOLEAN ;

(*
  GetDST - returns the number of minutes west of GMT.
*)

PROCEDURE GetDST (tz: timezone) : INTEGER ;

(*
  SetTimeval - sets the fields in timeval, tv, with:
               second, minute, hour, day, month, year, fractions.
*)

PROCEDURE SetTimeval (tv: timeval;
                    second, minute, hour, day,
                    month, year, yday, wday, isdst: CARDINAL) ;

(*
  SetTimezone - set the timezone field inside timeval, tv.
*)

PROCEDURE SetTimezone (tv: timeval;
                    zone: CARDINAL; minuteswest: INTEGER) ;

END wraptime.
```

4.5 Indices

—	
__cxa_begin_catch	178
__cxa_end_catch	178
__cxa_rethrow	178
A	
abort	184
abs	278, 297, 379
ABS	10
ack (const)	75
acos	193
acosf	193
acosl	193
Activate	323
ActualParameters (ebnf)	70
Add	89
ADDADR	48, 371
AddLongOption	107
AddOperator (ebnf)	67
ADDRESS (type)	47, 371
ADR	43, 48, 145, 264, 372
Again	230
Alignment (ebnf)	67
alloca	41, 81, 172
alloca_trace	42, 83
AllocateDeviceId	293
AllocateSource	283
ALLOCATE	155, 168, 387
Append	392
arccos	278, 297, 303, 350, 379
arcsin	278, 297, 303, 350, 379
arctan	114, 123, 144, 278, 297, 303, 350, 379
arg	278, 297, 379
ArgChan	326
ArgCEnvP (type)	116, 119, 315
ArmEvent	268
ArraySetRecordValue (ebnf)	67
ArrayType (ebnf)	68
asin	193
asinf	193
asinl	193
AsmElement (ebnf)	74
AsmList (ebnf)	73
AsmOperandName (ebnf)	73
AsmOperands (ebnf)	73
AsmStatement (ebnf)	73
Assert	77
Assign	89, 250, 391
AssignmentException	122, 318
AssignmentOrProcedureCall (ebnf)	70
AssignRead	252
AssignWrite	253
atan	193
atan2	38, 79, 173, 193
atan2f	38, 79, 173, 193
atan2l	38, 79, 173, 193
atanf	193
atanl	193
atexit	192
Attach	323
AttachVector	137
ATTACH	271
AttributeExpression (ebnf)	68
AttributeNoReturn (ebnf)	71
AttributeUnused (ebnf)	71
Available	155, 168
B	
BaseExceptionsThrow	134
bel (const)	75
BinToStr	125
BITSPERBYTE (const)	43, 145
BITSPERLOC (const)	47, 370
Block (ebnf)	72
BlockAnd	206
BlockBody (ebnf)	72
BlockClear	215
BlockEqual	216
BlockMoveBackward	215
BlockMoveForward	215
BlockNot	207
BlockOr	207
BlockPosition	216
BlockRol	208
BlockRor	208
BlockSet	215
BlockShl	208
BlockShr	207
BlockXor	207
Body (type)	322
bs (const)	75
bstoc	164
bstoi	164
BufferedMode	109
Builtin (ebnf)	71
BYTE (type)	48, 371
ByteAlignment (ebnf)	67
ByteAnd	209
ByteNot	210
ByteOr	209
ByteRol	210
ByteRor	210
ByteSar	210
ByteShl	210
ByteShr	210
BYTESPERWORD (const)	43, 145
ByteXor	209

C

cabs	40, 80, 174
cabsf	40, 80, 174
cabsl	40, 80, 174
cacos	175
cacosf	175
cacosl	175
can (const)	75
CanAppendAll	392
CanAssignAll	392
Cancel	269
CanConcatAll	393
CanDeleteAll	392
CanExtractAll	392
CanGetClock	395
CanInsertAll	392
CanReplaceAll	392
CanSetClock	395
Cap	156
Capitalize	394
CAP	10
carccos	41, 81
carccosf	40, 81
carccosl	41, 81
carcsin	40, 81
carcsinf	40, 81
carcsinl	40, 81
carctan	41, 81
carctanf	41, 81
carctanl	41, 81
CardinalToString	160
CardToStr	125, 405
carg	40, 80, 174
cargf	40, 80, 174
cargl	40, 80, 174
Case (ebnf)	71
CaseException	122, 318
CaseLabelList (ebnf)	69
CaseLabels (ebnf)	69
CaseStatement (ebnf)	71
CaseTag (ebnf)	69
casin	175
casinf	175
casinl	175
CAST	49, 372
catan	175
catanf	175
catanl	175
ccos	40, 81, 175
ccosf	40, 81, 175
ccosl	40, 81, 175
ceil	194
ceilf	194
ceill	194
cexp	40, 81, 174
cexpf	40, 81, 174
cexpl	40, 81, 174
cfgetispeed	199
cfgetospeed	199
cfmakeraw	200
cfsetispeed	199
cfsetospeed	199
cfsetspeed	199
ChanDev (type)	334
ChanException	291
ChanExceptions (type)	290
ChanFlags (type)	274
ChanId (type)	326, 340, 354, 376, 385, 389, 398
char	92
checkErrno	336
chown	188
CHR	10
Claim	375
clientInfo (type)	406
clientOpen	406
clientOpenIP	406
cln	40, 81
clnf	40, 81
clnl	40, 81
clog	174
clogf	174
clogl	174
close	186
Close	98, 130, 228, 277, 320, 356, 378, 389, 399
CloseInput	235
CloseOutput	236
CloseSource	149
Command (type)	228
Compare	393
CompareResults (type)	393
CompareStr	251
CompareTime	257
ComponentElement (ebnf)	67
ComponentValue (ebnf)	67
ConCat	88, 128, 251
Concat	392
ConCatChar	88
CondClaim	375
conj	40, 80, 174, 278, 297, 379
conjf	40, 80, 174
conjl	40, 80, 174
connectSpin	181
ConstActualParameters (ebnf)	67
ConstantDeclaration (ebnf)	66
ConstAttribute (ebnf)	67
ConstAttributeExpression (ebnf)	67
ConstExpression (ebnf)	66
ConstFactor (ebnf)	67
ConstructModules	116, 119, 315
Constructor (ebnf)	67
ConstSetOrQualidentOrFunction (ebnf)	67
ConstString (ebnf)	67
ConstTerm (ebnf)	67
ControlChar (type)	198
ConvertCardinal	221
ConvertHex	221

ConvertInteger	221	DefaultRecordAttributes (ebnf)	68
ConvertLongInt	221	DefExtendedFP (ebnf)	72
ConvertOctal	221	DefFormalParameters (ebnf)	72
ConvertShortInt	221	DefineBuiltinProcedure (ebnf)	71
ConvResults (type) ..	282, 299, 305, 346, 352, 402, 405	DefineComments	150
Copy	250	Definition (ebnf)	73
CopyOut	91	DefinitionModule (ebnf)	73
COROUTINE (type)	271	DefMultiFPSection (ebnf)	72
cos ..	38, 79, 114, 123, 144, 173, 193, 278, 297, 303, 350, 379	DefOptArg (ebnf)	73
cosf	38, 79, 173, 193	DefProcedureHeading (ebnf)	71
cosl	38, 79, 173, 193	del (const)	75
cpow	174	Delay	224
cpower	40, 81	Delete	228, 250, 391
cpowerf	40, 81	DeleteIndex	112
cpowerl	40, 81	DelKey	331
cpowf	174	DESCRIPTOR (type)	258
cpowl	174	Designator (ebnf)	69
cr (const)	75	Destroy	375
creat	187	Detach	323
Create	228, 322, 375	DETACH	272
csin	40, 81, 174	DevExceptionRange (type)	295
csinf	40, 81, 174	DeviceData (type)	294
csinl	40, 81, 175	DeviceErrNum (type)	291
csqrt	40, 81, 174	DeviceError	291
csqrtf	40, 81, 174	DeviceTable (type)	294
csqrtl	40, 81, 174	DeviceTablePtr (type)	293
ctan	40, 81, 175	DeviceTablePtrValue	294
ctanf	40, 81, 175	DeviceType (type)	334
ctanl	40, 81, 175	DIFADR	48, 371
ctos	163	DisableBreak	217
CurrentFlags	290	DispatchVector (type)	136
currentInterruptLevel	327	displayProcesses	325
currentMode	309, 311, 313	DISPOSE	11
CurrentNumber	283	dle (const)	75
CurrentPos	355	dogeterrno	332
currentThread	327	doGetErrno	338
CURRENT	272	Doio	232
D			
DateTime (type)	395	doLook	335
Day (type)	395	Done (var)	218, 235, 240, 247
dc1 (const)	75	doRBytes	338
dc2 (const)	75	dorbytes	332
dc3 (const)	75	doreadchar	332
dc4 (const)	75	doReadChar	338
DEALLOCATE	155, 168, 387	doReadLocs	335
DebugIndex	111	doReadText	335
DebugProcess	260	doSkip	335
DebugString	86	doSkipLook	335
DecException	122, 318	doUnReadChar	338
Declaration (ebnf)	72	dounreadchar	332
DeconstructModules	116, 119, 315	doWBytes	338
DEC	11	dowbytes	333
DefaultDecimalPlaces (const)	247	dowriteln	333
DefaultErrorCatch	134	doWriteLn	335
		doWriteLocs	335
		doWriteText	335
		doWrLn	339
		dtoa	179
		Dup	89, 127

dup 186
 DupDB 93
 DynamicArraySubscriptException 122, 318

E

echo (const) 274, 398
 EchoOff 110
 EchoOn 109
 EHBlock (type) 132
 em (const) 75
 EnableBreak 217
 END (type) 183, 184, 227, 262
 END M2LINK. (var) 118
 EndPos 355
 enq (const) 75
 entier 114, 123, 144
 Enumeration (ebnf) 68
 eof (const) 75
 EOF 99
 EOL (const) 75, 235
 EOLN 99
 eot (const) 75
 Equal 89, 393
 EqualArray 89
 EqualCharStar 89
 ErrChan 385
 Error 109, 130
 ErrorMessage 121, 317
 esc (const) 75
 etb (const) 75
 etx (const) 75
 EVENT (type) 268
 exception (const) 308, 310, 312
 ExceptionalPart (ebnf) 72
 ExceptionNumber (type) 283
 ExclException 122, 318
 ExcludeVector 137
 EXCL 11
 ExecuteInitialProcedures 120, 316
 ExecuteTerminationProcedures 120, 315
 execv 192
 Exists 97, 142
 exists 98
 exit 186
 ExitOnHalt 121, 317
 exitP (type) 184
 ExitToOS 226
 exp.. 39, 79, 114, 123, 144, 173, 194, 278, 297, 303, 350, 379
 exp1 (const) 303, 350
 exp10 39, 79, 173, 194
 exp10f 39, 79, 173, 194
 exp10l 39, 79, 173, 194
 expf 39, 79, 173, 194
 expl 39, 79, 173, 194
 ExpList (ebnf) 70
 expoMax (const) 308, 310, 312

expoMin (const) 308, 310, 312
 exponent 308, 310, 312
 Export (ebnf) 73
 Expression (ebnf) 70
 extend (const) 308, 310, 312
 ExtendedFP (ebnf) 72
 Extract 391

F

fabs 38, 79, 173
 fabsf 38, 79, 173
 fabsl 38, 79, 173
 Factor (ebnf) 70
 FdClr 151
 FdIsSet 151
 FdSet 151
 FdZero 151
 ff (const) 75
 FieldList (ebnf) 68
 FieldListSequence (ebnf) 68
 FieldListStatement (ebnf) 68
 FieldPragmaExpression (ebnf) 68
 File (type) 96, 227
 fileinode 203
 filetime 203
 FileNameChar 232
 FilePos (type) 355
 FilePosSize (const) 355
 filesize 203
 FileUnit (ebnf) 66
 Fin 87
 FinalBlock (ebnf) 72
 FindDiff 393
 FindNext 393
 FindPosition 102
 FindPrev 393
 finishSpin 181
 Flag (type) 198, 227
 FlagSet (type) 227, 274, 354, 376, 389, 398
 Float 233
 Float1 234
 FLOAT 11
 FLOATL 11
 FLOATS 11
 floor 194
 floorf 194
 floorl 194
 Flush 290
 FlushBuffer 98
 FlushOutErr 102
 FlushProc (type) 293
 ForcedModuleInitOrder (var) 118
 ForeachIndiceInIndexDo 113
 ForLoopBeginException 122, 318
 ForLoopEndException 122, 318
 ForLoopToException 122, 318
 FormalParameters (ebnf) 72

FormalReturn (ebnf)	69	GetExceptionSource	135
FormalType (ebnf)	73	GetExitStatus	130
FormalTypeList (ebnf)	69	GetFile	341
FormatCard	402	getFileName	102
FormatInt	402	GetFileName	102
FormatReal	299, 346	getFileNameLength	102
ForStatement (ebnf)	71	GetFlag	201
FPSection (ebnf)	72	GetFractions	410
Frac	233	GetHour	411
Frac1	234	GetIndice	112
fraction	308, 310, 312	GetKey	331
Fraction (type)	395	getLocalIP	196
fractpart	308, 310, 312	GetLongOptionArray	177
frame_address	42, 82	GetMessage	283
free	185	GetMinute	411
FreeProc (type)	294	GetMonth	411
FreeProcedure (type)	329	GetName	290
fs (const)	75	GetNameProc (type)	293
ftime	191	getnameuidgid	204
G			
GenDevIF (type)	337	GetNextSymbol	149
GeneralException	287	GetNumber	133
GeneralExceptions (type)	287	GetOpenResults	285
GetArg	76, 85, 139, 140	GetOpt	106
GetArgc	128	getopt	176
GetArgC	171	getopt_long	176
GetArgv	128	getopt_long_only	176
GetArgV	171	GetOptLong	107
GetBaseExceptionBlock	135	GetOptLongOnly	107
GetBits	209, 212	getpid	186
GetCh	129	GetPos	231
GetChar	202	getPushBackChar	407
getClientHostname	407	getrand	203
getClientIP	407	GetSecond	411
getClientPortNo	406	getsizeofClientInfo	407
getClientSocketFd	407	GetSummerTime	412
GetClock	395	GetTextBuffer	133
GetColumnPosition	131	GetTextBufferSize	133
GetCurrentInput	154	GetTicks	268
GetCurrentLine	131	GetTime	151, 256
GetCurrentOutput	154	GetTimeOfDay	151
GetCurrentProcess	260	gettimeofday	410
getcwd	188	GetTimeString	170
GetData	329	GetTimeVector	137
GetDay	411	GetUnixFileDescriptor	101
GetDeviceId	340	getusername	204
GetDevicePtr	341	GetYear	411
getDID	337	Group (type)	331
GetDST	412	gs (const)	75
getenv	186	gUnderflow (const)	308, 310, 312
GetEnvironment	95, 141		
GetEnvV	171		
geterrno	180		
geterrno (type)	337		
GetErrorCode	226		
GetExceptionBlock	133		

H

Halt 86, 121, 316
 HaltC 121, 317
 HALT 12, 120, 316
 HandleEscape 104
 Handler 324
 HANDLER 272
 HasHalted 317, 397
 HexToStr 125
 HighByte 214
 HighIndice 112
 HighNibble 211
 HIGH 12
 Hour (type) 395
 hstoc 164
 hstoi 163
 ht (const) 75
 huge_val 39, 80
 huge_valf 39, 80
 huge_vall 39, 80

I

i (const) 278, 297, 379
 Ident (ebnf) 66
 IdentList (ebnf) 68
 IEC559 (const) 308, 310, 312
 IEEE (const) 308, 310, 312
 IfStatement (ebnf) 70
 ilogb 39, 80, 173
 ilogbf 39, 80, 173
 ilogbl 39, 80, 173
 ImplementationModule (ebnf) 66
 ImplementationOrProgramModule (ebnf) 66
 Import (ebnf) 73
 IM 15
 InBounds 111
 IncException 122, 318
 InChan 385
 InclException 122, 318
 IncludeIndiceIntoIndex 113
 IncludeVector 137
 INC 12
 INCL 12
 index 41, 82, 175
 Index 90
 Index (type) 111
 IndexProcedure (type) 111
 IndexStrCmp 128
 IndexStrNCmp 128
 Init 138, 169
 init 327
 InitChanDev 334
 InitChanId 340
 InitData 329
 InitExceptionBlock 133
 InitExceptionHandler 167
 InitGenDevIF 337

InitGroup 331
 InitialBlock (ebnf) 72
 InitIndex 111
 InitInputVector 136
 InitLongOptions 106
 InitOption 127
 InitOptions 177
 InitOutputVector 136
 initPreemptive 321
 InitProcess 258
 InitSemaphore 259
 initSemaphore 327
 InitSet 151
 InitString 87
 InitStringChar 88
 InitStringCharDB 93
 InitStringCharStar 88
 InitStringCharStarDB 92
 InitStringDB 92
 InitTermios 198
 initThread 327
 InitTime 151
 InitTimeval 409
 InitTimeVector 136
 InitTimezone 409
 InitTM 410
 Insert 250, 391
 InsertCipherLayer 384
 InstallBreak 217
 InstallInitialProcedure 120, 316
 InstallTerminationProcedure 119, 316
 Int 233
 Integer (ebnf) 66
 IntegerToString 160
 interactive (const) 274
 INT 15
 INTERRUPTSOURCE (type) 84, 271
 Intl 234
 intpart 308, 310, 312
 IntToStr 125, 405
 InvalidChan 288
 IOException 295
 IOTRANSFER 263, 271
 IsActive 97
 IsArgPresent 326
 IsAttached 323
 IsATTACHED 272
 isatty 185
 IsChanException 290
 IsCMathException 279, 298, 380
 IsControl 276
 IsCurrentSource 283
 IsDevice 295
 iseof 333
 iseof (type) 337
 isEOF 339
 iseoIn 333
 iseoIn (type) 337

isEOLN	339
IsErrnoHard	285
IsErrnoSoft	285
isError	339
iserror	333
iserror (type)	337
IsExceptionalExecution	283
isfinite	38, 79, 172, 204
isfinitef	38, 79, 173, 204
isfinitel	38, 79, 173, 205
IsGeneralException	287
IsIn	331
IsIndicesInIndex	112
IsInExceptionState	134
isinf_sign	173
isinf_signf	173
isinf_signl	173
IsIOException	295
IsLetter	276
IsLower	276
IsLowException	309, 311, 313
IsM2Exception	117, 314
IsMem	320
IsNoError	96
IsNumeric	276
ISO (const)	308, 310, 312
IsProcessesException	324
IsRConvException	299, 346
IsRMathException	303, 350
IsRndFile	355
IsRndFileException	355
IsSeqFile	377
IsSocket	277
IsStorageException	387
IsStreamFile	389
IsSubString	159
IsTermFile	398
IsTerminating	317, 397
IsUpper	276
IsValidDateTime	395
IsWhiteSpace	276
IsWholeConvException	403
itos	163

K

KeyPressed	239, 253, 254
KillChanDev	334
KillChanId	340
KillData	329
KillExceptionBlock	133
KillGenDevIF	339
KillGroup	331
KillIndex	111
KillLongOptions	107
KillOption	127
KillOptions	177
KillProcess	258

KillSet	151
KillString	87
KillTermios	198
KillTime	151
KillTimeval	409
KillTimezone	409
KillTM	410

L

large (const)	308, 310, 312
ldtoa	182
Length	88, 121, 231, 251, 318, 391
LengthCard	403
LengthEngReal	299, 346
LengthFixedReal	299, 346
LengthFloatReal	299, 346
LengthInt	402
LENGTH	15
lf (const)	75
LFLOAT	13
LIA1 (const)	308, 310, 312
Listen	137
ListenLoop	264, 273
LISTEN	263, 272
ln	114, 123, 144, 278, 297, 303, 350, 379
localtime	191
localtime_r	411
LOCSPERBYTE (const)	47, 370
LOCSPERWORD (const)	47, 370
log	38, 79, 173, 194
log10	39, 79, 173
log10f	39, 79, 173
log10l	39, 79, 173
logf	38, 79, 173, 194
logl	38, 79, 173, 194
LongCardinalToString	162
LongIntegerToString	161
LongIntToStr	105
longjmp	41, 82, 192
LongOptions (type)	106
LongRealToStr	105
LongRealToString	245
LongrealToString	165
Look	288
LookProc (type)	293
Lookup	228
LoopStatement (ebnf)	71
LowByte	214
Lower	156
LowIndices	112
LowNibble	211
lseek	187
LTRUNC	13

M

M2Exception 117, 314
M2Exceptions (type) 117, 314
MAKEADR 48, 371
MakeChan 293
MakeModuleId 329
malloc 185
Mark 88
MaxFdsPlusOne 151
maxSecondParts (const) 395
MAX 13
Me 324
memcmp 41, 82, 175
MemCopy 124
memcpy 41, 81, 172, 189
memmove 41, 82, 175, 189
memset 41, 82, 175, 189
MemZero 124
Min (type) 395
MIN 13
Mode (type) 179, 182
Modes (type) 308, 310, 312
modf 39, 80, 173
modff 39, 80, 173
modfl 39, 80, 173
ModuleDeclaration (ebnf) 73
ModuleId (type) 329
Month (type) 395
MulOperator (ebnf) 67
Mult 90
MultDB 93
MultiFPSection (ebnf) 72
MyParam 324

N

nak (const) 75
NamedOperand (ebnf) 73
Narg 76, 85, 139, 140
NEW 13
NEWCOROUTINE 21, 271
NewPos 355
NEWPROCESS 263
nextafter 39, 80, 173
nextafterf 39, 80, 173
nextafterl 39, 80, 173
NextArg 326
nexttoward 39, 80, 174
nexttowardf 39, 80, 174
nexttowardl 39, 80, 174
NilChanId 340
nl (const) 75
nModes (const) 308, 310, 312
no_argument (const) 106
NoException 122, 318
NonVarFPSection (ebnf) 72
NoReturnException 122, 318
NormalPart (ebnf) 72

np (const) 75
nul (const) 75
NullChan 385
Number (ebnf) 66

O

OctToStr 125
ODD 13, 15
old (const) 274, 354, 376, 389
one (const) 278, 297, 379
Open 129, 389, 398
open 187
OpenAppend 376
OpenClean 354
OpenForRandom 97, 143
openForRandom 98
OpenInput 235
OpenOld 354
OpenOutput 235
OpenRead 320, 377
OpenResults (type) 274, 354, 376, 389, 398
OpenSocket 277
OpenSource 149
OpenToRead 97, 142
openToRead 98
openToWrite 98
OpenToWrite 97, 142
OpenWrite 319, 376
OptArg (ebnf) 73
optarg (var) 176
opterr (var) 176
optind (var) 176
Option (type) 127
optional_argument (const) 106
Options (type) 176
optopt (var) 176
OptReturnType (ebnf) 69
ostoc 164
ostoi 164
OutChan 385

P

Parameter (type) 322
ParameterException 122, 318
perror 187
pi (const) 303, 350
places (const) 308, 310, 312
PointerNilException 122, 318
PointerType (ebnf) 69
polarToComplex 279, 298, 380
PopAllocation 94
PopAllocationExemption 94
PopHandler 134
PopInput 154
PopOutput 153
Pos 250

pow 194
 power 278, 297, 303, 350, 379
 powf 194
 powl 194
 pred 308, 310, 312
 printf 190
 Priority (ebnf) 73
 ProcedureBlock (ebnf) 72
 ProcedureDeclaration (ebnf) 71
 ProcedureHandler (type) 132
 ProcedureHeading (ebnf) 71
 ProcedureParameter (ebnf) 69
 ProcedureParameters (ebnf) 69
 ProcedureType (ebnf) 69
 PROCESS (type) 262
 ProcessesException 324
 ProcessesExceptions (type) 322
 ProcessName 260
 PROCEXCEPTION (type) 167
 ProcRead (type) 153
 ProcWrite (type) 153
 ProgramModule (ebnf) 66
 PROT 272
 PROTECTION (type) 84, 271
 Ps 260
 PtrToChar (type) 118
 PtrToInteger (type) 106
 ptrToTM (type) 183
 PushAllocation 93
 PushHandler 133
 PushInput 154
 PushOutput 153
 PutCh 129
 putenv 186
 PutEnvironment 95, 141
 PutIndice 112
 PutKey 331
 PutStr 129
 PutString 129

Q

Qualident (ebnf) 66

R

radix (const) 308, 310, 312
 Raise 132
 RAISEdevException 295
 RaiseEOFInLook 334
 RaiseEOFInSkip 335
 RaiseGeneralException 287
 RAISE 283
 rand 190
 RandomBytes 242, 342
 RandomCard 242, 343
 RandomInit 242, 342
 RandomInt 242, 342

Randomize 242, 342
 RandomLongCard 343
 RandomLongInt 343
 RandomLongReal 243, 344
 RandomReal 243, 343
 RandomShortCard 343
 RandomShortInt 343
 RandomShortReal 343
 raw (const) 274, 354, 376, 389, 398
 RawRead 289
 RawReadProc (type) 293
 RawWrite 289
 RawWriteProc (type) 293
 read 184
 Read 109, 153, 236, 239, 252, 254, 345, 361
 read (const) 274, 354, 376, 389, 398
 ReadAgain 254
 ReadAny 99
 ReadBin 125
 ReadByte 229
 readbytes (type) 337
 ReadCard 125, 237, 307, 360, 366, 369, 383, 404
 ReadCardinal 101, 218
 ReadChar 100, 229, 367, 400
 readchar (type) 337
 ReadCharRaw 151
 ReadHex 125, 218
 ReadInt 125, 237, 307, 360, 366, 369, 383, 404
 ReadLongCardinal 219
 ReadLongHex 219
 ReadLongInt 105, 240
 ReadLongReal 105, 248
 ReadNBytes 98, 230
 ReadOct 125
 ReadProcedure (type) 252
 ReadReal 105, 247, 301, 348, 358, 362, 364, 381
 ReadRestLine 367, 400
 ReadResult 290, 296, 357
 ReadResults (type) 292, 296, 357
 ReadS 143, 238
 ReadShortCardinal 220
 ReadShortHex 220
 ReadShortReal 248
 ReadString 101, 157, 236, 254, 367, 400
 ReadToken 367, 400
 readv 187
 ReadWord 229
 Real (ebnf) 66
 realloc 185
 REALLOCATE 155, 168, 387
 RealToEng 305, 352
 RealToEngString 280, 281
 RealToFixed 305, 352
 RealToFixedString 280, 281
 RealToFloat 305, 352
 RealToFloatString 280, 281
 RealToStr 105, 306, 353
 RealToString 245

RealValueException	122, 318
ReArmEvent	269
ReArmTimeVector	136
RecordFieldPragma (ebnf)	68
RecordType (ebnf)	68
RegisterModule	116, 119, 315
Relation (ebnf)	66
Release	375
RemoveCipherLayer	384
RemoveComment	90
RemoveIndicesFromIndex	112
RemoveWhitePostfix	91
RemoveWhitePrefix	91
rename	191
Rename	228
RepeatStatement (ebnf)	71
Replace	391
RequestDependant	116, 119, 315
required_argument (const)	106
Reread	320, 377
Reschedule	324
Reset	231, 290
ResetProc (type)	293
Response (type)	227
Resume	258
RetryStatement (ebnf)	70
return_address	42, 83
ReturnException	122, 318
Rewrite	320, 377
RE	15
RIndex	90
rindex	41, 82, 175
RotateException	122, 318
RotateLeft	46, 51, 148, 267, 374
RotateRight	46, 51, 148, 267, 374
RotateRunQueue	260
RotateVal	45, 50, 148, 266, 374
ROTATE	43, 48, 146, 264, 372
round	303, 309, 311, 313, 350
Round	233
Roundl	234
rounds (const)	308, 310, 312
rs (const)	75
S	
scalarMult	279, 298, 380
scalb	174
scalbf	174
scalbl	174
scalbln	39, 80, 174
scalblnf	39, 80, 174
scalblnl	39, 80, 174
scalbn	39, 80, 174
scalbnf	39, 80, 174
scalbnl	39, 80, 174
scale	309, 311, 313
ScanCard	402
ScanClass (type)	282
ScanInt	402
ScanReal	299, 346
ScanState (type)	282
Sec (type)	395
Select	151
select	327
SEMAPHORE (type)	258
SetBits	209, 212
SetChar	202
SetClock	395
SetDebug	130
SetDeviceId	341
SetDevicePtr	341
setenv	190
SetErrChan	386
SetErrorCode	226
SetExceptionBlock	132
SetExceptionSource	135
SetExceptionState	134
SetFile	341
SetFlag	202
SetInChan	386
setjmp	42, 82, 191
setMode	309, 311, 313
SetModify	231
SetNoOfDecimalPlaces	247
SetNoOfExponentDigits	244
SetOfFd (type)	151
SetOpen	231
SetOption	177
SetOrDesignatorOrFunction (ebnf)	70
SetOutChan	386
SetPos	231, 355
SetPositionFromBeginning	101
SetPositionFromEnd	101
setPushBackChar	407
SetRead	230
SetReadResult	290
SetTime	151, 256
settimeofday	410
SetTimeval	412
SetTimezone	412
SetType (ebnf)	69
SetWrite	230
SFLOAT	14
ShiftException	122, 318
ShiftLeft	45, 50, 147, 266, 373
ShiftRight	45, 50, 147, 266, 373
ShiftVal	45, 50, 147, 266, 373
SHIFT	44, 49, 146, 265, 372
ShortCardinalToString	162
shutdown	191
si (const)	75
sign	308, 310, 312
signal	327
Signal	259
signalThread	327

signbit	39, 80, 204	stor	165
signbitf	39, 80, 204	StorageException	387
signbitl	39, 80, 204	StorageExceptions (type)	387
significand	173	strcat	41, 82, 175
significandf	173	strchr	41, 82, 175
significandl	173	strcmp	41, 82, 175
SimpleConstExpr (ebnf)	66	StrConCat	158
SimpleDes (ebnf)	70	StrCopy	158
SimpleExpression (ebnf)	70	strncpy	41, 82, 175, 188
SimpleType (ebnf)	68	strcspn	41, 82, 175
sin	38, 79, 114, 123, 144, 173, 193, 278, 297, 303, 350, 379	StrEqual	158
sinf	38, 79, 173, 193	string	92
sinl	38, 79, 173, 193	string (ebnf)	66
SIZE	43, 145, 264	String (type)	87
Skip	288	String1 (type)	391
SkipLine	367, 400	StringToCardinal	161
SkipLook	288	StringToInteger	161
SkipLookProc (type)	293	StringToLongCardinal	162
SkipProc (type)	293	StringToLongInteger	162
Sleep	268	StringToLongreal	164
sleep	192	StringToLongReal	246
sleepSpin	181	StringToReal	246
Slice	90, 127	StringToShortCardinal	163
SliceDB	93	StrLen	158
small (const)	308, 310, 312	strlen	41, 82, 175, 188
snprintf	190	strless	158
so (const)	75	strncat	41, 82, 175
soh (const)	75	strncmp	41, 82, 175
Sources (type)	322	strncpy	41, 82, 175, 188
sp (const)	75	strpbrk	41, 82, 175
Sprintf0	103	strrchr	41, 82, 175
Sprintf1	103	StrRemoveWhitePrefix	159
Sprintf2	103	strspn	41, 82, 175
Sprintf3	103	strstr	41, 82, 175
Sprintf4	103	strtime	203
sqrt	38, 79, 114, 123, 144, 173, 193, 278, 297, 303, 350, 379	StrToBin	126
sqrtf	38, 79, 173, 193	StrToBinInt	126
sqrtl	38, 79, 173, 193	StrToCard	125, 405
rand	190	strtod	179
Start	322	StrToHex	125
StartPos	355	StrToHexInt	126
Statement (ebnf)	70	StrToInt	125, 405
StatementSequence (ebnf)	70	strtold	182
StaticArraySubscriptException	122, 318	StrToLongInt	105
StaticInitialization (var)	118	StrToLongReal	105
StatusProcedure (type)	252	StrToLowerCase	156
StdErr (var)	96	StrToOct	125
StdErrChan	385	StrToOctInt	126
StdIn (var)	96	StrToReal	105, 305, 352
StdInChan	385	StrToUpperCase	156
StdOut (var)	96	STRUNC	14
StdOutChan	385	stx (const)	75
stoc	163	sub (const)	75
stoi	163	SUBADR	48, 371
stolr	165	SubDesignator (ebnf)	69
StopMe	322	SubrangeType (ebnf)	68
		succ	308, 310, 312
		Suspend	259

SuspendMe	322
SuspendMeAndActivate	323
Swap	211, 214
Switch	323
SwitchCaps	261
SwitchExceptionState	135
SwitchLeds	261
SwitchNum	261
SwitchScroll	261
syn (const)	75
synthesize	309, 311, 313
system	184

T

tab (const)	75
TagIdent (ebnf)	68
tan	114, 123, 144, 193, 278, 297, 303, 350, 379
tanf	193
tanl	193
TBITSIZE	44, 49, 146, 265, 372
tcdrain	200
tcflowoffi	201
tcflowoffo	201
tcflowoni	201
tcflowono	201
tcflushi	200
tcflushio	201
tcflusho	200
tcgetattr	199
tcpClientConnect	197
tcpClientIP	197
tcpClientPortNo	197
tcpClientSocket	197
tcpClientSocketFd	197
tcpClientSocketIP	197
tcpClientState (type)	195
tcpServerAccept	195
tcpServerClientIP	196
tcpServerClientPortNo	196
tcpServerEstablish	195
tcpServerEstablishPort	195
tcpServerIP	196
tcpServerPortNo	196
tcpServerSocketFd	196
tcpServerState (type)	195
tcsdrain	200
tcsendbreak	200
tcsetattr	200
tcsflush	200
tcsnow	199
Term (ebnf)	70
termCH (var)	235
Terminate	120
TerminateOnError	149
TERMIOS (type)	198
text (const)	274, 354, 376, 389, 398
TextRead	289

TextReadProc (type)	293
TextWrite	289
TextWriteProc (type)	293
THROW	44, 49, 146, 265, 372
TicksPerSecond (const)	268
time	190
time_t (type)	183
timeb (type)	183
TimeToString	257
TimeToZero	257
timeval (type)	409
Timeval (type)	151
timezone (type)	409
tm (type)	183, 409
ToDecimalPlaces	166
ToLower	91
ToSigFig	166
ToUpper	91
transfer	327
TRANSFER	263, 271
TrashList (ebnf)	74
Trunc	233
trunc	309, 311, 313
Trunc1	234
TRUNC	14
TRUNCL	14
TRUNCS	14
TSIZE	43, 49, 145, 264, 372
ttyname	192
TurnInterrupts	264, 272
turnInterrupts	327
Type (ebnf)	68
TypeDeclaration (ebnf)	68

U

ulp	308, 310, 312
UnaryOrConstTerm (ebnf)	67
UnassignedPriority (const)	271
UnAssignRead	252
UnAssignWrite	253
UnAvailable	285
UnBufferedMode	109
UnInstallBreak	217
unlink	189
UnMakeChan	293
UnReadChar	100
unreadchar (type)	337
Urgency (type)	322
UrgencyOf	324
us (const)	75
userdeverror (type)	227
UTCDiff (type)	395

V

ValueCard	402
ValueInt	402
ValueReal	299, 346
VAL	14
VarFPSection (ebnf)	72
VariableDeclaration (ebnf)	69
VarIdent (ebnf)	69
VarIdentList (ebnf)	69
Variante (ebnf)	69
VarianteCaseLabelList (ebnf)	69
VarianteCaseLabels (ebnf)	69
vt (const)	75

W

wait	327
Wait	259, 323
WaitForIO	259
WaitOn	269
waitThread	327
WarnError	130
WarnString	130
WasEOLN	100
WhileStatement (ebnf)	71
WholeNonPosDivException	122, 318
WholeNonPosModException	122, 318
WholeValueException	122, 318
WholeZeroDivException	122, 318
WholeZeroRemException	122, 318
WithStatement (ebnf)	71
WORD (type)	47, 371
WordAnd	212
WordNot	213
WordOr	212
WordRol	213
WordRor	213
WordSar	213
WordShl	213
WordShr	213
WordXor	212
write	184
Write	109, 153, 225, 236, 253, 255, 345, 361

write (const)	274, 354, 376, 389, 398
WriteAny	99
WriteBin	125
WriteByte	229
writebytes (type)	337
WriteCard	125, 237, 307, 360, 366, 369, 383, 404
WriteCardinal	101, 218
WriteChar	99, 229, 367, 401
WriteCharRaw	151
WriteEng	301, 348, 358, 362, 364, 381
WriteError	149
writeFieldWidth	390
WriteFixed	301, 348, 358, 362, 364, 381
WriteFloat	301, 348, 358, 362, 364, 381
WriteHex	125, 219, 238
WriteInt	125, 237, 307, 360, 366, 369, 383, 404
WriteLine	100
WriteLn	157, 236, 255, 289, 368, 401
writeln (type)	337
WriteLnProc (type)	293
WriteLongCardinal	219
WriteLongHex	219
WriteLongInt	105, 240
WriteLongReal	105, 248
WriteLongRealOct	248
WriteNBytes	99, 230
WriteOct	125, 237
WriteProcedure (type)	252
WriteReal	105, 247, 302, 349, 358, 362, 364, 382
WriteRealOct	248
WriteS	143, 238
WriteShortCardinal	219
WriteShortHex	220
WriteShortReal	248
WriteShortRealOct	249
WriteString	100, 157, 236, 255, 368, 401
writeString	390
writew	187
WriteWord	229

Z

zero (const)	278, 297, 379
--------------	---------------

Short Contents

1	Overview of GNU Modula-2	1
2	Using GNU Modula-2	3
	GNU General Public License	54
3	EBNF of GNU Modula-2	66
4	PIM and ISO library definitions	75

Table of Contents

1	Overview of GNU Modula-2	1
1.1	What is GNU Modula-2	1
1.2	Why use GNU Modula-2	1
1.3	How to get source code using git	1
1.4	GNU Modula-2 Features	2
2	Using GNU Modula-2	3
2.1	Example compile and link	3
2.2	Compiler options	3
2.3	Elementary data types	9
2.4	Permanently accessible base procedures	10
2.4.1	Standard procedures and functions common to PIM and ISO	10
2.4.2	ISO specific standard procedures and functions	15
2.5	GNU Modula-2 supported dialects	16
2.5.1	Integer division, remainder and modulus	16
2.6	Exception implementation	17
2.7	How to detect run time problems at compile time	17
2.8	GNU Modula-2 language extensions	18
2.8.1	Optional procedure parameter	20
2.9	Type compatibility	21
2.9.1	Expression compatibility	23
2.9.2	Assignment compatibility	23
2.9.3	Parameter compatibility	23
2.10	Unbounded by reference	24
2.11	Building a shared library	25
2.12	How to produce swig interface files	26
2.12.1	Limitations of automatic generated of Swig files	27
2.13	How to produce a Python module	28
2.14	Interfacing GNU Modula-2 to C	31
2.15	Interface to assembly language	33
2.16	Data type alignment	33
2.17	Packing data types	35
2.18	Accessing GNU Modula-2 Built-ins	37
2.19	The PIM system module	42
2.20	The ISO system module	46
2.21	Release map	51
2.22	Documentation	52
2.23	Regression tests for gm2 in the repository	52
2.24	Limitations	52
2.25	Objectives	52
2.26	FAQ	52
2.26.1	Why use the C++ exception mechanism in GCC, rather than a bespoke Modula-2 mechanism?	52

2.27	Community	52
2.28	Other languages for GCC.....	53
2.29	License of GNU Modula-2	53
GNU General Public License		54
	Contributing to GNU Modula-2.....	64
3	EBNF of GNU Modula-2.....	66
4	PIM and ISO library definitions.....	75
4.1	Base libraries.....	75
4.1.1	gm2-libs/ASCII	75
4.1.2	gm2-libs/Args	76
4.1.3	gm2-libs/Assertion.....	77
4.1.4	gm2-libs/Break	78
4.1.5	gm2-libs/Builtins	79
4.1.6	gm2-libs/COROUTINES	84
4.1.7	gm2-libs/CmdArgs	85
4.1.8	gm2-libs/Debug	86
4.1.9	gm2-libs/DynamicStrings.....	87
4.1.10	gm2-libs/Environment	95
4.1.11	gm2-libs/FIO.....	96
4.1.12	gm2-libs/FormatStrings	103
4.1.13	gm2-libs/FpuIO	105
4.1.14	gm2-libs/GetOpt	106
4.1.15	gm2-libs/IO	109
4.1.16	gm2-libs/Indexing.....	111
4.1.17	gm2-libs/LMathLib0	114
4.1.18	gm2-libs/LegacyReal	115
4.1.19	gm2-libs/M2Dependent	116
4.1.20	gm2-libs/M2EXCEPTION	117
4.1.21	gm2-libs/M2LINK.....	118
4.1.22	gm2-libs/M2RTS	119
4.1.23	gm2-libs/MathLib0.....	123
4.1.24	gm2-libs/MemUtils.....	124
4.1.25	gm2-libs/NumberIO	125
4.1.26	gm2-libs/OptLib	127
4.1.27	gm2-libs/PushBackInput	129
4.1.28	gm2-libs/RTExceptions.....	132
4.1.29	gm2-libs/RTint	136
4.1.30	gm2-libs/SArgs.....	139
4.1.31	gm2-libs/SCmdArgs	140
4.1.32	gm2-libs/SEnvironment.....	141
4.1.33	gm2-libs/SFIO	142
4.1.34	gm2-libs/SMathLib0.....	144

4.1.35	gm2-libs/SYSTEM	145
4.1.36	gm2-libs/Scan	149
4.1.37	gm2-libs/Selective	151
4.1.38	gm2-libs/StdIO	153
4.1.39	gm2-libs/Storage	155
4.1.40	gm2-libs/StrCase	156
4.1.41	gm2-libs/StrIO	157
4.1.42	gm2-libs/StrLib	158
4.1.43	gm2-libs/StringConvert	160
4.1.44	gm2-libs/SysExceptions	167
4.1.45	gm2-libs/SysStorage	168
4.1.46	gm2-libs/TimeString	170
4.1.47	gm2-libs/UnixArgs	171
4.1.48	gm2-libs/cbuiltin	172
4.1.49	gm2-libs/cgetopt	176
4.1.50	gm2-libs/cxxabi	178
4.1.51	gm2-libs/dtoa	179
4.1.52	gm2-libs/errno	180
4.1.53	gm2-libs/gdbif	181
4.1.54	gm2-libs/ldtoa	182
4.1.55	gm2-libs/libc	183
4.1.56	gm2-libs/libm	193
4.1.57	gm2-libs/sckt	195
4.1.58	gm2-libs/termios	198
4.1.59	gm2-libs/wrapc	203
4.2	PIM and Logitech 3.0 Compatible	206
4.2.1	gm2-libs-log/BitBlockOps	206
4.2.2	gm2-libs-log/BitByteOps	209
4.2.3	gm2-libs-log/BitWordOps	212
4.2.4	gm2-libs-log/BlockOps	215
4.2.5	gm2-libs-log/Break	217
4.2.6	gm2-libs-log/CardinalIO	218
4.2.7	gm2-libs-log/Conversions	221
4.2.8	gm2-libs-log/DebugPMD	222
4.2.9	gm2-libs-log/DebugTrace	223
4.2.10	gm2-libs-log/Delay	224
4.2.11	gm2-libs-log/Display	225
4.2.12	gm2-libs-log/ErrorCode	226
4.2.13	gm2-libs-log/FileSystem	227
4.2.14	gm2-libs-log/FloatingUtilities	233
4.2.15	gm2-libs-log/InOut	235
4.2.16	gm2-libs-log/Keyboard	239
4.2.17	gm2-libs-log/LongIO	240
4.2.18	gm2-libs-log/NumberConversion	241
4.2.19	gm2-libs-log/Random	242
4.2.20	gm2-libs-log/RealConversions	244
4.2.21	gm2-libs-log/RealInOut	247

4.2.22	gm2-libs-log/Strings	250
4.2.23	gm2-libs-log/Termbase	252
4.2.24	gm2-libs-log/Terminal	254
4.2.25	gm2-libs-log/TimeDate	256
4.3	PIM coroutine support	258
4.3.1	gm2-libs-coroutines/Executive	258
4.3.2	gm2-libs-coroutines/KeyBoardLEDs	261
4.3.3	gm2-libs-coroutines/SYSTEM	262
4.3.4	gm2-libs-coroutines/TimerHandler	268
4.4	M2 ISO Libraries	270
4.4.1	gm2-libs-iso/COROUTINES	271
4.4.2	gm2-libs-iso/ChanConsts	274
4.4.3	gm2-libs-iso/CharClass	276
4.4.4	gm2-libs-iso/ClientSocket	277
4.4.5	gm2-libs-iso/ComplexMath	278
4.4.6	gm2-libs-iso/ConvStringLong	280
4.4.7	gm2-libs-iso/ConvStringReal	281
4.4.8	gm2-libs-iso/ConvTypes	282
4.4.9	gm2-libs-iso/EXCEPTIONS	283
4.4.10	gm2-libs-iso/ErrnoCategory	285
4.4.11	gm2-libs-iso/GeneralUserExceptions	287
4.4.12	gm2-libs-iso/IOChan	288
4.4.13	gm2-libs-iso/IOConsts	292
4.4.14	gm2-libs-iso/IOLink	293
4.4.15	gm2-libs-iso/IOResult	296
4.4.16	gm2-libs-iso/LongComplexMath	297
4.4.17	gm2-libs-iso/LongConv	299
4.4.18	gm2-libs-iso/LongIO	301
4.4.19	gm2-libs-iso/LongMath	303
4.4.20	gm2-libs-iso/LongStr	305
4.4.21	gm2-libs-iso/LongWholeIO	307
4.4.22	gm2-libs-iso/LowLong	308
4.4.23	gm2-libs-iso/LowReal	310
4.4.24	gm2-libs-iso/LowShort	312
4.4.25	gm2-libs-iso/M2EXCEPTION	314
4.4.26	gm2-libs-iso/M2RTS	315
4.4.27	gm2-libs-iso/MemStream	319
4.4.28	gm2-libs-iso/Preemptive	321
4.4.29	gm2-libs-iso/Processes	322
4.4.30	gm2-libs-iso/ProgramArgs	326
4.4.31	gm2-libs-iso/RTco	327
4.4.32	gm2-libs-iso/RTdata	329
4.4.33	gm2-libs-iso/RTentity	331
4.4.34	gm2-libs-iso/RTfio	332
4.4.35	gm2-libs-iso/RTgen	334
4.4.36	gm2-libs-iso/RTgenif	337
4.4.37	gm2-libs-iso/RTio	340

4.4.38	gm2-libs-iso/RandomNumber	342
4.4.39	gm2-libs-iso/RawIO	345
4.4.40	gm2-libs-iso/RealConv	346
4.4.41	gm2-libs-iso/RealIO	348
4.4.42	gm2-libs-iso/RealMath	350
4.4.43	gm2-libs-iso/RealStr	352
4.4.44	gm2-libs-iso/RndFile	354
4.4.45	gm2-libs-iso/SIOResult	357
4.4.46	gm2-libs-iso/SLongIO	358
4.4.47	gm2-libs-iso/SLongWholeIO	360
4.4.48	gm2-libs-iso/SRawIO	361
4.4.49	gm2-libs-iso/SRealIO	362
4.4.50	gm2-libs-iso/SShortIO	364
4.4.51	gm2-libs-iso/SShortWholeIO	366
4.4.52	gm2-libs-iso/STextIO	367
4.4.53	gm2-libs-iso/SWholeIO	369
4.4.54	gm2-libs-iso/SYSTEM	370
4.4.55	gm2-libs-iso/Semaphores	375
4.4.56	gm2-libs-iso/SeqFile	376
4.4.57	gm2-libs-iso/ShortComplexMath	379
4.4.58	gm2-libs-iso/ShortIO	381
4.4.59	gm2-libs-iso/ShortWholeIO	383
4.4.60	gm2-libs-iso/SimpleCipher	384
4.4.61	gm2-libs-iso/StdChans	385
4.4.62	gm2-libs-iso/Storage	387
4.4.63	gm2-libs-iso/StreamFile	389
4.4.64	gm2-libs-iso/StringChan	390
4.4.65	gm2-libs-iso/Strings	391
4.4.66	gm2-libs-iso/SysClock	395
4.4.67	gm2-libs-iso/TERMINATION	397
4.4.68	gm2-libs-iso/TermFile	398
4.4.69	gm2-libs-iso/TextIO	400
4.4.70	gm2-libs-iso/WholeConv	402
4.4.71	gm2-libs-iso/WholeIO	404
4.4.72	gm2-libs-iso/WholeStr	405
4.4.73	gm2-libs-iso/wrapsock	406
4.4.74	gm2-libs-iso/wraptime	409
4.5	Indices	413