Samsung

KNOX

# White Paper : An Overview of Samsung KNOX™

April 2013
Enterprise Mobility Solutions
Samsung Electronics Co., Ltd.

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# Contents

# Acronyms

| | |
|---|---|
| **AES** | Advanced Encryption Standard |
| **BYOD** | Bring Your Own Device |
| **CAC** | U.S. Common Access Card |
| **DAR** | Data-at-Rest |
| **DISA** | U.S. Defense Information Systems Agency |
| **DIT** | Data-in-Transit |
| **DoD** | U.S. Department of Defense |
| **FIPS** | Federal Information Processing Standard |
| **IPC** | Inter Process Communication |
| **MAC** | Mandatory Access Control |
| **MDM** | Mobile Device Management |
| **NIST** | National Institute of Standards and Technology |
| **NSA** | (US) National Security Agency |
| **ODE** | On Device Encryption |
| **PKCS** | Public Key Cryptography Standards |
| **ROM** | Read-Only Memory |
| **SAFE** | Samsung For Enterprise |
| **SBU** | Sensitive But Unclassified |
| **SE for Android** | Security Enhancements for Android |
| **SE Linux** | Security-Enhanced Linux |
| **SRG** | Security Requirements Guide |
| **TIMA** | TrustZone-based Integrity Measurement Architecture |
| **VPN** | Virtual Private Network |

## Samsung KNOX incorporates key technologies patented by the NSA

# Android and the Enterprise

With over 75% of the smartphone market share as of 3Q 2012[1], Android is currently the world's most popular smartphone platform.

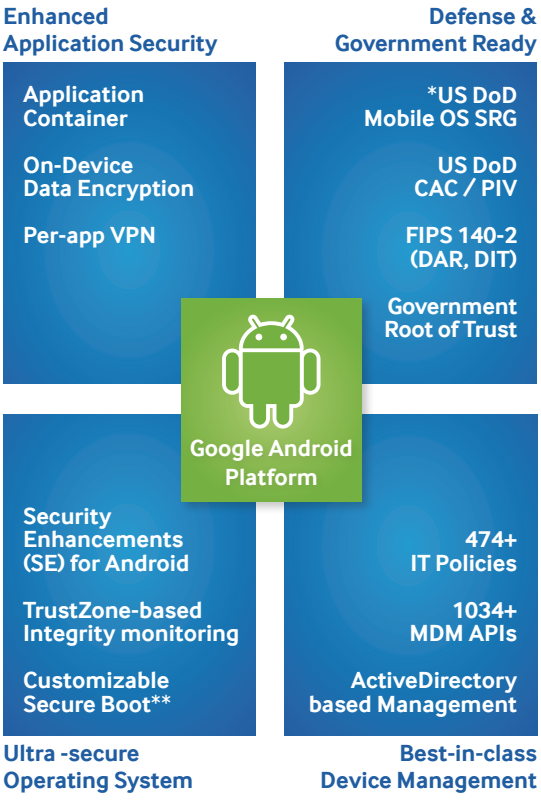
There are several factors behind Android's success: the open source aspect attracted early adopters and developers, while Google's services and the abundance of third party applications drove consumer adoption.

The success of Android among consumers and the developer community has, however, not translated to the enterprise. An April 2012 survey by Gartner found that fewer than 10% of enterprises planned on deploying Android devices in the next 12 months.[2] The principal reasons cited were a perceived lack of security and limited management capability.

As a global leader in Android smartphones, Samsung developed Samsung KNOX to provide a more compelling and secure enterprise experience.

1. IDC, "Worldwide Quarterly Mobile Phone Tracker," 2012
2. Gartner, "Magic Quadrant for Mobile Device Management Software," 2012

# Introducing Samsung KNOX™




* in process
** Customizable Secure Boot availability varies depending on hardware specification.

Figure 1 – Samsung KNOX Makes Android Enterprise-Ready

Samsung KNOX is a new Android-based solution designed from the ground up with security in mind to address the perception of the current open source Android platform. Samsung KNOX retains full compatibility with Android and the Google ecosystem while integrating fundamental security and management enhancements. All of these advantages make Samsung KNOX the perfect choice for both regulated and general enterprise environments.

Samsung KNOX incorporates key technologies patented by the National Security Agency (NSA) and leverages hardware-level features to provide enhanced security to protect the operating system and applications. In addition, Samsung KNOX has been submitted to the US Government and Department of Defense (DoD) for compliance with initiatives, requirements and standards for mobile device security to enable its use in government and other highly regulated enterprise environments.

Finally, Samsung KNOX features one of the most comprehensive Mobile Device Management (MDM) capabilities available. Samsung KNOX, combined with its unique application container technology, enables enterprises to support both BYOD and Corporate-Liable models without compromising corporate security or employee privacy.

Samsung KNOX addresses security at the operating system level in a comprehensive, three-prong strategy

# Technology Overview

This section describes the technical aspects of four key features of Samsung KNOX:

1. Platform Security
2. Application Security
3. Mobile Device Management
4. Theft Recovery

## 1. Platform Security

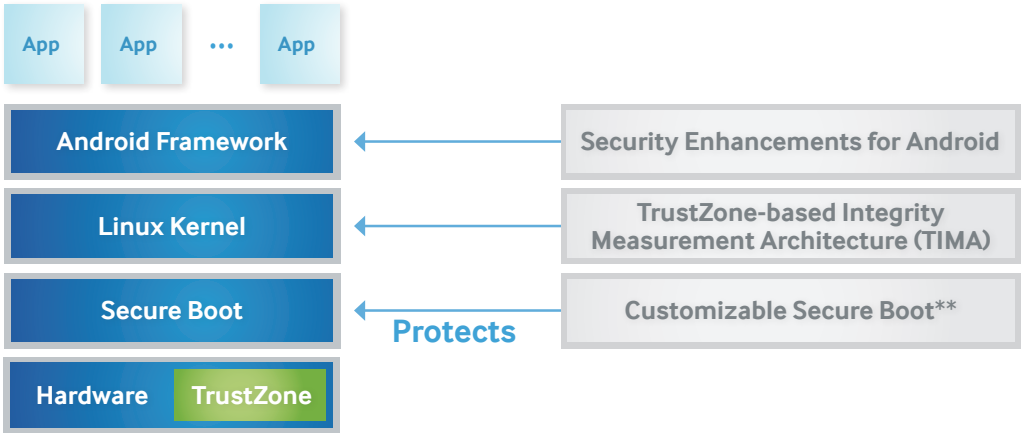



Figure 2 – Samsung KNOX System Security Overview

Samsung KNOX addresses security in a comprehensive, three-prong strategy:

- Customizable Secure Boot**
- TrustZone-based Integrity Measurement Architecture (TIMA)
- Security Enhancements for Android

Samsung KNOX also takes full advantage of all available hardware elements to enhance this security posture.

## 1. Platform Security

- **Customizable Secure Boot**
- TrustZone-based Integrity Measurement Architecture
- Security Enhancements for Android

Secure Boot is a procedure that prevents "unauthorized" operating systems and software from loading during the startup process. Firmware images (that is, operating systems and other system components) that are cryptographically signed by known, trusted authorities are considered as "authorized" firmware. Secure Boot is the first line of defense against malicious attacks on KNOX-based mobile devices.

Secure Boot requires the device boot loader, kernel, and system software to be cryptographically signed by a key verified by the hardware. Secure Boot uses X.509 certificates and public keys which are embedded into the boot loader of the device. A secure hash of the certificates is fused into hardware Read-Only Memory (ROM) at the time of manufacture. The Secure Boot loader will only continue if the authorized secure signed binaries are present. Next, Secure Boot verifies the cryptographic signature of the Linux kernel and system image before handing control to the OS.

The use of the industry standard X.509 certificates and keys provides a strong degree of robustness and confidence in the trusted boot scheme. By default, the root of trust is a Samsung-issued certificate. However, additional roots of trust can be provisioned at the factory; for example, an additional root of trust could be a government-issued (approved) certificate.

# Platform security of Samsung KNOX is the first line of defense against malicious attacks

## 1. Platform Security

- Customizable Secure Boot
- **TrustZone-based Integrity Measurement Architecture**
- Security Enhancements for Android

Samsung KNOX utilizes SE for Android (Security Enhancements for Android) to enforce Mandatory Access Control policies to isolate applications and data within the platform. SE for Android, however, relies on the assumption of OS kernel integrity. If the Linux kernel is compromised (by a perhaps as yet unknown future vulnerability), SE for Android security mechanisms could potentially be disabled and rendered ineffective.

Samsung's TrustZone-based Integrity Measurement Architecture (TIMA) was developed to close this vulnerability. Introduced in Samsung KNOX as a unique feature on Samsung mobile devices, TIMA uses ARM TrustZone hardware and provides continuous integrity monitoring of the Linux kernel. The ARM TrustZone hardware effectively partitions memory and CPU resources into a "secure" and "non-secure" world. TIMA runs in the secure-world and cannot be disabled, while the SE for Android Linux kernel runs in the "non-secure" world.

TIMA is used along with Customizable Secure Boot** and SE for Android to form the first line of defense against malicious attacks on the kernel and core boot strap processes. When TIMA detects that the integrity of the kernel or the boot loader is violated, it takes a policy-driven action in response. One of the policy actions disables the kernel and powers down the device.

## 1. Platform Security

- Customizable Secure Boot
- TrustZone-based Integrity Measurement Architecture
- **Security Enhancements for Android**

Security-Enhanced Linux (SE Linux) is a technology invented by the NSA in 2000 and has long been established as the standard for securing enterprise Linux assets. Samsung R&D teams have worked very closely with the NSA to port and integrate this technology into Android. This port of SE Linux to Android is commonly referred to as Security Enhancements for Android, or "SE for Android".

SE for Android provides an enhanced mechanism to enforce the separation of information based on confidentiality and integrity requirements. It incorporates a strong, flexible Mandatory Access Control (MAC) architecture into the major kernel subsystems and isolates applications and data into different domains.

This architecture prevents a compromise in one domain from propagating to other domains or the underlying mobile operating system (OS). This additional security, on top of Linux, reduces threats of tampering and bypassing of application security mechanisms. It also minimizes the amount of damage that can be caused by malicious or flawed applications, as applications are provided the minimum amount of permission required for their task.

SE for Android includes a set of security policy configuration files designed to meet common, general-purpose security goals.

Out of the box, Samsung KNOX is provisioned with a set of security policy configuration files designed to strengthen the core Android platform and meet general enterprise needs. Samsung KNOX offers management APIs that allow the default SE for Android policies to be replaced with stricter or enterprise-specific policies. These new policies can be pushed to the device.

## Samsung KNOX provides Enterprises the ability to create and manage a secure container within their employee's personal mobile device

### 2. Application Security

In addition to securing the platform, Samsung KNOX provides solutions to address the security needs of individual applications:

- Application Containers
- On-device Data Encryption
- Virtual Private Network Support

### 2. Application Security



Samsung KNOX Container is a virtual Android environment within the mobile device, completed with its own home screen, launcher, applications, and widgets.


Figure 3 – Samsung KNOX Container

Applications and data inside the container are isolated from applications outside the container, that is, applications outside the container cannot use Android inter-process communication (IPC) or data-sharing methods with applications inside the container.

Likewise, applications inside the container generally do not have the ability to interact with applications or access data outside the container. However, some applications inside the container can be granted read-only access to data outside the container via a policy configuration.

For example, photos taken from the camera inside the container won't be viewable from the Gallery outside the container in a user's personal area. Likewise, any contacts or bookmarks created outside the container won't be available inside the container. The same applies to calendar events and copying/pasting.

## 2. Application Security

- Application Containers
- On-device Data Encryption
- Virtual Private Network Support

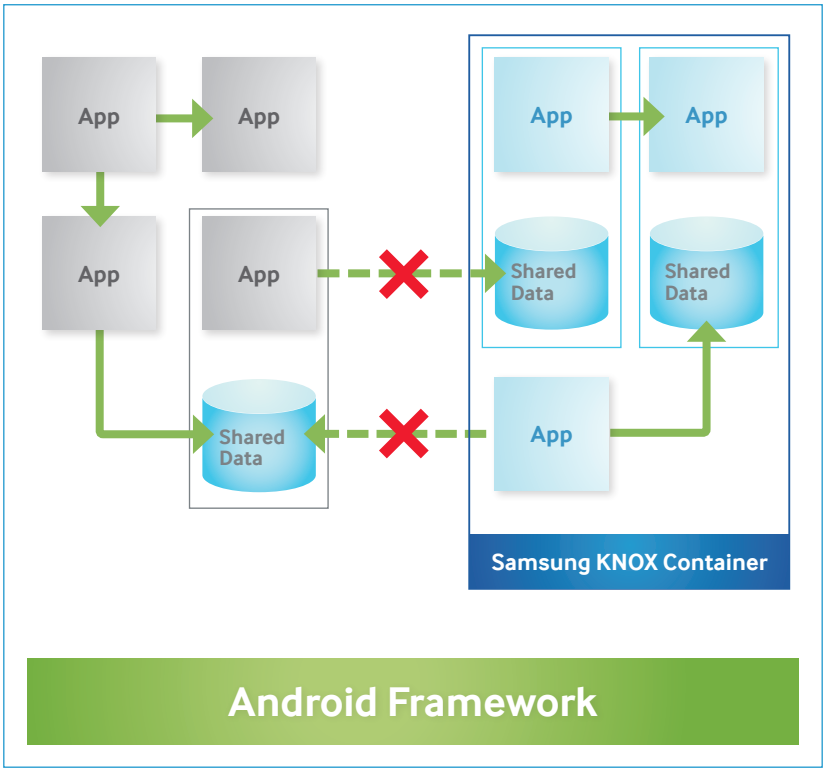



Figure 4 – Application Isolation in Samsung KNOX

This total isolation of applications and data within the container enables a powerful solution for the "data leakage" associated with the BYOD model. Data leakage occurs when a user sends sensitive or critical information outside of the corporate network via a personal email account, social network site, or public cloud storage system.

Samsung KNOX allows a "Work" container to be setup for corporate applications such as email, calendar, browser, storage clients, and so on, and the container will ensure that any data downloaded from the enterprise, such as email attachments and files, cannot be accessed by applications outside the container, All the data stored by applications inside the container are encrypted via strong encryption algorithms (AES-256). A password is required to gain access to applications inside the container.

Samsung KNOX Container is deeply integrated into the native Android platform – unlike other third party container solutions that are available via download from an app store. This deep integration enables a superior user experience that clearly separates the two environments to minimize user confusion, preserves the Android navigation paradigm in each environment for consistency, and provides a unified but privacy-aware view of notifications and active applications for efficiency.

Furthermore, the deep integration allows Samsung KNOX Container to execute at the system level and leverage additional security and isolation guarantees provided by Security Enhancements for Android.

The enterprise can manage the container like any other IT asset using an MDM solution. Samsung KNOX supports many of the leading MDM solutions on the market. Container management is affected by setting policies in the same fashion as traditional MDM. Samsung KNOX Container includes a rich set of policies for authentication, data security, VPN, email, application blacklisting, whitelisting, etc.

# Samsung KNOX offers the most comprehensive support for an Enterprise virtual private network (VPN) found in any mobile device

## 2. Application Security

- Application Containers
- On-device Data Encryption
- Virtual Private Network Support

The On-device Data Encryption (ODE) feature allows users and enterprise IT administrators to encrypt data on the entire device, as well as any configured Samsung KNOX Container. The ODE feature on Samsung devices uses a FIPS 140-2 certified Advanced Encryption Standard (AES) cipher algorithm with a 256-bit key (AES-256) and offers the levels of security required by government and regulated industries such as healthcare and finance. The key utilized for this encryption is developed from a user-created passphrase using well-known key-derivation algorithms such as Password-Based Key Derivation Function 2 (PBKDF2).

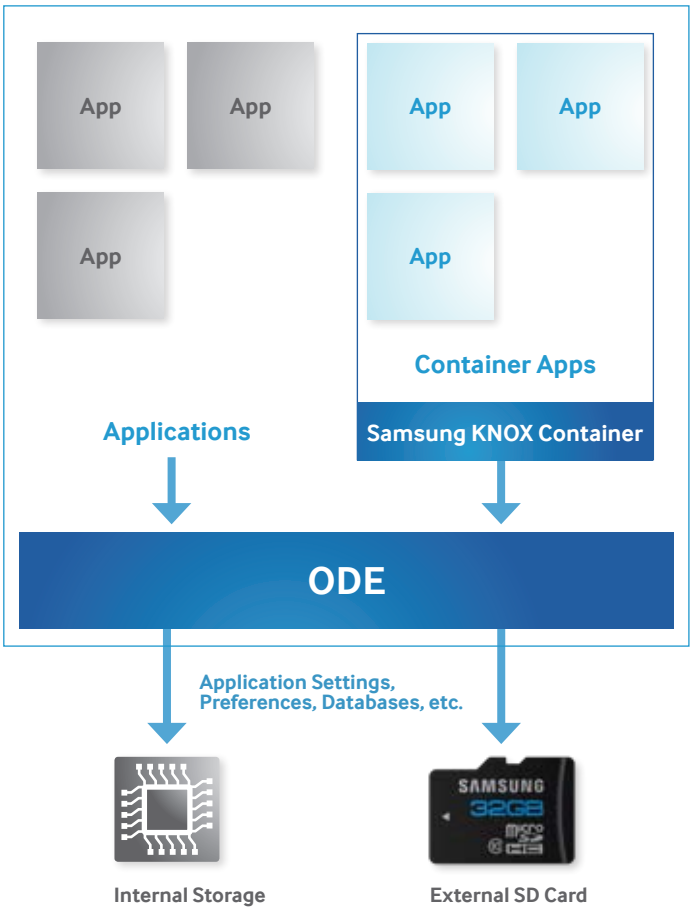



Figure 5 – On-Device Data Encryption in Samsung KNOX

The encryption feature spans both internal storage (system partition and internal SD card) as well as any user-installed external SD card. Hardware acceleration is employed to speed up the encryption and de-cryption process and minimizes the impact of the overhead on the overall user experience.

Encryption can be activated directly by the user via the “Settings” user interface, or remotely by the enterprise IT administrator as a policy setting using Exchange ActiveSync or an MDM system.

The use of NIST-compliant algorithms for ODE in Samsung KNOX devices satisfies Federal data-at-rest (DAR) requirements.

## MDM enables a company's IT department to monitor, control and administer all deployed mobile devices across multiple mobile service providers

### 2. Application Security

- Application Containers
- On-device Data Encryption
- Virtual Private Network Support

Samsung KNOX offers a high level of comprehensive support for an enterprise virtual private network (VPN). This enables businesses to offer their employees an optimized, secure path to the enterprise intranet from their BYOD or corporate-issued device.

Samsung KNOX VPN implementation offers broad support for the IPSec protocol suite:

- Internet Key Exchange (IKE and IKEv2)
- Triple DES (56/168-bit), AES (128/256-bit) encryption
- Split tunneling mode
- NSA Suite B Cryptography

Samsung KNOX VPN is FIPS 140-2 certified enabling its use in regulated environments like government, healthcare, finance, etc.

Another distinguishing feature of Samsung KNOX VPN feature is the ability for enterprise IT administrators to configure, provision, and manage the use of VPN on a per-application basis. This capability allows the enterprise to automatically enforce the use of VPN only on a specific set of corporate applications. This has the benefit of ensuring that enterprise data is communicated on a secure connection while keeping the user's personal data from overloading the company's Internet connection.

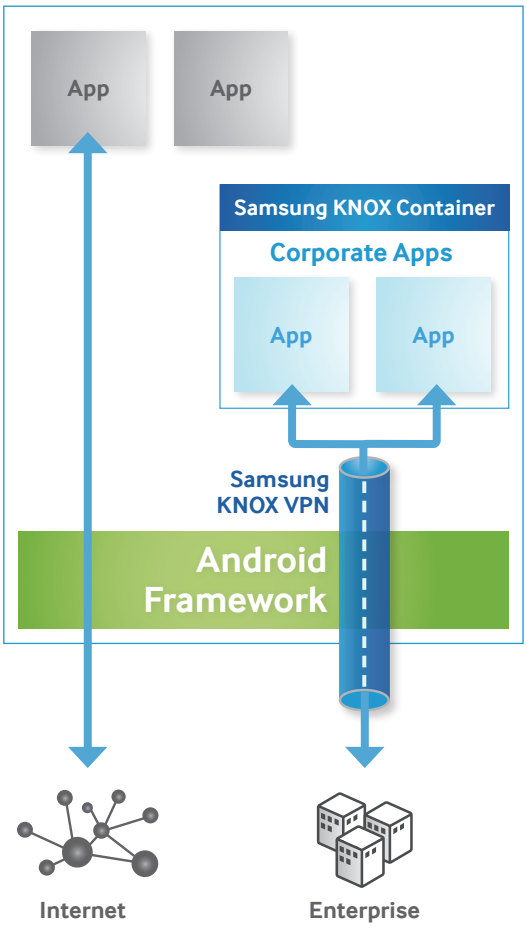



Figure 6 – Per-App VPN in Samsung KNOX

In addition, the per-app VPN feature allows personal-use applications to bypass the VPN and connect directly to the Internet, preserving the users privacy.

The per-app VPN capability is also available for applications within Samsung KNOX Container.

Other features of Samsung KNOX VPN implementation include:

- Up to 5 simultaneous VPN connections
- RSA SecureID® support for Cisco VPN gateways
- Common Access Card (CAC) support for government use

## Samsung KNOX offers tamper-proof anti-theft capability combined with a theft recovery service

### 3. Mobile Device Management

Mobile Device Management (MDM) enables the enterprise IT department to monitor, control, and administer all deployed mobile devices across multiple mobile service providers.

Samsung KNOX builds upon Samsung's industry leading SAFE® MDM capabilities by providing additional policies for security, enterprise integration, and enterprise applications such as asset tracking, remote control, and so on.

| Enterprise need | KNOX MDM Policy Groups*** | | |
|---|---|---|---|
| Remote Management | WiFi | Security | Email Accounts |
| | Bluetooth | Password | Browser |
| Limit Features and Functions | Kiosk Mode | Application permissions | Firewall |
| Secure Access to Enterprise Resources | Application | VPN | Exchange Account |
| Geo-fencing | Location | | |
| Real-time Device Status and Activity | Device Inventory | | |
| Manage Voice and Data Usage | Roaming | Phone Restrictions | APN Settings |
| Real-time Mobile User Support | Remote Control | | |
| Prevent Data Leakage | Email Forwarding | Container Management | Integrity Management |
| Enterprise Integration | Single Sign-on | Active Directory | |

*** Availability of Samsung KNOX features may vary by MDM partners.

Figure 7 – KNOX MDM Policy Groups

Specific MDM enhancements include:

- Policies to comply with the US DoD Mobile OS Security Requirements Guide (MOS SRG)
- Support for Samsung KNOX Container
- Support for management via ActiveDirectory/Group Policy Manager
- VPN and Wi-Fi Provisioning
- Idle screen and lock screen configuration

## 4. Theft Recovery

An undesirable consequence of the rapid growth of smartphones is the equally rapid rise in the theft of mobile devices. Over 40% of robberies in major metropolitan cities are smartphone related[3]. Factors behind this phenomenon include the high resale value of the device, inability to disable the device when stolen, and the ability to sell the personal information on the device.

Samsung KNOX includes a built-in anti-theft solution that provides both tracking and recovery services in the event of theft. The anti-theft capability is integrated into the device firmware and cannot be disabled even if the device is “factory reset”.

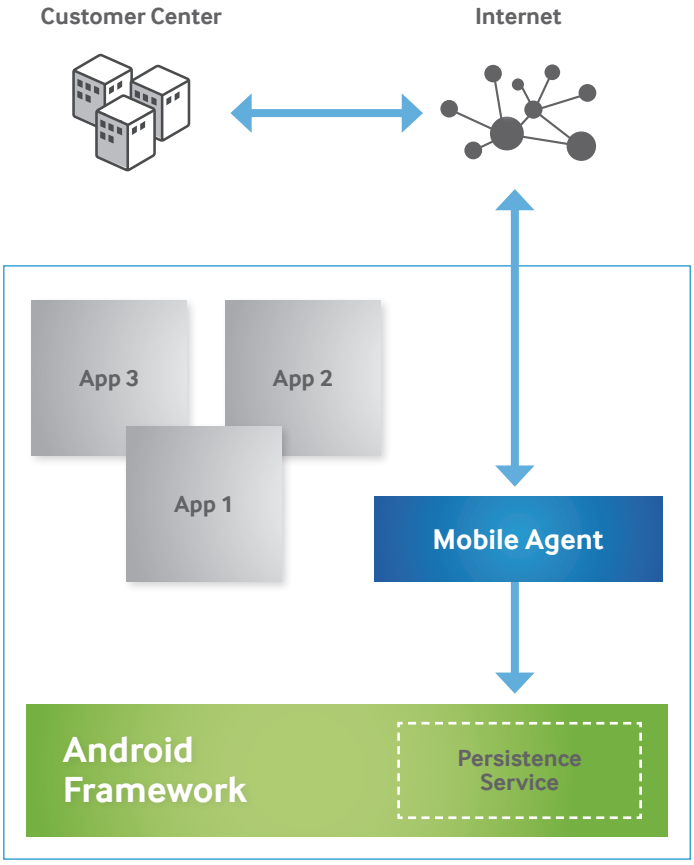



Figure 8 – Theft Recovery solution of Samsung KNOX

The solution consists of two components – the Persistence Service that resides in the device firmware, and the Mobile Agent that runs as an Android application.

The Persistence Service is dormant until the user subscribes to the theft recovery service and installs the Mobile Agent via an installer. At this point the Persistence Service enables the device for tracking, and ensures that the Mobile Agent is always present, even if the device undergoes a factory reset.

When a device is stolen, the user must first report the incident to the local law enforcement agency. The user must then contact the Theft Recovery Customer Center with the police case number assigned. Theft recovery personnel then transmit commands to the Mobile Agent to activate monitoring and tracking, and coordinate with law enforcement to recover the device.

3.CNBC, "The Top 10 Cities for Smartphone Theft and Loss," 2012

Samsung KNOX meets the requirements for FIPS 140-2 Level 1 certification for both DAR and DIT

# Samsung KNOX for Government and High Security Use

For government and DoD installations, KNOX provides additional security features, including:

1. Boot Attestation
2. Smartcard - CAC Support
3. Certification & Validations

## 1. Boot Attestation

Samsung KNOX technology uses a Secure Boot protocol that requires the device boot loader, kernel, and system software to be cryptographically signed by a key whose root of trust is verified by the hardware. Commercially sold Samsung devices will have Samsung-issued root certificates.

Government deployments generally require that government agencies be the custodian of the entire mobile device firmware including the root certificate . Samsung KNOX technology allows additional roots of trust to be provisioned at the factory. One of these additional roots of trust is reserved for government agencies or their trusted partners to create their own chain of trust.

Note that only one root of trust can be active, and all commercially sold devices already have the Samsung root of trust activated. To enable government deployments, Samsung KNOX technology provides tools to government agencies to perform a one-time change of the root of trust from Samsung to the appropriate government agency (or its trusted security partner).

This customizable aspect of Secure Boot is unique to Samsung KNOX and gives government entities control over their own approval and chain of trust. The Government can nominate one of its trusted security partners to generate audited, signed firmware images for use on Samsung KNOX devices.

## 2. Smartcard - CAC Support

The United States Department of Defense (US DoD) has mandated the use of Public Key Infrastructure (PKI) certificates for employees to "sign" documents digitally, encrypt and decrypt email messages, and establish secure online network connections.

In compliance with DoD regulations, Samsung KNOX allows the PKI certificates to be stored securely on the mobile device (software certificates) or be retrieved from a CAC (hardware certificates).

Samsung KNOX provides applications access to the hardware certificates on the CAC via standards-based Public Key Cryptography Standards (PKCS) APIs. This enables the use of the CAC card by the browser, email application, and VPN client as well as other custom government applications.

In addition, Samsung KNOX allows the lock screen to be secured by the CAC card, providing an additional level of device security.

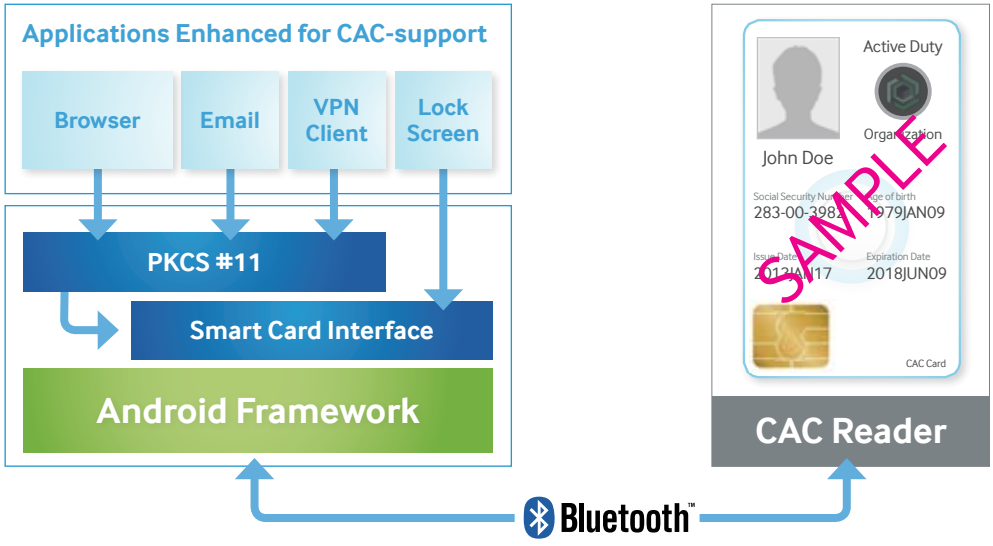



Figure 9 – Samsung KNOX Support for CAC

## 3. Certification & Validations

- FIPS 140-2 Certification
- DISA MOS SRG Compliance

Issued by the National Institute of Standards and Technology (NIST), the Federal Information Processing Standard (FIPS) is a US security standard that helps ensure companies that collect, store, transfer, share and disseminate sensitive but unclassified (SBU) information and controlled unclassified information (CUI) can make informed purchasing decisions when choosing devices to use in their workplace.

Samsung KNOX meets the requirements for FIPS 140-2 Level 1 certification for both data-at-rest (DAR) and data-in-transit (DIT). The Samsung KNOX support for DIT covers the following:

- Web browser (HTTPS)
- Email (S/MIME)
- IPSec VPN

## 3. Certification & Validations

- FIPS 140-2 Certification
- DISA MOS SRG Compliance

The Defense Information Systems Agency (DISA) is an agency within the US DoD that publishes Security Requirements Guides (SRGs) as processes to improve the security of DoD information systems.

In 2012, DISA published the Mobile Operating System SRG to specify the security requirements that commercially available mobile devices should meet in order to be deployed within the DoD.

Samsung KNOX complies with the June, 2012 version of the SRG specification.

# Summary

Reasons cited by CIOs for the poor acceptance of Android in the enterprise stem primarily from concerns over the current state of security in the platform, as well as the lack of management policies. For example, attacks against mobile devices and especially Android devices have been increasing at an alarming rate:

- In their "2012 Q2 Threats Report", McAfee, a leading security technology company, has discovered nearly 13,000 different types of mobile malware in 2012, up from 2,000 in 2011. They also announced that Android malware reports nearly doubled in Q3 2012 compared to Q2 2012.

- Trend Micro, in their "5 Predictions for 2013 and Beyond" report for small/medium businesses (SMBs), estimates that the number of malicious and high-risk Android applications will increase three-fold from about 350,000 in 2012 to more than 1 million in 2013.

Furthermore, as more and more employees are bringing their own devices to work (BYOD), IT adminis tra-tors are concerned about the increased risk to corporate data and network resources:

- In a survey of 500 leading British CIOs by Virgin Media Business, 51% indicated their secure IT network was breached due to employees using personal services. In addition, smaller businesses experienced 25% less breaches of security compared to larger organizations.

With its multi-tiered security model and industry-leading device management capability, Samsung KNOX fully addresses the shortcomings of the open source Android platform for broad enterprise adoption.

- The enhanced security at the operating system level provided by Secure Boot**, Security Enhancements for Android, and TIMA protect against malware attacks and hacking.

- Samsung KNOX Container allows enterprises embracing the BYOD trend to create a secure zone in the employee's device for corporate applications. Access to corporate data and network resources can be restricted to applications within the container.

- The rich set of MDM policies enables IT administrators to better manage their employees' devices and offer improved support by being able to remotely configure various features including Wi-Fi, VPN and email.

# About Samsung Electronics Co., Ltd.

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