RSA Conference2015
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SESSION ID: HTA-F01

# To Swipe or Not to Swipe: A Challenge for Your Fingers

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# Functionalities Using Fingerprints

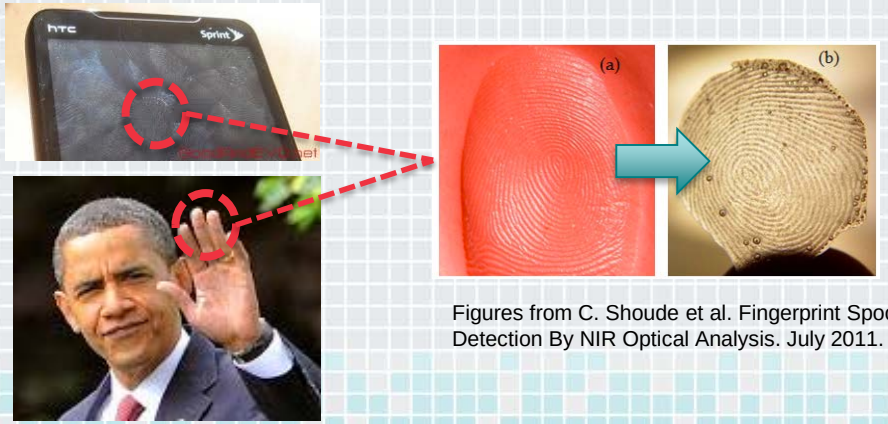
- Authentication
  - System screen unlock
  - Login in FIDO alliances' services
- Authorization
  - iTunes/App store pay
  - Apple Pay
  - Transaction authorization using FIDO

# Risk: Fingerprints Never Expire

- Password leaked? Fine, you can easily replace it with a new one.
- Fingerprint leaked? Well, it is leaked for the rest of your life.
- Moreover, it is associated with your identity record, immigration history, etc.

# Existing Optical Attacks

- Fingerprints can be stolen from its owner if a person touched any object with a polished surface like glass or a smartphone screen.
- Fingerprints can even be extracted from a waving hands photo.
- Attackers can spoof fingerprints accordingly using electrically conductive materials.




Figures from C. Shoude et al. Fingerprint Spoof Detection By NIR Optical Analysis. July 2011.

# System Attacks against Fingerprints?!

This talk will show attacks on Android devices:

- Confused Authorization Attack
  - Bypass pay authorizations protected by fingerprints
- Fingerprint DB Manipulating
- Fingerprint Sensor Spying Attack
  - Collect fingerprints through malware

# Outline

- Design of Android Fingerprint Frameworks
  - Fingerprint Recognition
  - Mobile Fingerprint Frameworks
- System Attacks against Fingerprints
  - Confused Authorization Attack
  - Fingerprint DB Manipulating
  - Fingerprint Sensor Spying Attack
- Takeaways

# Outline

- **Design of Android Fingerprint Frameworks**
  - Fingerprint Recognition
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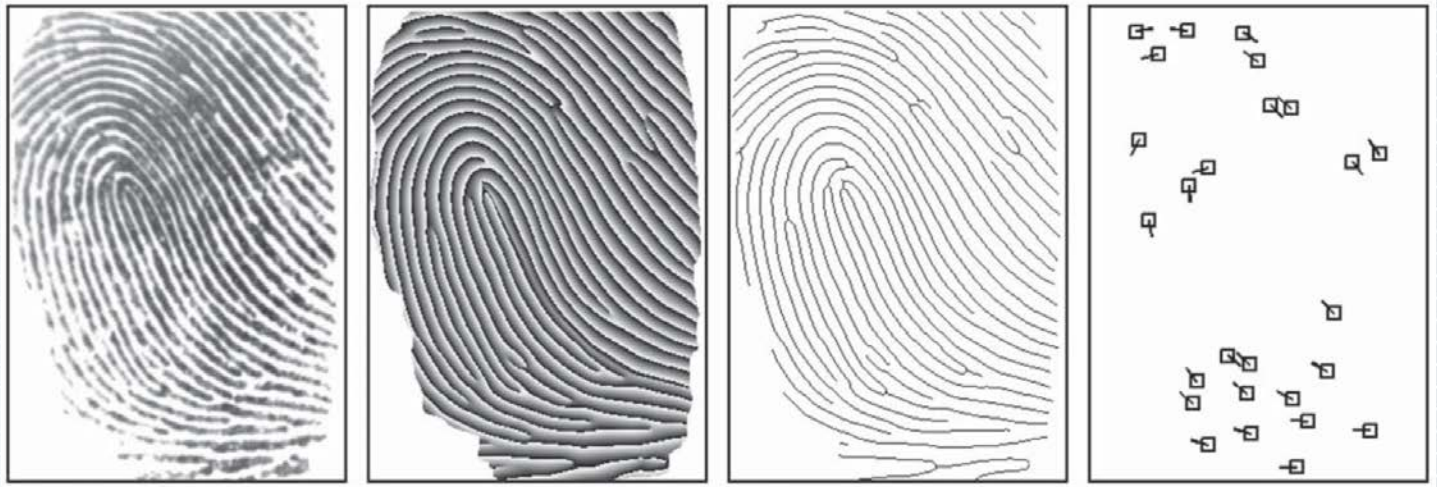
# Fingerprint Recognition

# Fingerprint Recognition: Minutiae Extraction



Grayscale Image

Phase Image

Skeleton Image

Minutiae

Figures from J. Feng and A. Jain, Fingerprint Reconstruction: From Minutiae to Phase
IEEE TRANSACTIONS ON PATTERN ANALYSIS AND MACHINE INTELLIGENCE, VOL. 33, NO. 2, FEBRUARY 2011

# Fingerprint Recognition: Minutiae Matching

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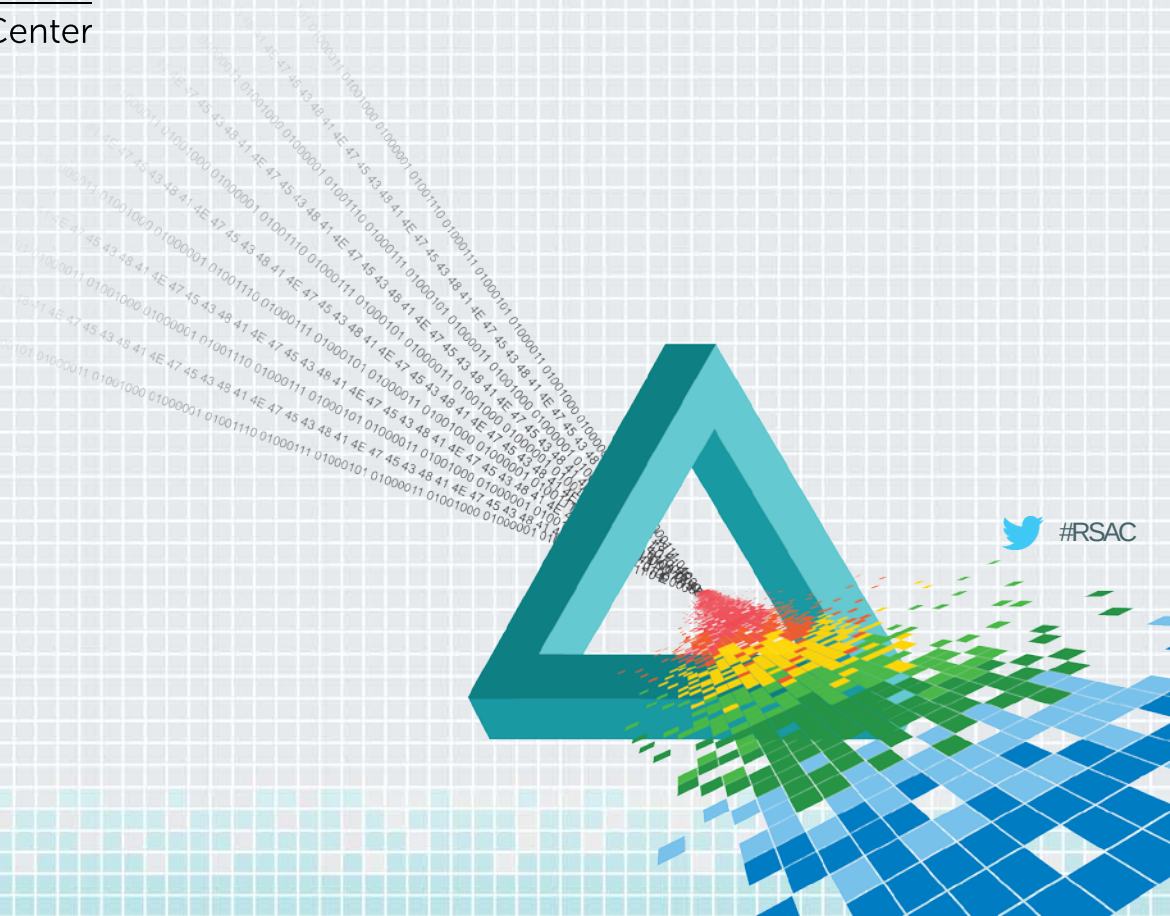
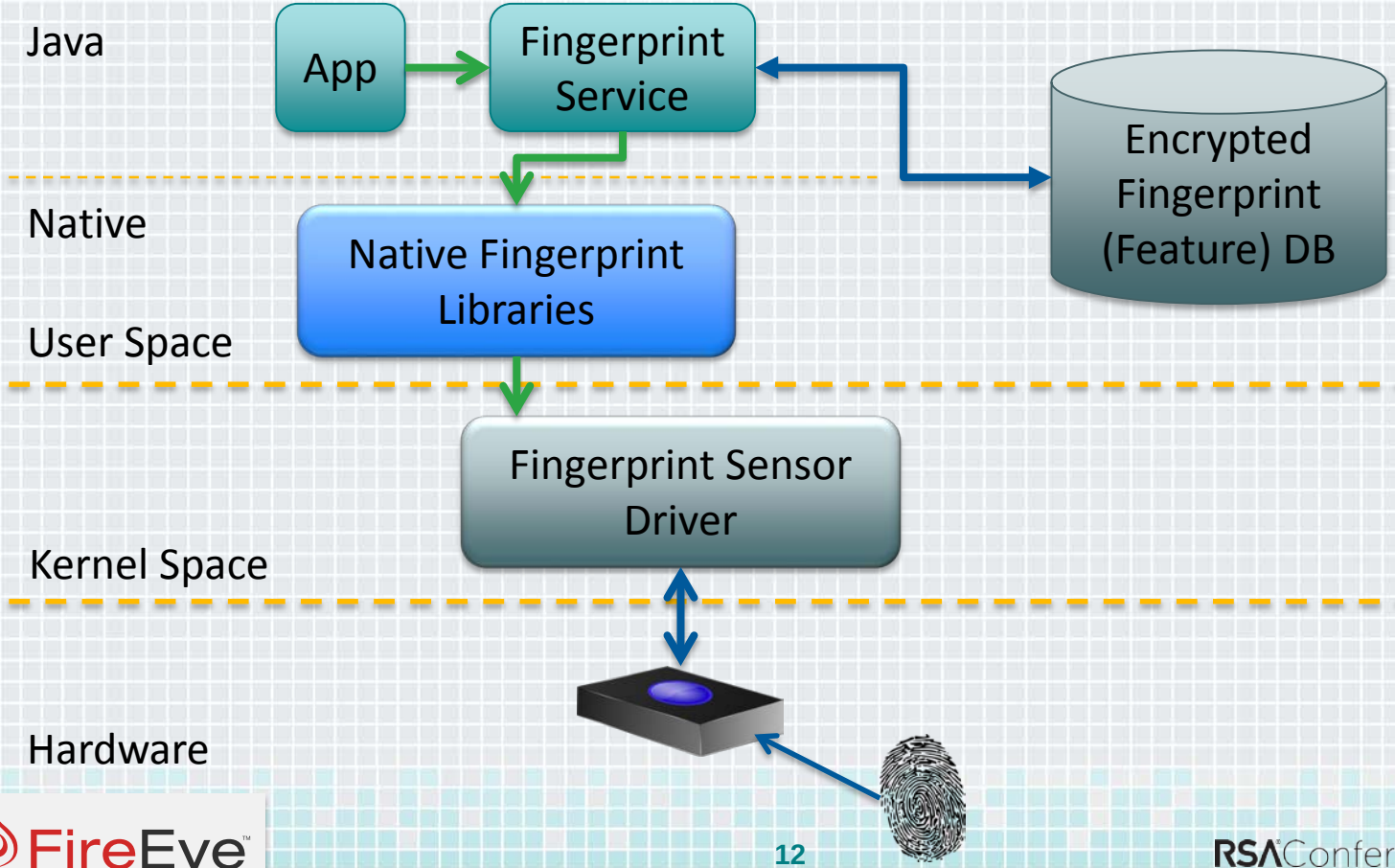
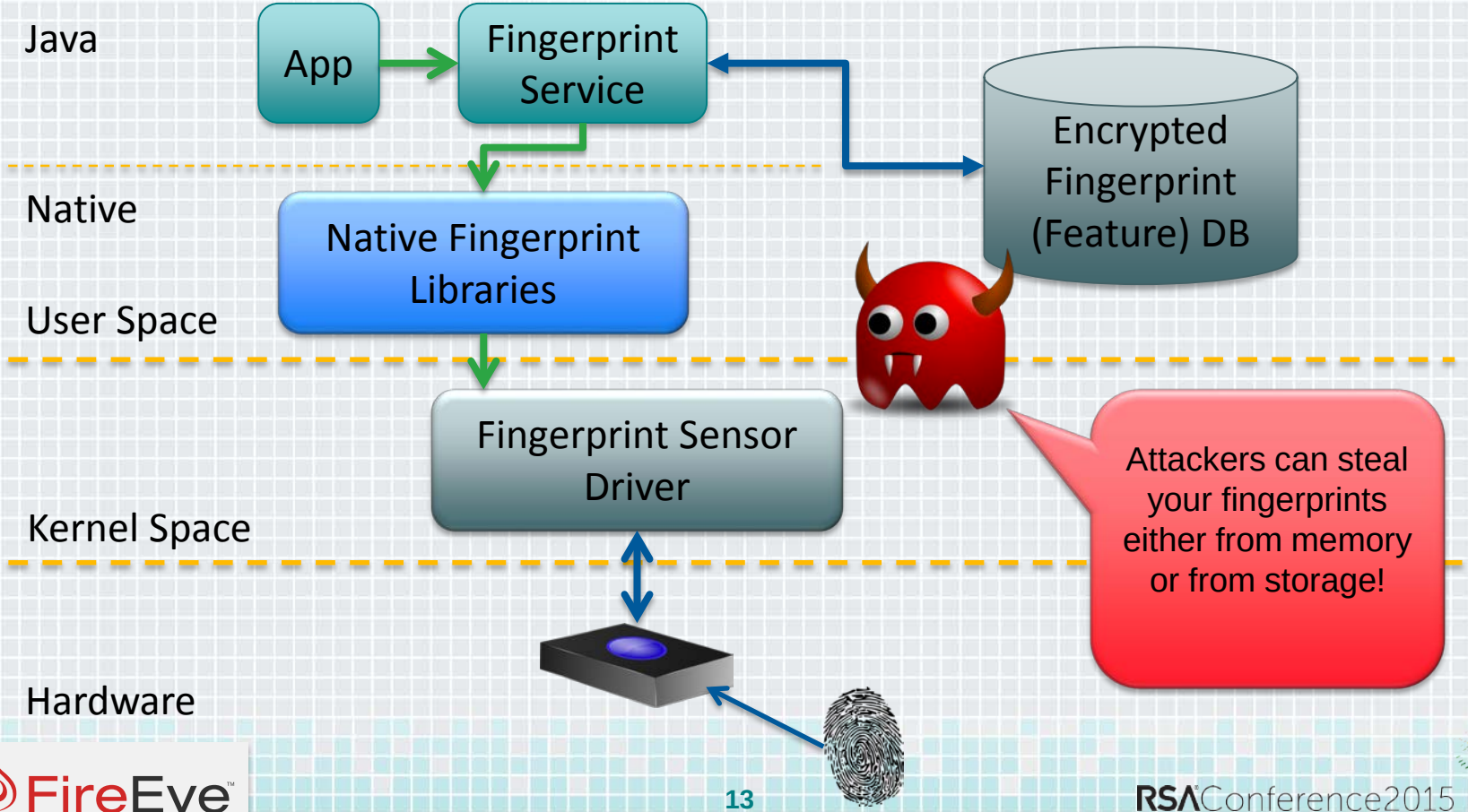
# Mobile Fingerprint Frameworks



# Fingerprint Framework without TrustZone



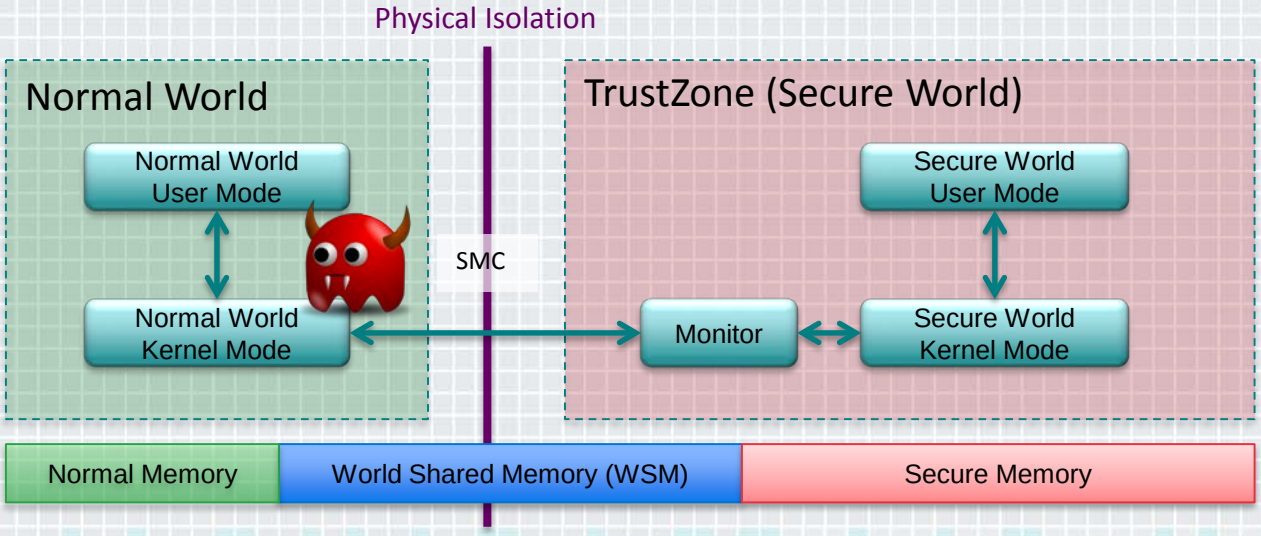
# Threat: Rooting Attacks



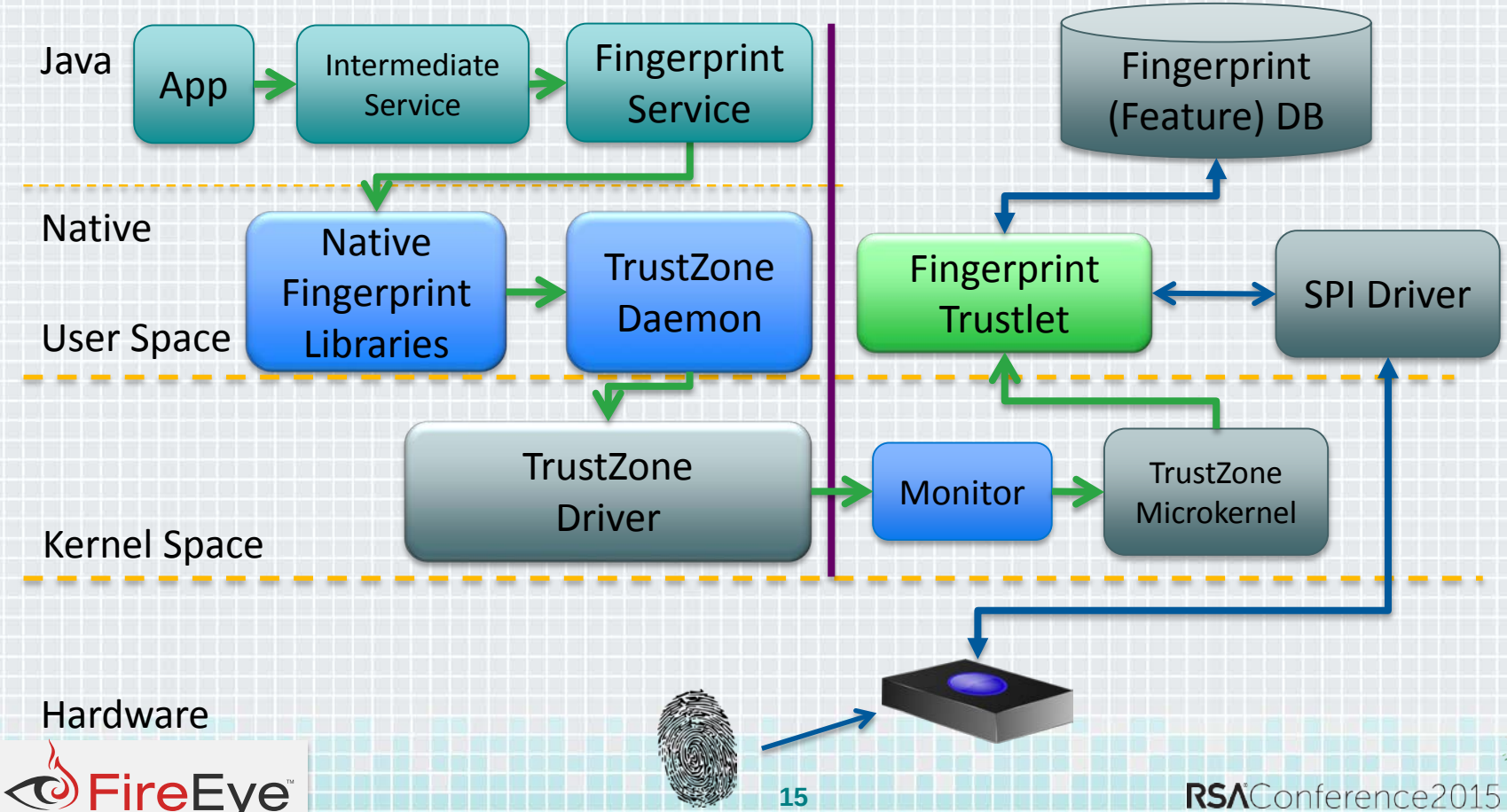
# How to Defend against Rooting Attacks?
# TrustZone

ARM TRUSTZONE System Security

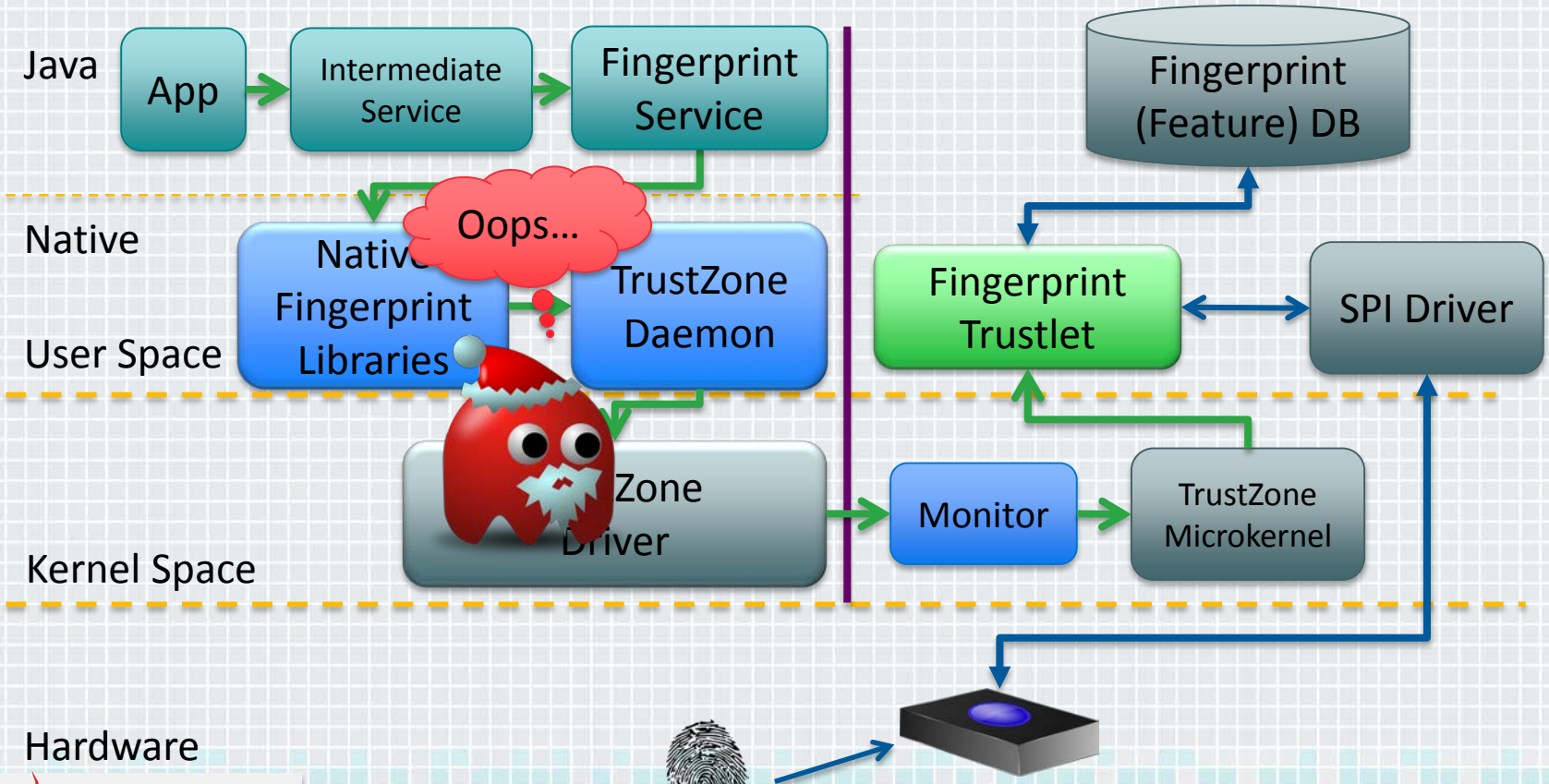
- Separate the system to the Normal World, and the Secure World
- Contain potential compromises in the Normal World



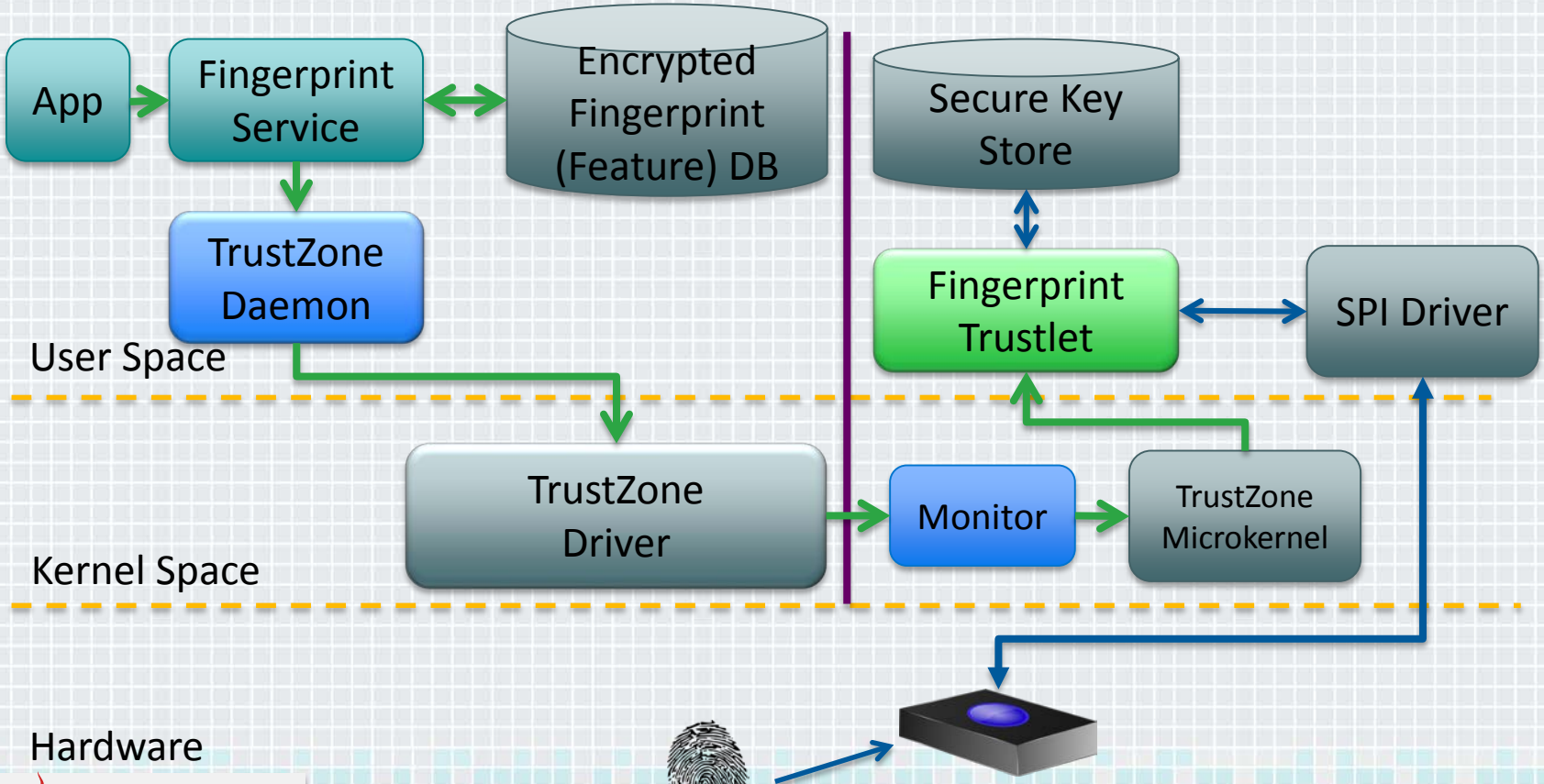
# Fingerprint Framework with TrustZone



# Rooting Attackers Cannot Access Fingerprints in TrustZone



# Fingerprint Authorization Framework with TrustZone



# FIDO Alliance


Alibaba Group
ARM
Microsoft
NXP
DISCOVER
CrucialTec
VISA
Synaptics
Google
lenovo FOR THOSE WHO DO.
IdentityX
MasterCard
Nok Nok LABS

# Outline

- Design of Android Fingerprint Frameworks
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  - Fingerprint DB Manipulating
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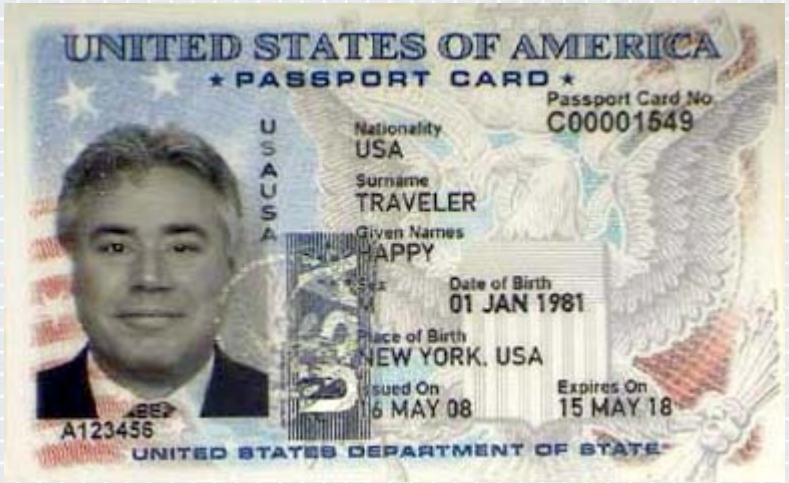
# Confused Authorization Attack

# Confused Authorization Attack

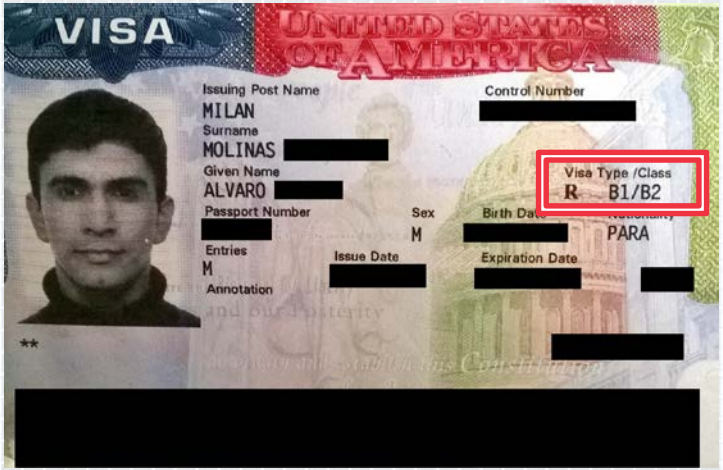
## Authentication

- Who you are (Passport)




## Authorization

- What you can do (Visa)




Figures from Wikipedia

# Authenticating

Figures from fcssllc.com

# Authorizing


Figures from dailytech.com

# Authorizing: Context!


Figures from dailytech.com

# To Swipe or Not To Swipe, without A Context?


Figures from dailytech.com

# What are your fingerprints?


OR

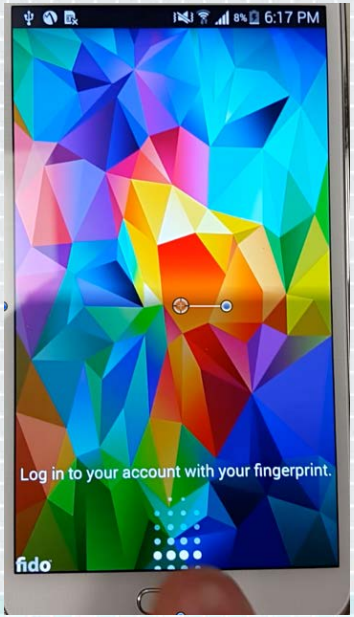
# Confused Authorization Attack

- Do you ever have a second thought when you swipe to unlock the device?

It can enable background attacker to steal your money from your PayPal account!!!

# Confused Authorization Attack






# Confused Authorization Attack

- Question

How can I testify what's happening behind the finger swiping?

You can't tell…

What's the difference of swiping to unlock the device with swiping to authorize a transaction?

You can't tell…

# Confused Authorization Attack

- Applications often mistakenly treat authorization as authentication, and fail to provide context proofs for authorization.
- Without proper context proof, the attacker can mislead the victim to authorize a malicious transaction by disguising it as an authentication or another transaction.

# Protections

- Long term: unlike authentication, authorization needs trusted contexts
  - The modules in TrustZone (trustlets) should provide such supports
  - The current FIDO framework doesn't support it yet.
- Short term:
  - Upgrade your system to the latest version to fix all the known vulnerabilities.
  - Only install popular apps from Google Play on your phone with fingerprint sensors

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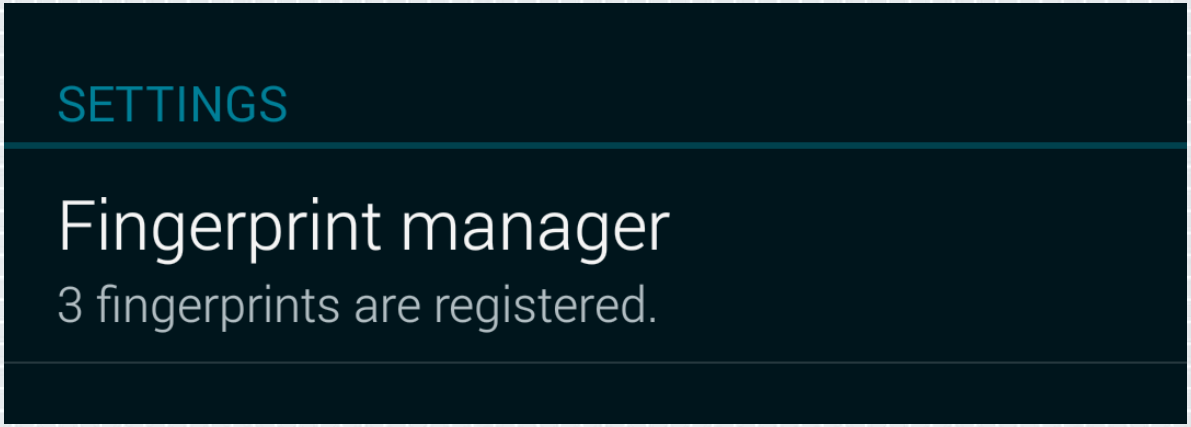
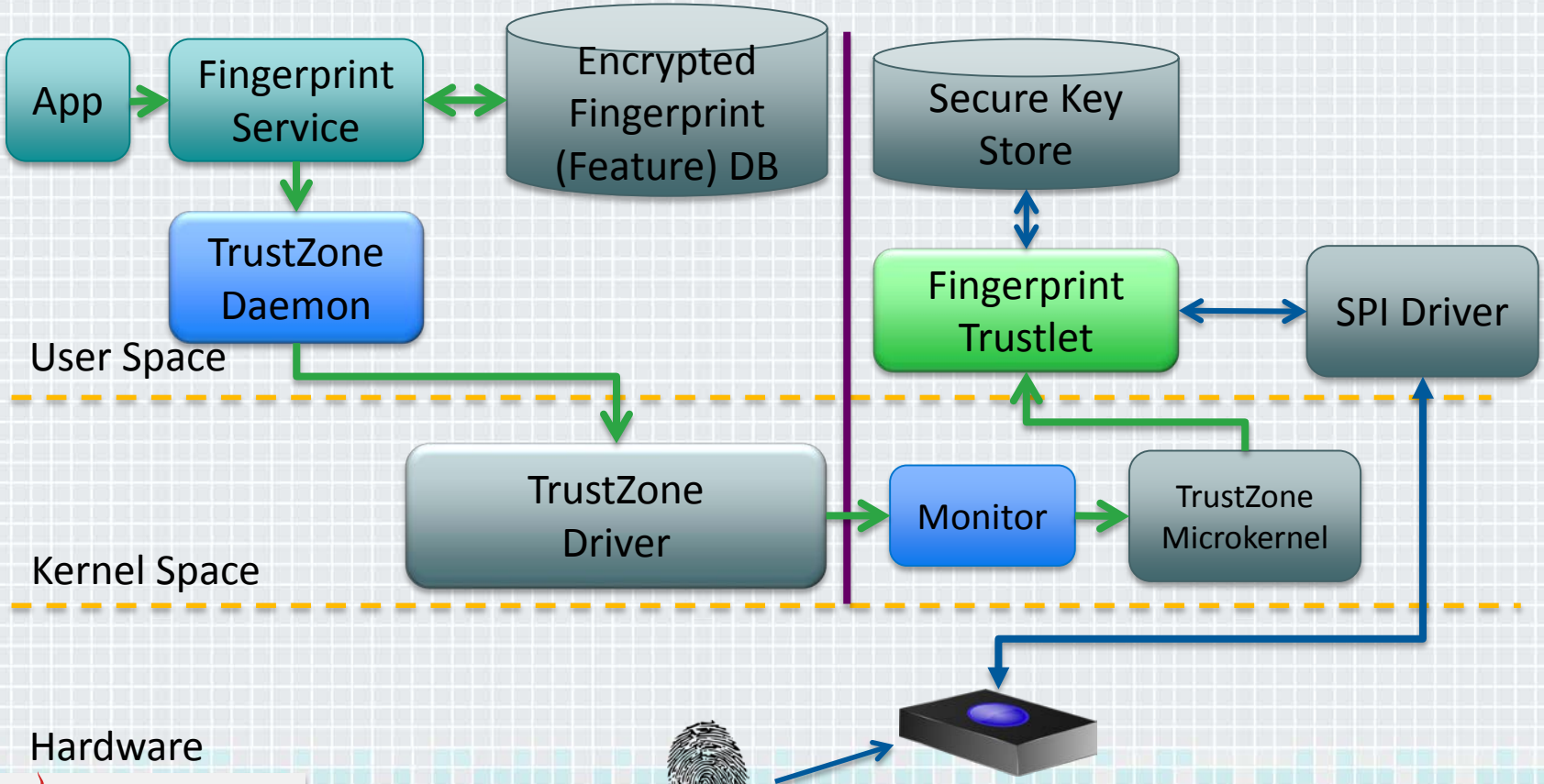
# Fingerprint DB Manipulating

# Fingerprint Settings

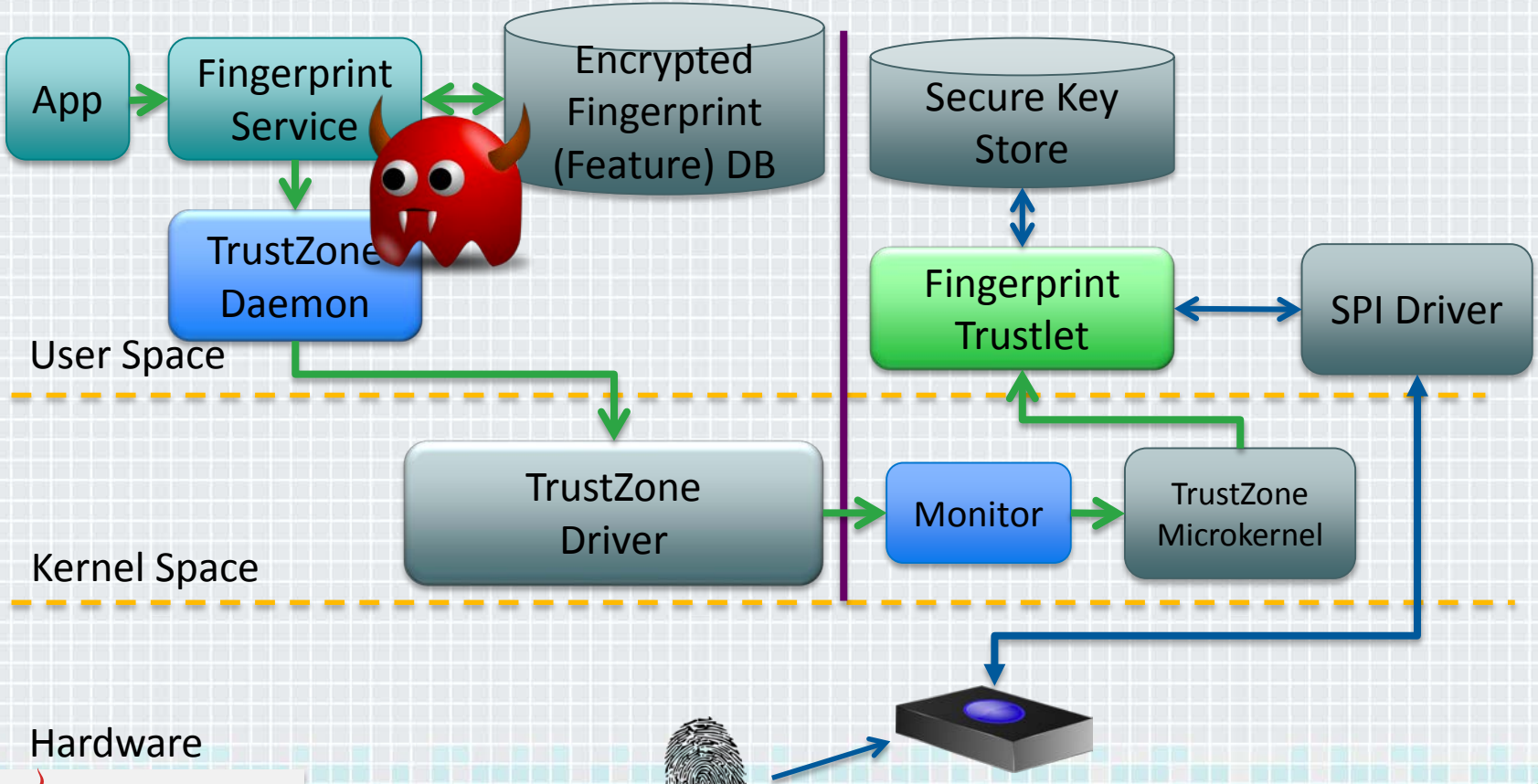



- How can you attest that only 3 fingerprints were registered?

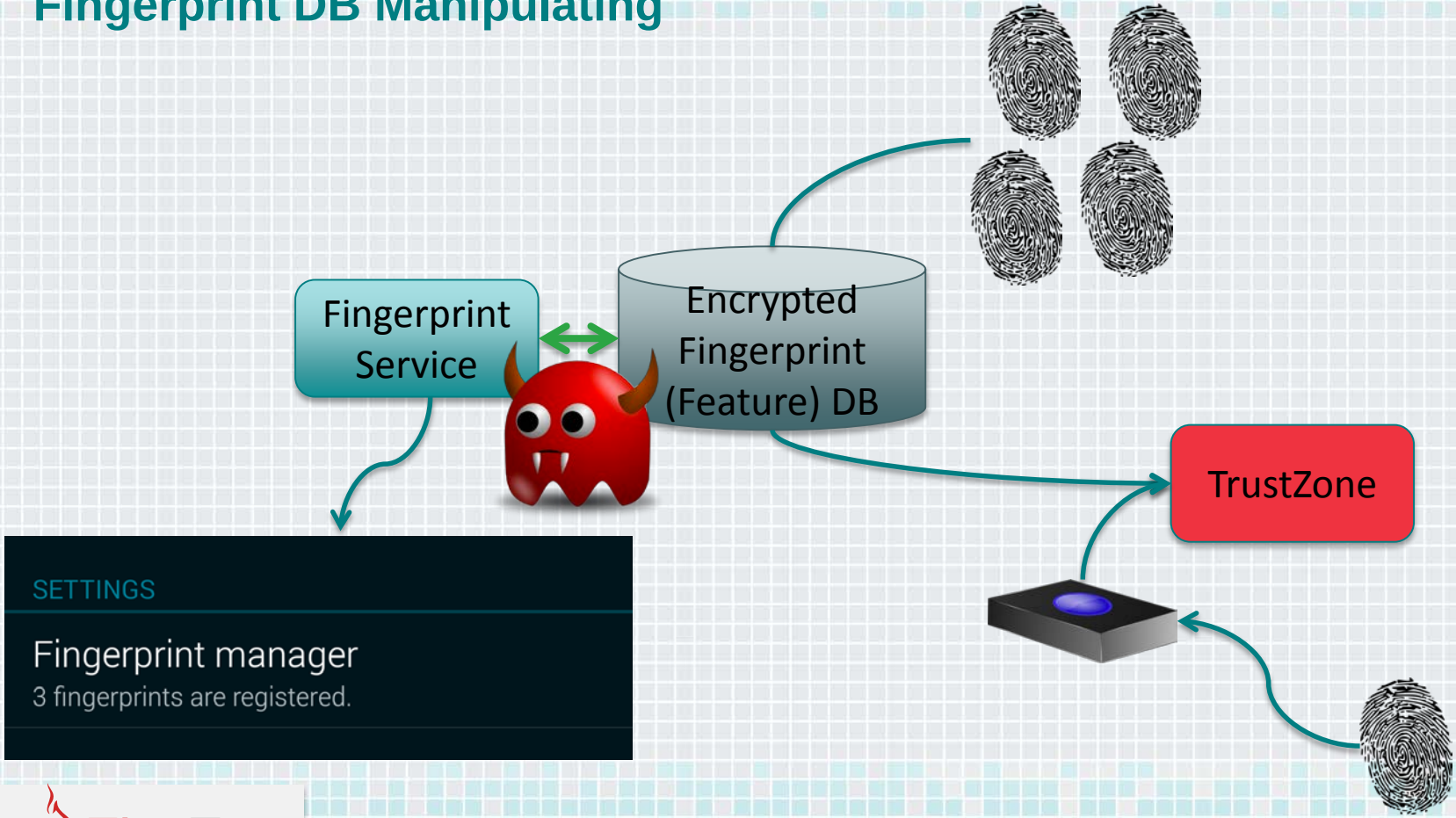
# Fingerprint Framework



# Fingerprint DB Manipulating



# Fingerprint DB Manipulating



# Fingerprint DB Manipulating

- TrustZone just scans a fingerprint and matches it against encrypted fingerprints fed from the normal world
  - It knows nothing about the number of fingerprints stored by the normal world
- An attacker can tamper the normal world framework to stealthily pre-embed special fingerprint blob (maybe fake)
  - So he/she can unlock the device or authorize other operations
  - Leave no explicit traces

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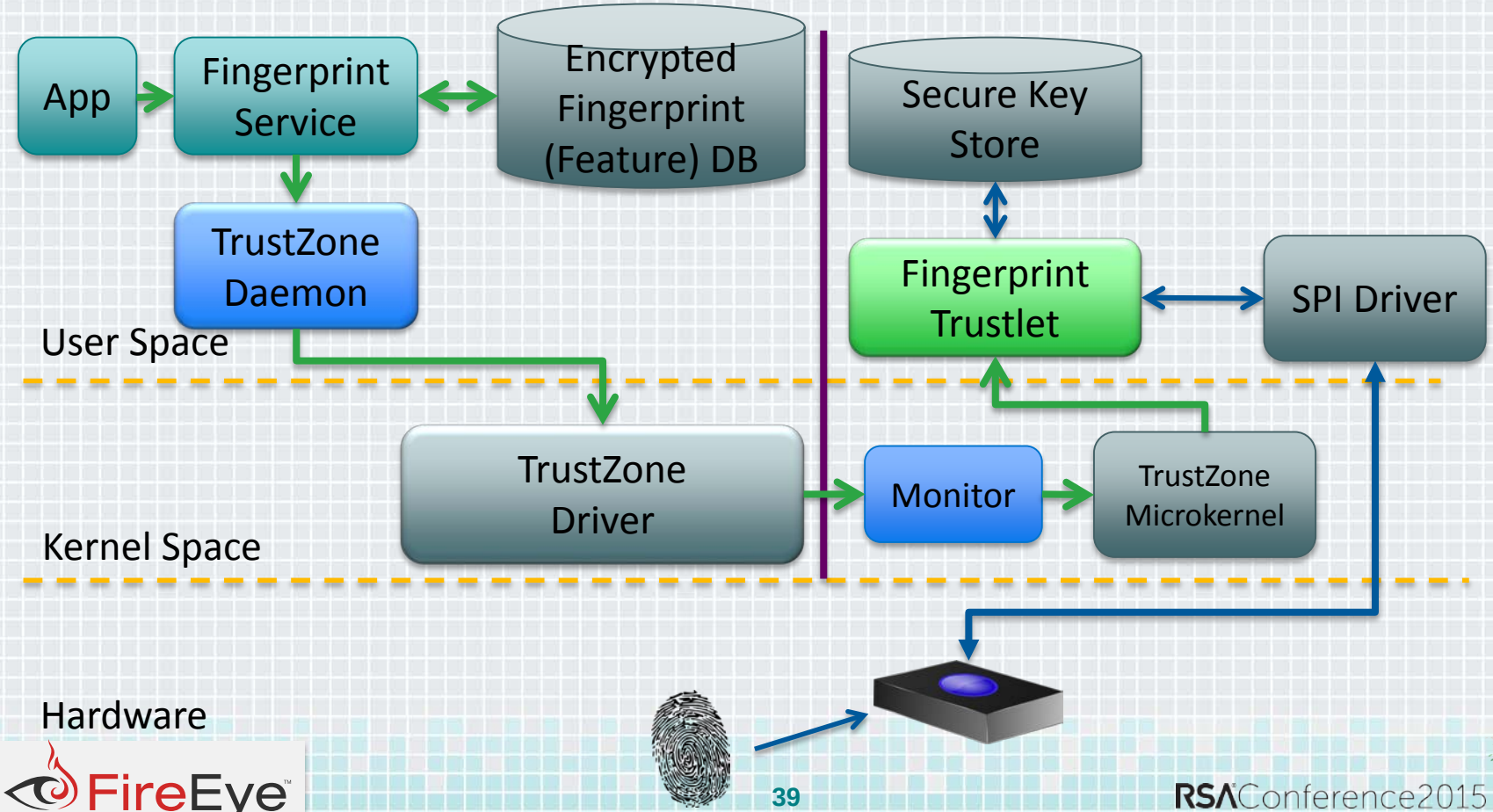
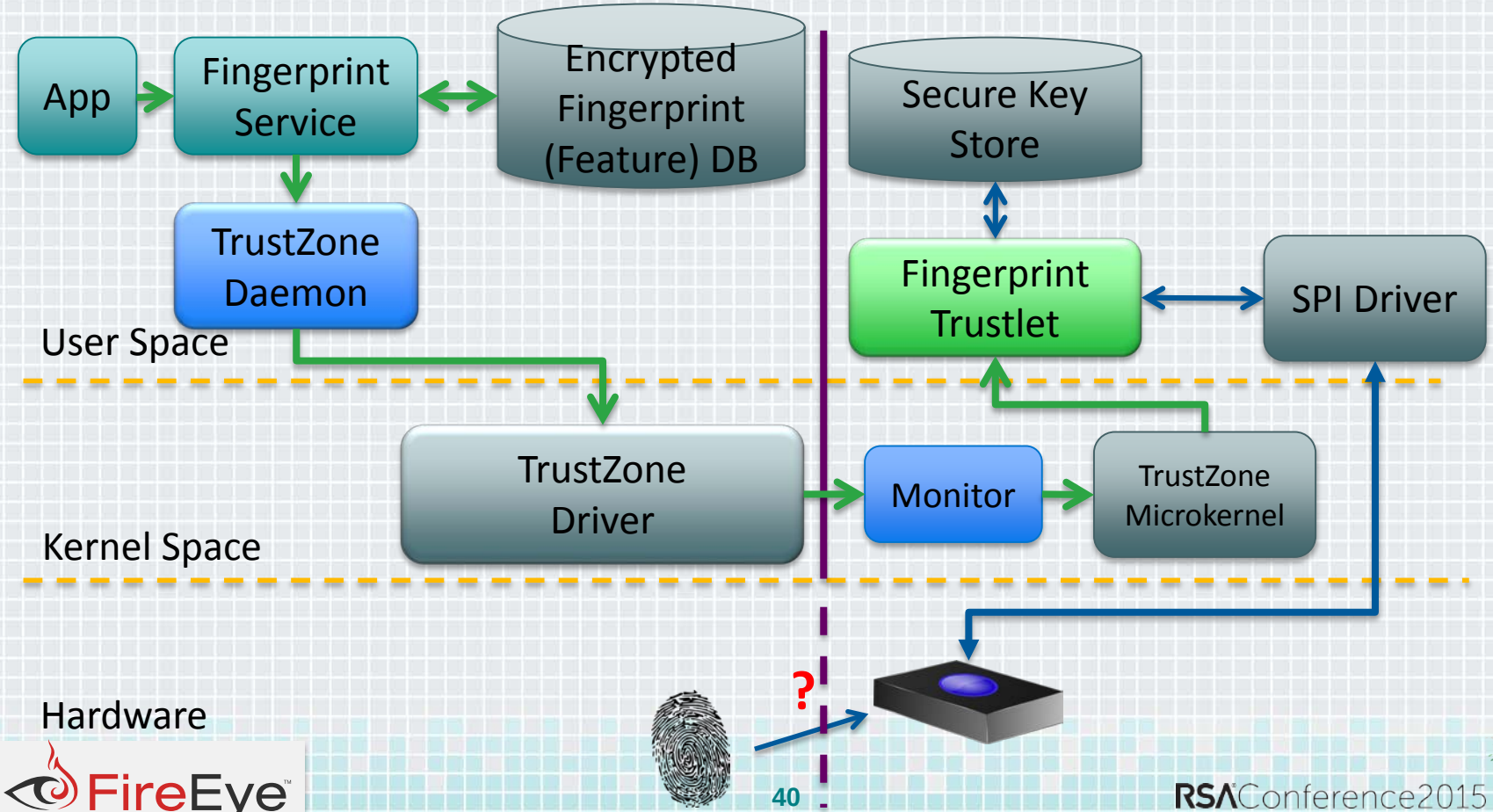
# Fingerprint Sensor Spying Attack

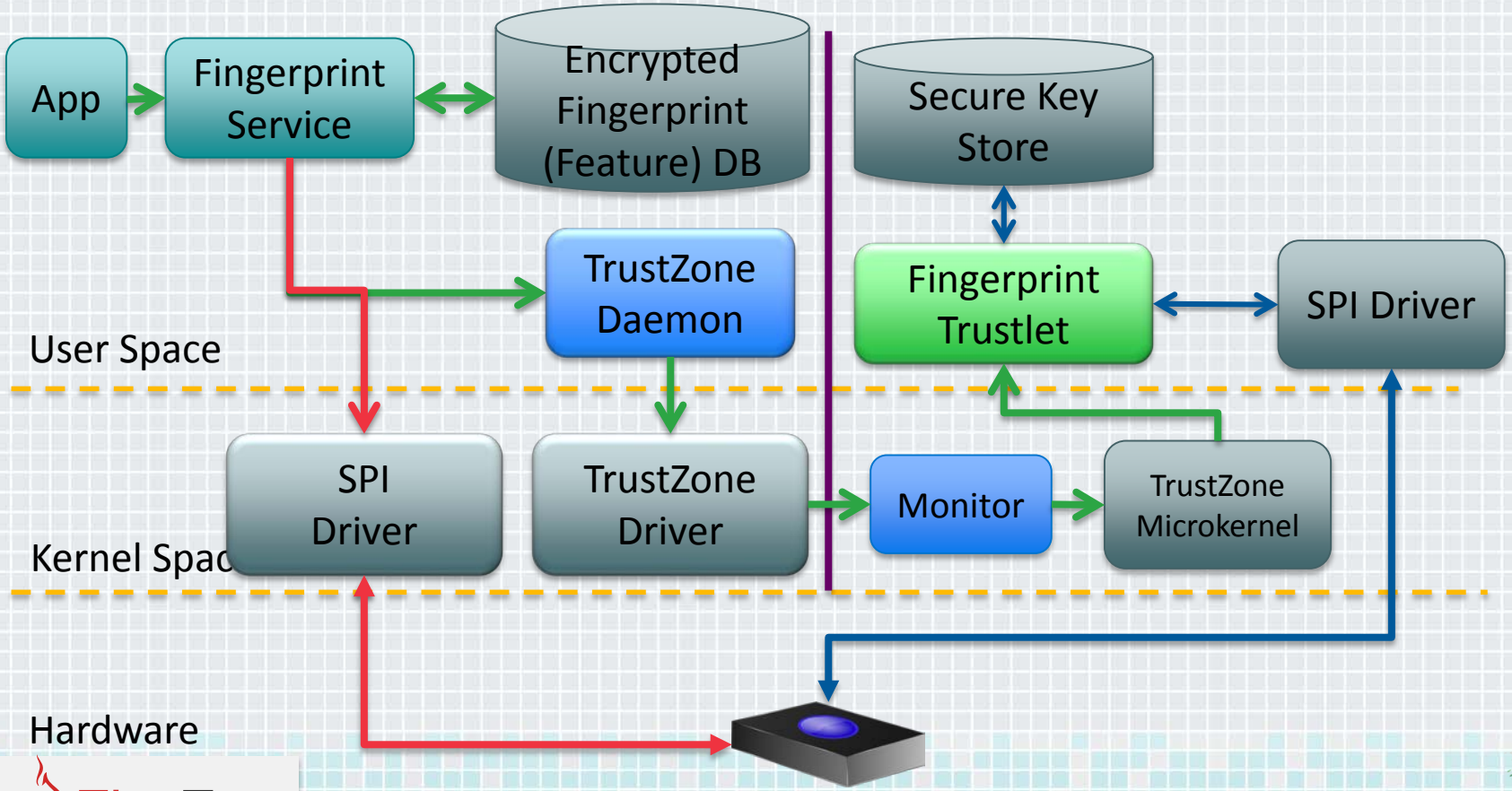
# Fingerprint Framework with TrustZone



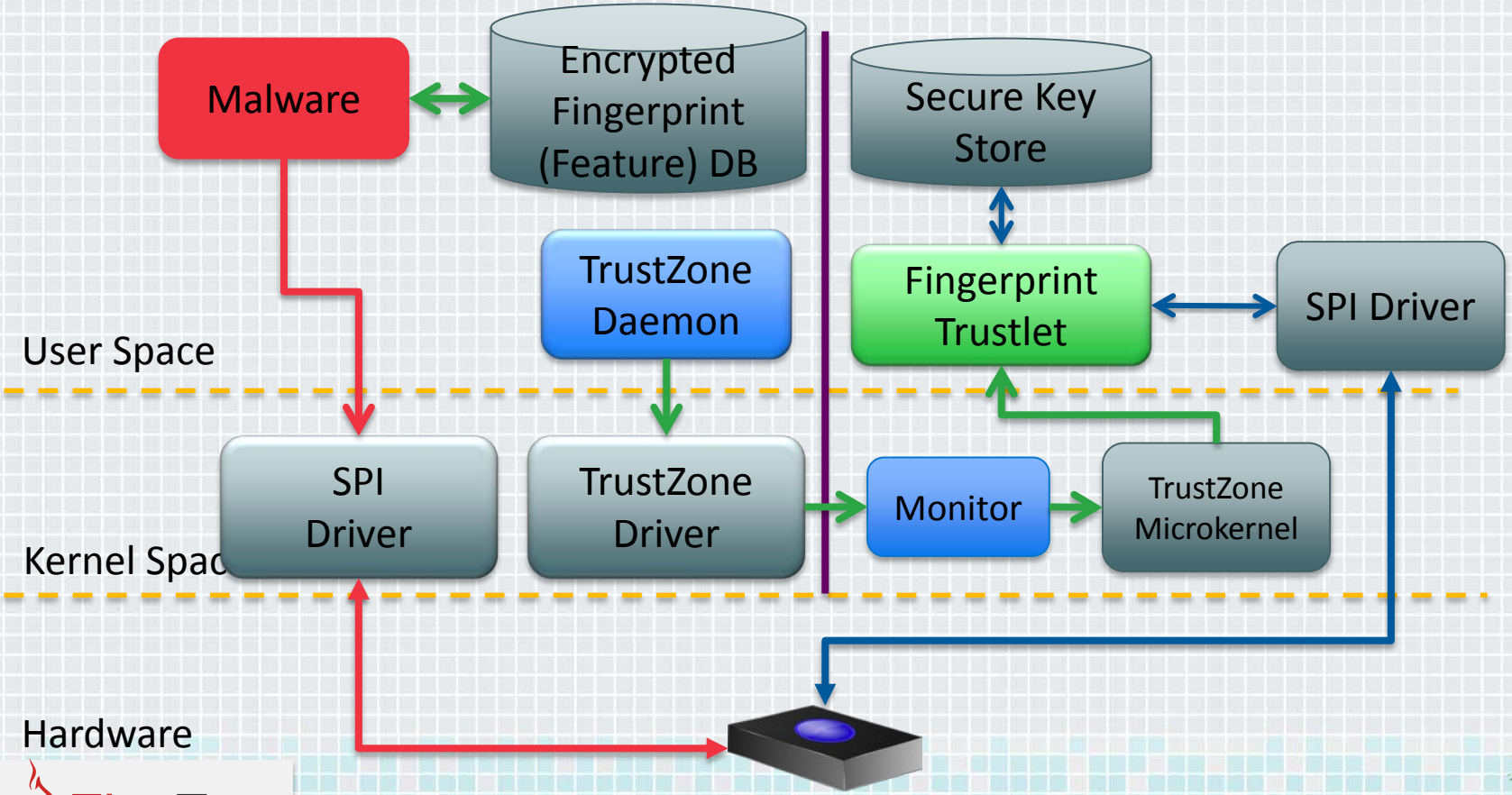
# How about the isolation of fingerprint sensor devices?



# One Fingerprint Framework with TrustZone



# Malware can read directly from the sensor



# Fingerprint Sensor Spying Attack

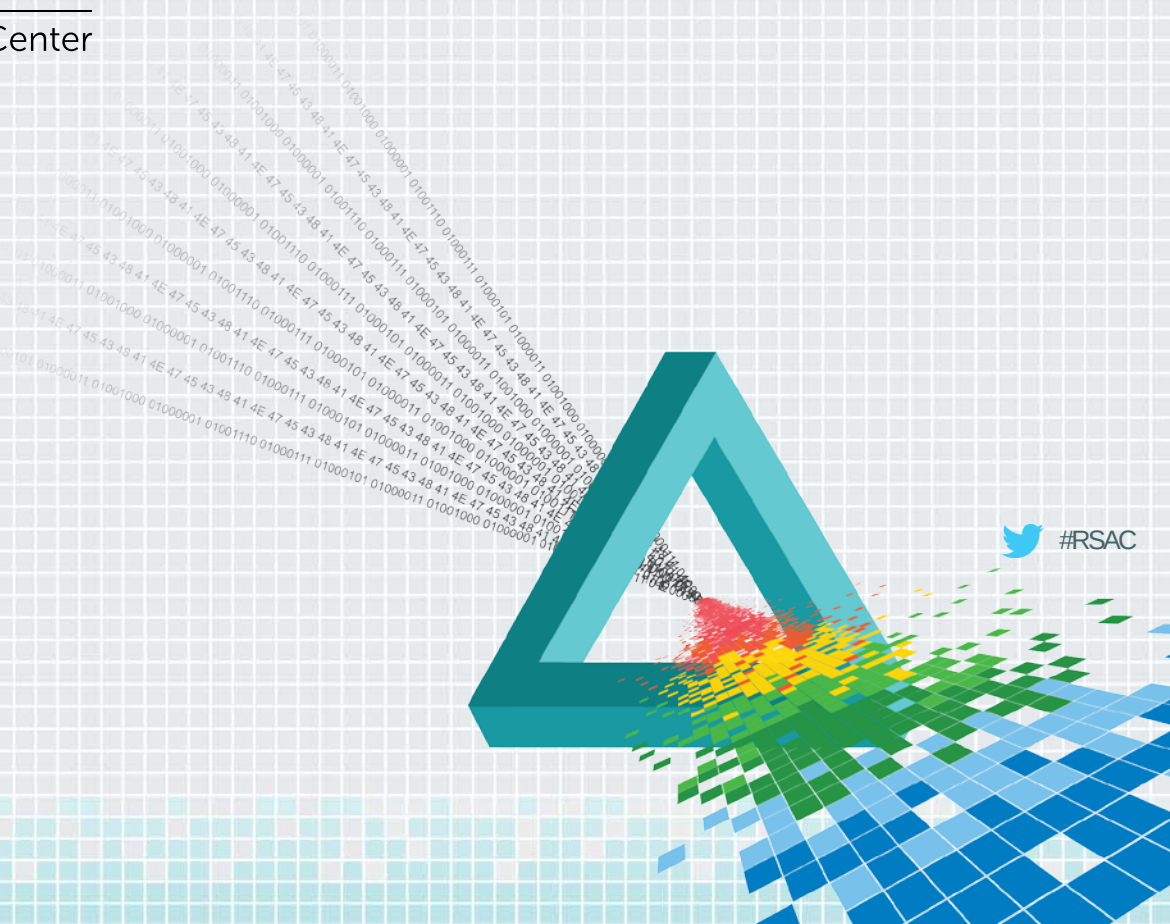
## Demo!

- While it is a really big challenge to reverse-engineer all the fingerprint operations, we made it.

# Protections

- Long term:
  - Isolate fingerprint sensors securely
- Short term:
  - Upgrade your system to the latest version to fix all the known vulnerabilities
  - Only install popular apps from Google Play on your phone with fingerprint sensors

# Conclusions



# Key Takeaways

- Mobile devices with fingerprint sensors are more and more popular
- But they still have severe security challenges, such as
  - Confused Authorization Attacks
  - Rooted kernel in normal world
  - TrustZone security flaws
- Such security flaws can lead fingerprint leakages
- Industry should pay more attention to audit existing design and implementations of fingerprint frameworks

# Recommendations I

- Stick to mobile device vendors with timely patching/upgrading to the latest version (e.g. Android Lollipop), and always keep your device up to date
- Always install popular apps from reliable sources
- Enterprise/government users should seek for professional services to get protections against advanced targeted attacks

# Recommendations II

- Mobile device vendors should improve the security design of the fingerprint auth framework
  - Improved recognition algorithm against fake fingerprint attacks
  - Better protection of both fingerprint data and the devices
  - Differentiating authorization with authentication
- The existing fingerprint auth standard should be further improved to provide more detailed and secured guidelines for developers to follow
- Given a security standard, vendors still need professional security vetting/audits to enforce secure implementations

# Q & A

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