Magic UI 6.0 Security Technical White Paper

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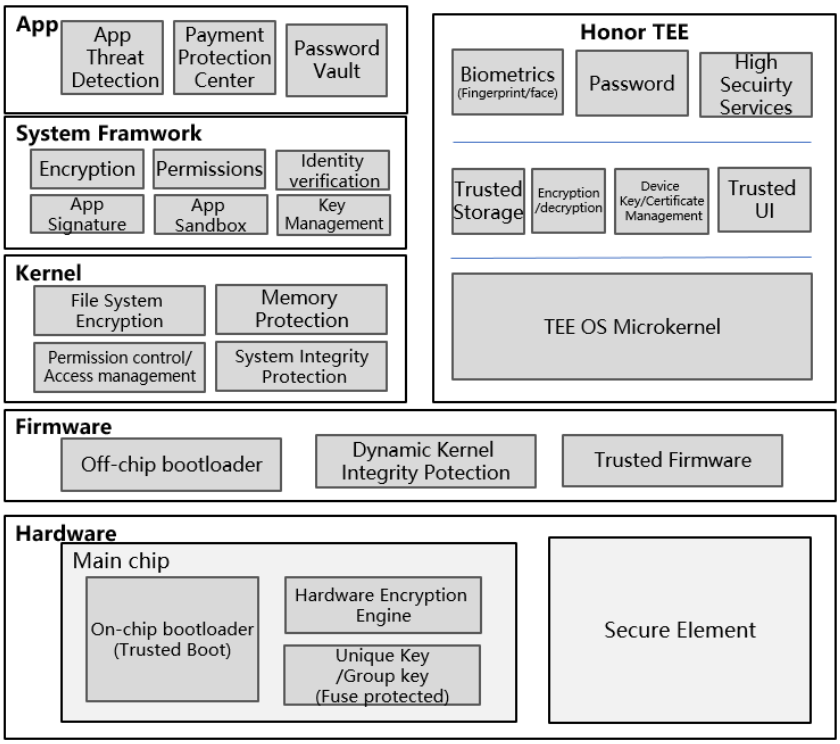
Note: * indicates a feature not supported by all devices. Supported features vary depending on device models or market characteristics in difference countries. For more information, refer to specific product descriptions.

1 Overview

Introduction

Magic UI is a secure, data-centric, and chip-based platform that combines hardware and software to provide a complete solution for user data security and privacy protection needs (Overall architecture shown below). It provides end-to-end security protection (hardware, system, apps, and the cloud). The security and privacy protection encompass chips, trusted execution environments, system kernels, data, apps, networking, connectivity and services.



Magic UI security architecture

Magic UI provides a secure boot mechanism from underlying hardware chips to prevent the read-only memory (ROM) image from being tampered with. The ROM image can only run on a device after passing signature verification. This ensures secure boot for the bootloader, recovery, and kernel images, and prevents tampering and malicious code

implantation by attackers during the boot process, thereby ensuring security from hardware chips to system boot.

To ensure data security, Magic UI encrypts user data using a hardware unique key (HUK) and a user lock screen password. Data files from various apps are stored in the sandboxes of the corresponding apps, preventing files from one app from being accessed by another. The data erasure function is provided to permanently erase data during device recycling or factory restoration, thereby preventing unauthorized data restoration. Magic UI also allows cloud services to help users back up and synchronize data to ensure data security.

For app security, in addition to mechanisms such as security sandbox and permission management, Magic UI pre-installs System Manager to provide virus scanning, block and filter, traffic management, notification management, and other functions. Utilizing these functions, Magic UI can automatically detect viruses and Trojans within apps, and provide fine-grained permission, traffic, and notification management functions.

This document contains the following chapters:

- Hardware security: secure boot, hardware encryption/decryption engine and random number generator (RNG), HUK, device group key, secure element.
- TEE: secure OS, trusted storage services, encryption and decryption, device attestation, etc.
- System security: integrity protection covering Honor Kernel Integrity Protection (HKIP), Integrity Measurement Architecture (IMA), and system software update; kernel security covering system access control and kernel address space layout randomization (KASLR); identity authentication.
- Data security: Universal Key Library, lock screen password protection, data encryption, secure erasure, and password vault.

- App security: app signature verification, app sandbox, runtime protection, secure input, app threat detection, malicious website detection, and SMS verification protection.
- Network and communication security: virtual private network (VPN), Transport Layer Security (TLS), Wi-Fi security, and protection against fake base stations.
- Interconnection security: interconnection security between devices logged-in with the same HONOR ID; IoT device interconnection security.
- Service security: HONOR ID, Find Device & Activation Lock, Payment protection center,
- Privacy protection: permission management, privacy access history, audio/video recording reminder, location access, device identifier system, differential privacy, and privacy statement

Magic UI is applied to products running a variety of hardware chip platforms. As such, security implementation may differ depending on hardware and chips. For the specifications relating to a particular device, refer to its product manual.

2 Hardware security

Magic UI adopts security capabilities based on hardware chips, and delivers overall security with secure software solutions. Hardware chip security is the core of the Magic UI security system. This chapter describes Honor device hardware chip security, including the following security features:

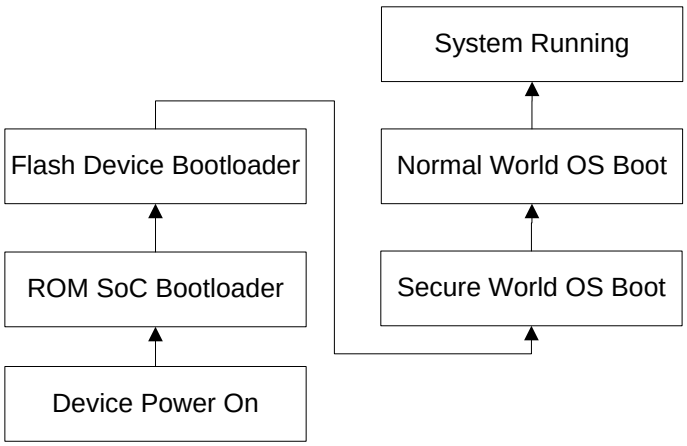
Secure Boot

Secure boot prevents the loading and running of unauthorized apps during device boot. The boot program uses a public key to verify the digital signatures of software, ensuring integrity and trustworthiness. Only the image files that pass the signature verification can be loaded. These

files include bootloader, kernel, and baseband firmware image files. If the signature verification fails during boot, the boot process is terminated.

When a device is started, a boot program in the chip, known as the ROM SoC Bootloader, is executed first. This code snippet is written into the ROM inside the chip during manufacturing and is not modifiable after delivery. It is the root of trust for device boot.

The ROM SoC Bootloader performs basic system initialization and then loads the Flash Device Bootloader from the flash storage chip. The ROM SoC Bootloader uses the public key hash in the eFuse space (using the fuse technique and cannot be changed once the fuse blows) of the main chip to verify the public key, and then uses the public key to verify the digital signature of the Flash Device Bootloader image. The Flash Device Bootloader is executed once verification is successful. The Flash Device Bootloader then loads, verifies, and executes the next image file. A similar process is repeated until the entire system is booted, thereby ensuring a trust chain transfer and preventing unauthorized programs from being loaded during the boot process.



A.1.1.1.1.a.i.1 Secure Boot

Products running Magic UI supports the Verified Boot feature. When accessing a read-only system partition with Verified Boot protection enabled, the system verifies the integrity of the accessed area using the integrity protection information generated when building the read-only partition image. This feature helps prevent malware from permanently

residing on the system partition and ensures that the user boots the device in the same state as the last time it was used.

Hardware encryption and decryption engine and random number generator

To meet the requirements of high-performance encryption/decryption and key protection, Magic UI utilizes the hardware security engine to perform operations such as data encryption/decryption and key derivation. The chip provides a high-performance hardware encryption and decryption acceleration engine that supports the following main algorithms and functions (including but not limited to).

- 3DES, AES128, AES256
- SHA1, SHA256
- HMAC-SHA1, HMAC-SHA256
- RSA1024, RSA2048
- ECDSA-P256, ECDH-P256
- CTR_DRBG RNG compliant with NIST SP800-90A and hardware entropy source compliant with NIST SP800-90B

Hardware Unique key(HUK)

An HUK is a unique identifier in a chip. It can only be used by the hardware encryption/decryption engine for key derivation and varies depending on the chip. The HUK provides a device-unique key for Magic UI. It is applied to lock screen password protection, file system encryption, and other functions.

Device Group Key

A device group key is an identifier in a chip. It can only be used by the hardware encryption/decryption engine for key derivation and is the same

across devices of the same type. The device group key enables Magic UI to derive the same key for the same type of devices.

Secure Element*

The Secure Element is a chip that provides secure execution, data storage protection and industry security certification to meet the security requirements of mobile payments. Secure Elements have independent memory, persistent storage media, encryption/decryption logic circuits, processors, and software systems to protection applications and data against external attacks. Honor products also use secure elements to ensure the security of payment-related functions. The secure elements have passed CC EAL6+ (hardware) and EAL5+ (software) security certifications and international standards such as EMVco.

Mobile Shield*

The Mobile Shield function supported by Honor products uses Secure Element to support the mobile certificate service of banks, combining the traditional USB plug-in U shield with the mobile phone and turning it into the mobile shield to provide financial-grade hardware protection for electronic payments.

When the user opens Mobile Shield, Magic UI's Trusted Service Management Platform (TSM) will act as the manager of the Secure Element, and the functional modules on the phone will communicate with the Secure Element by establishing a Secure Channel Protocol (SCP) and creating a trusted, independent, and secure operation space within the Secure Element. The banking application will then generate key pairs and certificates for transactions in this secure space and requires the user to set up PIN protection.

When using Mobile Shield, the user first enters the PIN code for authentication through the trusted UI interface. Then the Secure Element will digitally sign the user's transaction request using the private key generated during the creation process. The bank transaction system

performs signature verification when processing the transaction request to ensure the security of the transaction.

When the user logs out of (closes) Mobile Shield, the system destroys the key pairs stored in the Secure Element and makes sure they cannot be recovered.

From the generation of the certificate and the public and private keys to the destruction of the certificate, the private key will be stored in the Secure Element during the whole life cycle to guarantee the security of the certificate keys.

Electronic ID*

The Electronic ID (eID) provides the user with convenient and credible identity authentication, assumes the same function as a physical ID card, and can complete user identification without revealing the user's explicit identity information.

The user can create the eID in the portal provided by the eWallet app. In the creation process, the user uses the phone's NFC to read the physical ID card and complete face authentication, and then the resident identification system sends the eID information to the phone's Secure Element for storage.

The data processing of the whole process on the terminal is carried out in the independent trusted execution environment (HTEE) and Secure Element. The process follows Honor's standard procedures for eID, providing life cycle management of eID on the terminal side, and offering the user a convenient and safe digital identification service. Honor's eID solution provides strong end-to-end security protection for the creation, download, use, and cancellation processes based on eSE Secure Element, HTEE security OS, and local biometric technology.

Independent secure storage chip*

Some of Honor's products use a secure storage chip that is independent of the main chip. The chip meets the hardware-grade CC EAL5+ security

standard and has independent memory, permanent storage media, processor, hardware encryption and decryption engine, and software system to further enhance the protection of lock screen password verification, biometric data, and activation lock data to protect users' data security.

The HTEE uses Secure Channel Protocol (SCP) and shared key pairs for secure communication between the controller program and the secure storage chip. The key pair is pre-set during the production of the device using the Hardware Unique Key (HUK) of the main chip and injected into the secure storage chip through the HTEE to achieve a one-to-one binding between the secure storage chip and the main chip, avoiding the security risks associated with chip replacement and removal.

The communication keys used by the secure channel protocol are derived at the establishment of the communication by randomly generated factors and the key pair to prevent compromise.

*Note: This function is available only for certain chip models.

3 Trusted Execution Environment (TEE)

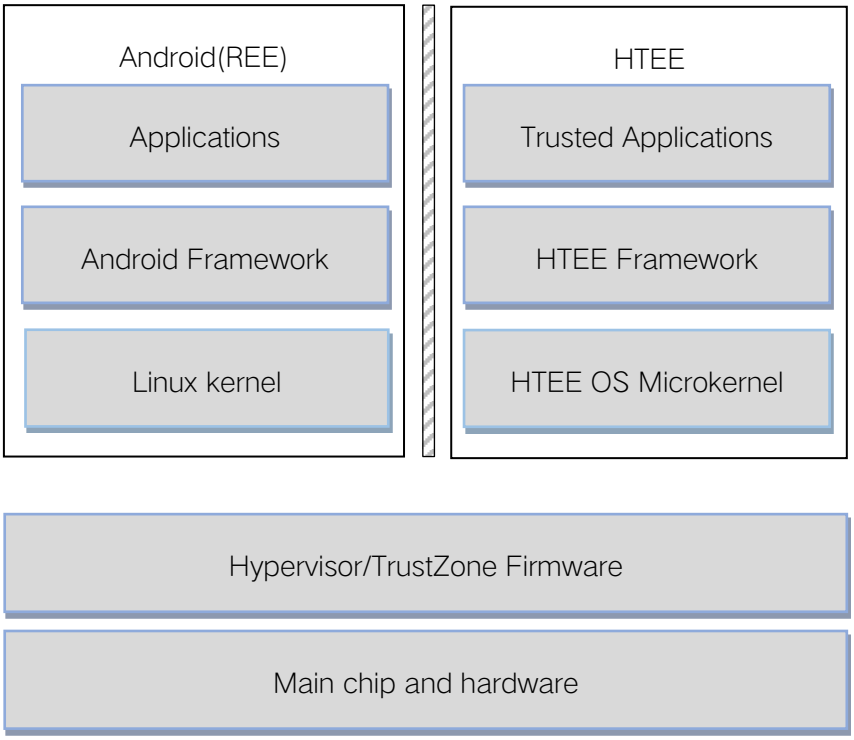
Honor provides a TEE in compliance with Global Platform (GP) TEE specifications. It is a secure OS independently developed by Honor based on the formal microkernel, and features high security, performance, scalability, and stability.

Honor Trusted Execution Environment(HTEE)

HTEE is a trusted execution environment implemented by Honor based on the microkernel technology. It includes a secure OS kernel, framework layer and trusted system core applications, and is built on TrustZone and virtualization technology. TrustZone enables hardware-level security and balances performance, security, and cost. This technology allows CPUs to operate in a TEE or an REE. Special instructions are used to switch a CPU between the TEE and REE, in order to provide hardware isolation. A TEE protects and isolates hardware resources, such as memory and

peripherals. End-to-end security is achieved by protecting the execution process, key confidentiality, data integrity, and access permissions, which prevents malware attacks from an REE.

Hypervisor virtualization is a widely used technology. Virtualization allows for the isolation of virtual machines running on the same physical core. This allows multiple execution environments to share the same hardware environment. For chips with ARM architecture, Hypervisor runs at the EL2 exception level. Only software running at the EL2 exception level or higher can access and configure various virtualization features. HTEE runs in a VM, which is isolated from other VMs and communicates with other VMs through Hypervisor.



*Note: Some product models use a TEE provided by the main chip manufacturer that may differ from the Honor HTEE in function and specification.

Microkernel

HTEE utilizes microkernel technology, which simplifies kernel functions and adopts a modular design to implement more system services outside the kernel. The microkernel provides only the most basic services, with

system services remaining in user mode for most of the time. On-demand scaling improves system performance and reduces the attack surface. Fine-grained permission design is enhanced, allowing the HTEE to have the following advantages:

Good scalability: A unified security kernel is built for distributed devices, allowing heterogeneous devices to support various services, such as multi-core, on-demand concurrency, and large- and small-core scheduling.

Easy to implement and debug: Stable underlying library interfaces facilitate application development and porting, as well as supporting the development of the security service ecosystem.

Formal Verification

HTEE uses formal verification to improve the TEE kernel's system security level significantly, thus building trust and security. Formal verification uses mathematical theorems to verify system correctness (without vulnerabilities) from the source. Conventional verification methods (such as function verification and attack simulation) apply only to limited scenarios, while formal verification can use data models to verify all software running paths. This process verifies the correctness of core modules, core APIs, and high-level mechanisms, such as process isolation and permission management, preventing data race and memory access errors.

HTEE is constantly working toward a TEE without vulnerabilities to provide higher security assurance for products.

In addition, the HTEE implements comprehensive security hardening for REE-side systems, channels, and authentication as well as TEE-side systems, and uses kill-chain-based security defense techniques to enhance system security, such as image anti-reverse engineering, system anti-intrusion, and data anti-damage. For example, anti-reverse engineering is used to prevent attacks in the intrusion preparation phase by encrypting images. Image encryption is enabled in the chip delivery phase to prevent reverse engineering attacks. Anti-intrusion encrypts authentication information and strictly authenticates REE-TEE

communication sessions to ensure that TEE data from the REE is intact and trusted. Anti-attack uses control flow protection, stack canary, and other techniques to defend against common kernel vulnerability exploits.

HTEE also builds proactive defense capabilities to identify abnormal program behavior and REE-side system exceptions, enabling security responses to be made in advance and protecting sensitive information.

The HTEE secure OS ensures the safe running of security apps by providing a TEE, thereby safeguarding security services. Major security services are as follows:

Content protection	Applies to the digital rights management (DRM) field to ensure security and anti-copy during playback.
Mobile payment	Ensures the security of input information and can be used together with Near Field Communication (NFC). HTEE protects user input information against theft from malicious programs.
Application logic protection	Protects critical application logic from being stolen or tampered with.

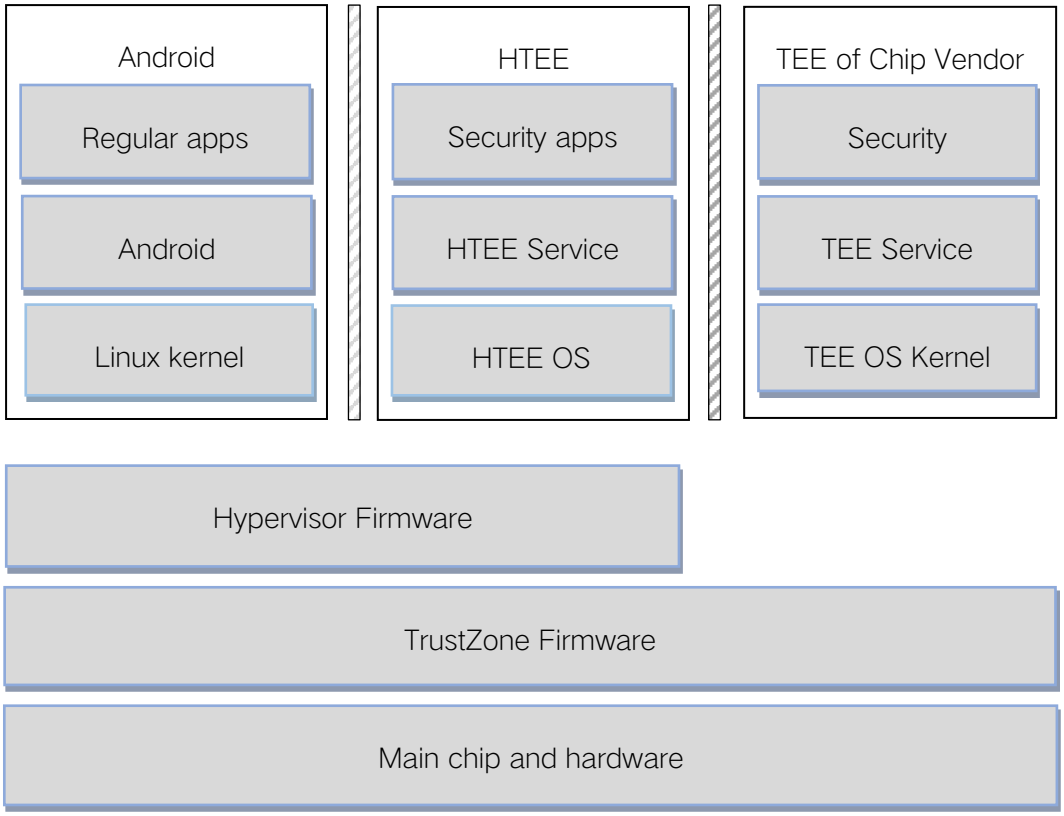
As an example, Magic UI provides a TEE to protect the security of services on Honor mobile phones, such as fingerprint/face unlock and payment, and secure key management.

Dual TEE system

Creating a dual TEE system in some products by combining Main chip manufacturer TEE and Honor HTEE (Based on Trustzone and Hypervisor virtualization). Thus, building trustworthy system security capabilities and a friendly security ecosystem.

SoC chip vendor TEE continues to build a hardware security framework based on the chip's own core capabilities of secure boot, secure hardware (RPMB, hardware encryption engine), and key management, providing hardware-level security capabilities such as trusted storage, encryption and decryption, and file encryption.

With the ability to develop, deploy manage, and maintain security applications throughout their entire life cycles and basic capabilities such as formal verification, multi-core multi-threading, and encryption, HTEE can achieve rapid integration of existing security services and continuous expansion.



*Note: the dual TEE feature is only available for certain chip models.

HTEE supports the following basic security capabilities:

Trusted Storage Service

Trusted storage of HTEE secure OS is classified into two types: SFS and RPMB. An SFS stores ciphertext to a specific secure storage partition, and an RPMB stores ciphertext to a specific storage area of the NAND Flash. The RPMB supports anti-deletion and anti-rollback. Trusted Storage supports device binding and isolation between different security applications. Each security application can only access its own stored content and cannot open, delete or tamper with the data of other applications.

The Secure File System (SFS) based on HTEE Secure OS provides critical data storage protection capabilities. It can be used to store information such as keys, certificates, personal privacy data, and fingerprint templates to ensure confidentiality, integrity, atomicity, isolation, etc.

The TA (Trusted Application) running in HTEE can encrypt data and store it in the secure file system through the secure storage API. Encrypted data can only be accessed by the TA itself and not by external applications.

The secure storage uses AES256 hardware encryption/decryption and is compatible with the GP TEE standard specification. The key of the secure storage is derived through the unique key of the device and does not go out of the TEE secure zone. Data encrypted by the key cannot be decrypted outside the secure zone.

Magic UI further provides a Flash-based RPMB (Replay Protected Memory Block) partitioning feature to protect critical system data from unauthorized deletion and access. RPMB is directly managed by HTEE for security, the access authentication key of RPMB is bound with the unique key of the device. As an API is not provided at REE side, only HTEE can access the protect contents of the RPMB partition. RPMB data is protected by built-in counters/keys and HMAC verification to prevent replay attacks and ensure that the data is not maliciously overwritten or tampered with.

Encryption/Decryption Service

HTEE supports multiple symmetric and asymmetric encryption and decryption algorithms, as well as key derivation algorithms. It supports the same key derived on a chip platform, HUK, keys derived of hardware based on secure elements, and international standard cryptographic algorithms. It also provides support for third-party development of service TAs that store and use keys, and complies with GP TEE specifications.

To improve security, key generation and calculation in HTEE is implemented by independent hardware chips. Keys are stored in a separate secure storage chip or in a secure storage space that is strictly encrypted. Users can develop TAs based on service needs to use the trusted key service.

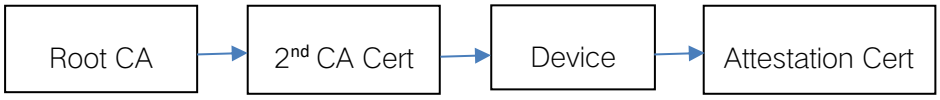
Device Attestation

To ensure that Magic UI devices are trusted, device certificates and public-private key pairs are already provisioned during the production stage. Device certificates and public-private key pairs are different for each device and are used to identify the device. The certificates and keys are written to TEE and then encrypted and stored. This information can only be accessed through the Honor key management service.

Device certificates are issued by the Honor PKI system and contains a three-level certificate chain as follows.

If the device, user or account needs to be verified for services with high security requirements such as payment and account management, the corresponding certificates (also called Attestation certificates) can be issued by the device certificate and private key to form a certificate chain. Operations can only be executed after verification, ensuring that only trusted devices can carry out the corresponding operations.

The service certificate is issued in the TEE through the device certificate, which contains a four-stage certificate chain as follows. An operation can only proceed if device legitimacy is proven by simultaneously passing the four-stage certification chain and the signature verification.



Trusted Display and Input (TUI)

In app environments in the REE, the displayed payment amounts or input passwords may be hijacked by malicious apps. To counter such threats, HTEE provides the Trusted UI (TUI) display technology (compliant with GP standards) that disables screenshots to protect content displayed by TAs, and prohibits access from the REE side. In this way, the TUI prevents the hijacking and tampering of displayed data and input by malicious apps, so that such apps cannot view information on the screen or access the touchscreen.

The TUI ensures that the information displayed to users is not intercepted, modified, or obstructed by any software in the REE or unauthorized apps in the TEE. Displayed information is not transferred to the REE, and permission control is used to ensure that only authorized TEE apps can access the information. In the TUI, preset images or texts are displayed to indicate the secure display and input state.

The TUI supports basic controls such as PNG images, texts, buttons, and text input boxes, display of Chinese characters, English letters, symbols, and digits in the same size, customized UI, randomized keypad, and various controls and window management. In addition, the UI is consistent in style with Magic UI.

*Note: The TUI feature is available only for certain chip models.

4 System Security

System security aims to ensure that Magic UI devices leverage the security capabilities of hardware chips to provide basic hardware-based software security capabilities for apps running on the Magic UI system. Magic UI builds system security capabilities primarily from the following aspects:

- Integrity protection: This is the basis of system security, ensuring that trusted system software provided by vendors is running at initial device operation. In addition, Honor Kernel Integrity Protection (HKIP) and the Integrity Measurement Architecture are used to ensure that the kernel is not maliciously compromised during runtime and that any compromised system is promptly detected.
- System software update: When the system becomes faulty or maliciously compromised, the minimum system can be used to perform security update of the system software. Only authentic system software can be used for device updates.
- Kernel vulnerability anti-exploitation: At runtime, the system faces the risk of malicious exploitation of kernel vulnerabilities. If the kernel is compromised, the system cannot provide basic protection for upper-layer apps, and confidential data of apps may be disclosed. For this reason, multiple kernel vulnerability anti-exploitation technologies are needed in different scenarios. For example, Kernel Address Space Layout Randomization (KASLR) can ensure that vulnerabilities are not discovered at the kernel's runtime. Even if vulnerabilities are discovered, exploitation can be prevented using Privileged Access Never (PAN)/Privileged eXecute Never (PXN) and Control Flow Integrity (CFI).
- Mandatory access control (MAC): After a secure and trusted system kernel base is built using the preceding four technologies, MAC can be used for the kernel, defining policy rules for different apps in the system to properly use different resources, ensuring that the entire system provides basic security capabilities for upper-layer apps.

- Identity Authentication: Magic UI provides two biometric identification capabilities: fingerprint recognition and facial recognition. That is, Magic UI uses the unique physiological features (fingerprint and facial features) to authenticate personal identities. These capabilities can be applied to identity authentication scenarios such as device unlocking, payment, and app login.

Integrity Protection

Honor Kernel Integrity Protection(HKIP)

Although secure boot and verified boot ensure the authenticity and integrity of software during startup, vulnerabilities in authentic code may still be exploited by attackers. HKIP uses the hypervisor mode provided by the ARMv8 processor to protect the kernel, preventing key system registers, page tables, and code from being tampered with. This protects system integrity and prevents privilege escalation during system runtime. HKIP protects not only static data such as code and read-only data segments, but also some dynamic data using the write-rare protection mechanism. HKIP uses this mechanism to secure kernel data that is read most of the time but rarely modified. Even if attackers exploit vulnerabilities to write the memory at the kernel level, they cannot modify the protected data.

Currently, HKIP supports the following security protection mechanisms:

- Code snippets of the kernel and driver module cannot be tampered with.
- Read-only data of the kernel and driver module cannot be tampered with.
- Non-code snippets of the kernel cannot be executed.
- Critical dynamic kernel data cannot be tampered with.
- Critical system register settings cannot be tampered with.

*Note: This function is available only for certain MTK chip models.

Integrity Measurement Architecture

Honor Integrity Measurement Architecture measures and detects the integrity of critical code and resource files of the system, and provides a system integrity measurement framework. This framework offers a unified service for measuring the integrity of critical system components or processes, and addresses runtime measurement as well as dynamic measurement of user-mode processes. This detects whether protected processes have been maliciously tampered with so that handling policies can be provided. The integrity measurement framework consists of three parts:

1. Baseline extraction

The goal of baseline extraction is to generate static baseline metrics for software programs to be protected. Target files are hashed to generate baseline metrics. Two generation modes are available:

- Offline generation: Baseline metrics are calculated during the build process, and are protected by a private key signature and built into the software image version.
- Runtime generation: It is assumed that secure boot can ensure the validity of files. Baseline metrics are generated when target programs are loaded for the first time.

2. Static measurement

The integrity of a file means that its content or attributes have not been modified. From a cryptography point of view, the hash value of a file can be used to detect whether the file has been tampered with. Therefore, the hash values of measured objects are collected to determine the integrity of programs or data instances during memory loading.

3. Runtime measurement

In the measurement evaluation phase, the baseline metrics are compared with the measurement data collected during system operation to determine whether the programs running are consistent with the baseline

metrics. The integrity check result is provided, and service-specific decision makers then determine subsequent handling policies.

*Notes: This feature is only available on products using the MTK chip platform.

System Software Update

Magic UI supports over the air (OTA) update in order to quickly fix some defects or deliver some new features and services. The security protection process in system software updates is as follows.

The signature of an update package is verified during system software updates. Only verified update packages are considered authentic and can be installed.

In addition, the Magic UI provides software update control. At the beginning of OTA update and after a software package is downloaded, Magic UI applies for update authorization by sending the digest information of the device identifier, the version number and hash value of the update package, and the device upgrade token to the OTA server. The OTA server verifies the digest before authorization. If the digest verification succeeds, the OTA server signs the digest and returns it to the device. The upgrade can be implemented only after the device passes the signature verification. If the device fails the signature verification, an upgrade failure is displayed to prevent unauthorized software updates, especially updates using vulnerable software.

Magic UI periodically releases security patches. After the system is upgraded, required security patches are automatically updated to ensure the security of the Magic UI system. For more information about software security updates, visit https://www.hihonor.com/cn/support/bulletin/

Kernel Vulnerability Anti-exploitation

Kernel Address Space Layout Randomization(KASLR)

In a code reuse attack, a specific jump address must be determined for reused code. KASLR enables the address mapped to the kernel image to

have an offset relative to the link address, and this offset address is randomly generated upon each boot. As a result, the virtual address mapped to the kernel image varies with each boot. KASLR enables unpredictable address space layout, and makes it more difficult to launch code reuse attacks, thereby enhancing the security of the system kernel.

Privileged Access/eXecute Never(PAN/PXN)

Magic UI supports ARMv8-based PAN and PXN for security protection of kernels. These technologies prevent the kernel from accessing user space data and executing user space code.

Using some kernel attack methods, an attacker tampers with the data pointer in the data structure used by kernel so that it points to the data structure that the attacker prepared in user mode, which launches an attack by affecting kernel behavior. PAN prevents the kernel from accessing user-mode data, thereby preventing such attacks.

Using some kernel attack methods, an attacker can tamper with the code pointer in some data structures used by kernel so that the pointer can be redirected to the privilege escalation code in user mode, and executed by using system call. PXN prevents the kernel from directly executing user-mode code, thereby preventing such attacks.

Control Flow Integrity(CFI)

Return-oriented programming (ROP) and jump-oriented programming (JOP) are attack means to redirect program control flows to the code snippets of existing programs by exploiting program vulnerabilities. Attackers combine these code snippets to implement complete attack behavior.

A common method for implementing ROP/JOP attacks is to exploit a program vulnerability to overwrite a function pointer stored in memory. Therefore, a targeted check can be performed. CFI adds additional checks to confirm that control flows stay within the preset scope, in order to mitigate ROP/JOP attacks. If undefined behavior is detected in a program, the program execution is discarded. Although CFI cannot

prevent attackers from exploiting known vulnerabilities or even rewriting function pointers, it can strictly limit the scope of targets that can be effectively called, making it more difficult for attackers to exploit vulnerabilities.

Magic UI uses Clang CFI, stack protection technologies, and PA/BTI to reduce ROP/JOP attack threats to the kernel.

- CFI adds a check before each indirect branch to verify the validity of the target address and prevent an indirect branch from jumping to an arbitrary code location.
- The compiler supports link-time optimization (LTO) to determine all valid call targets for each indirect branch.
- Kernel modules can be loaded at runtime. Cross dynamic shared object (cross-DSO) can be enabled in compilation so that each kernel module contains information about valid local branch targets and the kernel looks up information from the correct module based on the target address and the modules' memory layout.
- Magic UI checks the stack layout when the function runs to the end and exits to prevent attackers from exploiting the overflow vulnerability to modify the return address.
- Pointer Authentication (PA)/Branch Target Identification (BTI) are hardware-based ROP/JOP attack mitigation measures. PA provides signature and signature verification for pointers to ensure the integrity of pointers. BTI restricts the target of function jumps to ensure the integrity of jump targets.

*Note: PA/BTI is chip-dependent and is only available on some products.

Mandatory Access Control(MAC)

Magic UI supports the SELinux feature. When a device is started, MAC policies are loaded to the system kernel and cannot be dynamically changed. This feature applies MAC to all processes when they access resources such as directories, files, and device nodes, and applies root-capability-based MAC to local processes with the root permission. This prevents malicious processes from reading and writing protected data or attacking other processes and limits the system impact of processes that

are maliciously tampered with to a local scale, providing strong support for the security defense of upper-layer apps.

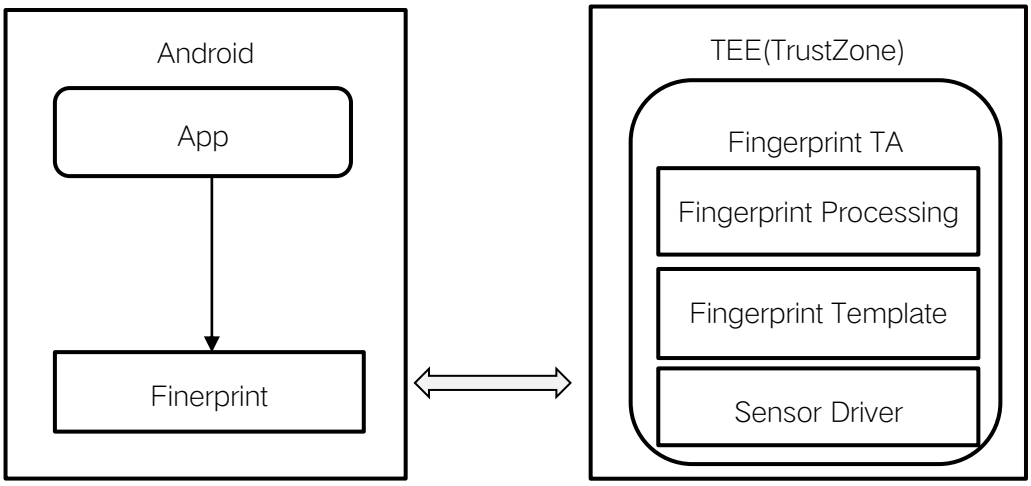
Magic UI also supports the secure computing (seccomp) feature that restricts the system calls that can be invoked by upper-layer application processes based on the rule files in the read-only file systems, preventing malicious apps from using sensitive system calls to compromise the system.

Identity Authentication

Fingerprint Recognition

Magic UI provides two fingerprint recognition modes: capacitive and optical. Both modes have similar recognition capabilities (recognition rate and anti-counterfeiting rate). Capacitive fingerprint recognition is applicable to devices with external fingerprint sensors, while optical fingerprint recognition is applicable to devices with under-display fingerprint sensors.

The following figure shows Magic UI's fingerprint recognition security framework.



Magic UI establishes a secure channel between a fingerprint sensor and TEE. Fingerprint information is transmitted to TEE through this secure channel, and the REE cannot obtain the information. Magic UI collects fingerprint image information, extracts features, detects live fingers, and

compares features in TEE and performs security isolation based on the TrustZone. The REE fingerprint framework is only responsible for fingerprint authentication initiation and authentication result data, and does not involve fingerprint data.

Fingerprint feature data is stored in the TEE secure storage, and data encryption and integrity protection are implemented using high-strength cryptographic algorithms. The key for encrypting fingerprint data cannot be obtained externally, ensuring that fingerprint data is not leaked. No external third-party app can obtain fingerprint data or transfer such data outside of TEE. Magic UI does not send or back up any fingerprint data to any external storage media including the cloud.

Magic UI's fingerprint recognition supports the anti-brute force cracking mechanism. If the fingerprints of a user fail to be identified five consecutive times in the screen-on state, fingerprint recognition will be disabled for 30 seconds. In the screen-off state, fingerprint recognition is disabled for 30 seconds after 10 consecutive failed fingerprint recognition attempts. If a user fails fingerprint recognition 20 consecutive times, the user must enter the password to unlock his/her device.

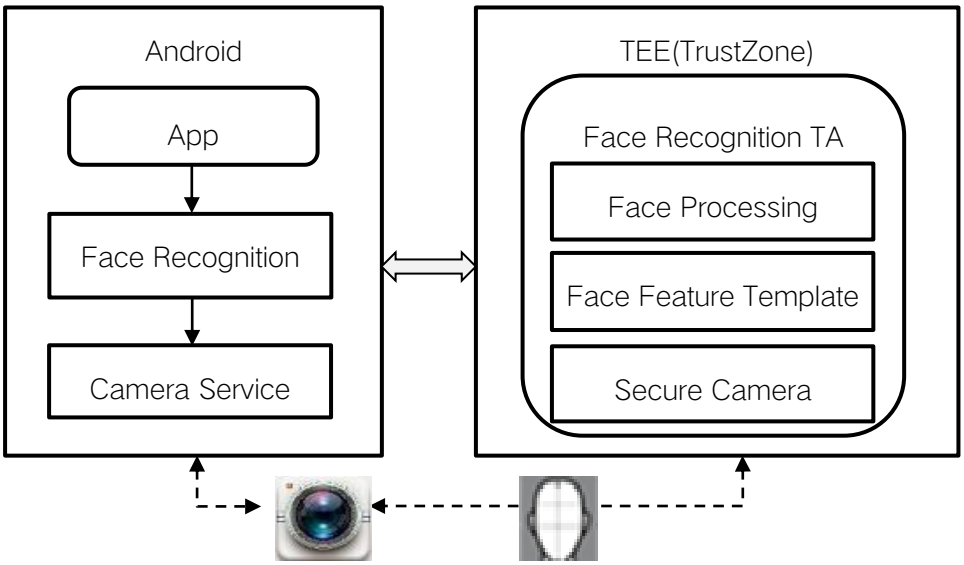
Dirty or damaged fingerprint sensors, dirty or wet fingers, and other external factors may affect the recognition rate, and should be avoided.

Fingerprint recognition facilitates identity recognition, but users may easily forget their lock screen passwords. Currently, if a user does not use his/her unlock password within 72 hours, the user is compelled to enter the password to unlock the screen, in order to reduce the likelihood of a forgotten password.

Facial Recognition*

Magic UI provides two types of facial recognition capabilities: 2D and 3D. Only devices with 3D face recognition capabilities can use this technology. The recognition rate and anti-counterfeiting capability of 3D face recognition are better than those of 2D face recognition. 3D face recognition can be applied to payment scenarios.

The following figure shows Magic UI's facial recognition security framework.



Magic UI establishes a secure channel between the camera and TEE. Face image information is transmitted to TEE through this secure channel, and the REE cannot obtain the information. Magic UI collects face images, extracts features, detects live faces, and compares features in TEE, and performs security isolation based on the TrustZone. The external facial framework is only responsible for facial authentication initiation and authentication result data, and does not involve facial data.

Facial feature data is stored in the TEE secure storage, and data encryption/decryption and integrity protection are implemented using high-strength cryptographic algorithms. The key for encrypting facial feature data cannot be obtained externally, ensuring that facial feature data is not leaked. No external third-party app can obtain facial feature data or transfer such data outside of TEE. Maigic UI does not send or back up facial data (either encrypted or unencrypted) to any external storage media including the cloud.

Magic UI's facial recognition supports the anti-brute force cracking mechanism. If the face of a user fails to be identified five consecutive times, the user must enter his/her password to unlock the screen.

The facial recognition rate is different for twins and siblings who are similar in appearance, as well as children under 13 years of age.

Fingerprint recognition or password authentication can be used in such cases.

Face recognition facilitates identity recognition, but users may easily forget their lock screen passwords. Currently, if a user does not use his/her unlock password within 72 hours, the user is compelled to enter the password to unlock the screen, in order to reduce the likelihood of a forgotten password.

*Note: 3D face recognition is only available on certain product models.

In products that support independent secure storage chip, the face and fingerprint template data recorded by the user in the device are encrypted by a double encryption mechanism, based on the HUK of the main chip and the key stored in the secure storage chip in the HTEE.

5 Data Security

This chapter describes Magic UI data security protection. The Magic UI file system is divided into a system partition and a user partition. The system partition is read-only, isolated from the user partition, and inaccessible from common apps. For data stored in the user partition, the system provides file-based data encryption and directory permission management to restrict data access between apps. Magic UI provides various mechanisms for critical data in the user partition to ensure the secure storage, use, and destruction of highly sensitive user data. Such mechanisms include lock screen password protection, secure storage of critical asset, secure erasure, and password vault. In addition, Magic UI provides app developers with HUKS framework capabilities, which facilitates application developers to store application keys and digital certificates securely, and securely use key encryption to protect confidential data in applications.

Honor Universal Keystore

Honor Universal Keystore(HUKS) is a key and certificate management system based on Java Cryptography Architecture/Extension (JCA/JCE) in

Magic UI, and provides keystore and crypto APIs for apps, including key management, symmetric/asymmetric encryption and decryption, certificate management, and other functions. It provides device authenticity verification based on device certificates. The cloud server can authenticate Magic UI devices through certificate authentication. In combination with biometric authentication, the HUKS can provide services such as login and payment with TEE security for payment apps.

HUKS managed keys and certificates are stored in the TEE, and all keys are protected by AES_256_GCM encryption based on hardware unique keys. When the key is used, the plaintext of the key is decrypted in the TEE before the data encryption and decryption operation, the plaintext of the key does not leave the TEE and the encryption and decryption process is protected by the TEE.

HUKS enforces strict access control over the use of keys. During key generation, HUKS records the UID (User ID, assigned by the system when the application is installed), signature, package name and other identity information of the application. When the application uses the key, HUKS first verifies the application's identity information and allows the application to use it only after the verification is passed.

HUKS supports enhanced key access control using biometric features (fingerprint/face recognition, etc.), and HUKS confirms biometric results before allowing applications to access and operate on the corresponding keys.

The HUKS also provides a key attestation function. A unique device certificate is written to each unit during manufacture. In the TEE, HUKS uses the device key and certificate to issue a key authentication certificate for the application key (see the device attestation chapter for details)

Lock Screen Password Protection

Magic UI allows lock screen passwords with six digits (default), four digits, an unfixed number of (four or more) digits, an unfixed number of

(four or more) hybrid characters, and patterns. After a user sets a lock screen password, the password can be used to unlock the device and provide entropy for the file system encryption key. This means that even if an attacker obtains a device, the attacker cannot access data protected by the lock screen password entropy without a screen lock password.

Magic UI increases the password attempt interval upon input of each incorrect password to prevent password brute forcing. A longer password and more character types indicate longer time needed to attempt all combinations.

Lock screen passwords are protected using the HUK. When a user creates or modifies a lock screen password, or unlocks the screen using the lock screen password for verification, the lock screen password is processed in TEE. This means that brute force cracking attempts can only be made on attacked devices. If a lock screen password contains six digits and letters, it will take 8 years to attempt all possible combinations using brute force cracking, even if the attempt interval increase is not considered. Even if the system beyond TEE is compromised, the lock screen password will still remain protected.

For products with a separate secure storage chip, the protection of the lock screen password verification process is enhanced by carrying out the lock screen password verification and anti-violence cracking mechanism (continuous error count and attempt interval timing) in the secure storage chip. Only after the password verification is passed, the controller program in the HTEE can obtain the material from the secure storage chip for key-derivation and decryption of the encrypted file, thus ensuring the security of user data.

Data Encryption

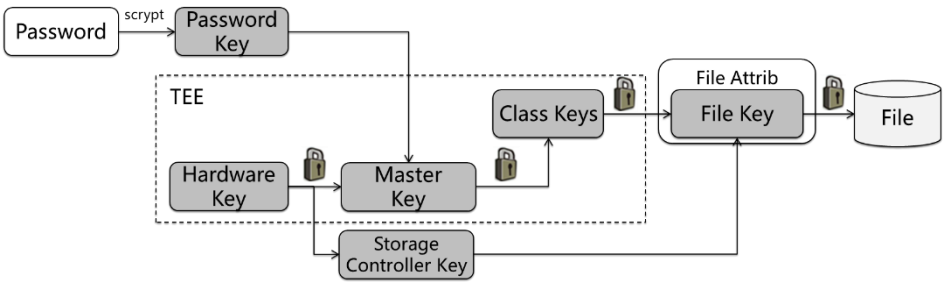
File encryption

Magic UI provide file-based encryption file system, based on the Linux Fscrypt frawework and hardware encryption engine, and use XTS-AES 256 algorithem to encrypt data in storage.

To ensure the security of user data and application experience, Magic UI provides the following data encryption solutions:

1. Credential encryption (CE): Apps use this type of data encryption solution by default. In this type of solution, file encryption class keys are linked to the lock screen password and are protected by using both the lock screen password and HUK. CE-protected data is accessible only after an Magic UI device is unlocked for the first time. Since data encryption is linked with the user's lock screen password, the device's data will not be decryptable if the password is forgotten. Therefore, it is recommended that users should protect their passwords and backup their data.

2. Device encryption (DE): DE-protected data, such as wallpapers, alarm clocks, and ringtones, can be accessible after the device is powered on, independent of whether the device is locked or not. DE-based class keys are protected using the HUK and irrelevant to the lock screen password.



File encryption key protection

Secure Storage of Critical Asset

Some apps may process short sensitive data, such as user passwords and authentication credentials. It is complex to store this type of data in a file system. Such data can be stored in the secure storage. The critical asset secure storage service provides security for this data and fine-grained access control to the data.

Encrypted critical asset (ciphertext) is protected using the HUK and app identity. Decryption and encryption are performed in the TEE, and the key for encrypting data is stored in the TEE. A single piece of ciphertext is

protected in AES_256_CCM mode, and batch ciphertext is protected in AES_256_CBC mode.

Two types of critical asset can be stored in the secure storage:

- Sensitive data: Sensitive data of key assets, e.g., users can save their account numbers and passwords to log in to applications quickly.
- Authentication credentials: authentication credentials or tokens, which are usually the credentials for an app to use a service. For example, when an app connects to a server, the token is used for session validation.

The secure storage service verifies the signature, package name, system assigned UID, and other information of the app that queries the stored data, in order to verify the access permission and ensure access security.

Secure Erasure

Normal factory restore operations cannot ensure that all data stored on physical storage is completely deleted. While logical addresses are usually deleted for efficiency, this method does not clear the physical address space, and the data can often be restored.

In factory restoration, Magic UI erases stored data securely. An overwrite command is sent to the physical storage to erase the data. Erased data is all 0s or all 1s. This ensures that sensitive user data cannot be restored using software or hardware means, and protects data security if devices are resold or abandoned. Meeting NIST SP800-88 requirements.

Password Vault

An ever-increasing number of apps are becoming available, and logins to these apps require user names and passwords, which can be forgotten at any time. A password vault is provided to store user app login information (user names and passwords) and associate the login information with relevant face IDs, touch fingerprints, or lock screen passwords so that the password vault automatically fills in a user's user name and password for login.

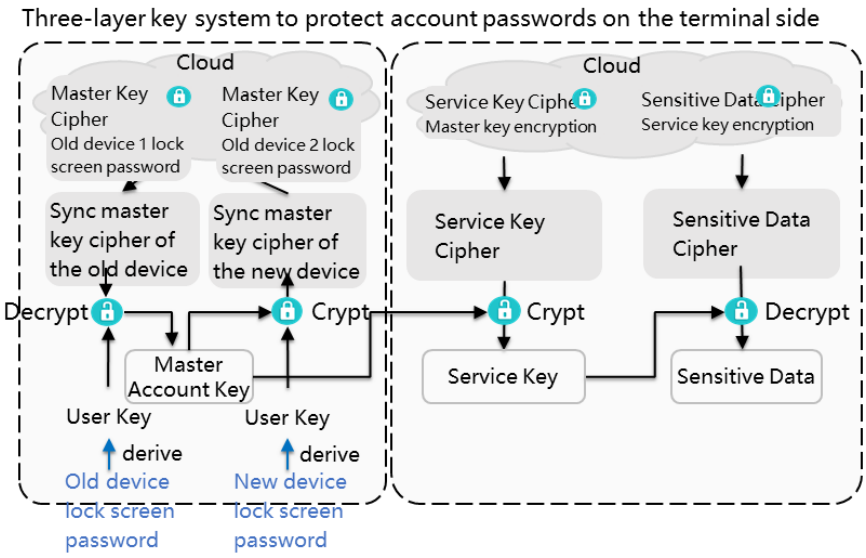
The password vault stores encrypted app accounts and passwords in the SQLite database of the file system on a device, providing hardware-level encryption and storage capabilities. The passwords are encrypted using AES_256_CCM. The encryption key is protected by TEE, and encryption/decryption is always performed in TEE.

Currently, the account and password data stored in the password vault can be encrypted and transferred between Honor devices that support the password vault through Device Clone (password vault clone is available only to the devices with Honor PKI certificate). Alternatively, users can backup and restore password data with a PC backup software.

The password vault data transmitted in the Device Clone process is encrypted using AES_256_CBC. The encryption key is obtained through key exchange using the asymmetric key generated by two phones in TEE. Key exchange is performed in TEE, which also protects the obtained clone encryption key. Encryption and decryption are performed in the REE, facilitating the quick execution of the clone operation for password vault data.

The password vault data transmitted in the PC-based backup process is also encrypted using AES_256_CBC, and the encryption key is derived from the hardware unique key(HUK). A device's backup data on a PC cannot be restored on other devices.

Starting with Magic UI 6.0, you can automatically sync your account and password to other devices logged in to your HONOR ID via HONOR Cloud. Your information will be encrypted and unreadable by others as well as Honor. Honor protects your information with end-to-end encryption to provide the highest level of data security. Your data is protected by a key generated from information unique to your device and a device password that only you know. Neither other persons nor Honor can access or read this data, and it is encrypted in transit or storage.



6 App Security

This chapter focuses on the security mechanisms for apps on Magic UI. Apps can be obtained from various channels, which can sometimes result in users downloading malicious apps. If not properly handled, malicious apps may compromise the security and stability of the system and present security risks to personal user data, and even personal property.

Magic UI provides a complete set of app security solutions to enable a secure environment for apps:

- During app installation, the signature verification mechanism prevents apps from being maliciously tampered with. The system will perform threat detection when an app is installed (e.g., virus, malware scan) and alerts the user if a risk is identified.
- When an app is running, app sandbox, runtime memory protection, secure input, and other mechanisms are used to prevent data generated in the app from being maliciously read by unauthorized apps, in order to prevent user data breaches.

Application Signature Verification

Only apps with complete signatures can be installed in Magic UI. App signatures can be used to verify the integrity and source legitimacy of apps. The system verifies the signature of an app to check whether it has been tampered with before installing the app. Apps that fail verification cannot be installed.

The system also verifies app signatures before updating pre-installed or user-installed apps. Such an app can only be updated when the signature of the target version is the same as the existing signature. This prevents malicious apps from taking the place of existing ones.

Magic UI supports the following three Android V1/V2/V3 application signature verification methods:

- Android V1 signature format - a JAR package based signature scheme. Since V1 signature scheme does not protect the ZIP metadata of APK, using V1 signature alone on the latest Android systems is not recommended.
- Android V2 signature format - a full-file signing scheme introduced after Android 7.0, is able to discover all changes made to protected parts of the APK (including ZIP central directory, end of central directory record and file data), thus helping to speed up verification and enhance integrity assurance. When using application signature scheme V2, an APK signature chunk will be inserted in the APK file. V2 signature and signer identity information will be stored in the application signature scheme V2 chunk. This can prevent attackers from forging V2 signature into V1 signature for verification.
- Android V3 signature format - a signature scheme introduced after Android version 9 that supports application key rotation. It enables applications to change their signature keys during application updates and upgrades.

New signature formats are backward compatible in V1/V2/V3. Magic UI verify app signatures according to API level information and markers in the signature chunk. Apps intended for Android 11 (API level 30) must be signed using signature scheme v2 or higher.

App Sandbox

Magic UI provides a sandbox mechanism. This mechanism enables all apps to run in isolation within the sandbox in order to ensure runtime security. When an app is installed, the system allocates a private storage directory to the app which cannot be accessed by other apps, ensuring static data security. Sandbox isolation technology protects the system and apps from malicious attacks.

The system allocates a unique UID to each app and builds the app sandbox based on UID. The sandbox provides multiple kernel access control mechanisms, such as discretionary access control (DAC) and

MAC, to restrict apps from accessing files and resources outside the sandbox. By default, all apps are sandboxed. To access information outside the sandbox, an app needs to use services provided by the system or open interfaces of other apps and obtain required permissions. The system will prevent access if an app does not have required permissions.

Apps with the same signature can share a UID, and share code and data in the same sandbox.

Mandatory partitioned storage

To allow users to better manage their files and reduce clutter, apps intended for Magic UI 4.0 (Android API level 29) and higher are given partitioned access to external storage (i.e. partitioned storage) by default. Each app can only access specific directories on external storage allocated by the system, as well as specific types of media files created by this app. To ensure data security, app-specific directories will not be accessible to other apps.

Runtime Protection

Malicious apps usually obtain memory addresses by viewing the memory if the allocated memory addresses are relatively fixed during app operation. Magic UI provides Address space layout randomization (ASLR) and secure computing mode (Seccomp) to address this issue.

ASLR is a security technique used to prevent the exploit of buffer overflow vulnerabilities. It randomizes the layout of linear areas such as heaps, stacks, and shared libraries, making it harder for attackers to predict target addresses and preventing them from locating attack code, which leads to reduced overflow attacks.

Seccomp can control the scope of system calls that can be executed by app processes and prevent processes not within scope from executing. This can effectively prevent the attacks that are executed against the process due to the vulnerability of some system calls.

App lock

App Lock protects the app entrance and prevents private information in the app from being disclosed Magic UI users can enable app lock by going to Settings > Security > App Lock, then set the app lock password and select the apps that need to be locked. After App lock is enabled, users will have to be authenticated (using password, fingerprint, face, etc.) before launching a locked app. When an app is locked, its thumbnail in the recent tasks list is also protected to prevent snooping.

Secure Input*

Magic UI provides secure input when users are entering passwords. Once secure input is enabled, the system will automatically switch to secure input when a user enters a password. Secure input and common input are managed separately. To safeguard user passwords, secure input does not remember or predict any entered passwords. It cannot connect to the Internet or collect user passwords. After secure input is enabled, screen recording cannot be performed in the backend, and no third-party apps can capture screenshots.

*Note: Third-party input methods will be used in some apps for entering passwords and secure input does not take effect in such cases.

App Threat Detection

Security threats may exist in apps as a result of unknown third parties, and downloading apps from unverified sources can introduce malicious threats. Magic UI can check whether app sources are legitimate during app installation. By default, apps from unknown third parties cannot be installed. It is recommended that default security settings be retained to prevent unnecessary risks.

Magic UI has an industry-leading built-in antivirus engine, which is used to detect viruses in user-installed apps. The antivirus engine supports local and online virus scanning and removal, to ensure that app risks are identified regardless of whether user devices are connected to the

Internet. The antivirus engine can scan viruses during app installation and in the backend. Once a virus is detected, a risk warning is reported to the user, prompting them to handle the virus.

Malicious URL detection*

Magic UI can detect phishing or malicious URLs in scenarios such as SMS and QR code scanning. It can automatically identify such URL when they are received in SMS messages or scanned by the camera.

*Note: This feature is only available on some chip models in China.

Verification code

Verification messages have become one of the important authentication factors for mobile applications nowadays. However, hijacked verification messages can put user privacy or even property at risk. Magic UI is built with verification SMS protection to prevent malicious apps from intercepting user SMS and stealing verification codes to mitigate such risks.

Magic UI features an intelligent system layer SMS verification code recognition engine. Recognized verification code messages will only be distributed to the default SMS client set in Magic UI. If the default SMS client is the system SMS client, the system SMS client will encrypt and save verification code messages and screen access to prevent third-party SMS clients or apps from reading these verification code messages. Even if the SMS database is read directly, the content of verification messages is still encrypted and cannot be decrypted by other apps.

7 Network and Communication Security

Secure connections are needed when devices connect to the network. Otherwise, they may connect to or be connected to malicious sites and

leak data. This chapter focuses on Magic UI's security mechanisms for network connection and transmission, and security protection that Magic UI provides for device communication, and device interconnection for data transmission.

VPN

A VPN enables a user to establish a secure private network using public network links for secure data transmission. Magic UI supports the following VPN protocols and authentication modes:

1.Point-to-Point Tunneling Protocol (PPTP), supporting Microsoft Challenge Handshake Authentication Protocol version 2 (MS-CHAP v2) password and RSA SecurID for user authentication as well as Microsoft Point-to-Point Encryption (MPPE)

2.Layer Two Tunneling Protocol (L2TP)/IP Security (IPsec), supporting MS-CHAPv2 password, pre-shared key (PSK), and certificate authentication

3.Internet Key Exchange version 2 (IKEv2)/IPsec, supporting shared key, RSA certificate, Elliptic Curve Digital Signature Algorithm (ECDSA) certificate, Extensible Authentication Protocol MS-CHAPv2 (EAP-MSCHAPv2), or EAP Transport Layer Security (EAP-TLS) for authentication

4.IPsec Xauth PSK, IPsec Xauth RSA certificate authentication, and IPsec Hybrid RSA certificate authentication

Magic UI supports the following VPN functions:

For networks based on certificate authentication, IT policies use VPN configuration description files to specify the domains that require VPN connections.

A VPN can be configured per app, for more accurate VPN connection.

A VPN can remain enabled. A user does not need to enable the VPN manually after connecting to the network.

The VPN function can be enabled or disabled for devices managed by the MDM solution, thereby ensuring data security within an organization.

TLS

Devices support TLS v1.0, v1.1, v1.2, and v1.3. TLS is a security protocol that protects data and data integrity during communication. Application-layer protocols can run transparently over TLS. TLS is responsible for the authentication and key exchange required for creating encrypted channels. Data transmitted using application-layer protocols is encrypted when passing through TLS. This ensures the communication stays private.

A device enables TLS v1.3 by default for all TLS connections. Compared with TLS v1.2, TLS v1.3 improves performance and security (for example, by removing weak and rarely used algorithms). The TLS v1.3 encryption suite is not user-defined, and after TLS v1.3 is enabled, the supported encryption suite remains enabled and ignores any operations that attempt to disable it.

Wi-Fi Security*

Magic UI provides multiple authentication modes for users requiring different levels of security. Such authentication modes include Wi-Fi Protected Access (WPA)/Wi-Fi Protected Access 2 (WPA2) PSK, Wi-Fi Protected Access 3 (WPA3) for some products, 802.1x EAP, and WLAN Authentication and Privacy Infrastructure (WAPI).

To prevent an Magic UI device from being tracked and enhance user privacy protection, the device uses a random MAC address to scan the network before connecting to Wi-Fi.

Devices use a random MAC address by default when connecting to Wi-Fi (supported by some products as it depends on chip capabilities). If a user trusts the target network, the user can manually change the setting and use the MAC address of the device for connection.

In addition, devices also support the Wi-Fi hotspot function, which is disabled by default. Wi-Fi hotspot, once enabled, supports WPA2 PSK authentication to ensure the connections are secure.

Public Wi-Fi may be convenient, but at the same time, it may be used illegally to steal users' private data and perform phishing. This can undermine a user's privacy and even result in financial losses. Magic UI provides a Wi-Fi threat detection engine for access points. It detects Wi-Fi hotspots before connection. If any security risks are detected, it will prompt users so that they can take measures to ensure the connection is secure.

*Note: This function is only available in China.

Protection Against Fake Base Station*

Unauthorized users can obtain user location and identity information by deploying fake base stations, or send advertisements and fraud messages to users, which not only seriously interferes with a user's normal communication, but can also result in financial losses. Magic UI provides chip-level protection against fake stations. It compares and analyzes network parameter characteristics for access and reselection of fake GSM/LTE stations and network parameter characteristics of normal stations, and rejects the residence and access of identified fake stations. (Fake LTE stations can only be identified by some chip platforms.) In addition to decoding system messages, the device can identify fake stations through combined process characteristics such as fake station attack without authentication redirection. This prevents a device from camping on or accessing cells with such characteristics.

*Note: This function is only available in China.

8 Device Interconnection Security

To ensure user data flows securely between devices, the devices must be trusted by each other, that is, they must have established a trust relationship, and be able to establish a secure channel after the trust relationship is verified.

The trust relationship can be established between Magic UI devices under the same HONOR ID or between Magic UI devices and IoT devices.

Interconnection Security for Magic UI Devices Under the Same HONOR ID

Magic UI provides authentication services for devices that are logged in with the same HONOR ID. Each Magic UI device that is logged in with a HONOR ID generates a public-private key pair using elliptic curve cryptography as the device identifier, and applies for public key authentication from the Honor servers. In the device interconnection service, authenticated devices with the same HONOR ID can authenticate each other and exchange their identity public keys to verify whether each other is a trusted device. Based on the identity public-private key pair, devices logged in with the same HONOR ID can exchange keys and establish a secure communication channel. Bogus devices and devices not registered under this HONOR ID will not be authenticated.

Networking Service for Magic UI Devices Under the Same HONOR ID

The device authentication service supports trusted networking of Magic UI devices that are logged in with the same HONOR ID, including mobile phones, and tablets. When the trusted networking service is enabled on an Magic UI device, the device authentication service performs identity authentication on each nearby device that is logged in with the same HONOR ID, and negotiates the session key between devices.

When a user enables family album for continuing playing a video on another Magic UI device under the same HONOR ID, device authentication and session keys negotiation are implemented for the

device based on the trusted device networking service, and the session key is used to encrypt data transmitted between the devices.

IoT Device Interconnection Security

Magic UI supports P2P trust relationships between devices that do not have a HONOR ID login UI on themselves (such as wearable devices) and Magic UI devices (such as mobile phones and tablets), and allow devices that have established a trust relationship to establish secure connections for E2E encryption and transmission of user data.

IoT Service Identifiers of Magic UI Devices

A Magic UI device generates different identifiers for different IoT device management services to isolate these services. The identifier can be used for authentication and communication between an Magic UI device and an IoT device. Similar to the account-level device identifier generated when a HONOR ID is used to log in to the device, the IoT service identifier is also an Ed25519 public-private key pair. The key pair is generated using elliptic curve cryptography in TEE of the Magic UI device, and the plaintext private keys are not transmitted out of TEE.

IoT Device Identifiers

An IoT device can generate its own device identifier for communicating with Magic UI devices. It also uses elliptic curve cryptography to generate an Ed25519 public-private key pair, and stores its private key locally. Each time the device is restored to factory settings, the public-private key pair will be reset.

The identifier can be used for secure communication between an Magic UI device and an IoT device. After both devices authenticate the service identifier or device identifier, they can perform key negotiation and establish a secure communication channel.

P2P Trusted Binding Between Devices

An Magic UI device and an IoT device establish a P2P trust relationship by exchanging the Magic UI device's IoT service identifier and the IoT device identifier.

During this process, the user needs to enter or scan the PIN provided by the IoT device on the Magic UI device. PIN is either dynamically generated if the IoT device has a screen, or preset by the manufacturer if it does not have a screen. A PIN can be a 6-digit number or a QR code. The Magic UI and IoT devices then use the Password-Authenticated Key Exchange (PAKE) protocol for authentication and session key exchange, thereby protecting the integrity of the exchanged identifiers.

On an Magic UI device, the peer's identity public key is stored in TEE. This ensures that the trust relationship with the communication peer end cannot be tampered with.

Communication Security Between Magic UI Devices and IoT Devices

When an Magic UI device and an IoT device communicate with each other after establishing a trust relationship, they authenticate each other and exchange the session key by using the locally stored identity public key of the peer. This verifies that the peer end is a bound device.

When OneHop or Multi-Screen Collaboration is used to share data between a mobile phone and an Honor PC, large-screen device, or tablet, a P2P trust relationship can be established through the secure binding process. For encryption of the transmitted data, the session key obtained during authentication is used.

9 Service Security

This chapter describes the security protection of services supported by Honor Magic UI products. For third-party payment apps, Magic UI can identify malicious apps and isolate the payment environment to ensure payment security.

HONOR ID

A HONOR ID can be used to access all Honor services. Ensuring the security of HONOR ID and preventing unauthorized access are important concerns for users. To achieve this goal, Honor requires users to use a

strong, eight characters or more complex password that is not commonly used and that contains at least three kinds of the following: lowercase letters, uppercase letters, special characters, and digits. On this basis, users can add characters and punctuation marks (the maximum password length is 32 characters) to make the password stronger and therefore more secure.

When the user changes the password or uses the HONOR ID on a new device, Honor system will send a text message, email, or notification to the user. If any exception occurs, Honor will prompt users to immediately change their passwords. Honor has also adopted various policies and procedures to protect users' HONOR IDs. These policies and procedures include limiting the numbers of login and password reset attempts, continuously monitoring fraudulent activities for attack identification, and regularly reviewing existing policies for timely update according to new information that may affect user security.

Two-Factor Authentication

Two-factor authentication is the optimal account protection solution and ensures that the use of HONOR IDs is more secure.

Account protection allows users to log in to their HONOR IDs using only their trusted devices. When attempting to log in from a new device, the user must enter the HONOR ID password and security verification code, which is automatically sent to the user's trusted phone number or displayed on the user's trusted device. If the new device passes verification, it will become the user's trusted device. This approach helps to enhance the security of HONOR IDs and associated HONOR ID services (such as HONOR Store and HONOR Club).

Heuristic Security Authentication

Users can change their phone number, email address, security phone number, or security email address through self-service means if they forget their HONOR ID password, want to reset the password, or the

phone number or email address bound to the HONOR ID is no longer available.

Account Risk Control

Honor provides an end-to-end risk identification mechanism and confrontation capabilities throughout the lifecycle of accounts. Risk prevention is provided across the entire process of account registration, login, service access, service operation, password reset, and account change. The system identifies fake accounts based on experts' rules, machine learning, and various means such as account operation exceptions, phone number exceptions, email exceptions, network risks, and geographical locations, to prevent malicious attacks on accounts and ensure the security of user assets and data.

Find Device & Activation Lock*

Magic UI provides the Find Device function. If your Honor phone or tablet is lost or stolen, you can log in to the official website of Honor Find Device (https://cloud.hihonor.com/findmydevice/wapFindPhone) or the Find Device app to find your lost device. The following functions can help you find your lost device, protect the data in your device, and protect your privacy.

Locate device: You can display the location of your device on the map. Including active location and automatic location reporting at a low battery level.

Play ringtone: The device will play the alert ringtone at maximum volume regardless of whether the device is in silent or vibration mode.

Turn-off verification password: When the function is turned on, the lock screen password will be required to turn off the device from the lock screen to avoid the device from getting turned off by the finder.

Remote internet connection: If the device is offline when you use the Find Device feature, Find Device will help you remotely turn on the mobile data of the lost device so that you can locate it.

Lost mode: The device's screen will be locked and enters a super power-saving mode, displays message and contact number on the screen, automatically reports the location, and displays the message when an internet connection is established. At the same time, the device will hide the contact information of the incoming call and the content of new text messages.

SIM card locking: You can lock the SIM card on the device after entering the lost mode. After locking, when the SIM card is inserted into other devices or the device is restarted, a password will be required before use.

Erase data: Restore the device to factory settings and permanently erase all data (including the storage card). You can still locate the device after erasing data, and your HONOR ID password will still be required when using the device.

Magic UI also provides the activation lock function. Enabling Find Device will automatically enable activation lock. If an unauthorized user attempts to forcibly erase data from a lost phone, the user is required to log in to the HONOR ID to re-activate the phone after it is rebooted. This function enhances phone security by preventing unauthorized users from activating or using the phone.

Uses can choose to unlock activation lock with the lock screen password, if set in the Activate Device page. After the lock screen password is verified, subsequent unlocking operations are performed remotely in the cloud in the same manner as when the activation lock is unlocked by using HONOR ID account and password.

*Note: This feature is not supported in overseas regions at this time.

Payment Protection Center

The payment protection center provides an independent secure environment for payment-related applications. The payment protection center ensures that payment apps are from official sources. It also strictly controls the interaction between payment apps and outside apps to reduce the risk of malicious calls and attacks on apps within the

protection center. Moreover, the system will test payment apps when they are running to ensure the security of the operating environment and protect user transactions and property.

MDM API*

Magic UI now provides a device management SDK for Honor mobile devices. It enables policy configuration, access control, and device management functions for enterprise mobile offices or industry-specific mobile device management (MDM) applications.

For device management APIs required by enterprise mobile office customers, Magic UI grants the customers corresponding use permissions by using the certificate. The enterprise customers can apply for the use permission of device management APIs from Honor Developer official website.

Honor issues device management certificates to qualified app developers. After the developer integrates the certificate into the developed Android package (APK), the APK can use the authorized APIs on Honor devices.

When a user installs an APK that has a device management certificate, Magic UI analyzes and verifies the certificate. If the certificate passes the verification, the APK obtains all permissions. If the certificate fails the verification, the APK will not have the permission. As a result, invoking the device management APIs fails and a security exception is displayed to ensure security of Honor devices.

*Note: Only available on China models.

10 Privacy Protection

This chapter describes Magic UI's user privacy protection. Honor devices may contain user privacy data, such as contacts, short messages, and photos. To protect user privacy, Magic UI ensures that pre-installed apps

fully meet privacy compliance requirements, and provides app permission management, notification management, location-based service (LBS), 7-day privacy access history and other privacy management functions. To further protect users' privacy, Magic UI provides the device identifier system, differential privacy, and other technical privacy protection means.

Permission management

The Magic UI system provides a permission management mechanism designed to allow or restrict apps' access to APIs and resources. By default, no permissions are granted to apps, and access to protected APIs or resources is restricted to ensure security of such APIs and resources. During installation or running, apps request permissions, and users determine whether to grant the permissions. Magic UI enables users to allow or deny permissions to an installed app for fine-grained control. The permission management function applies to the following:

- Phone
- SMS
- Contacts
- Call log
- Camera
- Location
- Microphone
- Calendar
- Body sensors
- Health
- Storage
- MMS
- Using call transfer (CT)

- Floating window
- Creating desktop shortcut

Magic UI 5.0 provides more detailed controls when an app requests to use the Camera, Microphone, and Location permissions by offering the "allow only while in use" and "allow this time" choices. If the user chooses the "allow only while in use" option, granted permissions will be removed once the app is switched to the background. On the other hand, permissions will be removed once an app is switched to the background or stopped by selecting the "allow this time" option and must be granted again during the next use.

Privacy Report

Mobile apps have become increasingly more powerful thanks to explosive developments. To make services richer, apps also require a myriad of permissions that frequently touches upon user privacy. However, due to the lack of effective control and supervision, some apps can obtain private user data without their knowledge. Even if information disclosure was to occur, there would be no records to resort to.

Magic UI 5.0 systematically records information such as app name, accessed permission, time, and outcome each time an app tries to access sensitive information. From the home screen, users can go to Settings > Privacy and view the top 5 apps that accessed the Location, Camera, Microphone, Contacts, and Storage permissions. Records are presented according to the time, app and permission for easy viewing and management.

Magic UI 6.0 implements detailed logging of apps' access to stored data. In the privacy access log, the stored data is subdivided into four types: image, audio, video, and other files, and four types of operations are recorded: read, create, modify, and delete. When images and video files are deleted by a three-party app, the system will move the deleted files to the recycle bin of the gallery and notify the user to protect the security of his/her data assets.

Audio/Video Recording Reminder

To prevent malicious apps from obtaining permission to access the microphone or camera through spoofing and recording audio or videos at the backend without users' knowledge, Magic UI provides the audio/video recording reminder function. When an app is using a microphone or camera, the system displays a prompt on the notification bar. When the user touches the prompt, the app interface or the app's permission management interface is displayed. The user can also tap the close button to close the app that is recording audio or a video.

Location Service

Magic UI allows a user to enable or disable location access in Settings. After location access is disabled, Magic UI also disables the Global Positioning System (GPS), Wi-Fi, Bluetooth, and mobile base station positioning. In this way, users' location service is disabled, ensuring user privacy.

If an app requires access to location information through LBS, it needs to apply for the location access permission. The user can determine whether to grant the permission (Allow, Always allow, or Deny) to the app based on the application scenario. If the user selects "Allow", the app can access location information but not at the backend. If the user selects "Always allow", the app can access location information during running and at the backend. If the user selects "Deny", the app cannot access location information.

When the user selects "Always allow", the system detects that the app is accessing location information at the backend and will periodically ask the user whether to allow backend access through notification. The system notifies the user only once for each app.

Magic UI 5.0 further provide users with the coarse location features in addition to precise and approximate locations. To prevent tracking, users can decide whether an app can only obtain coarselocation data instead of fine location by reducing the positioning accuracy.

Clear clipboard automatically

During daily use of the phone, some important information will inevitably enter the clipboard, such as shipping information, phone numbers, email addresses, and even passwords. To protect the user's private information from leakage, the clipboard will be automatically cleared in 15 minutes every time it is updated. When an app reads the clipboard, the system reminds the user of this behavior through a message.

Device Identifier

During system processing, unique identification is required. Magic UI provides multiple unique identifiers with different behavior features.

The app selects the most appropriate identifier based on different scenarios. These features involve privacy.

Scope

Magic UI identifiers have three scopes. Wider scope of an identifier indicates higher risk of being tracked.

Single App: The ID is only available to the app and cannot be accessed to any other apps.

App group: The ID is available to a group of apps, such as a group of apps provided by the same app developer.

Device: All apps installed on the device access a same ID.

Resettability and Durability

The resettability and durability define the lifecycle of identifiers. The longer an identifier is stored, the more vulnerable the user is to long-term tracking. When the app is reinstalled or the identifier is manually reset, the duration is shortened and the risk of being tracked is reduced.

To prevent apps from using device identifiers to track users, Magic UI prohibits third-party apps from obtaining permanent device identifiers, such as IMEI, SN, and MAC address.

The Magic UI identifier system includes:

ID Type	ID Name	Application Scenario & Scope	Generation Time	Reset
Resettability	UUID	Used in scenarios where apps are associated with random identifiers.	A random number is generated each time an identifier is invoked.	The UUID is regenerated each time an identifier is invoked.
User ID	HONOR ID	Used for Honor Cloud service features.	Generated upon creation of a HONOR ID.	Deleted upon deregistration of a HONOR ID.

Differential Privacy

This technology adds random noise to your data to prevent us from identifying the real data. The data can only be understood when combined with other user data to smooth out the randomly added noise. To provide users with a reliable, stable, and energy-efficient software and hardware system that delivers the ultimate experience, Honor will collect statistical data on the reliability, performance, power consumption, faults, and errors on user devices, as well as data on how user devices and apps are used. User data is sent to Honor only after users' explicit consent is obtained. We use differential privacy technologies to improve user experience and protect the data that you share with Honor.

Privacy Statement

Magic UI provides an explicit privacy statement and explicitly notifies users to check and confirm the statement in the startup wizard. In addition, users can check the privacy statement in Settings. Privacy policies vary in different countries. Therefore, users in different countries are provided with specific privacy statements on Magic UI released in the local countries.

Refer to the privacy statement as follows:
https://www.hihonor.com/privacy-policy/worldwide/

11 Conclusion

Honor attaches great importance to users' device security and privacy, and has designed Magic UI to provide end-to-end (from underlying chips and systems to apps) security protection capabilities. Magic UI constructs a trusted basic architecture for the device based on the chip hardware, and constructs security experience that balance both security and user experience based on enhanced security and strong computing performance of the device hardware.

While providing security solutions, Honor also attaches great importance to establishing security process and capabilities, which are vital for implementing security management of products throughout the lifecycle. Honor has set up a Security Response Center (SRC) dedicated to improving product security. Any organization or individual that finds security vulnerabilities in Honor products can contact Honor at security@hihonor.com. Honor SRC will reply promptly while organizing internal vulnerability fixing, releasing vulnerability warning, and pushing patches for update. Honor is sincere in its willingness to jointly build Honor device security with all stakeholders.

12 Acronyms and Abbreviations

List of abbreviations

English Abbreviations	English	Chinese
2D	Two Dimension	二维
3D	Three Dimension	三维
3DES	Triple Data Encryption Standard	三重数据加密标准
AES	Advanced Encryption Standard	高级加密标准
AI	Artificial Intelligence	人工智能
API	Application Programming Interface	应用软件编程接口
APK	Android application Package	Android 安装包
ARM	Advanced RISC Machines	高级精简指令集计算机器
ASLR	Address Space Layout Randomization	内存地址随机化机制
BLE	Bluetooth Low Energy	低功耗蓝牙
BTI	Branch Target Identification	分支目标识别
BYOD	Bring Your Own Device	携带自己的设备办公
CA	Certificate Authority	证书颁发中心
CC	Common Criteria	通用标准
CE	Credential Encryption	凭据加密
CFI	Control Flow Integrity	控制流完整性
CNN	Convolutional Neural Network	卷积神经网络
DE	Device Encryption	设备加密
DEP	Data Execution Prevention	数据执行保护
CMP	Certificate Management Protocol	证书管理协议

DAC	Discretionary Access Control	自主访问控制
DRM	Digital Rights Management	数字版权保护
ECB	Electronic Code Book	电子源码书
ECC	Elliptic Curve Cryptography	椭圆加密算法
ECDSA	Elliptic Curve Digital Signature Algorithm	椭圆曲线数字签名算法
EAP	Extensible Authentication Protocol	可扩展认证协议
eID	electronic IDentity	电子身份标识
EMM	Enterprise Mobility Management	企业移动管理
eMMC	Embedded Eultimedia Card	嵌入式多媒体卡
Magic UI	Magic UI	荣耀 Magic UI 系统
GP	GlobalPlatform	全球平台组织
GSM	Global System for Mobile Communications	全球移动通信系统
HKIP	Honor Kernel Integrity Protection	荣耀内核完整性保护方案
HMAC	Hash-based message Authentication Code	散列信息认证码
HOTA	Honor Over The Air	荣耀空中升级
HTEE	Honor Trusted Execution Environment	荣耀可信执行环境
HUK	Hardware Unique Key	硬件唯一密钥
HUKS	Honor Universal Keystore	荣耀通用密钥库系统
ID	Identifier	标识符
IMEI	International Mobile Equipment Identity	国际移动设备标识
IOT	Internet of Things	物联网
IPSec	Internet Protocol Security	因特网协议安全协议
IT	Information Technology	信息技术

JOP	Jump Oriented Programming	跳转导向编程
L2TP	Layer Two Tunneling Protocol	第 2 层隧道协议
LKM	Loadable Kernel Module	可加载内核模块
LSM	Linux Security Module	Linux 安全模块
LTE	Long-Term Evolution	长期演进
LTO	Link Time Optimization	链接时优化
MAC	Mandatory Access Control	强制访问控制
MAC	Media Access Control	媒体接入控制（MAC 地址即媒体接入控制地址）
MDM	Mobile Device Management	移动设备管理
MPPE	Microsoft Point-to-Point Encryption	微软点对点加密协议
NFC	Near Field Communication	近距离无线通信技术
NIST	National Institute of Standards and Technology	美国国家标准与技术研究院
NPU	Neural Processing Unit	神经网络处理单元
OS	Operating System	操作系统
OTA	Over The Air	空中升级
P2P	Peer to Peer	点对点
PA	Pointer Authentication	指针认证
PAN	Privileged Access Never	特权模式访问禁止
PIN	Personal Identification Number	个人身份识别码
PKI	Public Key Infrastructure	公共密钥基础设施
POS	Point of Sales	销售点
PPTP	Point-to-Point Tunneling Protocol	点到点隧道协议
PRNG	Pseudo-Random Number Generator	伪随机数生成器
PSK	Pre-Shared Key	预共享密钥

PXN	Privileged eXecute Never	特权模式执行禁止
REE	Rich Execution Environment	普通执行环境
ROM	Read-Only Memory	只读存储器
ROP	Return Oriented Programming	返回导向编程
RSA	Rivest Shamir Adleman	RSA 加密算法
RPMB	Replay Protected Memory Block	重放保护存储区
SCEP	Simple Certificate Enrollment Protocol	简单证书注册协议
SCP	Secure Channel Protocol	安全通道协议
SD	Secure Digital Memory Card	安全数字存储卡
SDK	Software Development Kit	软件开发工具包
SELinux	Security-Enhanced Linux	安全增强 Linux
SFS	Secure File System	安全文件系统
SHA	Secure Hash Algorithm	安全散列算法
SN	Serial Number	序列号
SOTER	Standard Of auThentication with fingERprint	指纹授权认证开源方案
SRC	Security Response Center	安全应急响应中心
SSL	Security Sockets Layer	安全套接层
TA	Trusted Application	可信应用
TEE	Trusted Execution Environment	可信执行环境
TLS	Transport Layer Security	传输层安全性协议
TSM	Trusted Service Manager	可信服务管理
TUI	Trusted User Interface	可信用户界面
UDID	Unique Device Identifier	设备唯一标识符
UID	User Identifier	用户身份标识符
UUID	Universally Unique Identifier	通用唯一标识符
VM	Virtual Machine	虚拟机

VPN	Virtual Private Network	虚拟专用网
WAPI	WLAN Authentication and Privacy Infrastructure	无线局域网鉴别和保密基础结构
WEP	Wired Equivalent Privacy	有线等效加密
WLAN	Wireless Local Area Network	无线局域网
WPA	Wi-Fi Protected Access	Wi-Fi 保护访问
WPS	Wi-Fi Protected Setup	Wi-Fi 保护设置

Modification record

Date	Modification description
2021-08-12	First released
2022-03-08	Magic UI 6.0 version update