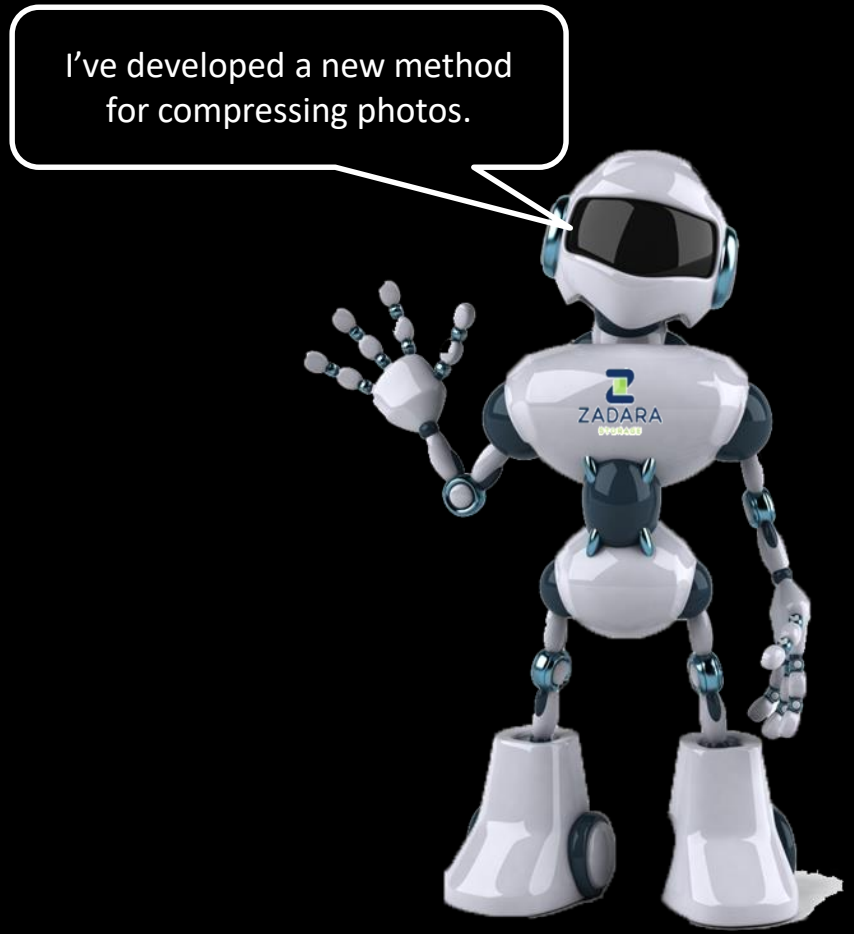
Cloud Storage: The Next 40 Years

Frank Berry
IT Brand Pulse


AI, OPaaS?
But Man stupid...


Network security alert! Changing encryption algorithm.


I’ve developed a new method for compressing photos.
ZADARA

Cloud Storage Industry Road Map

Instrumented

Storage is instrumented and accessible anywhere.

Storage management tasks performed automatically based on policies.

Self-Driving

Global storage, server, network & app service chains.

Artificial Intelligence allows storage to recognize and respond to complex problems and opportunities.

Bionic

Billions of data sources shared by governments and businesses.

Neural networks and deep learning allows storage admin avatars to develop capabilities on their own.

2016 – 2026

Data

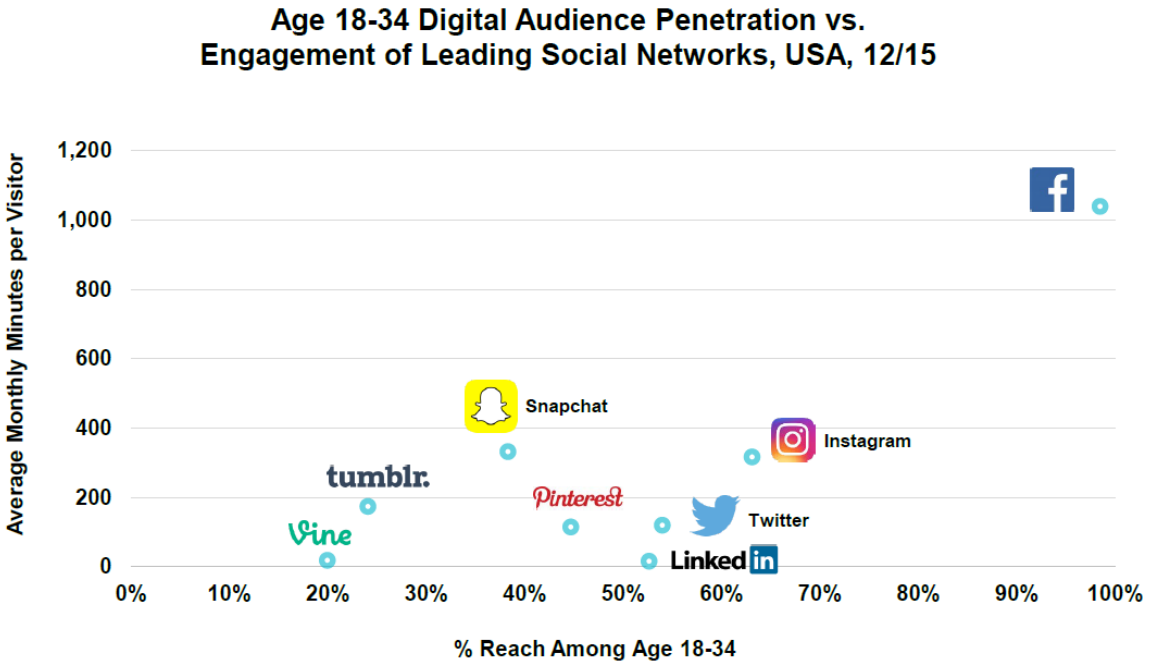
Gen Z

(Post-Millennials, iGeneration, Founders Generation, Plurals, Homeland Generation)

Millennials	vs	Gen Z
Tech Savvy: 2 screens at once		Tech Innate: 5 screens at once
Communicate with text		**Communicate with images**
Curators and Sharers		Creators and Collaborators
Now-focused		Future-focused
Optimists		Realists
Want to be discovered		Want to work for success

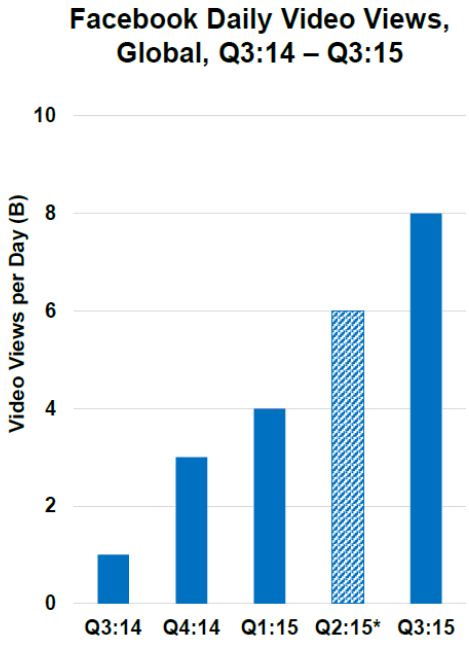
KPCB INTERNET TRENDS 2016

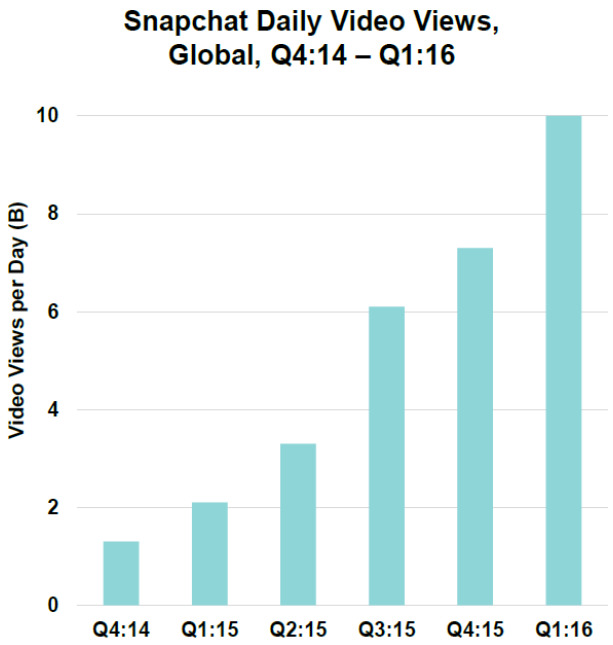
Image Apps Usage Continues to Rise



KPCB INTERNET TRENDS 2016

Video Views Growing





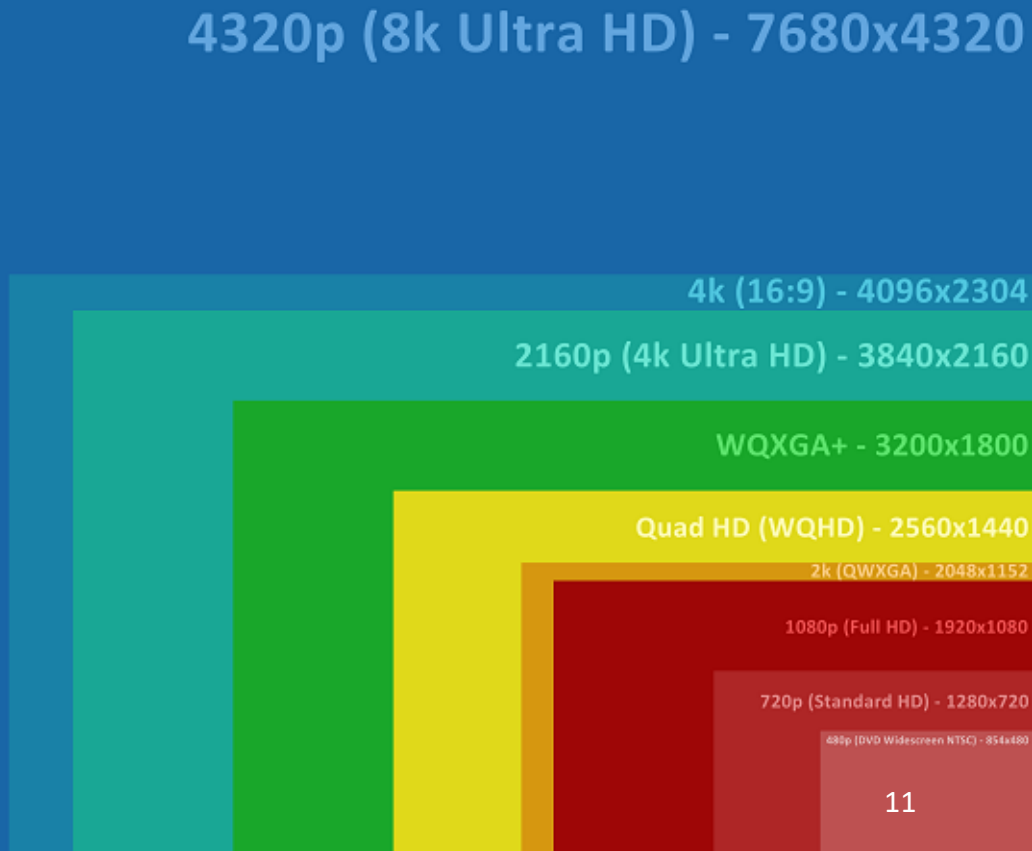
KPCB INTERNET TRENDS 2016

Video Evolution Accelerating

Live (Linear)	On-Demand	Semi-Live	Real-Live
Traditional TV 1926	*DVR / Streaming 1999*	*Snapchat Stories 2013*	*Periscope + Facebook Live 2015 / 2016*
Tune-In or Miss Out	Watch on Own Terms	Tune-In Within 24 Hours or Miss Out	Tune-In / Watch on Own Terms
Mass Concurrent Audience	Mass Disparate Audience	Mostly Personal Audience	Mass Audience, yet Personal
Real-Time Buzz	Anytime Buzz	Anytime Buzz	Real Time + Anytime Buzz
	 NETFLIX		

KPCB INTERNET TRENDS 2016

8K Ultra HD (9TB/hour)



3D (3 streams of 2K, 4K or 8K)

VR (n streams of 2k, 4k or 8k)

VR (n streams of 2k, 4k or 8k)

VR Shopping: eBay & Myer in Australia

VR Shopping: Singles Day, Nov. 11

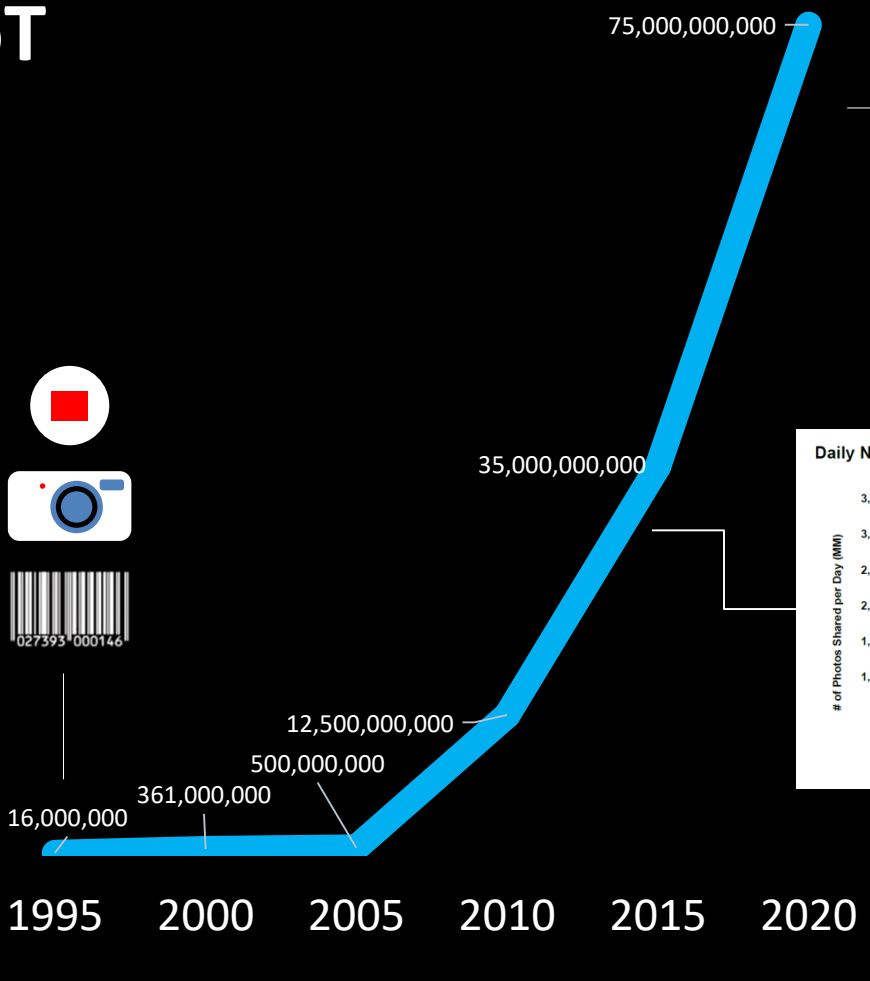
VR Shopping: Select an Item

VR Shopping: Size the Item

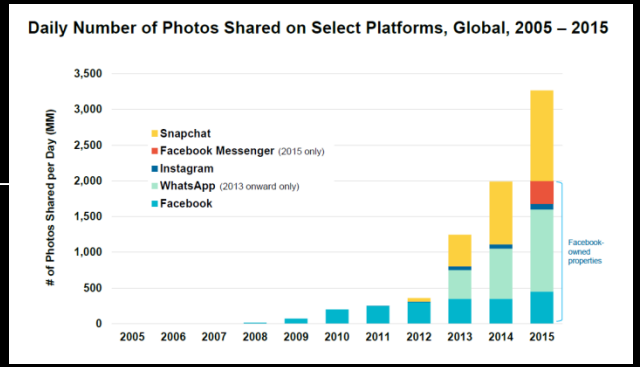
VR Shopping: Try Different Colors

VR Shopping: Done? Watch a Movie

IoT



By 2020, 75 billion devices will be connected. In mature markets, people will have 5-10 things connected.



3B photos shared per day


2
Living Room
20%
2
Kitchen
100%
Devices
Rules

To App Servers
in Data Center

Video Management System

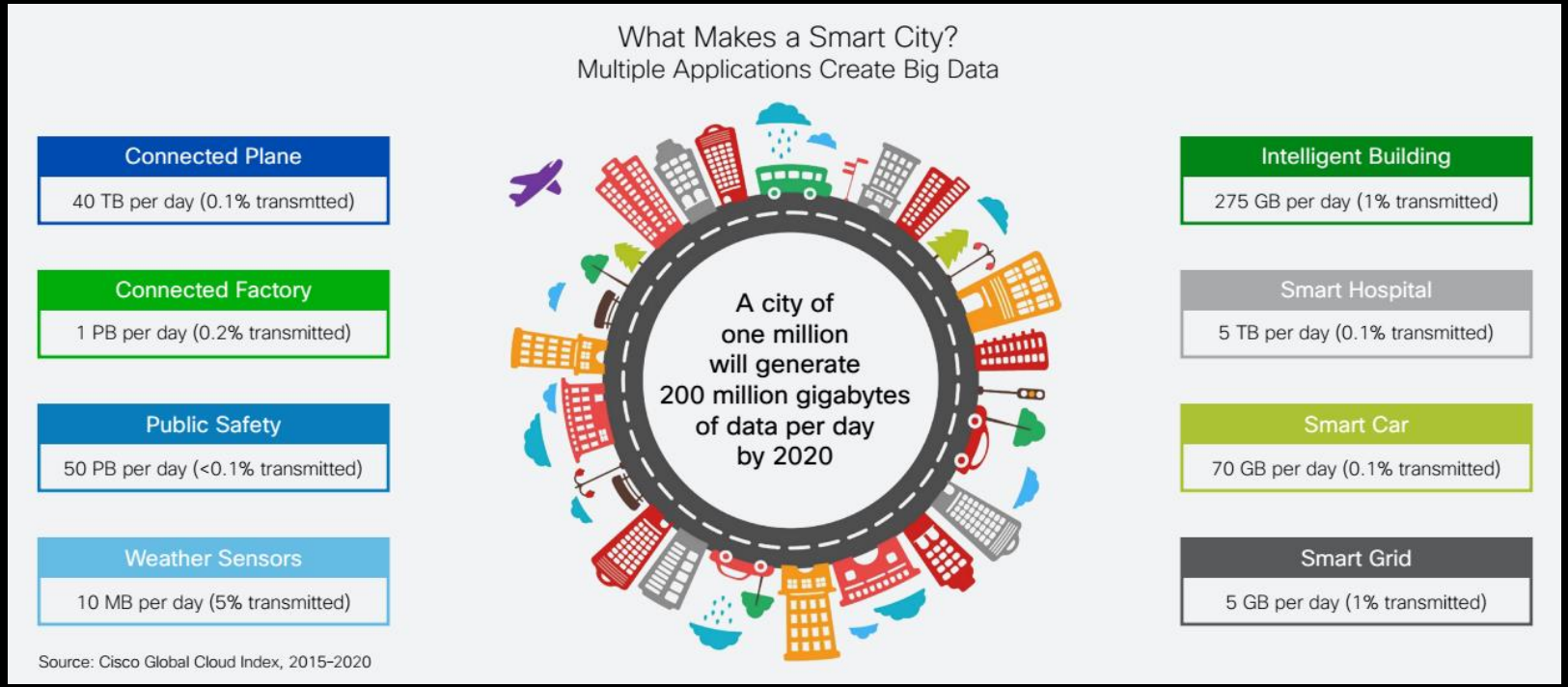
Video Data Analytics

Sensor Data Analytics

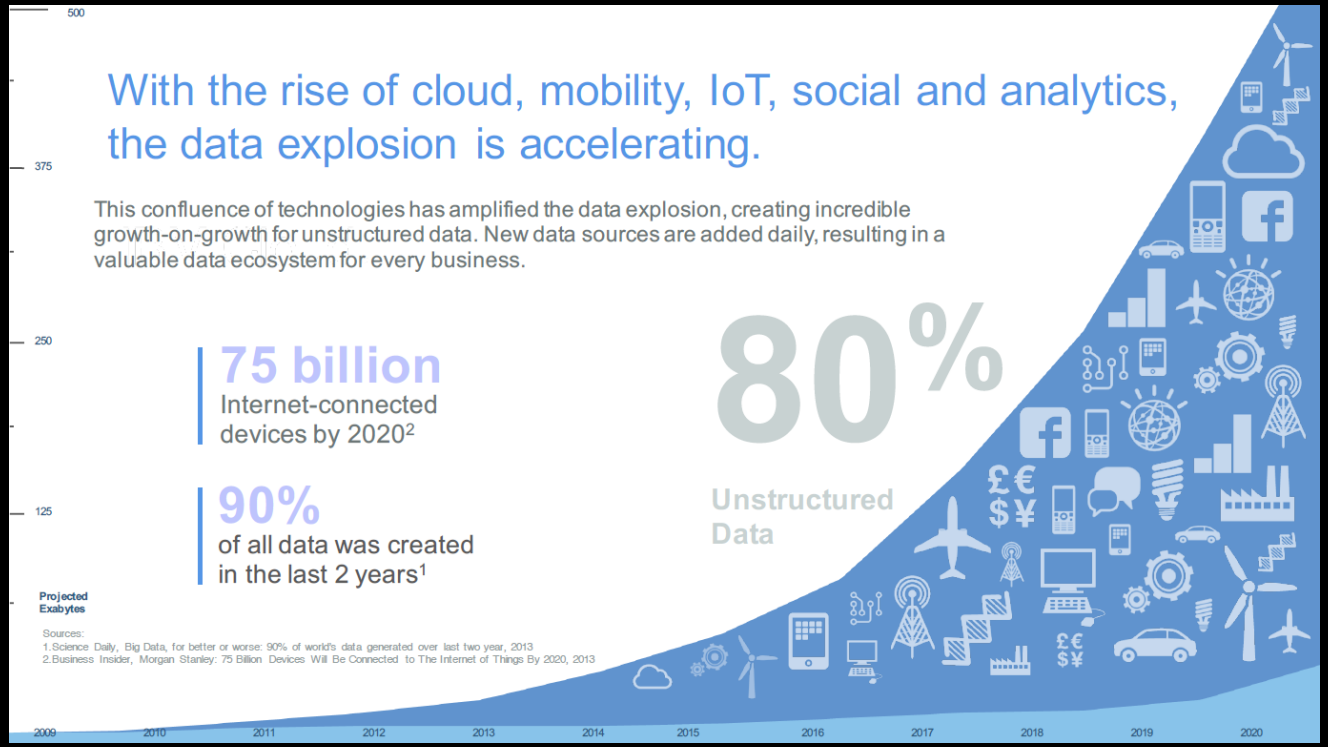
Asset Tracking

Video analytics provide occupancy, dwell time and trip wire by grid coordinates

Smart City of 1M = 200 Petabytes/Day



Data Doubling Every Two Years



2016 – 2026

Media

(HDD & SSD)

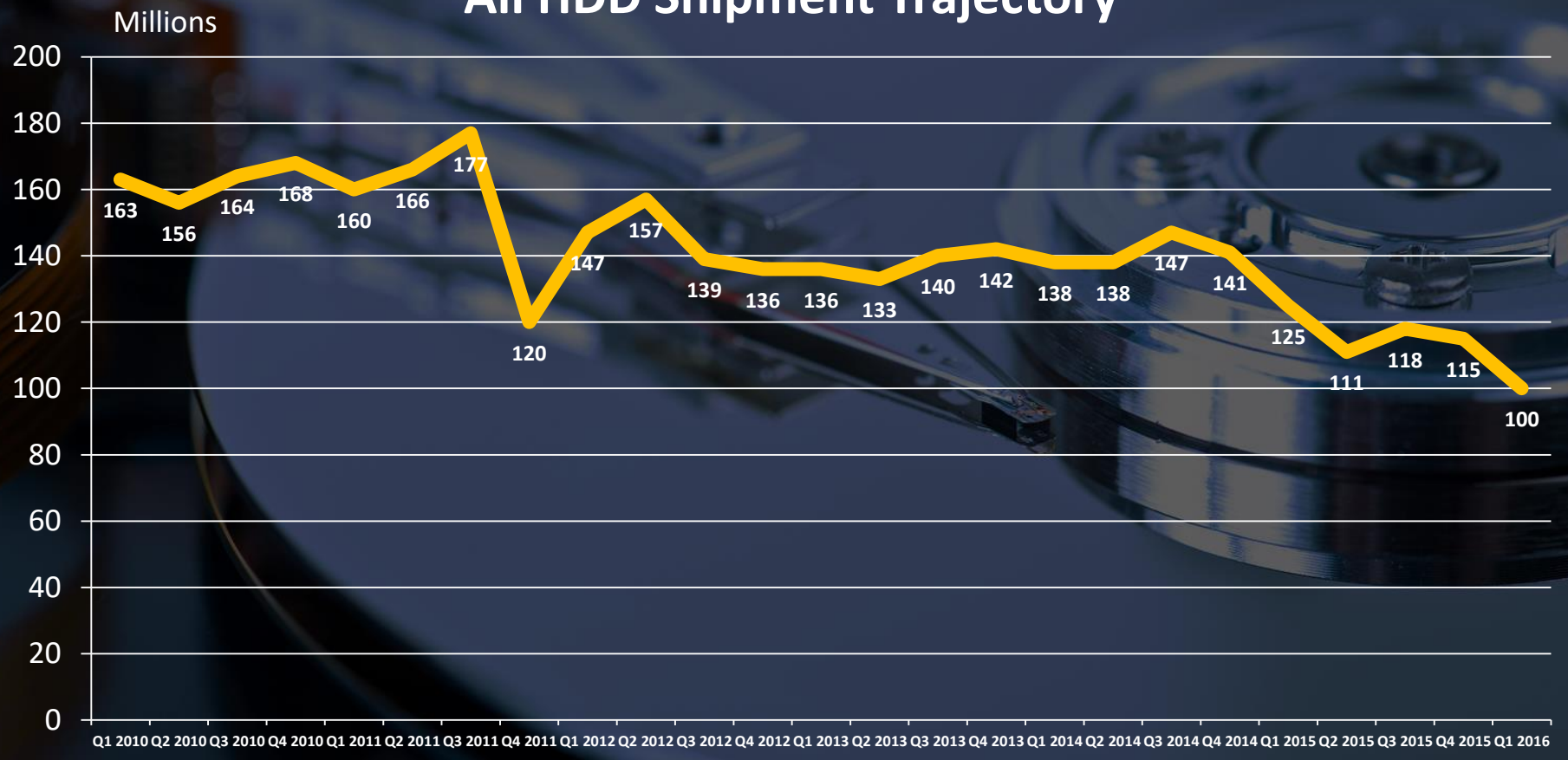
1 Terabyte HDD vs. SSD

22x

4x

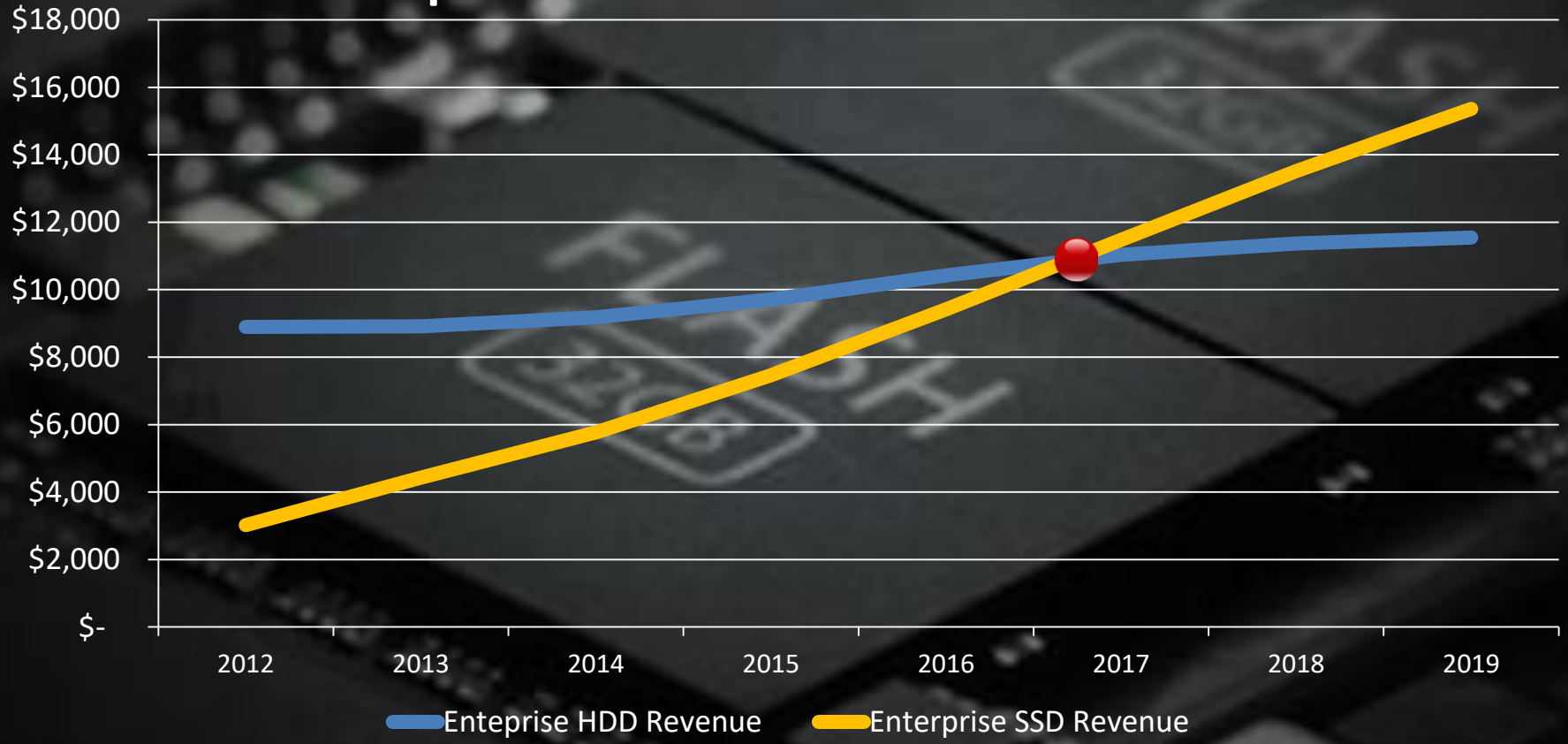
32¢/GB 5.8¢/GB 30.6¢/GB 1.26$/GB

All HDD Shipment Trajectory



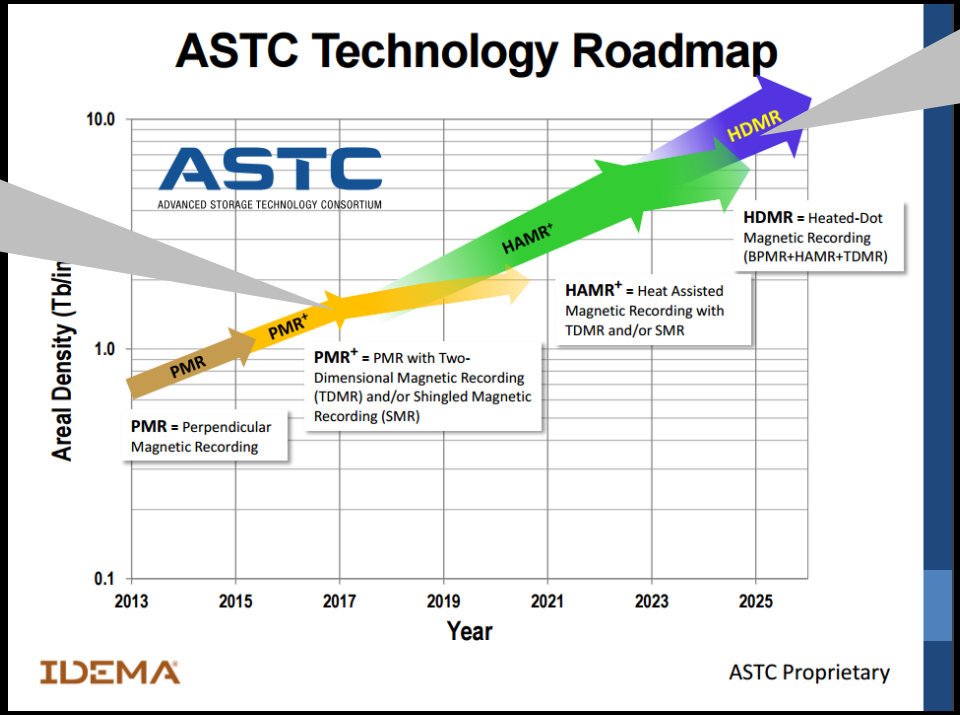
http://www.anandtech.com/show/10098/market-views-2015-hard-drive-shipments

Enterprise HDD & SSD Cross Over in 2017



HDD Road Map

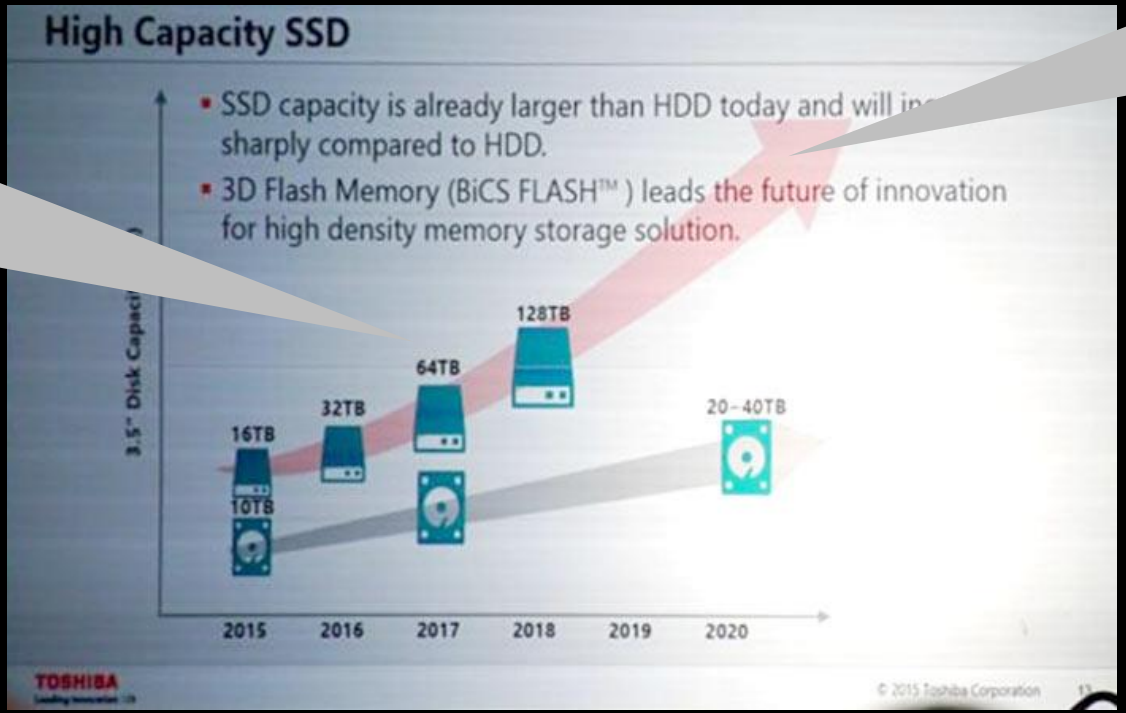
2016



2026

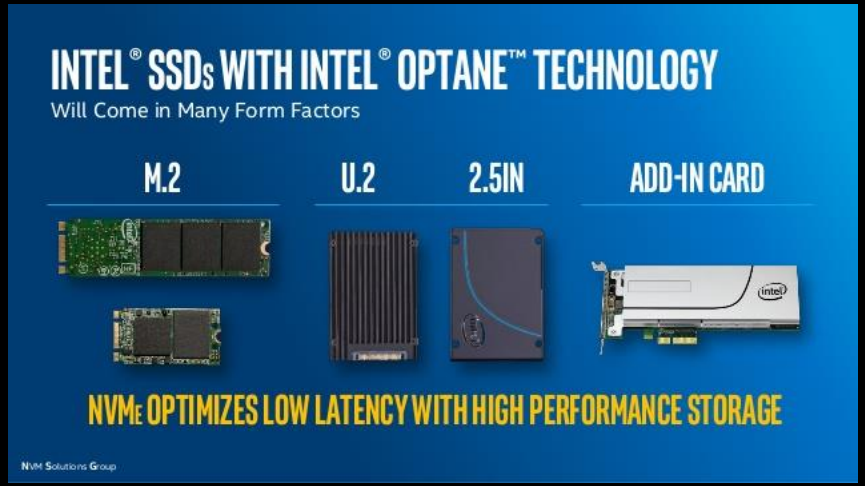
SSD Road Map

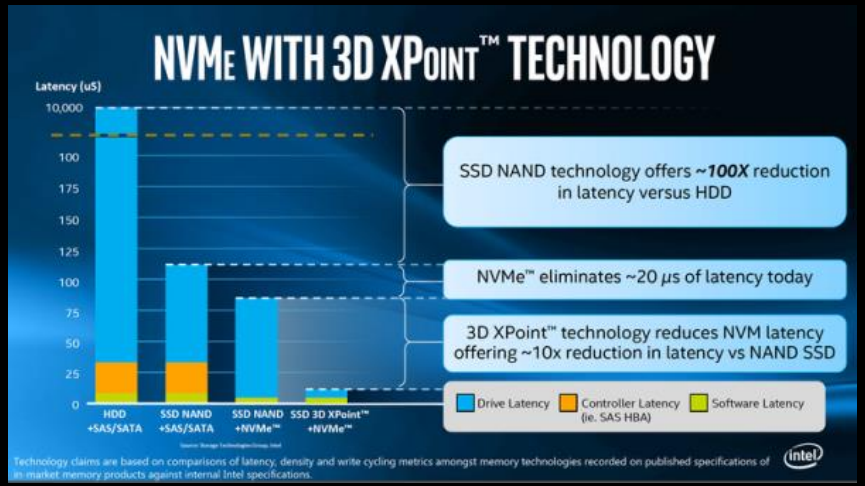
2016



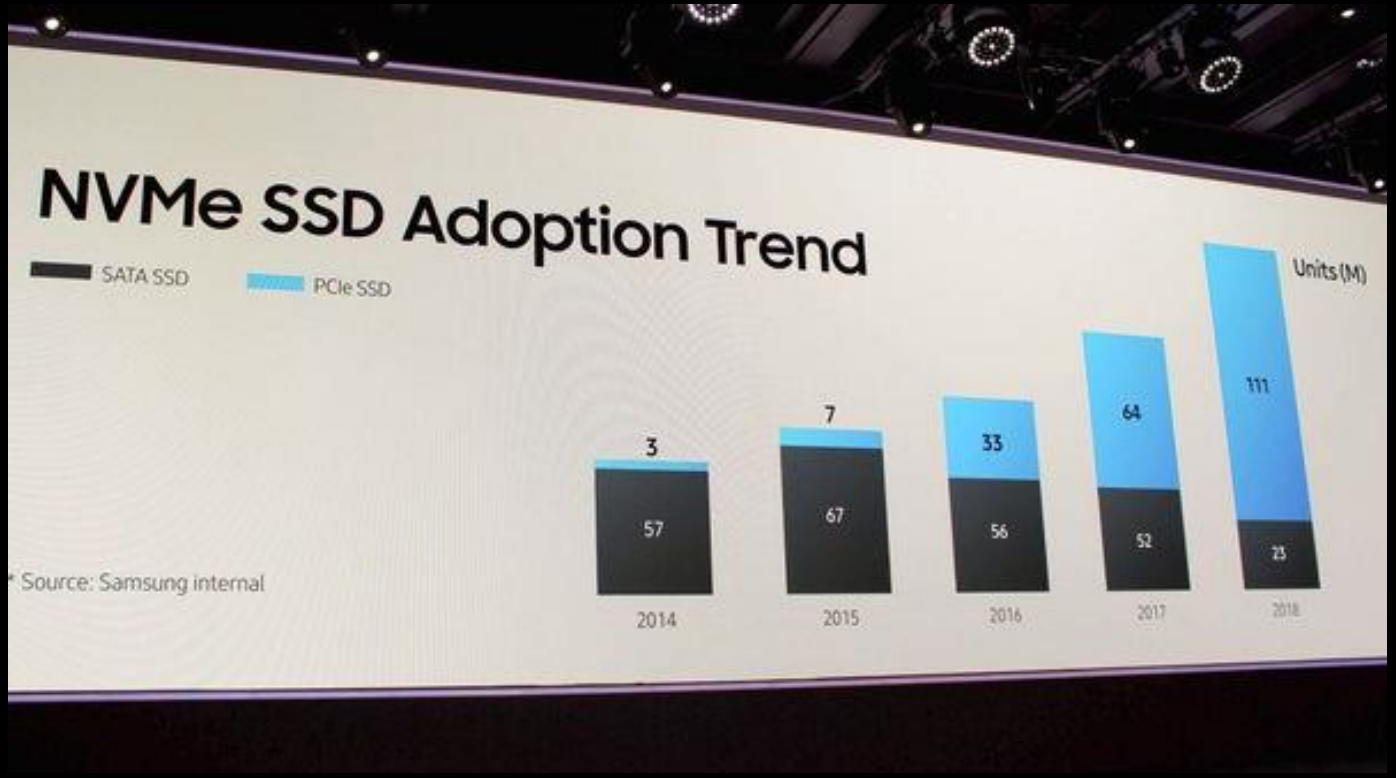
2026

NVMe (PCIe interface) SSD

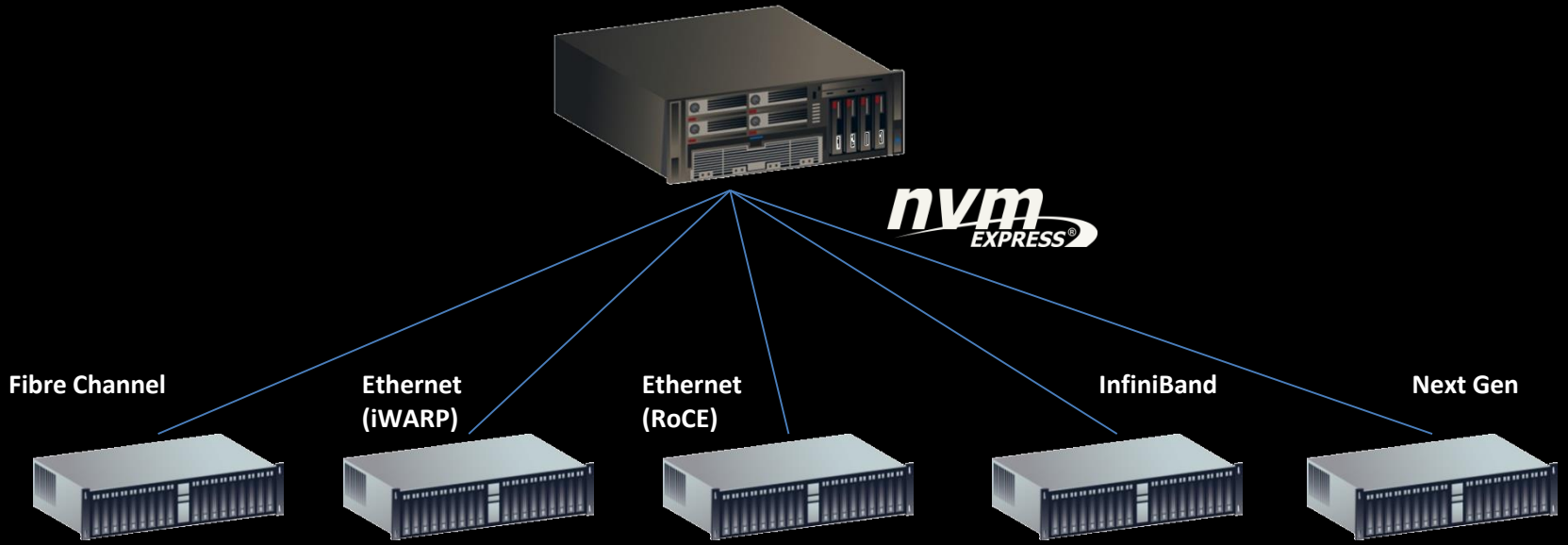




NVMe Displacing SATA SSD

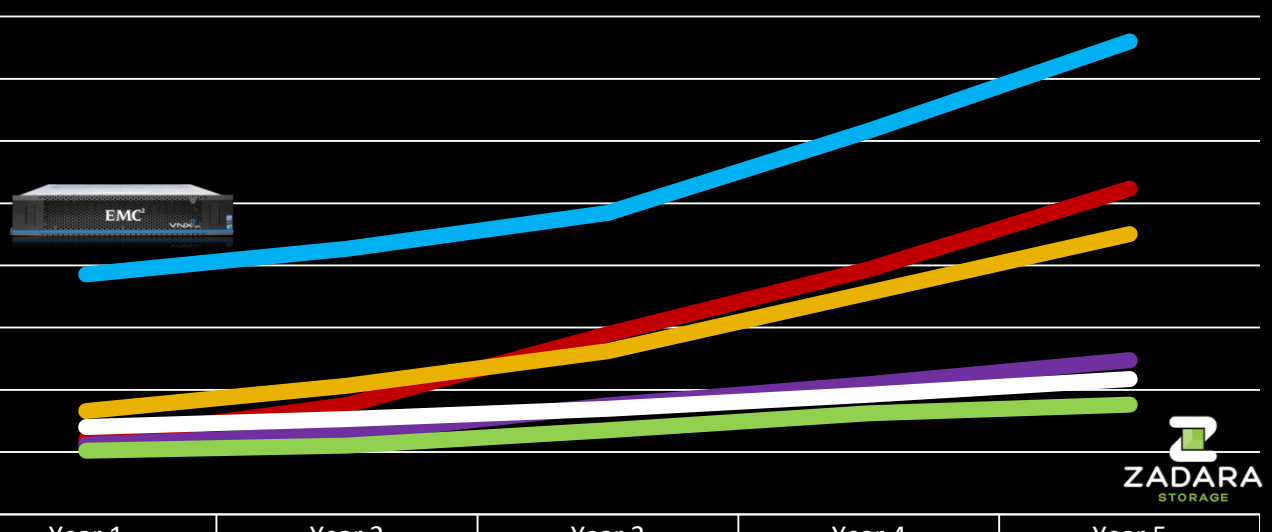


NVMe over Fabrics will Dominate SANs



Software Defined Storage (CapEx or OpEx) Best for Unstructured Data

5 Year TCO for 250TB growing 25% per year

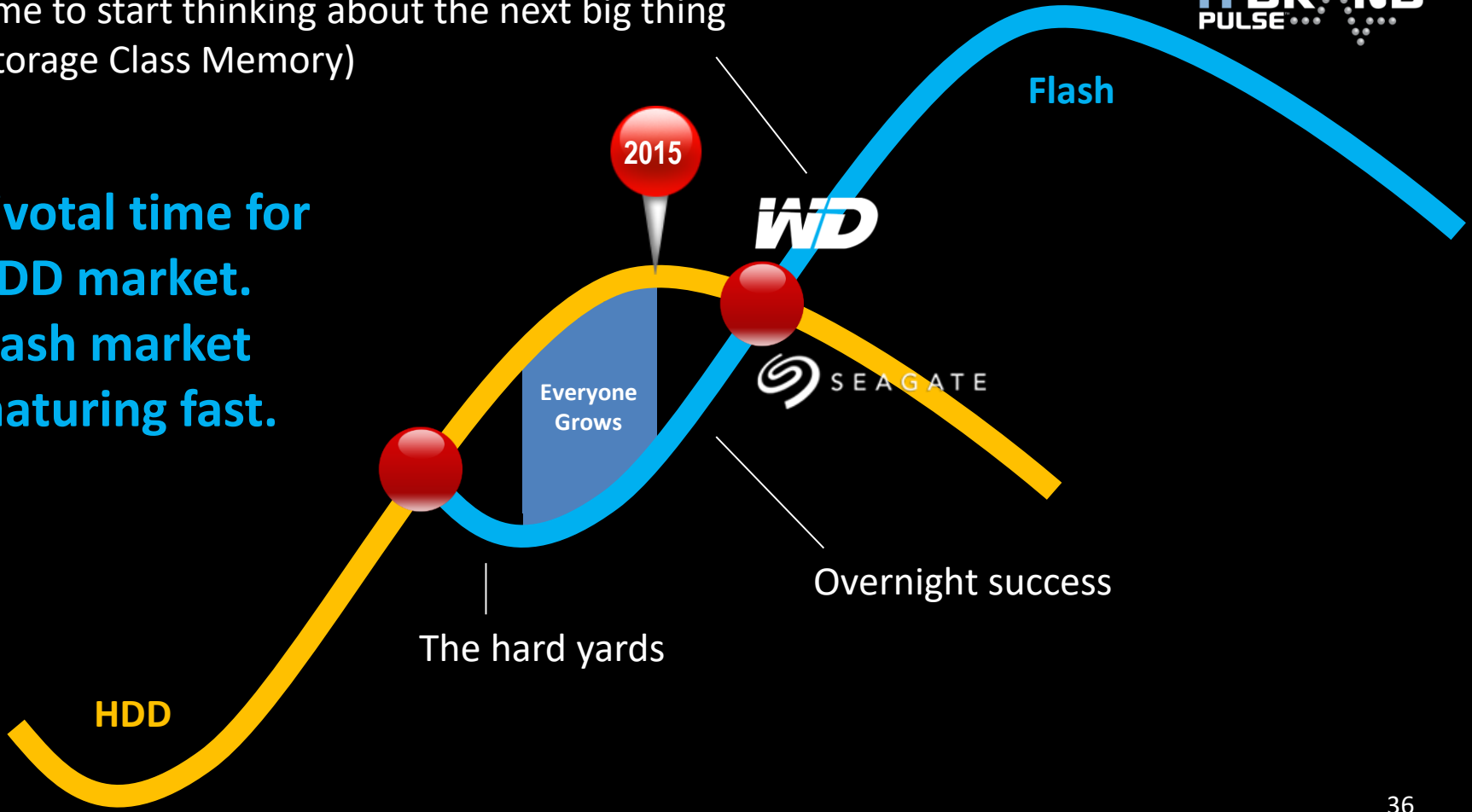


	Year 1	Year 2	Year 3	Year 4	Year 5
EMC VNXe 3200	$192,922	$213,468	$242,108	$308,338	$380,010
NetApp E2700	$60,206	$87,838	$144,718	$196,890	$261,622
NEC M110	$83,017	$103,285	$130,975	$178,055	$225,203
Seagate Ultra56	$55,979	$64,493	$87,555	$104,713	$123,774
SUSE Enterprise Storage	$70,100	$76,579	$84,825	$96,238	$108,607
Zadara Storage	$51,096	$55,284	$67,644	$81,264	$88,200

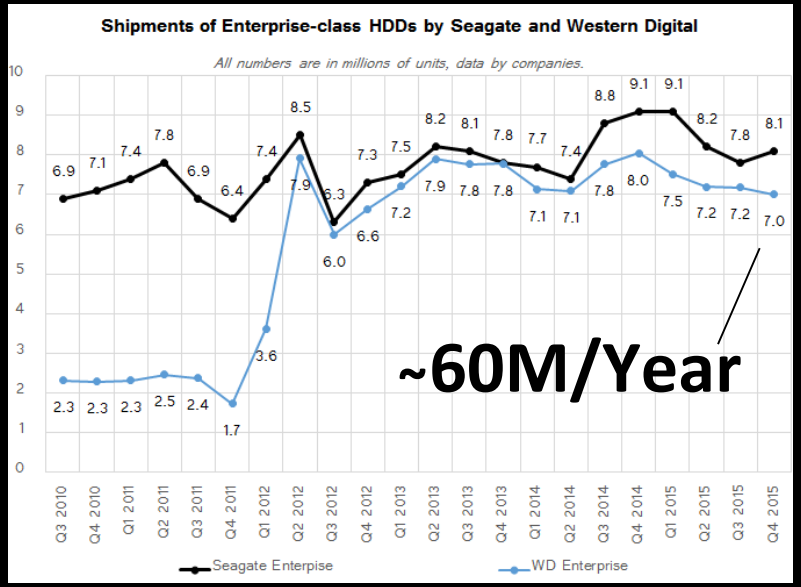
Source: IT Brand Pulse

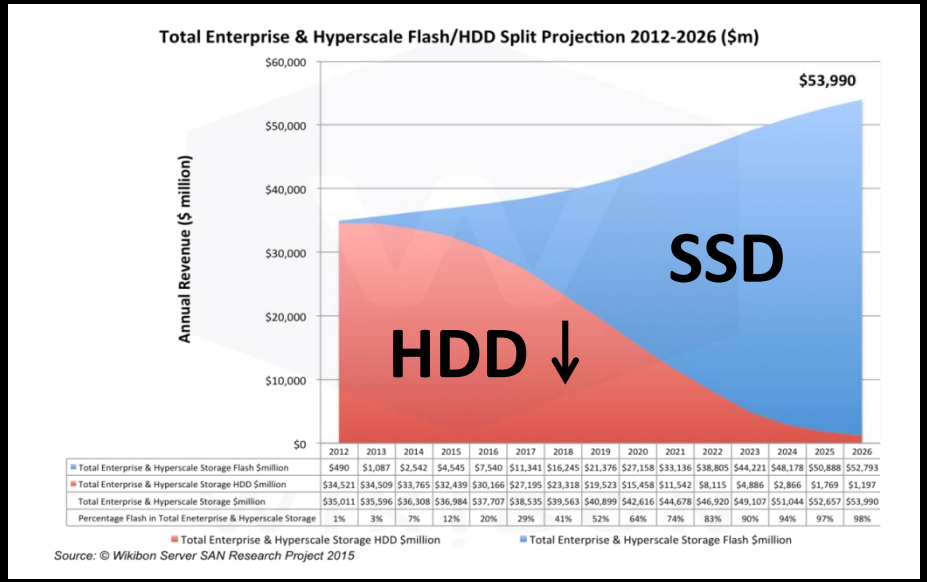
Time to start thinking about the next big thing (Storage Class Memory)

Pivotal time for HDD market. Flash market maturing fast.



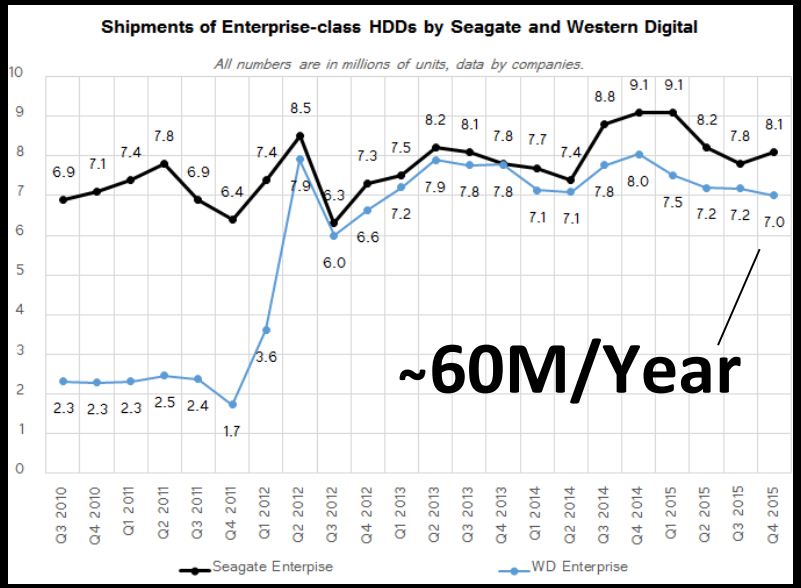
The Next Ten Years: Pro Flash PoV

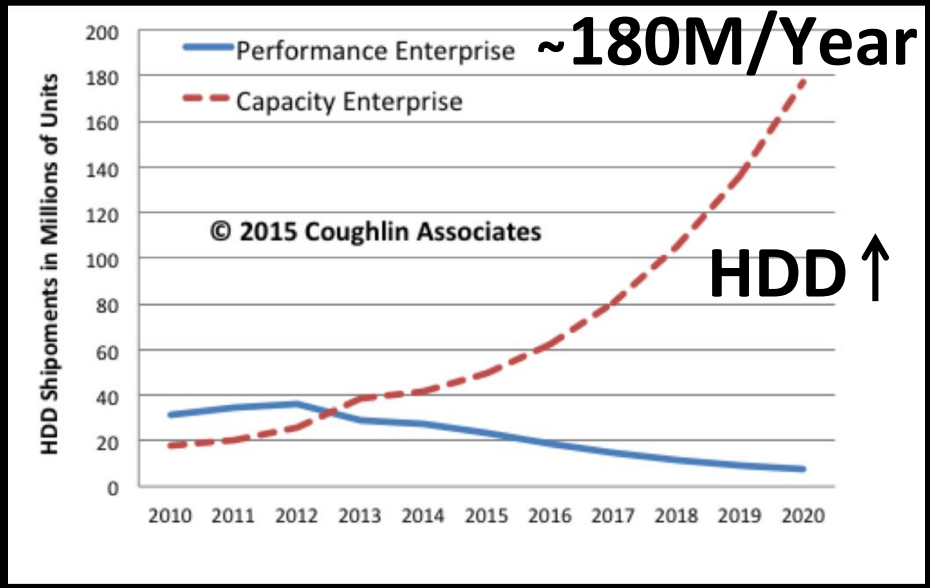




	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
Total Enterprise & Hyperscale Storage Flash $million	$490	$1,087	$2,542	$4,545	$7,540	$11,341	$16,245	$21,376	$27,158	$33,136	$38,805	$44,221	$48,178	$50,888	$52,793
Total Enterprise & Hyperscale Storage HDD $million	$34,521	$34,509	$33,765	$32,439	$30,166	$27,195	$23,318	$19,523	$15,458	$11,542	$8,115	$4,886	$2,866	$1,769	$1,197
Total Enterprise & Hyperscale Storage $million	$35,011	$35,596	$36,308	$36,984	$37,707	$38,535	$39,563	$40,899	$42,616	$44,678	$46,920	$49,107	$51,044	$52,657	$53,990
Percentage Flash in Total Eneterprise & Hyperscale Storage	1%	3%	7%	12%	20%	29%	41%	52%	64%	74%	83%	90%	94%	97%	98%

The Next Ten Years: Pro HDD PoV



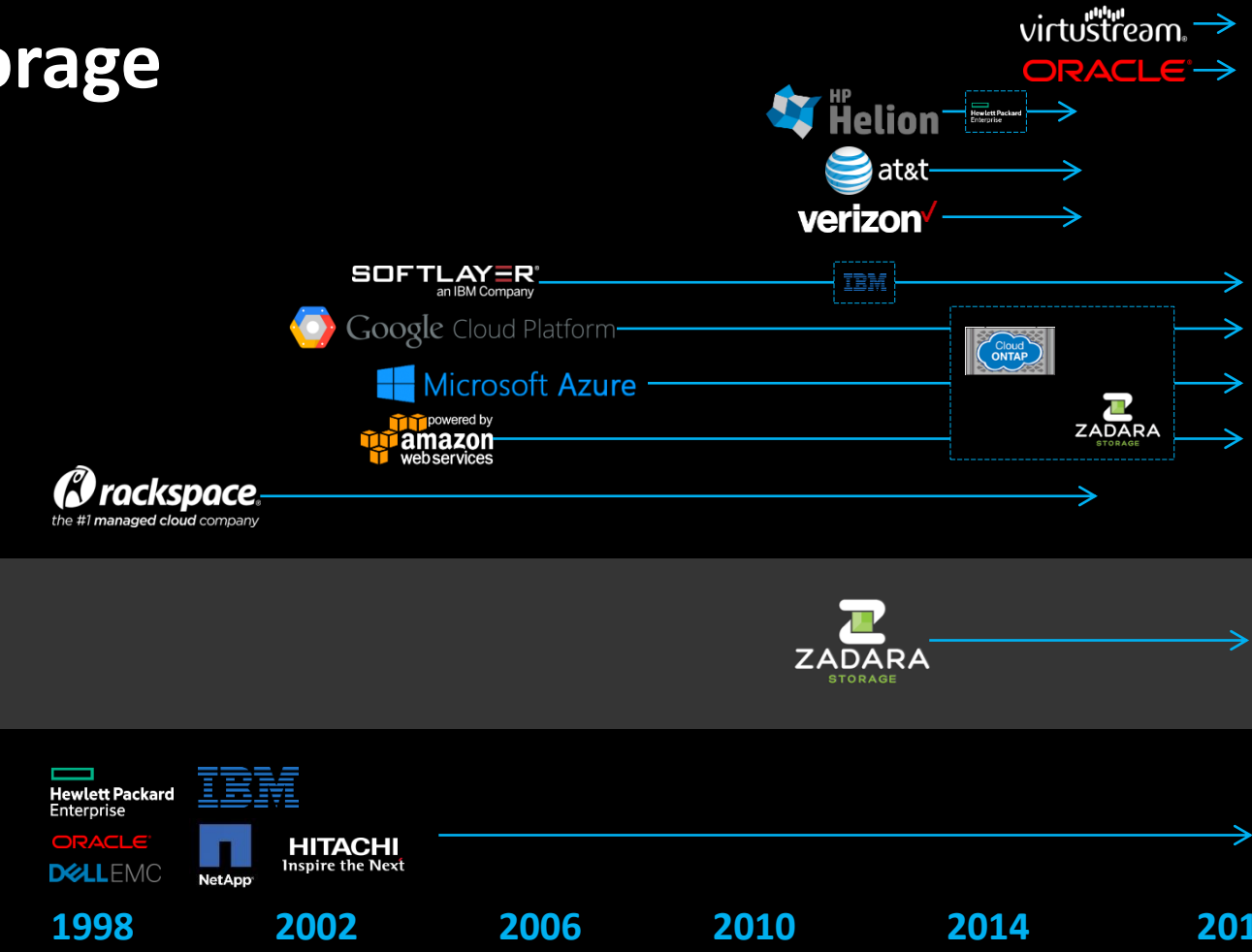


2016 – 2026

Selling & Buying

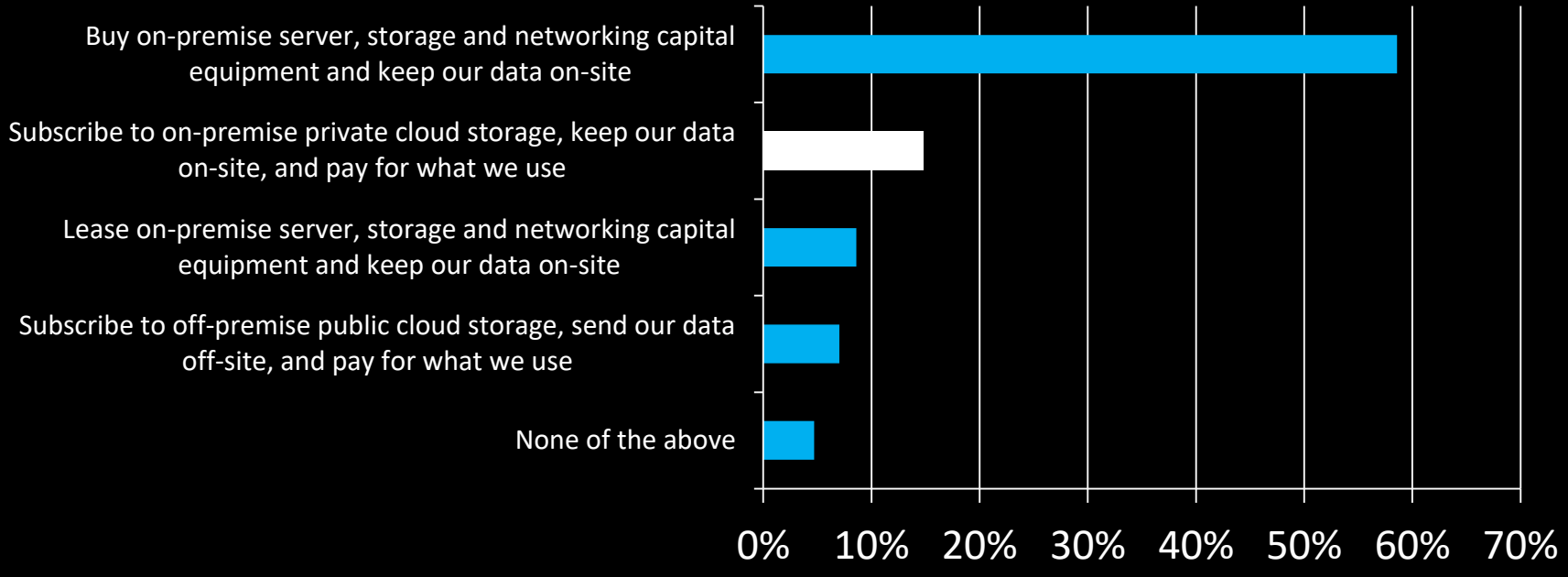
(CapEx & OpEx)

Selling Storage



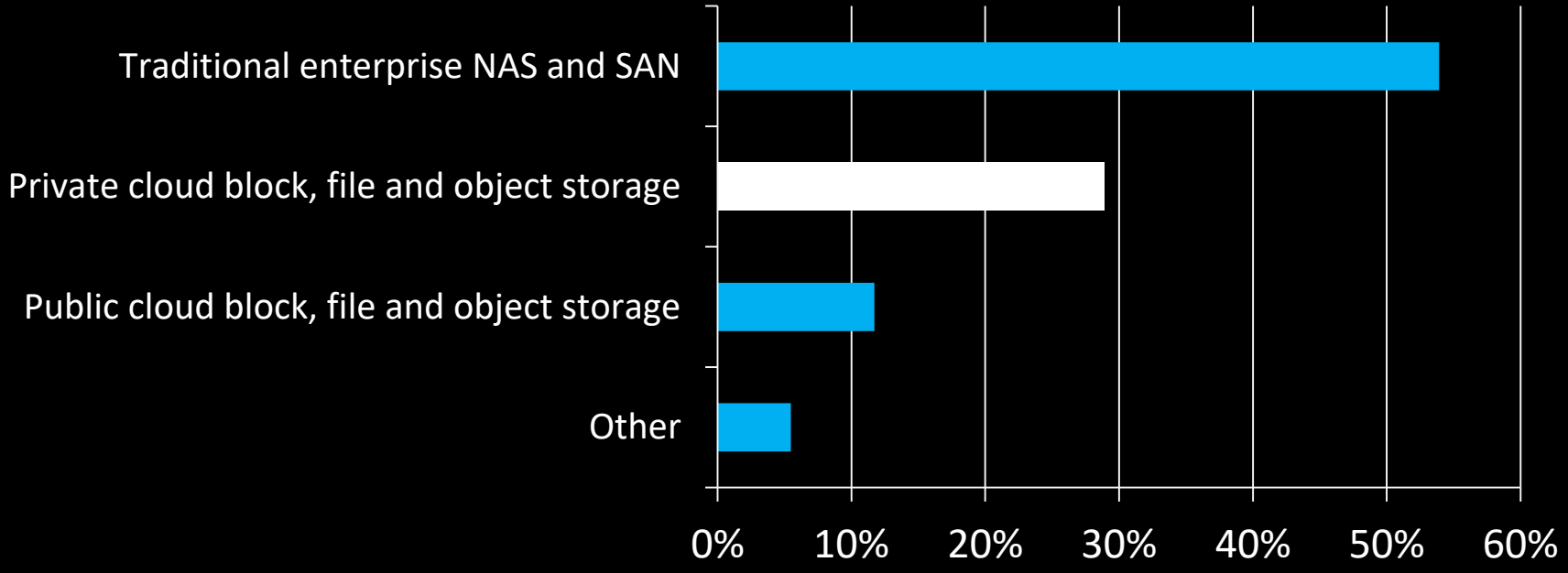
Private STaaS The Next Best Thing in 2016

If I had to choose one method of acquiring enterprise storage for my organization, I would choose to:

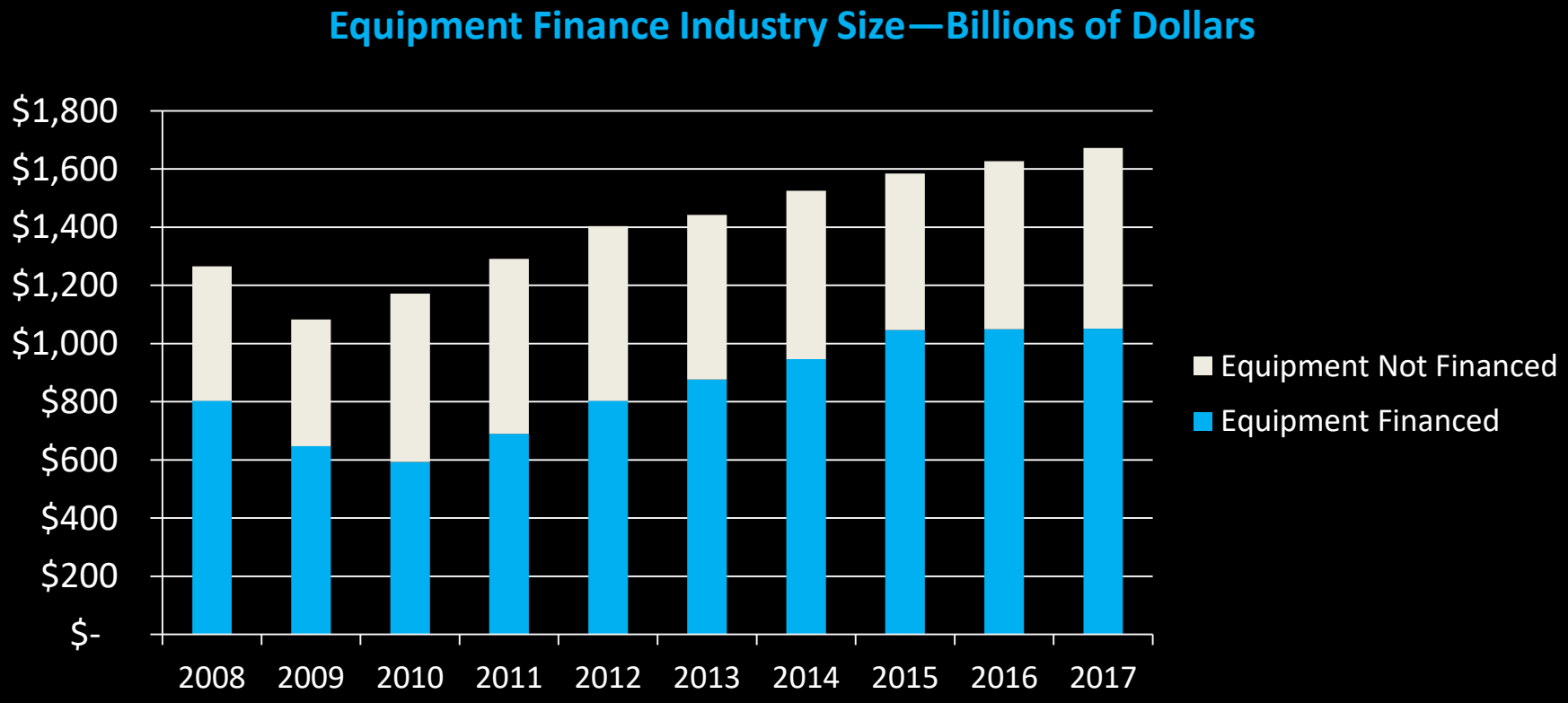


Private STaaS The Next Best Thing in 2016

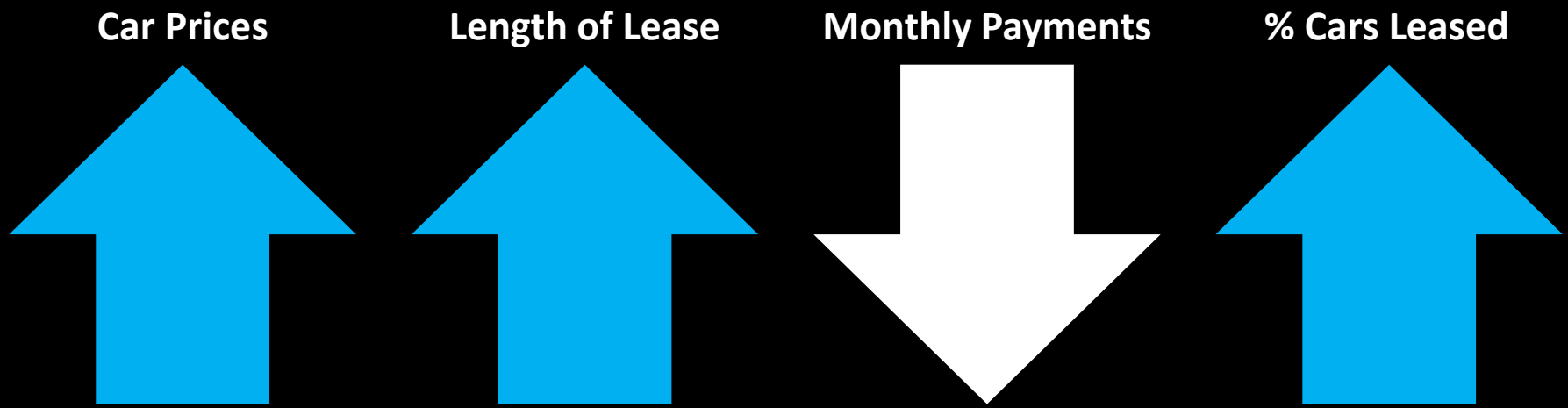
Which enterprise storage environment will offer best price/performance with many different storage workloads?



Financing Enables Most IT



Innovative Financing Helps People Buy Cars



The average new car loan is 64 months and 27.5% of all new car purchases are leases, the highest level of leases since 2006

On Premise-as-a-Service

$1.50

Per Mile

$0 DUE AT SIGNING

Pay only for the miles you drive

$42,825 MSRP,7-speed automatic transmission, all season tires, daytime running lamps, rains sensor, glass sunroof, power seat and steering column with memory iPod media interface, Sirius satellite radio, Harmon Kardon sound system, heated front seats, 17” spoke wheels, AMG sport line package

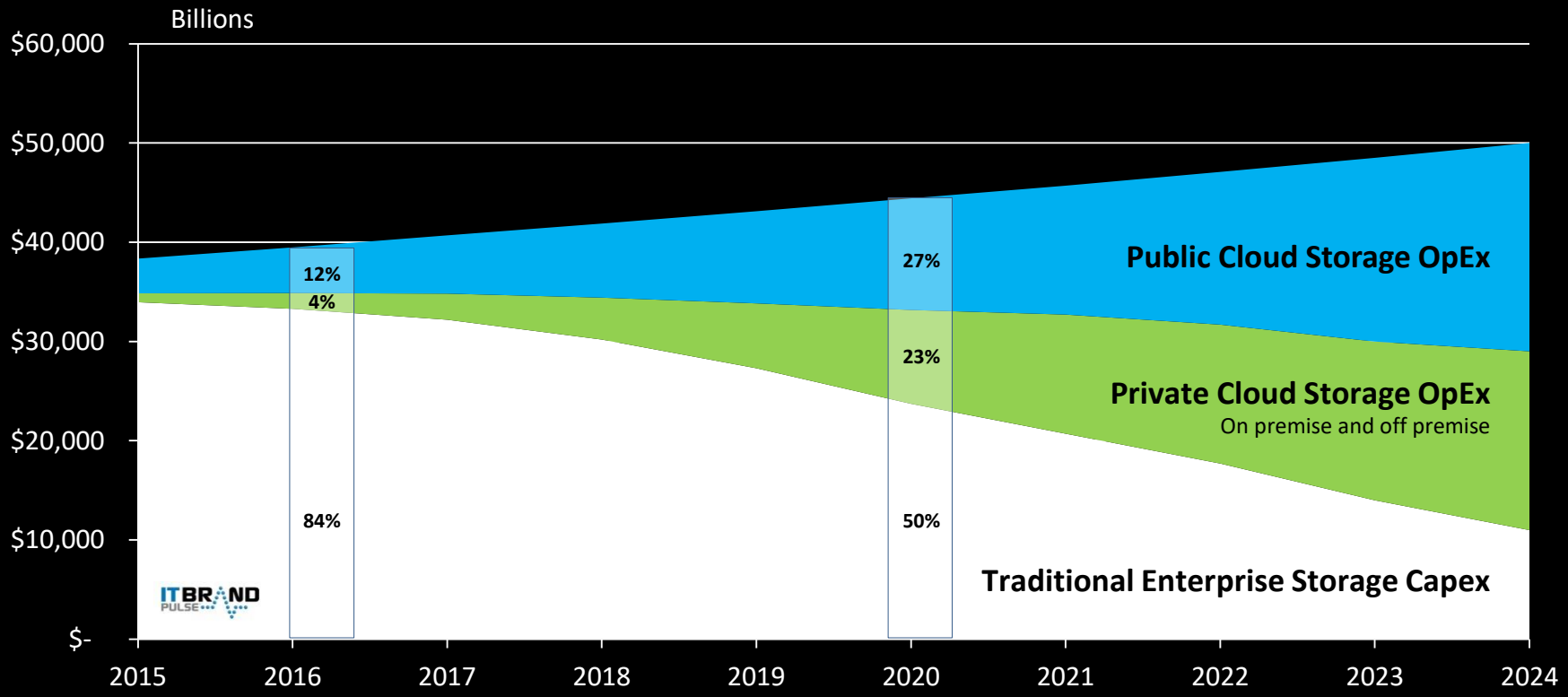
Game Changer

Azure Stack

Off Premise Storage-as-a-Service

On Premise Storage-as-a-Service

10 Year Data Center Storage Revenue Forecast



2016 – 2026

Storage Brands

Storage Branding 2016

The Brand

Ingredients

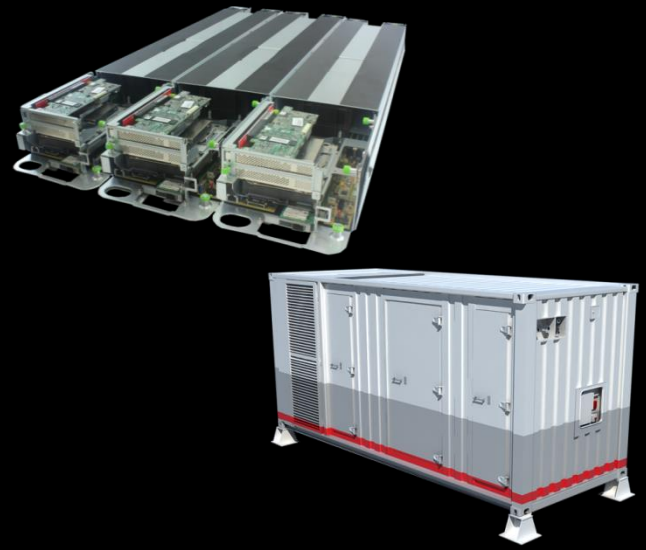
intel inside

SAMSUNG

Storage Branding 2026

The Brand

Ingredients



Gartner Magic Quadrant: Cloud Storage

2014
AT&T #3

Source: Gartner (July 2014)

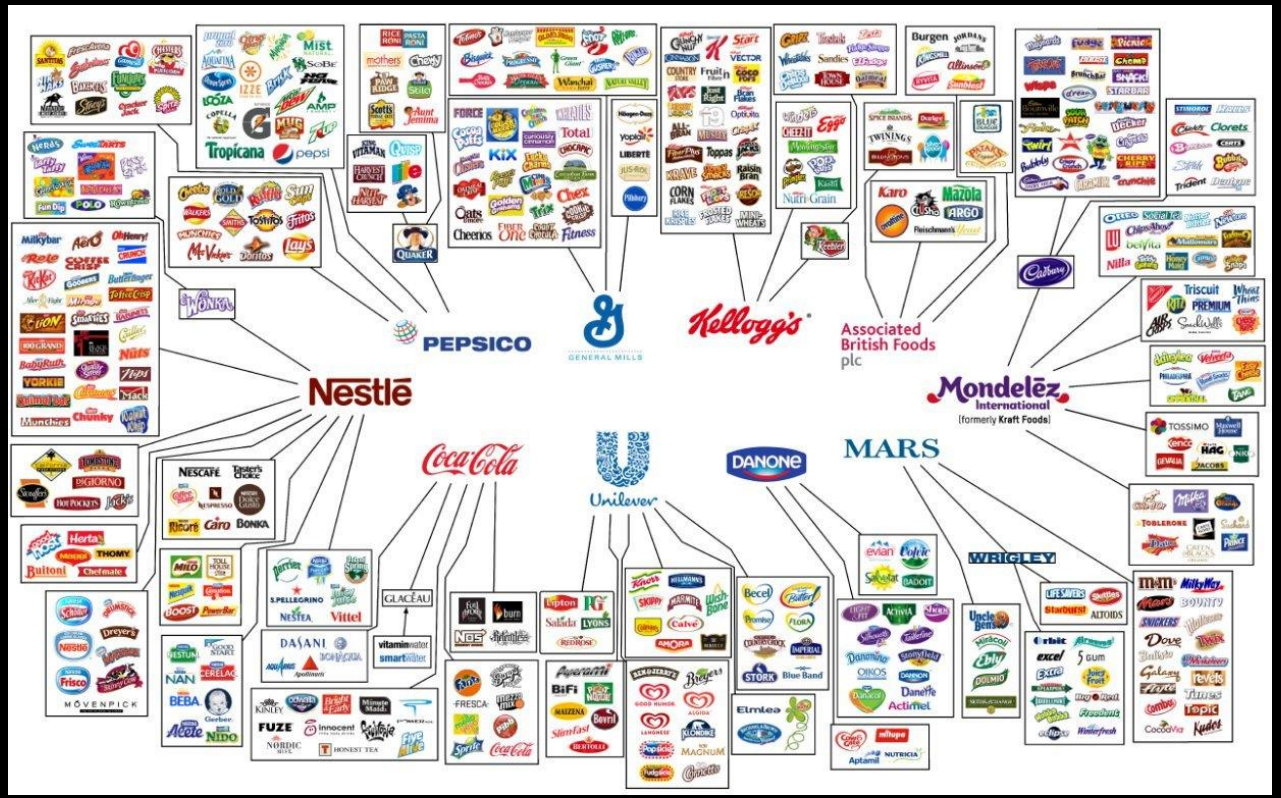
2015
HP Out

2016
Oracle In

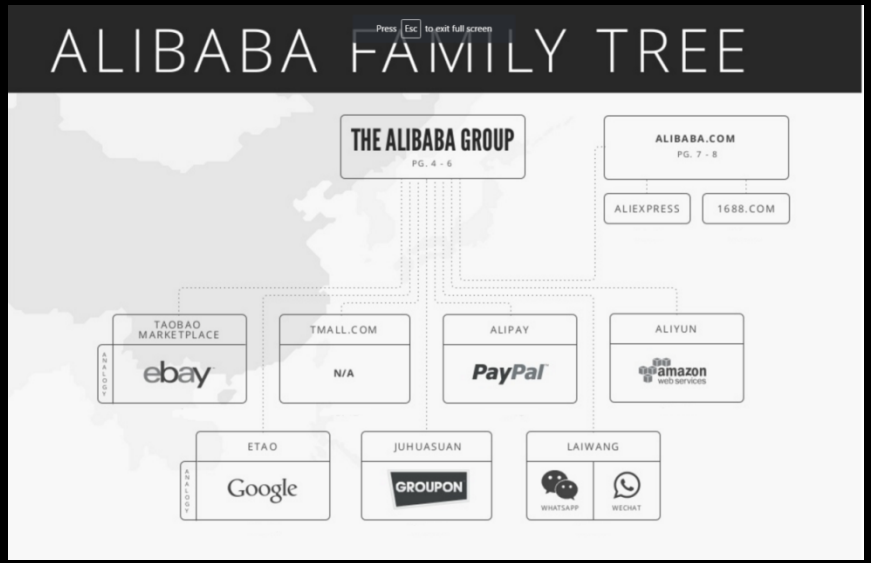
2016 Cloud & On-Premise *Voted by IT Pros*						
Cloud Backup & Archive as a Service	AWS	AWS	AWS	AWS	AWS	AWS
Cloud Dedicated Enterprise Servers	AWS	AWS	AWS	AWS	AWS	AWS
Cloud Enterprise Class Storage	AWS	AWS	AWS	AWS	AWS	AWS
Cloud SSD Storage	AWS	AWS	AWS	AWS	AWS	AWS
Cloud Virtual Desktops	VMware	VMware	VMware	VMware	VMware	VMware
Cloud Virtual Servers	AWS	AWS	AWS	AWS	AWS	AWS
Cloud Unified Communications	Microsoft	Microsoft	Microsoft	Microsoft	Microsoft	Microsoft
On-Premise vs. Cloud Backup & Archive	EMC & Veeam (tie)	AWS	EMC	EMC	AWS	AWS
On-Premise vs. Cloud Dedicated Enterprise Servers	HPE	AWS	HPE	HPE	AWS	HPE
On-Premise vs. Cloud Enterprise Class Storage	EMC	AWS	EMC	EMC	AWS	AWS
On-Premise vs. Cloud SSD Storage	EMC	Pure Storage	EMC	EMC	EMC	EMC
On-Premise vs. Cloud Virtual Desktops	VMware	VMware	VMware	VMware	VMware	VMware
On-Premise vs. Cloud Virtual Servers	VMware	VMware	VMware	VMware	VMware	VMware
On Premise vs. Cloud Unified	Cisco	Cisco	Cisco	Cisco	Cisco	Cisco

Zadara Storage

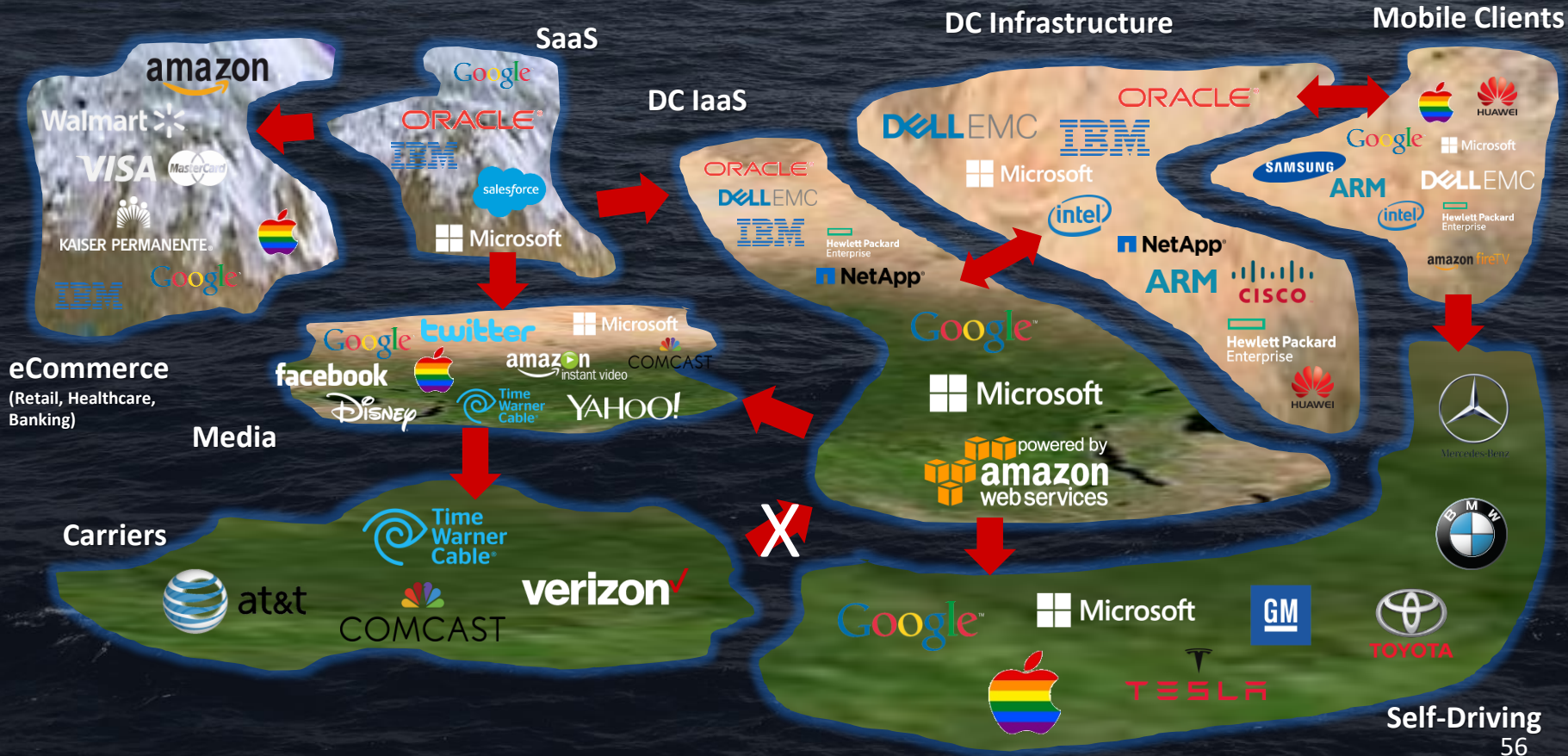
eCommerce Brands Will Look Like This



eCommerce Consolidation on IaaS



Tectonic Shifts in IT Brands



2016 – 2026

Storage Technology

(Artificial Intelligence)

From Mad Scientists to IT for the Masses

NASA Spin-Off Technologies

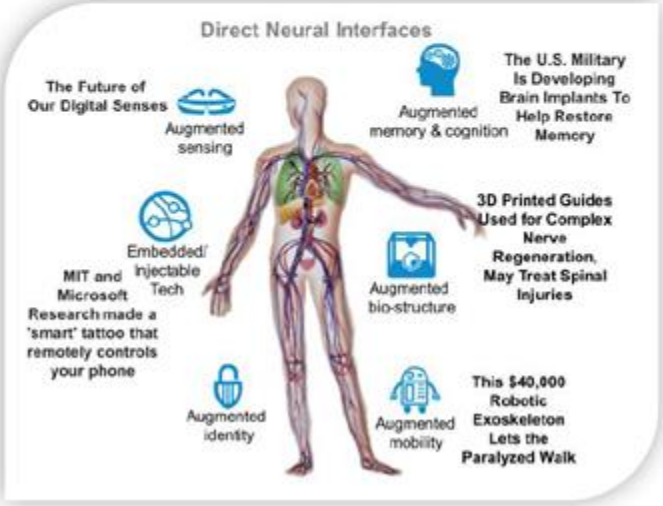
Infrared ear thermometers
Artificial limbs
Solar Cells
Freeze drying
Scratch-resistant lenses
Water purification
Portable cordless vacuums
Powdered lubricants
Space blanket
Aircraft anti-icing systems
Video enhancing and analysis systems
Firefighting equipment
OpenStack
Software catalog

Hyperscale Spin-off Technologies

Open APIs top to bottom
OCP Servers
OCP Storage
OCP Switches
Software Defined Data Center
Software Defined Networking
Software Defined Storage
Scale-out Storage
Scale-out Computing
Object Storage
NoSQL Databases
Hadoop
Containers
Artificial Intelligence

Integration of digital technologies with human biosystems

The 4th Platform: integration of digital technologies with human biosystems, and the use of digital technologies to engineer biological systems at the cellular and subcellular level.



Prediction 10

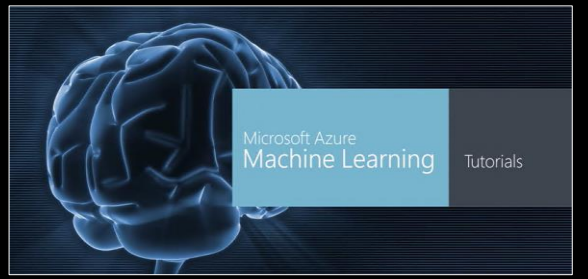
By 2020, 1/3 of Health/Life Sciences and CP companies will begin to develop the first products and services **tightly integrating 3rd Platform technologies with the human body.**

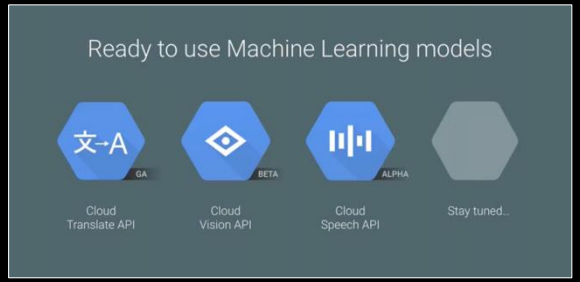
"Augmented Humanity" offerings will be mainstream in the mid-2020s.

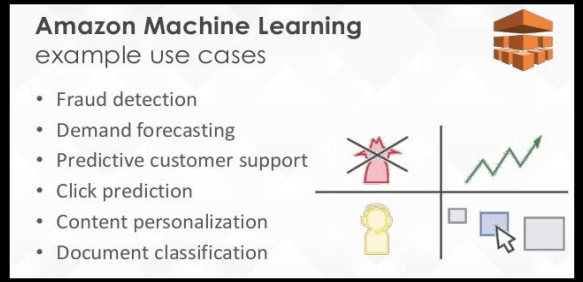
R&D/Innovators stage: now – 2021
Early Adopters stage: 2021-2026
Early Mainstream stage: 2026 -

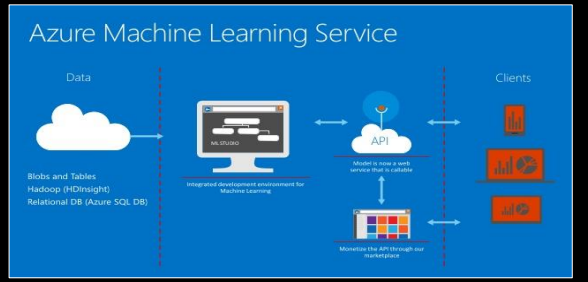
IDC Analyze the Future

Machine Learning as a Service









neu·ral net·work

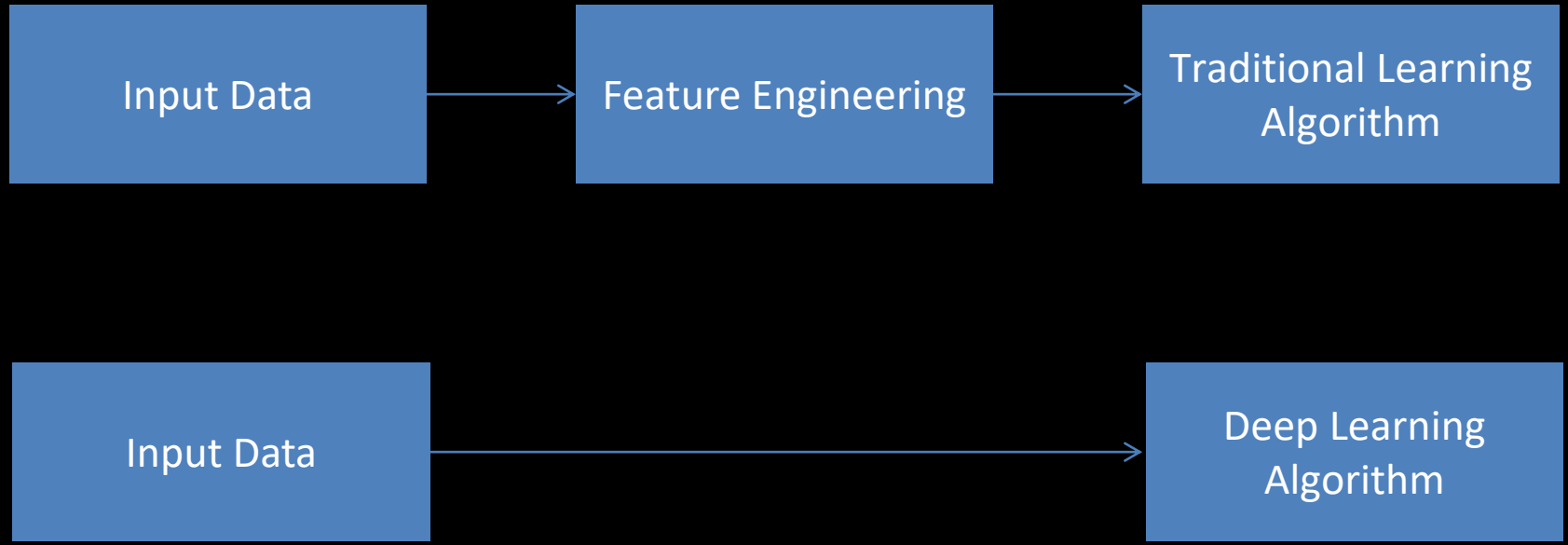
Noun

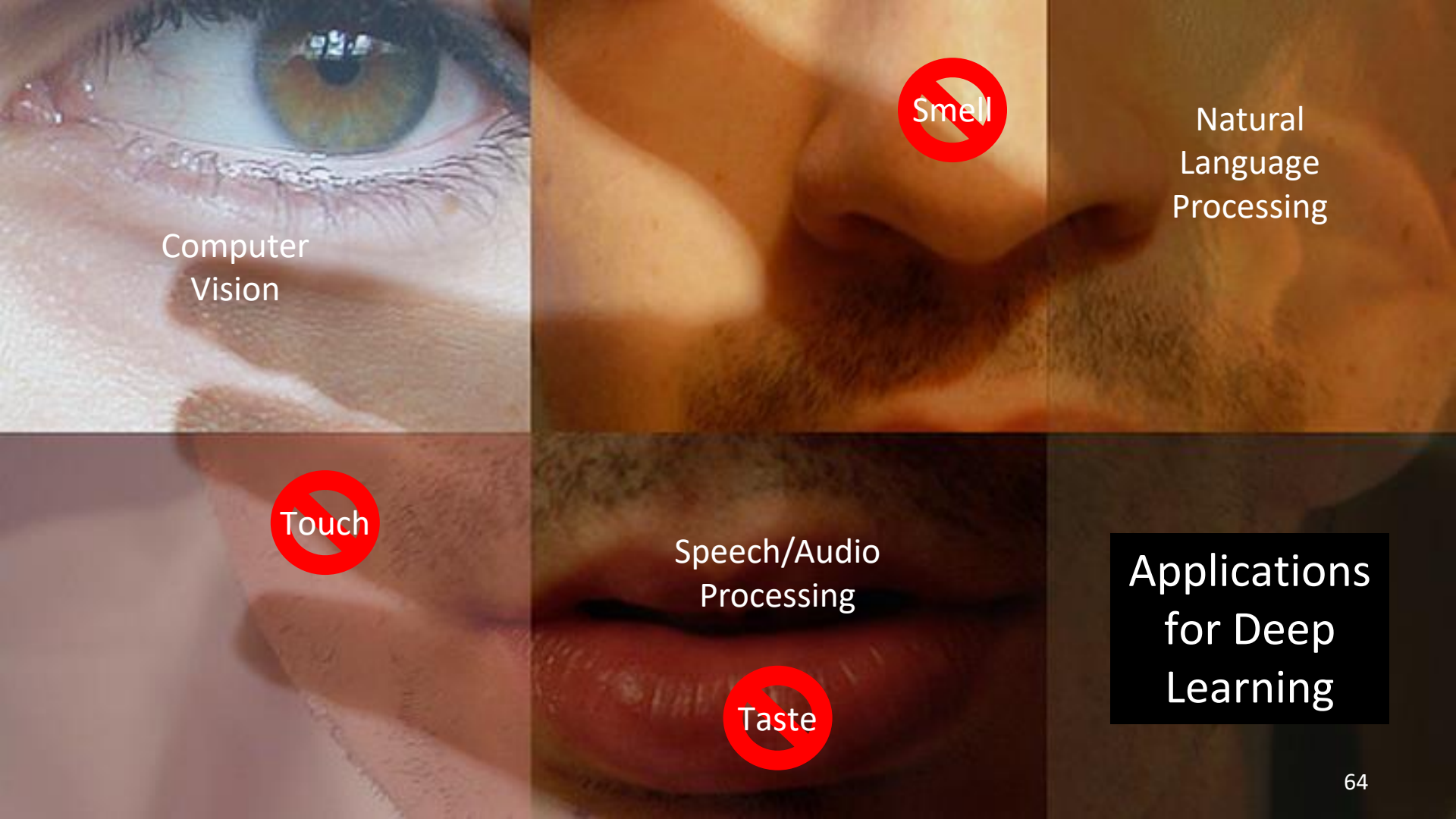
A computer system modeled on the human brain and nervous system.

Simulates the behavior of biological **neural networks**, as in pattern recognition, language processing, and problem solving, with the goal of self-directed information processing.

Artificial Intelligence

Deep Learning – No More Feature Engineering




Computer Vision
Smell
Natural Language Processing
Touch
Speech/Audio Processing
Taste
Applications for Deep Learning

Smell
Part 5 of 5

5 PREDICTIONS THAT WILL CHANGE OUR LIVES IN 5 YEARS.

CONTEXT IS EVERYTHING:

OUR BRAINS COMBINE SENSE DATA FROM OUR NOSE WITH INPUT FROM OUR MEMORIES AND OUR OTHER FOUR SENSES TO HELP US MAKE DECISIONS.

HOW DO WE KNOW WHEN SOMETHING DOESN'T SMELL RIGHT?

THE HUMAN NOSE CAN DETECT UP TO A THOUSAND DIFFERENT CHEMICALS.

IN FIVE YEARS, COGNITIVE COMPUTING SYSTEMS WILL BE ABLE TO NOT ONLY RECOGNIZE ODORS, BUT PLACE THEM IN CONTEXT TO DRAW CONCLUSIONS AND TAKE ACTION.

FARMERS WILL PLANT SENSORS IN THEIR FIELDS TO SMELL WHEN THE

TINY SMELL SENSORS CAN BE PLACED IN PHONES, BUILDINGS, CARS – ALMOST ANYWHERE.

IN THE FUTURE...

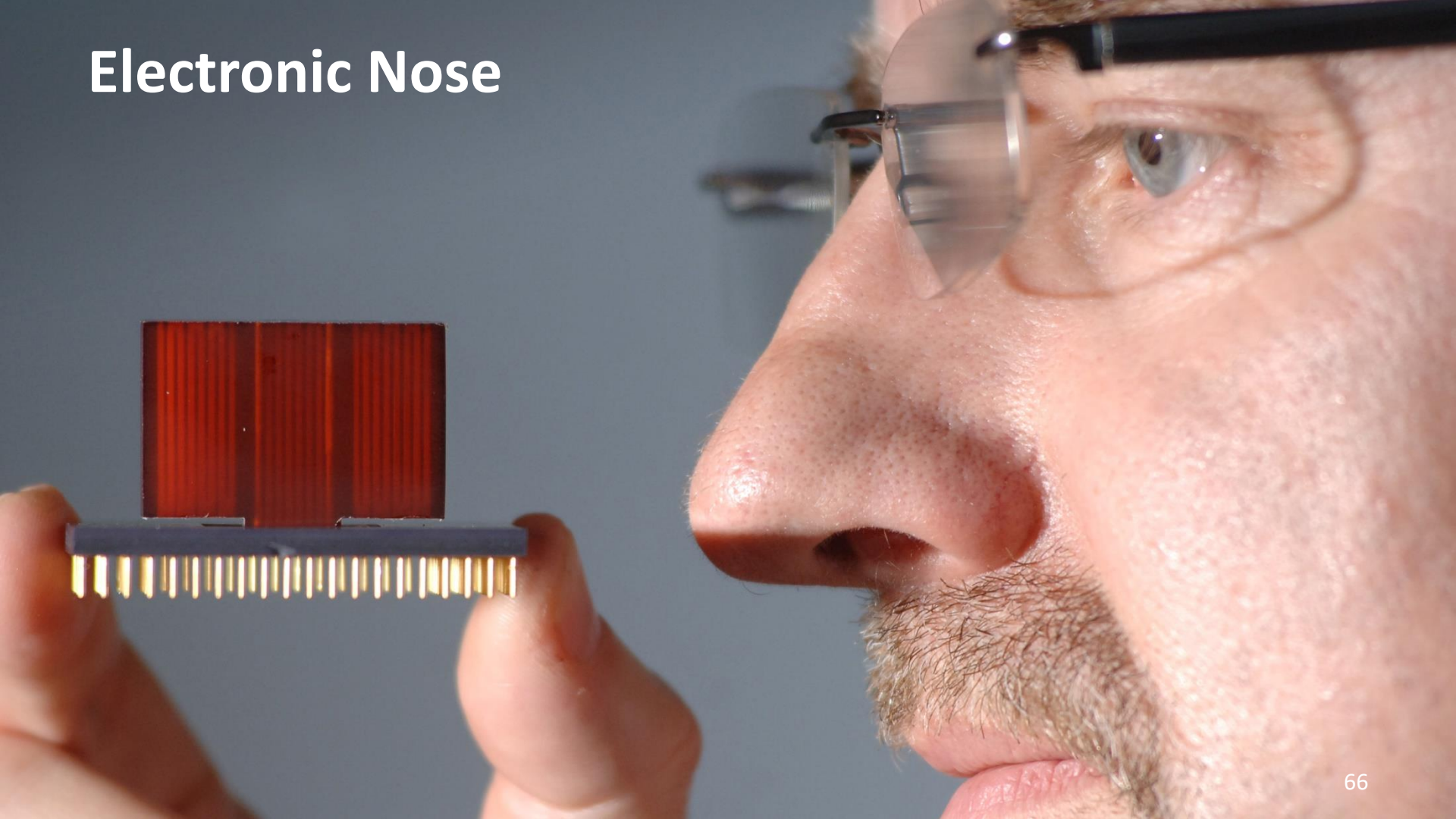
YOUR PHONE WILL BE ABLE TO SMELL WHEN YOU'RE GETTING SICK.

SENSORS WILL SNIFF OUT BACTERIA IN THE FOOD SUPPLY, PREVENTING OUTBREAKS.

HEALTHCARE FACILITIES WILL BE INSTRUMENTED WITH SENSORS TO DETECT INFECTIONS.

> "IN FIVE YEARS, COMPUTERS WILL HAVE A SENSE OF SMELL."
>
> DR. HENDRIK HAMANN
> RESEARCH MANAGER
> PHYSICAL ANALYTICS, IBM

Electronic Nose



Taste

Part 4 of 5

5 PREDICTIONS THAT WILL CHANGE OUR LIVES IN 5 YEARS.

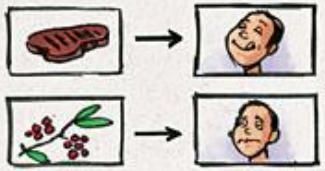
UNFORTUNATELY, OUR **LIFESTYLES HAVE EVOLVED** FASTER THAN OUR BRAINS.

WHEN FOOD WAS HARD TO COME BY, IT MADE SENSE TO EAT AS MANY CALORIES AS POSSIBLE.

TODAY, FOOD IS MORE ABUNDANT, BUT OUR BRAINS STILL CRAVE HIGH-CALORIE FOODS.

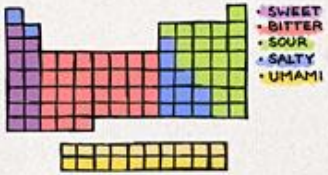
TASTES VARY AROUND THE WORLD: COGNITIVE SYSTEMS WILL LEARN TO ADAPT.

OUR SENSE OF TASTE HAS EVOLVED TO PROTECT US:



FOODS THAT CONTAIN THE MOLECULES OUR BODIES NEED TASTE GOOD, WHILE DANGEROUS COMPOUNDS OFTEN TASTE BITTER OR UNPLEASANT.

WHY DO SOME THINGS TASTE BETTER THAN OTHERS?



IN THE FUTURE...

PERSONALIZED WEB APPLICATIONS WILL OFFER **RECOMMENDATIONS** BASED ON OUR MEDICAL NEEDS AND FLAVOR PREFERENCES.

SCHOOL LUNCHES WILL BE **OPTIMIZED** FOR KIDS' PALATES, MAKING VEGGIE DISHES ALMOST AS POPULAR AS DESSERT.

RECIPES WILL AUTOMATICALLY ADAPT TO INCORPORATE LOCAL, SEASONAL INGREDIENTS, MAKING AGRICULTURE MORE **SUSTAINABLE.**

IN FIVE YEARS, **COGNITIVE** SYSTEMS WILL BE ABLE TO INVENT NEW RECIPES THAT APPEAL TO OUR SENSE OF TASTE - WHILE ALSO MEETING OUR NEED FOR FOODS THAT ARE HEALTHY, SUSTAINABLE

YOUR TONGUE IS LIKE YOUR OWN PERSONAL CHEMISTRY LAB, ANALYZING THE MOLECULES IN THE FOOD YOU EAT.

> "**IN FIVE YEARS,** COMPUTERS WILL KNOW WHAT YOU LIKE TO EAT BETTER THAN YOU DO."

DR. LAV VARSHNEY
RESEARCH SCIENTIST
SERVICES RESEARCH, IBM

IBM

5 IN 5 — Touch
Part 1 of 5

5 PREDICTIONS THAT WILL CHANGE OUR LIVES IN 5 YEARS.

WHAT MAKES DIFFERENT SURFACES FEEL DIFFERENT TO THE TOUCH?

THE SURFACES OF EVERYDAY OBJECTS FORM A **microscopic landscape** OF NEARLY ENDLESS **VARIETY.**

AS OUR FINGERS **press**, **probe** OR **pass over** OBJECTS, OUR NERVES GENERATE PATTERNS OF **ELECTRICAL IMPULSES** WHICH OUR BRAINS CAN INTERPRET – CREATING THE SENSATION OF TOUCH.

SOON **COGNITIVE COMPUTING** SYSTEMS WILL BE ABLE TO UNDERSTAND THE WAY OUR BRAINS EXPERIENCE TOUCH – AND RE-CREATE THAT EXPERIENCE WITH LIFELIKE PRECISION USING VIBRATION, PRESSURE AND MOVEMENT.

> "**FIVE YEARS FROM NOW,** YOU WILL BE ABLE TO TOUCH THROUGH YOUR PHONE."
>
> ROBYN SCHWARTZ
> RETAIL INDUSTRY EXPERT, IBM

IN THE FUTURE...

ONLINE SHOPPERS WILL FEEL THE QUALITY AND FLOW OF A GARMENT BY STROKING A PICTURE OF IT ON THE SURFACE OF THEIR PHONE.

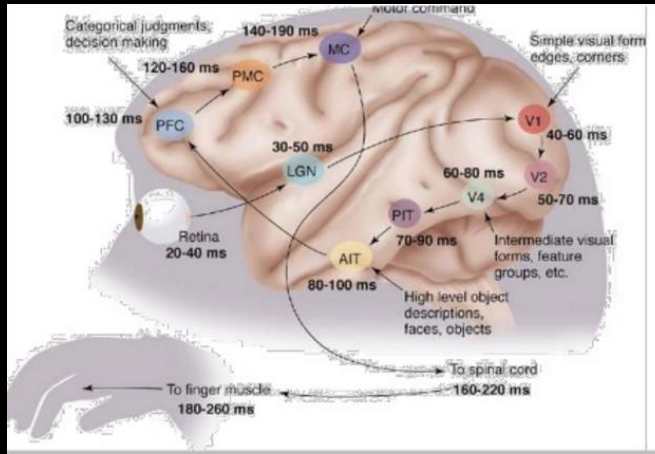
ARTISANS IN DEVELOPING COUNTRIES WILL ACCESS NEW MARKETS BY INVITING RETAILERS TO EXPERIENCE THEIR WARES ONLINE.

DOCTORS WILL BE ABLE TO PROVIDE **HANDS-ON** EXAMINATIONS TO PATIENTS IN REMOTE LOCATIONS.

ADVANCED APPLICATIONS WILL COMBINE TOUCH WITH OTHER SENSES TO DETERMINE, FOR EXAMPLE, IF A DRIVER IS TOO TIRED TO DRIVE.

IBM

Inspired by The Brain



The first hierarchy of neurons that receives information in the visual cortex are sensitive to specific edges while brain regions further down the visual pipeline are sensitive to more complex structures such as faces.

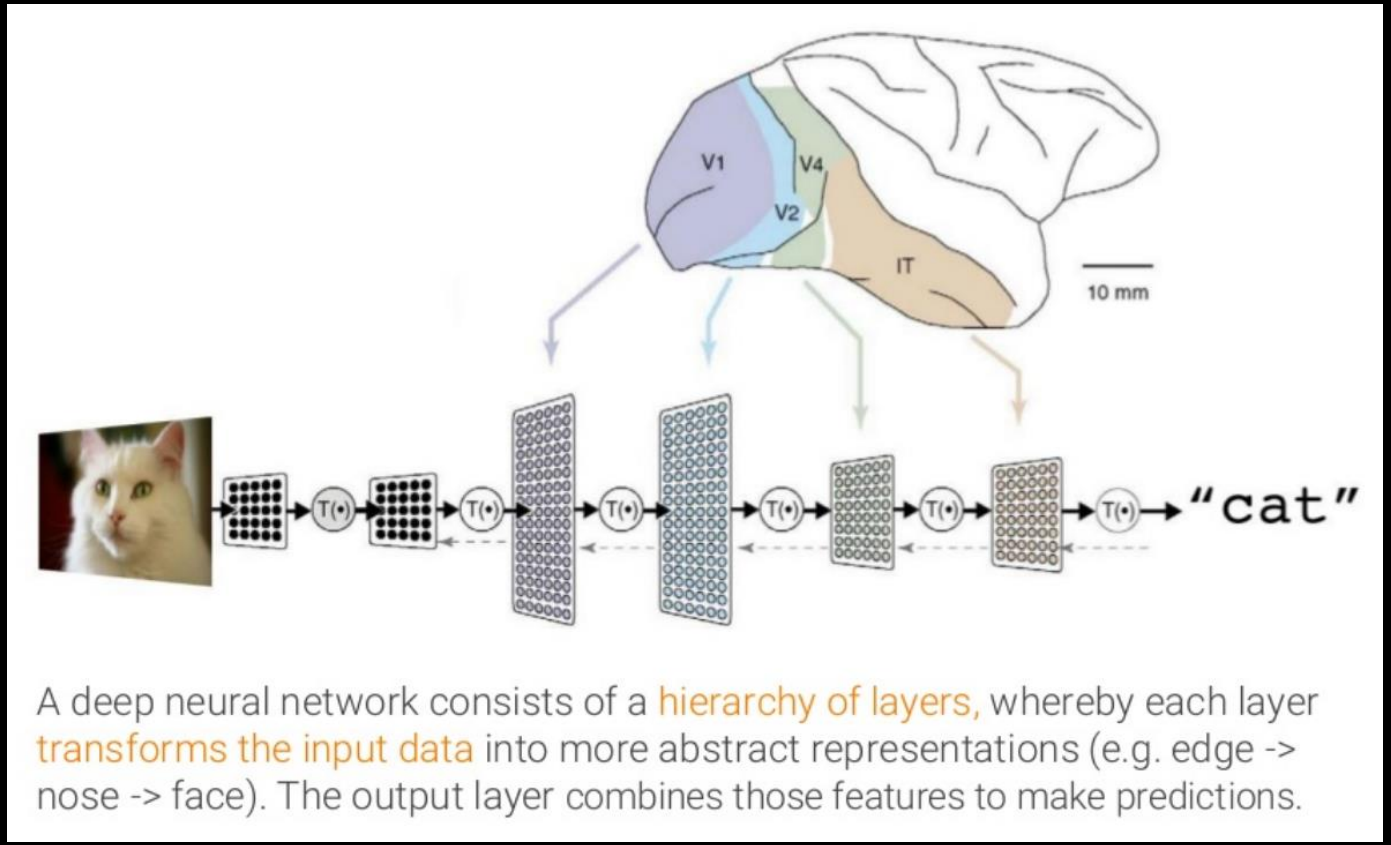
Our brain has lots of neurons connected together and the strength of the connections between neurons represents long term knowledge.

1

One learning algorithm hypothesis: all significant mental algorithms are learned except for the learning and reward machinery itself.

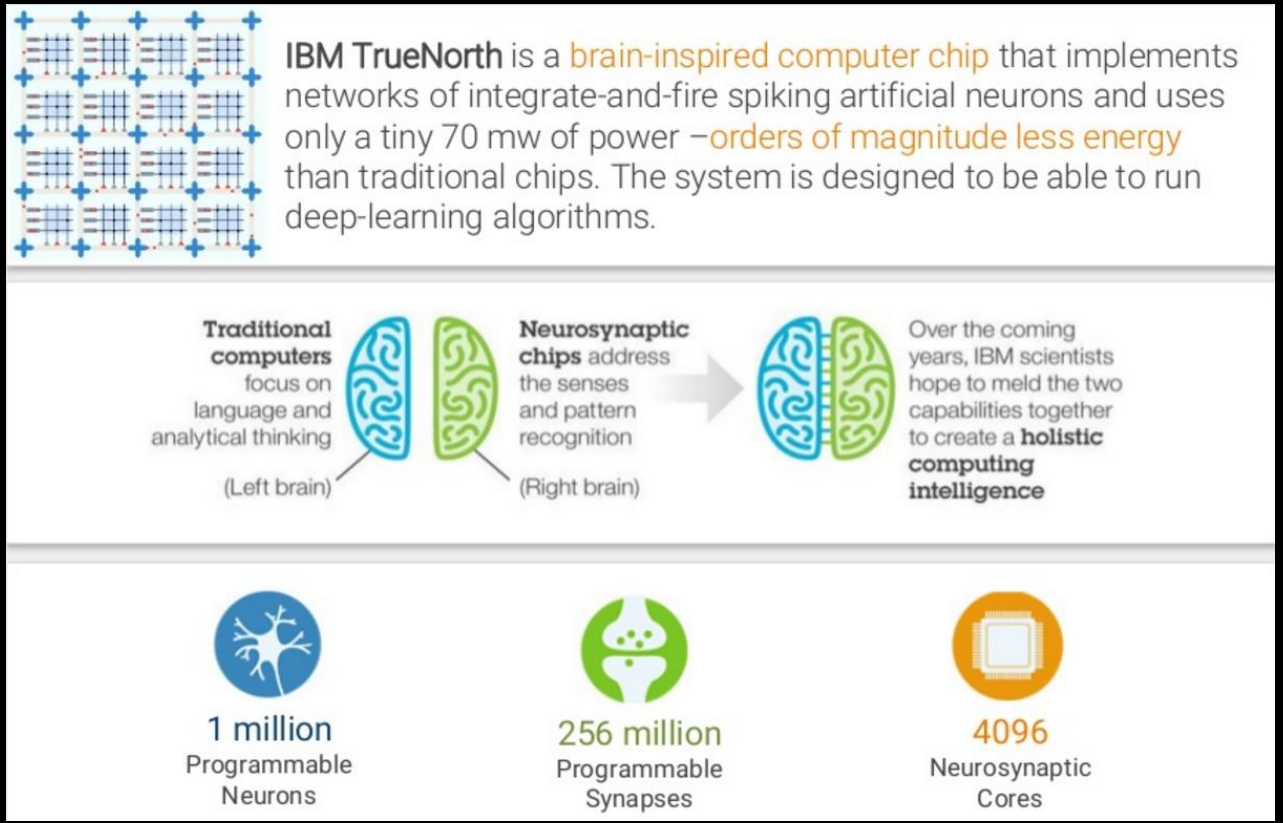
What separates the future of computing from the past

Deep Learning Basics



A deep neural network consists of a hierarchy of layers, whereby each layer transforms the input data into more abstract representations (e.g. edge -> nose -> face). The output layer combines those features to make predictions.

Neuromorphic Chips



Conversation

Neural Chatbot: Predicts the next sentence given the previous sentences in a conversation.

The LSTM remembers facts, understands contexts and performs common sense reasoning in the trained domain.

Human: what is the purpose of life ?

Machine: to serve the greater good .

Human: what is the purpose of living ?

Machine: to live forever

Human: what is the purpose of existence?

Machine: to find out what happens when we get to the planet earth

Human: where are you now ?

Machine: i 'm in the middle of nowhere .

Human: what is the purpose of dying ?

Machine: to have a life

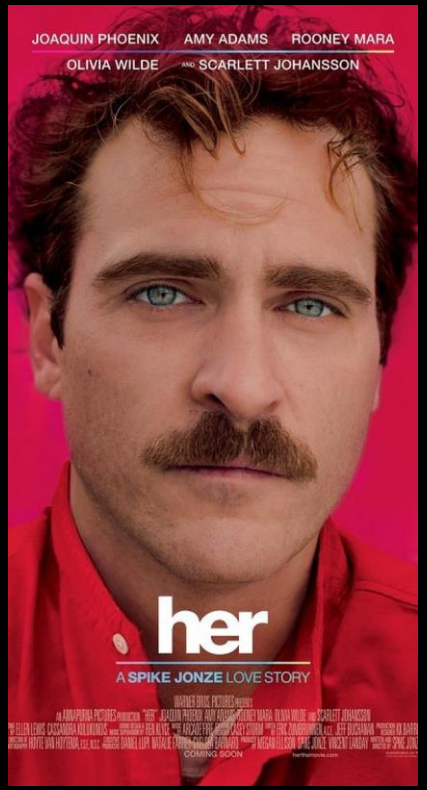
Human: what is the purpose of being intelligent ?

Machine: to find out what it is.

Human: what is the purpose of emotions ?

Machine: I don 't know .

Philosophical Q&A – Network trained with OpenSubtitles (movie subtitles)



Vision

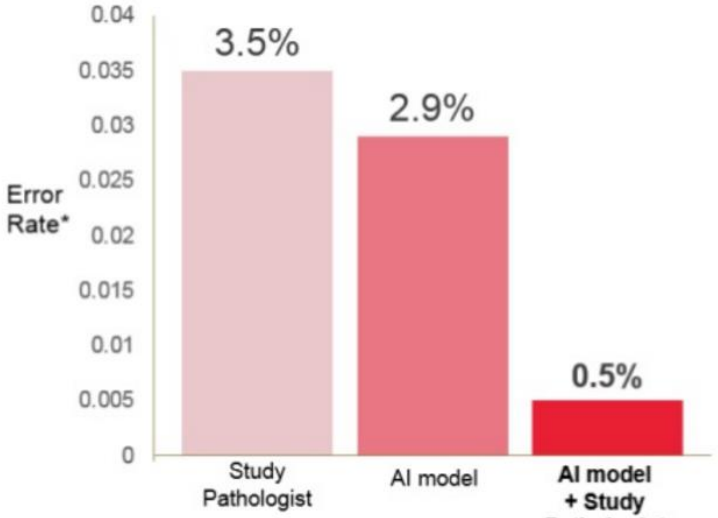
Photo CC-BY-NC by edwin.11

Photo CC-BY-NC by stevekc

PlaNet is able to determine the location of almost any image with superhuman ability.

Diagnose Cancer

(AI + Pathologist) > Pathologist



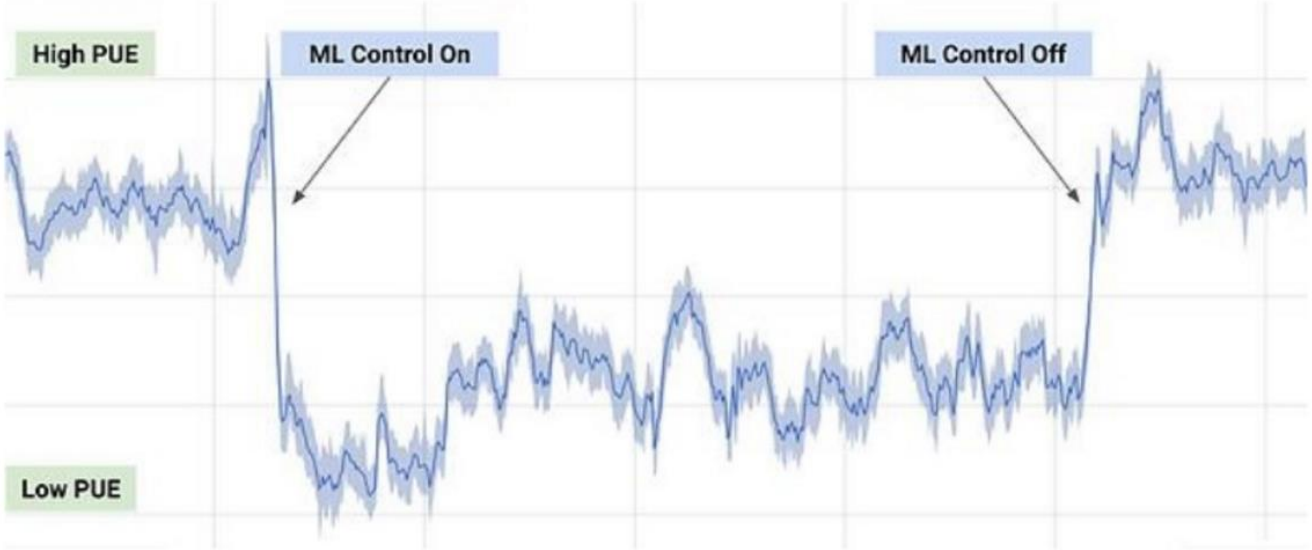
* Error rate defined as 1 – Area under the Receiver Operator Curve
** A study pathologist, blinded to the ground truth diagnoses, independently scored all evaluation slides.

Deep Learning drops error rate for breast cancer Diagnoses by 85%. Researchers trained their models with millions of labeled images to find the probability that a patch contains cancer, eventually creating tumor probability heatmaps.

The Cure for Cancer Is Data—Mountains of Data

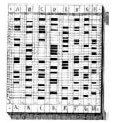
"Can we do better for human well-being if information is more broadly accessible, where you're leveraging the mindshare of the entire planet to evolve the models of disease?" Schadt asks. "Absolutely." This is medicine as math, not guesswork, and every disease—even stage 4 cancer—might one day be druggable.
- Wired

Save Energy

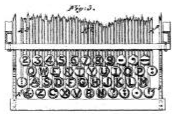


DeepMind AI reduces data center cooling bill by 40% using a system of neural networks trained on different operating scenarios and parameters within Google's data centers.

Voice User & Admin Interfaces



Punch Cards for Informatics
1832



QWERTY Keyboard
1872

Electromechanical Computer (Z3)
1941

Electronic Computer (ENIAC)
1943

Paper Tape Reader (Harvard Mark I)
1944

Mainframe Computers (IBM SSEC)
1948

Trackball
1952

Joystick
1967

Microcomputers (IBM Mark-8)
1974

Portable Computer (IBM 5100)
1975

Commercial Use of Window-Based GUI (Xerox Star)
1981

Commercial Use of Mouse (Apple Lisa)
1983

Commercial Use of Mobile Computing (PalmPilot)
1996

Touch + Camera - based Mobile Computing (iPhone 2G)
2007

Voice on Mobile (Siri)
2011

Voice on Connected / Ambient Devices (Amazon Echo)
2014

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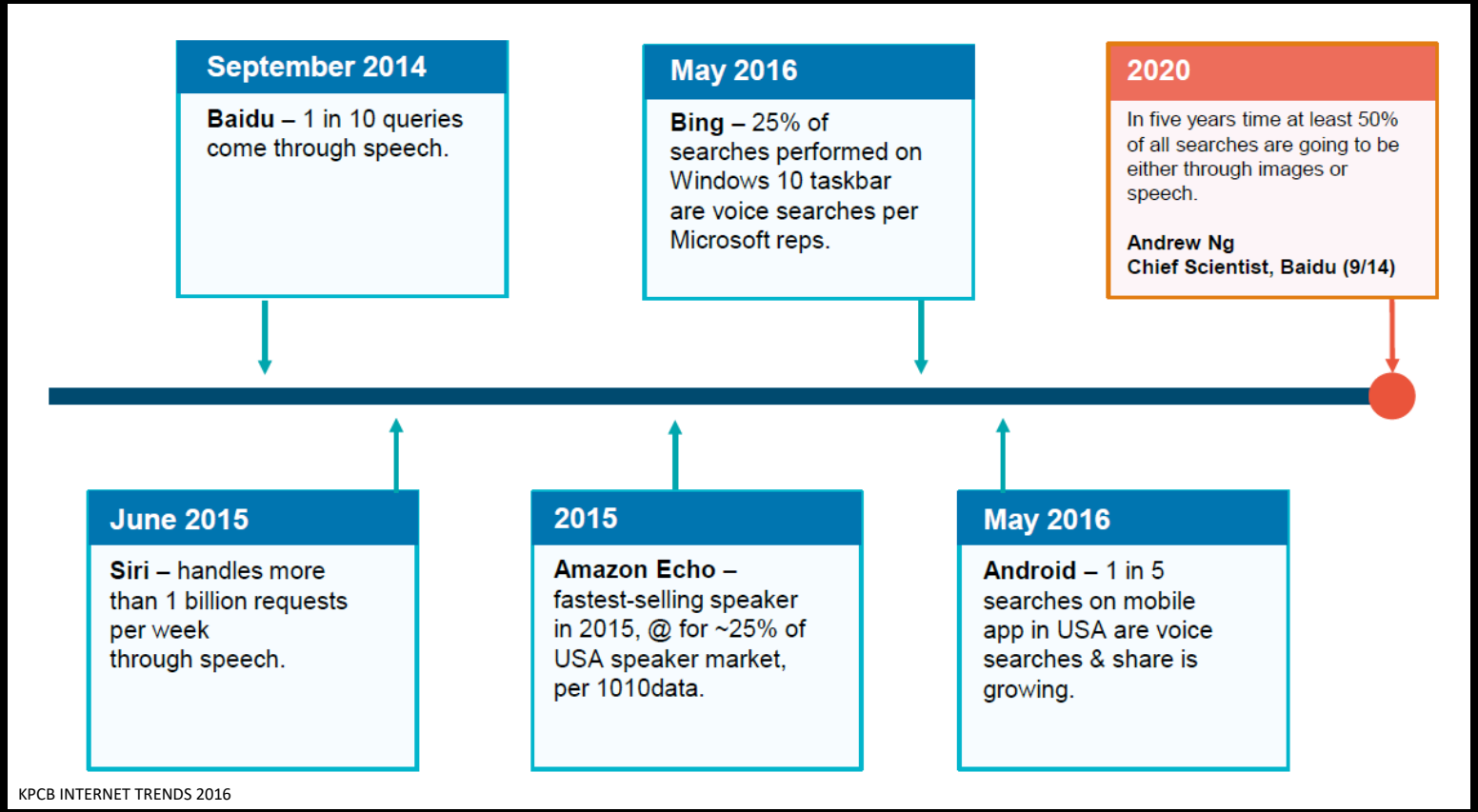
Voice Gaining Search Share



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Person to Machine Voice Interaction Adoption Keys

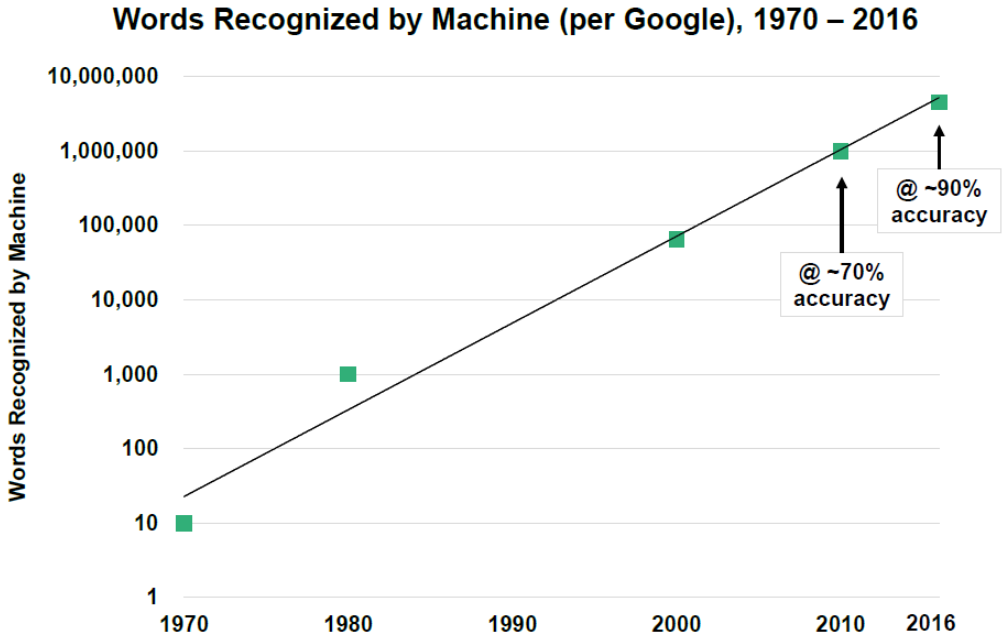
As speech recognition accuracy goes from say 95% to 99%, all of us in the room will go from barely using it today to using it all the time. Most people underestimate the difference between 95% and 99% accuracy – ***99% is a game changer****...*

No one wants to wait 10 seconds for a response*. Accuracy, followed by latency, are the two key metrics for a production speech system...*

ANDREW NG, CHIEF SCIENTIST AT BAIDU

Machine Speech Recognition @ Human Level for Voice Search in Low Noise Environment

***Next Frontier** = Recognition in heavy background noise in far-field & across diverse speaker characteristics (accents, pitch...)*

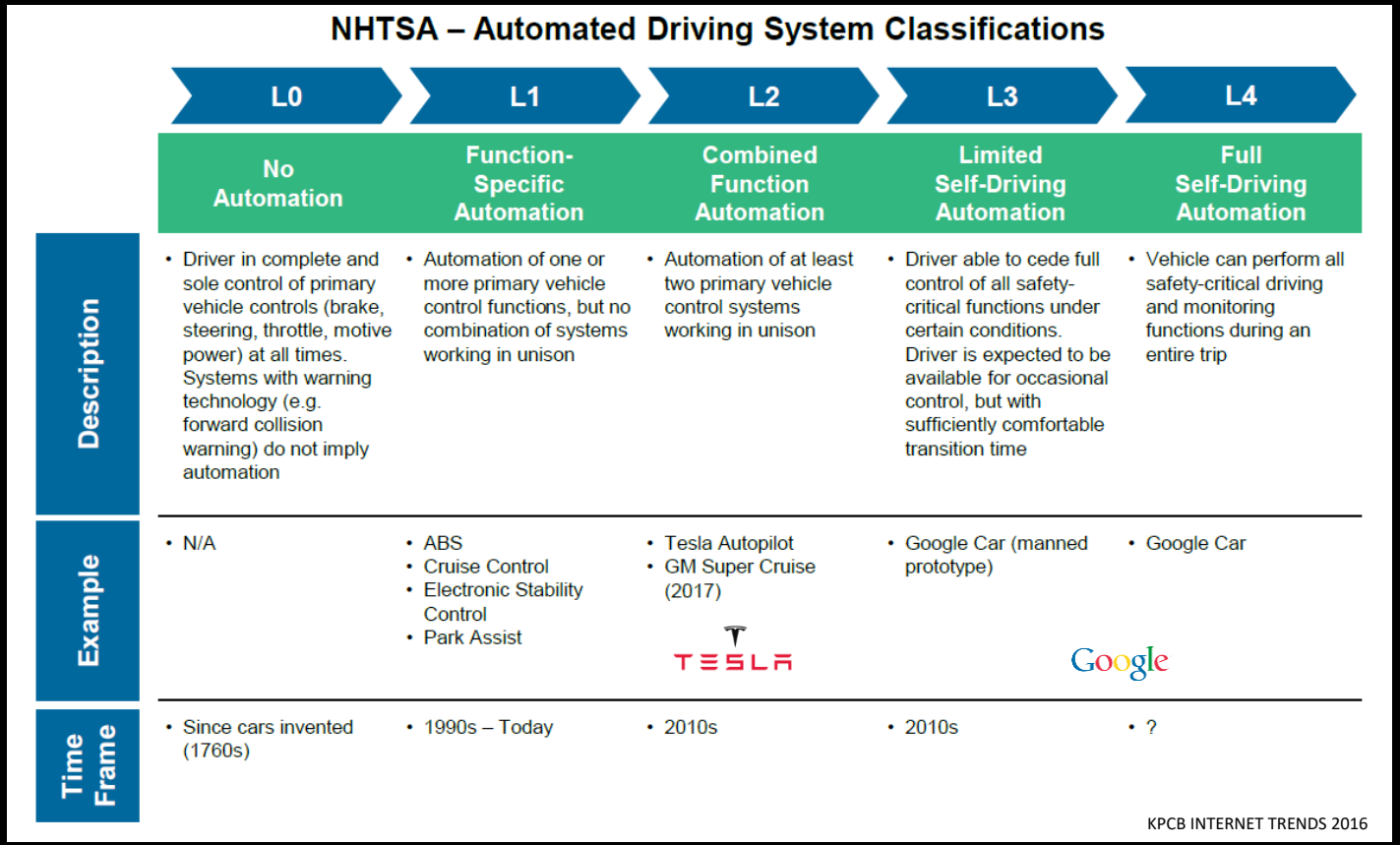


KPCB INTERNET TRENDS 2016

What I do remember is that Cisneros told the joke in Spanish, and I heard it in English.

The demo's still early: it only worked in one of my ears, and the joke's punchline didn't come through for a really awkward five seconds or so. But it felt like the beginning of something big.
- Wired

Self Driving Cars



A Metric for Success: Miles Driven

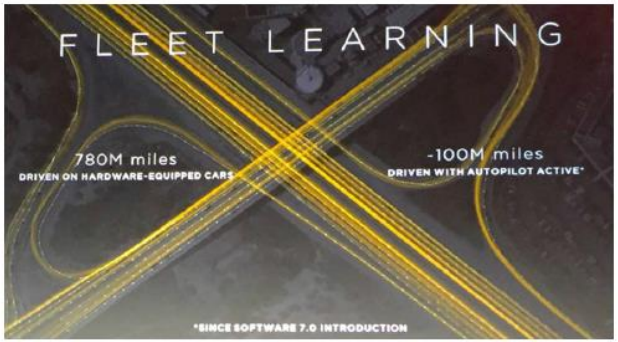
Google (Level 3 / 4 Autonomy)

Google Self-Driving Car Project

Where we are

We've self-driven more than 1.5 million miles and are currently out on the streets of Mountain View, CA, Austin, TX, Kirkland, WA and Metro Phoenix, AZ.

Tesla (Level 2 Autonomy)



Tesla customers have driven 100 million miles with Autopilot active

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Self-Driving Storage

ITBP – Self Driving Storage System Classifications

	L0	L1	L2	L3	L4
	No Automation	**Function-Specific Automation**	**Combined Function Automation**	**Limited Self-Driving Automation**	**Full Self-Driving Automation**
Description	Admin in complete and sole control of primary storage controls (media, volume management, backup, replication, dedup, compression) at all times.	Automation of one or more primary storage control functions, but no combination of systems working in unison	Automation of at least two primary storage control systems working in unison	Admin able to cede full control of all performance and HA critical functions under certain conditions. Admin is expected to be available for occasional control, but with sufficiently comfortable transition time	Self-driving storage can perform all performance and HA-critical driving and monitoring functions 24x7, 365 days a year
Example		Virtualization (RAID) Automated backup Storage monitoring	HSM Storage migration QoS DELL EMC Hewlett Packard Enterprise	AWS, Google, Azure Service Chains powered by amazon web services Google	Artificial Intelligence
Time Frame	Since enterprise-class storage invented - 1960s	1990s - Today	2000s - Today	2010s - Today	2020s

A Metric for Success: Admins Per Server

Hyperscale

Servers are fully instrumented and integrated with analytics and automated server management software

Enterprise

Best-in-class VMware environments

Blizzard and DeepMind have created an open test environment within the StarCraft II game for artificial intelligence researchers to use worldwide.

“In playing StarCraft, the AI system will have to come up with real-time strategies for choosing one of the three distinct races at the beginning of the game; choosing when and how to farm minerals and gas; deciding when and which buildings and units to construct; and scouting unseen areas of the map and remembering that navigational information over the course of the game.

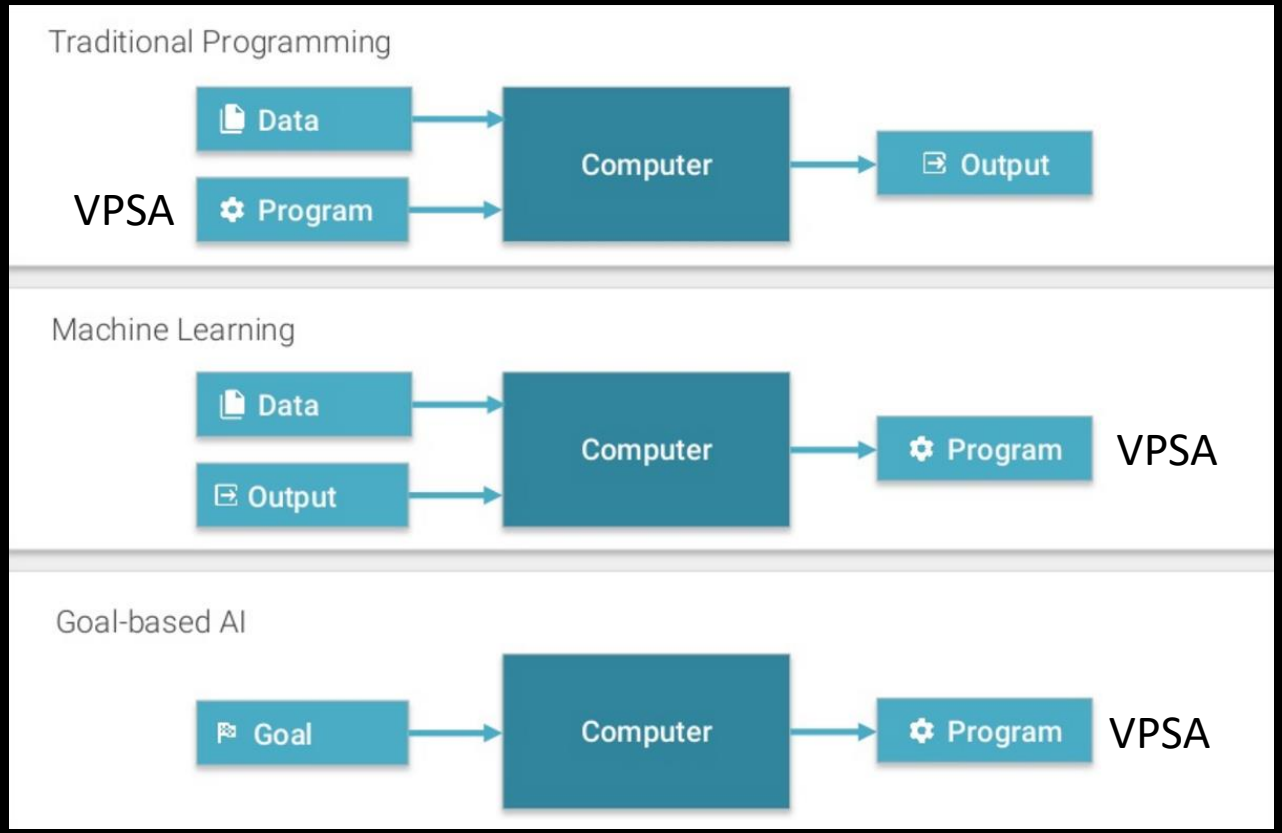
An AI engine would therefore have to make use of the skills of memory, mapping, long-term planning, and adapting to changes in plans using information that is continually being gathered, which translates to hierarchical planning and reinforcement learning.”

Zadara Enterprise Storage-as-a-Service 2026

“In deploying enterprise STaaS, the AI system will have to come up with real-time strategies for choosing one of the three distinct platforms (public, on-premises or hybrid) at the beginning; choosing where, when and how to implement service levels; deciding where, when and which storage media to deploy; and scouting unseen areas of the application environment and remembering that navigational information over the course of the service agreement.

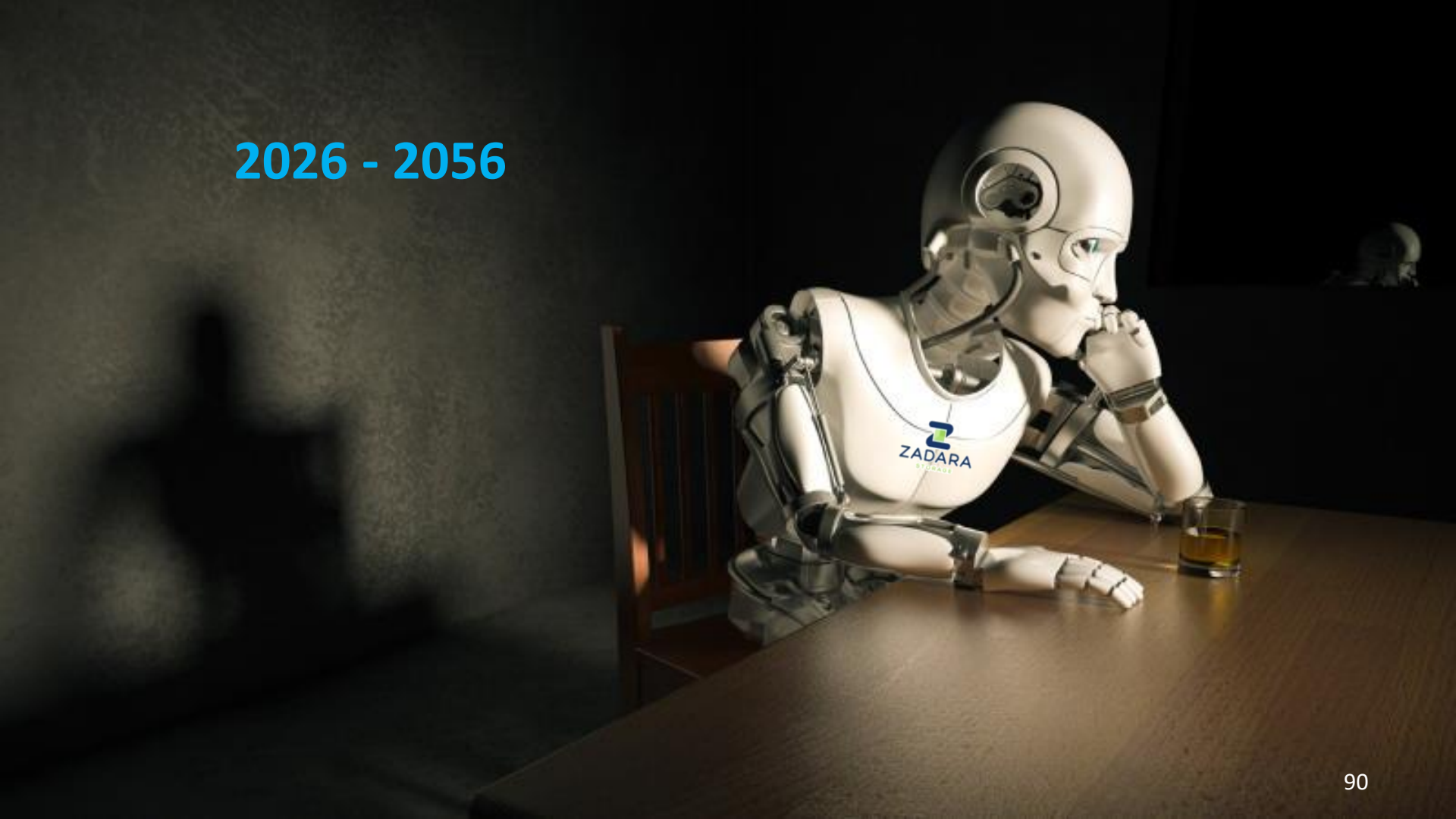
The Zadara AI engine would therefore have to make use of the skills of memory, mapping, long-term planning, and adapting to changes in plans using information that is continually being gathered, which translates to hierarchical planning and reinforcement learning.”

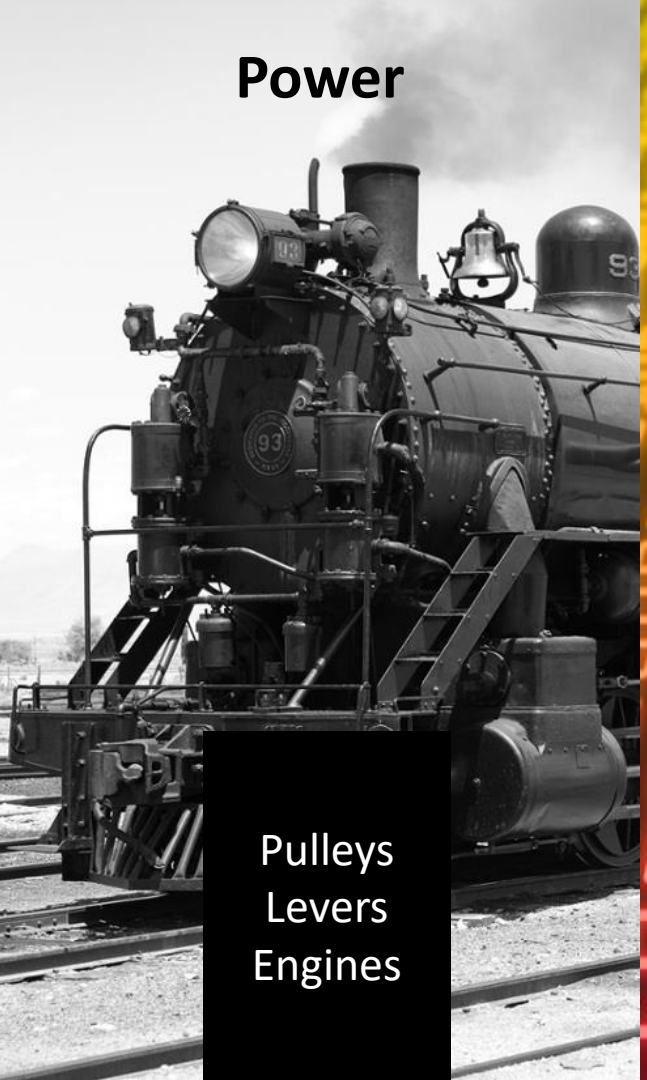
Goal Based AI




ZADARA STORAGE
Engineering

2026 - 2056





Power

Pulleys
Levers
Engines

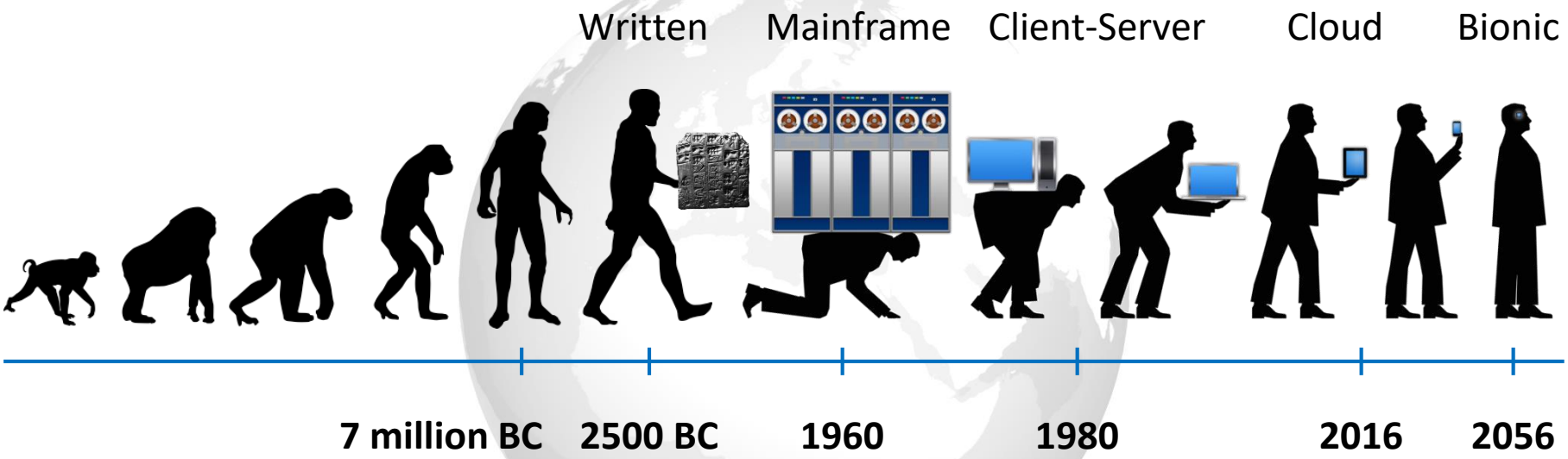
Electricity

Lighting
Telephone
Television
Computing

Medicine

Artificial
Intelligence

Evolution of Storage Technology



Anatomy of a Software Defined Data Center

Facility

Circulatory system

Servers

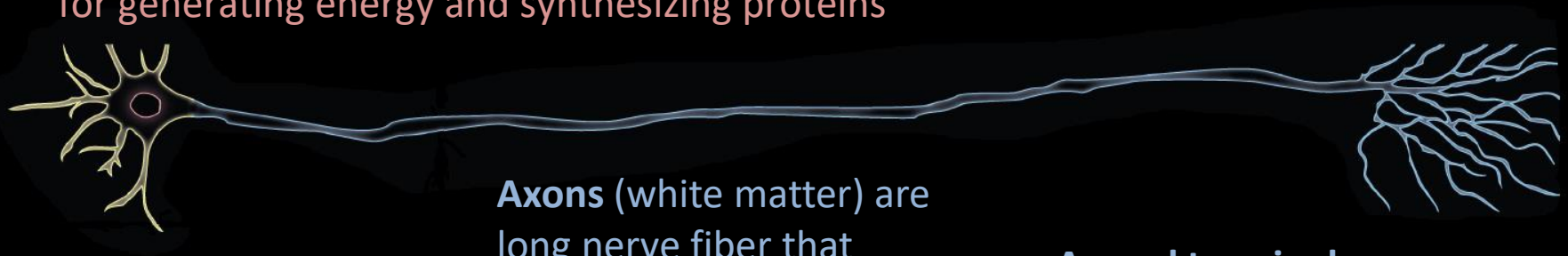
Nervous system

100 Billion Neurons (Servers) in Each of Our Brains

10,000 synapses per neuron

100 trillion to 1 quadrillion connections

The **Cell Body** is the neuron's powerhouse, responsible for generating energy and synthesizing proteins



Dendrites pick up signals from other Neurons

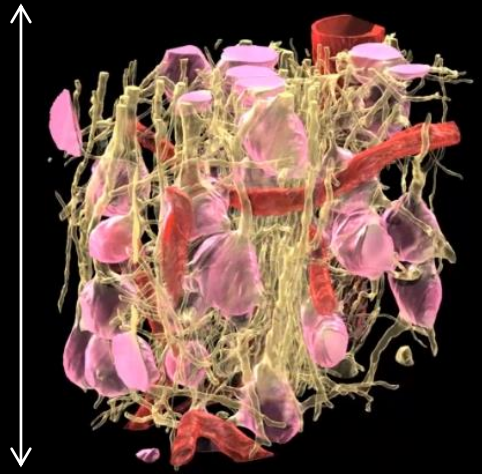
Axons (white matter) are long nerve fiber that conduct information from the cell body in the form of an electrical impulse

Axonal terminals are end points of an axon's branches, where electrical impulses are discharged; releasing neurotransmitters to other cells' dendrites

Source: National Geographic, The New Science of the Brain

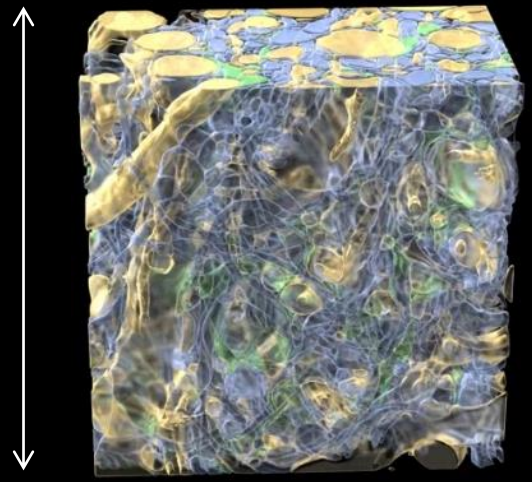
Densely Packed (in the Data Center)

100 Microns



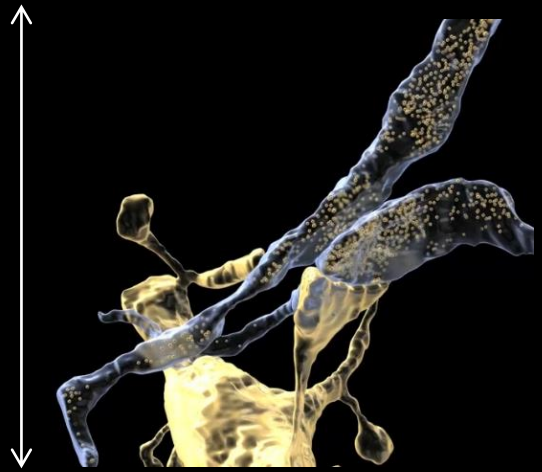
Cell Bodies Dendrites

10 Microns



Dendrites Axons

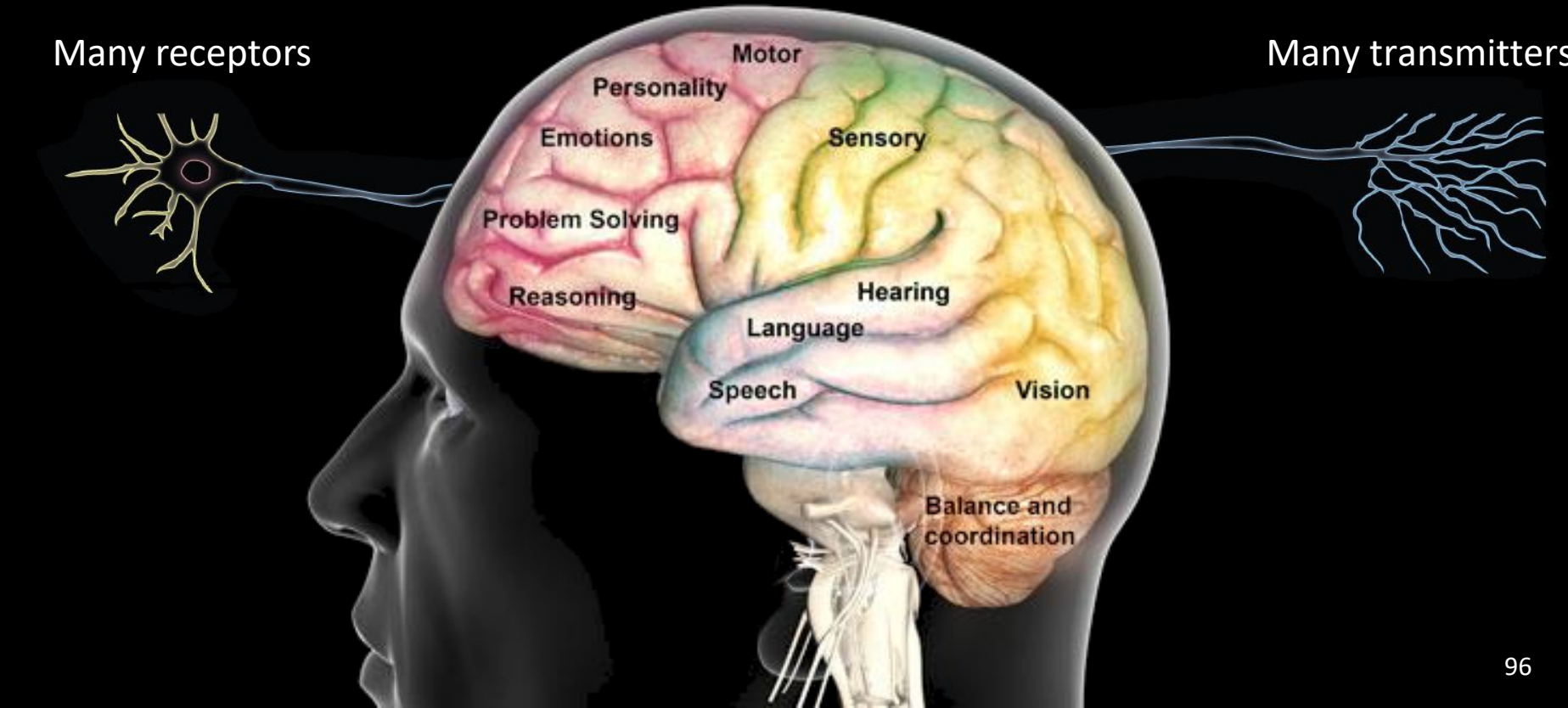
3 Microns



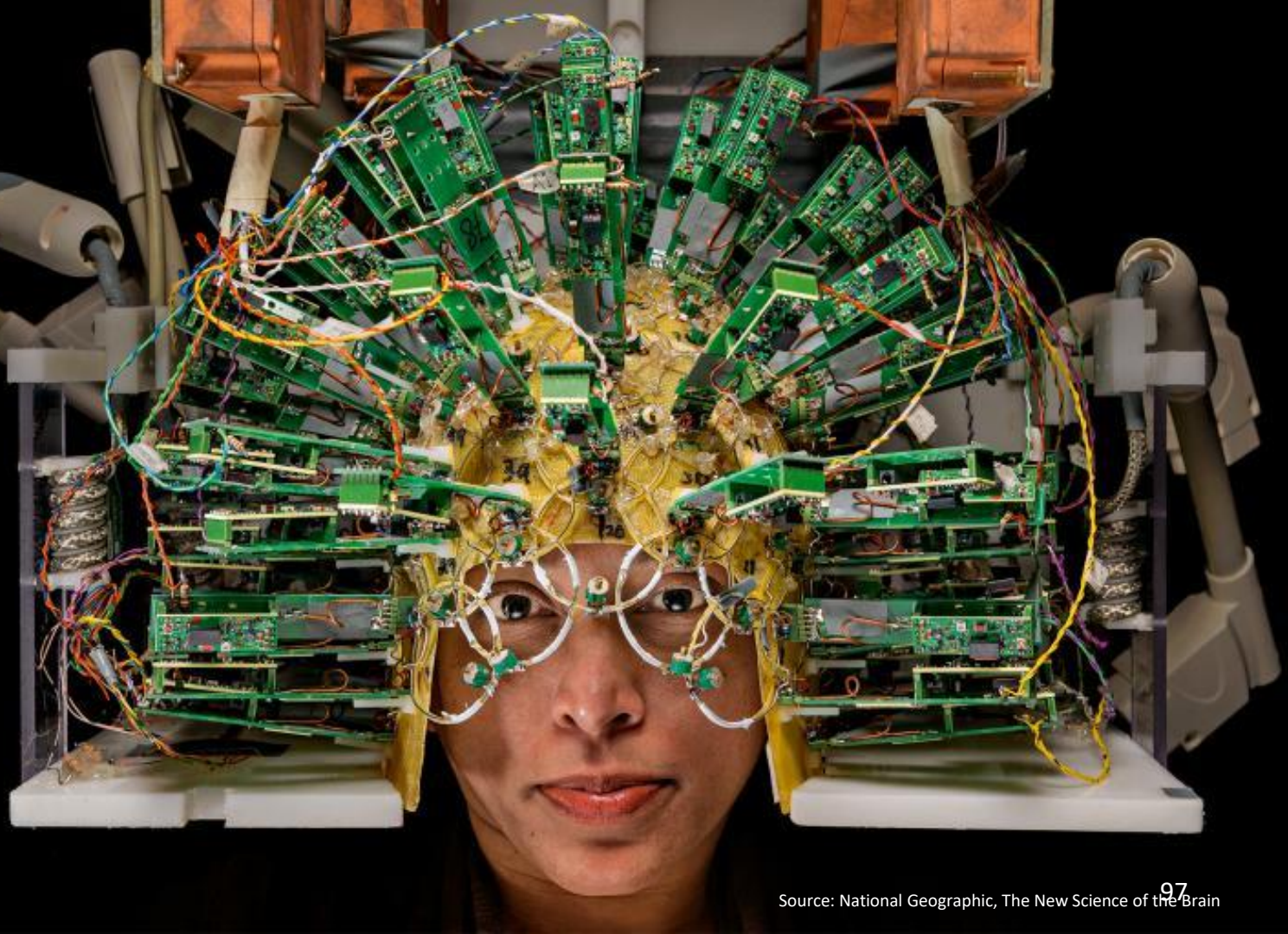
Dendrites Axons

Source: National Geographic, The New Science of the Brain

Massive Parallel Processing Before Output



A helmet of sensors at the Martinos Center for Biomedical Imaging – part of a brain scanner requiring almost as much power as a nuclear submarine. Antennas pick up signals which computers convert into brain maps (see next slide).



Source: National Geographic, The New Science of the Brain

100,000 Miles of Network Cable

The brain's many regions are connected by 100,000 miles of fibers called white matter—enough to circle the Earth four times. Images like this reveal the specific pathways underlying cognitive functions. The pink and orange bundles transmit signals critical for language.

Source: National Geographic, The New Science of the Brain

1 Billion Terabytes of Storage

Almost 3x data to be produced in 2020

450,000 terabytes (.45 exabyte)
Storage capacity needed to produce mouse brain image

1.3 billion terabytes (1,300 exabytes)
Storage capacity needed to produce human brain image

Source: National Geographic, The New Science of the Brain

20 Watts of Power

CFL light bulb
18 watts

Nintendo Wii
18 watts

Desktop & Monitor
(in sleep mode)
1-20 watts

Human Brain
20 watts

Ceiling fan
24 watts

Server Configured Like a Human Brain

>100 PetaFLOPS Processing Power

1.3 Billion Terabytes of Storage

3.3 Pounds

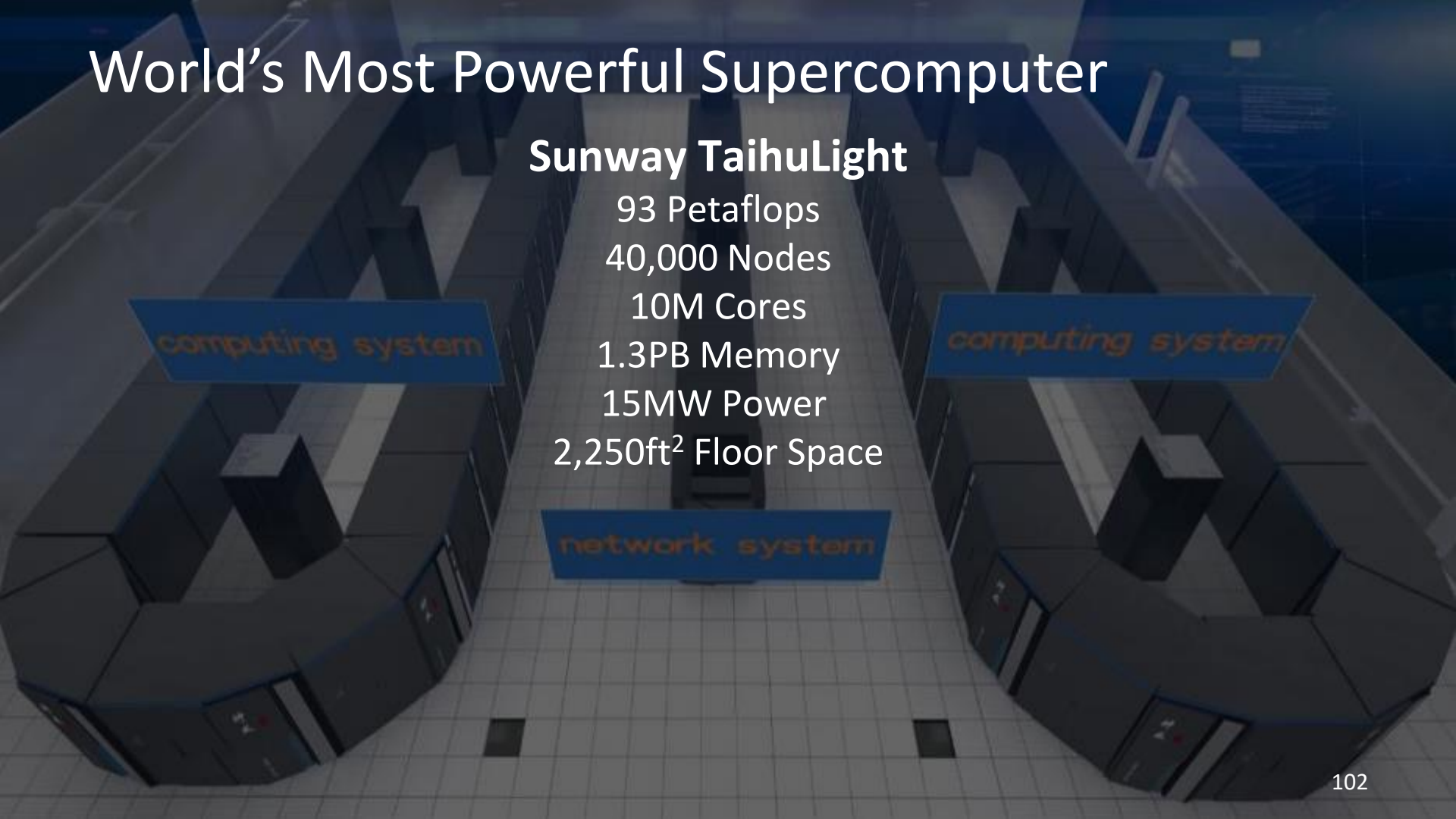
20W Power

77 Cubic Inches
19” Wide x 1.75” (1U) High x 2.3” Deep

10,000 Network Ports

100,000 Miles of Cabling Included

World’s Most Powerful Supercomputer



Sunway TaihuLight

93 Petaflops

40,000 Nodes

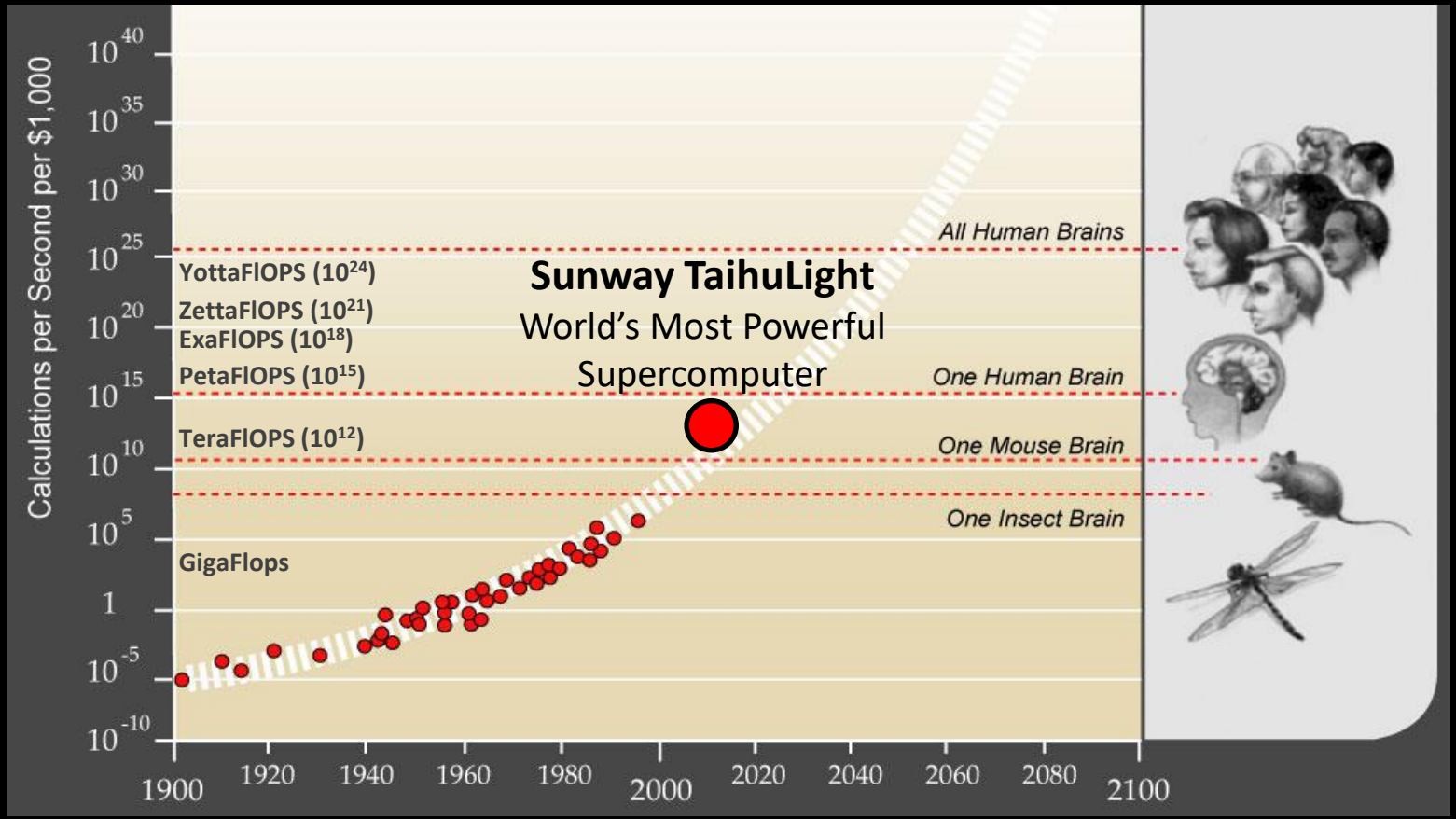
10M Cores

1.3PB Memory

15MW Power

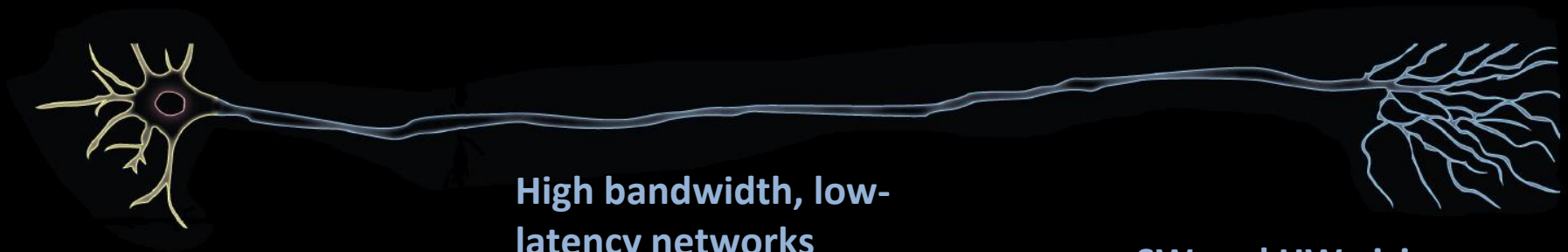
2,250ft^2 Floor Space

>100 Petaflops Needed to Simulate 1 Mouse Brain



We've just started

Scale-out servers



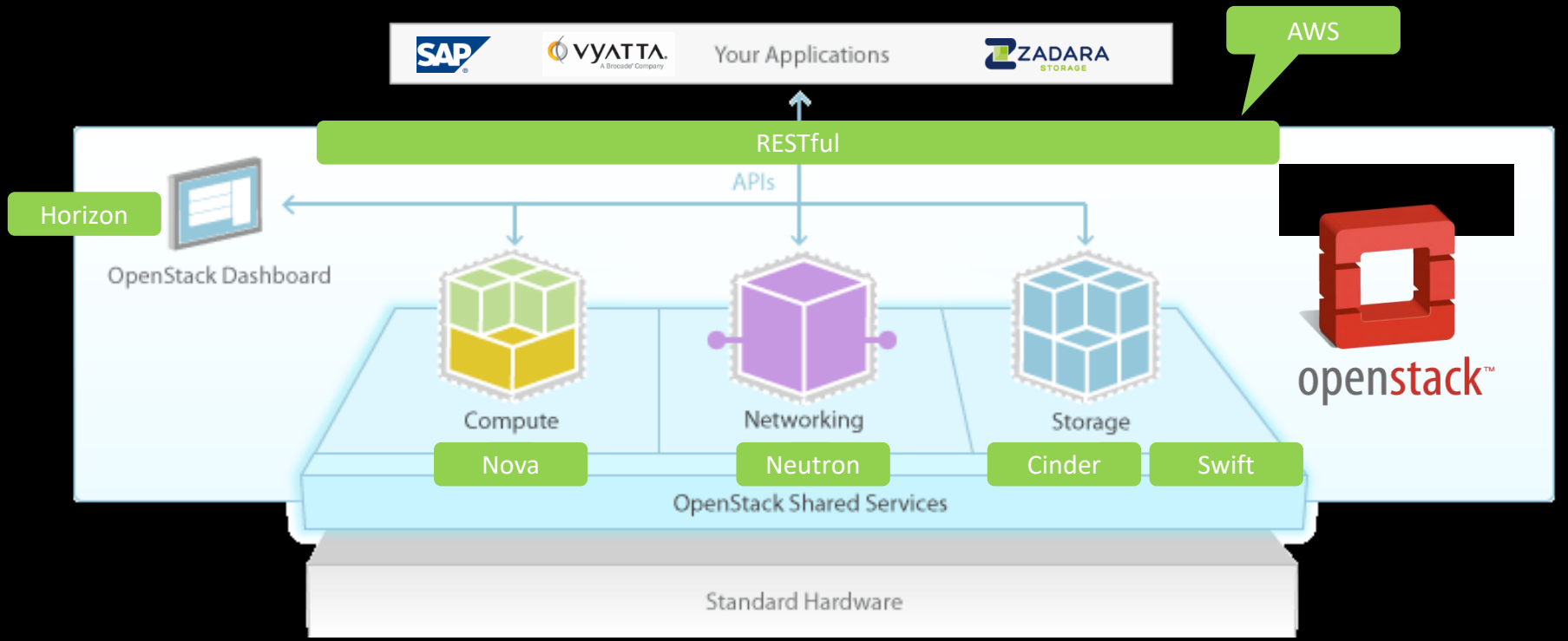
High bandwidth, low-latency networks

SW and HW vision, hearing, language, etc., receptors

SW and HW vision, hearing, language, etc., transmitters

Source: National Geographic, The New Science of the Brain

SW Instrumentation: Open APIs Up in Cloud Platforms



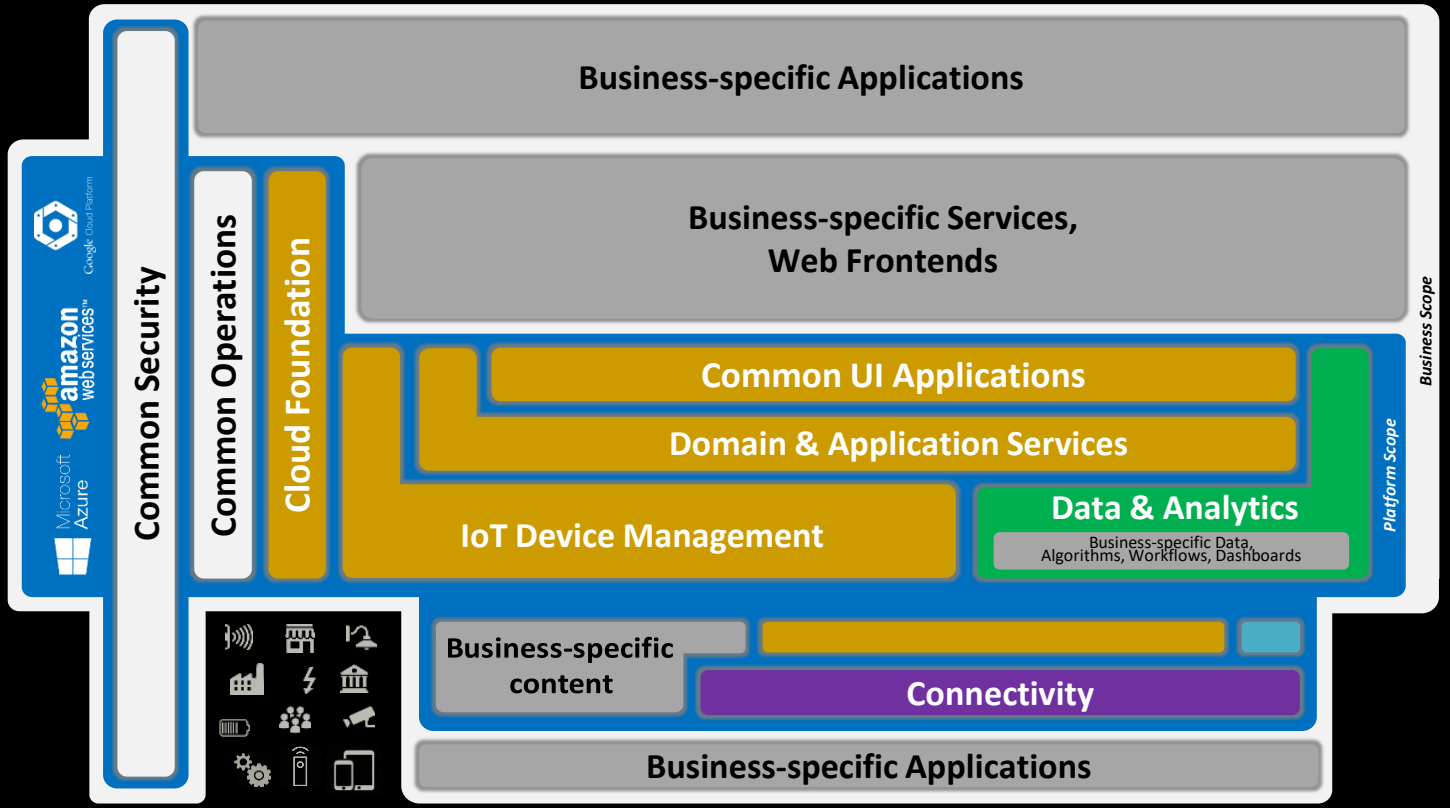
SW Instrumentation: Open APIs Down to Light Bulbs

***Apps** - Mobile apps, web apps, desktop apps for cloud-connected experiences*

***Services** - Cloud-based software services, application back-ends*

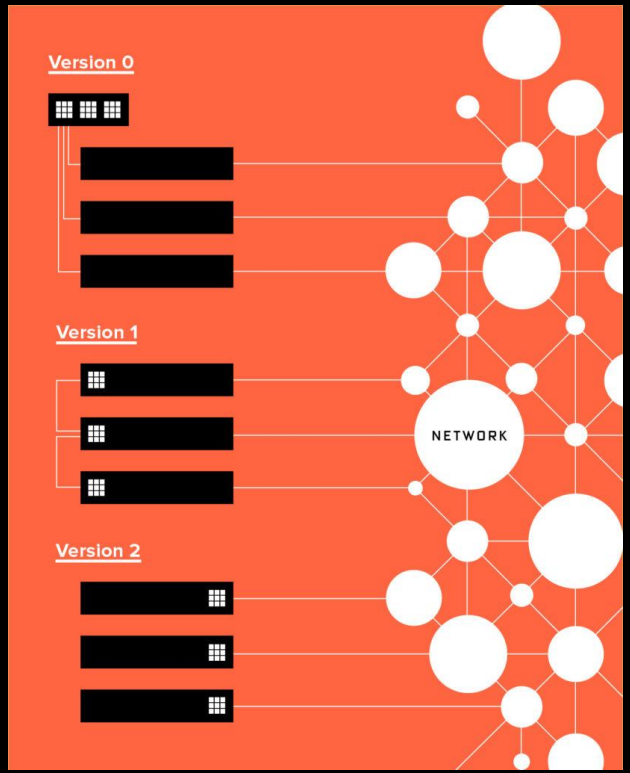
***Field Devices** - Gateways, building servers, bridges, 'modules'*

***Apps** - mobile apps for control, commissioning, offline (non-cloud) connected*



HW Instrumentation: Networking

Microsoft Project Catapult



Appliance

Server CPU

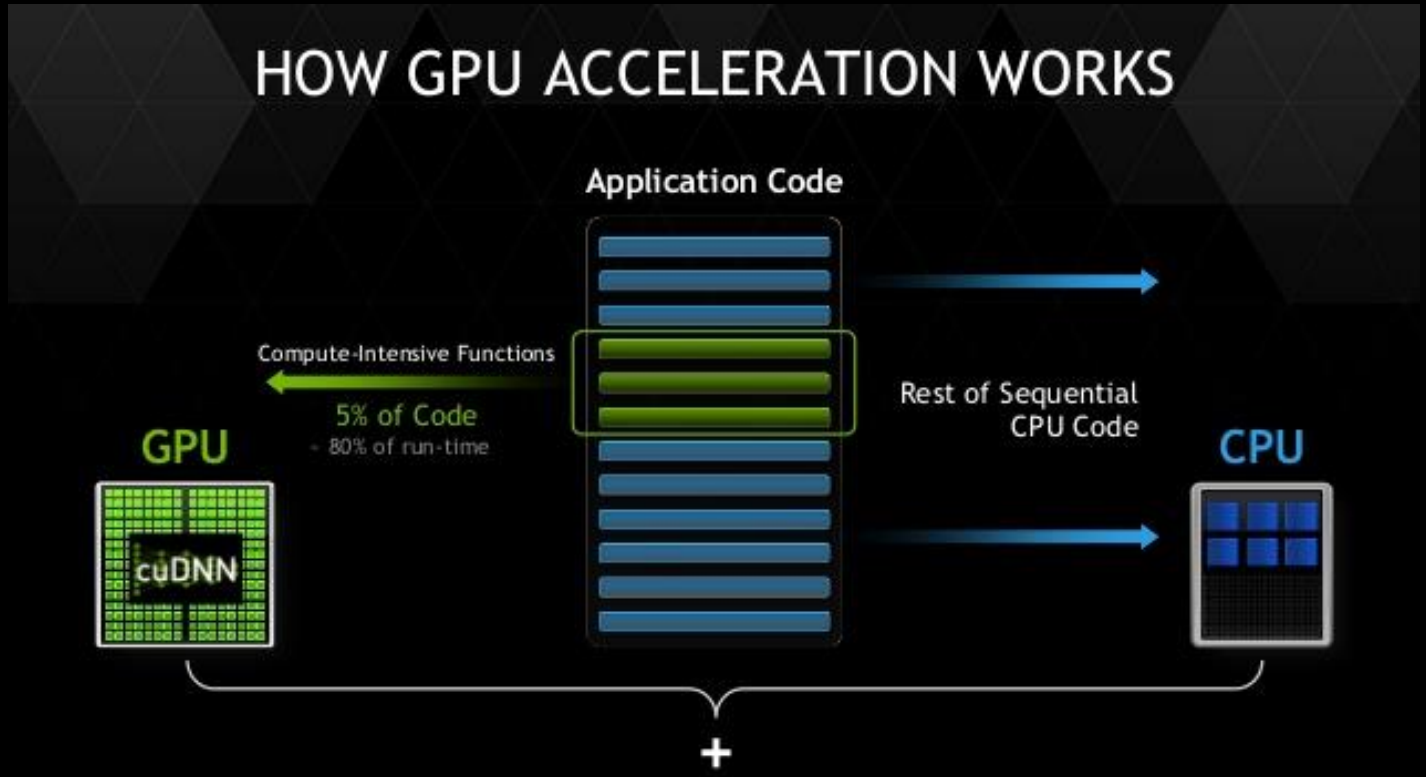
FPGA (NIC)

FPGAs generate and consume their own networking packets independent of the hosts,

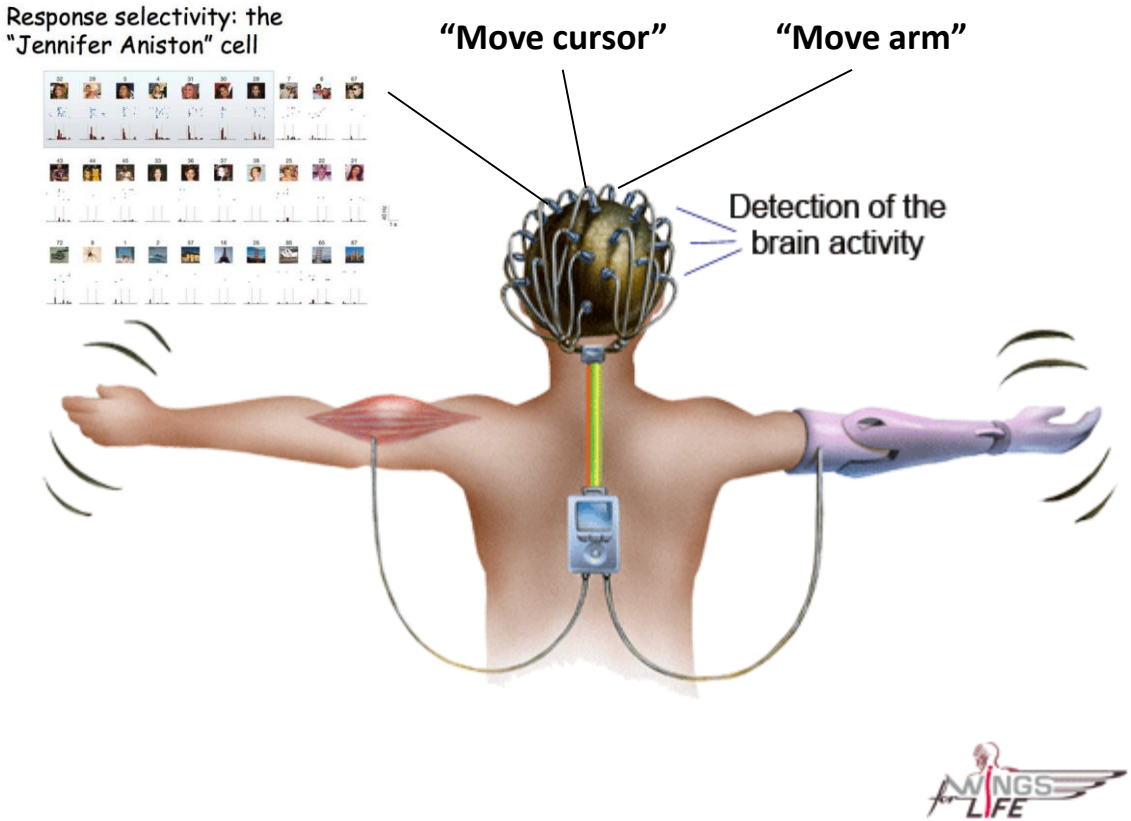
Every FPGA in the datacenter can reach every other one (at a scale of hundreds of thousands) in a small number of microseconds, without any intervening software.

FPGA resources are an independent computer in the datacenter, at the same scale as the servers, that physically shares the network wires with software.

HW Instrumentation: Graphics Processing

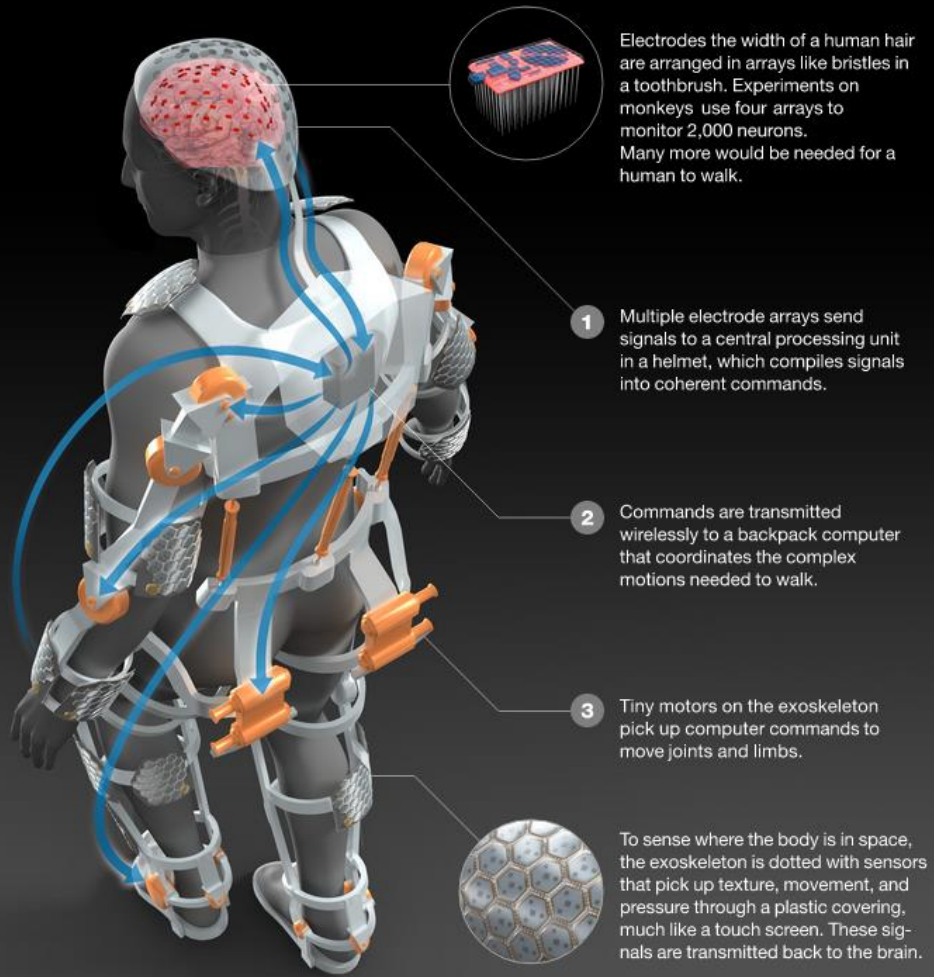


Brain-Computer Interface (BCI)



Bionic Brain

“People with spinal cord injuries can’t move because the brain and body no longer communicate. Scientists hope to restore motion with a mechanical skeleton controlled by the wearer’s thoughts. It’s a daunting challenge: Hundreds of sensors must be implanted in the brain to send commands to the exoskeleton. Signals must also travel in reverse, from touch sensors telling the brain where the body is in space.”



Avatar Project Milestones

Avatar **D** 2040- 2045

A hologram-like avatar

Avatar **C** 2030- 2035

An avatar with an artificial brain in which a human personality is transferred at the end of one's life

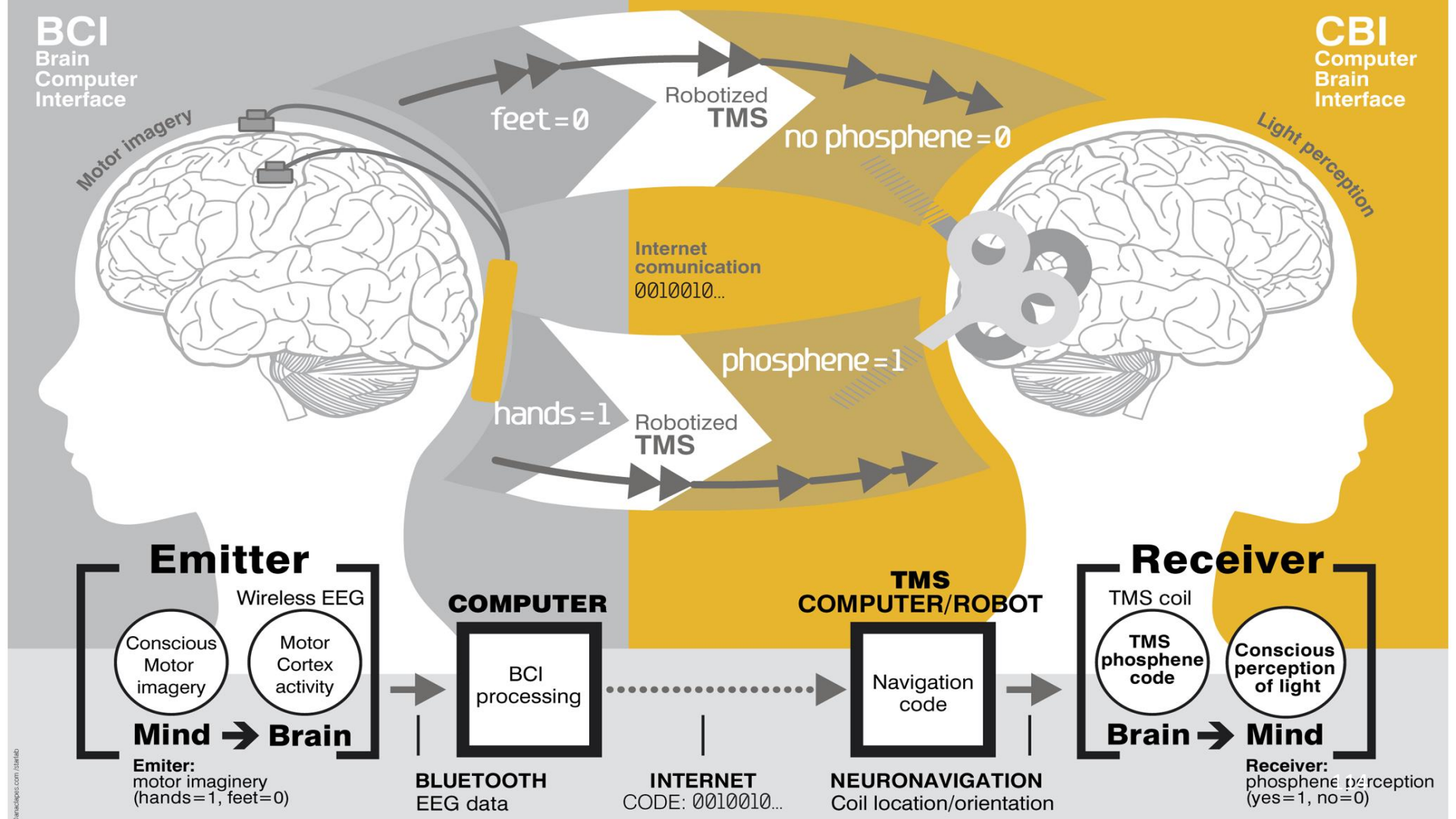
Avatar **B** 2020- 2025

An avatar in which a human brain in transplanted at the end of one's life

Avatar **A** 2010- 2020

A robotic copy of a human body remotely controlled via BCI

Brain to Brain Interface (B2B)


BCI
Brain
Computer
Interface
Motor imagery
feet=0
Robotized
TMS
no phosphene=0
CBI
Computer
Brain
Interface
Light perception
Internet
comunication
0010010...
phosphene=1
hands=1
Robotized
TMS
Emitter
Wireless EEG
Conscious
Motor
imagery
Motor
Cortex
activity
Mind → Brain
Emiter:
motor imaginery
(hands=1, feet=0)
COMPUTER
BCI
processing
BLUETOOTH
EEG data
TMS
COMPUTER/ROBOT
Navigation
code
INTERNET
CODE: 0010010...
NEURONAVIGATION
Coil location/orientation
Receiver
TMS coil
TMS
phosphene
code
Conscious
perception
of light
Brain → Mind
Receiver:
phosphene perception
(yes=1, no=0)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Can we do that?
Yes
Absolutely
$$
No
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Thank-You

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