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Android Enterprise Security Paper

Updated April, 2021

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Introduction

Android uses industry-leading security practices and works closely with the entire ecosystem to help keep our users' devices safe. Our robust, defense-in-depth approach to security is critical to support enterprises that must contend with ongoing threats. Organizations require strong security and privacy to protect their own data while also giving employees the flexibility to use mobile devices for essential tasks.

This security paper outlines the Android approach to mobile security and privacy for business and government customers, details the strengths of the Android platform, the range of management APIs available to control enterprise environments, and the role of Google security services, such as SafetyNet, in preventing threats and abuse.

Android offers a defense-in-depth security strategy with unique ways to keep data and devices safe. Beyond hardware and operating system protections, Android uses multi-profile support with device-management options that enable the separation of work and personal data, keeping company and personal data secure and isolated from each other. Google Play Protect offers built-in malware protection, identifying Potentially Harmful Applications (PHAs) and is continually working to keep data and devices safe.

This paper also details how the open source Android platform enables best-in-class enterprise security by leveraging the collective intelligence of the Android ecosystem. This information assists organizations in their decisions to implement Android and take advantage of its robust security tools.

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What's New in Android 11

Work Profile on Company-Owned Devices

Enterprise customers must ensure their fleet of devices meet high levels of security. They must also account for the expectation of personal privacy by employees when deploying a device, as noted in our blog on user privacy. Customers can deploy devices that are fully managed and combined with a work profile to separate personal and work data on a single device.

Since its debut in Android 5, the work profile has separated work and personal apps, giving IT full control over work apps and data, but with no visibility into or control over personal apps. We introduced work profile support for corporate-owned, personally enabled (COPE) devices in Android 8, giving admins complete control over the device to include deep visibility into the personal use. In Android 11, organizations can utilize the strong security and privacy protections on company-owned devices as well, in addition to new asset management and personal usage policies to keep company assets in compliance with corporate policy while helping protect personal privacy.

Beginning in Android 11, organizations can achieve three key outcomes of a successful COPE deployment:

- Protections for corporate data with strong device security
- Measures to help preserve employee privacy
- Enforce asset compliance with corporate policy.

This is possible because the work profile provides strong anti-exploitation and data loss controls on any device, regardless of who owns it, as well as the tools to identify a compromised device and protect against malware. Therefore, IT doesn't need full device visibility to protect corporate data and company assets; instead they can focus on protecting work data while respecting the privacy of personal data owned by users.

The security of the work profile is built on top of multiple layers of security found in all Android devices.

- First, Android uses a security model called sandboxing that includes isolation and containment of data, processes, and applications. The goal of sandboxing is to keep an application's data isolated from other apps, and prevent access from outside of the sandbox by other applications and processes.

- Second, key OS platform technology secures user and work data, such as FIPS 140-2 validated encryption. OS level data-at-rest protection further extends the separation of personal and work data on the file system.
- Google security services like Google Play Protect and SafetyNet attestation are added to protect against malware and device compromise which could introduce means for data exfiltration.
- Lastly, a secure management framework that enables enterprise grade controls over critical business data is built into every Android device running Google Mobile Services (GMS). This ensures that all original equipment manufacturers (OEMs) support modern management with Android Enterprise.

Work Profile Privacy Model

Regardless of who owns the device, the work profile provides consistent and industry-leading protections for company data. The principles of data separation described above ensure corporate data remains secure. Fundamental security and compliance features available to any work profile device includes preventing sideloading of apps, ensuring Google Play Protect is enabled, blocking device access over USB, and provides strong device security without the need for visibility into personal data.

Android 11 extends this model with improved work profile support for company-owned devices. If a work profile is added from the setup wizard using the provisioning tools added in Android 11, the device is recognized as company-owned and a wider range of asset management and device level controls are made available to the device policy controller (DPC). These capabilities enable easier management of both work and personal use on company-owned devices, while maintaining the privacy protections of the work profile.

Measures to help protect and preserve a user's privacy do not impact a device's overall security, but rather prevents an admin from viewing a user's potentially sensitive personal information such as personal apps.

Preserving privacy without compromising security

Common IT practice	Privacy concern	Work profile solution
Listing all applications on a device to audit for malicious or risky personal apps	Reveals private, personal apps and data	Only view work apps; Restrict personal apps to just Google Play-verified apps; Implement allow or block lists of personal apps on company-owned devices
Prevent a factory reset to maintain ownership of devices	Prevents users from removing personal info	Configure Factory Reset Protection to ensure only IT can set up device after reset
Configure always on VPN	Reveals personal browsing history	Set VPN to just work apps

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Work Profile Security Model

The work profile takes advantage of sandboxing components within Android to ensure a secure and protected separation between work and personal apps on the same device. Enforcing policy is done via a DPC application installed in the work profile and controlled by an EMM service. Device level security controls are also managed by the DPC from within the work profile. The separation of data on the personal profile from enterprise data on a single device leverages the Android multi-user framework. Separate “users" combined with application permissions & SELinux Mandatory Access Control (MAC) rules enforce strong data separation, much like how apps and processes are sandboxed. File-based encryption (FBE) is mandatory on new devices running Android 10 or later, and enhances data-at-rest separation with different encryption keys for each profile. Because of containment at every layer, isolation is extended from each profile down to the kernel, thus providing strict separation between profiles that have stronger data loss prevention (DLP) controls versus traditional containerization or mobile application management (MAM) solutions.

Android devices are built on a proven concept of fine-grained isolation and containment – sandboxing many parts of the platform combined with granular application permissions. These techniques are found in hardware, the OS, the kernel, and user applications to protect access and confine exploitation to a single process or app. The work profile is built with all of these principles and extended with a management layer for enterprise customers to control data separation while still protecting the entire device and helping preserve user privacy. Reduced visibility for admins does not reduce the security of a device, as the tools to protect a device are still present. Configuring the policies properly in an EMM and using signals from Google security services on Android devices provides strong integrity and malware detection. Combined with the many data loss prevention (DLP) controls and strong separation, admins can be assured full device security on devices deployed with a COPE model on Android 11, referred to as a work profile on company-owned devices.

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Privacy Changes

Following is a summary of the key changes related to privacy in Android 11.

Privacy change	What it is	Customer value
Scoped storage enforcement Apps that target Android 11 or higher are always subject to scoped storage behaviors.	Modification of the Files and Media (Storage) permission to allow only ***read access*** to photos, video and audio files in shared storage. Apps have unrestricted access to files in their own internal and external app specific directories. Apps can create files in shared storage without permission, but only in ***organized collections***. Apps can no longer access files in ***any*** other app's dedicated, app-specific directories by any method. Apps must use the Storage Access Framework to access non-media files created by other apps in shared storage or to create files outside of an organized collection. On Android 11, apps can use APIs that identify media files by file path in addition to Media Store APIs. Android 11 introduces a new permission All Files Access for broad access to shared storage. This is only granted to apps that can justify need and is enforced with Google Play policy. Scoped storage was introduced in Android 10 with an opt-out flag available. The opt-out flag is not functional in Android 11.	Stronger privacy and protection for user files. Prevents malicious apps from modifying or deleting files without user permission. Prevents apps from reading other apps' cache and data directories. Reduces file clutter on the device.
One-time permissions Users can grant temporary access to location, microphone, and camera permissions.	When apps request a permission related to location, microphone, or camera, users can opt for "Only this time." This option grants a temporary one-time permission for the app.	Limits an app's ability to access sensitive data each time users launch an app.

Privacy change	What it is	Customer value
Permissions auto-reset If users haven't interacted with an app for a few months on Android 11 or higher, the system auto-resets the app's sensitive permissions.	The system protects user data by automatically resetting sensitive runtime permissions if the app is not used for a few months.	Automatic denial of sensitive permissions to protect users privacy and company data.
Background location access Android 11 changes how users can grant the background location permission to apps.	The system enforces incremental location permission requests automatically requiring apps to request and receive access to foreground location before requesting access to background location. App requests for a foreground location and background location at the same time are ignored and neither permission is granted.	Offers users more control over when an app can access location information in the background to deliver enhanced privacy.
Package visibility Android 11 changes how apps query and interact with other installed apps on the same device	Apps can define the set of other packages that they can access. This helps encourage the principle of least privilege by telling the system which other packages to make visible to your app.	Helps Google Play assess the privacy and security that your app provides for users. Provides developers the ability to prevent enumeration or listings of their apps.
Foreground services Android 11 changes how foreground services can access location, camera, and microphone data.	When an app starts a foreground service while running in the background, the foreground service cannot access the microphone or camera. The service cannot access location unless your app has background location access.	Helps protect sensitive user and customer data
MAC Address	Non-privileged apps will no longer be able to access the device's real MAC address and only network interfaces with an IP address will be visible.	Provides privacy and security on networks.

Storage Changes

Android 11 (API level 30) gives better protection to app and user data preventing file clutter by enforcing scoped storage. Scoped storage gives users more control over their files by encouraging apps to save files in organized collections and limiting the reach of the Files and Media (Storage) permission. Android 11 introduces several enhancements to scoped storage including raw file path access for media, batch edit operations for media, and a new policy enforced permission for file management apps. In Android 11, app data is secured further by not granting any way for an app to read another app's private external directory.

Permissions Model

Android 11 gives users the ability to control and specify more granular permissions for location, microphone, and camera. To protect users, the system will reset permissions of unused apps automatically and require users to re-approve permissions when the app is used again.

When an app requests a permission related to location, microphone, or camera, the user-facing permissions dialog contains an option called **Only this time**. If the user selects this option, the app is granted a temporary *one-time permission*. If the app targets Android 11 or higher and isn't used for a few months, the system protects user data by automatically resetting the sensitive runtime permissions that the user had previously granted to the app. This action has the same effect as if the user viewed a permission in system settings and changed the app's access level to **Deny**.

When users tap **Deny** for a specific permission of an app more than once during the app's lifetime of installation, the user will no longer be prompted if the app requests that permission again. The user's denial of the permission two times is treated as **"don't ask again."** On previous Android versions, users would see the system permissions dialog each time the app requested a permission, unless the user had previously selected a **"don't ask again"** checkbox or option specifically. This new behavior in Android 11 prevents repeated requests for permissions that users have chosen to deny.

Location Access

On Android 11, whenever an app requests access to foreground location, the system permissions dialog includes an option called **“Only this time,”** as shown in figure 1. This option provides users with more control over when an app can access location information.

To learn more about how the system handles this, please visit one-time permissions.

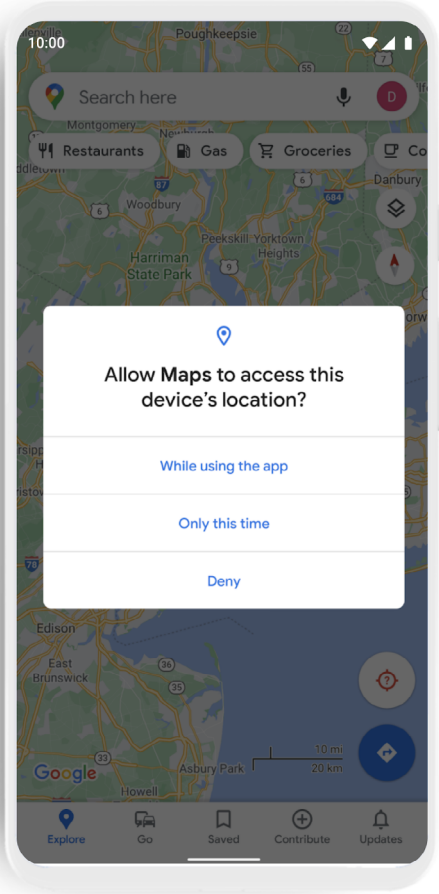

Figure 1. App permissions options.

Background Location Access

Android 11 changes how an app can gain access to background location. Apps must first request and receive access to foreground location before requesting background location. In order to enable background location access for an app, the user must set the **Allow all the time** option in Location Settings when prompted by the app. If an app requests a foreground location permission and the background location permission at the same time, the system ignores the request and doesn't grant the app either permission.

Package Visibility

Android 11 changes how apps can query and interact with other apps that the user has installed on a device. Apps can now define a set of other packages that they can access. This element helps encourage the principle of least privilege by telling the system which other packages to make visible to your app, and it helps Google Play assess the privacy and security that your app provides for users.

MAC Addresses in Android 11

MAC address randomization for Passpoint networks is per fully-qualified domain names (FQDNs). Non-privileged apps will no longer be able to access the device's MAC address and only network interfaces with an IP address will be visible. The following list is how apps are affected by this change:

- NetworkInterface.getHardwareAddress() returns null for every interface
- Apps cannot use the bind() function on NETLINK_ROUTE sockets
- The IP command does not return information about interfaces
- Apps cannot use RTM_GETLINK netlink API

Biometric Authentication

To help control the level of security for an app's data, Android 11 provides several improvements to biometric authentication that are extended in the Jetpack Biometric library. This improves the ability for an app to use the biometric capabilities built into Android 11, providing a uniform and secure method for apps to use built-in biometric authentication.

APK Signature Scheme v4

Android 11 supports a streaming-compatible signing scheme with the APK Signature Scheme v4. The v4 signature is based on the Merkle hash tree calculated over all bytes of the APK. It follows the structure of the fs-verity hash tree exactly (for example, zero-padding the salt and zero-padding the last block). Android 11 stores the signature in a separate file (<apk name>.apk.idsig) A v4 signature requires a complementary v2 or v3 signature.

Individual Key Attestation Support

Admins of company-owned devices that use a StrongBox security chip can request device attestation using individual attestation certificates. This provides stronger attestation for enterprise use cases (e.g., better detection of compromised devices, asset tracking and management).

Android Enterprise Enhancements

- Users are now notified when an admin:
  - Enables location services on their company-owned device. If the admin sets a global policy to auto-accept all permissions, the user is notified when an app requests, and is granted, location permission because of this policy.
  - Grants an app the permission to use the location of a personally-owned device.
- Pre-grant certificate access to work apps: DPCs targeting Android 11 now have the option to grant individual apps access to specific KeyChain keys**, allowing these apps to call** getCertificateChain() **and** getPrivateKey() **without having to first call** choosePrivateKeyAlias()**. For example, VPN apps that run as a background service can use this feature to gain access to the certificates they need without requiring any user interaction. A ne**w method is also available to revoke access.
  Note: Apps installed on unmanaged devices or in a device's personal profile can no longer install CA certificates using createInstallIntent(). Instead, users must manually install CA certificates in **Settings**.
- All methods related to setting password minimums require an appropriate password quality before they can be enforced.
  - setPasswordMinimumLength() requires at least: PASSWORD_ QUALITY_NUMERIC.
  - All other password minimum methods require at least: PASSWORD_ QUALITY_COMPLEX.
- Always-on VPN enhancements: Users can no longer disable always-on VPN when it is configured by an admin.
- Updates to ADMIN_POLICY_COMPLIANCE:
  - When provisioning an Android 11 device, the system now sends ADMIN_POLICY_ COMPLIANCE before setting DEVICE_PROVISIONED to true.
  - ADMIN_POLICY_COMPLIANCE can also be optionally used when adding a Google Account to provision a device. In the 2021 Android 12 release, it will be required for this provisioning method.

- New APIs are also available to:
  - Check and set whether auto time is enabled on a device. If enabled, the time is automatically obtained from the network. Replaces setAutoTimeRequired() and getAutoTimeRequired() (see Deprecations for more information).
  - Check and set whether the auto time zone is enabled on a device. If enabled, the time zone is automatically obtained from the network.
  - Check and set the factory reset protection (FRP) policy on a company -owned device.
  - Check and set whether a user can change admin-configured network settings on a company-owned device.
  - Check and set the protected packages on a fully managed device. Users can't clear app data or force-stop protected packages.

Common Criteria Mode

This mode addresses Common Criteria Mobile Device Fundamentals Protection Profile (MDFPP) specific requirements. Admins of company-owned devices can now enable Common Criteria Mode (and check if it's enabled) on a device. When enabled, Common Criteria Mode enables AES-GCM encryption of Bluetooth Long Term Keys and Wi-Fi configuration stores.

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About the Android Operating System

Android is an open source software stack created for a wide array of devices with different form factors. Android incorporates industry-leading security features and the Android team works with developers and device OEMs to keep the Android platform and ecosystem safe. A robust security model is essential to enable a vigorous ecosystem of apps and devices built on and around the Android platform and supported by cloud services. As a result, through its entire≈development lifecycle, Android has been subject to a rigorous security program.

The foundation of the Android platform is the Linux kernel. The Linux kernel has been in widespread use for years, and is used in millions of security-sensitive environments. Through its history of constantly being researched, attacked, and fixed by thousands of developers, Linux has become a stable and secure kernel trusted by many corporations and security professionals. Devices launching with Android 11 are now required to use the latest long-term support (LTS) kernel that is regularly maintained upstream with security updates & bug fixes.

Applications running on Android are signed and isolated into application sandboxes associated with their application signature. The application sandbox defines the privileges available to the application. Apps are generally built to execute in the Android Runtime and interact with the operating system through a framework that describes system services, platform APIs, and message formats. A variety of high-level and lower-level languages, such as Java, Kotlin, and C/C++, are allowed and operate within the same application sandbox.

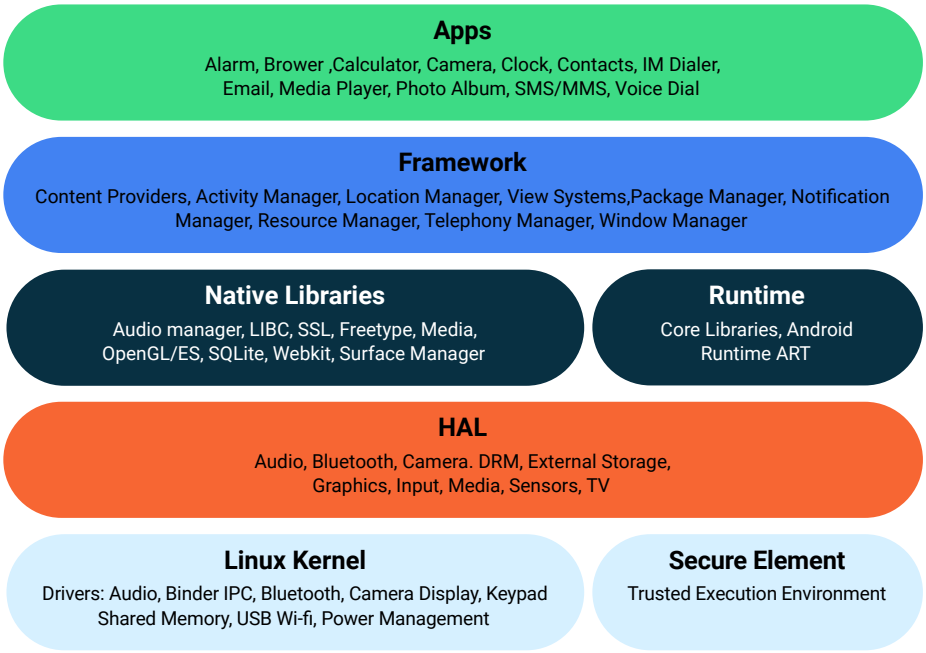


Figure 2. The Android software stack

Security by Design

Android uses hardware and software protections to achieve strong defenses. Security starts at the hardware level, where the user is authenticated with lock screen credentials. Verified Boot ensures the system software has not been tampered with, and hardware-assisted encryption and key handling help protect data in transit and at rest.

At the software layer, built-in protection is essential to helping Android devices stay safe. Google Play Protect is the world's most widely-deployed threat detection service, actively scanning over 100 billion apps on devices every day to monitor for harmful behavior. Google Play Protect scans all applications including public apps from Google Play, system apps updated by OEMs and carriers, and sideloaded apps.

Application sandboxing isolates and guards Android apps, preventing malicious apps from accessing private information. Android also protects access to internal operating system components, to help prevent vulnerabilities from becoming exploitable. Mandatory, always-on encryption helps keep data safe, even if devices fall into the wrong hands. Encryption is protected with Keystore keys, which store cryptographic keys in a container, making it more difficult to extract from a device. Developers can leverage the Android KeyStore with Jetpack Security safely and easily. Adiantum provides encryption capabilities for lower-powered devices that do not have Advanced Encryption Standard (AES) instructions as part of the CPU, potentially allowing businesses to use lower cost devices without forfeiting cryptographic security. In total, Android leverages hardware and software to keep devices safe.

Android Compatibility

The Android compatibility program consists of three key components. The Compatibility Definition Document (CDD) provides guidelines that cover many areas of security to include hardware and software:

- The Android Open Source Project source code
- The Compatibility Definition Document, representing the “policy” aspect of compatibility
- The Compatibility Test Suite (CTS), representing the “mechanism” of compatibility

To build an Android-compatible mobile device, follow this three-step process:

1. Obtain the Android software source code. This is the source code for the Android platform that you port to your hardware.
2. Comply with the Android Compatibility Definition Document (PDF, HTML). The CDD enumerates the software and hardware requirements of a compatible Android device.
3. Pass the Compatibility Test Suite. Use the CTS as an ongoing aid to evaluate compatibility during the development process.

After complying with the CDD and passing the CTS, your device is Android compatible, meaning Android apps in the ecosystem provide a consistent experience when running on your device. It also helps to ensure that device manufacturers have complied with mandated security requirements.

After building an Android compatible device, device manufacturers can apply for a Google Mobile Services (GMS) license. GMS is required to manage Android devices using Android Enterprise and also adds all of the Google security services to include SafetyNet, Google Play Protect, and SafeBrowsing. Google applications (Google Play, YouTube, Google Maps, Gmail, and more) and APIs help support functionality across devices. GMS is not part of the Android Open Source Project (AOSP) and is available only through a license with Google. For information on how to request a GMS license, see our Contact/Community page.

Hardware-backed Security

Android supports several hardware features that enable strong device security.

Verified Boot

Verified Boot cryptographically ensures that system code and data comes from a trusted source (e.g. device OEMs). It establishes a full chain of trust, starting from a hardware-protected root of trust to the bootloader, to the boot partition and other verified partitions including system, vendor, and optionally OEM partitions. During device boot up, each stage verifies the integrity and authenticity of the next stage before handing over execution.

In addition to ensuring that devices are running a safe version of Android, Verified Boot checks for the correct version of Android with rollback protection. Rollback protection helps to prevent a possible exploit from becoming persistent by ensuring devices only update to newer versions of Android. A kernel compromise (or physical attack) cannot install an older, more vulnerable, version of the OS on a system and boot it. Device manufacturers must integrate rollback protection and ensure that a device's state is stored in tamper-evident storage.

Verified Boot works by retrieving a statement signed by the secure hardware attesting to many attributes of Verified Boot along with other information about the state of the device. Enterprise customers can check the state of Verified Boot using KeyStore key attestation, which provides more confidence that the keys used are stored in a device's hardware-backed keystore. KeyStore key attestation is required for device manufacturers to use GMS.

Trusted Execution Environment

The processor provides the Trusted Execution Environment (TEE) - Trustzone on ARM devices. This secondary, isolated environment, the TEE, virtualizes the main processor and creates a secure trusted execution environment. This enables separation from any untrusted code. The capability is typically implemented using secure hardware.

Device makers then use a TEE OS and various TEE apps to provide services that AOSP consumes. The TEE OS runs on the same processor as the Android OS but is isolated from the rest of the system by both hardware and software. The TEE OS has access to the full power of a device's main processor and memory. The isolation protects the TEE OS from malicious apps installed by the user and potential vulnerabilities that may be discovered in Android. An example of a TEE OS is Trusty.

In a TEE implementation, the main processor is often referred to as "untrusted," meaning it cannot access certain areas of RAM, hardware registers, and write-once fuses where secret data (such as, device-specific cryptographic keys) are stored by the manufacturer. Software running on the main processor delegates any operations that require use of secret data to the TEE in the main processor.

The TEE can access device-specific keys required to decrypt protected content. The main processor sees only the encrypted content, providing a high level of security and protection against software-based attacks. There are≈many uses for a TEE such as mobile payments, secure banking, multi-factor authentication, device reset protection, and replay-protected persistent storage. The TEE is responsible for some of the most security-critical operations on the device, including:

1. **Digital Rights Management (DRM**): an extensible framework that lets apps manage rights-protected content according to the license constraints associated with the content.
2. **Lock screen passcode verification**: available on devices that support a secure lock screen. Lock screen verification is provided by the TEE unless an even more secure environment, for example a secure element such as the Titan M, is available.
3. **Fingerprint template matching**: available on devices that have a fingerprint sensor.
4. **Protection and management of KeyStore keys**: available on devices that support a secure lock screen.
5. **Protected Confirmation:** leverages a hardware-protected user interface called Trusted UI to facilitate high assurance to critical transactions. Protected Confirmation is an optional capability for device manufacturers to implement for devices running Android 9.0 and above.

Android Keystore System

The Android Keystore system is a foundation of data protection on devices. It stores cryptographic keys in a container, making it more difficult to extract them from the device. Once keys are in the keystore, they can be used for cryptographic operations with the non-exportable key material remaining. The Keystore restricts when and how keys can be used, such as requiring user authentication for key use or restricting keys to be used only in certain cryptographic modes.

Devices running Android 9 or higher can implement a StrongBox Keymaster, an implementation of the Keymaster HAL that resides in a hardware security module. The module contains its own CPU, secure storage, a true random-number generator and additional mechanisms to resist package tampering and unauthorized sideloading of apps. When checking keys stored in the StrongBox Keymaster, the system corroborates a key's integrity with the Trusted Execution Environment (TEE). For Android 11 devices that use a StrongBox security chip, admins of company-owned devices can request device attestation using individual attestation certificates.

Keystore supports symmetric cryptographic primitives such as AES (Advanced Encryption Standard), HMAC (Keyed-Hash Message Authentication Code), and asymmetric cryptographic algorithms. Access controls are specified during key generation and enforced for the lifetime of the key. Keys can be restricted to be usable only after the user has authenticated, and only for specified purposes or with specified cryptographic parameters.

For devices that support a secure lock screen, KeyStore must be implemented in secure hardware. Enterprise customers are provided strong assurances that even in the event of a kernel compromise, KeyStore keys are not extractable from the secure hardware, thus protecting encrypted business data.

KeyStore Key Attestation

Compatible devices support Key Attestation which empowers a server to gain assurance about the properties of keys used on a device. On devices that ship with hardware-level key attestation and Google Play services, the root certificate is signed with a Google attestation root key. The secure hardware on such devices can sign statements with the provisioned key, which attests to properties of keys protected by the secure hardware, such as the fact that the key was generated and can't leave the secure hardware. Key Attestation better secures the location of important properties about the device, such as the OS version, patch level, and whether it passed Verified Boot.

Enterprise customers can perform a device ID attestation, which ensures only known devices are enrolled into the enterprise. This helps customers ensure their fleet of devices remain compromise free.

Learn more about verifying hardware-backed keys with Key Attestation.

KeyChain

The KeyChain class provides access to private keys and their corresponding certificate chains in credential storage. KeyChain is often used by Chrome, Virtual Private Networks (VPNs), and enterprise apps to access keys imported by the user or by the EMM DPC deployed on managed devices.

Whereas the KeyStore is for non-shareable app-specific keys, KeyChain is for keys that are meant to be shared with a user and in a work profile. For example, an EMM DPC can import a key that Chrome will use to access an enterprise website.

Android 10 and higher makes use of several improvements in the KeyChain API. When an app calls KeyChain.choosePrivateKeyAlias, devices now filter the list of certificates a user can choose from based on the issuers and key algorithms specified in the call. KeyChain no longer requires a device to have a screen lock before keys or Certificate Authority (CA) certificates can be imported.

A benefit for Enterprise customers with Android 11 is that TLS client certificates can have their keys generated via secure hardware. This method is useful for creating a key in KeyChain that never leaves the secure hardware.

Key Decryption on Unlocked Devices

Android 9.0 and higher take advantage of the unlockedDeviceRequired flag. This option determines whether the Keystore requires the screen to be unlocked before allowing usage of a specified key. These types of keys are well suited for encrypting sensitive data stored on disk, such as health and enterprise data. The flag provides users a higher assurance that the data cannot be decrypted while the device is locked should their phone be lost or stolen.

Version Binding

In Keymaster 2, 3, and 4, all keys are also bound to the operating system and patch level of the system image. This ensures that an attacker who discovers a weakness in an old version of the Android system or TEE software cannot roll a device back to a vulnerable version and use keys created with the newer version. When a key with a given version and patch level is used on a device that has been upgraded to a newer version or patch level, the key is upgraded before it can be used, and the previous version of the key is invalidated. In this way, as the device is upgraded, the keys will "ratchet" forward along with the device, but any reversion of the device to a previous release will cause the keys to be unusable. Version binding provides enterprise customers assurances that lost or stolen devices cannot use newer System signing keys with older versions of Android.

Tamper-Resistant Hardware Support

Tamper-resistant hardware is used to verify the lock screen passcode. If verification succeeds, the tamper-resistant hardware returns a high entropy secret that can be used to derive the disk encryption key.

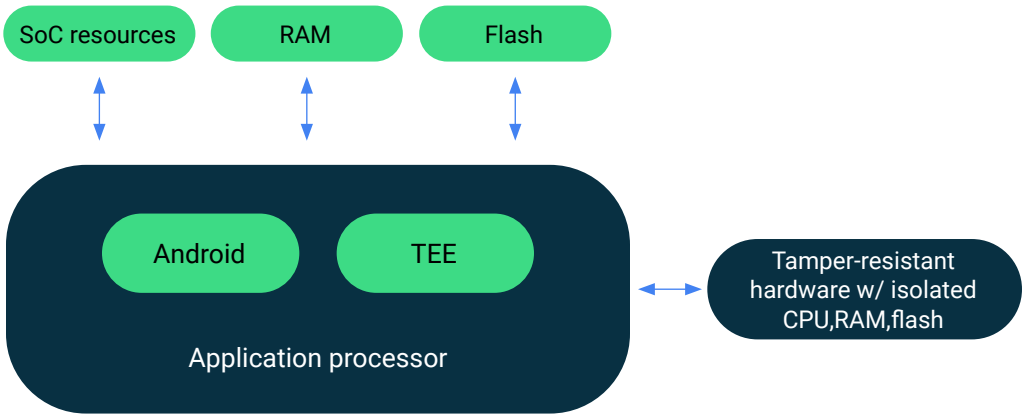


Figure 3. Security hardware provides numerous protections on the device.

Gatekeeper

Android supports Gatekeeper for PIN/pattern/password authentication. The Gatekeeper subsystem performs this authentication in the TEE, enrolling and verifying passwords via a Hash-Based Message Authentication Code (HMAC) with a hardware-backed secret key. On supported devices, PIN/pattern/password authentication is further hardened with Weaver, a system for communicating between codebases compiled independently and is intended for inter-process communication. This is executed inside discrete tamper-resistant hardware (Secure Element).

Biometrics

Android implements a tiered authentication model which is a conceptual classification of all the different authentication methods on Android, how they relate to each other, and how they are constrained based on this classification. The Android Compatibility Definition Document specifies the implementation requirements for biometric security.

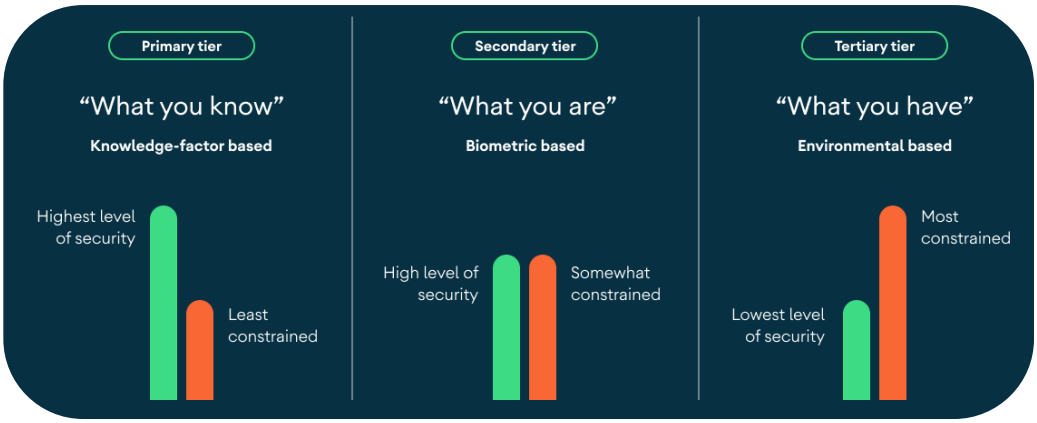


Figure 4. Biometric tiers

Authentication methods are classified into three buckets of decreasing levels of security and commensurately increasing constraints. The primary tier is the least constrained in the sense that users only need to re-enter a primary modality under certain situations (for example, after each boot or every 72 hours) in order to use its capability. The secondary and tertiary tiers are more constrained because they cannot be set up and used without having a primary modality enrolled first and they have more constraints further restricting their capabilities.

Devices can use biometric authentication to safeguard private information and essential corporate data accessible through devices used in an enterprise setting. The BiometricPrompt API is accessible to developers for integrating biometric authentication into their apps.

The Android framework includes face and fingerprint biometric authentication. Android can be customized to support other forms of biometric authentication, such as Iris scans. To participate in the BiometricPrompt class, biometric implementations must meet security specifications for

Class 2 or 3 as required in the Compatibility Definition Document (CDD). Only Class 3 biometrics allow third-party applications to access KeyStore keys.

Biometric-based unlock modalities are typically evaluated on the basis of a False Accept Rate (FAR). Android uses two additional metrics to help device manufacturers evaluate their security: the Imposter Accept Rate (IAR) and Spoof Accept Rate (SAR).

Additionally, Android device manufacturers can access recommendations of system security best practices for using biometric authentication. Biometric sensors are classified based on their spoof and imposter acceptance rates and on the security of the biometric pipeline. Test methodology is available to assist in measuring the implementation of these unlock methods and GMS devices must follow specific biometric security test protocols.

In Android 9 and above, the BiometricPrompt API system provides biometric authentication dialogs to be used on behalf of an application. This creates a consistent look, feel, and placement for the dialog, and gives users a greater confidence they're authenticating with biometrics using a trusted credential tracker. To help control the level of security for an app's data, Android 11 provides several improvements to biometric authentication that are extended in the Jetpack Biometric library. This improves the ability for an app to use the Biometric capabilities built into Android 11.

This API is used in conjunction with the Android Keystore system. Protecting biometric data is accomplished through a hardware security module in the form of Strongbox Keymaster, which securely stores and handles cryptographic keys on a device.

Fingerprint Authentication

On devices with a fingerprint sensor, users can enroll one or more fingerprints and use those fingerprints to unlock the device and perform other tasks. Android uses the Fingerprint Hardware Interface Definition Language (HIDL) to connect to a vendor-specific library and fingerprint hardware, such as a fingerprint sensor.

Face Authentication

Face authentication allows users to unlock their device simply by looking at the front of their device. Android 10 and above support the face authentication stack that can securely process camera frames, preserving security and privacy during face authentication on supported hardware. Android 10 and above also provides a method for security compliant implementations to enable application integration for transactions, such as online banking or other services.

Additional Authentication Methods

Android supports the Trust Agent Framework to unlock the device. Google Smart Lock uses that framework to allow a device to remain unlocked as long as it stays with the user, as determined by certain user presence or other signals.

However, Smart Lock does not meet the same level of assurance as other unlock methods on Android and is not allowed to unlock auth-bound KeyStore keys. Organizations can disable Trust Agents using the KEYGUARD_DISABLE_TRUST_AGENTS flag in the EMM policies.

Protected Confirmation

Android Protected Confirmation leverages a hardware protected user interface (Trusted UI) to perform critical transactions outside the operating system in devices that run Android 9 or above. This protects operations from fraudulent apps or a compromised operating system When an app invokes Protected Confirmation, control is passed to the Trusted UI, where transaction data is displayed and user confirmation of the data's correctness is obtained.

Once confirmed, the intention is cryptographically authenticated and tamper-proof when conveyed to the relying party. In total, the transaction has higher protection and security relative to other forms of secondary authentication.

Several use cases exist for Android Protected Confirmation, such as person to person money transfers, user authentication, or other innovations such as confirming correct insulin pump injections.

android

Operating System Security

Android utilizes a “defense in depth” approach to help keep the operating system secure. With each version of Android, the operating system is further hardened to have the right defenses for the ongoing threats that enterprises face.

Sandboxing

Enforcement of Android’s security model starts with sandboxing of applications and processes. Hardware components like a TEE help isolate sensitive processes and data like cryptographic operations and key storage. Process isolation provides the foundation for sandboxing of userspace processes and SELinux provides the primary enforcement mechanism.

- **Kernel Sandboxing** enforces restrictions on what actions the kernel may take and limits userspace access to kernel entry points such as device drivers.
- **System Process Sandboxing** applies sandboxing to all processes such as the media frameworks, telephony stack, WiFi services, and Bluetooth components.
- **Application Sandboxing** uses SELinux and a unique user ID (UID) to isolate apps from each other and the system. This sandbox keeps the application and its data secure.
- **Other areas of separation** include the TEE and userspace components. For example, the Android Keymaster integrates the keystore into the TEE, which guards cryptographic key storage from exposure and tampering. An attacker cannot read key material stored in the Keymaster even if the kernel is fully compromised. Android 9 and above devices with dedicated tamper resistant hardware can store keys in the StrongBox Keymaster. This implementation mitigates against the most sophisticated attacks such as cold boot memory attacks, power analysis, and other invasive attacks that can allow privilege escalation.

SELinux

Android uses Security-Enhanced Linux (SELinux) to enforce mandatory access control (MAC) over all processes, including those with root/superuser privileges. SELinux enables Android to better protect and confine system services, restrict access to app data and system logs, isolate malicious apps, and protect users from potential security vulnerabilities.

SELinux operates on the principle of default denial: Anything not explicitly allowed is denied Android includes SELinux and a corresponding security policy for components in AOSP. Disallowed actions are prevented and all attempted violations are logged via Linux tools: dmesg prints the message buffer of the kernel, and logcat, is a command-line tool that dumps a log of system messages.

With the Android system architecture, SELinux is used to enforce a separation between the Android

framework and the device-specific vendor components such that they run in different processes and communicate with each other via a set of allowed vendor interfaces implemented as Hardware Abstraction Layers (HALs).

Seccomp Filter

In conjunction with SELinux, Android uses Seccomp to further restrict entry points to the kernel by blocking access to system calls that are not explicitly included in an allowlist. Seccomp is a one-way trapdoor - once a process relinquishes certain system calls, it can never gain it back again. Seccomp is applied to processes in the media frameworks and all applications. Apps may optionally provide their own seccomp filter to further reduce the set of allowed system calls.

Unix Permissions

Android uses Linux/Unix permissions to further isolate application resources. Android assigns a unique user ID (UID) to each application and runs each user in a separate process. Apps are not allowed to access each other's files or resources just as different users on Linux are isolated from each other.

Anti-Exploitation

Android enables exploit protection such as Control Flow Integrity and Integer Overflow Sanitization. New compiler-based mitigations have been added to make bugs harder to exploit and prevent certain classes of bugs from becoming vulnerabilities. This expands existing compiler mitigations, which direct the runtime operations to safely abort the processes when undefined behavior occurs.

Android 10 introduced BoundsSanitizer (BoundSan), which adds instrumentation to insert bounds checks around array accesses. These checks are added if the compiler cannot prove at compile time that the access will be safe and if the size of the array will be known at runtime. BoundSan is deployed in Bluetooth, media codecs, and other components throughout the platform.

Unintended integer overflows can cause memory corruption or information disclosure vulnerabilities in variables associated with memory accesses or memory allocations. To combat this, Clang's UndefinedBehaviorSanitizer (UBSan) was added to signed and unsigned integer overflow sanitizers to harden the media framework. In Android 9 and above, the UBSan was expanded to cover more components which improved build system support. This is designed to add checks around arithmetic operations / instructions—which might overflow—to safely abort a process if an overflow does happen. These sanitizers can mitigate an entire class of memory corruption and information disclosure vulnerabilities where the root cause is an integer overflow, such as the original Stagefright vulnerabilities.

Android 10 and higher employ Scudo, a hardened memory allocator which employs multiple defense-in-depth strategies to detect and prevent use-after-free, double-free, and bounds-violations. This provides additional hardening of the platform and prevents memory unsafe errors from becoming exploits.

android

User and Data Privacy

Protecting user privacy is fundamental to Android. In Android 9.0 and higher, limiting background apps' access to device sensors, restricting information retrieved from Wi-Fi scans, implementing new permission groups related to phone calls, and phone states help ensure more user privacy. These changes affect all apps running on Android 9.0 and above, regardless of target SDK version or version of Android.

Android 10 extended the privacy and controls that users have over data and app capabilities. In total, they provide users and IT administrators with better clarity about how data and user location can be accessed.

The work profile creates a separate, self-contained profile on Android devices that isolates corporate data from personal apps and data. This can be added to personal devices in a BYOD setting or on a company-owned device used for both work and personal purposes. With this separate profile, the user's personal apps and data in the personal profile are outside of IT control.

To provide clear visibility to the user, when a work profile is applied to a device, the EMM DPC presents the terms of use and provides information relevant to data collection and visibility. The user must review and accept the user license agreement to set up the work profile. Users can view work profile settings via Settings > Accounts.

Developers are encouraged to ensure their apps are compliant with the latest privacy changes. Android 10 and above places restrictions on accessing data and system identifiers, accessing camera and networking information, and making several changes to the permissions model.

Restricting Access to Device Identifiers

Android provides random MAC addresses when probing new networks when not currently associated to a network. On Android 9 and above, the device can use a randomized MAC address when connecting to a Wi-Fi network if enabled by a developer option. In Android 10 and higher, the system transmits randomized MAC addresses by default. Additionally, device IMEI and serial numbers are unable to be accessed.

Location Control

Apps can provide relevant information to the user using location APIs. For example, if an app helps the user navigate a delivery route, it needs to continually access the device location to provide the right assistance. Location is useful in many scenarios — Android provides tools for developers to request the necessary permissions while granting users choice in what they allow.

Apps that use location services must request location permissions so the user has visibility and control over this access. In Android 10 and above, users see a dialog to notify them that an app wishes to access their location. This request can be for access only while using the app or all the time.

The user can choose to allow an app all-the-time access to device location. When an app accesses device location in the background for the first time after the user makes this choice, the system schedules a notification to send to the user. This notification reminds the user that they've allowed the app to access device location all the time.

Learn more about location updates.

Storage Access

To give users more control over their files and to limit file clutter, apps targeting Android 10 and higher are subject to new file access abilities, or scoped storage, by default. Apps have unrestricted access to only their own app-specific directory—accessed using Context.getExternalFilesDir()—and to create files in organized collections on shared storage. Developers are encouraged to use scoped storage as a best practice.

EMM administrators are able to prevent their organization's users from accessing external storage, such as an SD card connected to their device, to further mitigate the potential for any data loss.

Limited Access to Background Sensors

Android 9 and above limits the ability for background apps to access user input and sensor data. If an app is running in the background, the system applies the following restrictions to the app:

- Application cannot access the microphone or camera.
- Sensors that use the continuous reporting mode, such as accelerometers and gyroscopes, don't receive events.
- Sensors that use the on-change or one-shot reporting modes don't receive events

If an app needs to detect sensor events on devices, it must use a foreground service.

Lockdown Mode

A user can enable a lockdown option to further restrict access to the device. This mode displays a power button option that turns off Smart Lock, biometric unlocking, and notifications on the lock screen. It can be enabled via Settings > Lock screen preferences > Lockdown mode. Enterprise administrators can remotely lock the work profile and evict the encryption key from memory on enterprise devices by leveraging this capability.

Network Security

In addition to data-at-rest security—protecting information stored on the device—Android provides network security for data-in-transit to protect data sent to and from Android devices. Android provides secure communications over the Internet for web browsing, email, instant messaging, and other Internet apps, by supporting Transport Layer Security (TLS).

DNS over TLS

Android 9.0 and above includes built-in support for Domain Name System (DNS) over TLS. Users or administrators can enable a Private DNS mode in the Network and internet settings. Android 10 further extends the capabilities for administrators to configure DNS over TLS as well as prevent users from changing DNS settings, thus preventing DNS query leakage.

Devices automatically upgrade to DNS over TLS if the configured DNS server supports it.

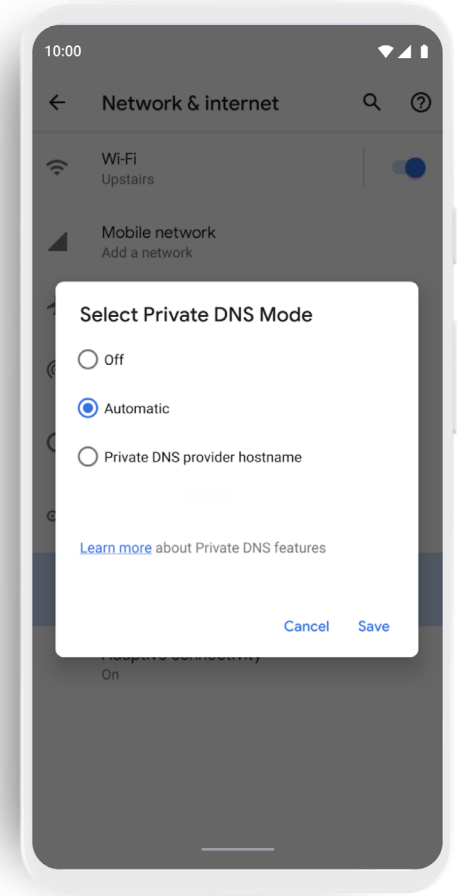


Figure 5. The Private DNS feature in the settings is enabled by default, with an option to input a private DNS provider hostname.TLS by Default

TLS by Default

Android helps keep data safe by protecting network traffic that enters or leaves a device with TLS. On Android 9 and above, the defaults for Network Security Configuration block all cleartext (unencrypted HTTP) traffic. Developers must explicitly opt-in to specific domains to use cleartext traffic in their applications. Android Studio also warns developers when their app includes a potentially insecure Network Security Configuration.

To prevent accidental unencrypted connections, the android:usesCleartextTraffic manifest attribute enables apps to indicate that they do not intend to send network traffic without encryption.

Android 10 and higher uses TLS 1.3 by default for all TLS connections. TLS 1.3 is a major revision to the TLS standard with performance benefits and enhanced security. TLS v1.3 is also more private as it encrypts more of the handshake process and offers stronger security by no longer supporting certificates signed with SHA 1. Benchmarks indicate secure connections can be established as much as 40 percent faster with TLS 1.3 compared to TLS 1.2.

Learn more about TLS 1.3 implementation.

Wi-Fi

Android 10 and above supports the Wi-Fi Alliance's Wi-Fi Protected Access version 3 (WPA3) and Wi-Fi Enhanced Open standards. WPA3 and Wi-Fi Enhanced Open improve overall Wi-Fi security, providing better privacy and robustness against known attacks. WPA3 is a new WFA security standard for personal and enterprise networks, taking advantage of modern security algorithms and stronger cipher suites.

WPA3 has two parts: personal and enterprise. WPA3-Enterprise offers stronger authentication and link-layer encryption methods, and an optional 192-bit security mode for sensitive security environments. WPA3-Personal uses simultaneous authentication of equals (SAE) instead of pre-shared key (PSK), providing users with stronger security protections against attacks such as offline dictionary attacks, key recovery, and message forging.

Wi-Fi Enhanced Open is a new WFA security standard for public networks based on opportunistic wireless encryption (OWE). It provides encryption and privacy on open, non-password-protected networks in areas such as cafes, hotels, restaurants, and libraries. Enhanced Open doesn't provide authentication.

Android also supports the WPA2-Enterprise (802.11i) protocol, also designed for enterprise networks and can be integrated into a broad range of Remote Authentication Dial-In User Service (RADIUS) authentication servers. The WPA2-Enterprise protocol support uses AES-128-CCM authenticated encryption.

In Android 10 and above, QR codes and NFC data used for device provisioning can contain Extensible Authentication Protocol (EAP) configuration and credentials—including certificates. When a person scans a QR code or taps an NFC tag, the device automatically authenticates to a local Wi-Fi network using EAP and starts the provisioning process without any additional manual input.

Learn more about EAP WI-Fi provisioning.

VPN

Android supports securely connecting to an enterprise network using a VPN:

- **Always-on VPN**—The VPN can be configured so that apps don't have access to the network until a VPN connection is established, which prevents apps from sending data across other networks.
  - Always-on VPN supports VPN clients that implement the VpnService. The system automatically starts the VPN after the device boots. Always-on VPN can be enabled for apps in enterprise use cases through the DevicePolicyManager#setAlwaysOnVpnPackage. Device owners and profile owners can require work apps to always connect through a specified VPN. Additionally, users can manually set Always-on VPN clients that implement VpnService methods using Settings>More>VPN. The option to enable Always-on VPN from settings is available only if the VPN client targets API level 24 or higher.
- **Per User VPN**—On multi-user devices, VPNs are applied per Android user, so all network traffic is routed through a VPN without affecting other users on the device. VPNs are applied per work profile, which allows an IT administrator to specify that only their enterprise network traffic goes through the enterprise-work profile VPN—not the user's personal profile network traffic.
- **Per Application VPN**—Support to facilitate VPN connections on allowed apps and to prevent VPN connections on disallowed apps.

In Android 10 and above, VPN apps can set an HTTP proxy for their VPN connection. A VPN app must configure a ProxyInfo instance with a host and port, before calling VpnService.Builder.setHttpProxy(). The system and many networking libraries use this proxy setting but the system doesn't force apps to proxy HTTP requests.

VPN Service Modes

VPN apps can also discover if the service is running because of always-on VPN and if lockdown mode is active. New methods added in Android 10 and higher can help developers adjust the user interface. For example, developers may disable the disconnect button in the VPN application when an always-on VPN controls the lifecycle of the service.

VPN Lockdown Modes

Lockdown modes allow administrators to block network traffic that does not use the VPN and exempt an app that allows it to use any available network if the VPN is down or unreachable. Administrators can also explicitly deny access to all networks for an app and this only allows communication to take place over the VPN.

Third-Party Apps

Google is committed to increasing the use of TLS in all apps and services.
As apps become more complex and connect to more devices, it's easier for apps to introduce networking mistakes by not using TLS correctly.

Network security configuration lets apps easily customize their network security settings in a safe, declarative configuration file without modifying app code. These settings can be configured for specific domains, such as opting out of cleartext traffic. This helps prevent an app from accidentally regressing due to changes in URLs made by external sources, such as backend servers. This safe-by-default setting reduces the application attack surface while bringing consistency to the handling of network and file-based application data.

Certificate Handling

All new Android devices must ship with the same certificate authority (CA) store. In addition, improvements in the TLS certificate handling were added where users are only asked to choose from certificates that match requirements specified by the server (compliance with RFC5246). If there are no certificates to choose from then the user is not presented with any prompt to protect from potential threats.

Certificate authorities are a vital component of the public key infrastructure used in establishing secure communication sessions via TLS. Establishing which CAs are trustworthy—and by extension, which digital certificates signed by a given CA are trustworthy—is critical for secure communications over a network.

These protections are further improved through preventing apps that target Android 9 and higher from allowing unencrypted connections by default. This follows a variety of changes made over the years to better protect Android users. Devices trust only the standardized system CAs maintained in AOSP. Apps can also choose to trust user or admin-added CAs. Trust can be specified across the whole app or only for connections to certain domains.

When device-specific CAs are required, such as a carrier app needing to securely access components of the carrier's infrastructure (e.g. SMS/MMS gateways), these apps can include the private CAs in the components/apps themselves. For more details, see Network Security Configuration. Improvements were made for local installation of CA certificates that help prevent tricking a user into installing bad CA certificates.

android

Application Security

Apps are an integral part of any mobile platform, and users increasingly rely on mobile apps for core productivity and communication tasks. Android provides multiple layers of application protection, enabling users to download apps for work or personal use to their devices with the peace of mind that they're getting a high level of protection from malware, security exploits, and attacks.

Google Security Services

Google Play Protect and SafetyNet attestation are services on GMS certified devices that help detect malware and device compromise. Exploitation code is often delivered to devices via malware. The combination of Google Play Protect and Verify Apps API can help prevent malware and threats from being installed. Android devices using managed Google Play have a PHA installation rate around .003%. Google Play Store security is further enhanced through the work of the App Defense Alliance, a collaboration with industry security partners. In addition, admins can create allow lists / block lists for the personal Google Play Store to provide greater specificity over which apps are allowed on devices. These resources all help to reduce the likelihood of malware infection.

EMM partners can use these services to ensure users cannot sideload applications and must only install applications from Google Play. SafetyNet attestation services provide real-time device integrity checking, like root detection and checking for unlocked bootloaders. EMMs can receive the signals from these on-device services to help detect and mitigate compromises.

Jetpack Security

Developers can leverage the Android KeyStore with Jetpack Security. MasterKeys allows developers to create a safe AES 256 GCM key out of the box or for advanced use cases that specify settings to control key authorization. Jetpack Security also provides higher level crypto abstractions for encrypting files (EncryptedFile) and SharedPreferences (EncryptedSharedPreferences). It is recommended that Jetpack Security be used by all Device Policy Controllers (DPCs), which control local device policies and system applications on devices, enterprise apps, public apps, and private apps.

Application Signing

Android requires that all apps be digitally signed with a developer key prior to installation. APK key rotation, supported in Android 9.0 and above, gives apps the ability to change their signing key as part of an APK update. To support key rotation, the APK signature scheme has been updated from v2 to v3 to allow old and new keys to be used.

Android uses the corresponding certificate to identify the application's author. When the system installs an update to an application, it compares the certificate in the new version with the one in the existing version, and allows the update if the certificate matches.

Android allows apps signed with the same key to run in the same process, if the apps so request, so that the system treats them as a single application. This capability is accomplished in the manifest with "sharedUserId." Android provides signature-based permissions enforcement, so that an application can expose functionality to another app that's signed with the same key. By signing multiple apps with the same key, and using signature-based permissions, an app can share code and data in a secure manner. NOTE: It is important to notethat this capability has been deprecated in Android 11.

App Permissions

Permissions protect the privacy of Android users and provide transparency about what resources or information apps wish to access. For apps to access system features, such as camera and the web, or user data, such as contacts and SMS, an Android app must explicitly request permission. These permission prompts are designed so the user has clear visibility into the request and the opportunity to approve or deny it.

A central design point of the Android security architecture is that no app, by default, has permission to perform any operations that would adversely impact other apps, the operating system, or the user. This includes reading or writing the user's private data (such as contacts or emails), reading or writing another app's files, performing network access, keeping the device awake, and others.

Android uses runtime permissions, which presents a dialog for the user to grant access to the specified permission at runtime. This approach streamlines the app install and update process, since the user does not need to grant permissions when they install or update the app. It also gives the user more control over the app's functionality; for example, a user could choose to give a camera app access to the camera but not to the device location. Users can revoke permissions at any time, even if the app targets a lower API level.

Users also have access to provide better control over the use of device identifiers. Privacy-sensitive persistent device identifiers are either no longer accessible or gated behind a runtime permission. For example, APIs that access the Wi-Fi MAC address have been removed except on fully managed devices.

On enterprise devices, device policy controllers (DPCs) can deny permissions on behalf of the user using the setPermissionPolicy API, a feature of managed Google Play.

Google Play Protect

Google Play Protect is a powerful threat detection service that actively monitors a device to protect it, its data, and apps from malware. The always-on service is built into all devices that have Google Play, protecting more than 2.5 billion devices.

The Google Play Protect service scans devices once everyday for harmful behavior and security risks. If it detects an app containing malware, it notifies the user. Google Play Protect may also remove or disable malicious apps automatically as part of its prevention initiative and use the information it gathers to improve the detection of PHAs. In addition, the user can opt to have unknown apps sent to Google for further analysis.

Google Play App Review

The Google Play Store has policies in place to protect users from malicious actors trying to distribute PHAs.

Developers are validated in two stages. They are first reviewed when they create their developer account based on their profile and credit cards. Developers are then reviewed further with additional signals upon app submission. Before applications become available in Google Play, they undergo an application review process to confirm they comply with Google Play policies. Google has developed an automated application risk analyzer that performs static and dynamic analysis of APKs to detect potentially harmful app behavior. The analyzer also leverages machine learning to detect harmful behaviours within applications. When Google's application risk analyzer discovers something suspicious, it flags the offending app and refers it to a security analyst for manual review. Google suspends developer accounts that violate developer program policies.

A developer is notified immediately if their app is flagged for a security issue. They receive details about how to improve the app and links to support page details for additional guidance. This notification usually includes a timeline for delivering the improvement and the goal is to focus on reducing security vulnerabilities. In some cases, security improvements to apps must be made before a developer can publish any further updates.

Another key element in minimizing risk is the use of updated APIs. Encouraging developers to use the most recent APIs encourages support for the most updated features, creating optimal security and performance. Both new apps and app updates must target at least Android 9, or API level 28, to meet API requirements.

Every new Android version introduces changes that bring significant security and performance improvements – and enhance the user experience of Android overall. Some of these changes only apply to apps that explicitly declare support through their targetSdkVersion manifest attribute, also known as the target API level. Reference the Google Play Developers documentation for more details on updating to the proper target API level requirement.

SafetyNet

SafetyNet is a set of services and APIs that developers may use to protect apps against security threats. They can mitigate against device tampering, bad URLs, PHAs, and fake users.

The SafetyNet Attestation API is an anti-abuse API that allows app developers to assess the Android device their app is running on. This API provides a cryptographically-signed attestation, assessing the device's integrity. In order to create the attestation, the API examines the device's software and hardware environment, looking for integrity issues, and comparing it with the reference data for approved Android devices. The generated attestation is bound to the nonce that the caller app provides. The attestation also contains a generation timestamp and metadata about the requesting app.

The SafetyNet Safe Browsing API offers services to determine if a URL has been marked as a known threat by Google. SafetyNet implements a client for the Safe Browsing Network Protocol v4, developed by Google. Both the client code and the v4 network protocol were designed to preserve users' privacy and keep battery and bandwidth consumption to a minimum. Developers can use this API to take full advantage of Google's Safe Browsing service on Android in the most resource-optimized way.

The SafetyNet service also includes the SafetyNet reCAPTCHA API, which protects apps from malicious traffic. This API uses an advanced risk analysis engine to protect apps from spam and other abusive actions. If the service suspects that the user interacting with the app might be a bot instead of a human, it serves a CAPTCHA that a human must solve before the app can continue executing.

The SafetyNet Verify Apps API allows an app to interact programmatically with Google Play Protect, to check whether there are known potentially harmful apps installed. If an app handles sensitive user data, such as financial information, developers should confirm that the current device is protected against malicious apps and is free of apps that may impersonate it or perform other malicious actions. If the security of the device doesn't meet the minimum security posture, developers can disable functionality within the app to reduce the danger to the user.

android

Data Protection

Android uses industry-leading security features to protect user data. The platform provides developer tools and services to aid in securing the confidentiality, integrity, and availability of user data.

Encryption

Encryption is mandatory on Android which protects user data if an Android device is lost or stolen. Android supports two methods for device encryption: file-based encryption (FBE) and legacy full-disk encryption.

File-Based Encryption

FBE enables storage areas to be encrypted with different keys and has been available for use on devices since Android 7. New devices running Android 10 and higher out of the box are required to use file-based encryption.

With FBE, the device boots directly to the lock screen, and the device is fully usable almost immediately when unlocked. Devices using FBE offer two kinds of storage locations to apps:

- Device Encrypted (DE) storage is available once the device boots, before the user unlocks the device. This storage is protected by a hardware secret and software running in the TEE that checks that Verified Boot is successful before decrypting data.
- Credential Encrypted (CE) storage is available only after the user has unlocked the device. In addition to the protections on DE storage, CE storage keys can only be derived after unlocking the device, with protection against brute force attacks in hardware.

Most apps store all data in CE storage and run only after credentials are entered, but apps such as alarm clocks or accessibility services such as Talkback can take advantage of the Direct Boot APIs and run before credentials are entered, using DE storage while CE is unavailable.

On devices with more than one user, each user has their own encryption keys, with CE keys bound to that user; this improves on FDE, which has only a single key bound to the first user, which unlocks all user data on the device. Encryption keys are 256 bits long and generated randomly on-device.

Devices running Android 9 and higher can use adoptable storage and FBE.
An additional layer of encryption protects information, such as directory layouts, file sizes, permissions and creation/modification times (collectively this is known as file system metadata).

Android 9.0 and higher support metadata encryption of the main user data partition where hardware support is present, using a single key protected by Keymaster and Verified Boot.

Full-Disk Encryption

Devices which first shipped with Android 5.0 to 9.0 may use full-disk encryption instead of file-based encryption. Full-disk encryption encodes all user data on an Android device using a single encryption key. As with file-based encryption, all user-created data is automatically encrypted before committing it to disk and all reads automatically decrypt data before returning it to the calling process.

Android full-disk encryption is based on dm-crypt, which is a kernel feature that works at the block device layer. The encryption algorithm is AES-128 with cipher-block chaining (CBC) and ESSIV:SHA256. The master key is encrypted with AES-128 via calls to the BoringSSL library. Some devices may use AES-256.

Upon first boot, the device creates a randomly generated 128-bit master key and then hashes it with a default password and stored salt. This hash is then passed through a keyed function based on RSA in the TEE , to prevent offline password guessing. When the user updates their passcode, the hash is regenerated without regenerating the master key.

Android Security Updates

Monthly device updates are an important tool to keep Android users safe. Every month, Google publishes Android Security Bulletins to update users, partners, and customers on the latest fixes. These security updates are available for Android versions for three years from the date of release.

Android OS framework uses a feature called project Treble, which accelerates the delivery of security fixes, privacy enhancements, and consistency improvements.
It enables device manufacturers and silicon vendors to develop and deploy Android updates faster than what was previously possible. All devices that launch with Android 9.0 and above are Treble-compliant and take full advantage of the Treble architecture.

Administrators of fully managed devices can install system updates via a system update file in Android 10 and above devices. With manual system updates, IT administrators can:

- Test an update on a small number of devices before installing them widely.
- Avoid duplicate downloads on bandwidth-limited networks.
- Stagger installations, or update devices only when they’re not being used.

Backup encryption

Devices that run Android 9.0 and above support enhanced backup encryption, a capability whereby the backed-up application data on a device can only be decrypted by a key that is randomly generated on that same device.

The randomly generated decryption key is securely shared with a custom-built security chip known as Titan, which is located at a Google datacenter, together with a hash of the user’s lockscreen PIN, pattern, or password. None of this data shared with the Titan chip is known to Google, and the device verifies the identity of the Titan chip by checking its root of trust before unlocking the stored backup.

With this Titan chip, there is a limited number of incorrect attempts strictly enforced by the custom firmware, which cannot be updated without erasing the contents of the chip. By design, this means that no one (including Google) can access a user's backed-up application data without specifically knowing their passcode.

Device Manufacturer Partner Updates

Security-critical fixes are pushed to all Pixel devices monthly directly from Google's over-the-air servers. Pixel firmware images are also available on the Google Developer site for manual update and flashing. Many device manufacturer partners follow a similar cadence in their security updates. Many also deliver their own security bulletins:

- Google
- Nokia
- Samsung
- LG
- Motorola
- Zebra

Users can find out whether they're running a recently patched device with the Security Patch Level, a value indicating the security patch level of a build. It's available through the attestation certificate chain, which contains a root certificate that is signed with the Google attestation root key, also visible in the device settings. EMM partners have the capability to call an API to detect which security update is installed and impose compliance rules for outdated devices.

Google Play System Updates

In Android 10 and higher, Google Play System Updates offer a simple and faster method to deliver updates. Key Android system components are modularized, and end-user devices receive the components from the Google Play Store or through a partner-provided over-the-air (OTA) mechanism.

The components are delivered as either APK or APEX files — APEX is a new file format which loads earlier in the booting process. Important security and performance improvements that previously needed to be part of full OS updates can be downloaded and installed similarly to an app update. Updates delivered from Google Play System Updates are secured by being cryptographically signed.

Google Play System Updates can also deliver faster security fixes for critical security bugs by modularizing media components, which accounted for nearly 40% of recently patched vulnerabilities, and allowing updates to Conscrypt, the Java Security Provider.

Conscrypt

The Conscrypt module accelerates security improvements and improves device security through regular updates via Google Play System Updates. It uses Java code and a native library to provide the Android TLS implementation as well as a large portion of Android cryptographic functionality such as key generators, ciphers, and message digests . Conscrypt is available as an open source library, though it has some specializations when included in the Android platform.

The Conscrypt module uses BoringSSL, a native library that is a Google fork of OpenSSL and which is used in many Google products for cryptography and TLS (most notably Google Chrome). The Conscrypt module is distributed as an APEX file that includes the Conscrypt Java code and a Conscrypt native library that dynamically links to Android NDK libraries (such as liblog). The native library also includes a copy of BoringSSL that has has been validated (Certificate #3753) through NIST's Cryptographic Module Validation Program (CMVP).

Adiantum

Adiantum is an encryption method designed for devices running Android 9 and higher whose CPUs lack AES instructions. This provides encryption to such devices with little performance overhead and enables a class of lower-powered devices to use strong encryption. The Android Compatibility Definition Document (CDD) reflects that all new Android devices be encrypted using one of the allowed encryption algorithms.

android

Device and Profile Management

Android Enterprise Device Use Cases

Android Enterprise offers APIs and other tools for developers to integrate support for Android into their enterprise mobility management (EMM) solutions.

Employee-owned devices: Personal devices can be set up with a work profile— a feature that allows work apps and data to be stored in a separate, self-contained space within a device. An employee can continue to use their device as normal; all their personal apps and data remain on the device's primary profile. The employee's organization has full management control over a device's work profile, but has no visibility or access to a device's personal profile. This distinct separation gives enterprises control over corporate data and security without compromising employee privacy.

Company-owned devices for knowledge workers: Organizations can exercise full management control over devices that they own and issue to employees. There are two deployment options available for these types of company-owned devices: **fully managed** and **work profiles on company-owned devices.**

- Fully managed deployments are for company-owned devices that are used exclusively for work purposes. Organizations can enforce the full range of management policies on the entire device, including device-level policies that are unavailable to work profiles.
- Work profiles on company-owned devices are for company-owned devices that are used for both work and personal purposes. The organization still manages the entire device, however, the separation of work data and apps into a work profile allows organizations to enforce two separate sets of policies. For example:

    - A stronger set of policies for the work profile that applies to all work apps and data.
    - A more lightweight set of policies for the personal profile all while preserving the users personal privacy.

Learn more about the capabilities available to device and profile owners, and about work profiles on company owned devices.

Company-owned devices for dedicated use: Dedicated devices are a subset of company-owned devices that serve a specific purpose. Android comes with a broad set of management features that allow organizations to configure devices for everything from employee-facing factory and industrial environments, to customer-facing signage and kiosk purposes.

Dedicated devices are typically locked to a single app or set of apps. This model offers granular control over a device's lock screen, status bar, keyboard, and other key features, to prevent users

from enabling other apps or performing other actions on dedicated devices.

Integrating Android

EMM Console: EMM partner solutions typically take the form of an EMM console—a web application that allows IT administrators to manage their organization, devices, and apps. To support these functions for Android, organizations integrate their console with the APIs and UI components provided by Android Enterprise.

The Android Management API provides EMM partners with an enterprise mobility management (EMM) solution to manage any Android device with a single, intuitive API. It enables a single API set with all available features for EMM partners thus reducing development time.

To deploy a production solution that uses the Android Management API, EMMs need to follow the steps outlined in "release your solution".

The Android Management API supports the work profile, fully managed device, and dedicated device solution sets.

Device Policy Controller: All Android devices that an organization manages through an EMM console must install a Device Policy Controller (DPC) app during setup. A DPC is an agent that applies the management policies set in an EMM console to devices. On a device with a work profile, the DPC controls the creation and policies of the work profile, or the profile owner (PO). A device that is fully managed, or a device owner (DO) profile that is device wide, is also controlled by a DPC.

The DPC runs in one of two main modes:

1. **Device Owner**: runs in the primary profile and has the ability to manage a device in fully managed device mode. This is appropriate for company-owned devices.
2. **Profile Owner**: runs in and manages only the work profile.

Similarly, a BYOD configuration also no longer includes a DPC running in the personal profile. When only work apps and data are present on the device, such as in a typical dedicated device configuration, then only the primary profile exists with a DPC running.

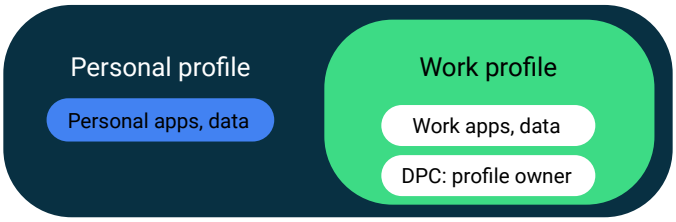


Figure 6. BYOD configuration.

Android 10 introduces new features and APIs for fully managed devices — manual system updates, extending QR code and NFC provisioning to include credentials for an EAP Wi-Fi network, and support for DNS over TLS.

OEMConfig

OEMConfig is an Android standard that enables device makers to create custom device features for immediate and universal support from EMMs. Instead of integrating enterprise APIs from each OEM to support their custom features such as control of barcode scanners or enabling extra security features, EMMs can easily use an OEM-built application that configures all of the unique capabilities of a device.

OEMConfig takes advantage of managed configurations, enabling developers to provide built-in support for the configuration of apps. For example, an app may have the option to only sync data when a device is connected to Wi-Fi. With such abilities, IT administrators can specify the managed configuration and apply them to devices.

The managed configurations iFrame is an embeddable UI that lets IT administrators save, edit, and delete an app's managed configuration settings. Developers can, for example, display a button (or similar UI element) in an app's details or settings page that opens the iFrame.

Within the iFrame, an IT administrator can set configurations and save them as a configuration profile. Each time an IT administrator saves a new configuration profile, the iFrame returns a unique identifier called mcmID. This makes it possible for IT administrators to create multiple profiles for the same app.

Device Policies

EMMs developing a DPC or apps for managed Google Play can refer to Android Developers documentation for new APIs, features, and behavior changes.

Most capabilities available to the DPC are accessible via the DevicePolicyManager APIs, the Android Management API, and user restrictions in UserManager. Below is a list of some of the available features.

They can prevent sharing of files from the work profile or device, such as:

1. DISALLOW_BLUETOOTH_SHARING: disallows transferring files via Bluetooth.
2. DISALLOW_USB_FILE_TRANSFER: disallows sending files via USB.
3. DISALLOW_OUTGOING_BEAM: disallows beaming out data from apps using NFC.
4. DISALLOW_MOUNT_PHYSICAL_MEDIA: disallows mounting physical external media.

Device owner and profile owner mode also have a lot of control over other aspects of the device or profile. Below are some of the available policies:

1. DISALLOW_DEBUGGING_FEATURES: disallows access to debugging capabilities.
2. DISALLOW_AUTOFILL: disallows autofill services.
3. Setting device passcode policy using APIs such as setPasswordQuality().
4. Disabling less secure unlock methods using setKeyguardDisabledFeatures().
5. Disabling the camera using setCameraDisabled().
6. Setting permitted accessibility services using setPermittedAccessibilityServices().
7. Setting permitted input methods using setPermittedInputMethods().
8. Disabling screen capture using setScreenCaptureDisabled().
9. Automatically accepting/denying some runtime permissions with setPermissionPolicy().
10. If the device is lost, DPC can lock (lockNow()) or wipe (wipeData()) the device.
11. Disable backups using setBackupServiceEnabled().
12. Disallow adding a personal account using DISALLOW_MODIFY_ACCOUNTS. This makes it harder to copy corporate data to personal cloud accounts.
13. Require Google Play Protect to be enabled and enforce app verification across all users on the device using ENSURE_VERIFY_APPS.
14. Require only installing apps from known sources such as the Play store using DISALLOW_INSTALL_UNKNOWN_SOURCES.
15. Install keys and certificates into the profile-wide KeyChain using installKeyPair(), and control access to those keys. These can be used as machine certificates to identify the device.
16. Set always on VPN using setAlwaysOnVpnPackage()

As a general guide, Device Owner (DO) controls the primary profile and Profile Owner (PO) controls the work profile. However, there are circumstances whereby PO can enable a global user restriction. Google provides an open-source app, Test DPC, for testing enterprise functionality in the DPC app. Test DPC is available from github or Google Play. The Test DPC can be used to:

- Simulate features in Android
- Set and enforce policies
- Set app and intent restrictions
- Set up work profiles
- Set up fully managed Android devices
- Fully Managed Device Provisioning

Fully Managed Device Provisioning

The lifetime of the DPC is always tied to the lifetime of the device or profile it manages. IT managers, or the end user, must enroll a device into fully managed device mode, which provisions the device policy client as a device owner. Provisioning must occur during the initial setup of a new device, or after a factory reset. In the case of DO, it can only be provisioned during initial device setup and only be removed by the DO itself.

A number of options exist to provision a device into fully managed device mode:

- Zero-touch enrollment - after creating a configuration in the zero-touch portal, the IT administrator can ship a device directly to an end-user. Enrollment is automatic at first boot, or after factory reset, and is enforced to prevent the user from breaking out of the zero-touch enrollment process.
- NFC / QR code - An administrator provisioning large numbers of devices or an employee setting up their own single device can perform an NFC bump using a programmed NFC tag or scan a QR code to install the necessary DPC and initiate the enrollment process.
- Google Workspace or Cloud Identity account - With this provisioning method, the DPC guides the user through the provisioning steps after the user adds their Google Account during the initial device setup or via settings.

A device in fully managed mode can have a policy added that prevents a user from factory resetting a device.

Work Profile Security

Work profile mode is initiated when the DPC issues a managed provisioning flow. The work profile is based on the Android multi-user concept, where the work profile functions as a separate Android user segregated from the primary profile. The work profile shares common UI real estate with the primary profile. Apps, notifications, and widgets from the work profile have a blue badge icon to distinguish them from the personal apps and notifications.

With the work profile, enterprise data does not intermix with personal application data. The work profile has its own apps, its own downloads folder, its own settings, and its own KeyChain. It is encrypted using its own encryption key, and it can have its own passcode to gate access.

The work profile is provisioned upon installation, and the user can only remove it by removing the entire work profile. Administrators can also remotely instruct the device policy client to remove the work profile, for instance, when a user leaves the organization or a device is lost. Whether the user or an IT administrator removes the work profile, user data in the primary profile remains on the device.

Android 10 and above uses provisioning and attestation features for company-owned devices that only require a work profile. During the provisioning of a company-owned device, a new intent extra allows DPCs to initiate a work profile on a company owned device enrollment flow. After a

work profile is created or full management is established, DPCs must launch policy compliance screens to enforce any initial policies.

A device with a work profile can be configured with factory reset protection so that if the device is incorrectly reset, the organization has the ability to reset the factory reset protection, which is a feature that prevents device theft.

Separate Work Challenge

Android supports a separate work challenge to enhance security and control for the work profile. The work challenge is a separate passcode that protects work apps and data. Administrators managing the work profile can choose to set the password policies for the work challenge differently from the policies for other device passwords. Administrators managing the work profile set the challenge policies using the usual DevicePolicyManager methods, such as setPasswordQuality() and setPasswordMinimumLength(). These administrators can also configure the primary device lock, by using the DevicePolicyManager instance returned by the DevicePolicyManager.getParentProfileInstance() method.

As part of setting up a separate work challenge, users may also elect to enroll fingerprints to unlock the work profile more conveniently. Fingerprints must be enrolled separately from the primary profile as they are not shared across profiles.

As with the primary profile, the work challenge is verified within secure hardware, ensuring that it's difficult to brute-force. The passcode, mixed in with a secret from the secure hardware, is used to derive the disk encryption key for the work profile, which means that an attacker cannot derive the encryption key without either knowing the passcode or breaking the secure hardware.

Cross Profile Data Sharing

While data in the work profile is segregated by default from the user's personal data, there are instances where sharing is useful. Android allows sharing between profiles in ways that can be managed by the DPC.

For example:

1. Disallow copy & paste between profiles: DISALLOW_CROSS_PROFILE_ COPY_PASTE
2. Allow the primary profile to handle web links from the work profile: ALLOW_PARENT_ PROFILE_APP_LINKING
3. Allow widgets from the work profile, such as a calendar widget, to be added on the home screen: addCrossProfileWidgetProvider()
4. Set whether work profile Caller ID is shown in primary profile: setCrossProfileCallerIdDisabled()
5. Set whether work profile contacts are shown in primary profile: setCrossProfileContactsSearchDisabled()
6. Set which apps can see notifications from the work profile: setPermittedCrossProfileNotificationListeners()
7. Set whether apps in the primary profile using the ACTION_SEND intent may share into the work profile using the DISALLOW_SHARE_INTO_MANAGED_PROFILE user restriction available as of Android 9.0. Note that, to reduce the risk of data leakage, the opposite direction is not allowed by default, though it can be enabled by the DPC.

IT administrators can also control cross profile intents using the addCrossProfileIntentFilter and clearCrossProfileIntentFilters methods. By default, during work profile creation, the system automatically configures the following intents to be forwarded to the primary profile:

- **Telephony intents:** administrators can also allowlist a dialer for work, which allows a "business" phone account to make and receive work calls instead of forwarding telephony intents to the primary profile dialer. In this case, all calls from the work dialer are inserted into the work call log.
- **Home intent**: to invoke the launcher in the primary profile since it doesn't run in the work profile.
- **Get content:** the user has the option to resolve in either the primary or work profile.
- **Open document**: the user has the option to resolve in either the primary or work profile.
- **Picture:** the user has the option to resolve in either the primary or work profile if an app that can handle a camera exists in the work profile.
- **Set clock:** the user has the option to resolve in either the primary or work profile.
- **Speech recognition:** the user has the option to resolve in either the primary or work profile.

Application Management

Android Enterprise provides IT administrators with powerful tools to deploy, configure and manage applications on a variety of device form factors.

Enterprise Mobility Management Apps

The EMM DPC controls which work apps may be installed. On a fully managed device, the DPC can call the PackageInstaller APIs directly to silently install, uninstall, and update apps. It can also listen for broadcasts such as ACTION_PACKAGE_ADDED, ACTION_PACKAGE_REMOVED, and ACTION_PACKAGE_REPLACED to be notified of changes to installed apps.

On devices that ship with Google Play, an EMM can delegate app management to Google Play. Through managed Google Play, an enterprise version of Google Play, IT administrators can easily find, deploy, and manage work apps while ensuring that malware and other threats are neutralized.

Managed Google Play

Managed Google Play provides APIs to EMM partners that allow them to manage apps on Android devices. Organizations can build a customized and secure mobile application storefront for their teams, featuring public and private applications, which can be delivered to devices directly from the managed Google Play store. This eliminates the need to sideload any applications onto devices.

Installation of apps in either the work profile or on fully managed devices is possible via direct user request in the managed Google Play Store app (pull), or as a result of a call to the EMM API (push). The APIs provide functionality for use (indirectly) by EMM-managed enterprise administrators as follows:

- An IT administrator can remotely install or remove apps on managed Android devices. This action is limited to devices or profiles that are under management by the EMM.
- An IT administrator can define which users see which apps. A user running the Play Store app within the work profile only sees apps allowlisted for them. The user can install these apps, but not others.
- Enterprise administrators can see which users have apps installed or provisioned, and the number of licenses purchased and provisioned from managed Google Play.

Managed Google Play also provides additional app management options for IT administrators. With the managed Google Play iFrame, administrators can approve apps in the managed Google Play store directly from the EMM console. By using managed configurations, administrators can allowlist specific apps for employee use, and selectively approve only the permissions they want

their apps to use.

Additionally, administrators can enforce update preferences through managed Google Play. While the recommendation is for users to leave auto updates enabled, administrators can push an urgent update out to devices automatically.

Private Apps

With managed Google Play, an enterprise customer can publish apps and target them privately (i.e., they're only visible and installable by users within that enterprise). Private apps are logically separated in Google's cloud infrastructure from public Google Play for consumers. There are two modes of delivery for private apps:

- Google-hosted: By default, Google hosts the APK in its secure, global data centers.
- Externally-hosted: Enterprise customers host APKs on their own servers, accessible only on their intranet or via VPN. Details of the requesting user and their authorization is provided via a JSON Web Token (JWT) with an expiry time. The JWT is signed by Google using the key pair associated with the specific app metadata in managed Google Play, and should be verified before trusting the authorization contained in the JWT.

In both cases, Google Play stores the app metadata—title, description, graphics, and screenshots. In all cases, apps must comply with all Google Play policies.

Managed Configurations

Managed configurations allow an organization's IT administrator to remotely specify settings for apps. This capability is useful for organization-approved apps that are deployed to a work profile. Managed configurations allow an IT administrator to remotely control the availability of features, configure settings, or set in-app credentials, via the Google Play EMM API. As an example, an app may have an option to only sync data when a device is connected to Wi-Fi, or allowlist or blocklist specific URLs in the web browser. Managed configuration options can be changed by the developer and updated in managed Google Play where the EMM will pick up on the changes for new and existing app deployments.

Google Chrome is an example of an enterprise-managed app that implements policies and configurations that can be fully managed according to enterprise policies and restrictions.

Applications from Unknown Sources

Administrators may need to prevent the installation of applications from outside Google Play, or apps from unknown sources. Devices and data can be at increased risk when such apps are installed from unverified sources.

To prevent the installation of apps from unknown sources, administrators of fully managed devices and work profiles can add the DISALLOW_INSTALL_UNKNOWN_SOURCES user restriction.

When the administrator of a work profile adds DISALLOW_INSTALL_UNKNOWN_SOURCES, the restriction only applies to the work profile. However, the administrator of a work profile can place a device-wide restriction by setting a managed configuration for Google Play.

android

Programs

A number of Google-backed initiatives and collaborations help advance the Android ecosystem that support partners and customers in their use of Android in enterprise settings.

Android Enterprise Recommended

The Android Enterprise Recommended program sets an elevated standard for enterprise devices and services. Validated devices in the program meet a set of specifications for hardware, deployment, security updates, and user experience. In addition, device manufacturers receive an enhanced level of technical support and training. Organizations may select devices from the curated list with confidence that they meet a common set of criteria required for inclusion in the Android Enterprise Recommended program.

Learn more about the program's device requirements.

Android Partner Vulnerability Initiative (APVI)

The Android Partner Vulnerability Initiative (APVI) was created to drive remediation and provide transparency to users about security issues we have discovered at Google that affect device models shipped by Android partners. Past disclosures of Google-discovered security issues are available at this link.

Android Security Rewards Program

The Android Security Rewards (ASR) program incentivizes researchers to find and report security issues, providing key assistance to Android security efforts. This program covers security vulnerabilities discovered in the latest available Android versions for Pixel phones and tablets.

Google Play Security Reward Program

The Google Play Security Reward Program incentivizes researchers to report vulnerabilities discovered in apps with 100 million or more installs, as well as apps using the Exposure Notification API and other Contact Tracing apps hosted on Google Play. All of Google's apps are included in the program, and developers of popular Android apps are invited to opt-in.

Developer Data Protection Reward Program

The Developer Data Protection Reward Program aims to identify and mitigate data abuse issues in popular Android applications, Chrome extensions, and applications leveraging the Google API. It recognizes the contributions of individuals who help report apps that are violating applicable program policies and are potentially putting user data at risk.

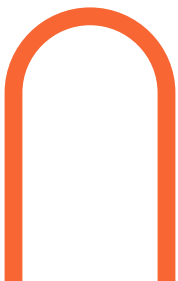
App Security Improvement Program

The App Security Improvement Program is a service that helps Google Play developers improve the security of their apps. The program provides tips and recommendations for building more secure apps and identifies potential security issues and mitigations when apps are uploaded to Google Play.

App Defense Alliance

The App Defense Alliance is a collaboration between Google and ESET, Lookout, and Zimperium. It was created to further enhance the safety of the Google Play Store by working with partners to quickly find PHAs and take action to protect users.

Integrating Google Play Protect detection systems combined with partner's scanning engines generates new app risk intelligence as apps are being queued to publish. Partners will analyze that dataset and act as another set of eyes prior to an app going live on the Play Store.



android

Industry Standards and Certifications

Devices running Android and the cloud services they utilize comply with various industry standards and have received numerous security certifications which demonstrate our strong commitment to the highest security standards.

ioXt Alliance

The Internet of Secure Things Alliance (ioXt) manages a security compliance assessment program for connected devices. ioXt has over 300 members across various industries, including Google, Amazon, Facebook, T-Mobile, Comcast, Zigbee Alliance, Z-Wave Alliance, Legrand, Resideo, Schneider Electric, and many others. With so many companies involved, ioXt covers a wide range of device types, including smart lighting, smart speakers, webcams, and Android smartphones.

The core focus of ioXt is "to set security standards that bring security, upgradability and transparency to the market and directly into the hands of consumers." This is accomplished by assessing devices against a baseline set of requirements and relying on publicly available evidence. The goal of ioXt's approach is to enable users, enterprises, regulators, and other stakeholders to understand the security in connected products to drive better awareness towards how these products are protecting the security and privacy of users.

ioXt's baseline security requirements are tailored for product classes, and the ioXt Android Profile enables smartphone manufacturers to differentiate security capabilities, including biometric authentication strength, security update frequency, length of security support lifetime commitment, vulnerability disclosure program quality, and preloaded app risk minimization.

ISO and SOC certification

Android Enterprise has received ISO 27001 certification and SOC 2 and 3 reports for information security practices and procedures for Android Management API, zero-touch enrollment and managed Google Play. This designation ensures these services meet strict industry standards for security and privacy.

Granted by the International Organization for Standardization, ISO 27001 outlines the requirements for an information security management system. It specifies best practices and details a list of security controls regarding information risk management.

The SOC 2 and 3 reports are based on American Institute of Certified Public Accountants (AICPA) Trust Services principles and criteria. To earn this, auditors assess an organization's information systems relevant to security, availability, processing integrity and confidentiality or privacy.

An independent assessor performed a thorough audit to ensure compatibility with the established principles. The entire methodology of documentation and procedures for data management are reviewed during such audits, and must be made available for regular compliance review.

Learn more about these security designations.

Government Grade Security

FIPS 140-2 CAVP & CMVP

Federal Information Processing Standards (FIPS) are standards and guidelines for Federal computer systems that are developed by the National Institute of Standards and Technology (NIST) in accordance with the Federal Information Security Management Act (FISMA) and approved by the Secretary of Commerce. Although FIPS are developed for use by the federal government, many in the private sector voluntarily use these standards as well. The National Institute of Standards and Technology's (NIST) Cryptographic Algorithm Validation Program (CAVP) provides validation testing of approved cryptographic algorithms and their individual components. The goal of the Cryptographic Module Validation Program (CMVP) is to promote the use of validated cryptographic modules and provide Federal agencies with a security metric to use in procuring equipment containing validated cryptographic modules.

Common Criteria/NIAP Mobile Device Fundamentals Protection Profile

Common Criteria is a driving force for the widest available mutual recognition of security products with 31 participating countries. The National Information Assurance Partnership (NIAP) serves as the U.S. representative to the Common Criteria Recognition Arrangement (CCRA). In partnership with NIST, NIAP approves Common Criteria Testing Laboratories to conduct security evaluations in private sector operations across the U.S. This certification process has enabled the Android team to build some of the requirements to achieve this certification directly into the Android Open Source Project (AOSP), which enables device manufacturers the ability to attain certification in much less time.

DISA Security Technical Implementation Guide (STIG)

The Security Technical Implementation Guides (STIGs) are the configuration standards for Department of Defense Information Assurance (IA) and IA-enabled devices/systems. The STIGs contain technical guidance to "lock down" information systems/software that might otherwise be vulnerable to a malicious computer attack. The Google Android 10 and Google Android 11 STIGs provide a standard implementation for configuring and locking down any Android device using Android Enterprise management controls.

android

Conclusion

The open source development approach of Android is a key part of its security. Developers, device manufacturers, security researchers, SoC vendors, academics, and the wider Android community create a collective intelligence that locates and mitigates vulnerabilities for the entire ecosystem.

With Android, multiple layers of security support the diverse use cases of an open platform while also enabling sufficient safeguards to protect user and corporate data. Additionally, Android platform security keeps devices, data, and apps safe through tools like app sandboxing, exploit mitigation and device encryption. A broad range of management APIs gives IT departments the tools to help prevent data leakage and enforce compliance in a variety of scenarios. The work profile enables enterprises to create a separate, secure profile on users' devices where apps and critical company data are kept secure and separate from personal information.

Google Play Protect, the world's most widely deployed mobile threat protection service, delivers built-in protection on every device. Powered by Google machine learning, it works to catch and block harmful apps and scan the device to root out any PHAs or malware. Google Safe Browsing in Chrome protects enterprise users as they navigate the web by warning of potentially harmful sites.

Enterprises rely on smart devices for critical business operations, collaboration, and accessing proprietary data and information. Google continues to invest in resources to further strengthen the security of the Android platform, and we look forward to further contributions from the community and seeing how organizations will use Android to drive business success.