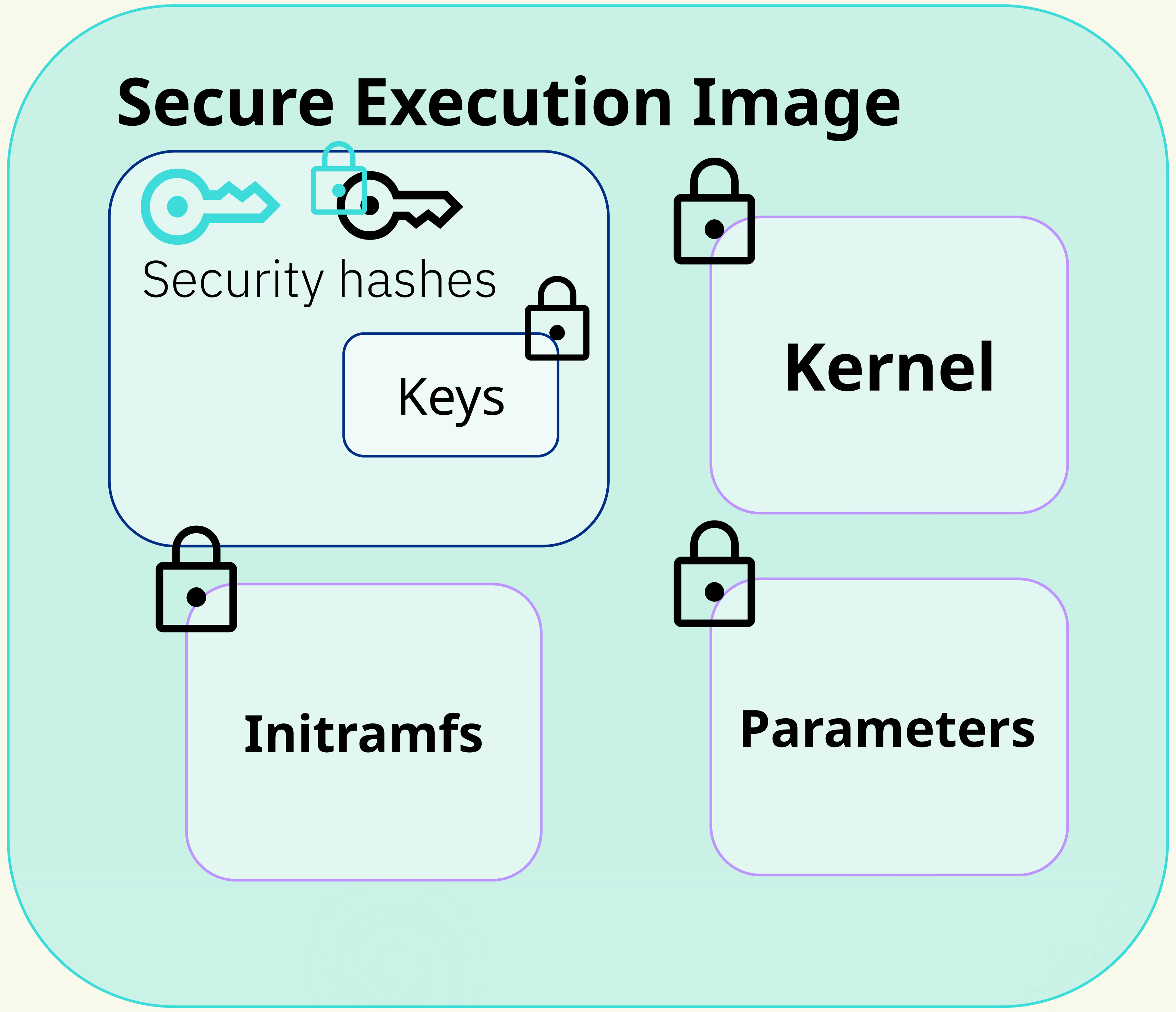
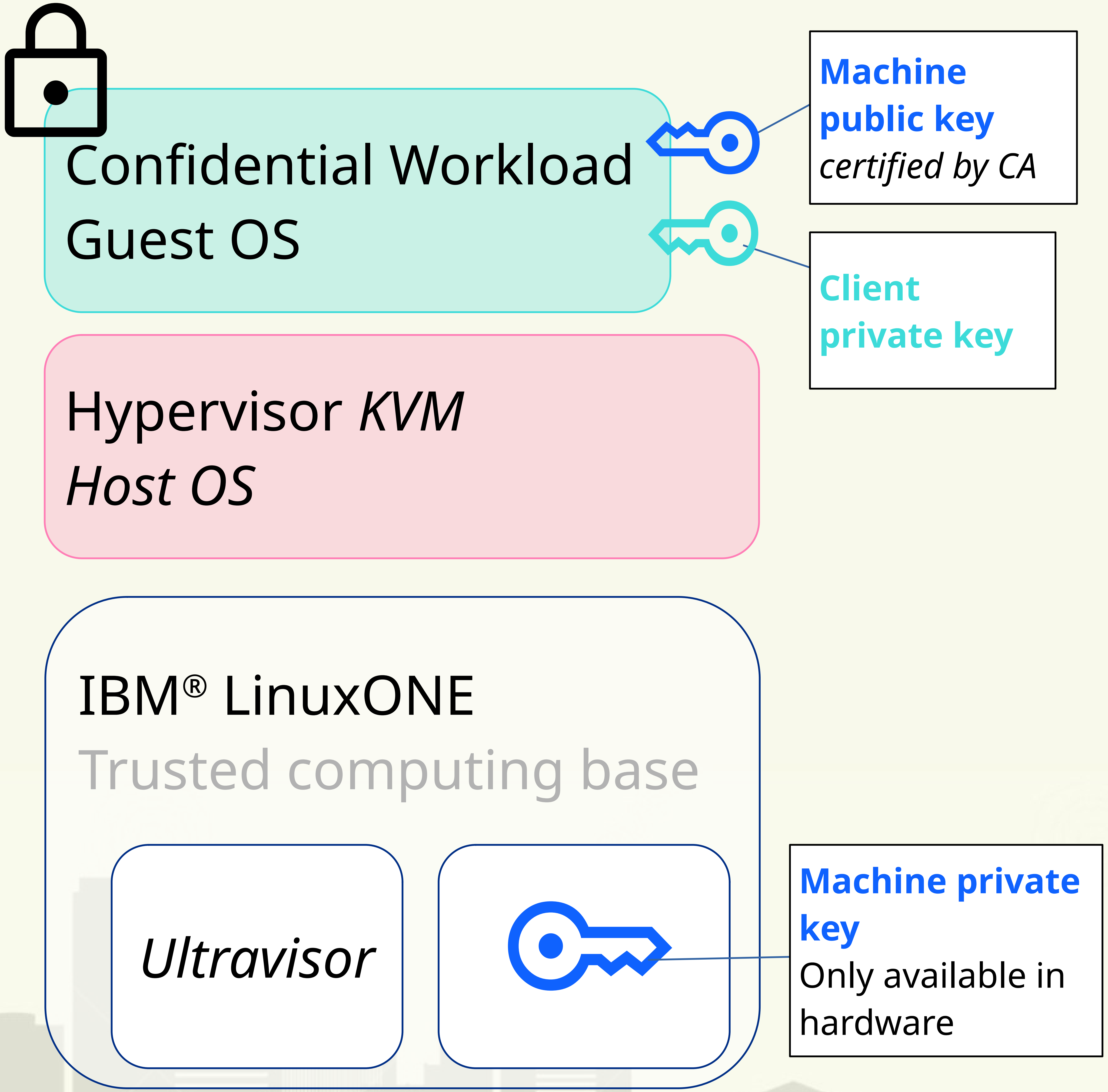
Linux Plumbers Conference | Richmond, VA | Nov. 13-15, 2023

Secure I/O


Secure Execution Image
Security hashes
Keys
Kernel
Initramfs
Parameters


Confidential Workload
Guest OS
Machine public key
certified by CA
Client private key
Hypervisor KVM
Host OS
IBM® LinuxONE
Trusted computing base
Ultravisor
Machine private key
Only available in hardware

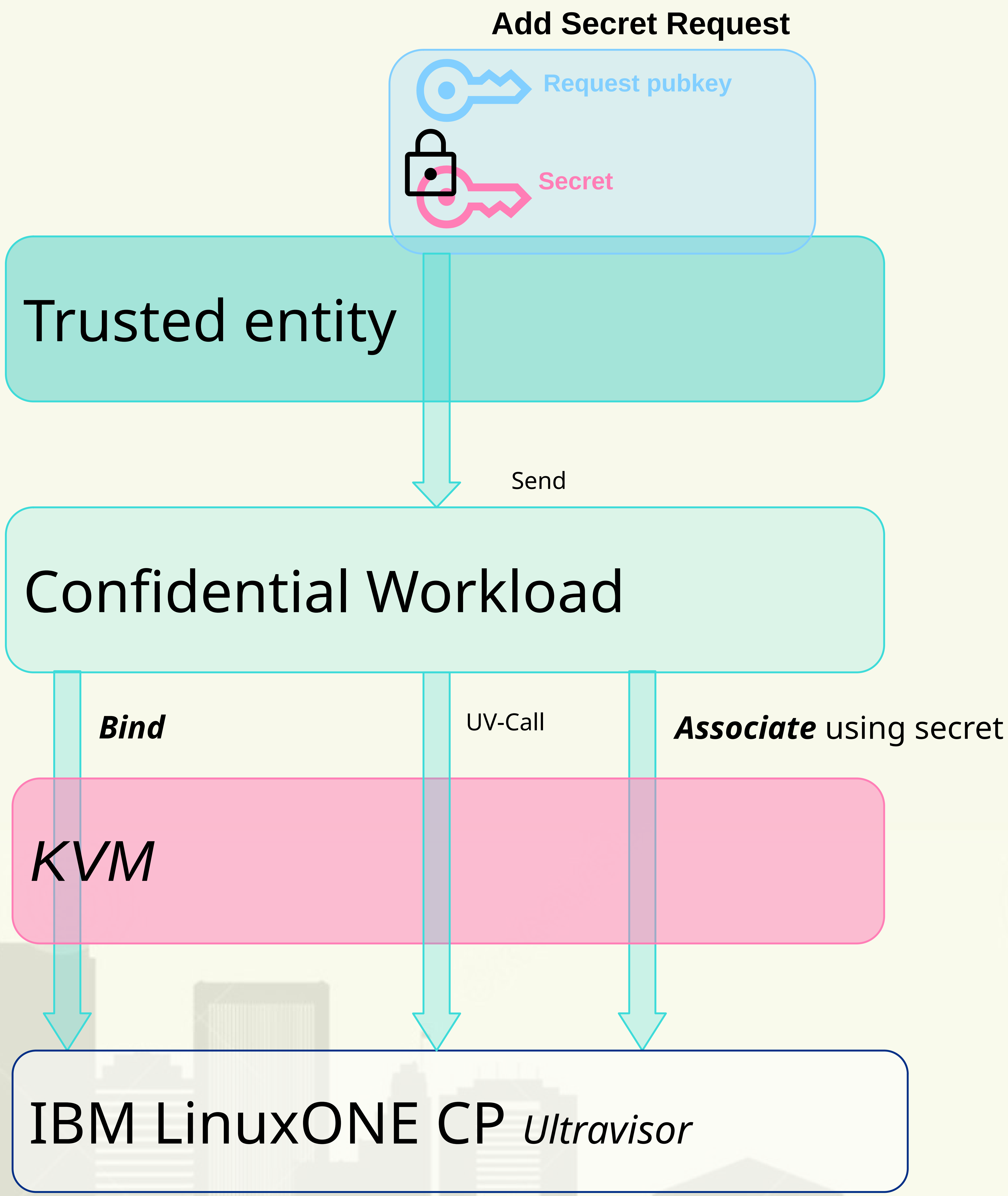
Connecting an EP11 cryptography co-processor to an IBM Secure Execution Guest

Goal
Ensure that KVM/Host cannot get any key material

Bind
- Binds an EP11 exclusively to a SE-guest

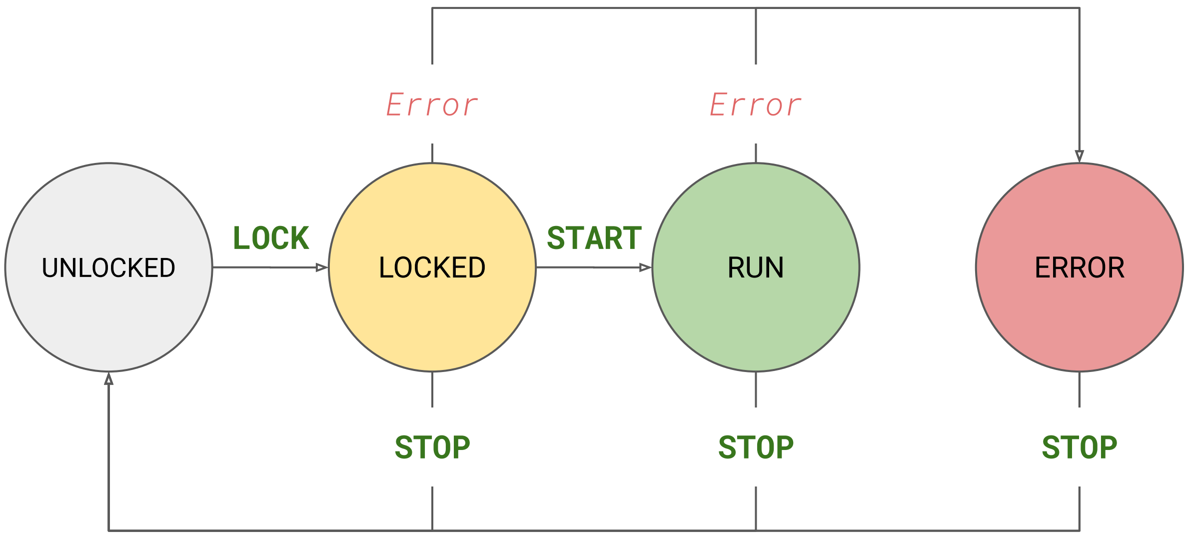
Associate
- Create a session
    - **Secret** defines session
- All key material is session bound
    → Only usable in this session
- Sessions can be continued later

Association Secret
- Encrypted secret, created on another trusted machine
- Secrets are managed by UV per SE guest instance



TDISP State Machine

- One state machine per TDI
- State transitions
  - TDISP command from the host
  - Device or function reset
  - Error condition



State	Device Config Changes?	DMA/MMIO	Device hold confidential data?	Usage
UNLOCKED	Yes	Yes - Not Confidential	No	Legacy
LOCKED	No	No	No	Verification by TVM
RUN	No	Yes - Confidential	**Yes**	TDI in use by guest
ERROR	No	No	**Yes**	Fatal Error - Confidential data wiped

CoVE-IO

RISC-V Secure I/O

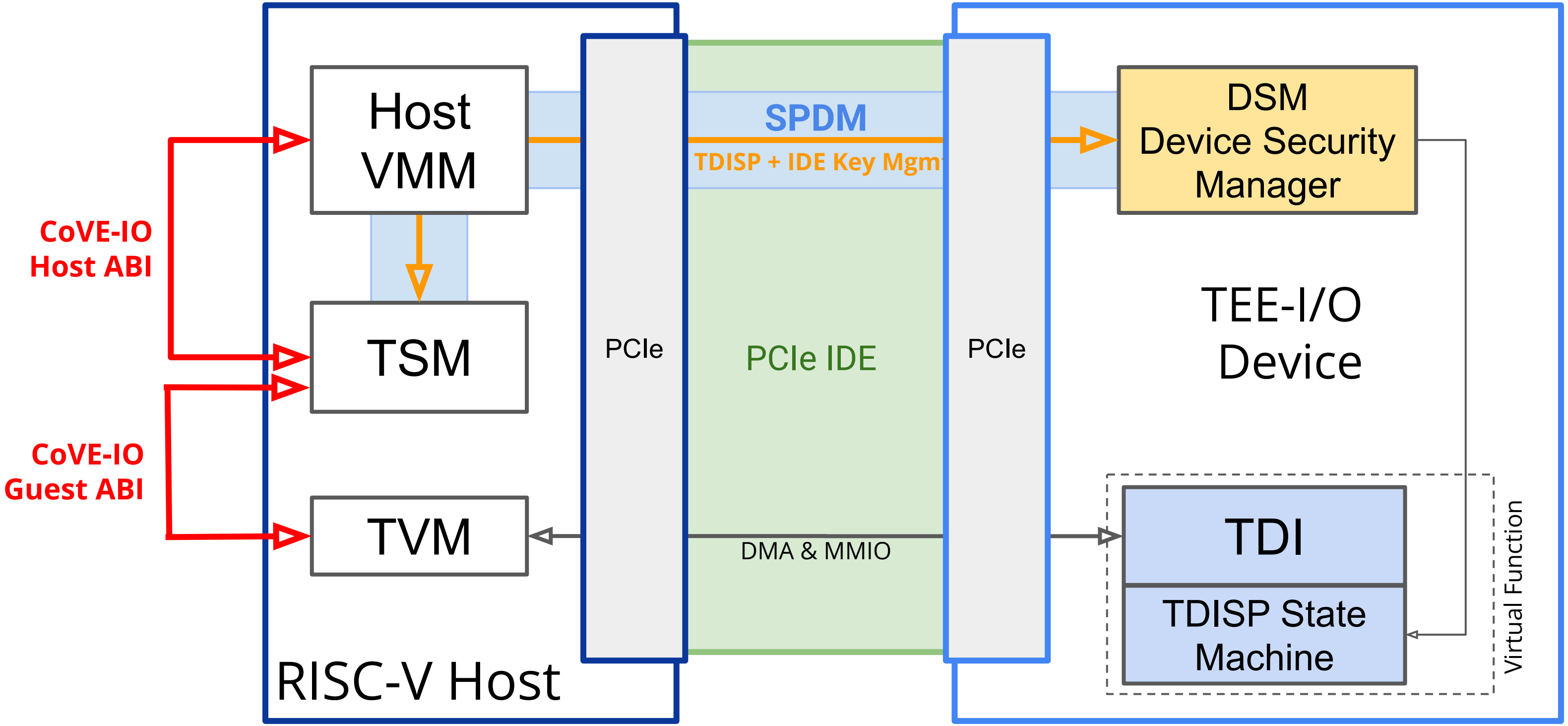
Jiewen Yao (Intel) / Samuel Ortiz (Rivos)

[RISC-V AP-TEE-IO TG]

Rivos

CoVE-IO

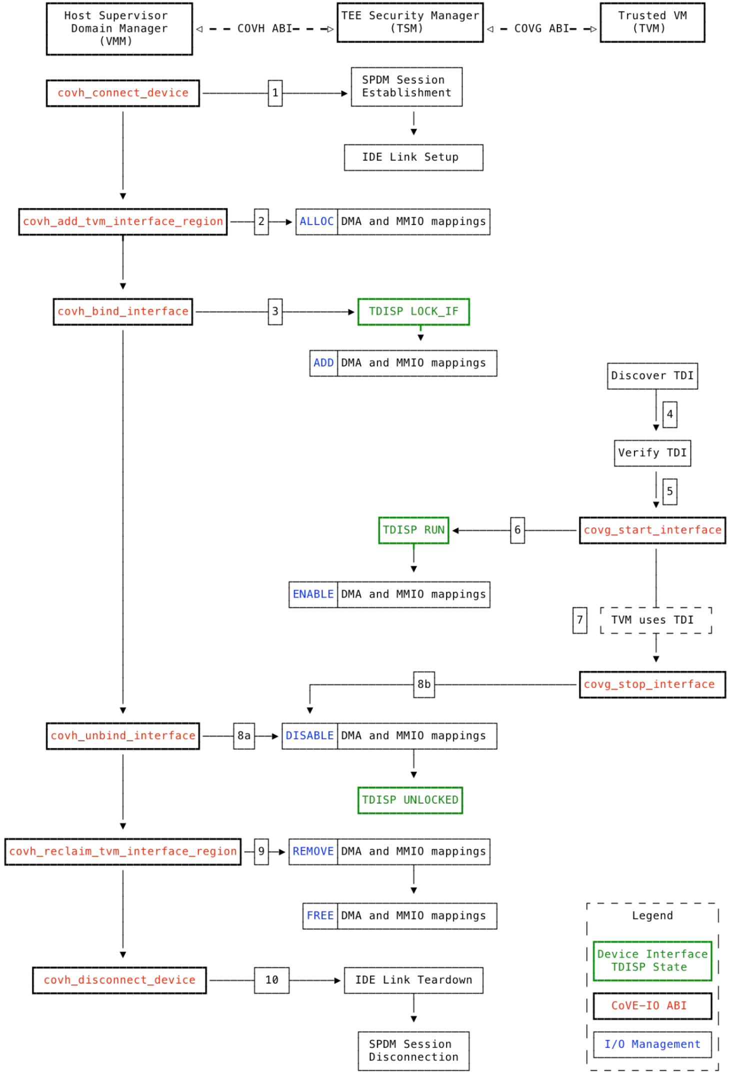
- Confidential Virtual machine Extensions for I/O
- Extension of the [RISC-V Confidential Computing ISA]() (a.k.a. CoVE)



Rivos

CoVE-IO ABI and Flows

- **connect() → bind() → start()**
- **TSM owns the SPDM session**
  - And manages TDISP and the IDE keys
- **TSM manages DMA & MMIO mappings**
- **Host VMM owns the physical device**
  - Host initiates the SPDM session establishment
  - VMM →TSM: **`covh_connect_device()`**
- **Host VMM binds the device interface**
  - VMM →TSM: **`covh_bind_interface()`**
- **Guest verifies the bound interface**
- **Guest starts the interface**
  - Guest →TSM: `covh_start_interface()`



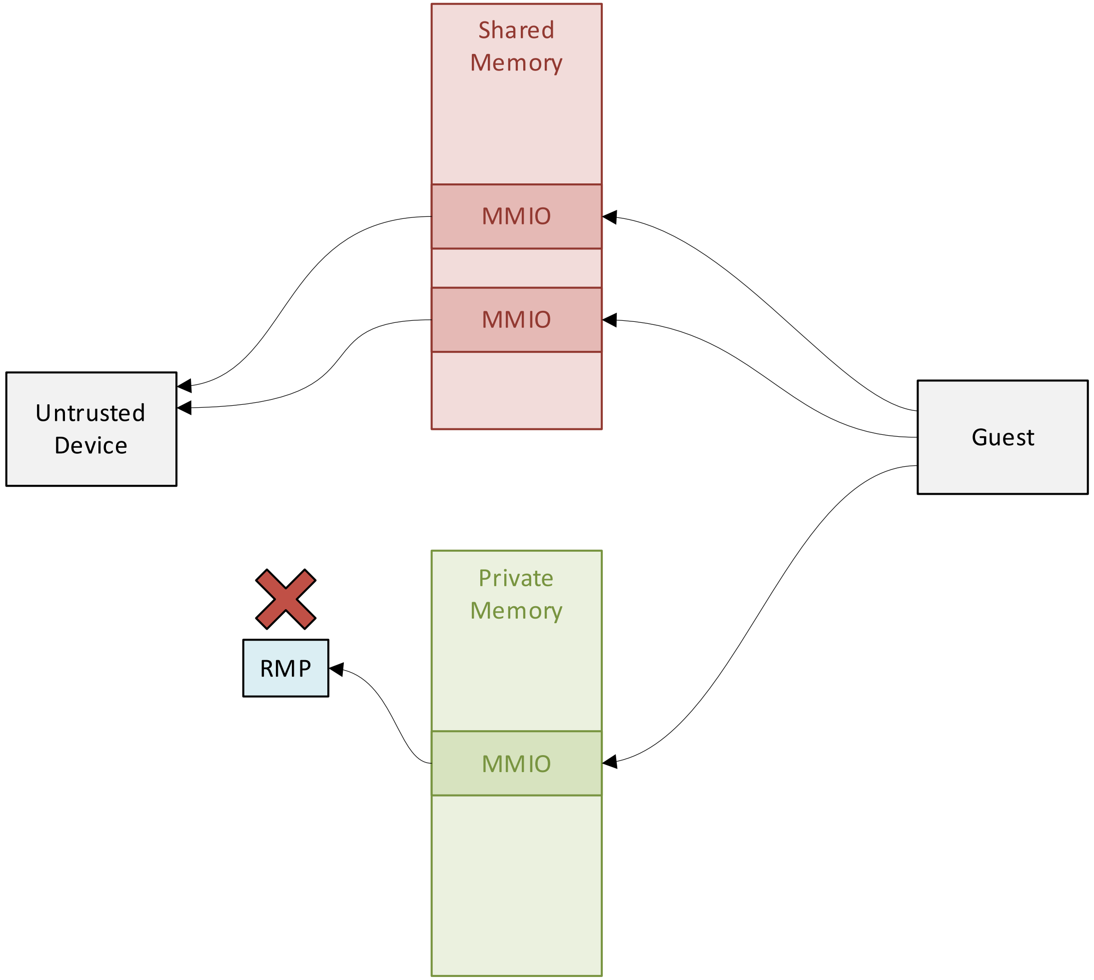
Rivos

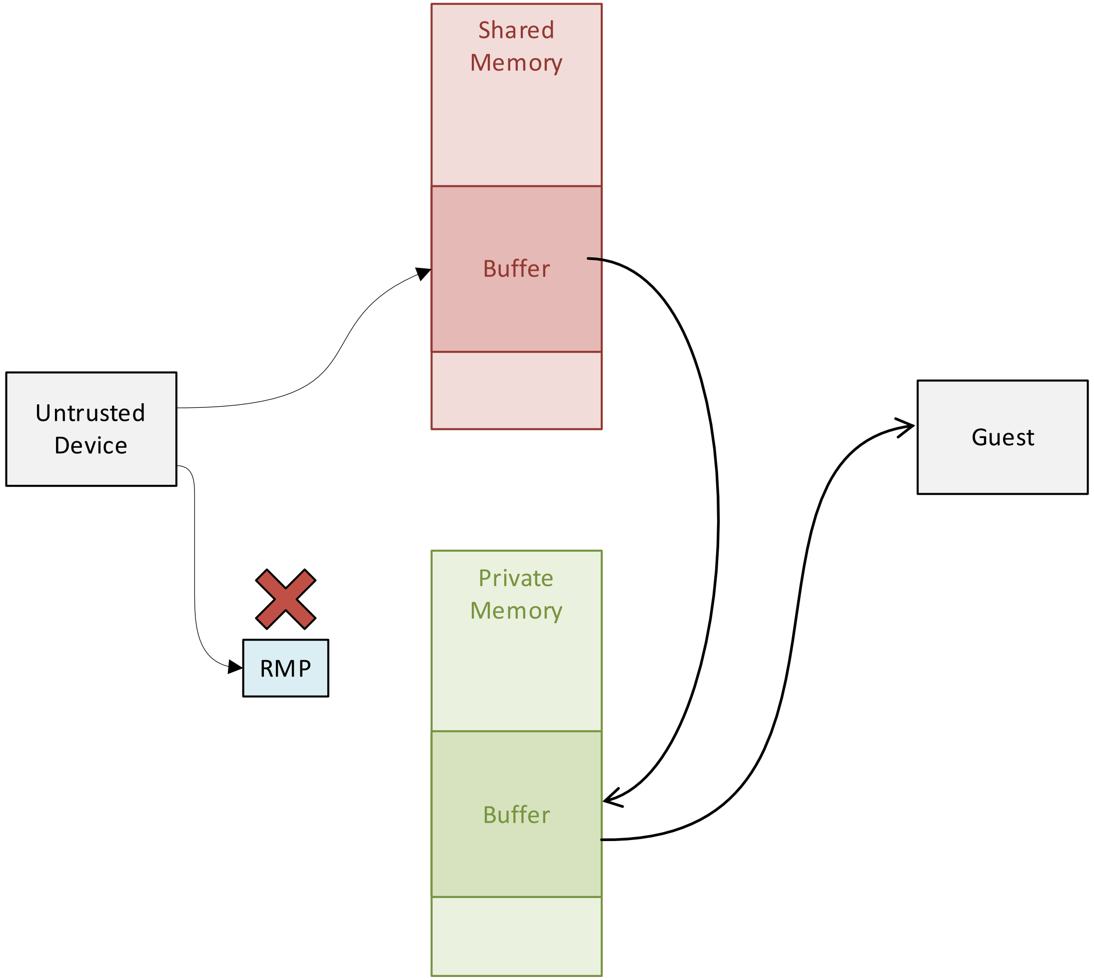
SEV-TIO: Trusted I/O for SEV-SNP Guests

Jeremy Powell & Tom Lendacky

together we advance_

SEV-SNP – Untrusted Devices

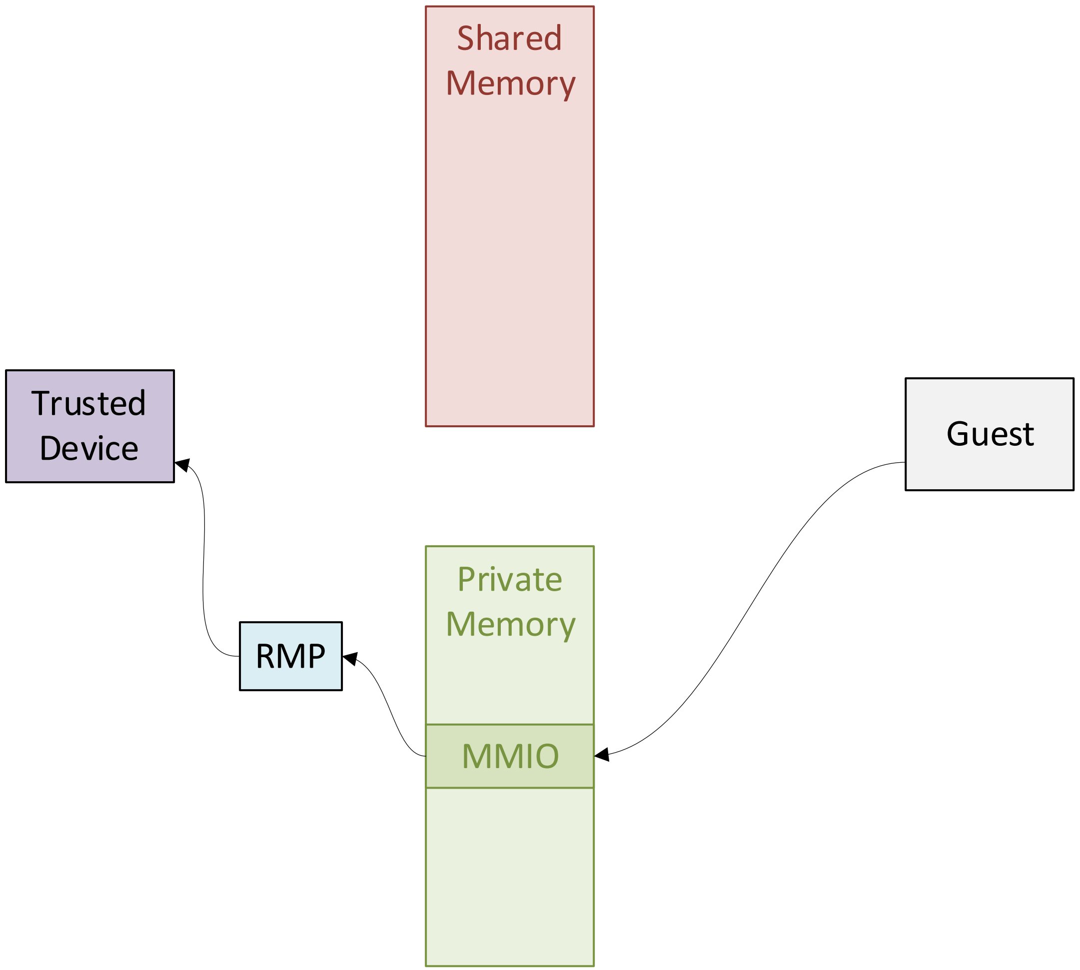




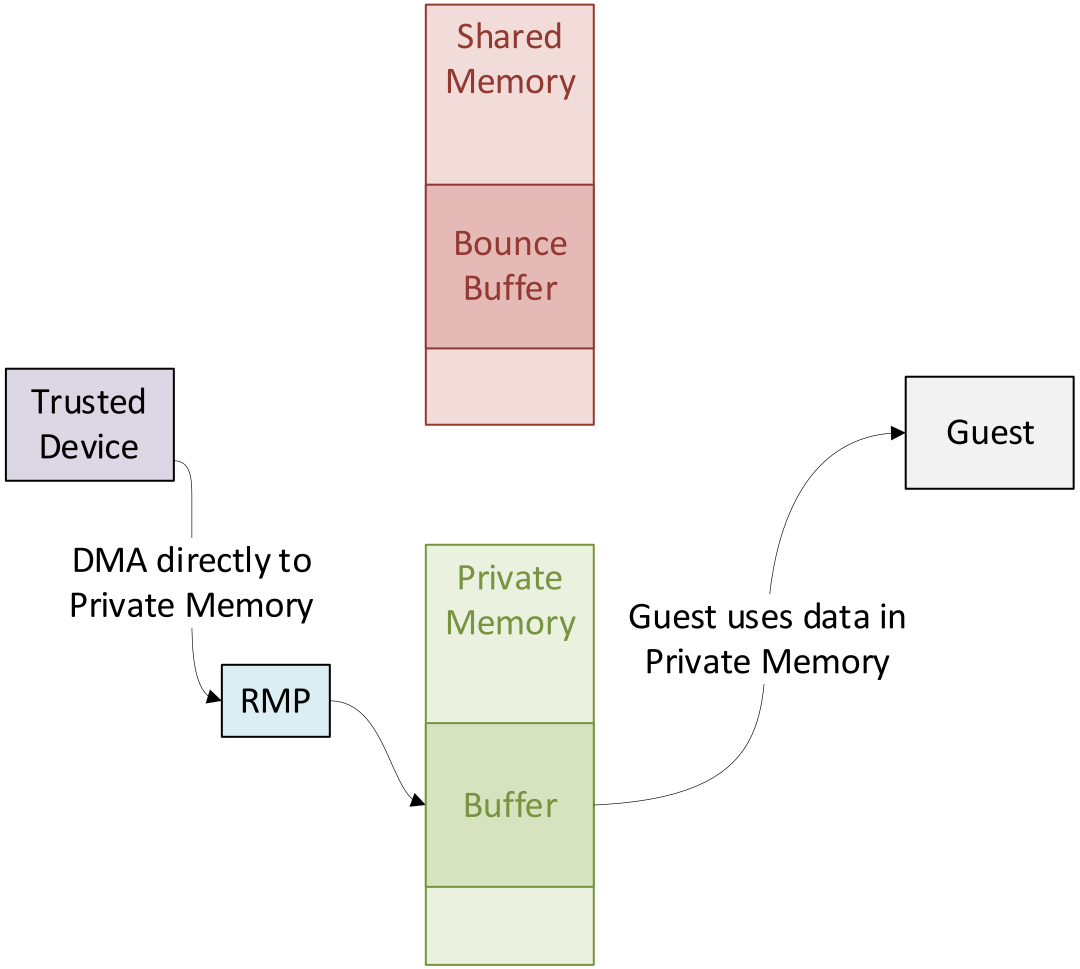
MMIO Cannot Map to Private Memory

DMA to Private Memory Blocked

SEV-TIO – Trusted Devices



MMIO Can Map to Private Memory



DMA to Private Memory Allowed

Guest & TDI Lifecycle

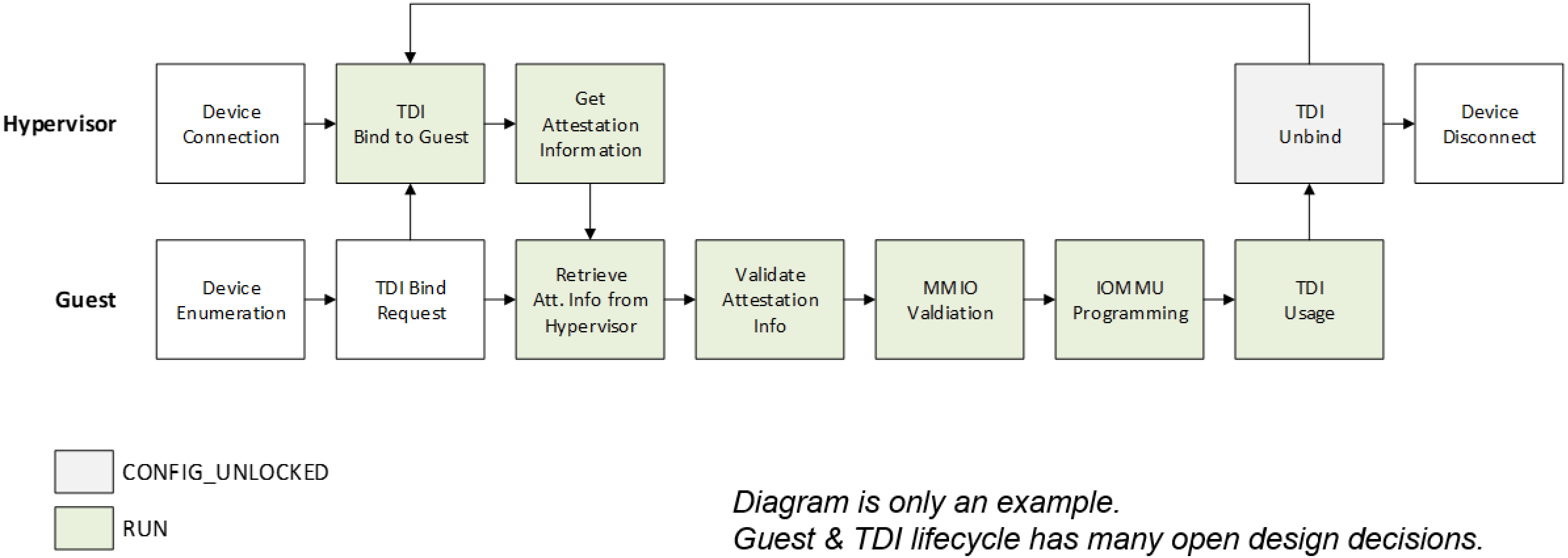
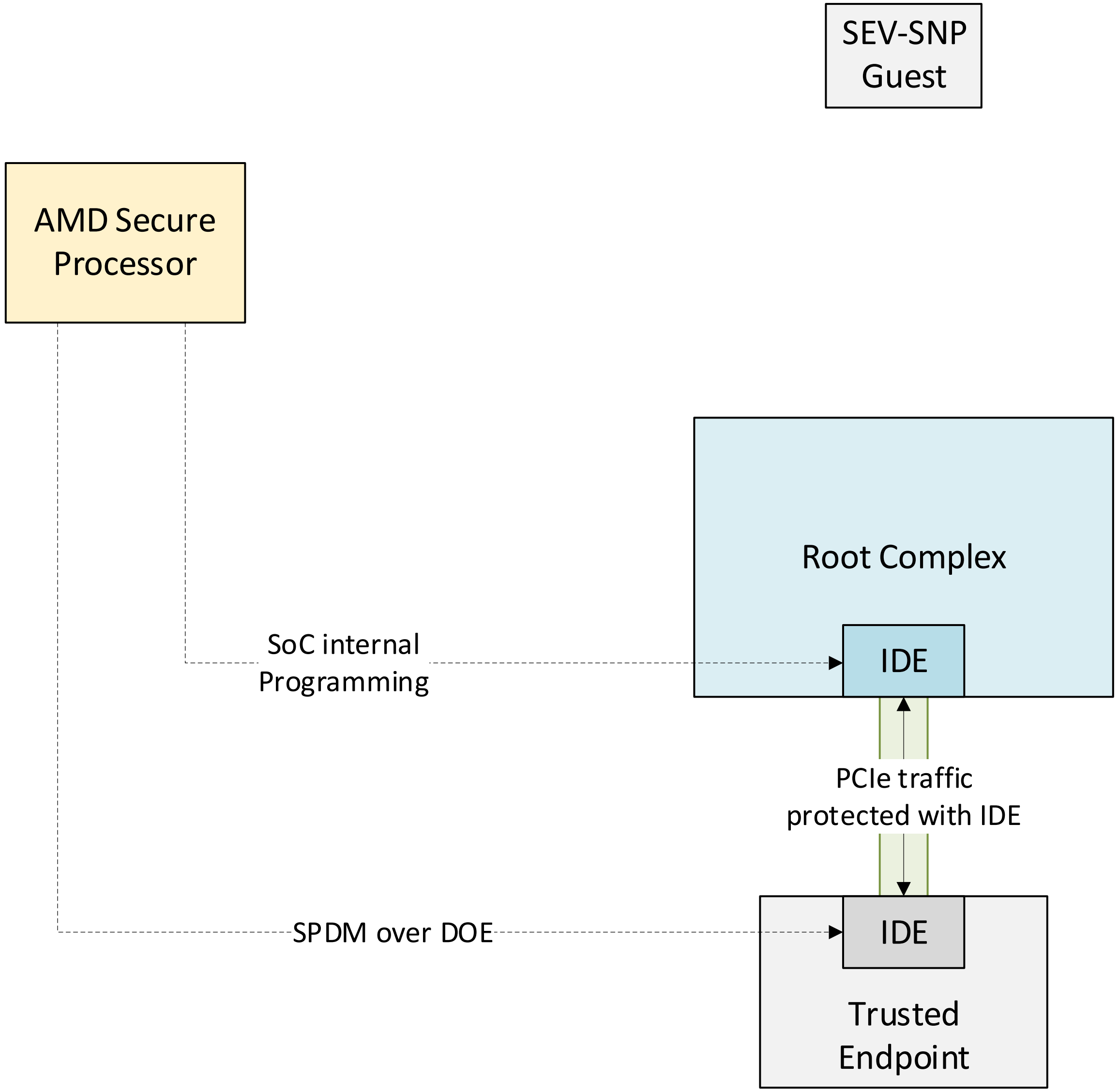


Diagram is only an example.
Guest & TDI lifecycle has many open design decisions.

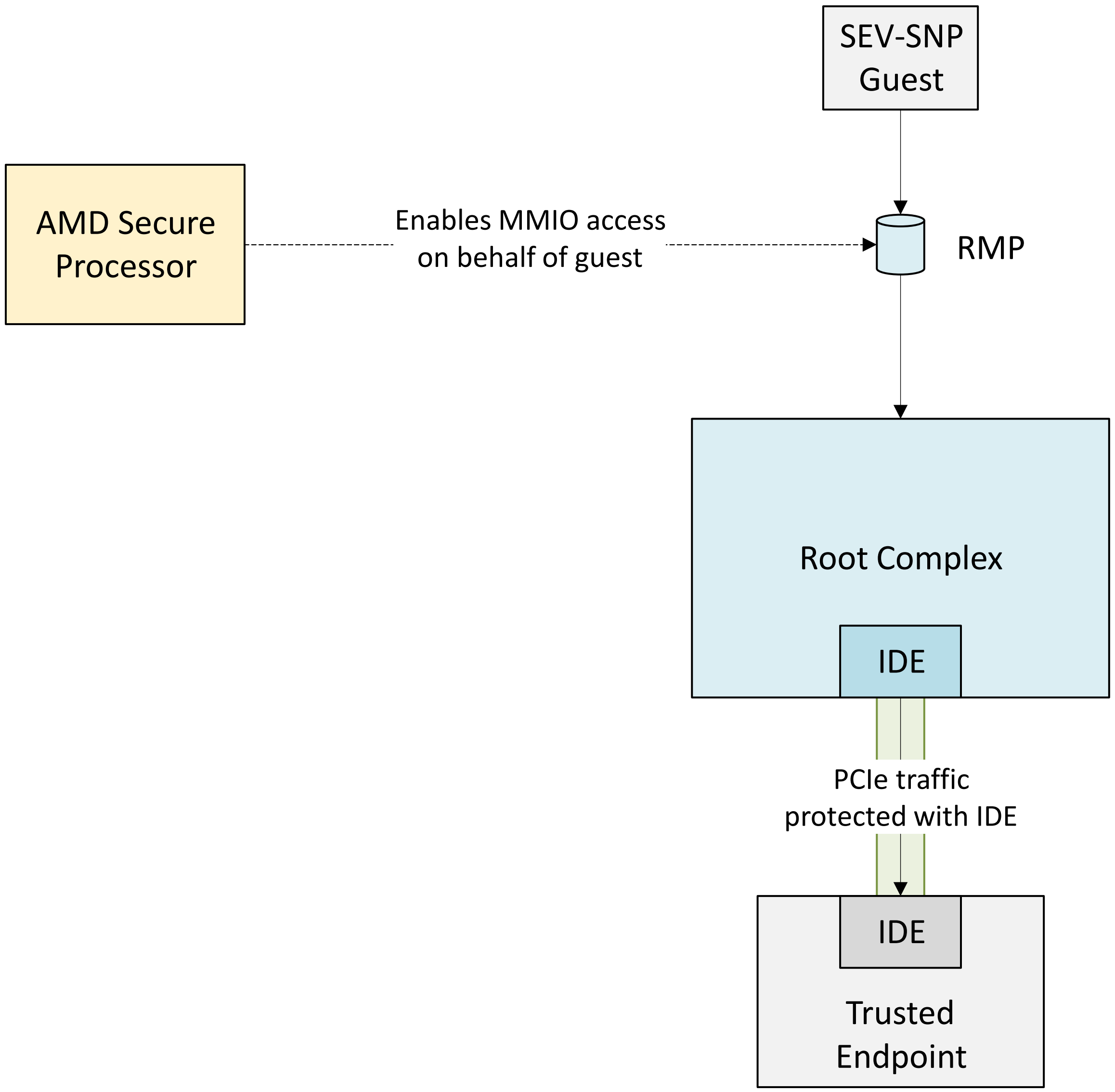
Protecting PCIe Traffic

- Secure Protocol and Data Model (SPDM)
  - Protocol connecting device to ASP
  - Encrypted and integrity protected
  - Control path for configuring trusted device
- PCIe Integrity and Data Encryption (IDE)
  - Confidentiality and authenticity between PCIe ports
  - Keyed by ASP using SPDM
  - PCIe traffic protected at transaction layer



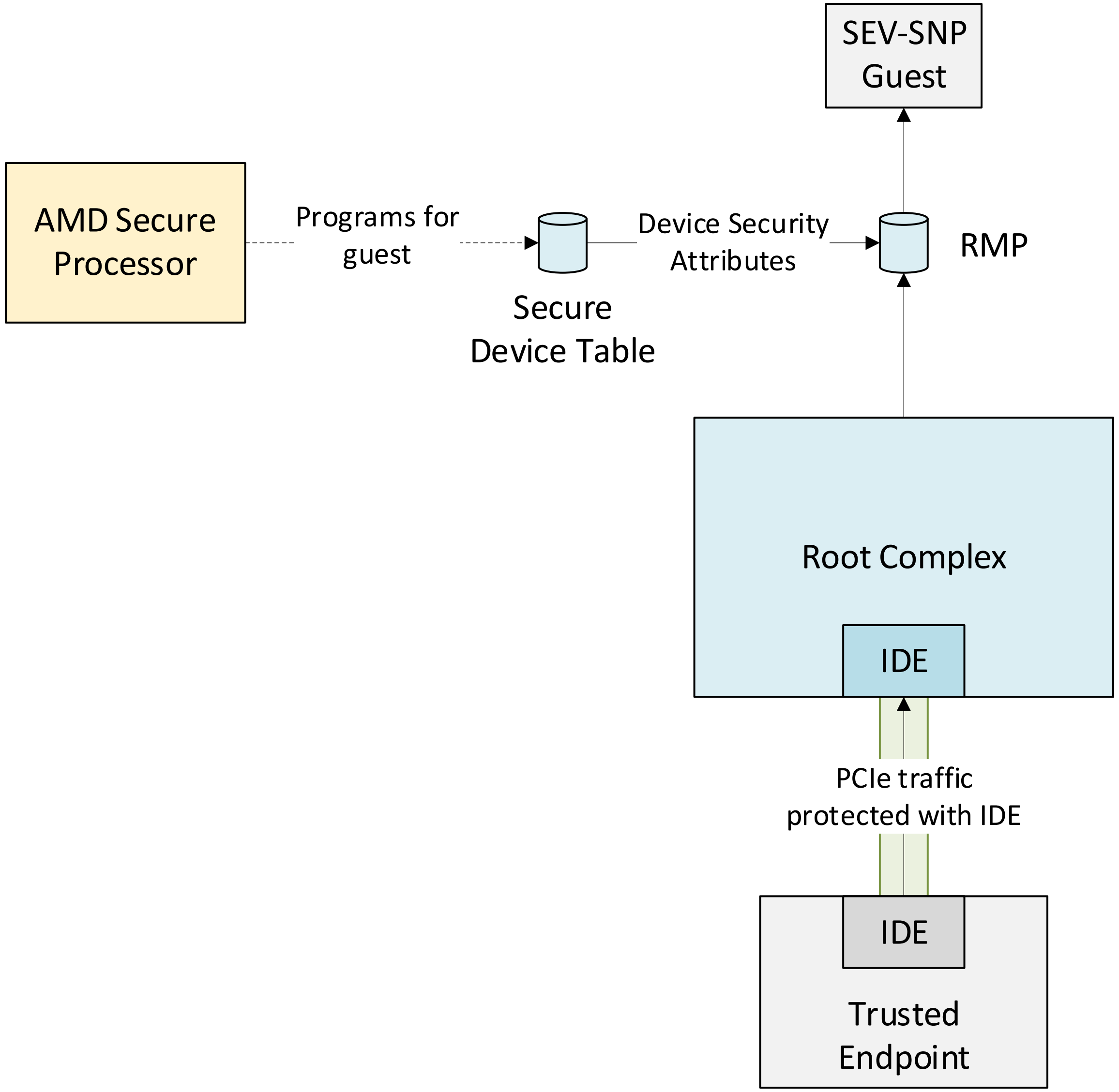
Enabling Secured MMIO

- Private MMIO ranges
  - Located in private guest memory
  - ASP verifies configuration (system physical ⇔ device mapping)
  - Configures RMP for secure MMIO
- Guest MMIO access
  - Existing RMP checks prevent remapping attacks
  - MMIO access is routed to appropriate device through the device's IDE stream



Enabling Secured DMA

- Secure Device Table (SDT)
  - Additional RID-indexed table
  - Associates the RID with the guest
  - ASP programs on behalf of guest
- Access control on DMA
  - Hardware routes and tags traffic per SDT entries
  - IOMMU performs RMP checks like CPU MMU
  - Guest manages DMA targets like any other private guest memory (i.e., using PVALIDATE instruction)



AMD
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AMD

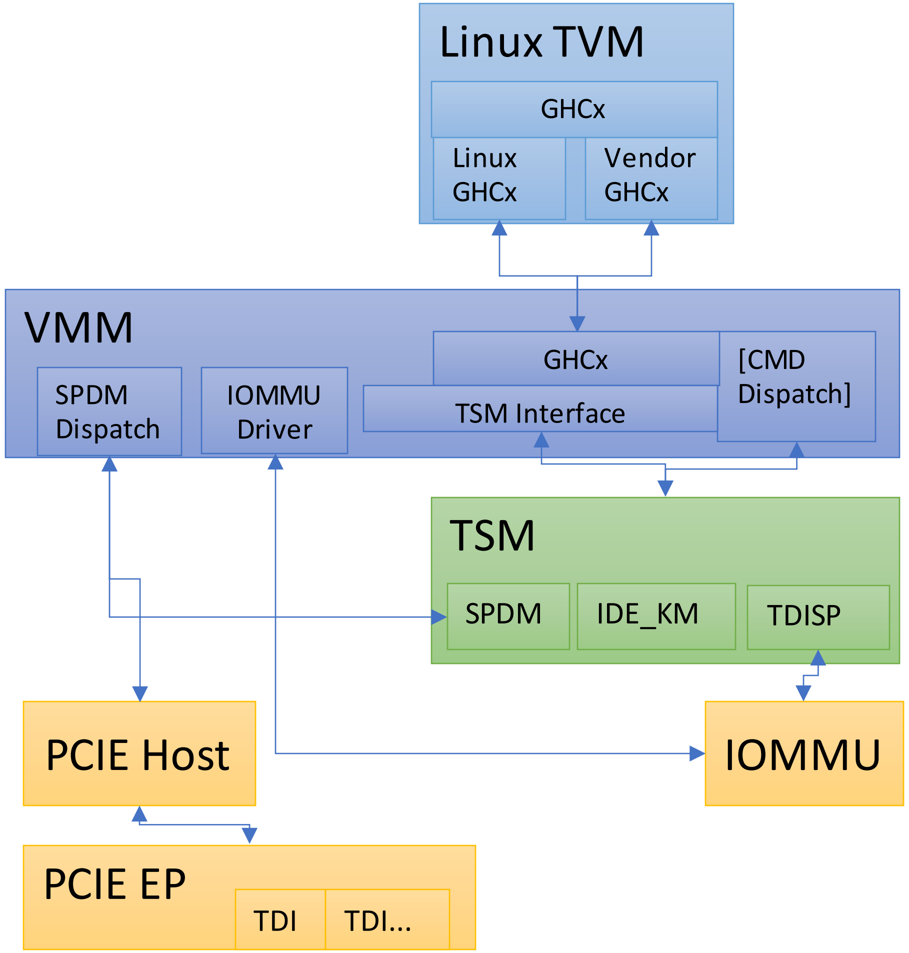
Framing Questions

- What if there was a standard Platform Secure I/O interface definition?
  - How much deviation would upstream tolerate from that standard?
- Given there is no standard and multiple vendor interface proposals in flight what is Linux's role in mitigating differentiation?
- Given the fundamental complexity of Secure I/O where do we start as a community?

Towards a Linux Secure I/O Interface Definition

- Guiding principles:
  - Find the coarsest grained (externalizes the least amount of complexity to Linux) and minimal set of verbs to transition a device-instance into and out of Secure I/O operation. Advocate for vendors to move their interfaces to that standard.
  - Start with the most ruthlessly simple implementation, but no simpler, and incrementally evolve to address more use cases.

Apply the Principles



- SPDM, IDE, and TDISP protocol abstracted behind TSM
- Common TSM verbs: Connect, Bind, Unbind, Disconnect, Info (Certs, Measurements, Report)
- Linux GHCx for common guest to host operations
- Dispatcher(s) to help limited TSM execution environments offload protocol handling complexity