Confidential

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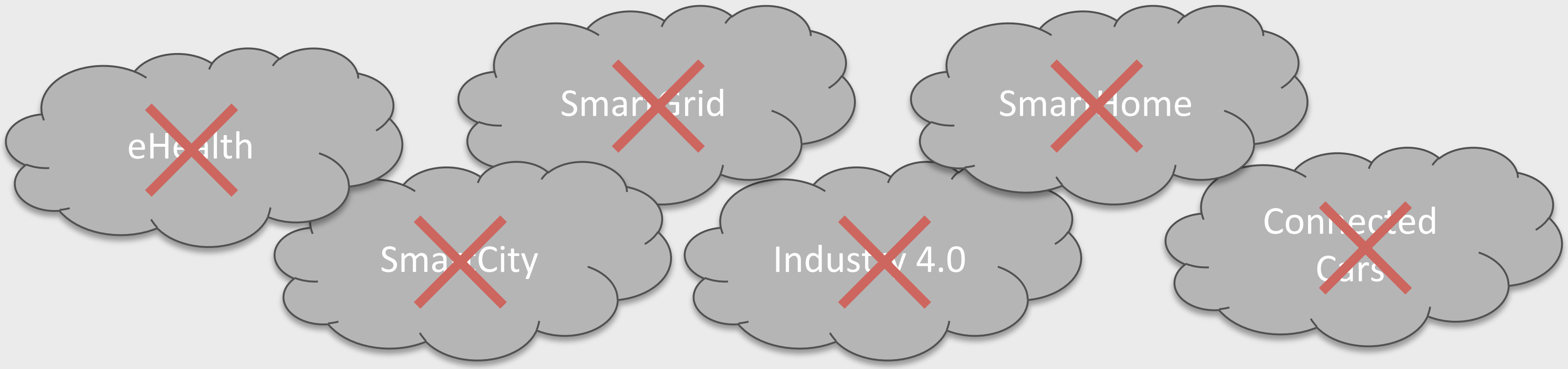
Our mission

Enable the Internet of Tomorrow = Internet of Things + Security

Without security:

- Impossible to deploy a network of connected devices
- Impossible to scale the Internet of Things
- Impossible to trust a system to keep data private & confidential



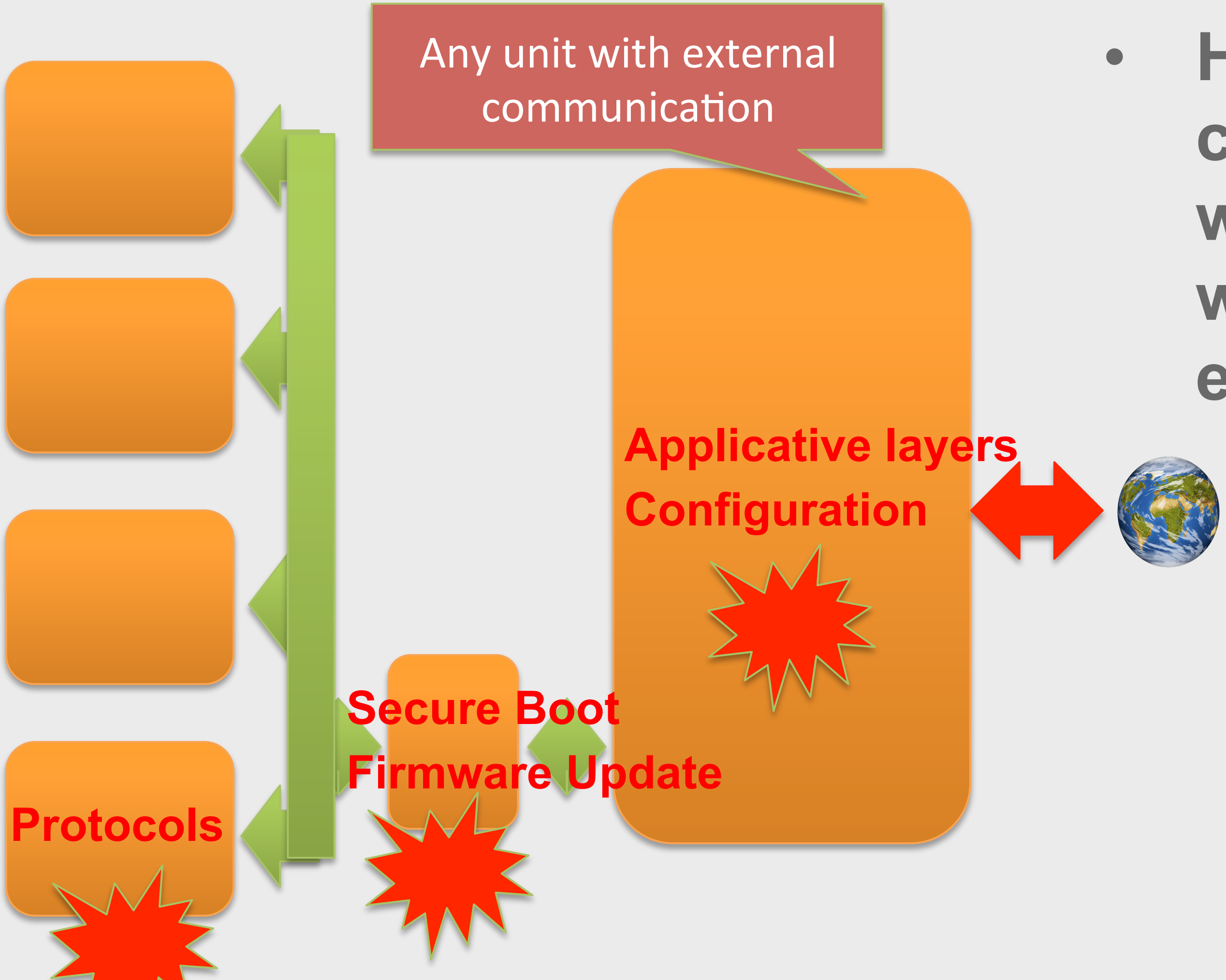
July 2015 Miller & Valasek's Attack

- **Malicious connection to infotainment through Uconnect™.**
- **Malicious firmware update.**
- **Sending of fake / impersonating commands (commands for the conditioning, for the engine, …)**

Wired magazine 7/21/2015

⇒ Combination of logical problems on open architecture

Car Hacking – Jeep example



- Hackers can use communications with the external world to exploit errors in:
  - Applicative layers,
  - Protocols,
  - Configuration,
  - Personalization,
  - Firmware update,
  - Secure Boot,
  - OS/Kernel,
  - …

Errors in security rationale

The Security Challenge

- Security chain:
  - Cryptographic algorithms
  - Cryptographic protocols
  - Physical attacks resistant subsystems (e.g. secure elements)
  - <u>Robustness of the Trusted Computing Base (TCB) to logical attacks</u>

- Issues with errors and vulnerabilities, particularly in operating systems:
  - An already alarming situation which is still degrading (e.g. the NIST database statistics).

The main challenge is to secure the software

- **Hackers will exploit bugs, weaknesses and errors that exist in thousands in the software of embedded systems**
- It is not possible to **directly** protect against attacks OSes such as iOS, Android, Linux, large RTOS ... There are issues with:
  - Size of the software stack to secure
  - “Trusted Computing Base” (TCB) includes kernel whose size and complexity are too big to build trust (and correctness of security properties)
- **➔ Issues & vulnerabilities, particularly in operating systems.**

Security need evolution (1/2)

- **Small TCB with few peripherals and small attack surface**
  - ***Secure element is usually the right solution***
  - ***Resistance to physical attack is the biggest challenge***
- **More peripherals and thus larger TCB and larger attack surface (typically mobile security)**
  - ***Use a small secure OS/kernel (TEE),***
  - ***Resistance to physical attack can be addressed with secure elements or similar embedded IP,***
  - ***Resistance to logical attack becomes the biggest challenge***

Security need evolution (2/2)

- **IOT case : Still more peripherals, better business model for hackers, larger damages at stake, with large TCB and large attack surface, in many cases remote device is unattended, etc.**
  - ***Logical and Physical TCB are to be distinguished***
  - ***Resistance to physical attack can still be addressed with secure elements or similar embedded IP***
  - ***The secure OS/kernel (such as the TEE), and all other complex part of the TCB need to be formally verified***
  - ***Resistance to logical attack is achieved using a trusted and reliable security rationale (Attacks exploit error in the security rationale)***

Prove & Run answer's to the challenge

- **Two critical secure COTS (ready for integration) that are needed to host "security sensitive" applications and build layered security perimeters:**
  - ***ProvenCore*** : microkernel proven for security to secure gateways and connected devices (Industrial Things), smartphone, tablets, etc.
    - Execution of security critical applications
    - Secure protection of the "Smart and Safe world" (Existing OS)
    - Provided together with its *secure boot*
  - ***ProvenVisor:*** proven secure hypervisor for mobile devices and IoT virtualization solutions
    - Secure isolation of existing OS and legacy SW stack
  - ***Built with ProvenTools***: a patented software development tool that makes it possible to formally prove the correctness of the software
    - Be as close as possible to "zero-bug"

Quality of Security Rationale is Essential

- The rationale of why security is achieved should be provided in an explicit and auditable format
  - Risk analysis,
  - Product security requirements,

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→ **Confidence in rationale is key**

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The TCB against logical attacks

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→ **TCB should be small enough to be trustabe**

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Large Oses such as Linux, Or Android when used should not be part of the TCB

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→ **Layered architectures highly recommended**

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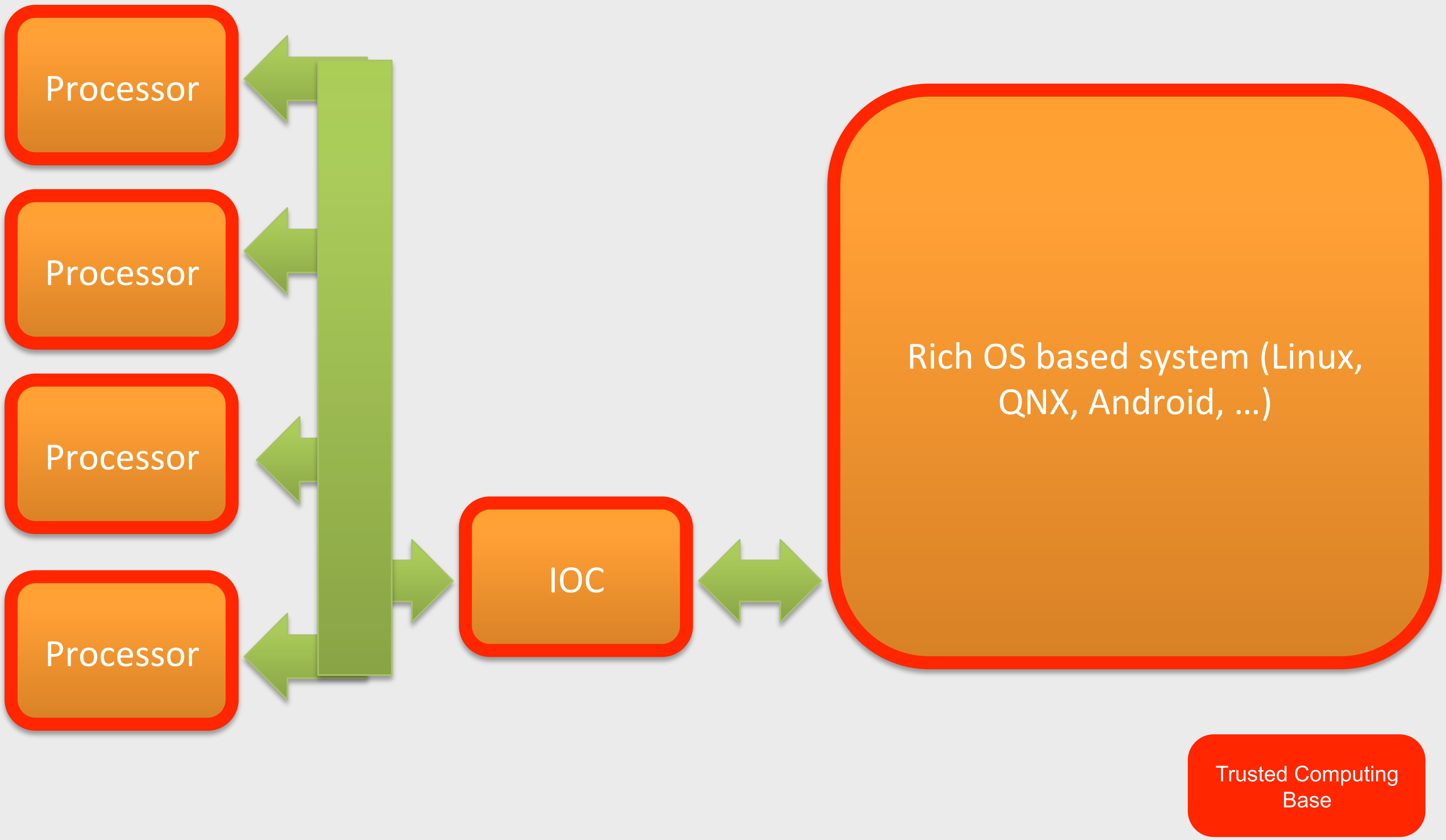

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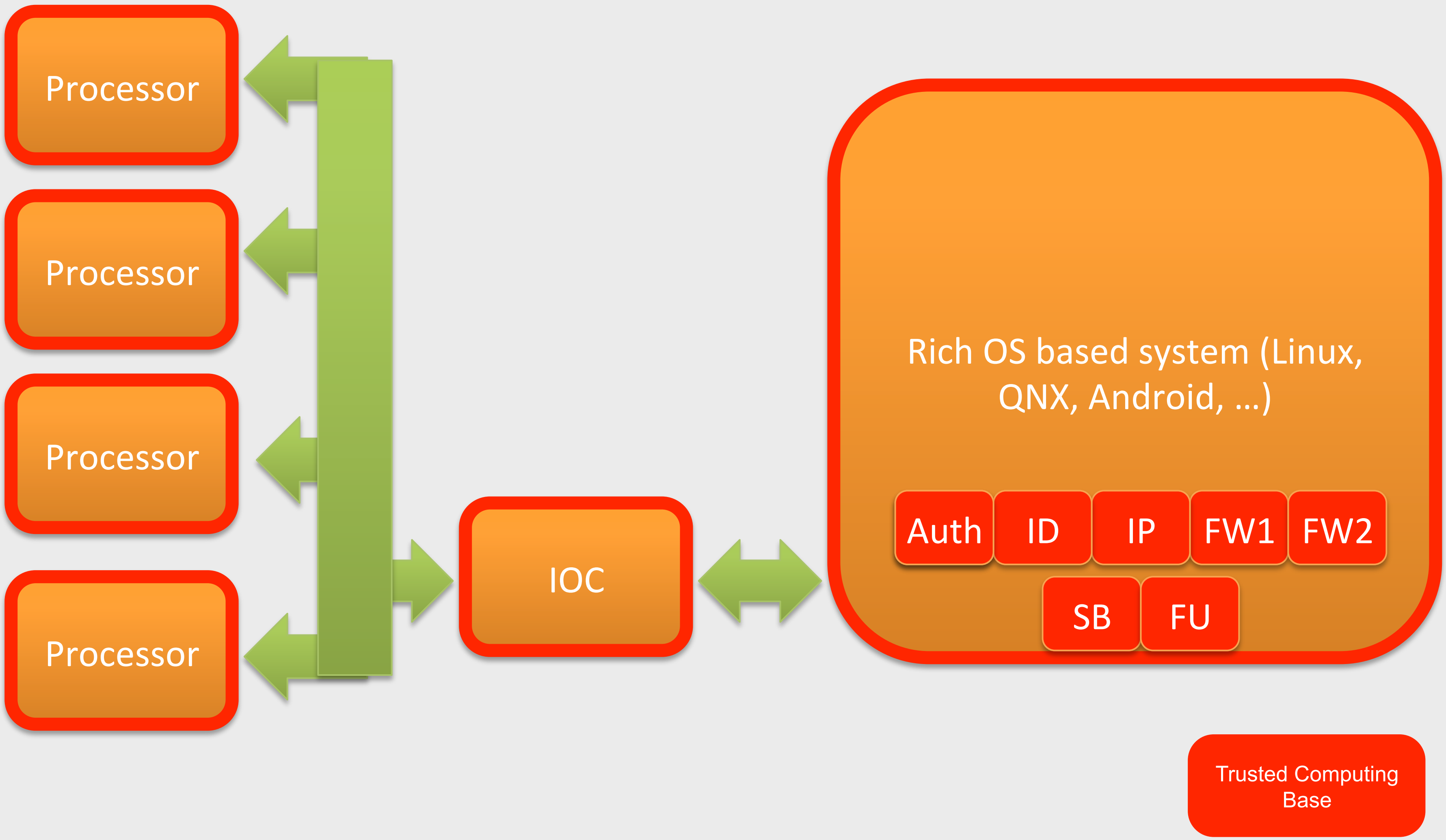

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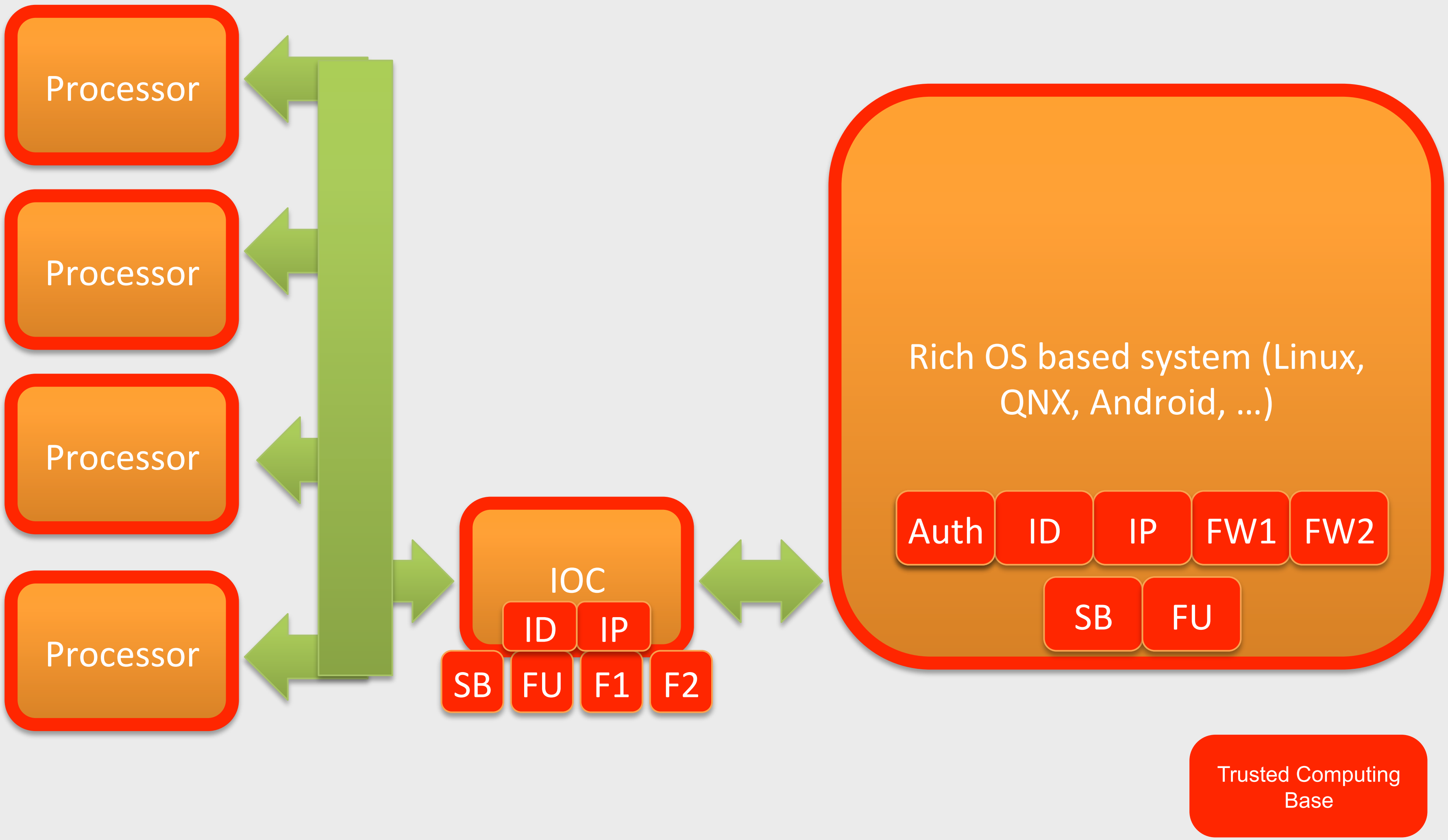

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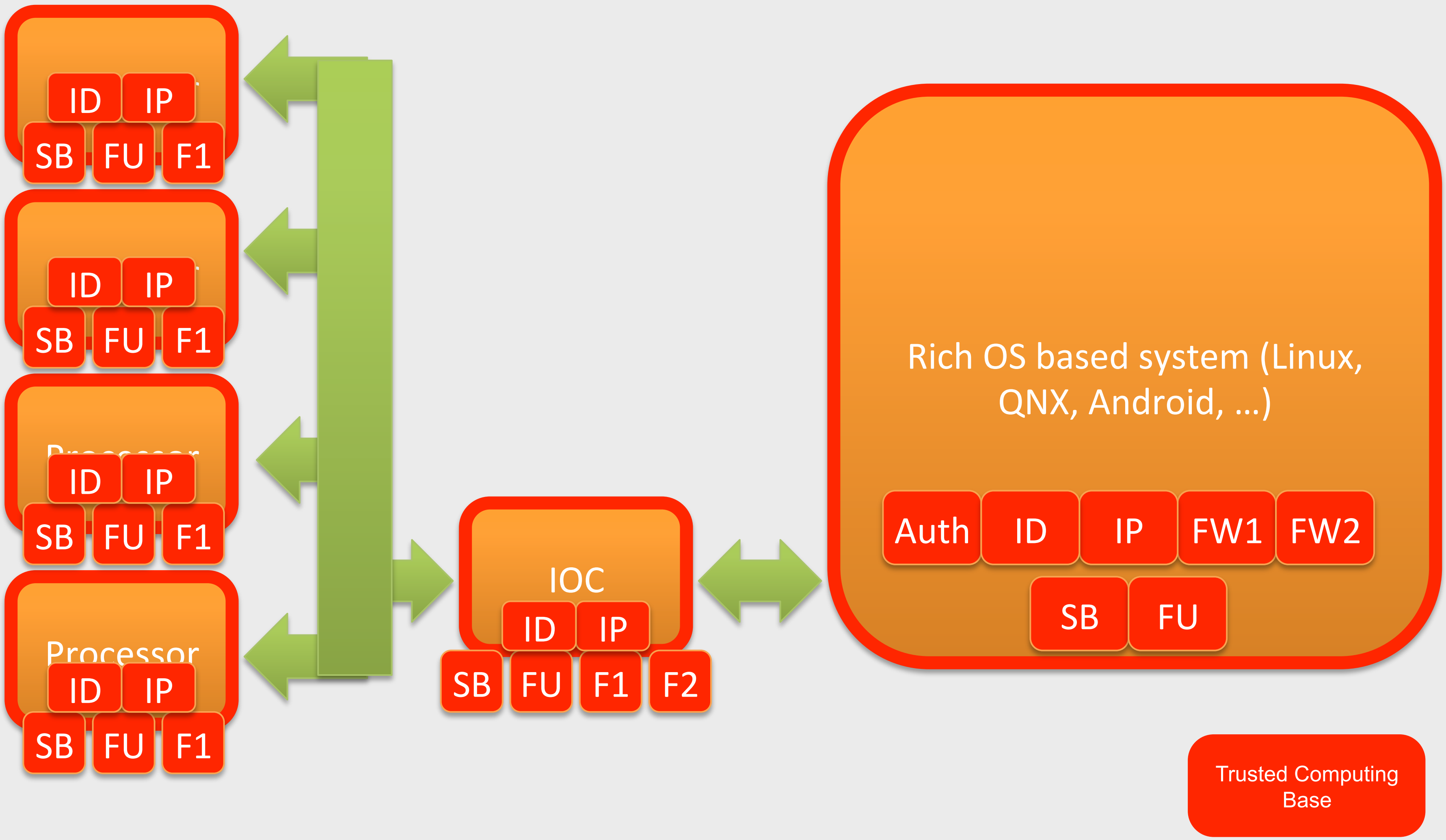

Trusted Computing Base

Remote attacks exploit entry points

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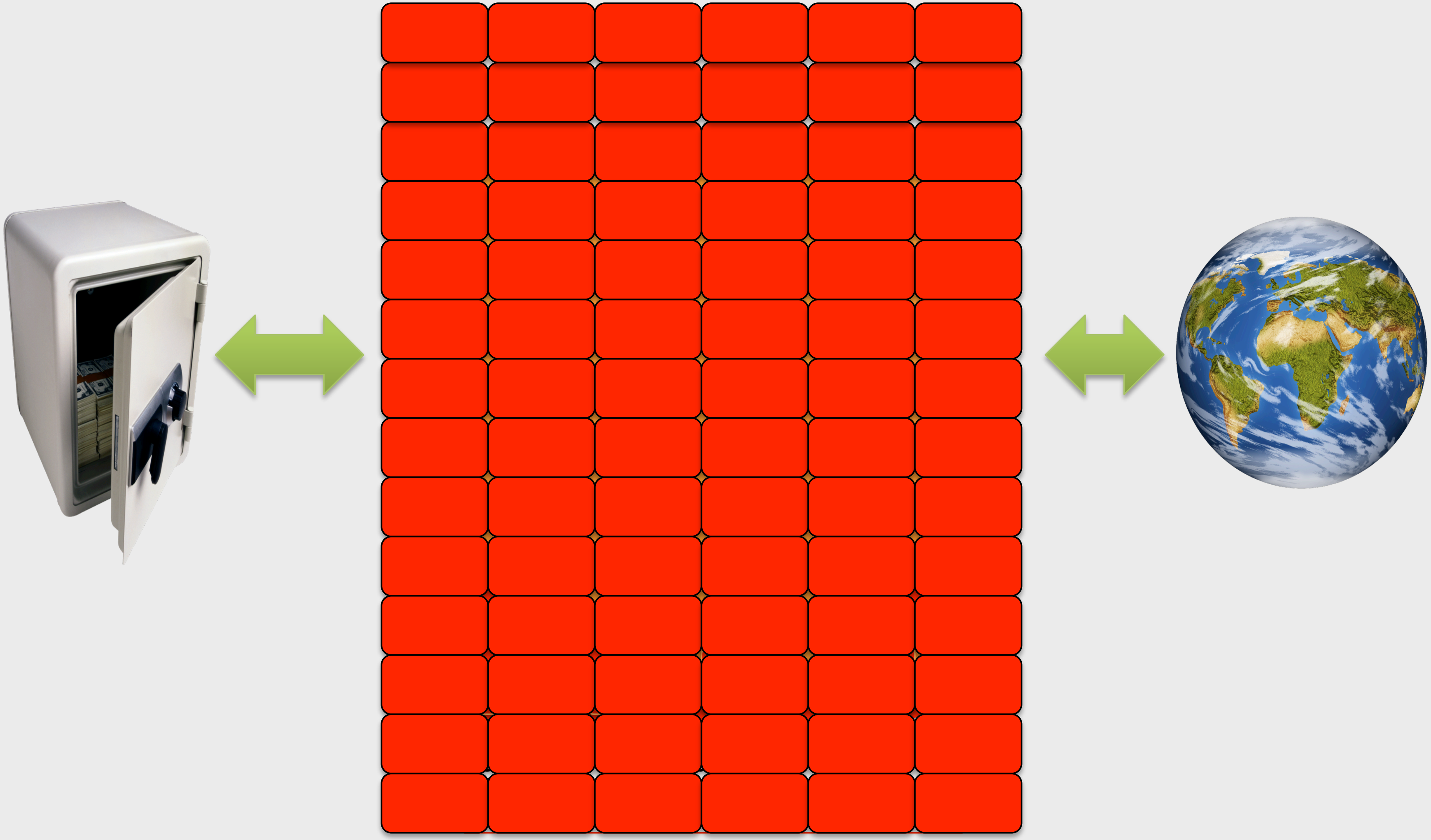
SB: Secure Boot
FU: Firmware Update
FW: Firewall
SS: Secure Storage
CL: Crypto Library
AUT: Authentication

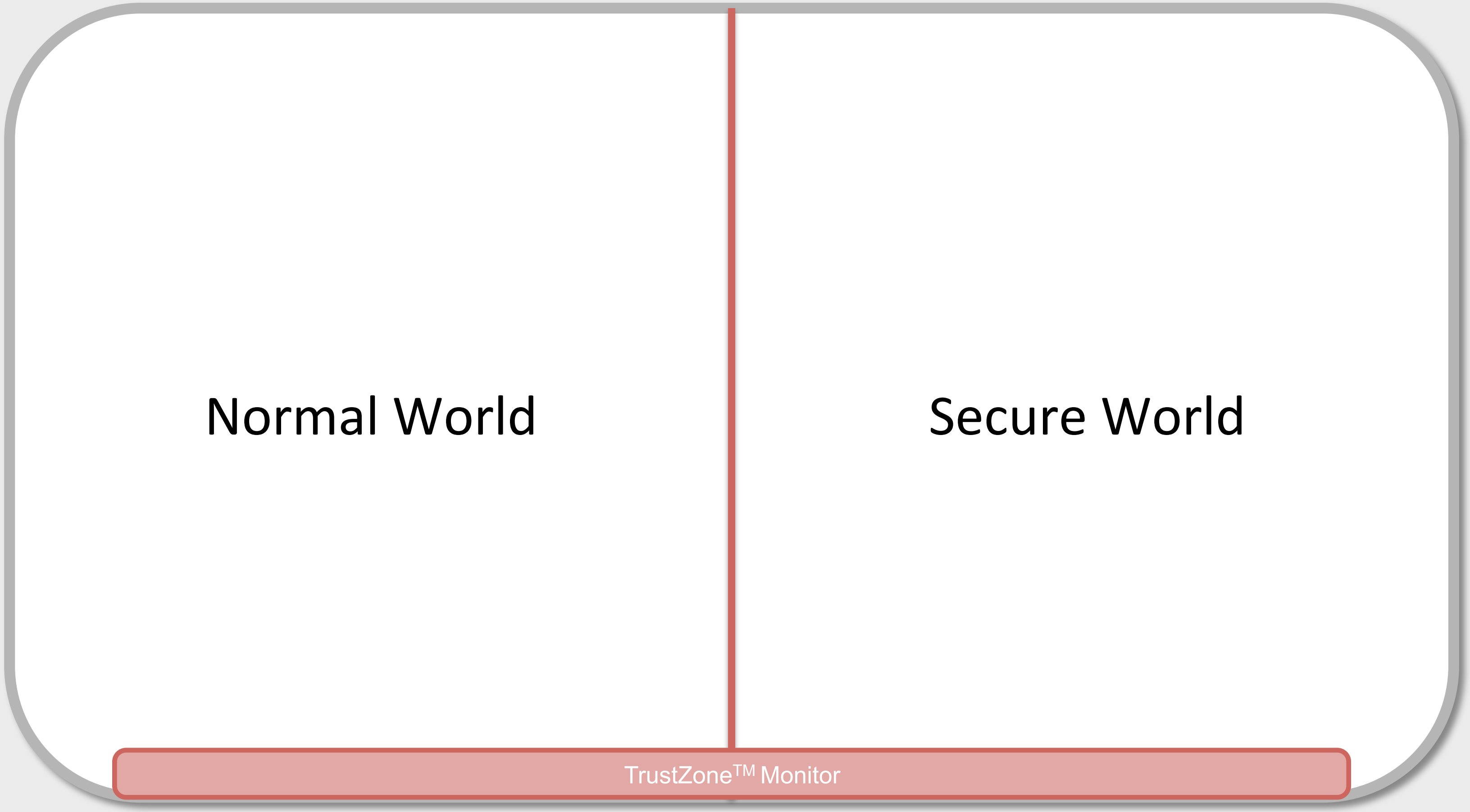
Trusted Computing Base

Remote attacks exploit entry points



Introduction to TrustZone

TrustZone ARM Cortex A – High Level Principles



I/O devices can be configured to be controlled by Secure World

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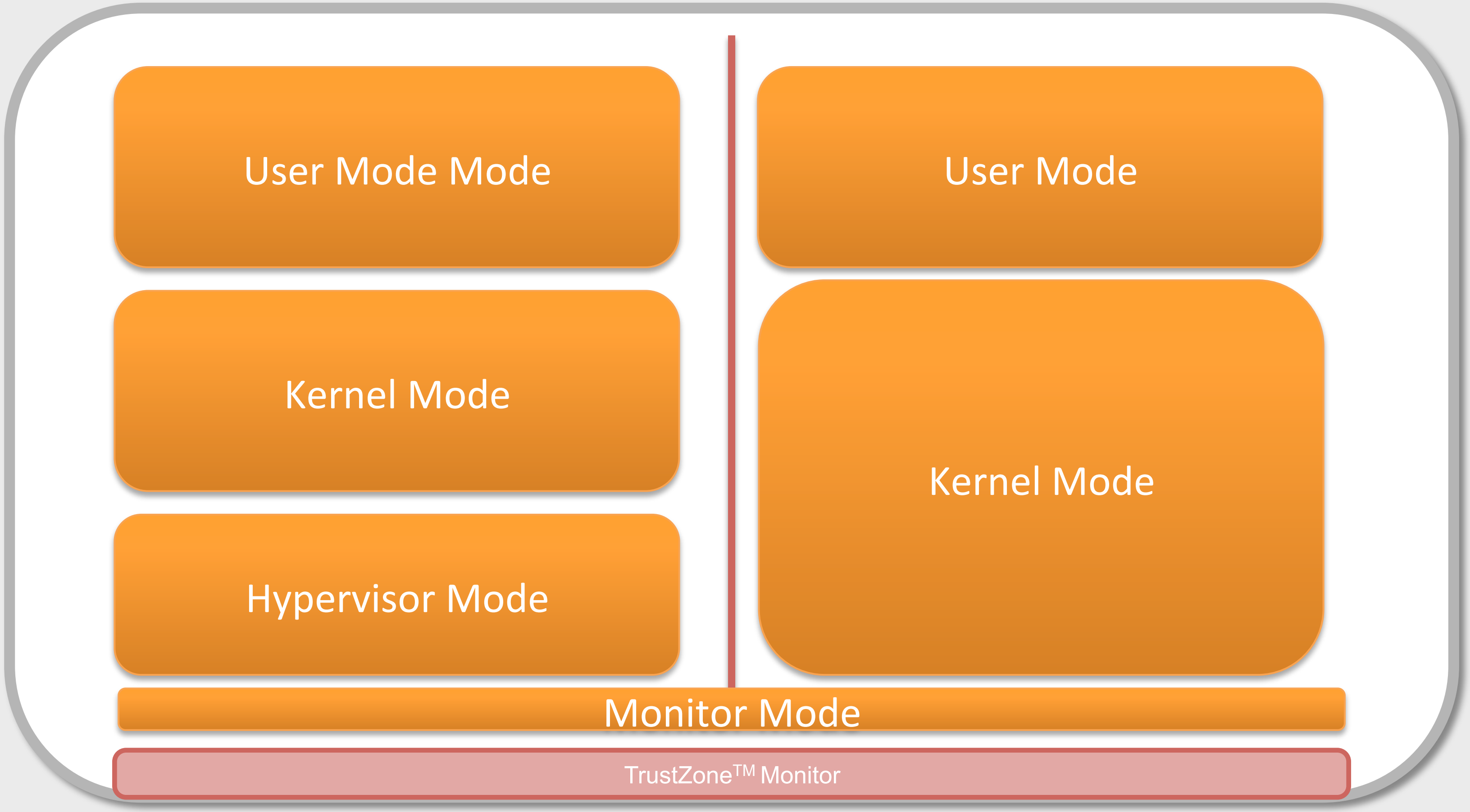

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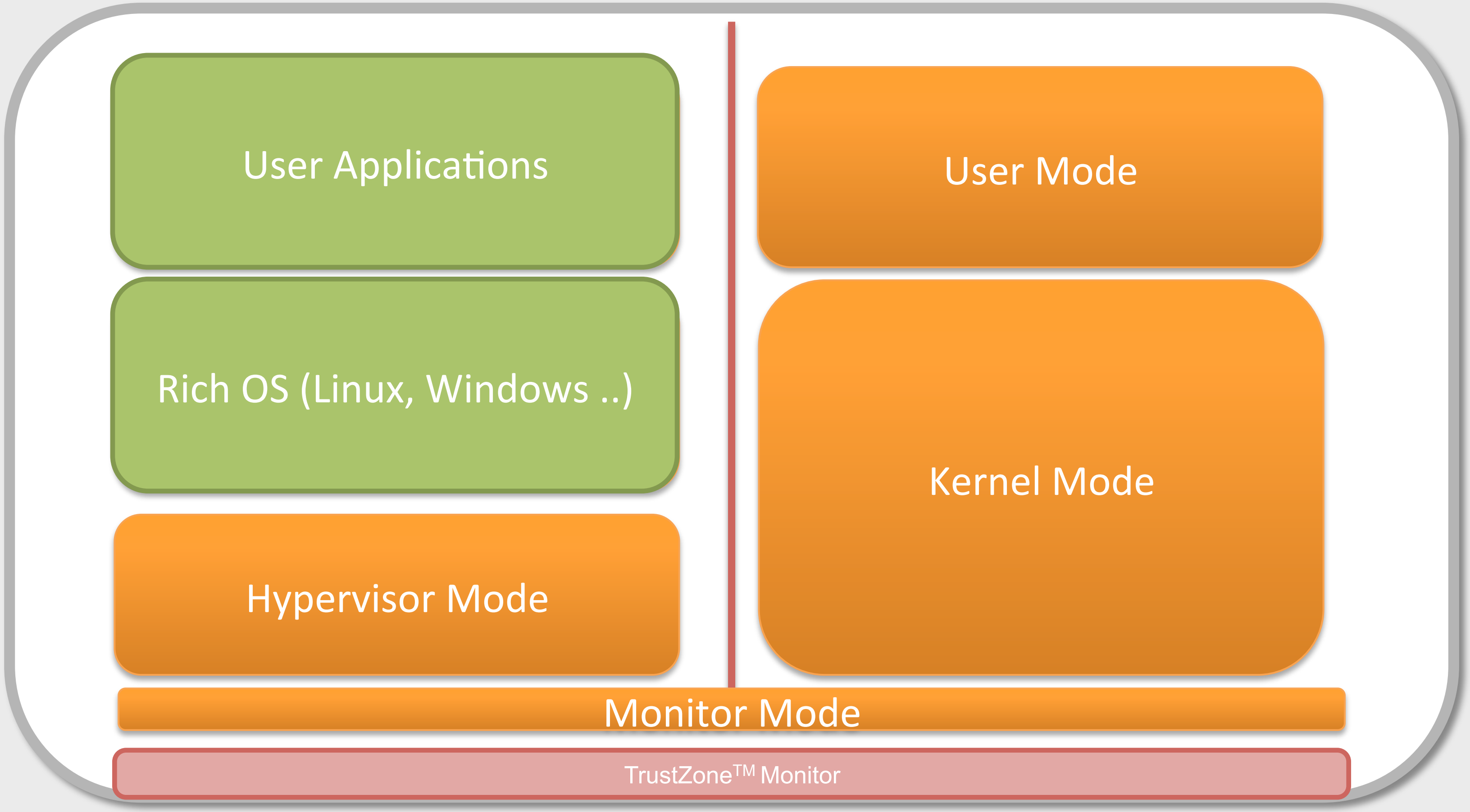

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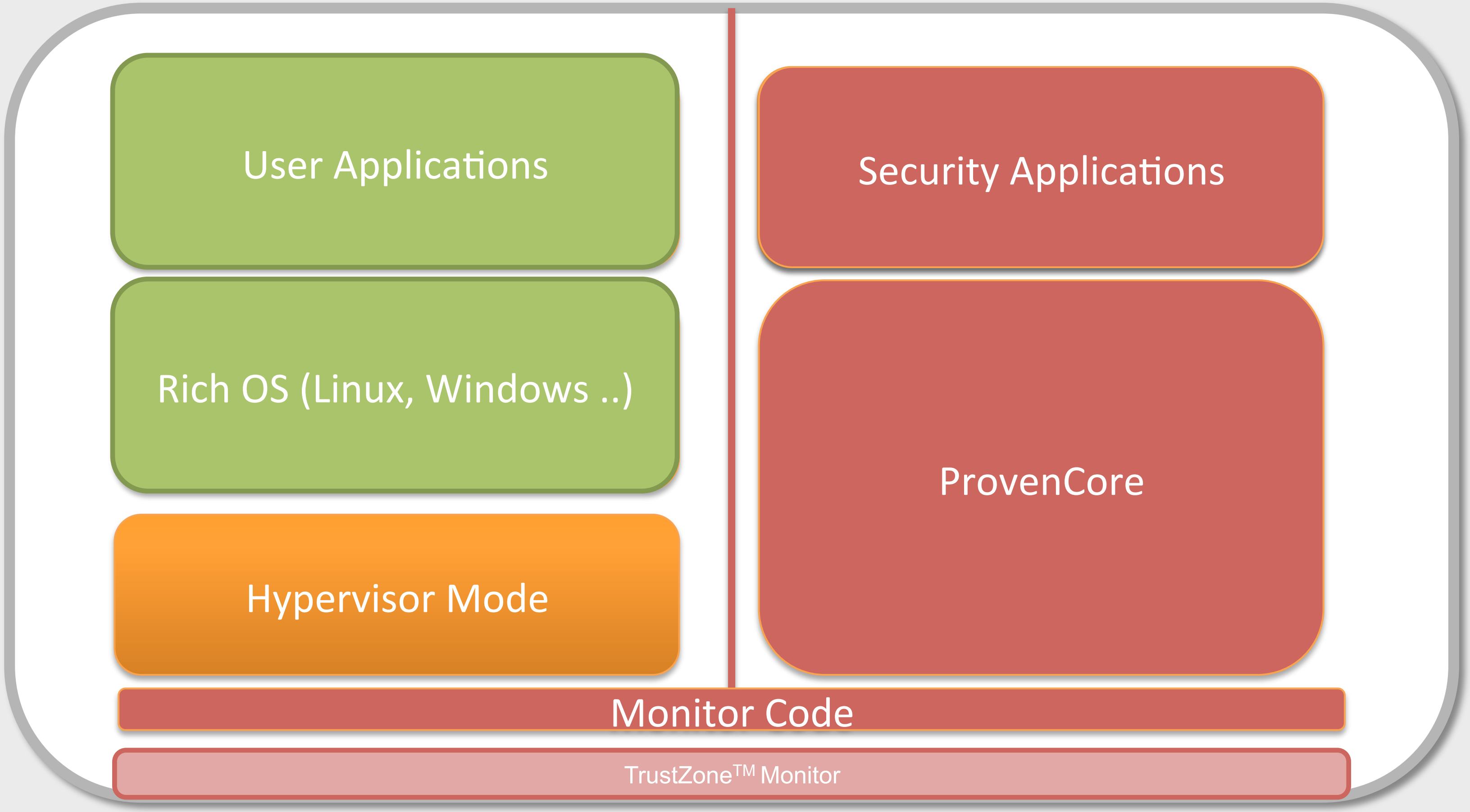

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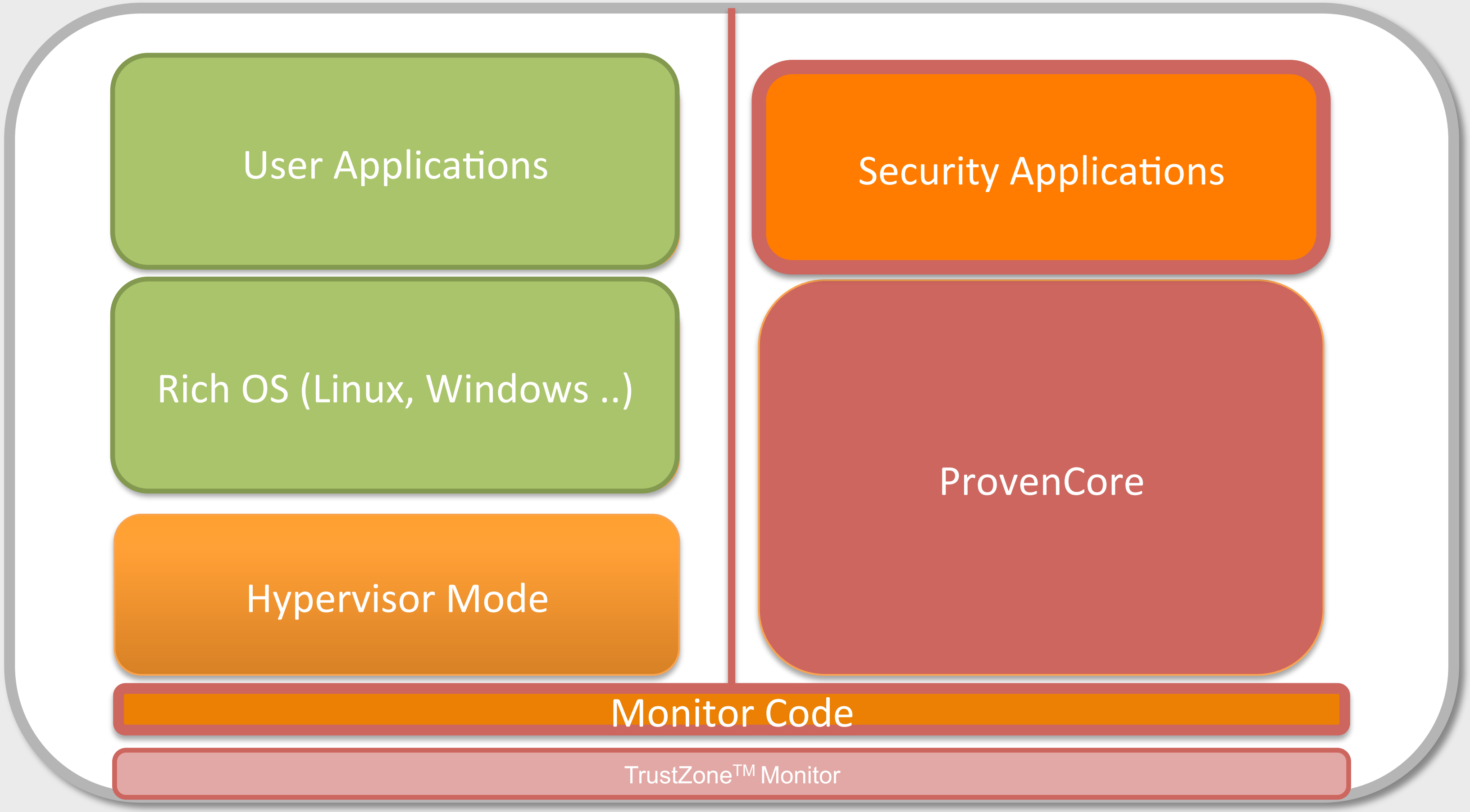

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ARM Cortex M – v8 (Next Generation)

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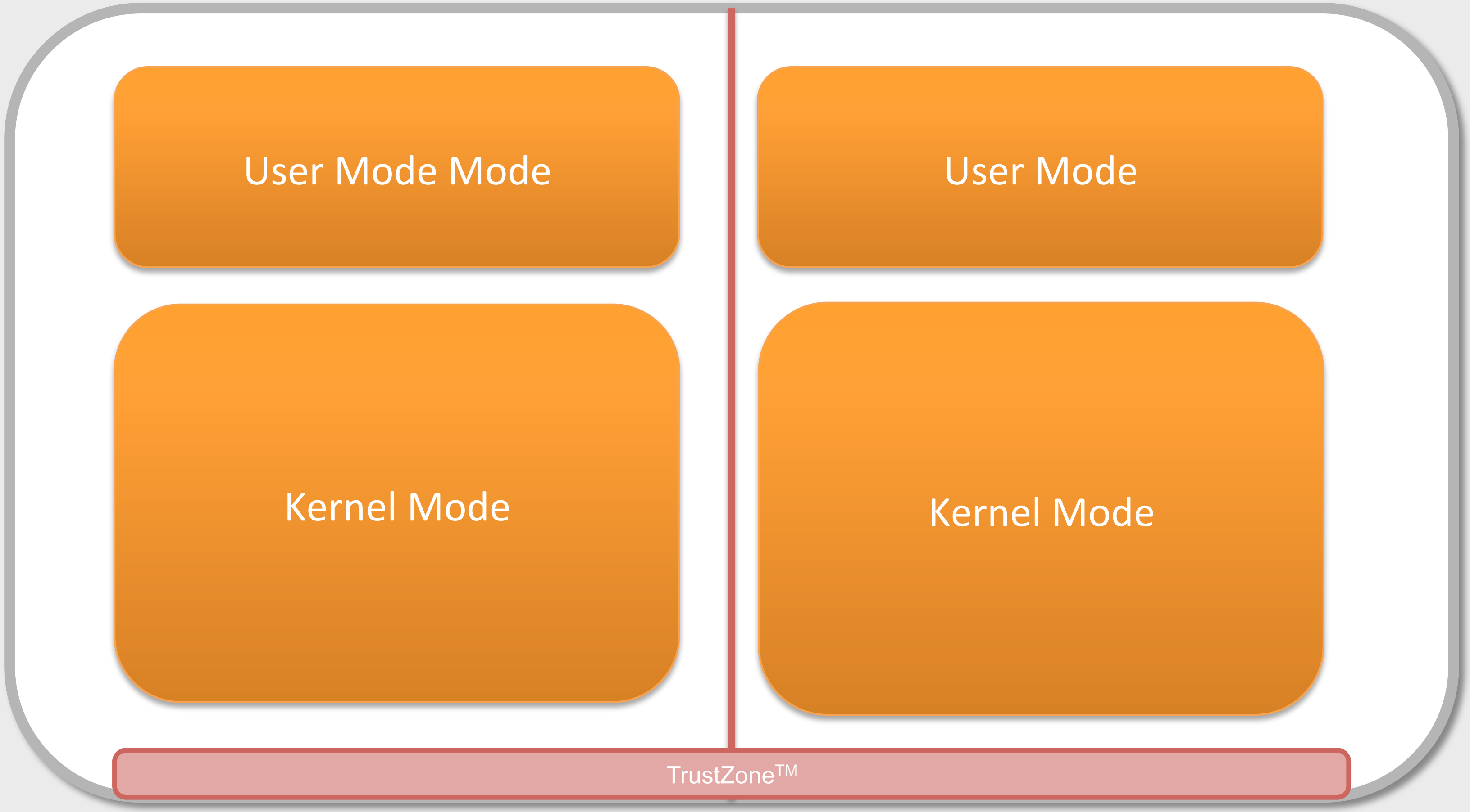

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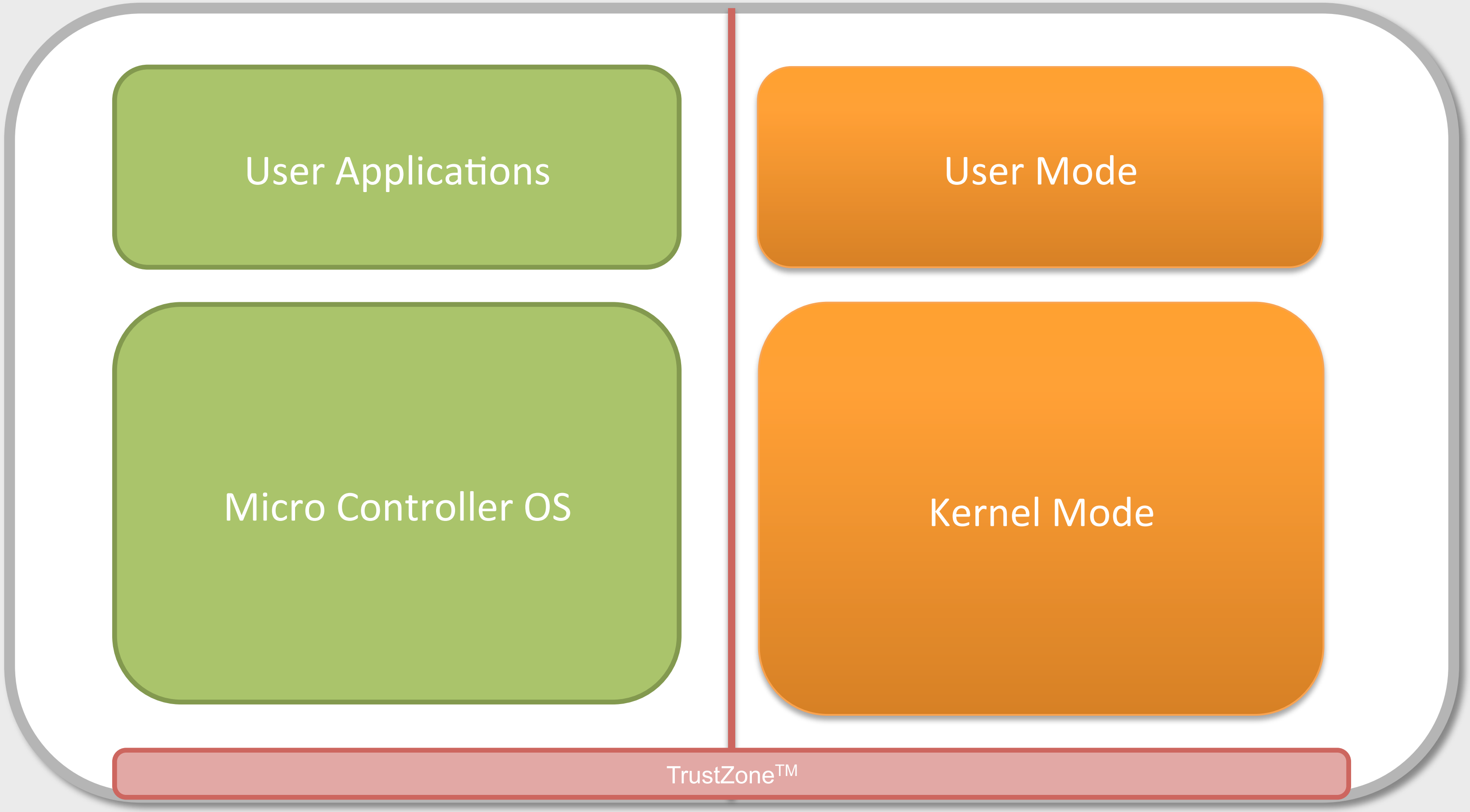

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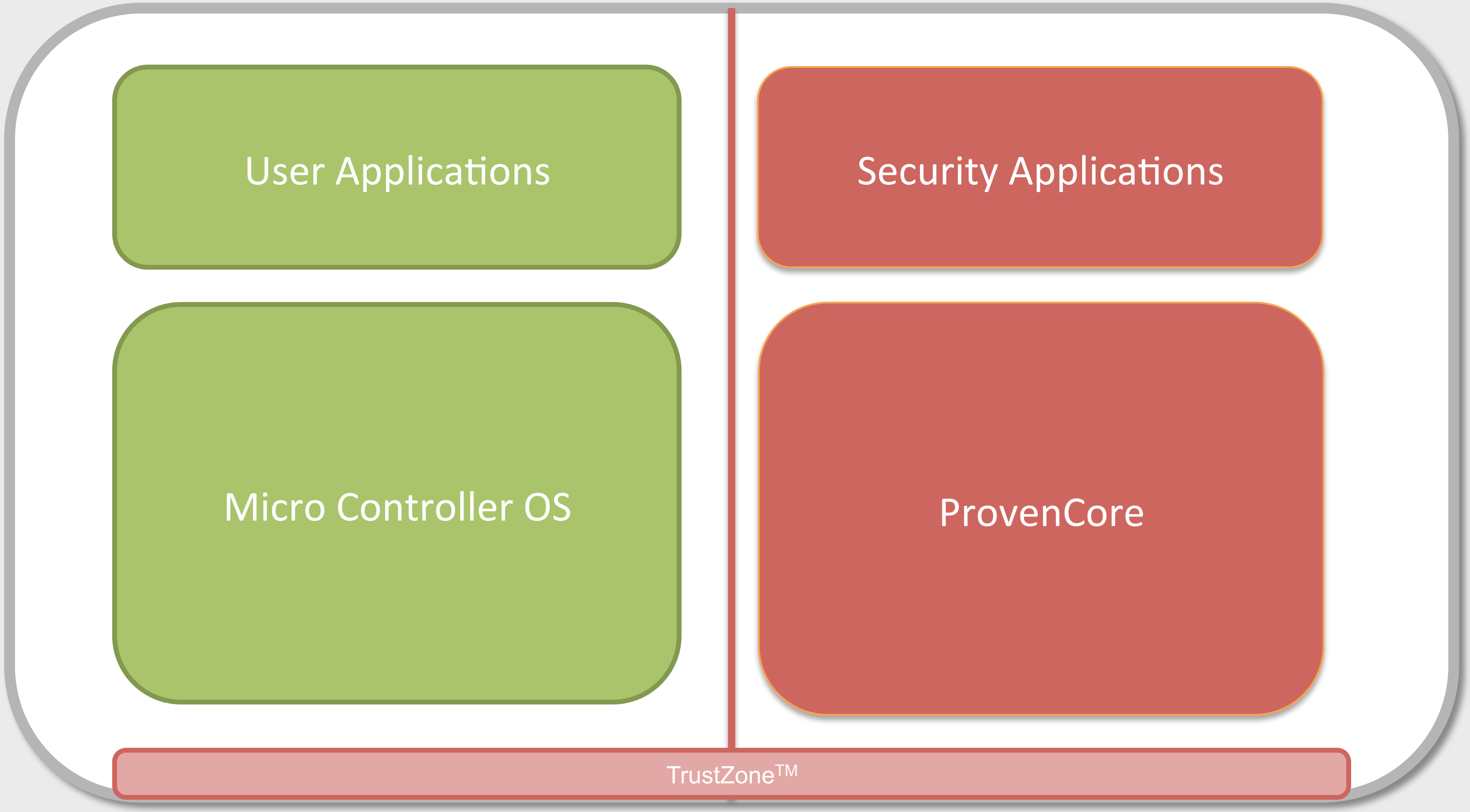

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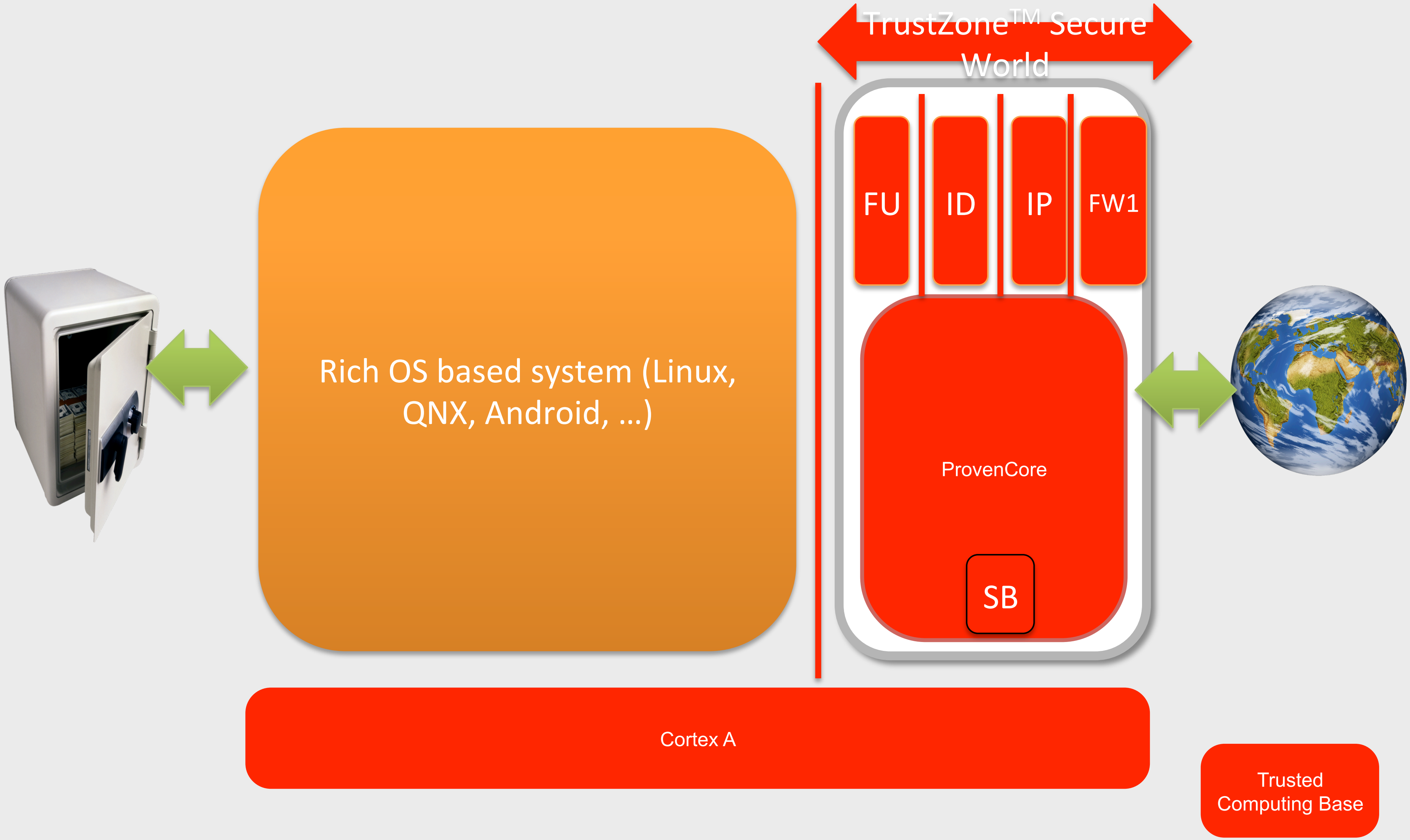
TrustZone™ Secure World
FU
ID
IP
FW1
Rich OS based system (Linux, QNX, Android, …)
ProvenCore
SB
Cortex A
Trusted Computing Base

Quality of Security Rationale is Essential

- The rationale of why security is achieved needs to be provided in an auditable format
  - Risk analysis,
  - Product security requirements,
  - Identifying the TCB,
- Confidence in the rationale becomes the key to security
  - Some parts of the rationale can be informal and be tested and/or evaluated using traditional approaches,
  - For some others trust and confidence in the absence of errors can only be achieved using formal proof.
    - <u>This is the case of kernels that are part of the TCB</u>

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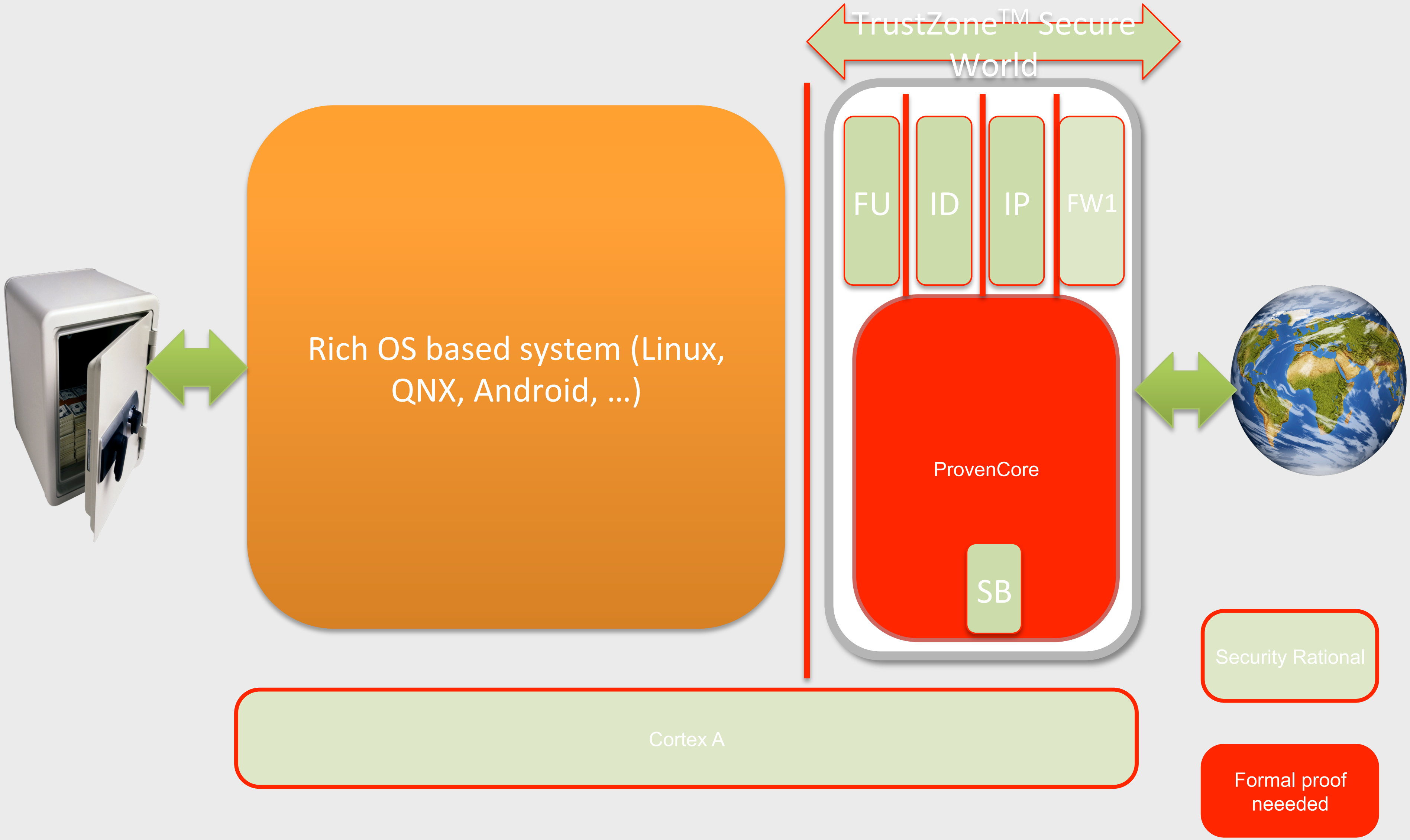
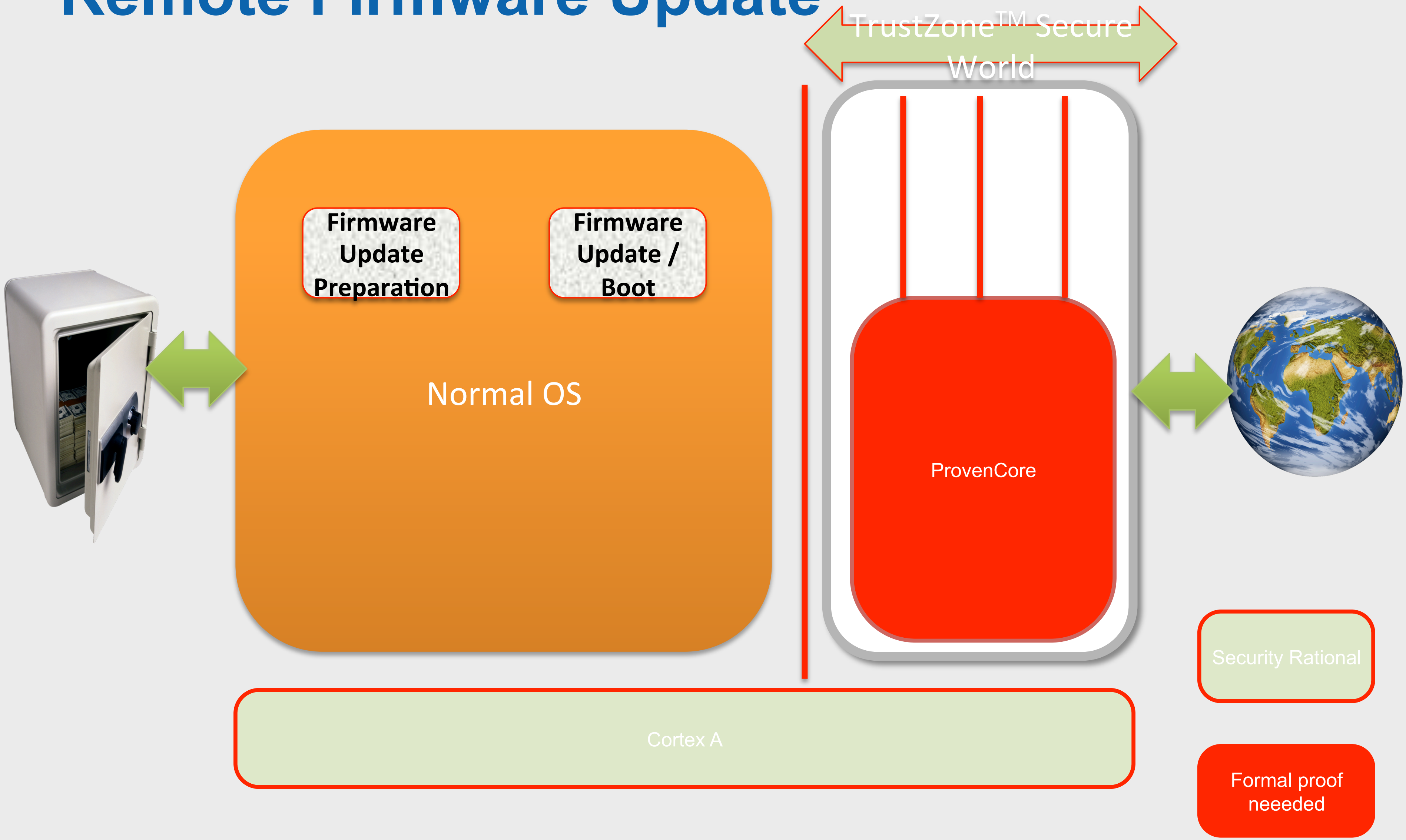


Looking more closely to the Secure Remote Firmware Update



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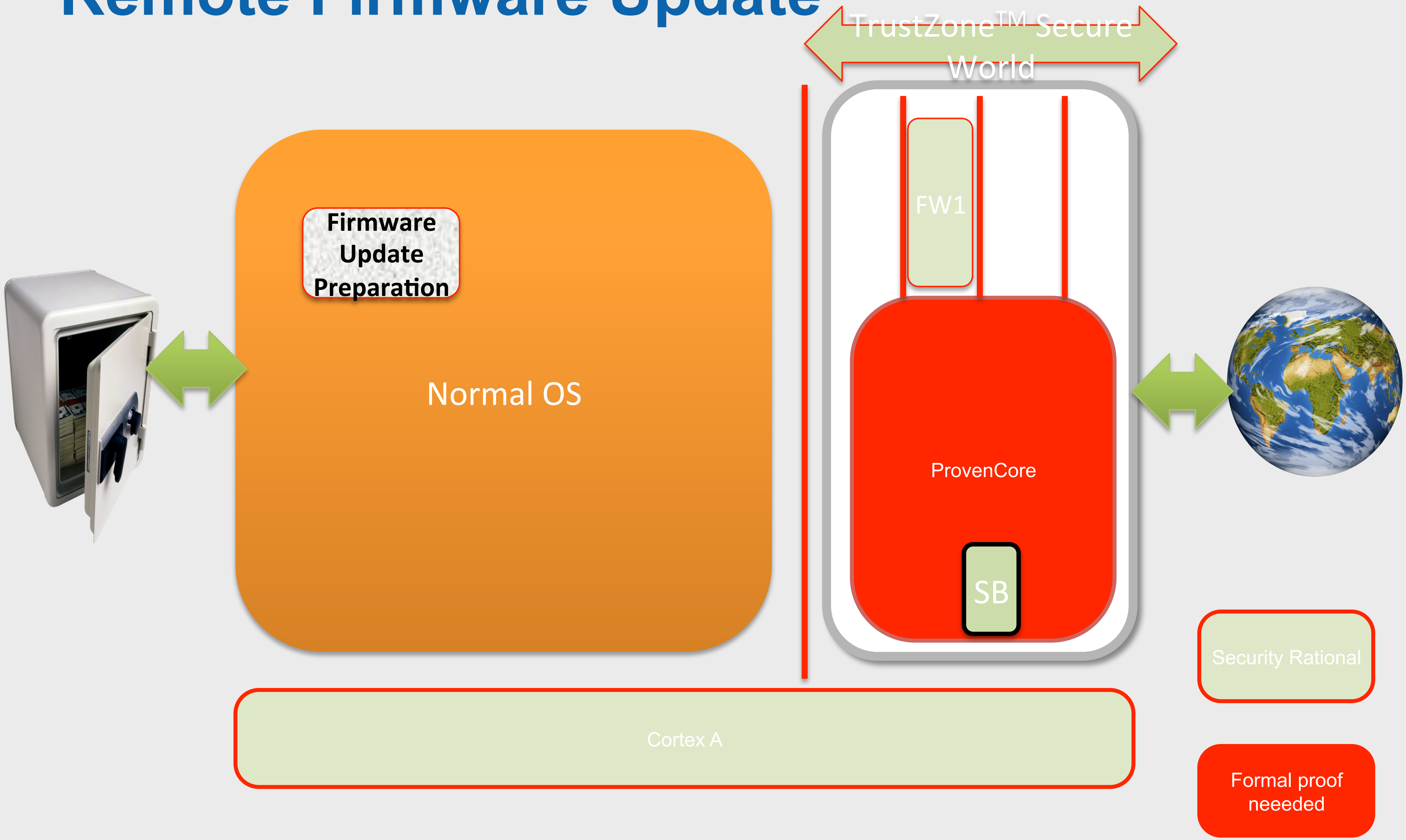
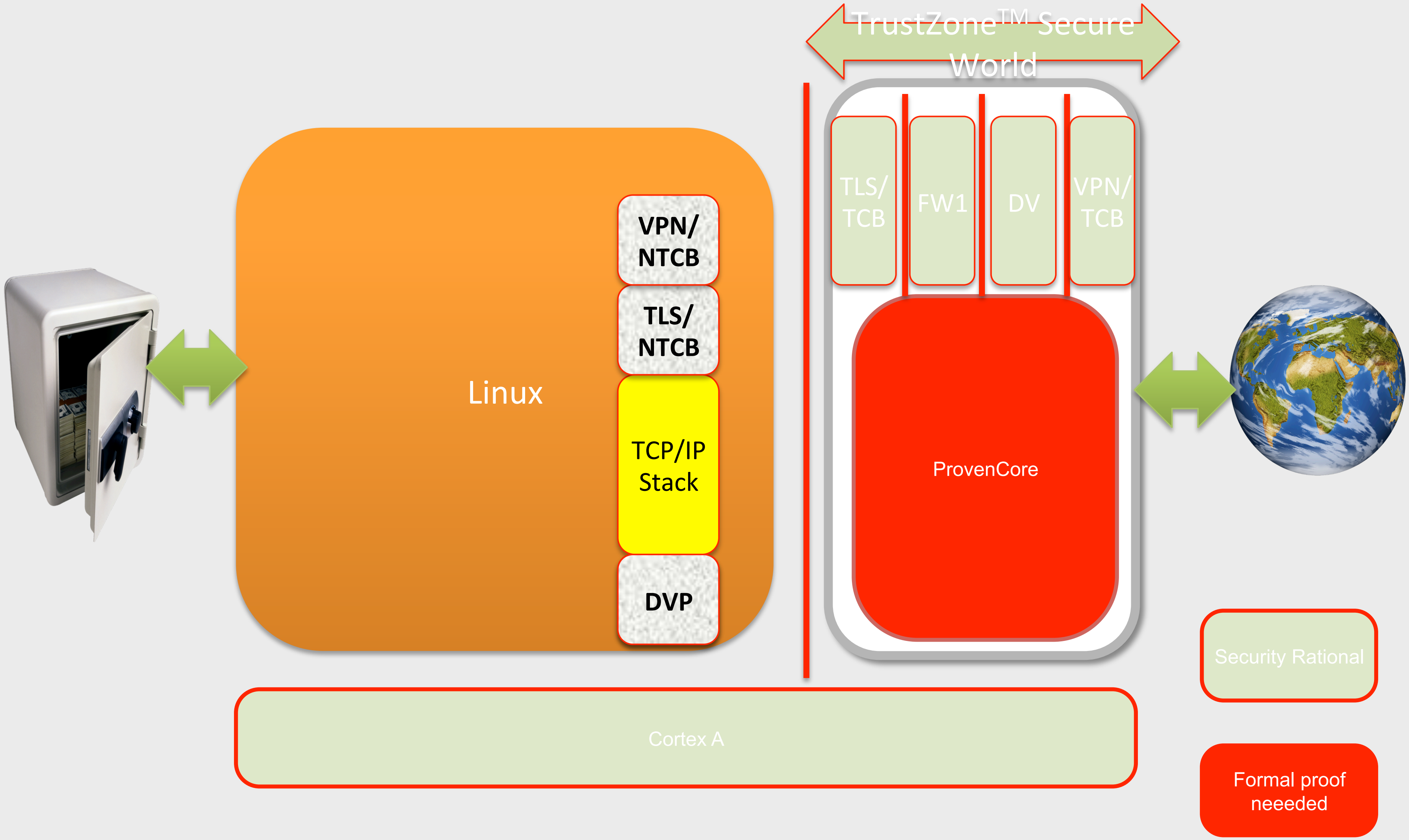
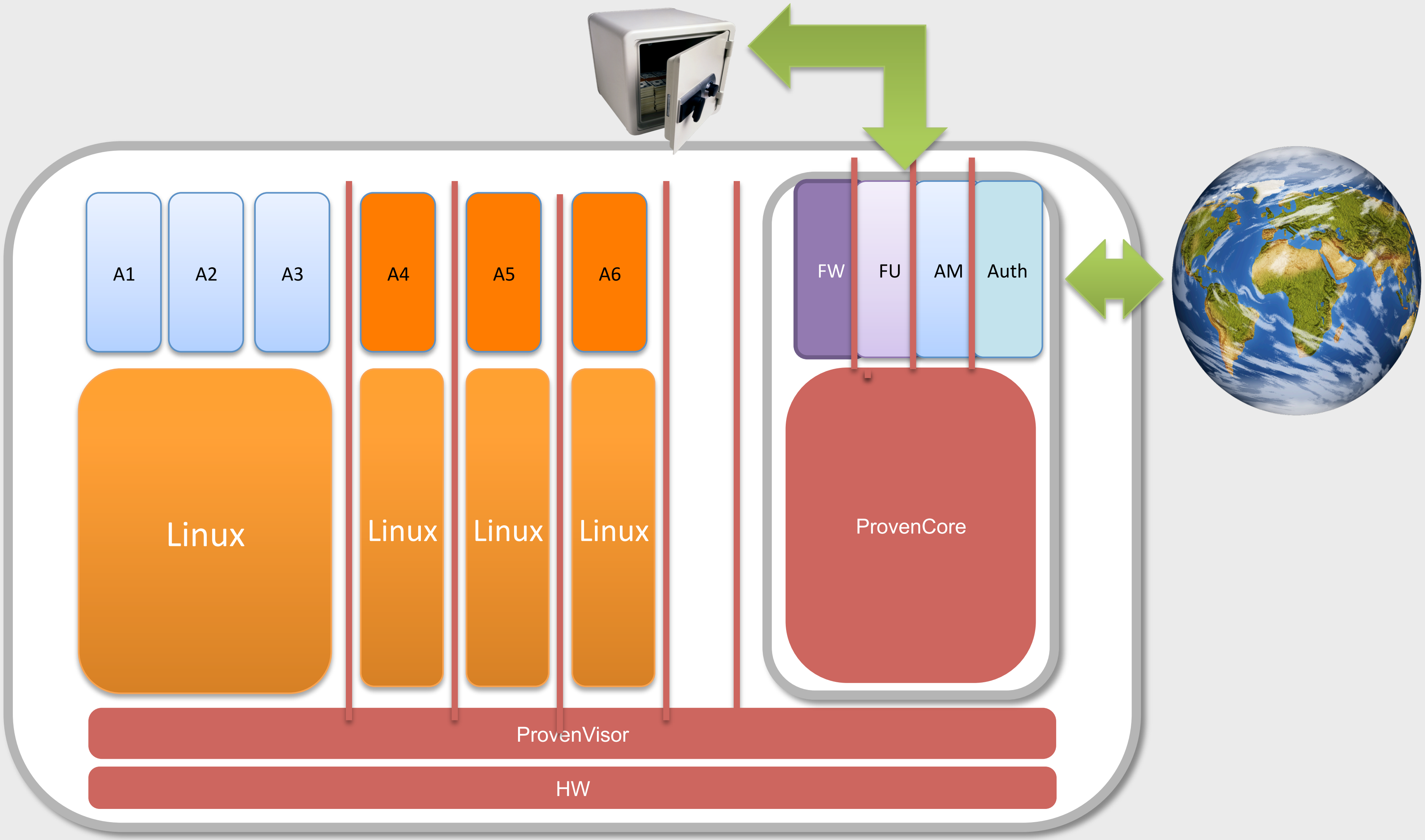


Looking more closely to the TCP/IP FW



Using a Hypervisor



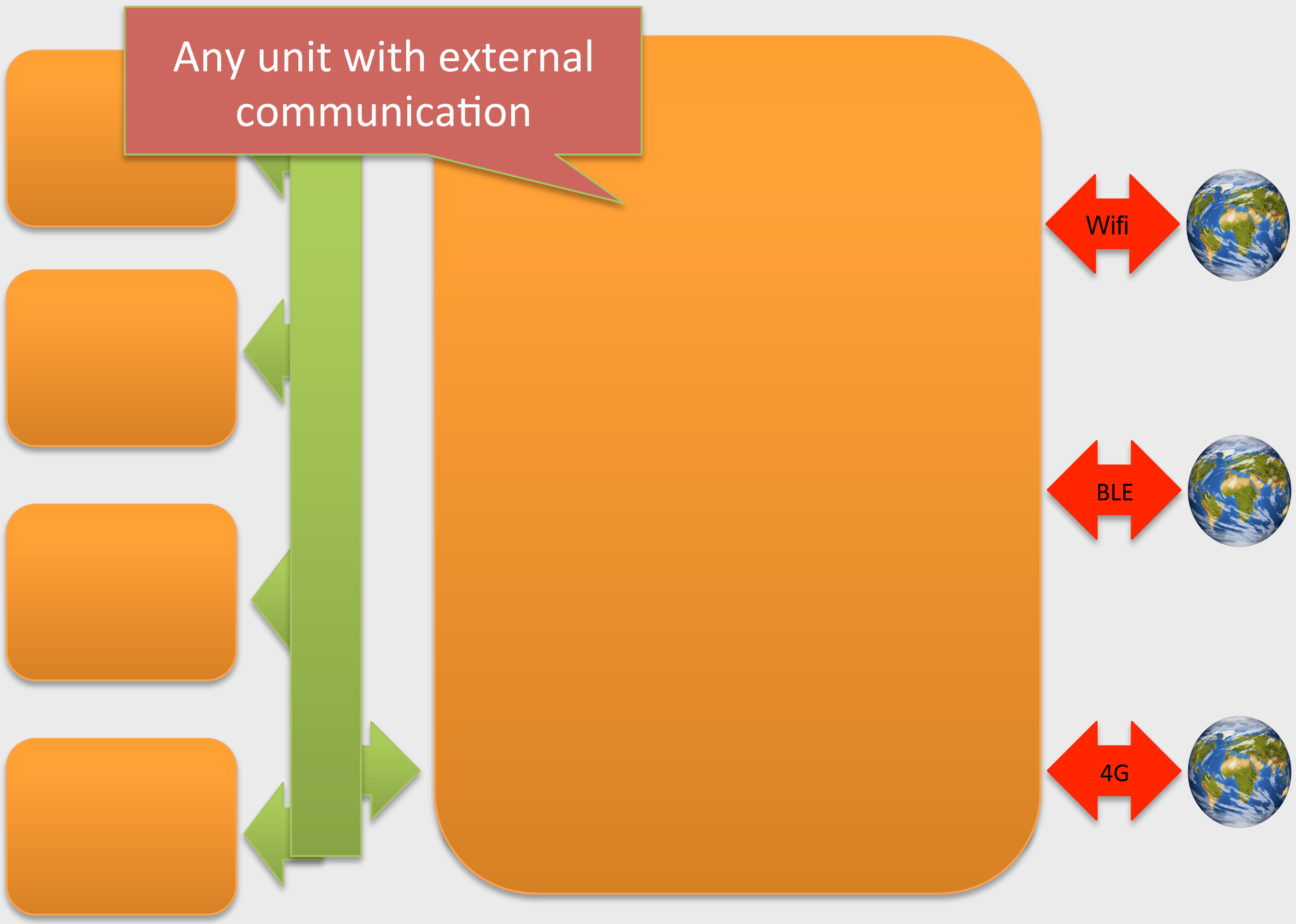
Wrong expectations about Hypervisors

Prove & Run answer’s to the challenge

- An hypervisor is used to virtualize hardware
  - Either because you want to replace two or more processors by a single one
  - Or because you want to have more virtual chips to isolate software stacks.
- It is thus important to do it securely and this is why we need a really secure hypervisor such as **ProvenVisor**

But an hypervisor is just not enough

A Formally Proven OS/Kernel is required



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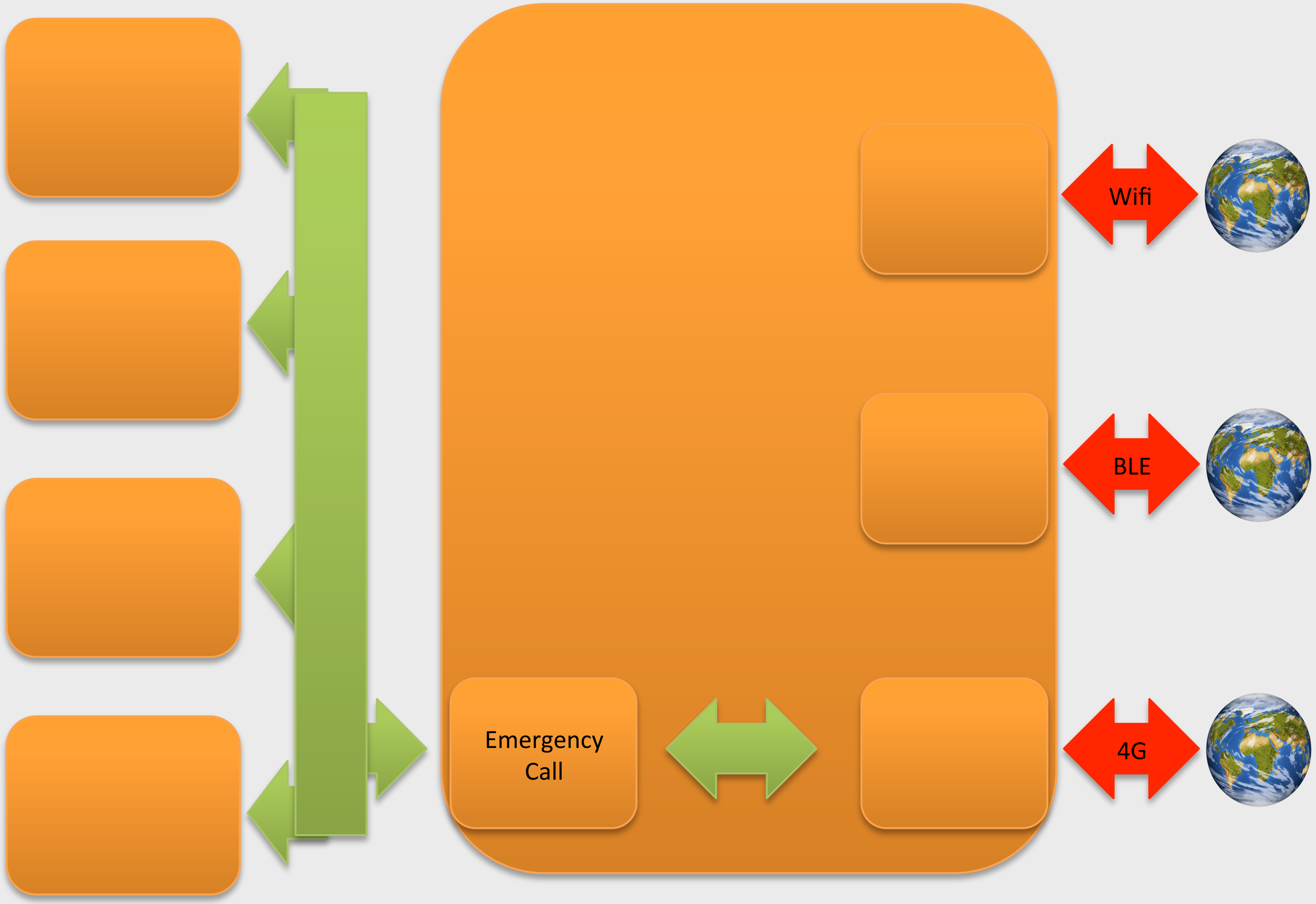
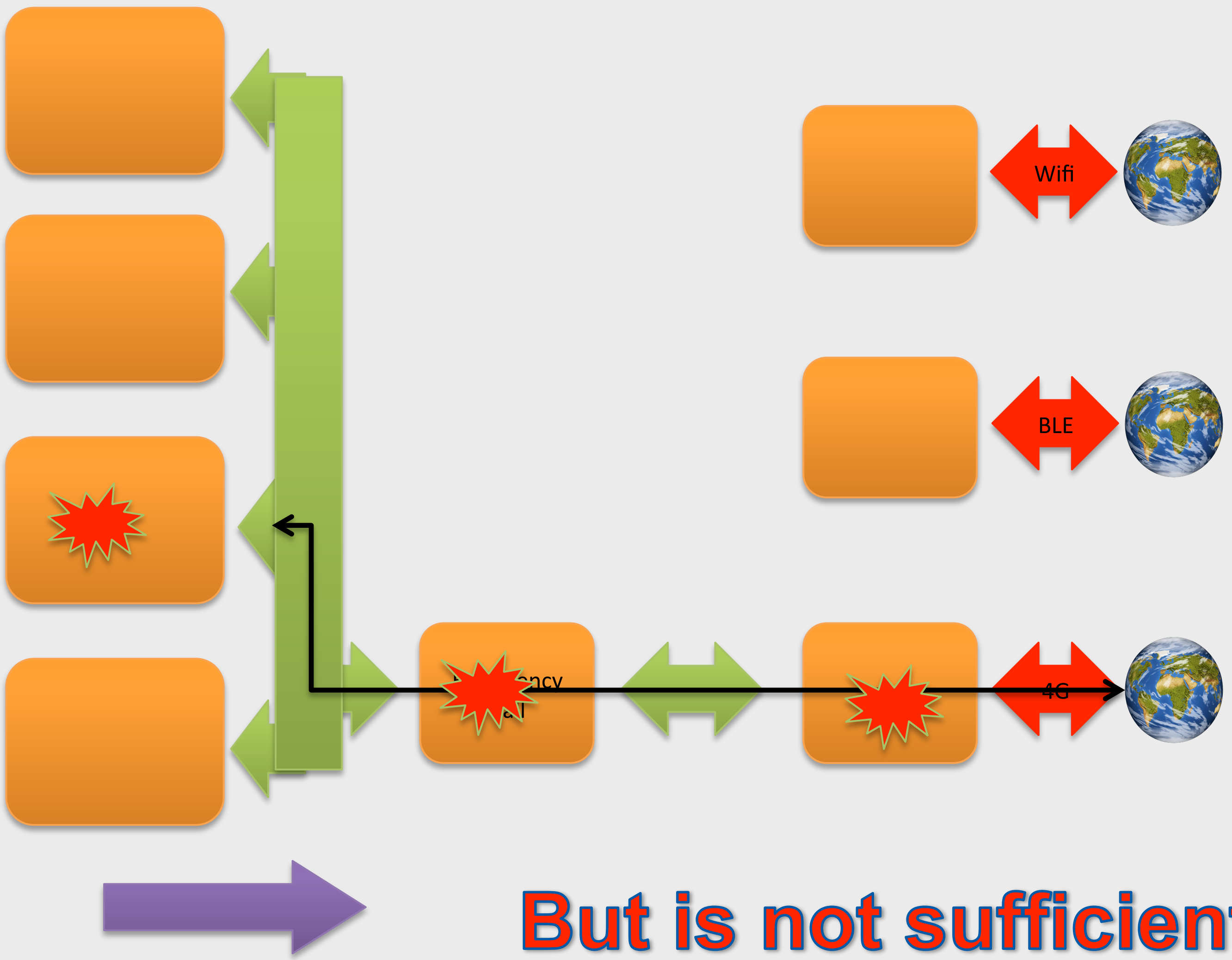


Hypervisor might be useful

A Formally Proven OS/Kernel is required



But is not sufficient

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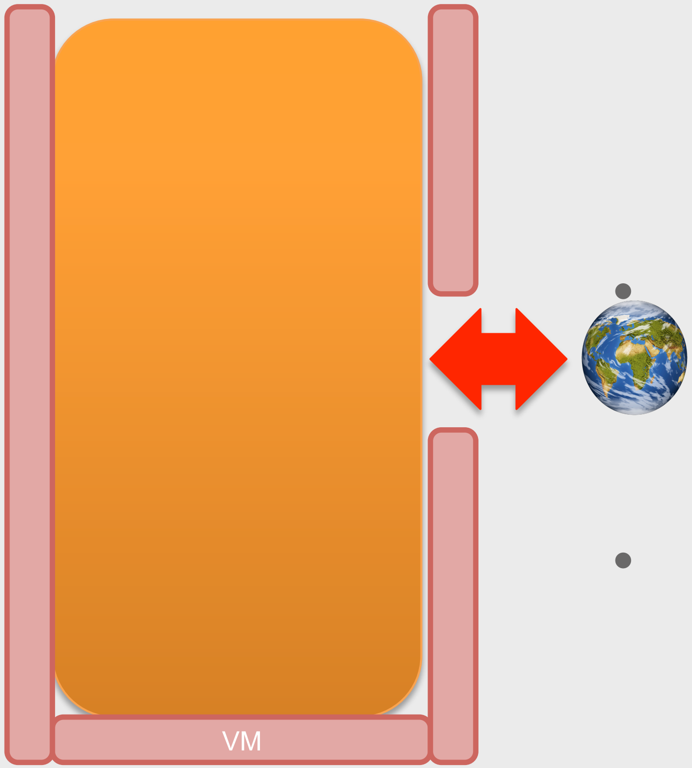
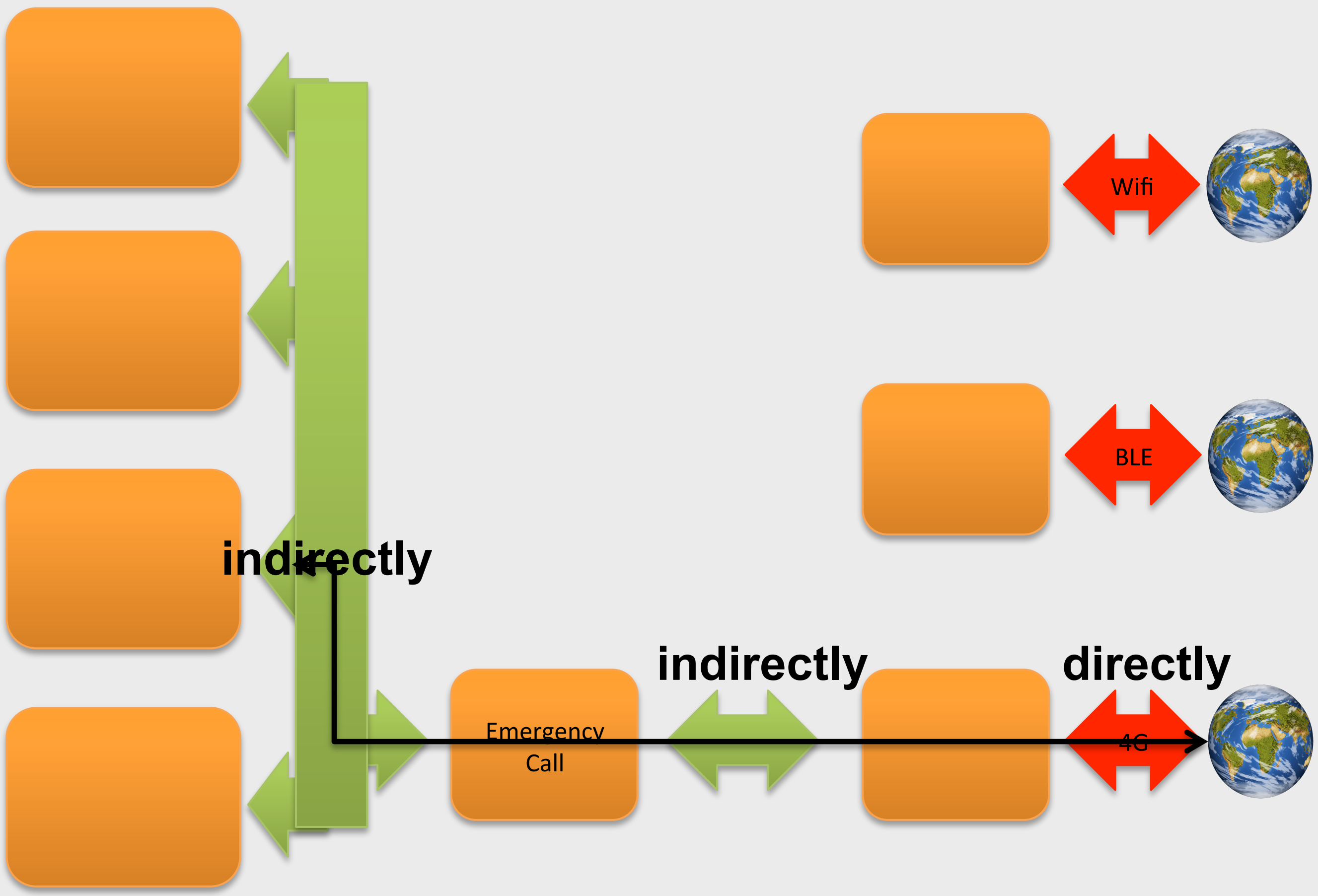


- A kernel such as the one of Linux, QNX, Android, etc. is too large to be practically proven or shown to be secure,
  - Hackers will always find weaknesses to exploit.
- So such a kernel cannot be put **directly in contact** with the external world,
- A (secure) hypervisor is not the solution for that problem either
  - As you have to let the same communication media open

Some sub-systems remain in contact



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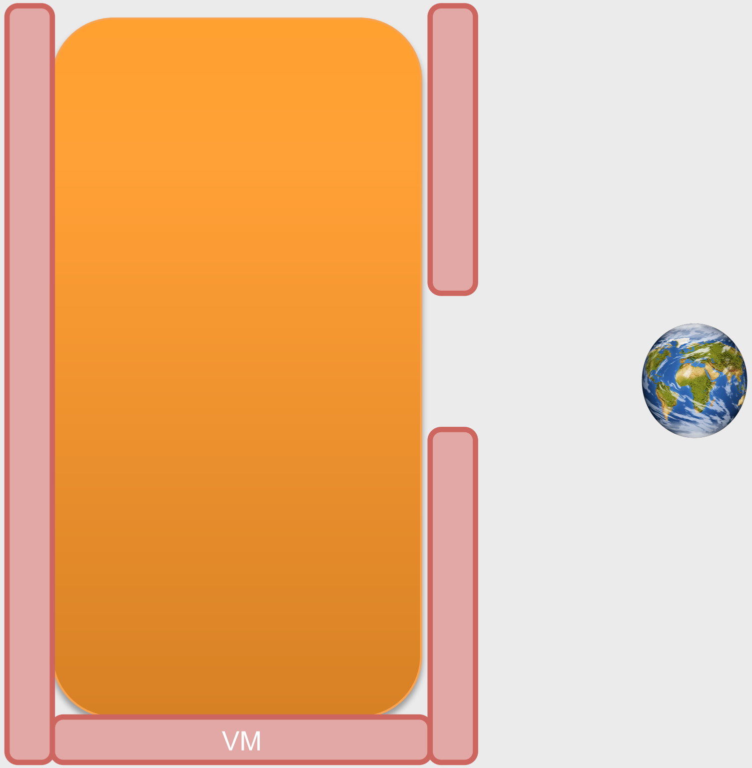
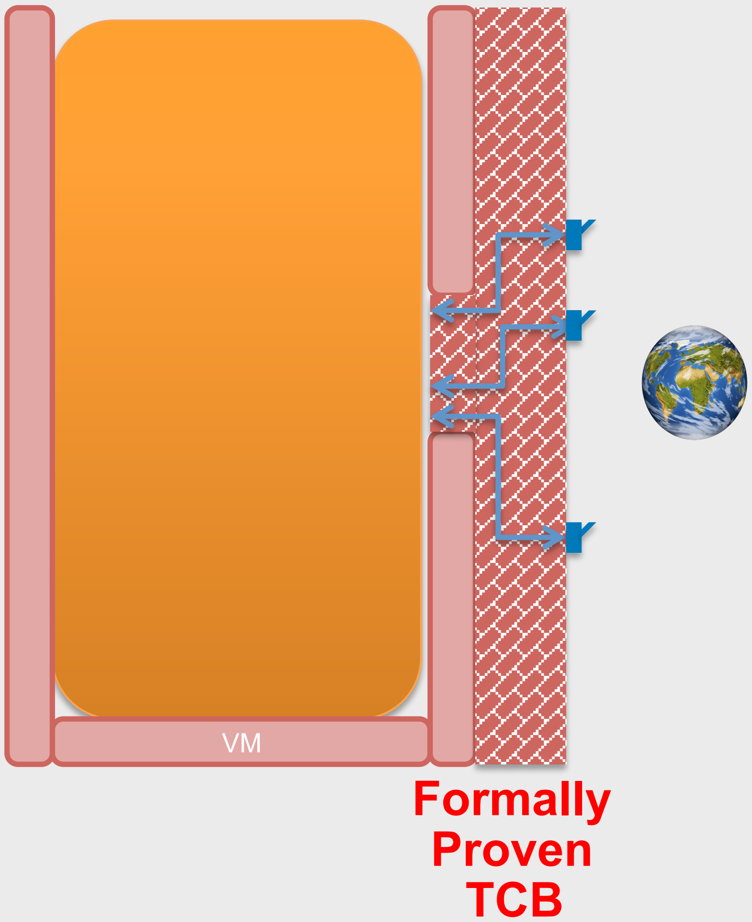


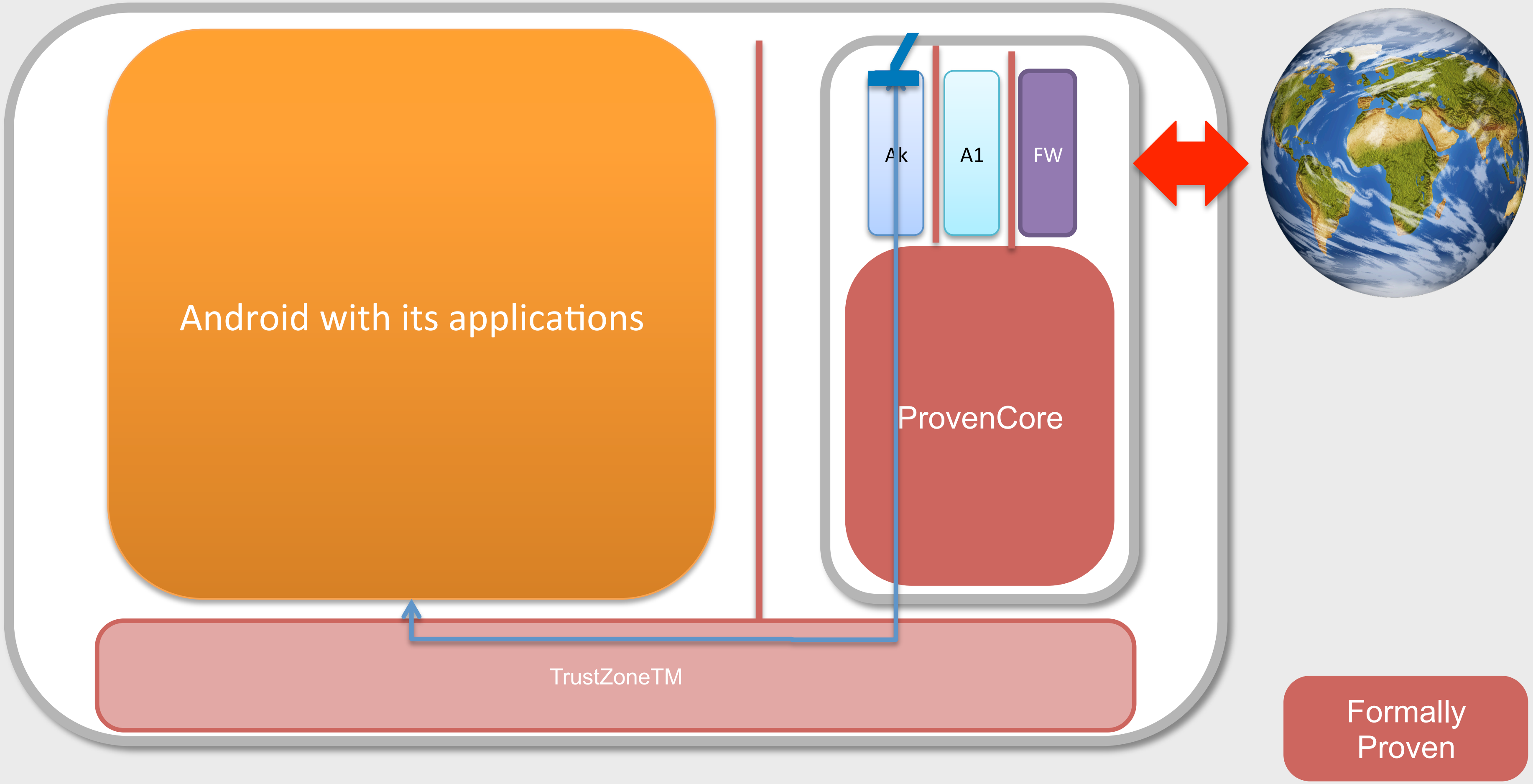
- **Secure applications are needed to implement**
  - firewalling (low level and high level),
  - Secure application management,
  - Secure (OTA) firmware update,
  - Secure authentication,
  - Etc.

A Formally Proven OS/Kernel is required

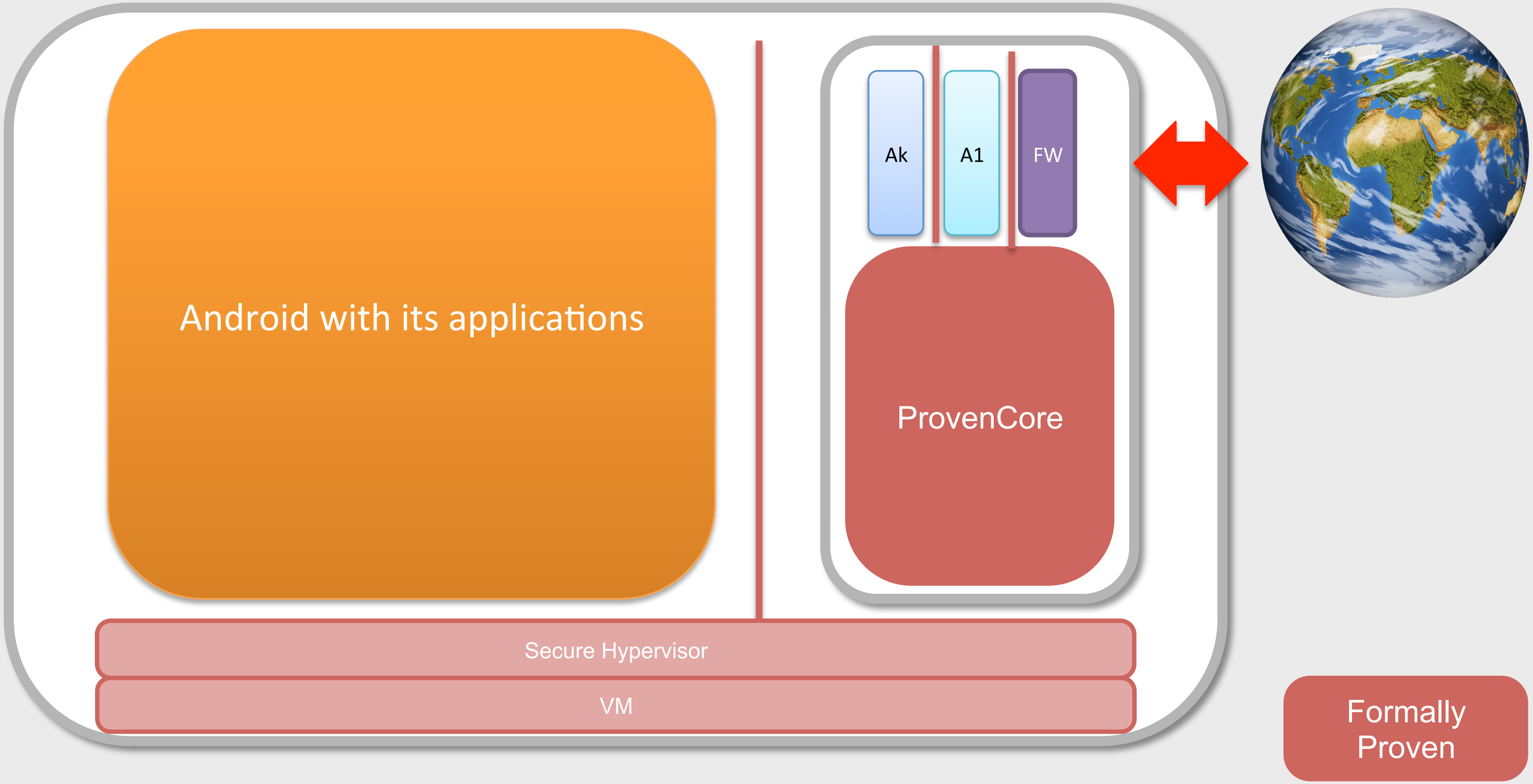


- Such applications cannot be implemented on bare metal
  - Otherwise too complex and error prone => would need to be formally proven by themselves,
- They cannot be implemented on a non proven kernel (otherwise same problem again).
- They can only be implemented on top of a formally proven kernel that is close to zero bug.

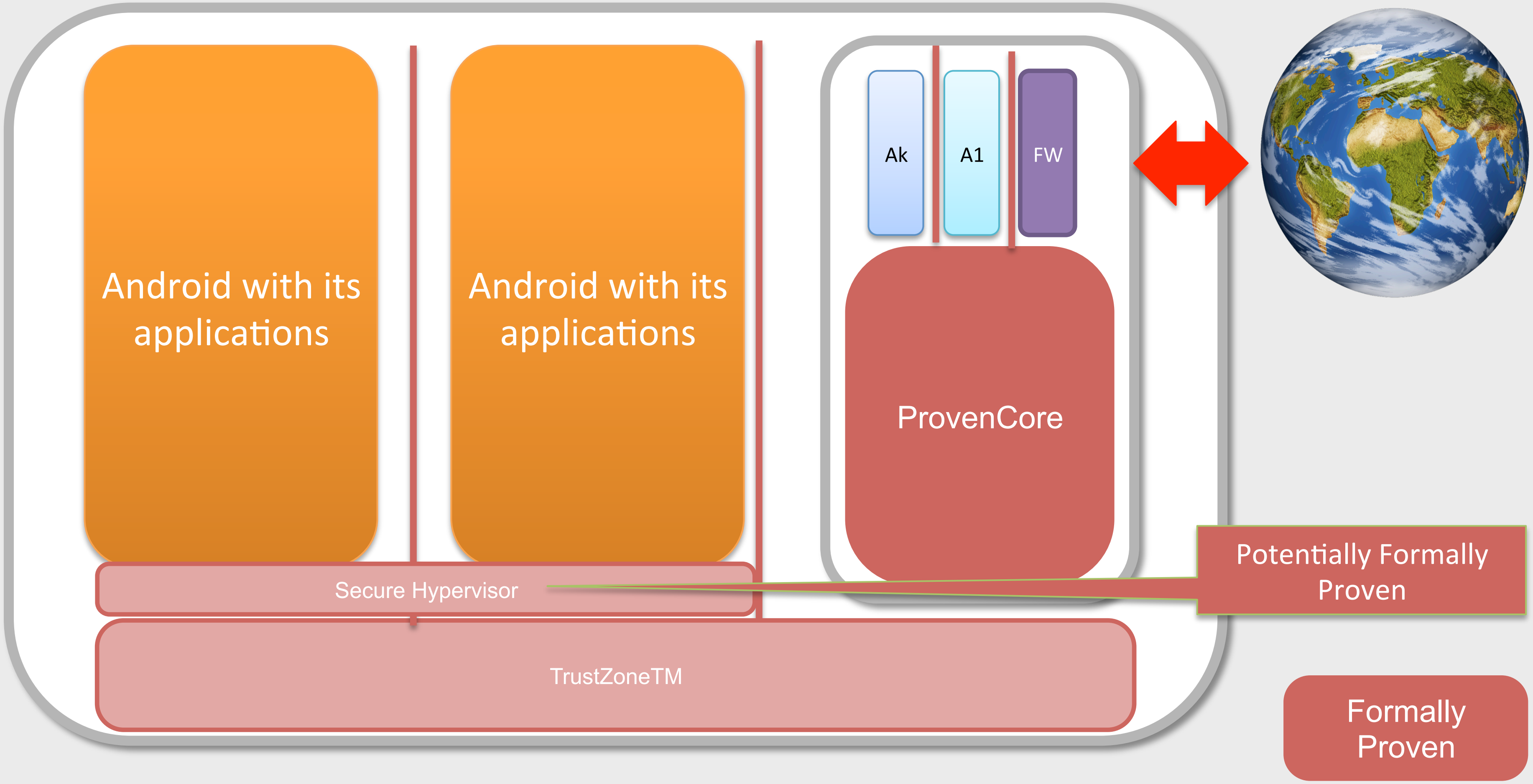
Implementation (Main Use Case)



Implementation (Other Possibility)



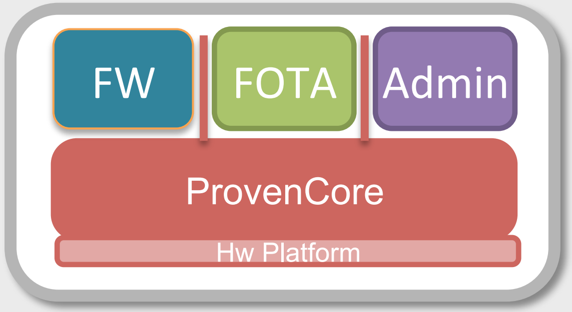
Implementation (To further isolate applications)



A secure OS/Kernel is required

- You need to have security applications to do various tasks:
  - Filtering on various communications channels, using and managing keys, administrating configurations and security, logging events, possibly performing various analysis and attack responses, …
- You need to place such secure applications on a trusted and robust ground :
  - Not on large untrusted OS, Not on Linux (even sitting on a hypervisor, as it will have to communicate and interact with the peripherals and is this thus vulnerable)
  - Not on hardware,
  - Not on an hypervisor (which would provide by definition a similar hardware abstraction)

Requires a secure OS/kernel



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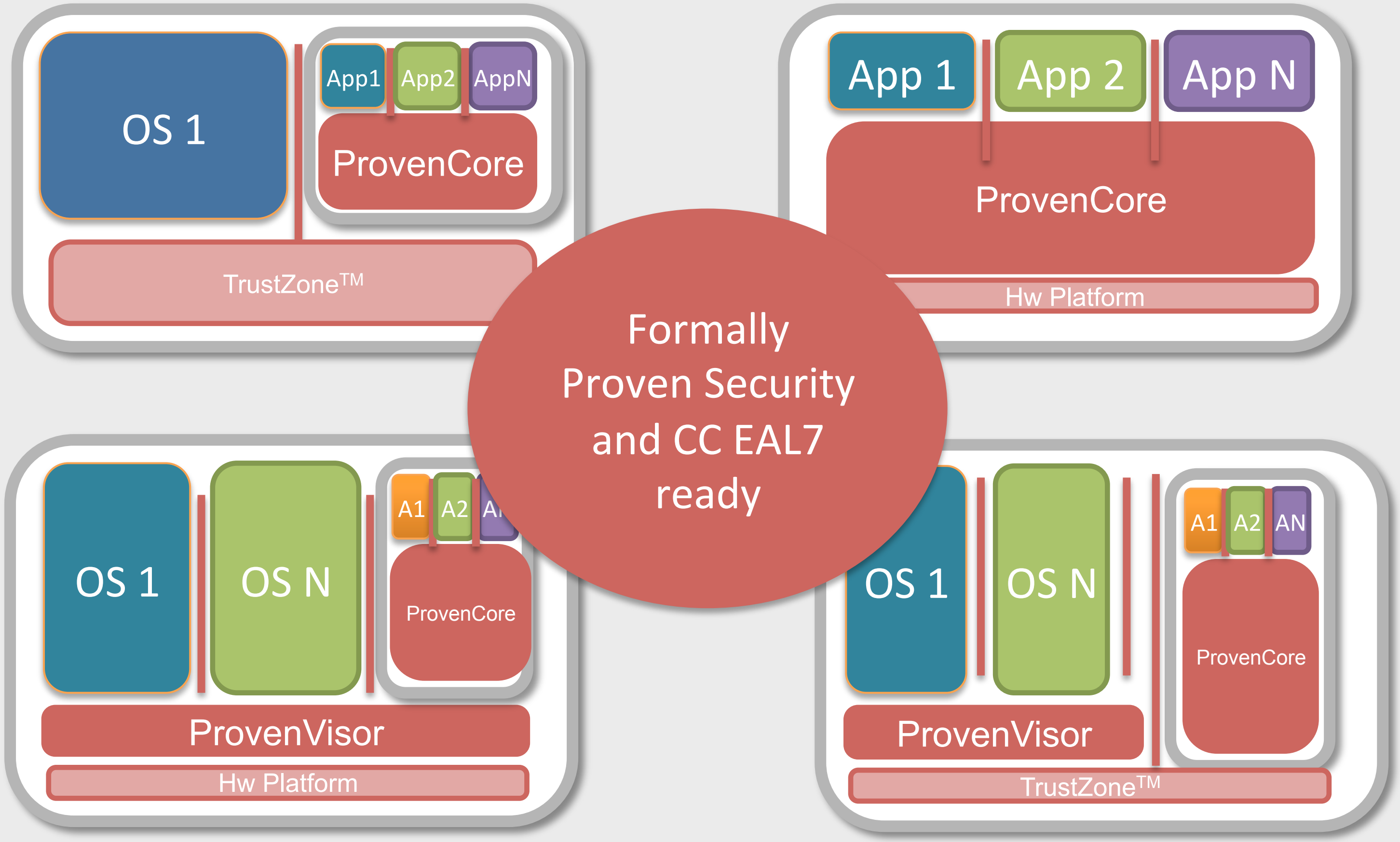
  - ***ProvenCore*** : microkernel proven for security to secure gateways and connected devices (Industrial Things), smartphone, tablets, etc.
    - Execution of security critical applications
    - Secure protection of the "Smart and Safe world" (Existing OS)
    - Provided together with its *secure boot*
  - ***ProvenVisor:*** proven secure hypervisor for mobile devices and IoT virtualization solutions
    - Secure isolation of existing OS and legacy SW stack
  - ***Built with ProvenTools***: a patented software development tool that makes it possible to formally prove the correctness of the software
    - Be as close as possible to "zero-bug"

With ProvenCore and ProvenVisor, Secure a Smart and Safe Embedded World



The 2 missing bricks needed to create the Internet of Tomorrow

Conclusion

- **With a secure boot and one or two COTS you can secure virtually any architecture:**
  - ***ProvenCore*** : a microkernel proven for security.
    - Execution of security critical applications (firewalling, FOTA, etc.)
    - Secure protection of the “Smart and Safe world” (Existing OS)
  - ***ProvenVisor*** (optional) *:* a proven secure
    - Secure isolation of existing OS and legacy SW stack
  - ***Built with ProvenTools*:**
    - To be as close as possible to “zero-bug”