Zero Architecture

Huawei's Next-Generation Virtualization 3.0 Integrates Hardware and Software

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Gaps Between Current Virtualization and Cloud Service Requirements

- **Performance**: 3%–15% virtualization overhead, 15% computing loss
- **Cost**: 10%–20% CPU reserved, 10%–20% memory reserved
- **Security**: VM escape, Data leak
- **Stability**: Neighbor noise, Unstable performance
Evolution of Virtualization Technology

Virtualization 1.0
Till 2003

- Software Virtualization
  - Stanford: Binary Translation
  - Cambridge: Para Virtualization
  - Complicated and insecure

Virtualization 2.0
2004–2017

- Intel & AMD: Hardware-assisted
  - CPU: VT-x with high overhead
  - Memory: EPT enables memory isolation with low overhead
  - I/O: VT-d with ecosystem and scalability issues

Virtualization 3.0
2018 to now

- Cloud Vendors: Customized Hypervisors & Chips
  - CPU: ultra-simplified customization with no virtualization overhead
  - Memory: adopts mature isolation mechanisms
  - I/O: Hardware offloading and acceleration with high and scalable I/O performance

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**Zero Components**

**Zero** = Zero Hypervisor + Zero Virtualization Controller + Zero I/O

**Near-Bare Metal Computing**
- Split-hypervisor: ~0 resource reserved
- Ultra-simplified customization: ~0 computing loss
- Performance close to BMS: ~0 jitter
- Enterprise-class virtualization: ~0 overhead

**High Scalability and Security**
- Virtualization SOC Chip
- Online configuration of Virtio, SR-IOV, and NVMe
- Unified management of VMs and BMSs
- Supporting pass-through live migration
- Supporting x86 and ARM
- Supporting Huawei security chip and providing enterprise-class Roots of Trust
- Hardware isolation and mini-TCB, providing enterprise-class trusted baseline

**High-Performance I/O**
- Huawei Network chip, I/O offload and acceleration
- High performance network: 18 Mpps @full stack + 45 Gbit/s
- High performance storage: 1 M IOPS + 100 μs
Zero Supports BMSs, VMs, and Containers

- Supports BMSs, VMs, and containers
- Performance and stability close to BMSs
- EVS: 1M iops, 100 μs
- VPC: 18M pps, 45 Gbit/s
- Online upgrade
Zero Computing System

Single control card
- Provides management API
- Coordinates all other cards and host

Multi I/O cards
- Optional and configurable
- Support native VPC interface
- Support native EBS interface

Host
- No local disk, no network
- Tiny Linux, least TCB
- ECS mode, BMS mode, Container mode, fast switch
- All CPU/MEM sold
Zero I/O System

Software define chip function

- PCIe : Virtio-blk/Virtio-scsi/Virtio-net/NVMe/…
- Fast switch among above modes
- Un-modified guest OS

Bare Metal-like performance

- PCIe pass-through
- Descriptor prefetch
- Batch processing requests
- Reduce DMA frequency
Zero O&M: Pass-Through Live Migration

Pass-through migration framework:
- Virtio-blk/Virtio-scsi/Virtio-net/NVMe/…
- Native guest OS, no modification
- Dirty page tracking
- Device state save and restore

Best performance:
- Concurrent log sync/ save/ restore
- Pause and resume asynchronously
- Downtime: 50ms
Thank you.

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Bring digital to every person, home and organization for a fully connected, intelligent world.

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