AMD

SECURE ENCRYPTED VIRTUALIZATION – WHAT'S NEXT

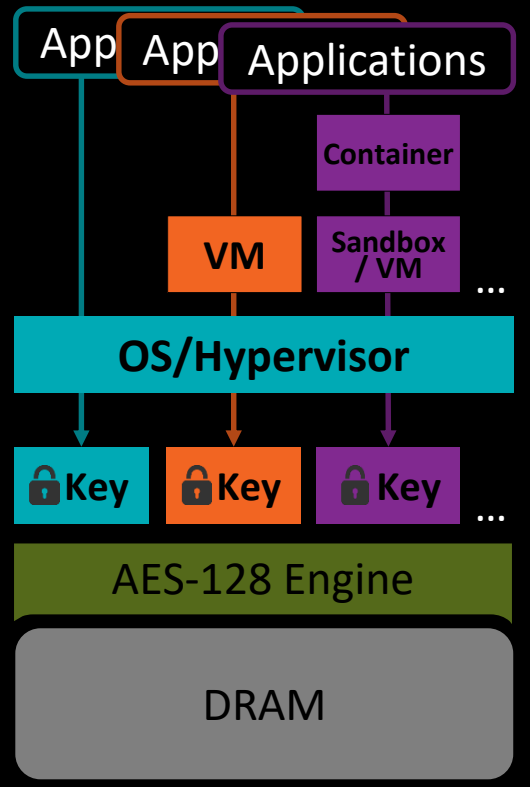
KVM FORUM - 2019

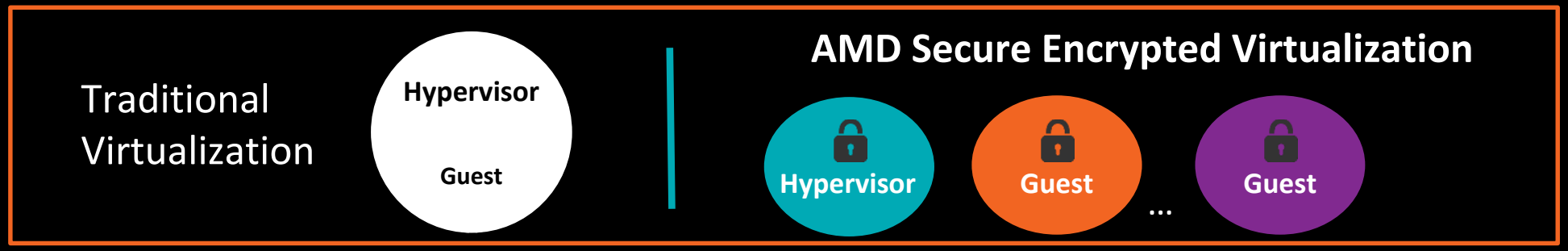
AGENDA

- SEV
  - Review
  - Live Migration
  - Migration Helper
  - Performance Work
- SEV-ES
  - Review
  - Status
- SEV-SNP

SEV REVIEW

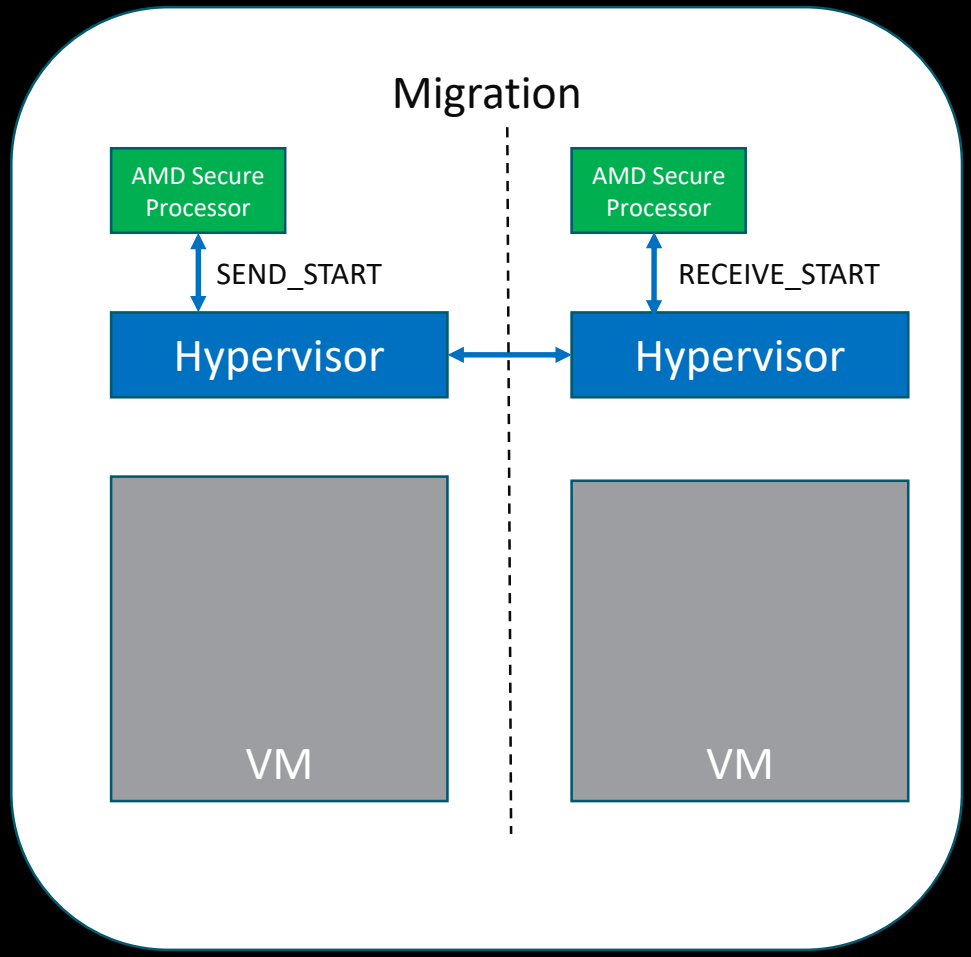
- Protects VMs/Containers from each other, administrator tampering, and untrusted Hypervisor
- One key for Hypervisor and one key per VM or VM/Sandbox with multiple containers
- Cryptographically isolates the hypervisor from the guest VMs
- Integrates with existing AMD-V™ technology
- System can also run unsecure VMs





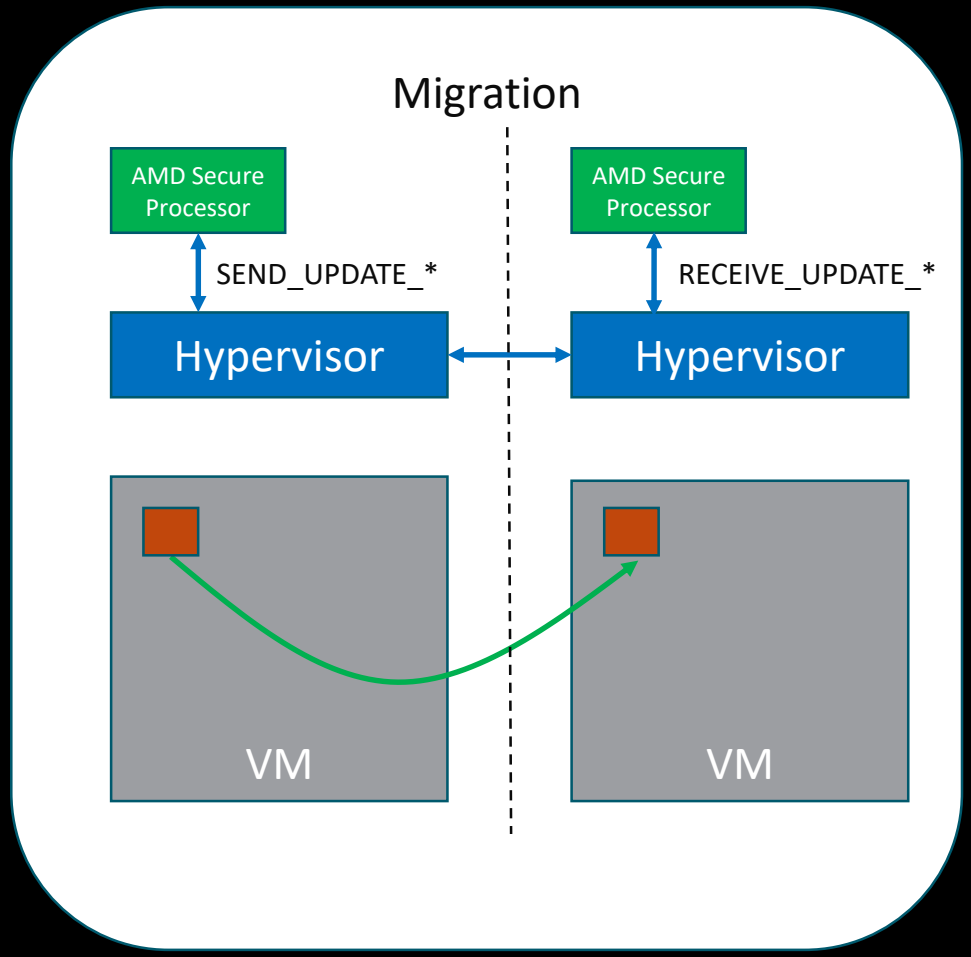
SEV LIVE MIGRATION

- Hypervisor can’t just copy encrypted memory to destination machine
  - VM encryption key is not migrated
    - Different key for source and destination SEV VMs
  - Physical location in memory matters
    - Even if key was identical, location in DRAM matters
- SEV firmware required to securely copy encrypted memory
  - Source and Destination machines negotiate transport keys
  - Encrypted pages are wrapped using transport keys



SEV LIVE MIGRATION…

- Hypervisor maintains a bitmap of guest page encryption state
  - Hypercall from guest notifies of change in encryption state
- Source Hypervisor
  - Uses SEND API for encrypted pages
    - Transforms the page for transport
- Destination Hypervisor
  - Uses RECEIVE API for encrypted pages
    - Transforms the page for use in the guest
- At completion, guest page encryption state is migrated

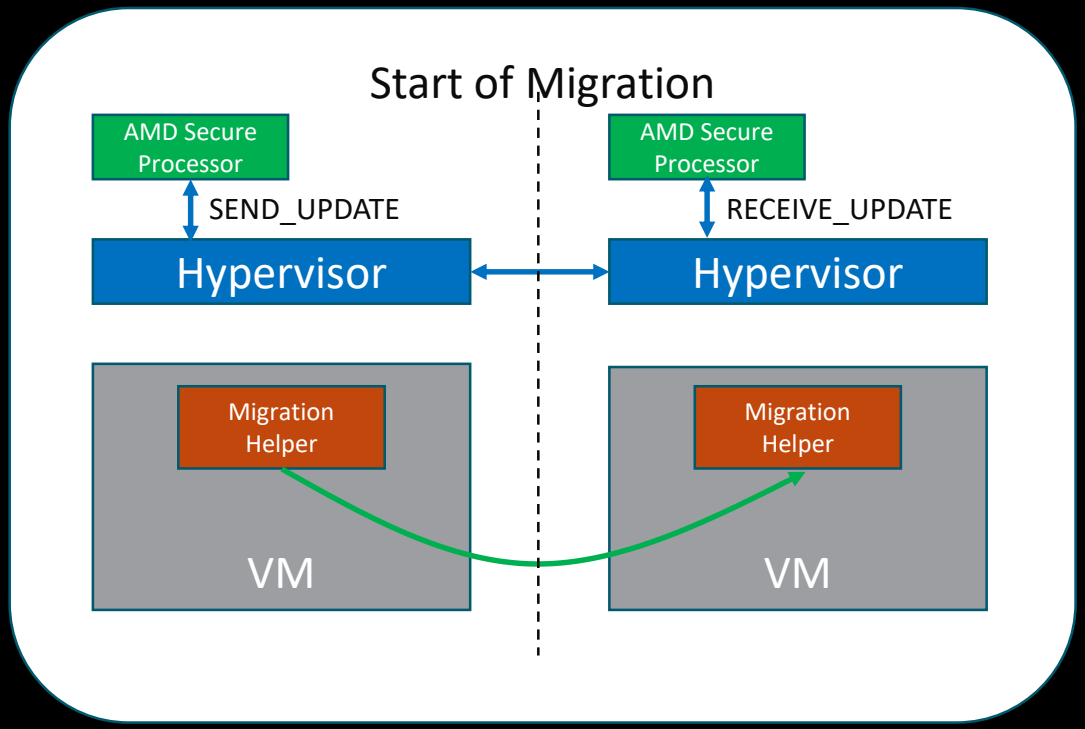


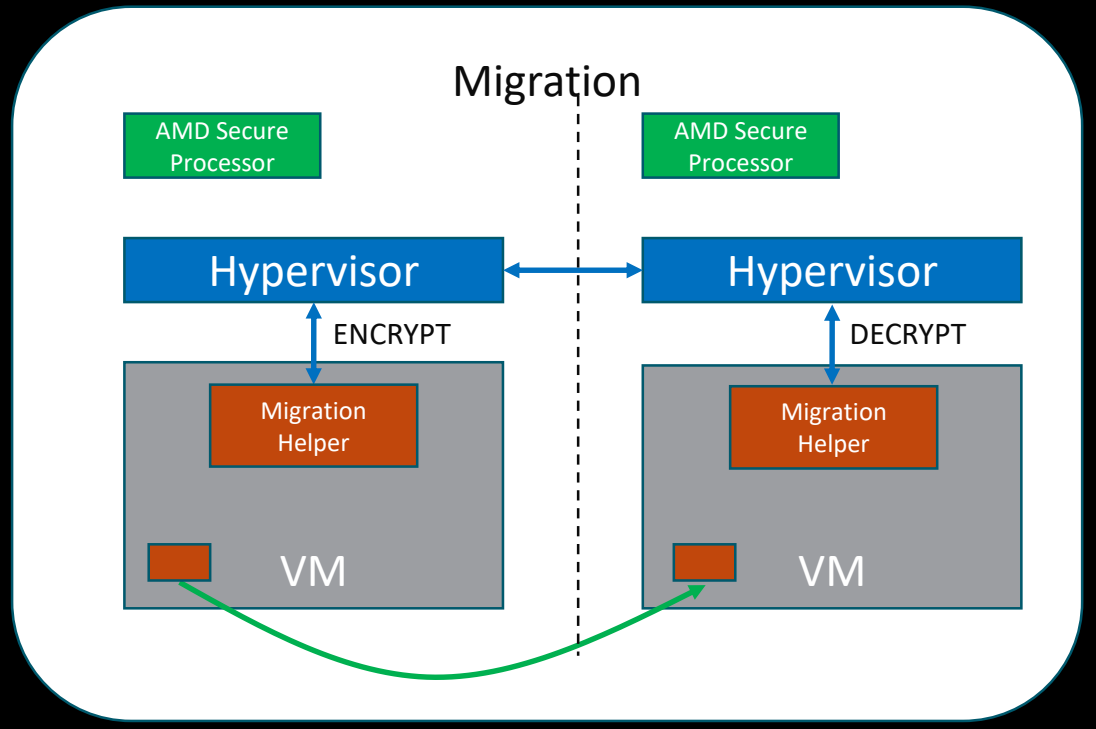
SEV MIGRATION HELPER

- AMD Secure Processor becomes a performance bottleneck
- Migration can be broken down into Authentication and Data Movement
- Authentication
  - Performed by AMD Secure Processor
  - Enforces guest migration policy
- Data Movement - Migration Helper (MH)
  - Proof of Concept
  - Runs on a “hidden” vCPU
    - Not visible to the guest
    - Runs only migration helper code with full access to guest memory
  - Listens for migration commands
    - INIT – Generates the migration key
    - ENCRYPT – Encrypts page for migration
    - DECRYPT – Decrypts page for use by guest

SEV MIGRATION HELPER…

- Source hypervisor uses SEND API to migrate the MH
- Destination hypervisor uses RECEIVE API to receive the MH
- MH migrates the remainder of the guest
  - Uses CPU AES instruction, AMD Secure Processor not involved
  - Migration at multiple Gbps



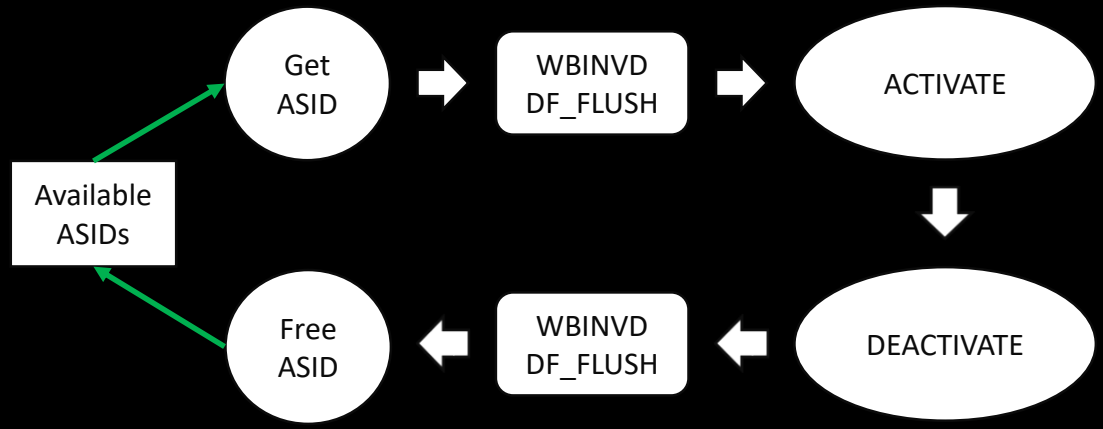


SEV PERFORMANCE

- All guest memory is currently pinned
  - Physical location in memory matters
    - Can’t just “move” a guest encrypted page
  - Higher initial resource requirements
  - Slower guest startup
- Investigating Options:
  - Prevent page movement (migration/swapping) of an SEV guest page
    - Mark page as an SEV guest page
    - Eliminate need to pin all the guest memory before boot
  - SEV firmware required to securely move encrypted memory
    - Need to hook into page migration / compaction / swap path
      - Need to determine if the page is encrypted – build upon Live Migration bitmap
    - Move encrypted page using new COPY API
      - If COPY API is not supported, prevent page from being moved
    - Prevent page from being swapped
      - No API currently in place to swap out a page

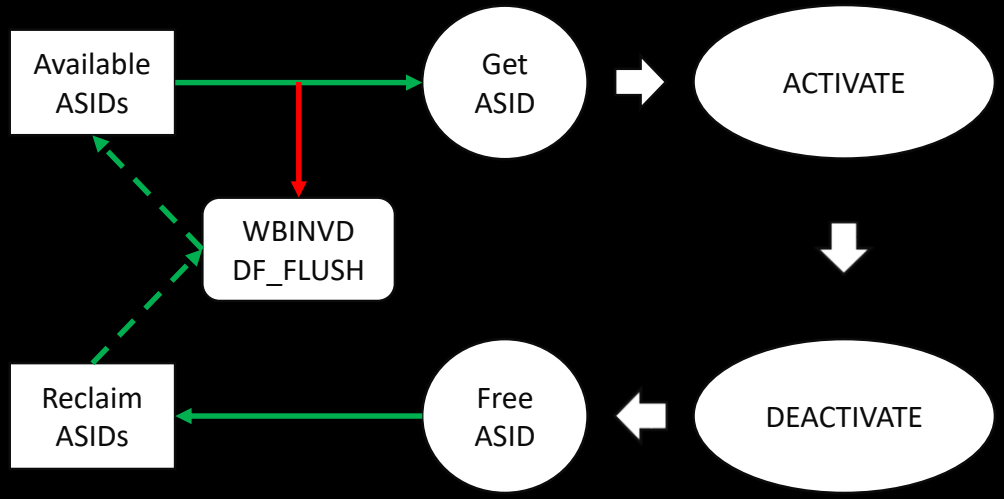
SEV PERFORMANCE…

- SEV ASID Activation
  - 1st generation EPYC supports 15 SEV ASIDS, 2nd generation EPYC supports 509 SEV ASIDS
  - WBINVD / DF_FLUSH command done on every LAUNCH and DEACTIVATE
    - Very expensive operations



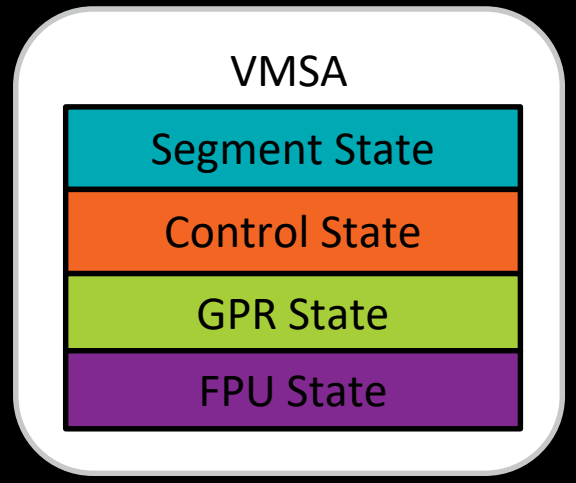
SEV PERFORMANCE…

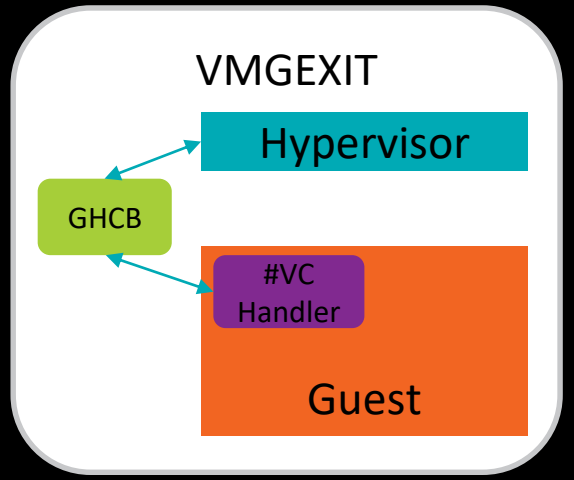
- SEV ASID Reclaim
  - Reduce the number of WBINVD / DF_FLUSH command invocations
  - Track ASIDs on DEACTIVATE as reclaimable
  - Issue WBINVD / DF_FLUSH command when there is no available SEV ASID
    - Reclaims ALL ASIDs



SEV-ES REVIEW

- Guest register state protection
  - Register state is initialized with known state (Initial Processor State)
  - Register state is encrypted and measured as part of the SEV LAUNCH process
  - Integrity check performed on each VMRUN
  - World switches now swap ALL register state
- VMCB under SEV-ES
  - Control Area (VMCB) and Save Area (VMSA) now separated
    - VMCB now points to VMSA
  - VMSA extended to save more state
- Guest-Hypervisor Communication Block (GHCB)
  - Allows guest ←→ hypervisor communication of the state needed to satisfy the guest service request
  - Shared (un-encrypted) page between the hypervisor and the guest
  - GHCB specification (in process)
    - Defines the format of the GHCB and how to communicate with the hypervisor





SEV-ES

- Current Status:
  - Guest-Hypervisor Communication Block protocol (near) final
    - Adding requirements for ensuring proper CPUID and MSR values are set for the guest
  - OVMF patches submitted
    - RFC stage
  - Kernel patches being completed
    - A few areas to address to be able to use a single kernel as hypervisor and guest
  - Qemu patches being completed
    - Uses the memory encryption policy object to indicate SEV-ES
    - More investigation on register accesses
  - GitHub trees:
    - https://github.com/AMDESE

SEV-SNP

- SEV-SNP – Secure Encrypted Virtualization - Secure Nested Paging
  - Next step in the evolution of SEV
  - SEV/SEV-ES provides Confidentiality
    - SEV – Encryption of VM memory
    - SEV-ES – Adds Encryption of VM registers
  - SEV-SNP builds on SEV-ES and adds Integrity Protection
    - Prevents replay attacks, corruption attacks, remapping attacks

- Linux Security Summit presentation on Friday @ 2:20PM
  - Upcoming x86 Technologies for Malicious Hypervisor Protection - David Kaplan, AMD
- White Paper
  - “AMD SEV-SNP: Strengthening VM Isolation with Integrity Protection and More”

REFERENCES

- Links to the following reference material can be found at https://developer.amd.com/sev
  - White Papers & Specifications
    - Protecting VM Register State with SEV-ES Whitepaper
    - Guest Hypervisor Communication Block Specification
    - AMD64 Architecture Programmer's Manual Volume 2: System Programming
      - Sections 7.10, 15.34 and 15.35
- Code / Patches
  - https://github.com/AMDESE

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