Improving the Security of Commodity Hypervisors for Cloud Computing

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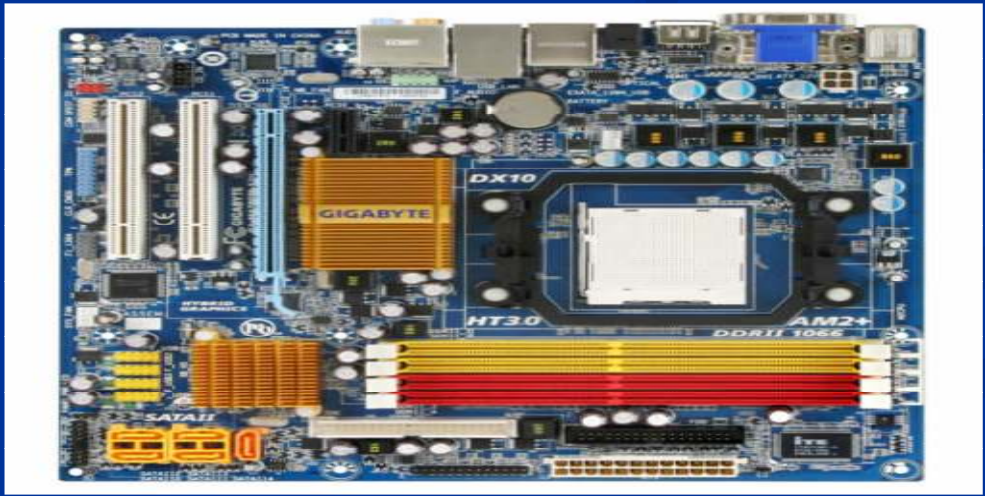
Today's cloud computing hypervisors have very large trusted computing bases!

Hyper-V Architecture

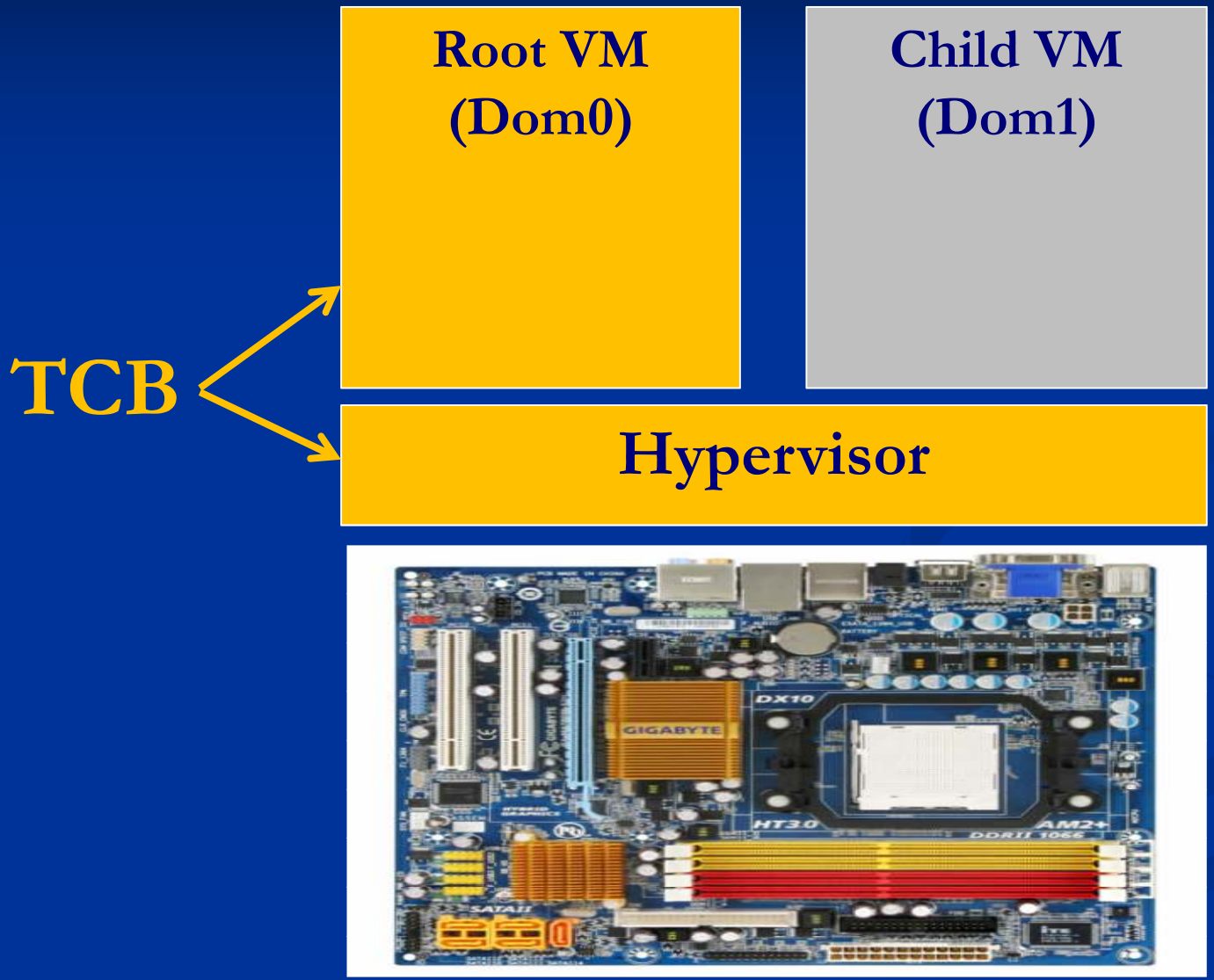
Root VM (Dom0)

Child VM (Dom1)

Hypervisor



Hyper-V Architecture



How Large is the TCB?

Hypervisor	Lines of Code
Xen	250 KLOC
Hyper-V	100+ KLOC

OS	Lines of Code
Linux 2.6.32	11.2 MLOC
Windows Server 2008	50 MLOC

TCB of commodity hypervisors consists of tens of millions of lines of code!

Two Classes of Attacks

1. Attacks from guest VMs
   - Cases of malicious customer software already documented:
     - On Amazon EC2, customer sent spam & launch DoS
2. Physical attacks
   - Many already have access to "locked" datacenters
   - Providers are starting to outsource to 3rd-parties
     - Code offload servers deployed in coffee shops, mall areas

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Outline

- Motivation
- Requirements and design alternatives
- Design of Bunker-V
- Conclusions

Req#1: Hypervisors Must Accommodate Legacy OSes

Year	OS Supported by Amazon EC2
2007	RedHat
2008	Solaris, Oracle Linux, Win Server 2003
2009	Win Server 2008
Future	Fedora, openSUSE, Gentoo, Ubuntu, Debian

Future cloud computing goal: hosting home desktops

Req#2: High Performance

- Performance remains critical for cloud computing hypervisors:
  - Higher degree of multiplexing → $$$
- The need for high performance is making the cloud push its computation closer to the edge
  - Cloudlets for code offload

Summary of Requirements

- Cloud hypervisors must:
  1. Be secure
  2. Accommodate legacy OSes
  3. Have high performance

- Next, we look at hypervisor alternatives

Alt#1: "Tiny" Hypervisors

- Recent project built a hypervisor in 7889 LoC!
  - Can run legacy OS!
  - Remove full-fledged OS from root VM
- Drawback: must compromise on functionality
  - Can't run more than one VM at a time

Refs: SecVisor[SOSP'07], TrustVisor[Oakland'10]

Alt#2: Disaggregated Hypervisors

- Improves security:
  - Any exploit remains isolated in one compartment
- However, it does not reduce the size of TCB
  - We suspect TCB is even larger to include interface code among compartments

Refs: NOVA[Eurosys'10], S. Hand's group[OASIS'04, VEE'08]

Our Approach: Bunker-V

- Bunker-V: reduce TCB's attack surface by minimizing the interface between the TCB and guest VMs
- Even if vulnerability exists inside TCB, system remains secure as long as attacker cannot exploit it
- Re-think the design of a hypervisor for cloud scenario: eliminate unnecessary virtual devices

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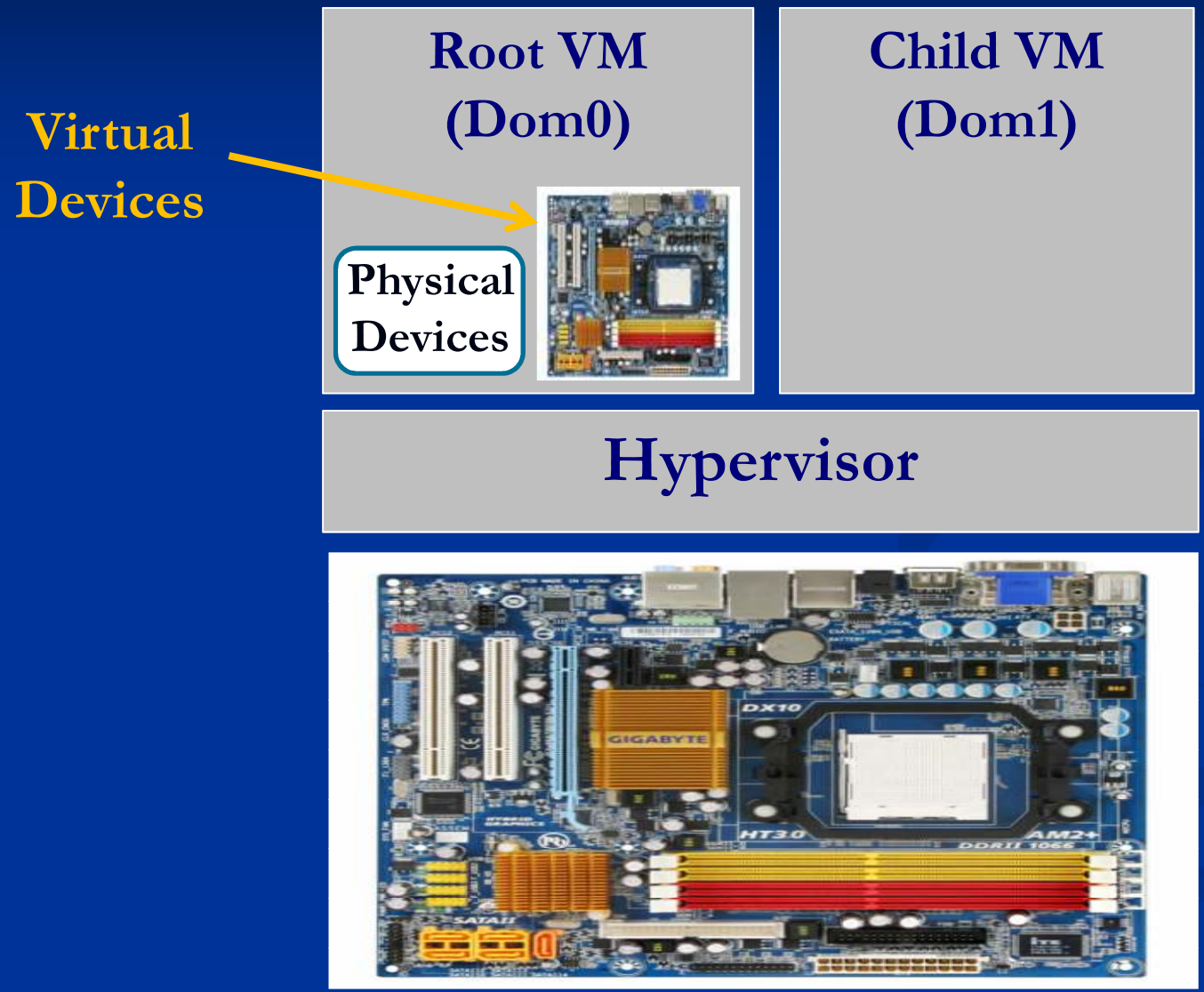
Virtual Devices: Interface btw. Root & Child VMs



Categories of Virtual Devices (vdev)

- Extraneous vdevs: not needed in the cloud
  - e.g., floppy, keyboard, mouse, monitor, serial port
- Legacy vdevs: not needed in the cloud, but OS cannot boot without them
  - e.g., keyboard controller, PIT, ISA bus
- Required vdevs: needed to run in the cloud
  - e.g., storage, NIC, PIC, PCI bus

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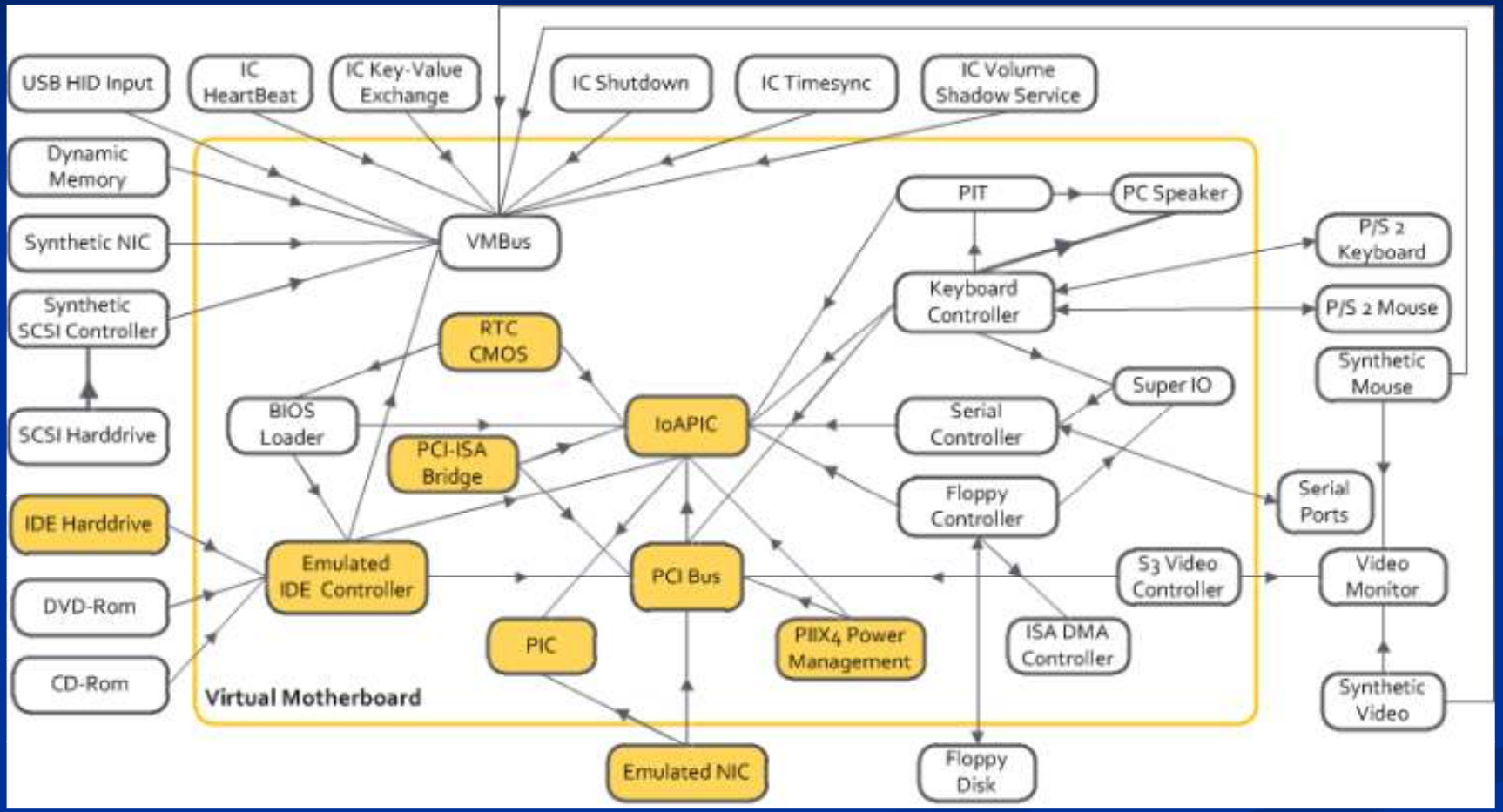
Bunker-V's Interface



Challenge: Handle Guest OS Booting

- Approach: delusional boot
- Boot OS on a separate node:
  - Separate node has legacy vdevs enabled
  - Separate node is isolated from datacenter

Conclusions

- Bunker-V improves security of hypervisors for cloud computing:
  - 79% reduction of TCB's interfaces
  - Can run legacy OSes with high performance
- Delusional Boot: new technique for booting legacy OSes in the absence of many devices

Questions?

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