Laying a Secure Foundation for Mobile Devices

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Trusted Systems Research

- Conduct and sponsor research to provide information assurance for national security systems.
- Enabling safe operation in risky or compromised environments.
- Research into cryptographic algorithms and protocols, system analysis and design methods, trust mechanisms, and systems behavior.
- Creators of SE Linux, Xen Security Modules, Linux Kernel Integrity Monitor, and SE Android.

Our Motivation

- Increasing demand to use mobile devices.
  - NSA Mobility Program
- Desire to use commodity solutions.
  - NSA Commercial Solutions for Classified (CSfC)
- Risks posed by currently available solutions.
  - Exploitation over wireless, radio, NFC, ...
  - Data Leakage
  - Application privilege escalation

Why It Matters for Everyone

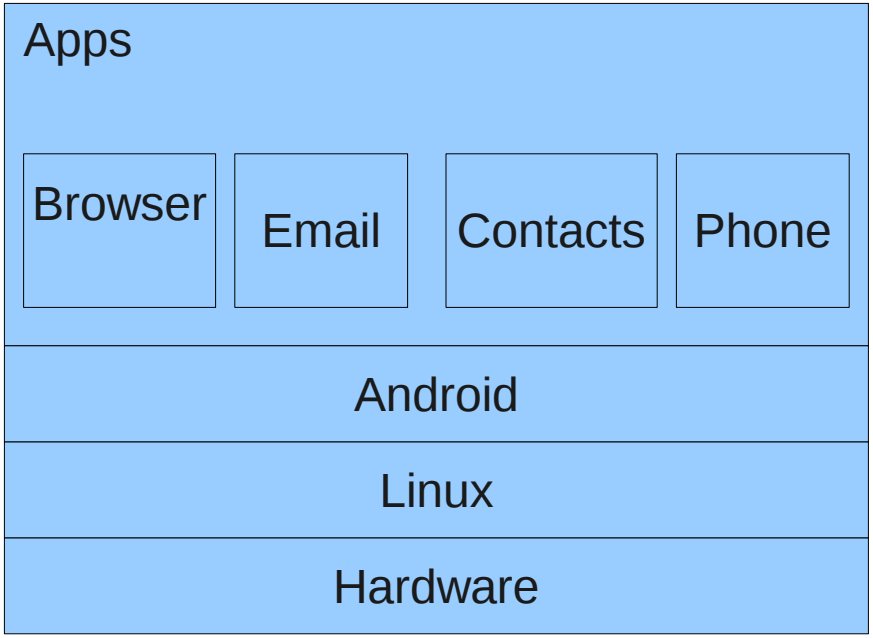
- Explosion in mobile malware.
  - Rapid growth, increasing sophistication.
- Increasing market drivers for mobile device attacks.
  - Payment, banking, remote control.
  - BYOD trend for corporate/enterprise use.
  - Increasing use of mobile platforms in non-traditional venues, including safety-critical.
- It isn't just a problem for government use.

A Step in the Right Direction

- NSA Security Enhanced (SE) Android project.
- Identify and address critical gaps in the security of Android.
- Why Android?
  - Open source platform: suitable for a reference implementation accessible to anyone.
  - Broad market adoption: opportunity to improve the security of a widely used mobile platform.

Android Security Concerns

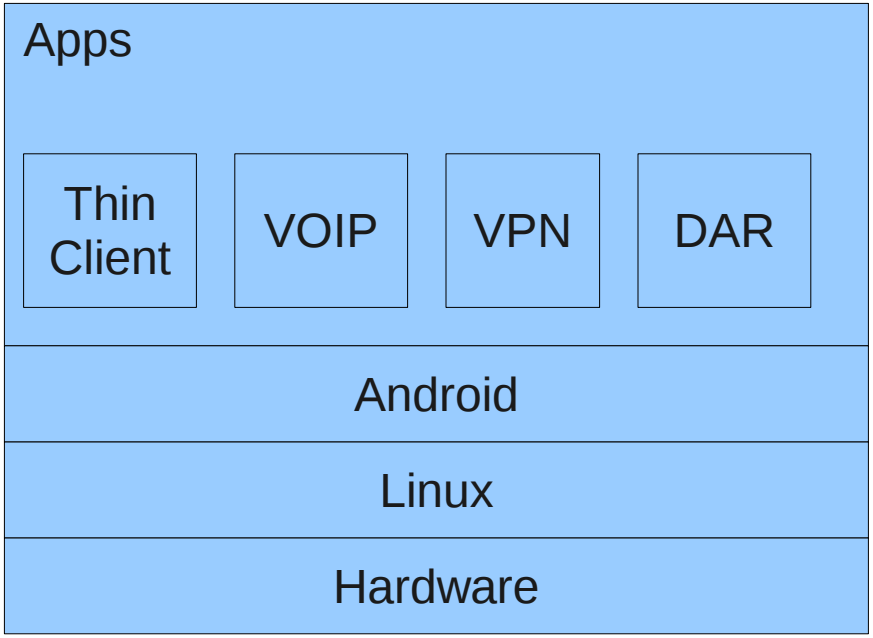
- Weak separation.
- Prone to privilege escalation.
- Lack of support for enforcing organizational security goals.



Secure Solutions on Android

Security Concerns

- Exposure of secrets.
- Protection of app mechanisms and configurations.
- No guaranteed invocation.



Building on a Solid Foundation

- Critical role of operating system protection mechanisms in supporting higher level security goals.
  - *The Inevitability of Failure: The Flawed Assumption of Security in Modern Computing Environments,* 21st NISSC, Oct 1998.
  - Flexible Mandatory Access Control (MAC) as a key mechanism
- SE Linux as a well-established foundation for mitigating threats posed by flawed and malicious applications.

SE Android Enhancements

- Kernel Mandatory Access Control (MAC).
  - SELinux-based.
  - Root exploits are no longer fatal.
  - Apps can be strongly separated.
- Middleware Mandatory Access Control (MMAC).
  - Taking Android permissions out of the hands of users and apps.

Effective Against

Root Exploits

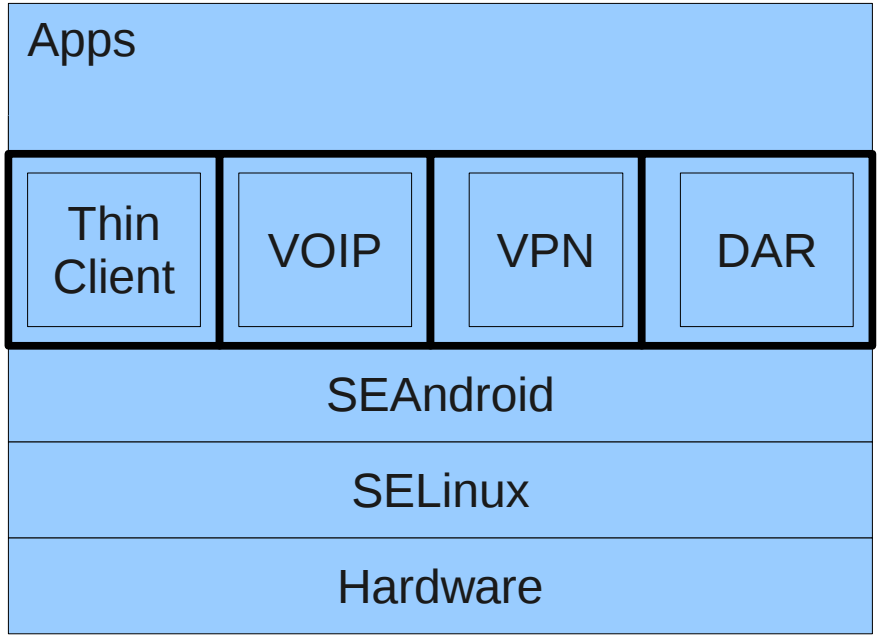
- GingerBreak
- Exploid
- Zimperlich
- RageAgainstTheCage
- Mempodroid
- KillingInTheNameOf

Vulnerable Apps

- Skype
- Lookout Mobile Security
- Opera Mobile

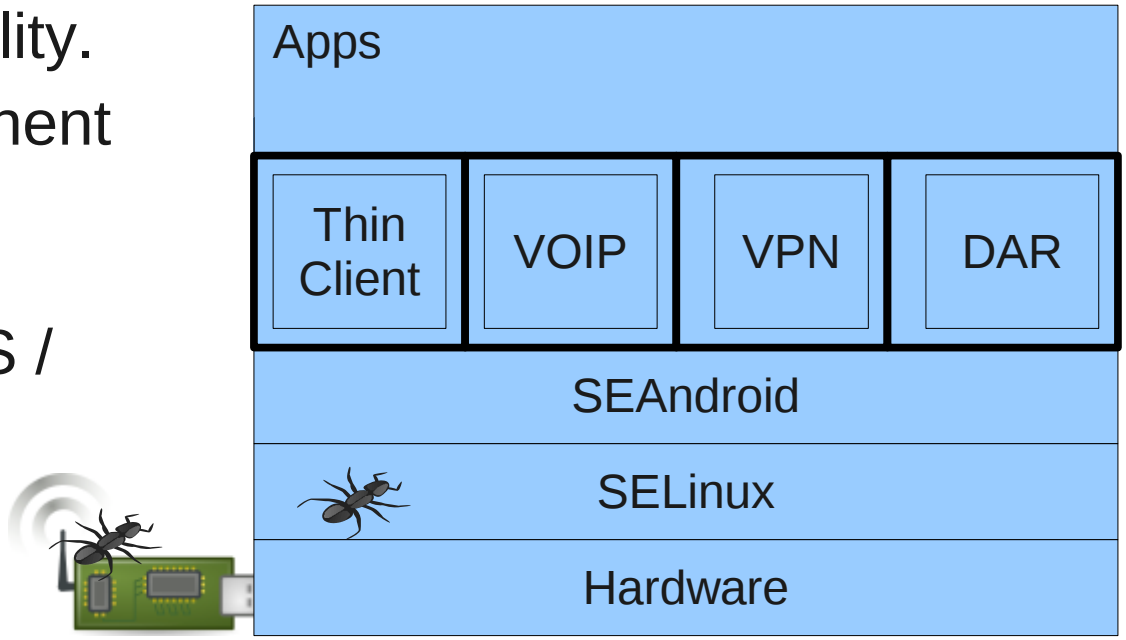
SE Android: Security Benefits

- Strong separation of apps.
- Prevents privilege escalation by apps.
- Enforces organizational security goals.
- Protects app mechanisms & configurations.



SE Android: Residual Risks

- Kernel vulnerability.
- Platform component vulnerability.
- Loading an unauthorized OS / configuration.



Addressing the Risks

- Requires mechanisms outside the scope of what any operating system mechanism can provide.
  - Cannot be addressed via SE Android.
  - Also true for SE Linux (or any other secure OS).
- Two key enablers emerged in commodity PC hardware:
  - Virtualization
  - Trusted Computing

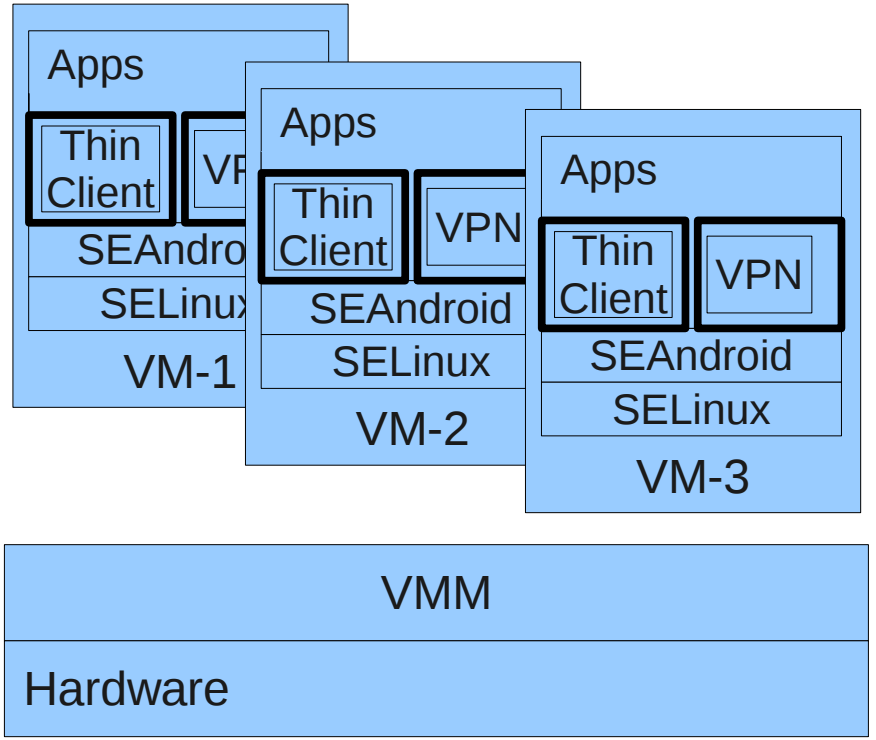
Secure Virtual Platform (SVP)

- NSA research program dating back to circa 2002.
- Explored the use of emerging hardware support for virtualization and trusted computing to address these same kinds of concerns for SE Linux.
- Investigated application of virtualization and trusted computing to construct an overall secure system architecture.

Basic Virtualization

Security Benefits

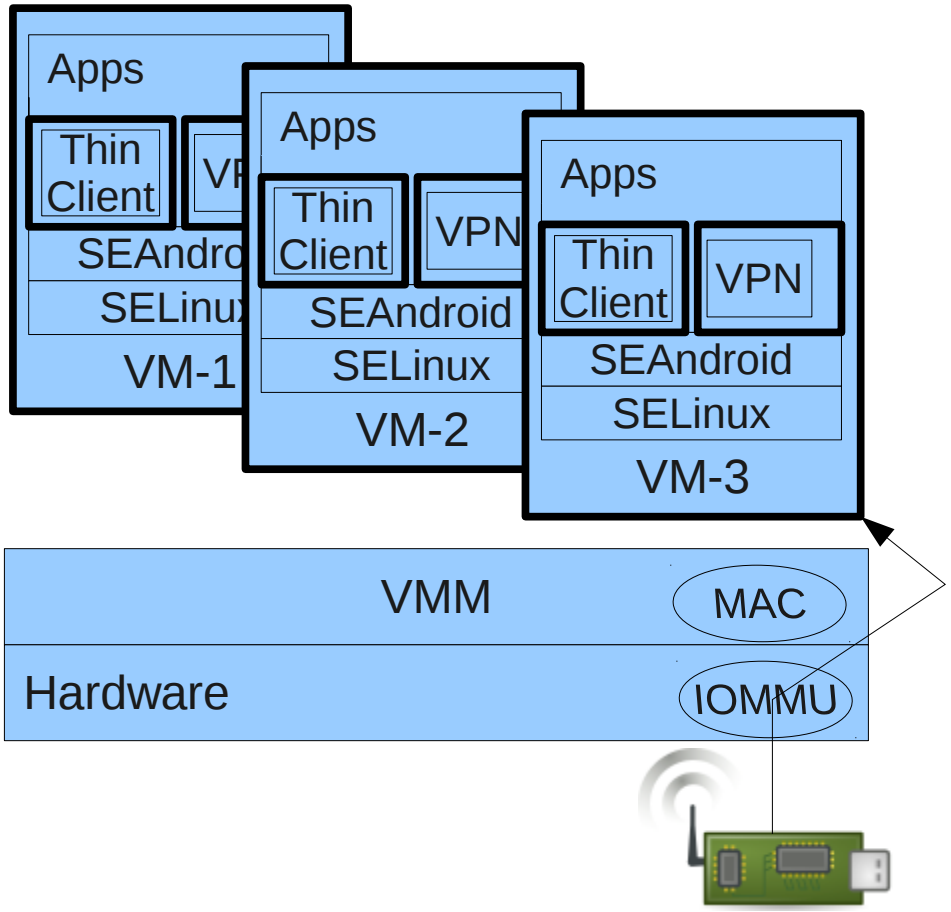
- Guest kernel vulnerability contained to single VM.
- Isolated environments via separate VMs.



Secure Virtualization

Security Benefits

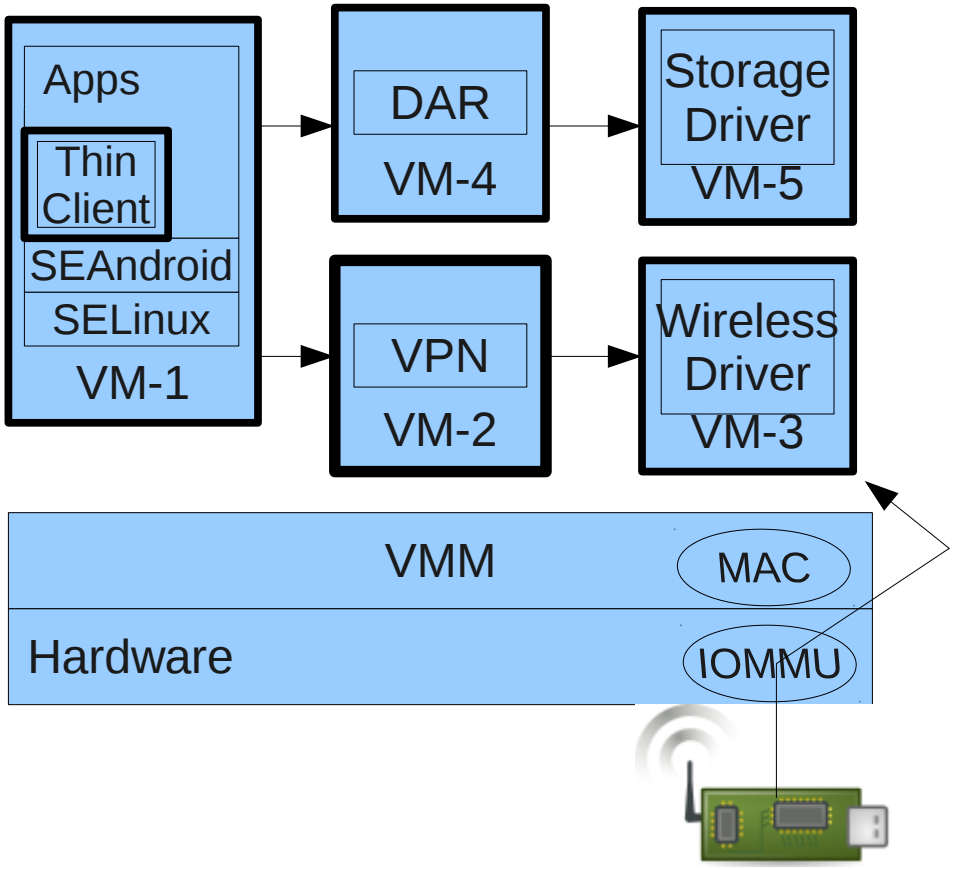
- Platform component vulnerability contained to single VM.
- VM interactions and privileges controlled by MAC policy.



Virtualization for Security

Security Benefits

- Driver isolation.
- Protection of security services.
- Assured invocation of security services.



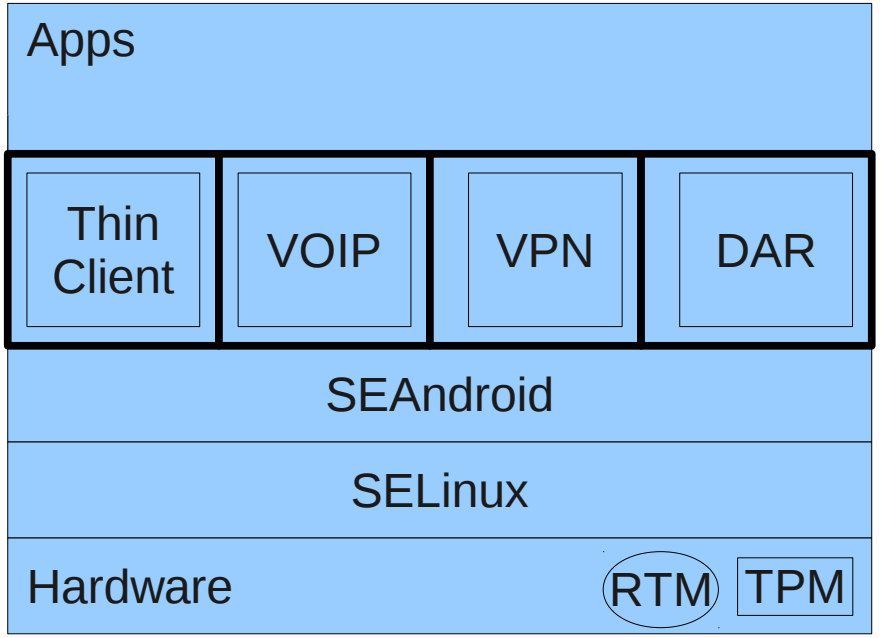
Virtualization instead of SE Android?

- Virtualization does not eliminate the need for a secure OS.
  - Unable to enforce security goals within guest OS.
  - Does not address need for controlled sharing.
  - Does not protect the data as it is being processed.
  - Still need to protect shared services & control plane.
  - Limited scalability and flexibility.

Trusted Computing

Security Benefits

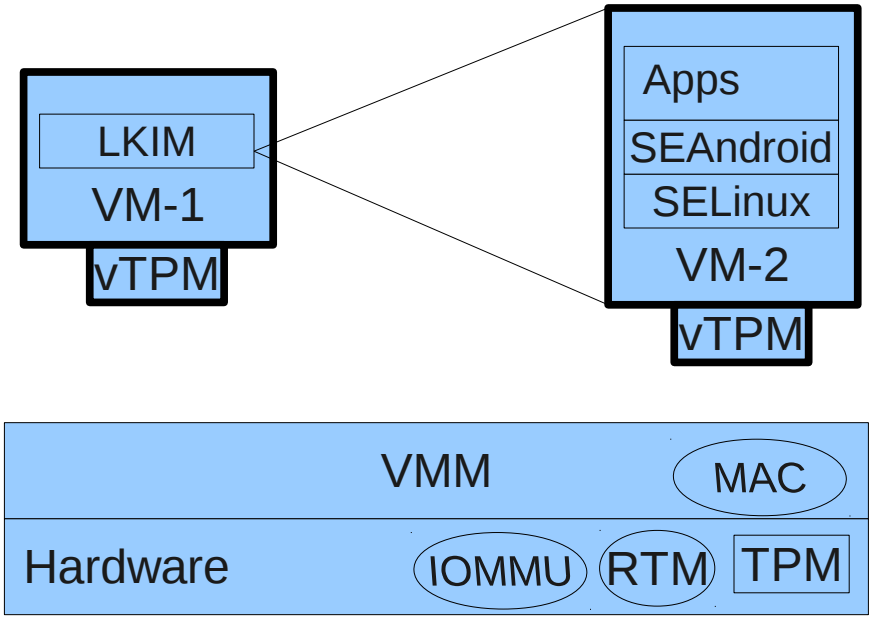
- Verifiable, trustworthy report of loaded software & configuration.
- Protection of long term secrets from leakage or misuse by unauthorized software.
- Hardware roots of trust.



Trusted Computing & Virtualization

Security Benefits

- Extend same benefits to each VM.
- Scalable measurement & attestation.
- Runtime integrity measurement of VMs.



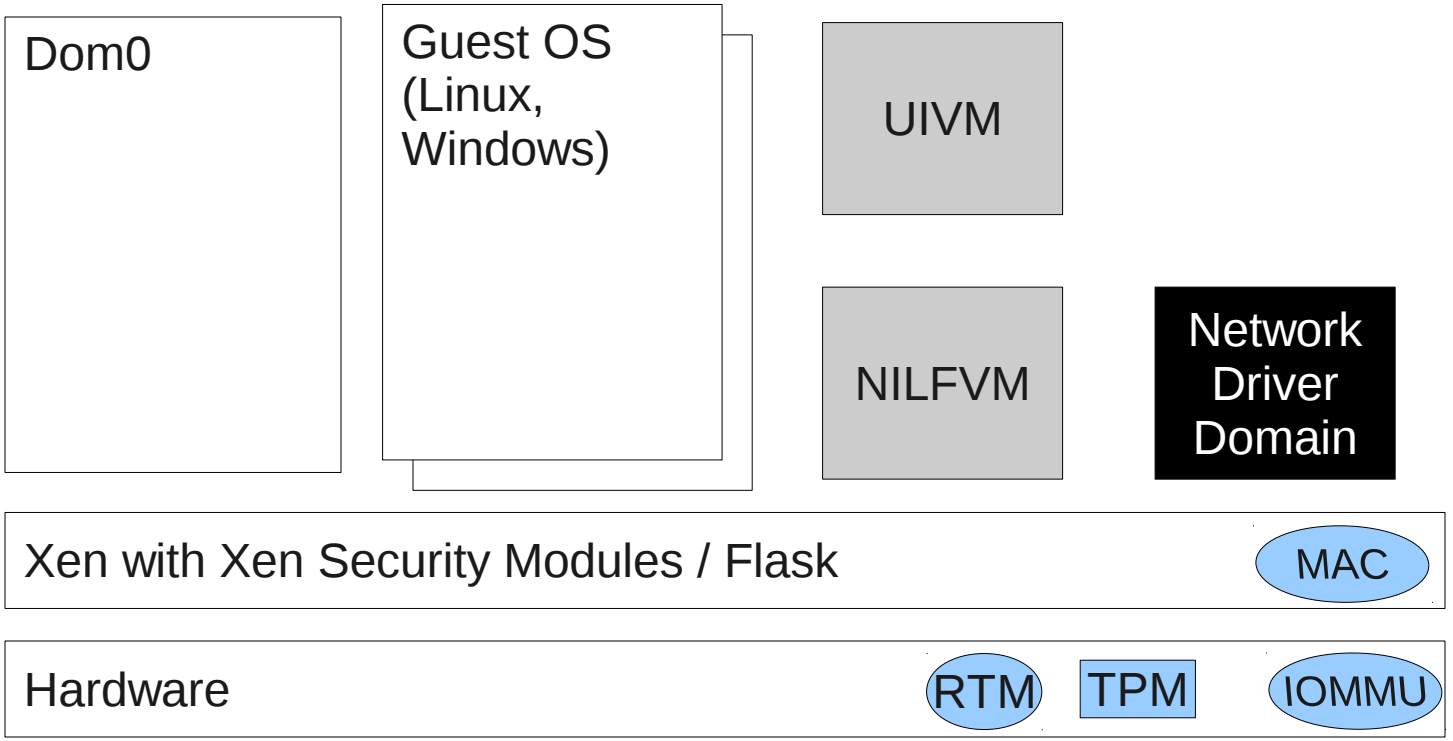
Trusted Computing instead of SE Android?

- Trusted Computing ≠ Secure Computing.
  - Does not remove vulnerabilities in design or implementation.
- Provides a way to validate system assumptions for secure computing.
  - Did the device boot the expected secure OS?
  - Is the secure OS running in the expected state?
- Not a substitute for a secure OS.

SVP Technology Transfer

- Some SVP concepts and code contributed to open source.
  - Xen Security Modules / Flask, vTPM, Linpicker
  - openAttestation
- Partial realization in commercial products and solutions.
  - XenClient XT product
  - AFRL SecureView solution

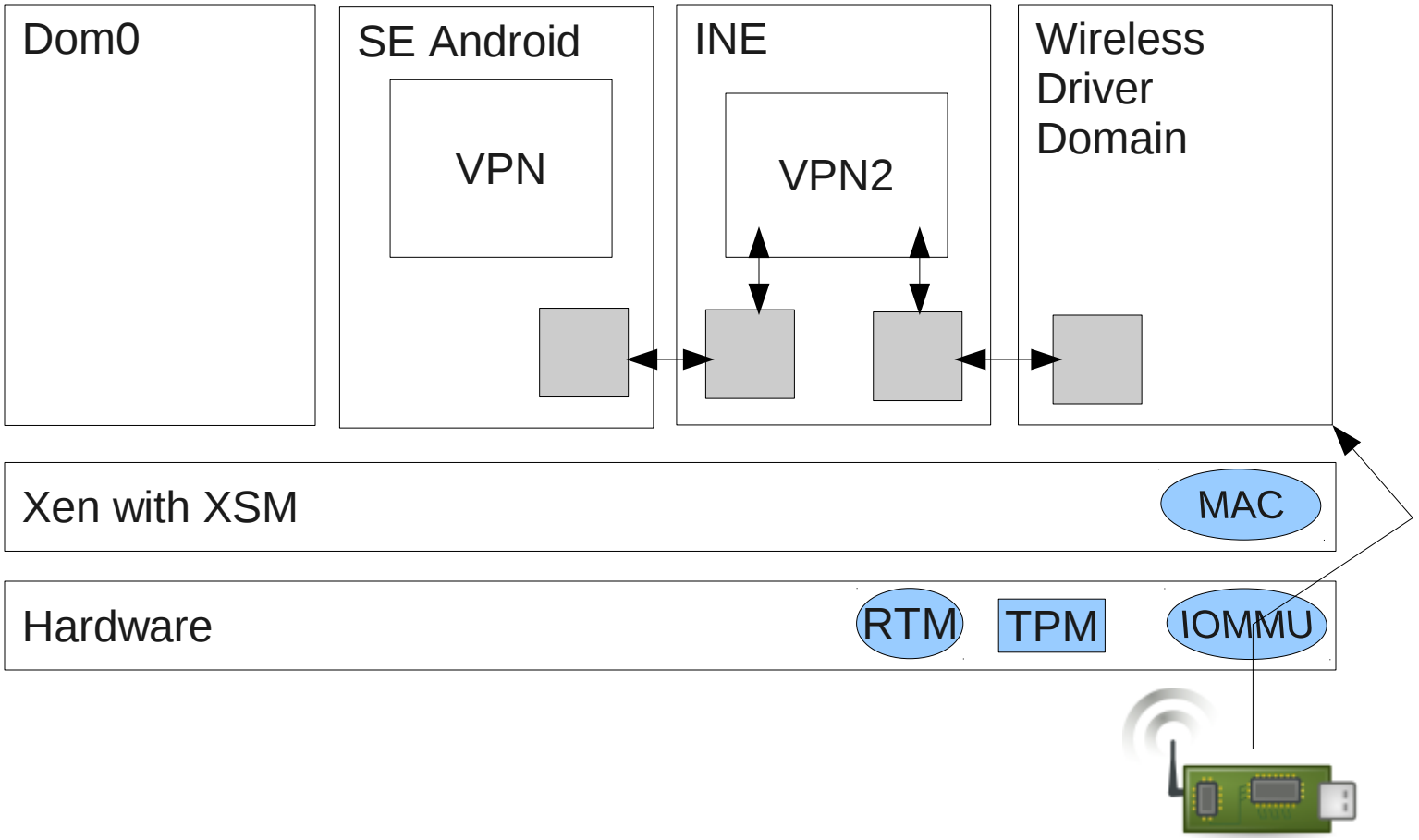
XenClient XT/SecureView



SVP: Going Mobile

- Originally implemented on PC hardware.
  - Able to leverage PC hardware primitives for virtualization and trusted computing.
  - Including TPM, RTM, IOMMU capabilities.
- Directly transferred to laptops.
  - Being leveraged in real solutions.
- Successfully ported to x86-based tablets.

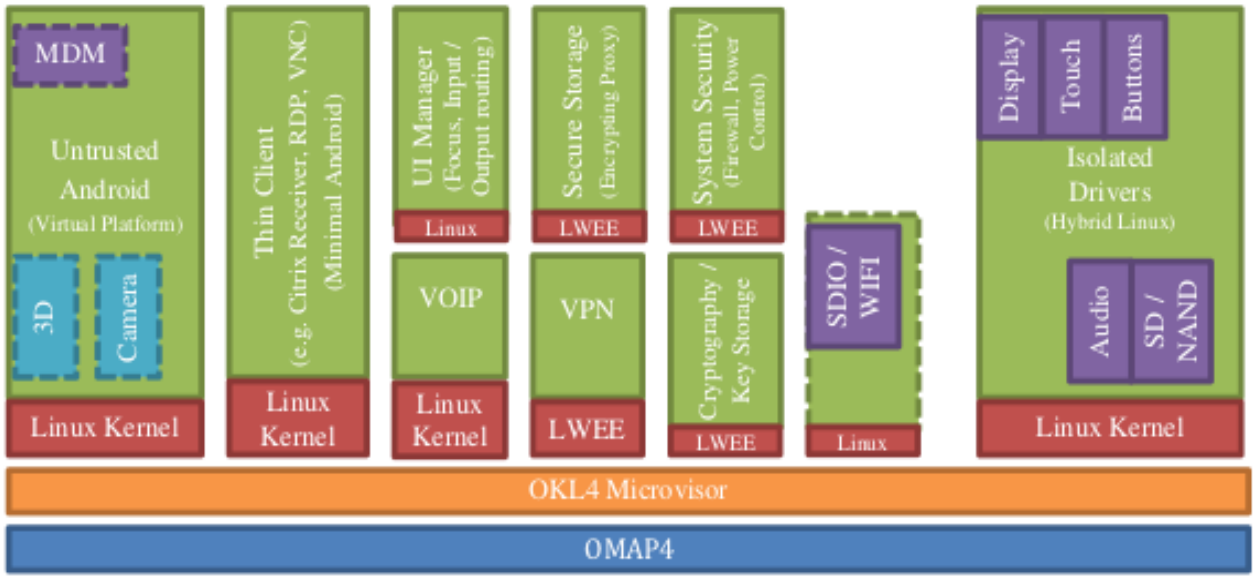
Tablet (x86) Architecture



SVP for ARM: Virtualization

- Leveraging OKL4 microvisor for para-virtualization.
- Looking ahead to ARM virtualization extensions.

OKL4-based Architecture



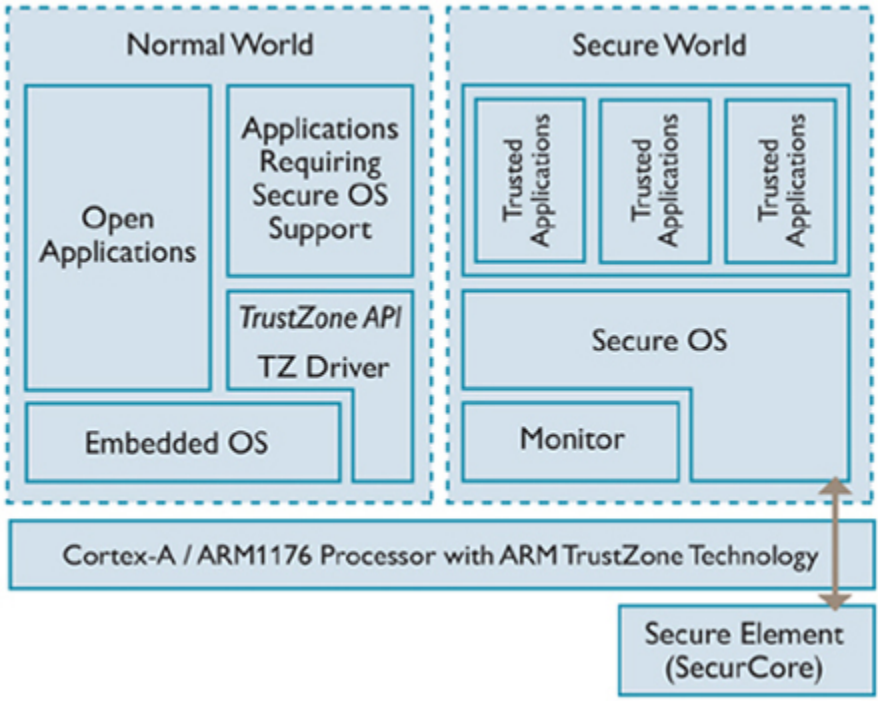
Concerns with ARM virtualization

- Lack of mature, deployed virtualization solutions for ARM.
- Need for OEM cooperation.
- Frequent lack of IOMMU support.
- Static configuration of VMs.

SVP for ARM: Trusted Computing

- TrustZone as the likely foundation.
  - Becoming more commonly available.
  - Provides support for isolated execution and protected storage.
  - Possible to tie to hardware root of trust.
  - Possible place to host a MTM.

TrustZone



Source: www.arm.com/products/processors/technologies/trustzone.php

Concerns with TrustZone

- No measured launch or attestation for secure monitor and secure world OS.
- Lack of widely available MTM implementations with standard APIs.
- Lack of / unclear state of separation of trusted applications.
- Lack of public details on many aspects of implementation important to security.
- Variability across hardware.

TrustZone instead of SE Android?

- Cannot address all security concerns of interest.
  - Cannot protect data as it is being processed within the normal world.
  - Similar to discussion of virtualization.
  - Trying to address all security concerns via TrustZone will only lead to functional and API bloat, making it less secure.
- Also requires secure OS functionality for the secure world.

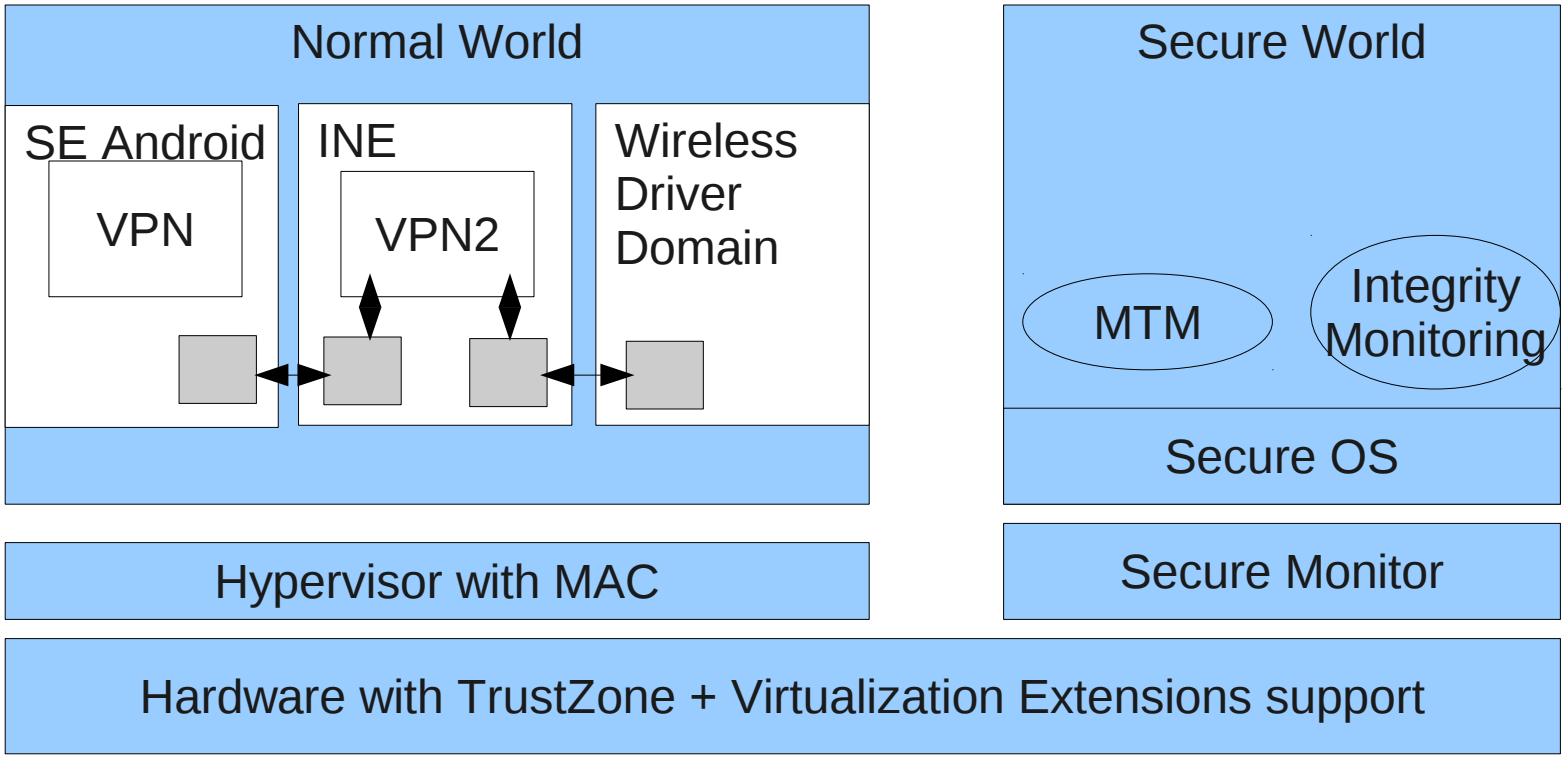
TrustZone instead of Virtualization?

- Only supports secure world vs non-secure world partitioning.
- Cannot support multiple VM architecture for security.
- Would likewise end up pushing too much functionality into TrustZone secure world.

TrustZone Correctly Applied

- Measured launch for normal world hypervisor and control plane.
- Provide MTM functionality.
- Safe place for runtime integrity monitoring of hypervisor.
- Protect the underpinnings of a system with virtualization and secure OS functionality.

Putting it all together



Reaching the Goal

- Processor, SOC and device makers:
  - Make virtualization and trusted computing primitives ubiquitously available.
  - Enable use of virtualization and trusted computing by third party developers.
- Mobile platform developers:
  - Include secure OS functionality.
  - Leverage virtualization and trusted computing for security.
  - Enable third party developers to leverage this functionality / extend to applications.

Avoiding the PC malware plague

- PC industry did not address these threats early.
  - Plagued with malware as a result.
  - Trapped in a quagmire of legacy / compatibility requirements.
- Don't make the same mistake for mobile devices.
  - Device OEMs and mobile OS developers have an opportunity to do it right.
  - Mobile device ecosystem makes it possible to still change.

Questions?

- My email: sds@tycho.nsa.gov
- SE Android project: http://selinuxproject.org/page/SEAndroid
- Public SE Android list: Send “subscribe seandroid-list” to majordomo@tycho.nsa.gov.
- NSA SE Android team: seandroid@tycho.nsa.gov