Virtualization in the Cloud: Featuring Xen and XCP

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A Brief History of Xen in the Cloud

Late 90s

XenoServer Project

A Brief History of Xen in the Cloud

Late 90s   **'03**

**XenoServer
Project**

Xen 1.0

A Brief History of Xen in the Cloud

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Amazon EC2
and Slicehost
launched

Rackspace
Cloud

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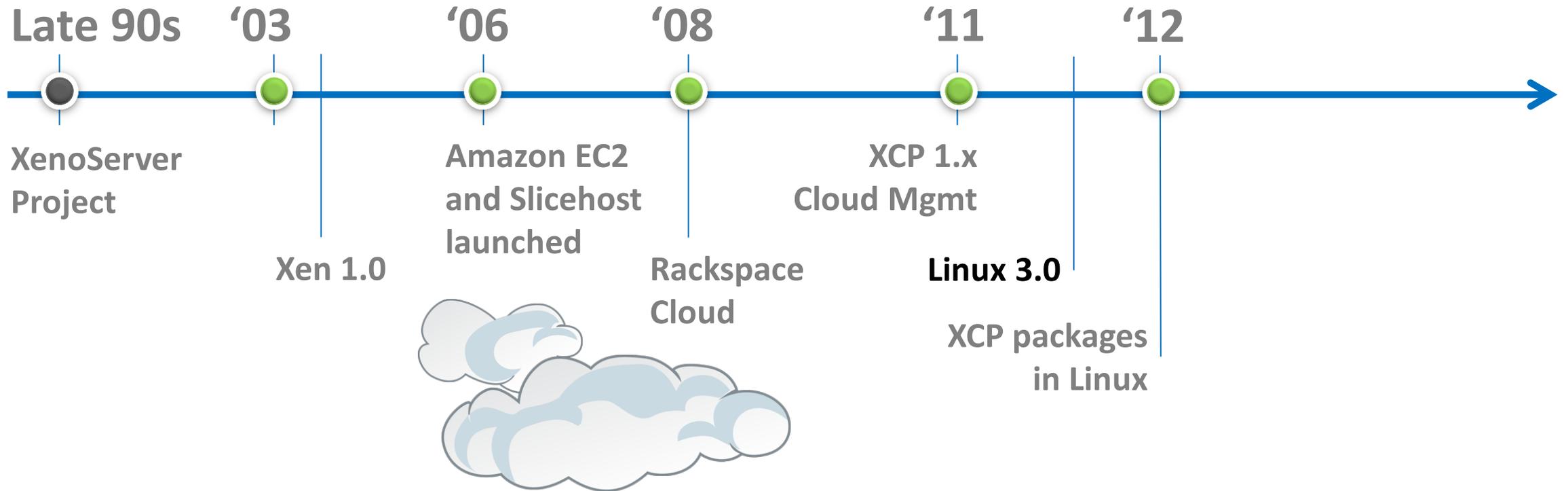
Late 90s   **'03**   **'06**   **'08**   **'11**   **'12**

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XCP 1.x
Cloud Mgmt

XCP packages
in Linux

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Xen

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Rackspace Cloud

XCP 1.x Cloud Mgmt

Linux 3.0

XCP packages in Linux

Xen for ARM servers

10th birthday

Xen.org

- Guardian of Xen Hypervisor and related OSS Projects

- Xen Governance similar to Linux Kernel
  - Plus project lifecycle and Project Management Committee (PMC)

- Projects
  - Xen Hypervisor
    (led by 5 committers, 2 from Citrix, 1 from Suse, 2 Independent)
  - Xen Cloud Platform aka XCP (led by Citrix)
  - Xen ARM : Xen for mobile devices (led by Samsung)

Xen contributor community is diversifying
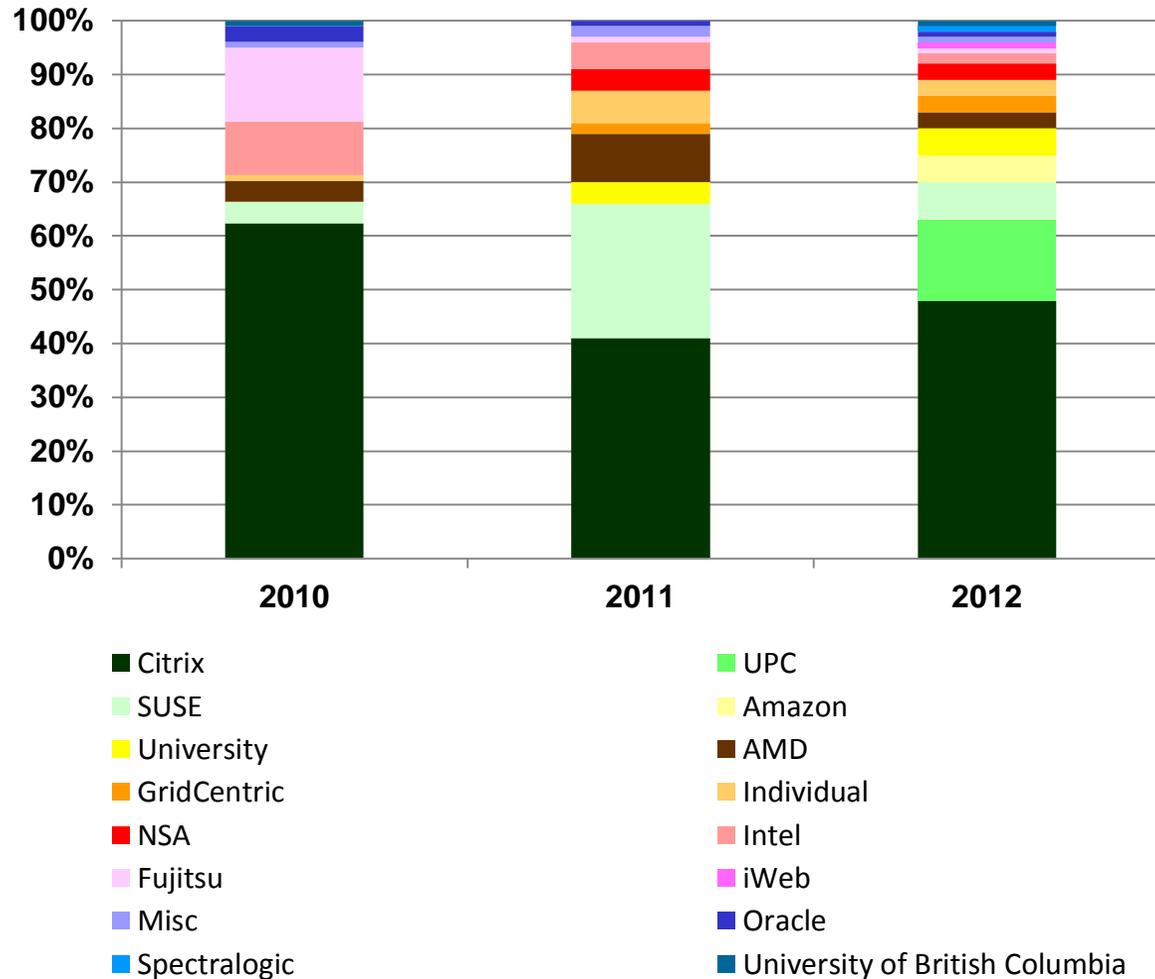
- The number of "significant" active vendors is increasing

- New feature development driving new participation

Legend:
- Citrix
- SUSE
- University
- GridCentric
- NSA
- Fujitsu
- Misc
- Spectralogic
- UPC
- Amazon
- AMD
- Individual
- Intel
- iWeb
- Oracle
- University of British Columbia

Xen Overview

Hypervisor Architectures

Type 1: Bare metal Hypervisor

A pure Hypervisor that runs directly on the hardware and hosts Guest OS's.

VM_n

VM_1

VM_0

Guest OS and Apps

Hypervisor

Device Drivers/Models

Scheduler

MMU

Host HW

I/O

Memory

CPUs

Provides partition isolation + reliability, higher security

Hypervisor Architectures

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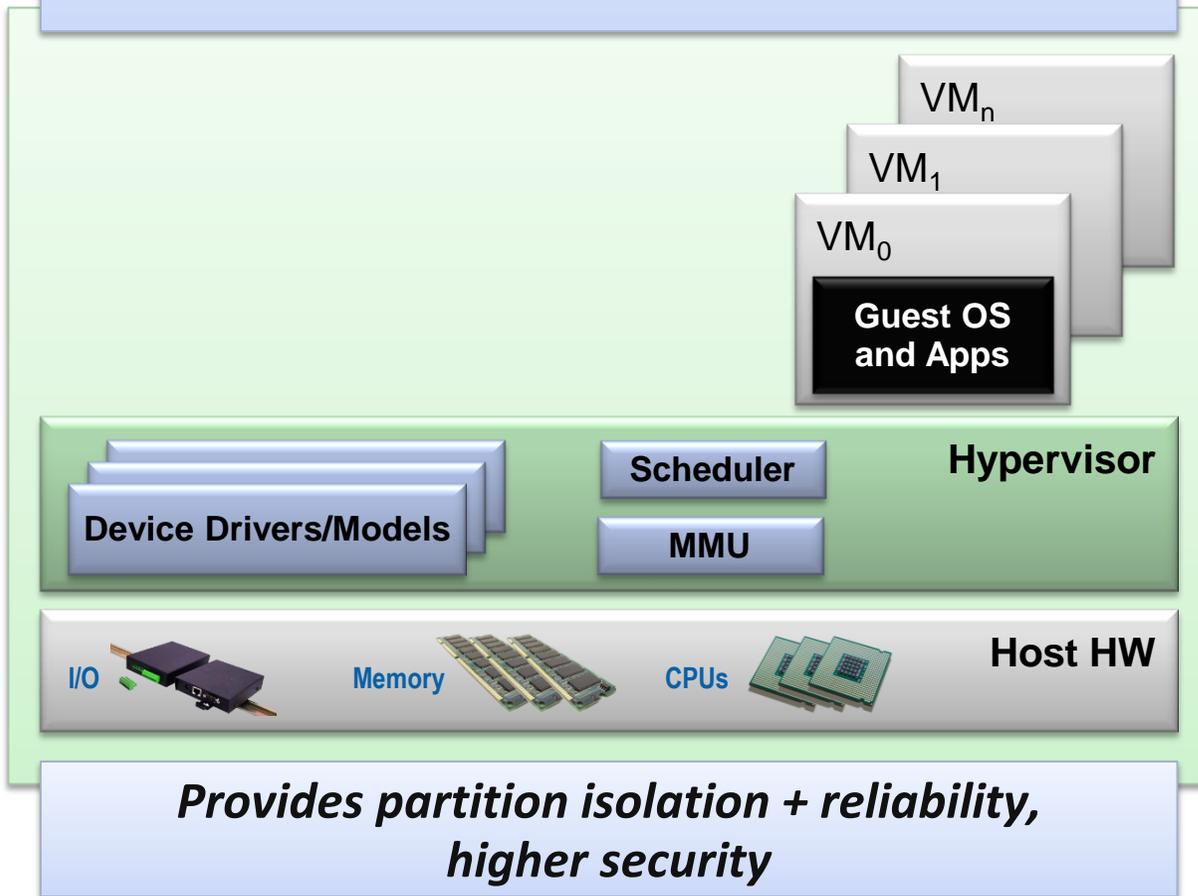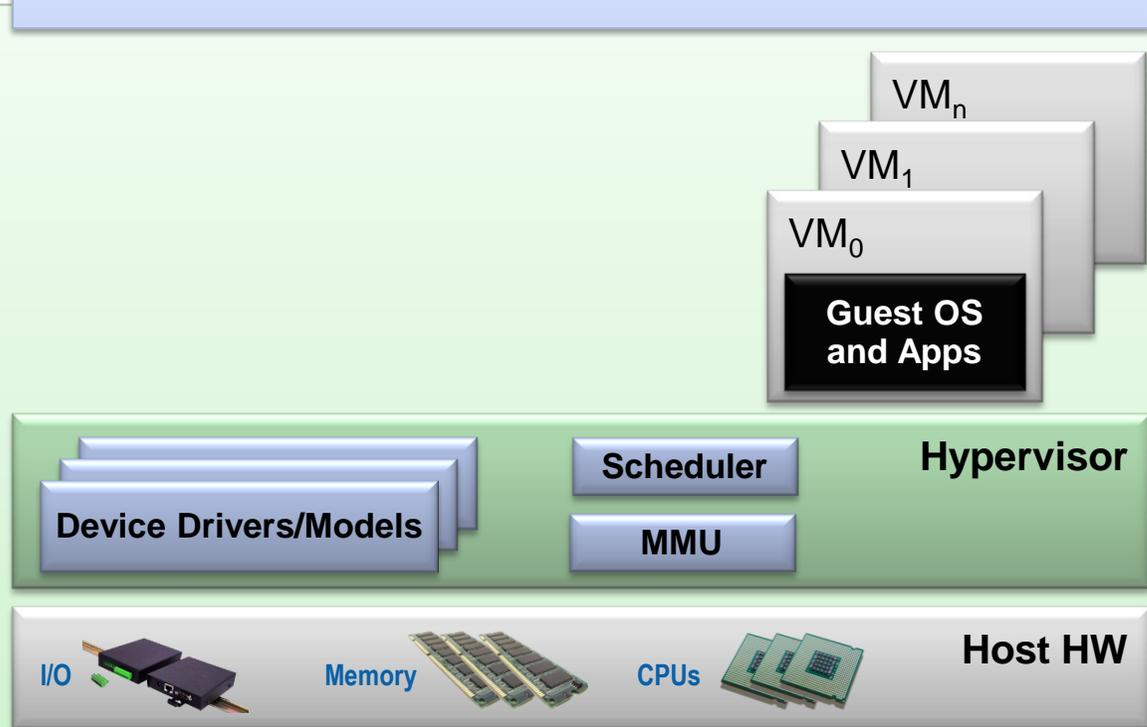
Provides partition isolation + reliability, higher security

Type 2: OS 'Hosted'

A Hypervisor that runs within a Host OS and hosts Guest OS's inside of it, using the host OS services to provide the virtual environment.

User-level VMM

User Apps

Device Models

VM_n

VM_1

VM_0

Guest OS and Apps

Host OS

Device Drivers

Ring-0 VM Monitor "Kernel "

Host HW

I/O   Memory   CPUs
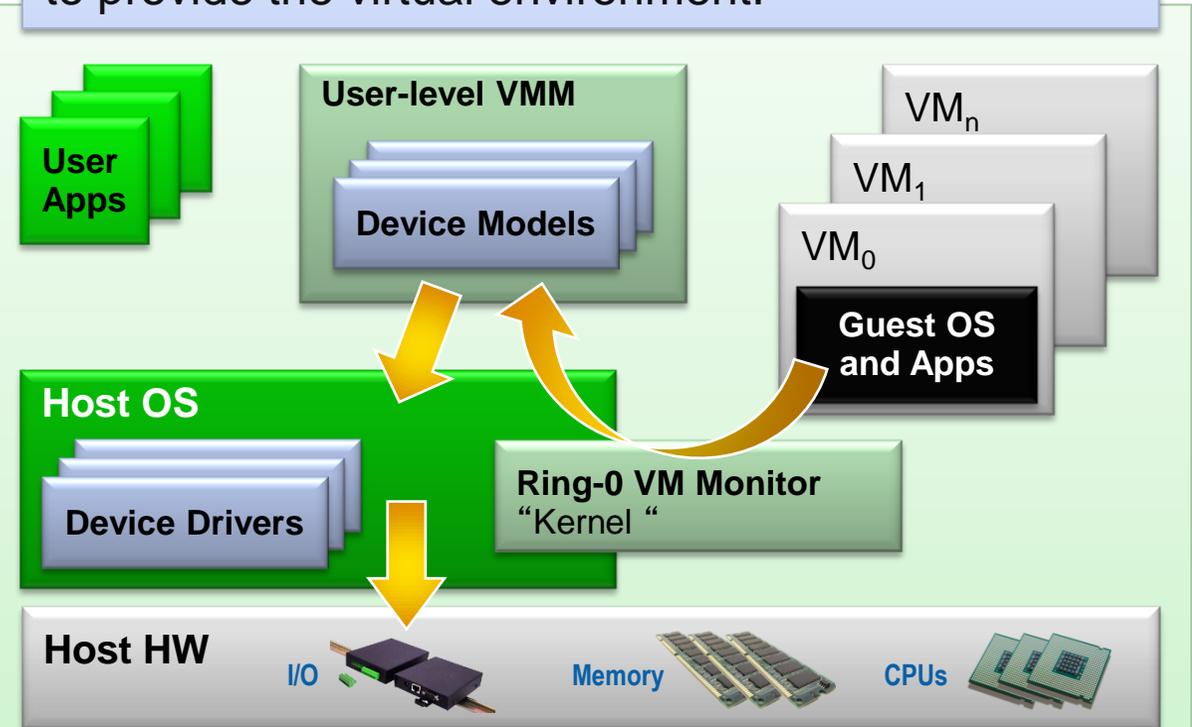
*Low cost, no additional drivers
Ease of use & installation*

Xen: Type 1 with a Twist
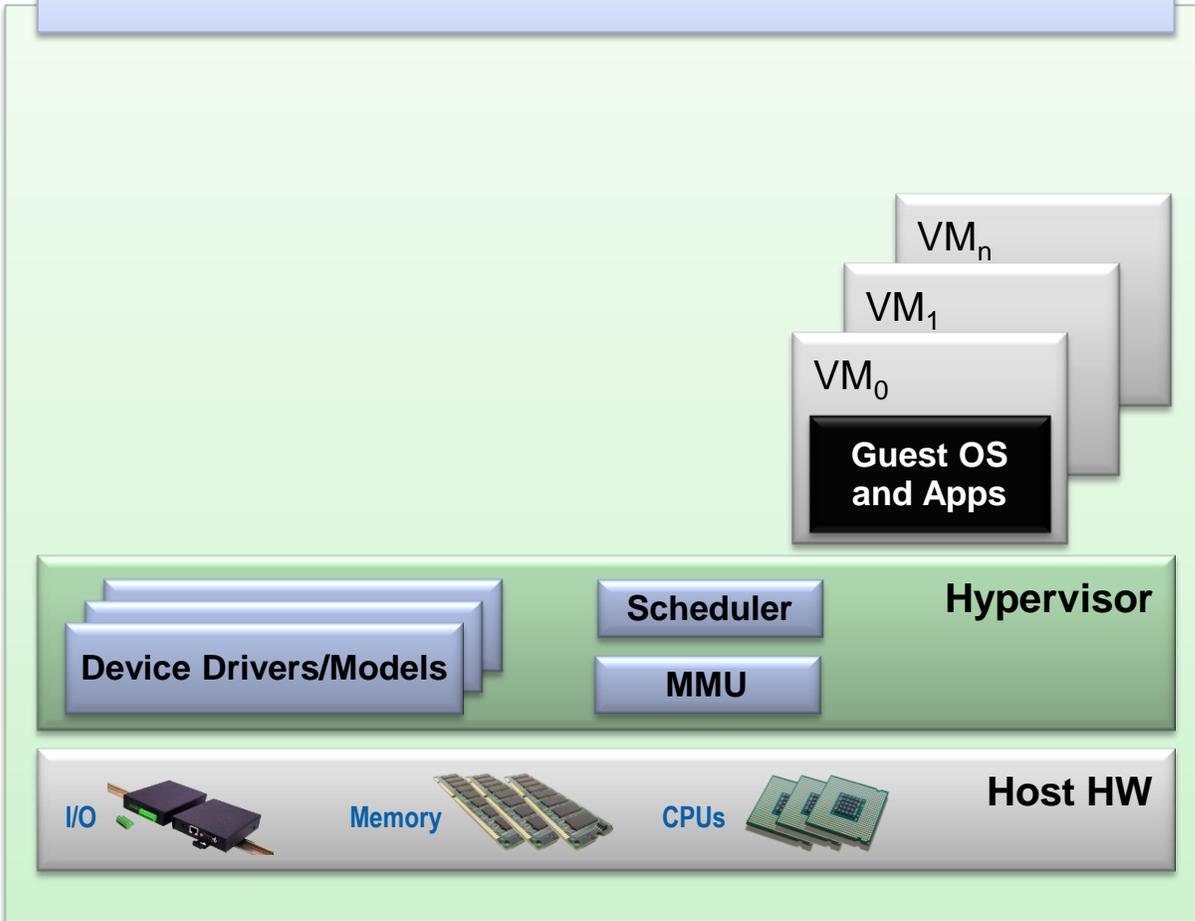
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**Device Drivers/Models**

MMU

Host HW

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VM$_n$

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Hypervisor

I/O Memory CPUs **Host HW**

Xen Architecture

VM$_n$

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Guest OS and Apps

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VM_n

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Guest OS and Apps

Device Drivers/Models

Scheduler

Hypervisor

MMU

I/O   Memory   CPUs   **Host HW**

Xen Architecture

Control domain (dom0)

Device Models

Drivers

Linux & BSD

VM_n

VM_1

VM_0

Guest OS and Apps

Scheduler   **MMU**   **Hypervisor**

I/O   Memory   CPUs   **Host HW**
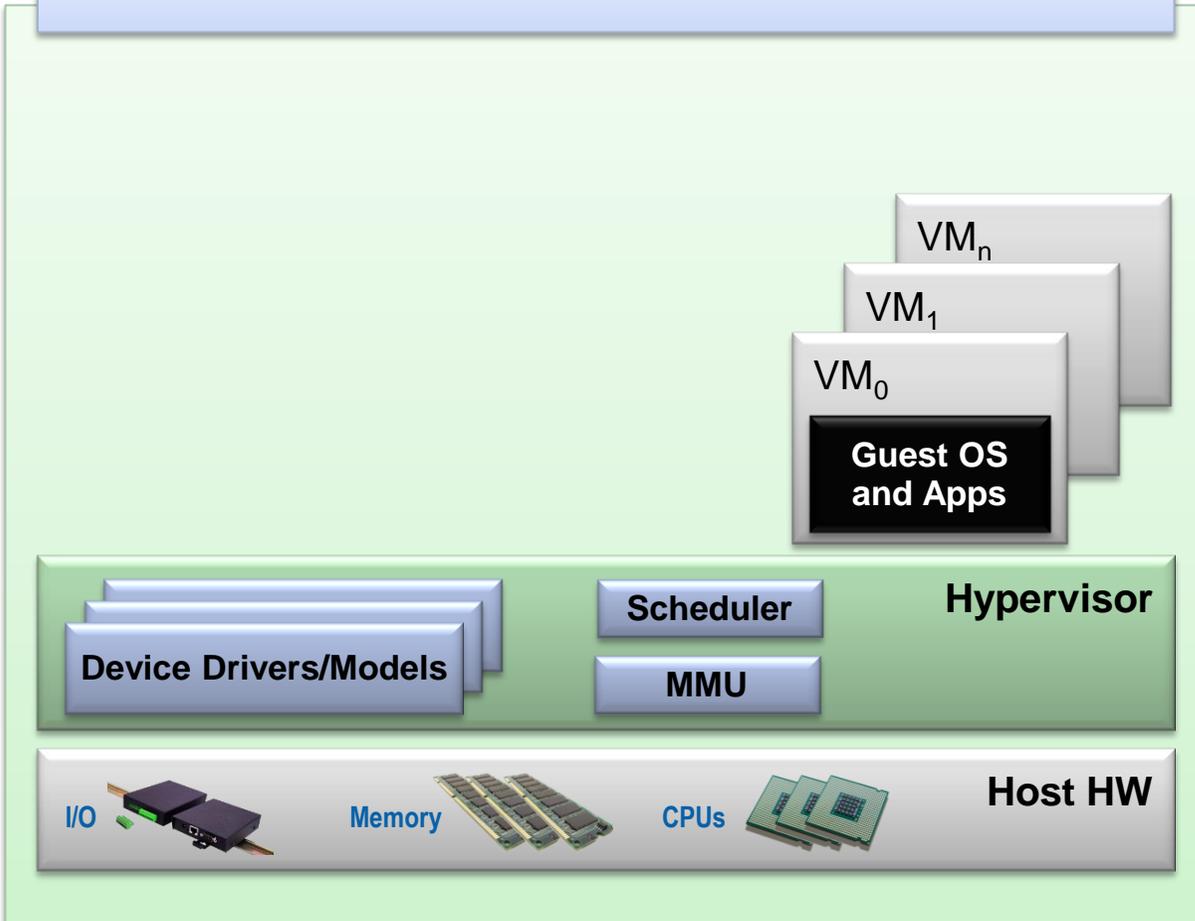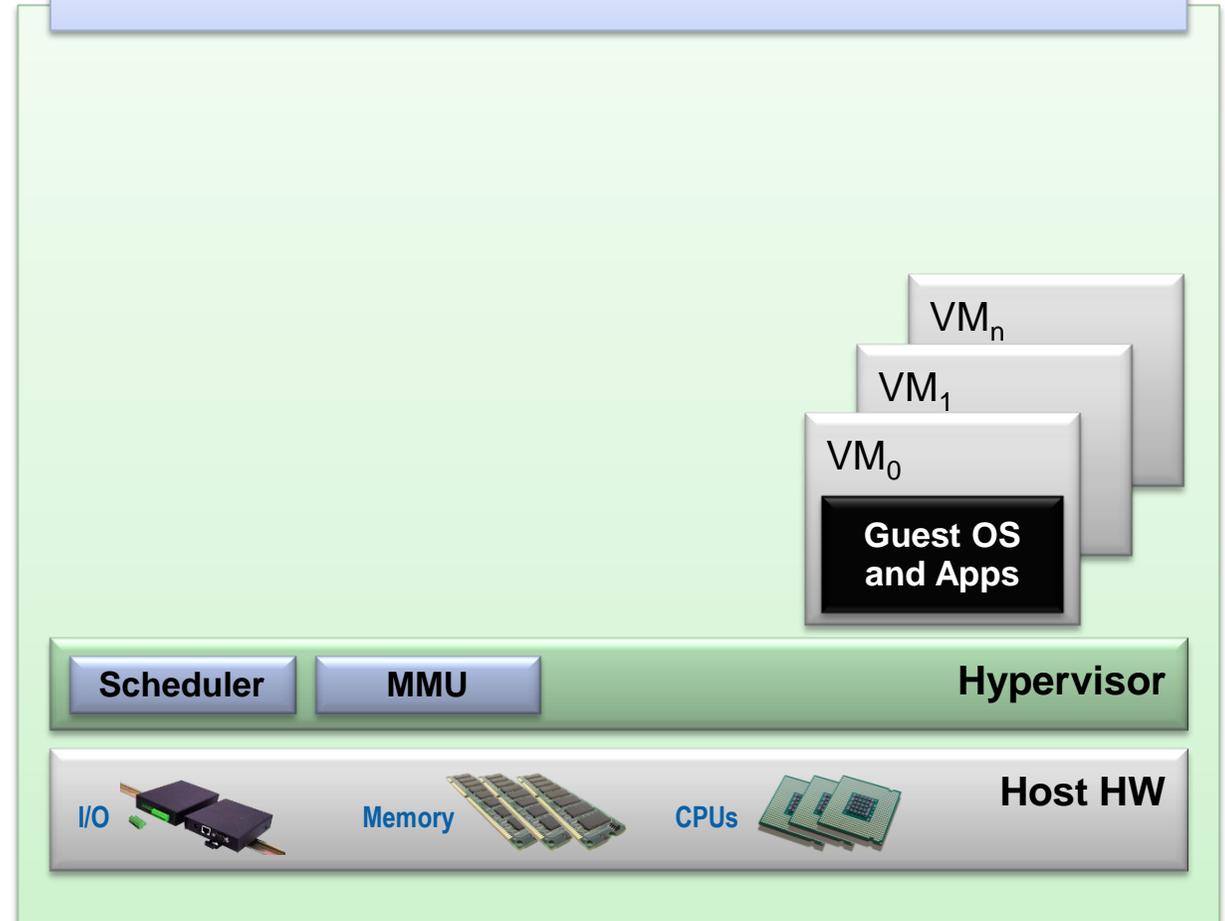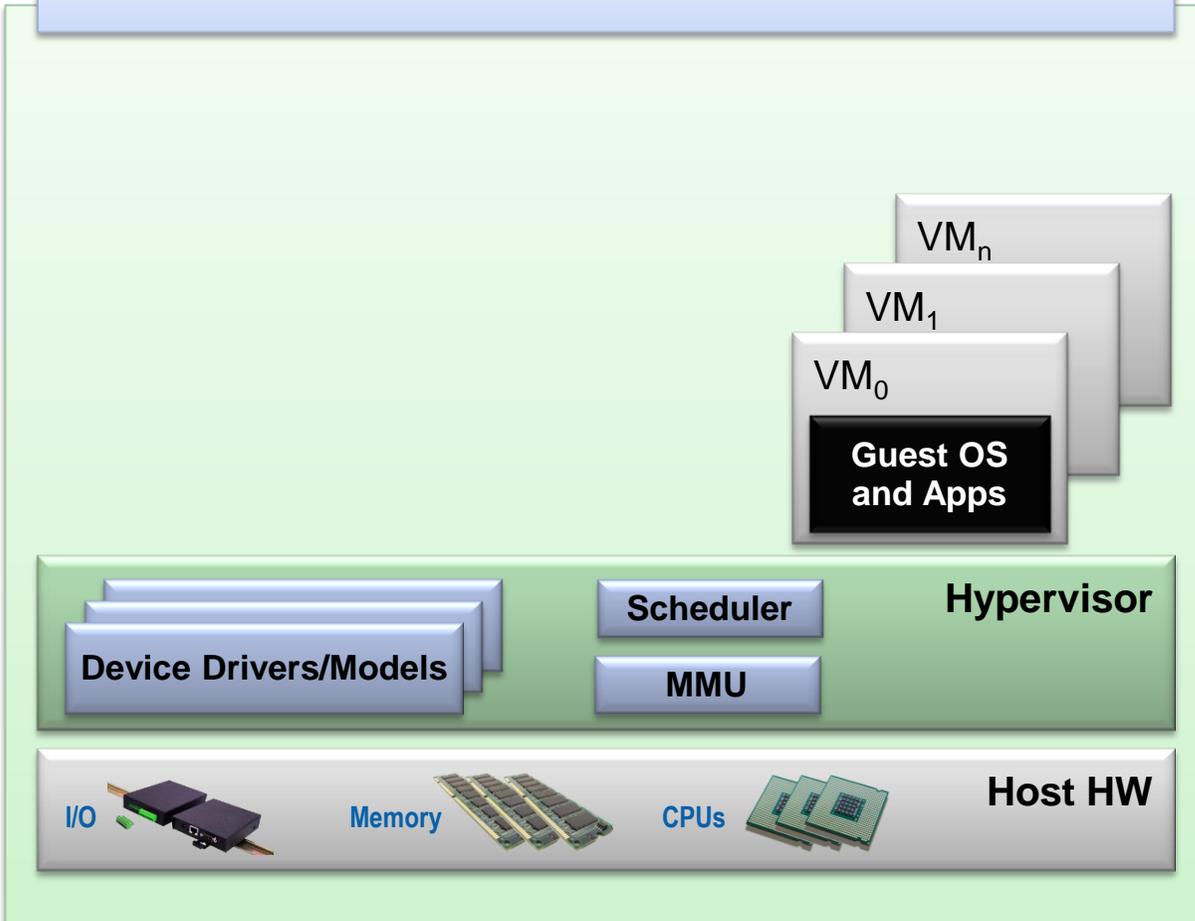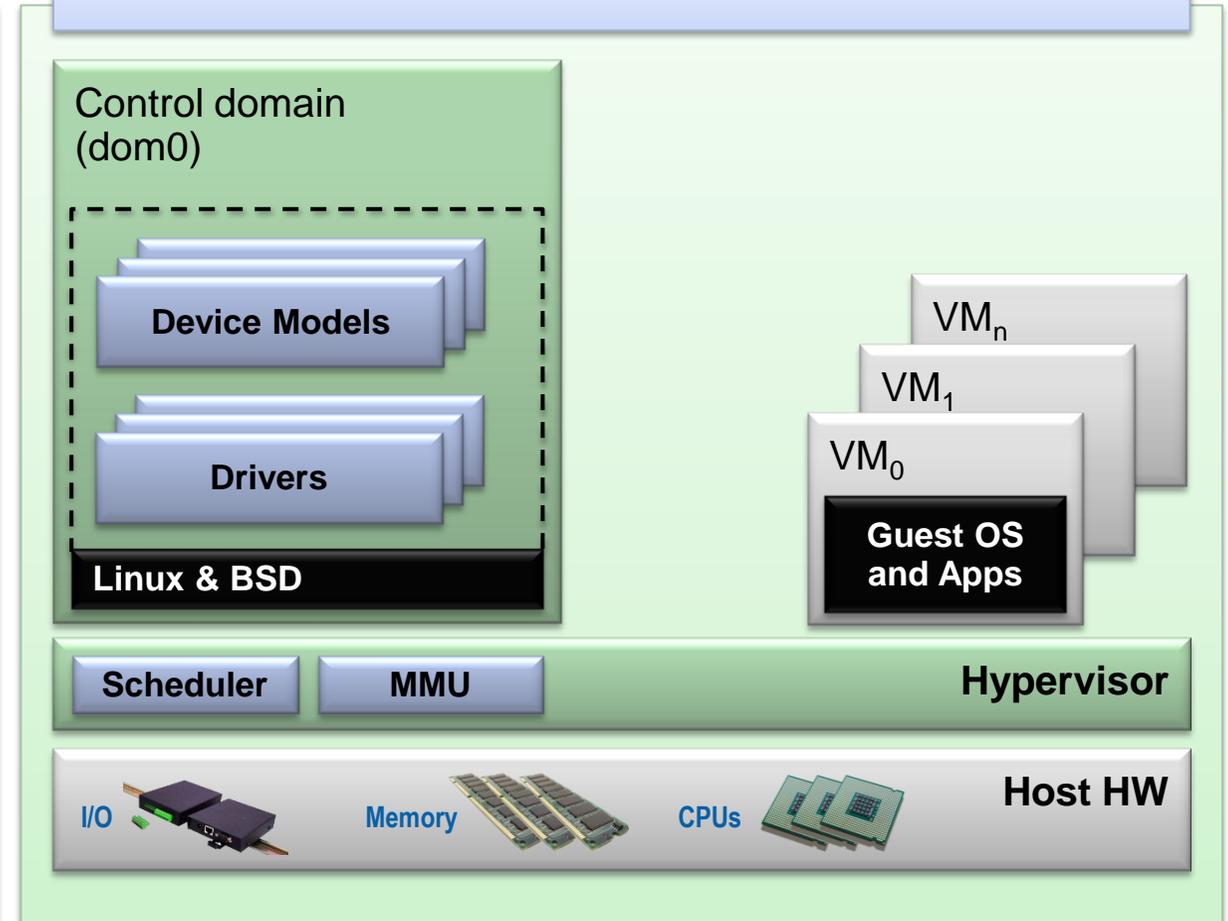
Xen and Linux

- Xen Hypervisor is **<u>not</u>** in the Linux kernel

- **<u>BUT</u>**: everything Xen and Xen Guests need to run is!

- Xen packages are in all Linux distros (except RHEL6)
  - Install Dom0 Linux distro
  - Install Xen package(s) or meta package
  - Reboot
  - Config stuff: set up disks, peripherals, etc.

More info: wiki.xen.org/wiki/Category:Host_Install

Basic Xen Concepts
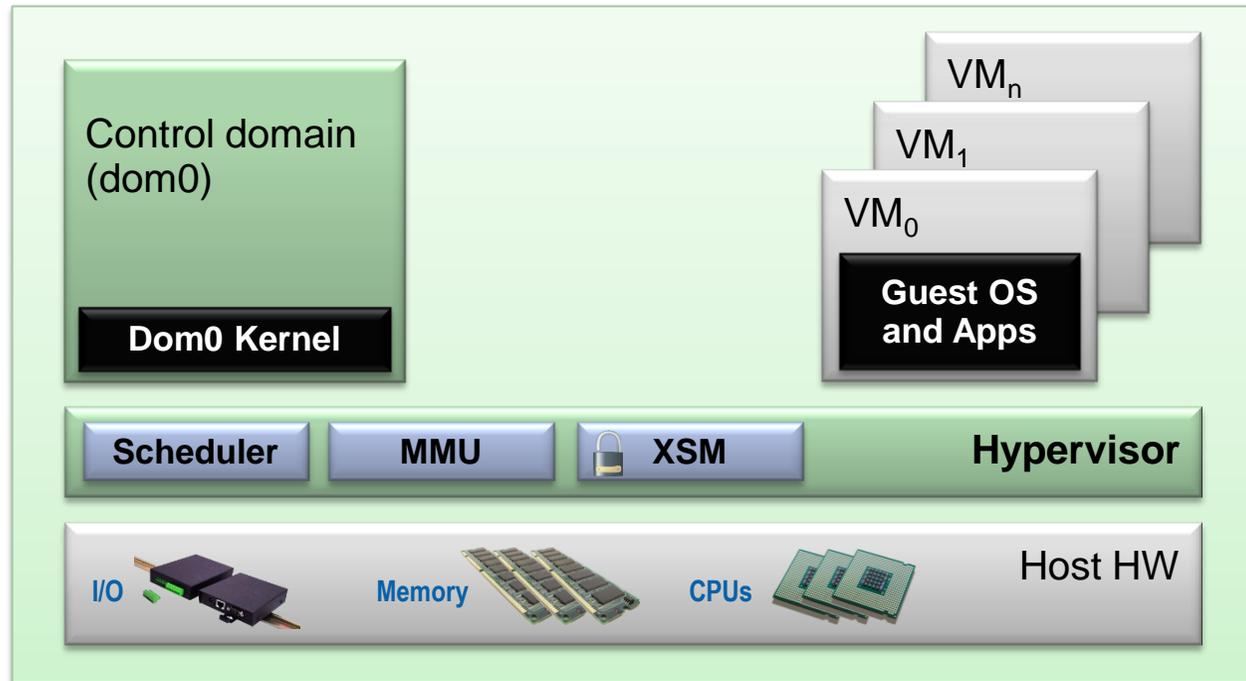
Control Domain aka Dom0
- Dom0 kernel with drivers

Guest Domains
- Your apps

Basic Xen Concepts

Console

Console
- Interface to the outside world

Control Domain aka Dom0
- Dom0 kernel with drivers
- Xen Management Toolstack

Guest Domains
- Your apps

Diagram labels:

Control domain (dom0)
- Toolstack
- Dom0 Kernel

VM_n
VM_1
VM_0
- Guest OS and Apps

Scheduler | MMU | XSM | **Hypervisor**

I/O | Memory | CPUs | Host HW

Trusted Computing Base

Basic Xen Concepts

Console

Control domain (dom0)

Toolstack

Dom0 Kernel

One **or more** driver, stub or service domains

VM$_n$

VM$_1$

VM$_0$

Guest OS and Apps

Scheduler | **MMU** | **XSM** | **Hypervisor**

I/O | Memory | CPUs | Host HW

Trusted Computing Base

Console
- Interface to the outside world

Control Domain aka Dom0
- Dom0 kernel with drivers
- Xen Management Toolstack

Guest Domains
- Your apps

Driver/Stub/Service Domain(s)
- A "driver, device model or control service in a box"
- De-privileged and isolated
- Lifetime: start, stop, kill

Xen Variants for Server & Cloud

Hypervisor

Xen

Xen Variants for Server & Cloud

| Hypervisor	Xen		
Toolstack / Console	**Default / XL (XM)**	**Libvirt / VIRSH**	**XAPI / XE**

Increased level of functionality and integration with other components ➤

Single Host
Basic Functions

Single Host
Additional Functionality

Multiple Hosts
Additional Functionality

Xen Variants for Server & Cloud

Hypervisor	Xen		XCP
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Get Binaries from ...	**Linux Distros**	**Linux Distros**	**Debian & Ubuntu**
			ISO from Xen.org

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Products	Oracle VM	Huawei UVP	Citrix XenServer

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Used by ...			
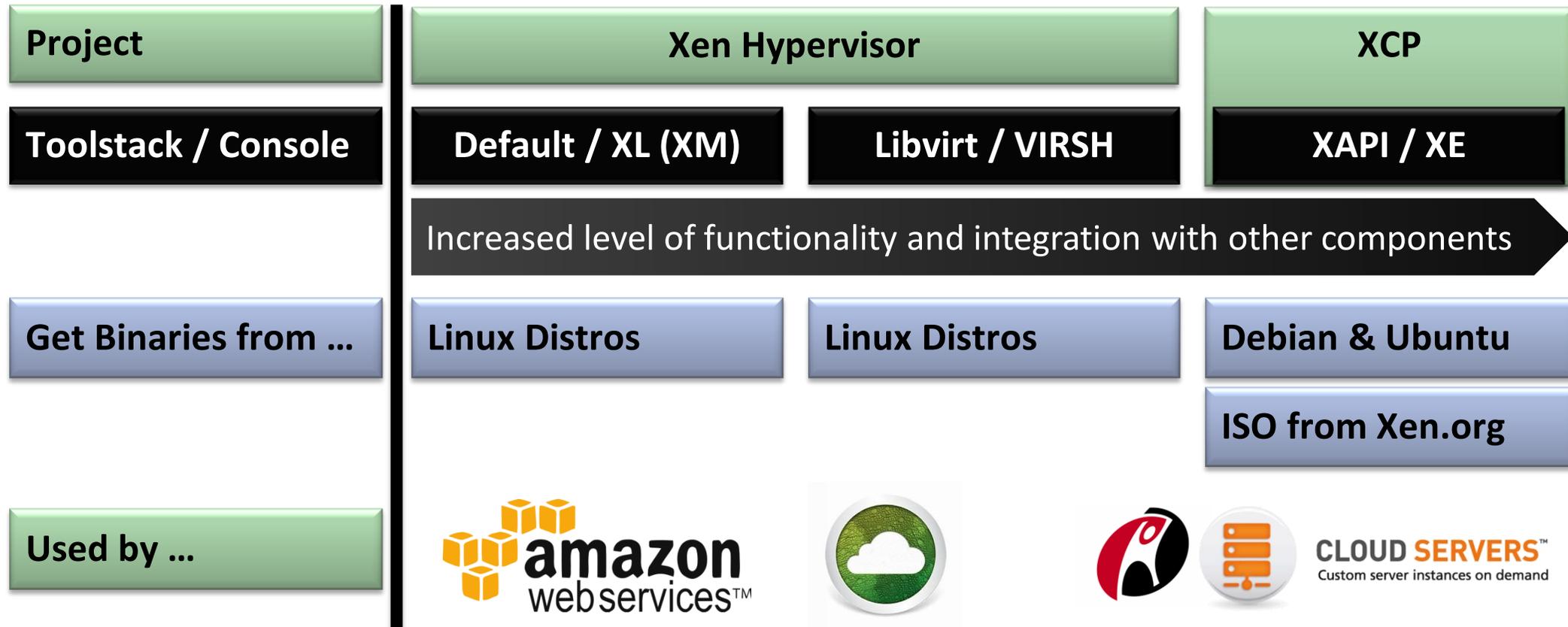
More info: xen.org/community/ecosystem.html
xen.org/community/presentations.html
xen.org/products/case_studies.html

Xen : Types of Virtualization

PV Domains
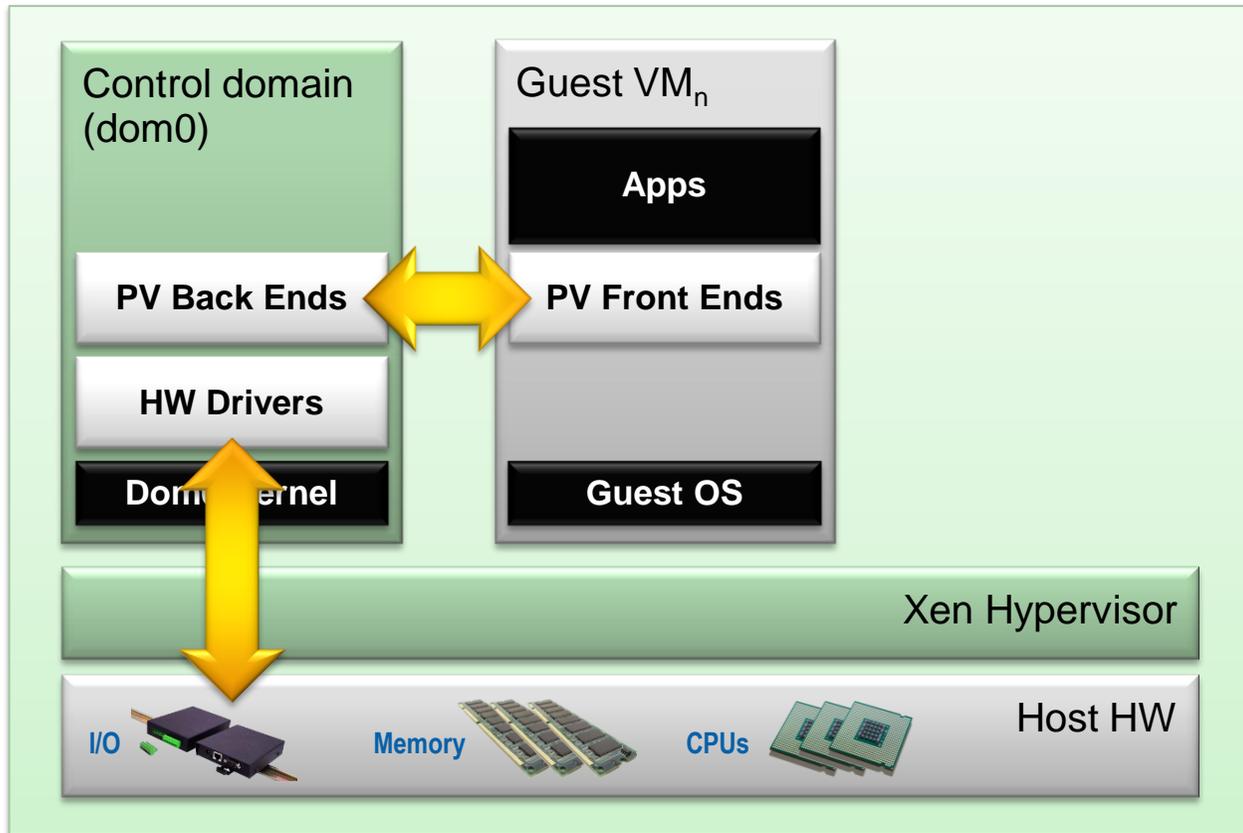
Control domain (dom0)

PV Back Ends

HW Drivers

Dom0 kernel

Guest VM$_n$

Apps

PV Front Ends

Guest OS

Xen Hypervisor

I/O   Memory   CPUs   Host HW

<u>Technology:</u>
- Paravirtualization

<u>Linux PV guests have limitations:</u>
- limited set of virtual hardware

<u>Advantages</u>
- Fast
- Works on any system
(even without virt extensions)

PV Domains & Driver Domains

Control domain (dom0)

- PV Back Ends
- HW Drivers
- Dom0 Kernel

Guest VM_n

- Apps
- PV Front Ends
- Guest OS

Driver Domain e.g.
- Disk
- Network

- PV Back End
- HW Driver
- DomU Kernel*

Xen Hypervisor

Host HW

I/O   Memory   CPUs
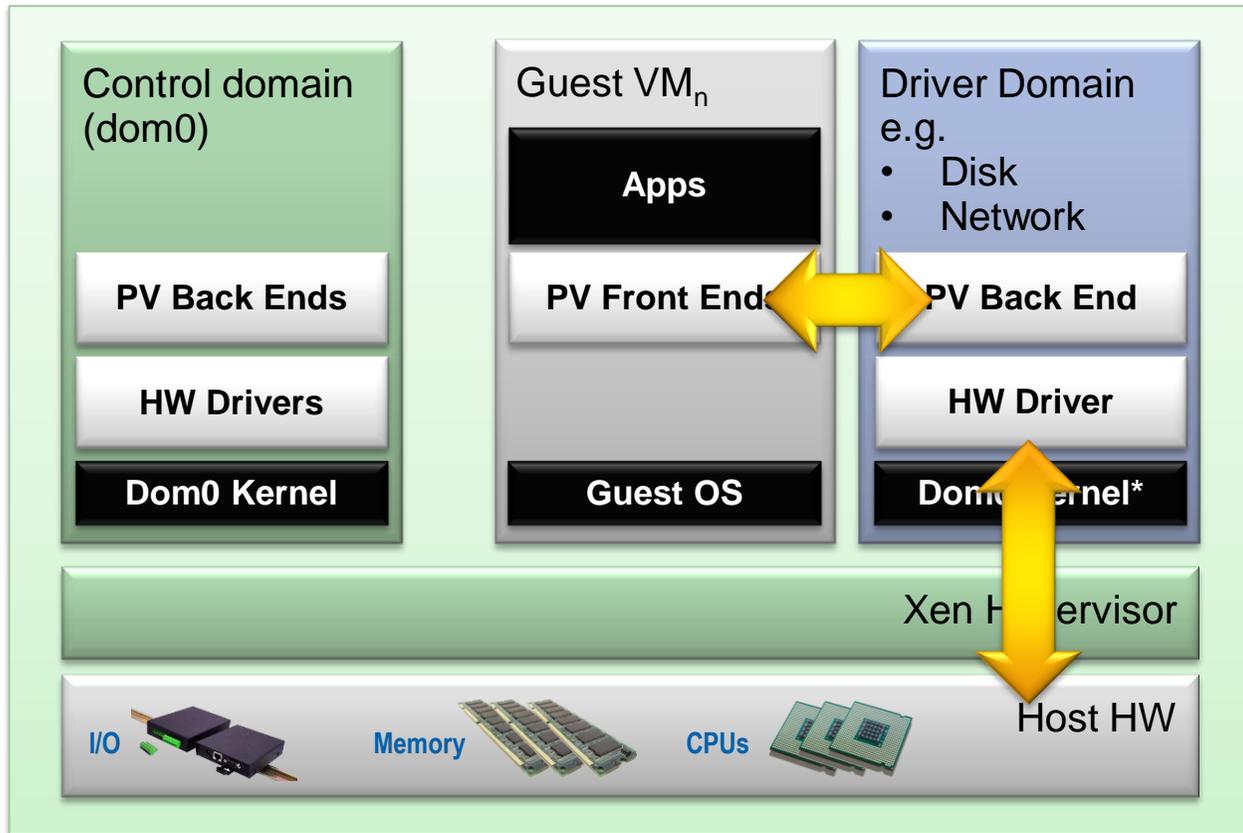
*) Can be MiniOS

Technology:
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Driver Domains
- Security
- Isolation
- Reliability and Robustness

HVM & Stub Domains
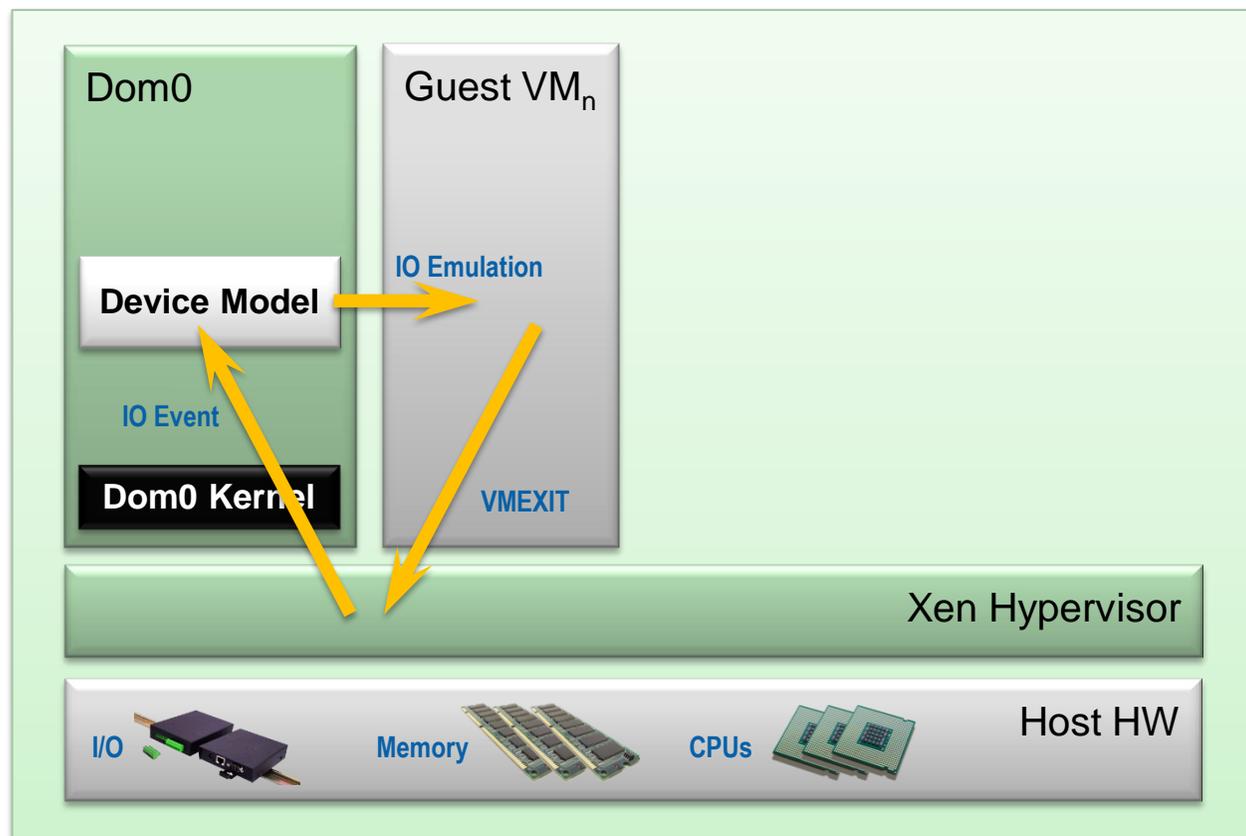
Technology:
- Shows emulation using QEMU/Device Model
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- In other situation HW can be used

Disadvantages
- Emulation slower than PV
(mainly I/O devices)

Advantages
- No kernel support needed

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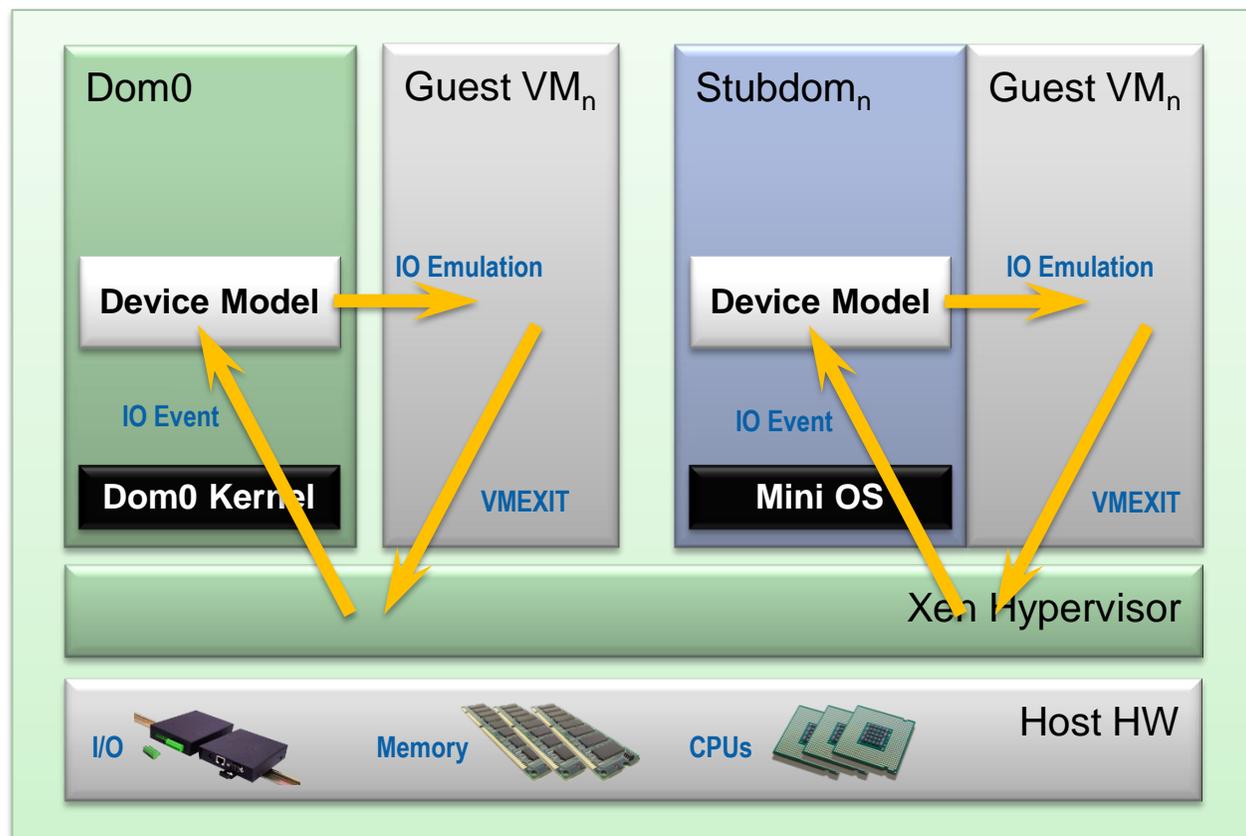
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Stub Domains
- Security
- Isolation
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The Virtualization Spectrum

		Disk and Network	Interrupts, Timers	Emulated Motherboard, Legacy boot	Privileged Instructions and page tables	
Fully Virtualized (FV)		VS	VS	VS	VH	⎫
FV with PV for disk & network		P	VS	VS	VH	⎬ HVM mode/domain
PVHVM		P	P	VS	VH	⎭
PVH	🔵 NEW Xen 4.3	P	P	P	VH	⎫ PV mode/domain
Fully Paravirtualized (PV)		P	P	P	P	⎭

Legend:

VS	Virtualized (SW)
VH	Virtualized (HW)
P	Paravirtualized

The Virtualization Spectrum

	Optimal performance
	Scope for improvement
	Poor performance

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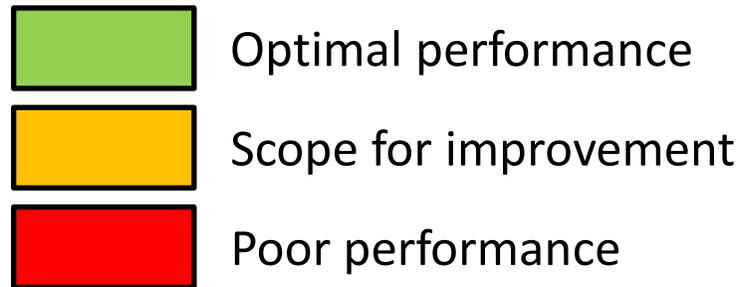
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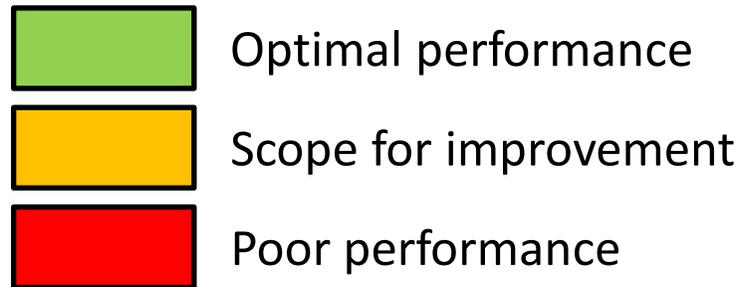
Important: Xen automatically picks the best option based on HW & OS capabilities and available drivers.

As a Xen user I chose a HVM or PV domain.

	Disk and Netw...	Interrupts, Ti...	Emulated Mo... Legacy boot	Privileged In... and page ta...	
Fully Virtualized (FV)	VS	VS	VS	VH	⎱ HVM mode/domain
FV with PV for disk & network	P	VS	VS	VH	
PVHVM	P	P	VS	VH	
PVH 🔵NEW Xen 4.3	P	P	P	VH	⎱ PV mode/domain
Fully Paravirtualized (PV)	P	P	P	P	

XCP Project

XCP – Xen Cloud Platform
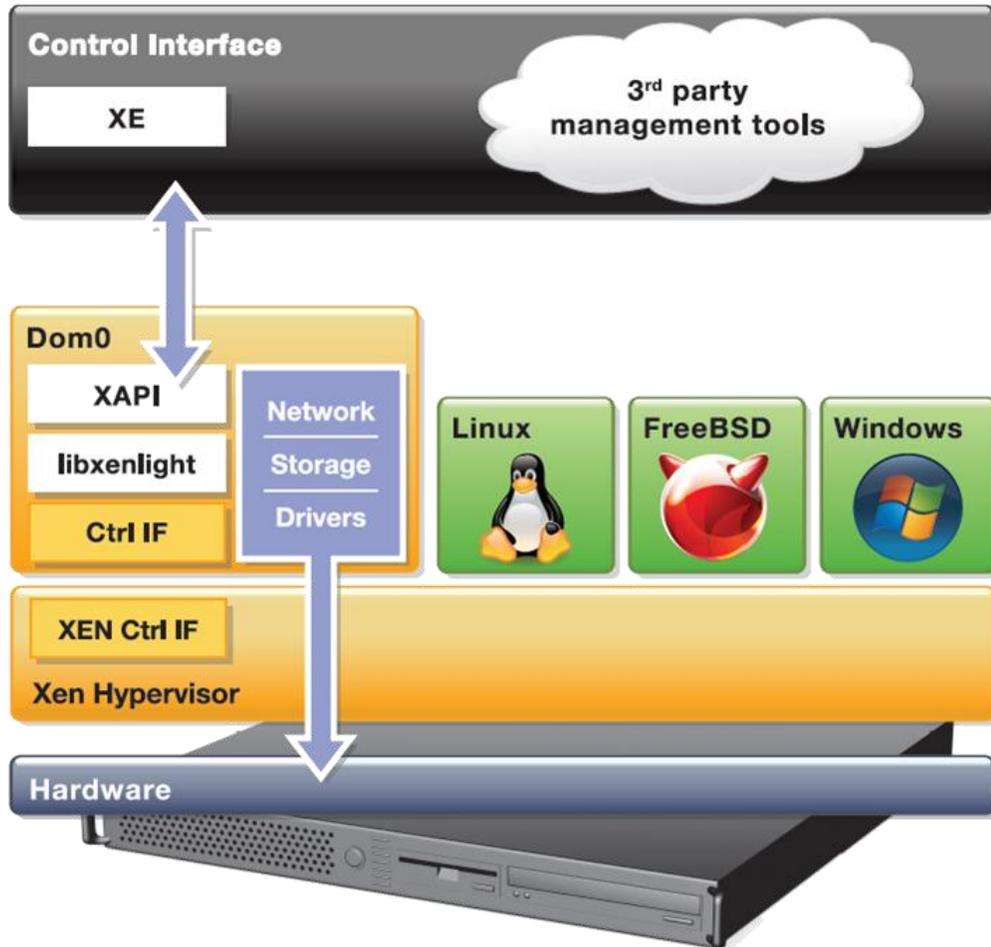
Complete stack for server virtualization

- Extends Xen to cover multiple hosts
- Adds further functionality and integrations for cloud, storage and networking to Xen HV
- GPLv2
- XenServer is a commercial XCP distro

Two Flavours

- Appliance (ISO using CentOS Dom0)
- Packages in Debian & Ubuntu (more distros to come)

Major XCP Features

- VM lifecycle: live snapshots, checkpoint, migration

- Resource pools: flexible storage and networking

- Event tracking: progress, notification

- Upgrade and patching capabilities

- Real-time performance monitoring and alerting

- Built-in support and templates for Windows and Linux guests

- Open vSwitch support built-in (default)
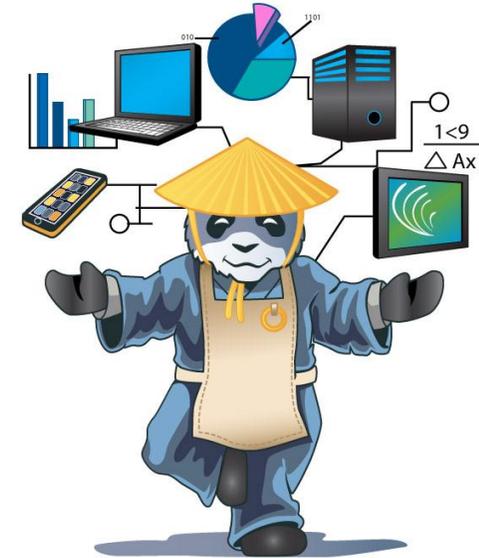
More info: wiki.xen.org/wiki/XCP_Release_Features

XCP 1.6

- **New format Windows drivers:**
  installable by Windows Update Service

- **Networking:** Better VLAN scalability, LACP bonding, IPv6

- **Storage XenMotion:**
  - Migrate VMs between hosts or pools without shared storage
  - Move a VM's disks between storage repositories while the VM is running

- **Other: more templates, latest Xen, OVS, etc.**

More info: xen.org/download/xcp/releasenotes_1.6.0.html &
xen.org/download/xcp/index_1.6.0.html

XCP and Cloud Orchestration Stacks
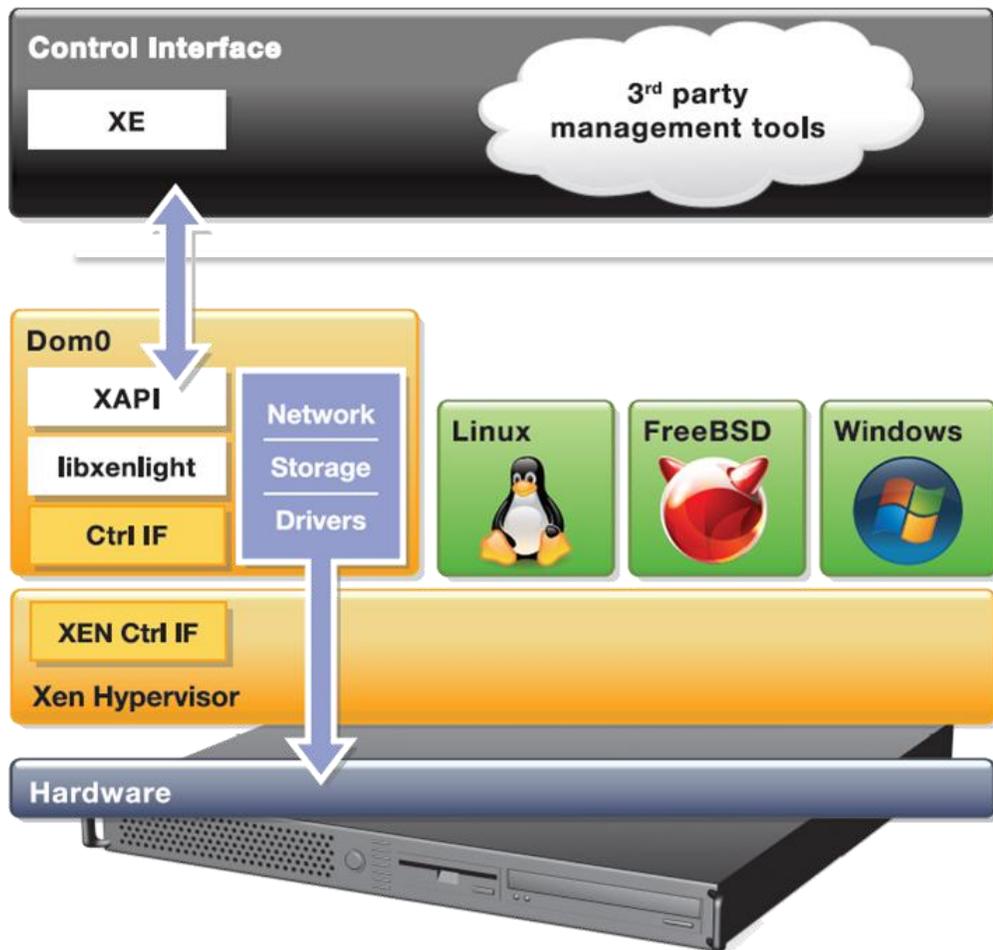
Challenges for FOSS hypervisors

"Security and QoS/Reliability are amongst the top 3 blockers for cloud adoption"

www.colt.net/cio-research

System characteristics cloud users care about:
"Robustness, Performance, Scalability & Security"
Results XCP User Survey 2012 – 90% of users quoted these as most important attributes

Disaggregation

Split Control Domain into Driver,
Stub and Service Domains

- See: "Breaking up is hard to do" @ Xen Papers
- See: "Domain 0 Disaggregation for XCP and XenServer"

Used today by Qubes OS and Citrix XenClient XT

Prototypes for XCP
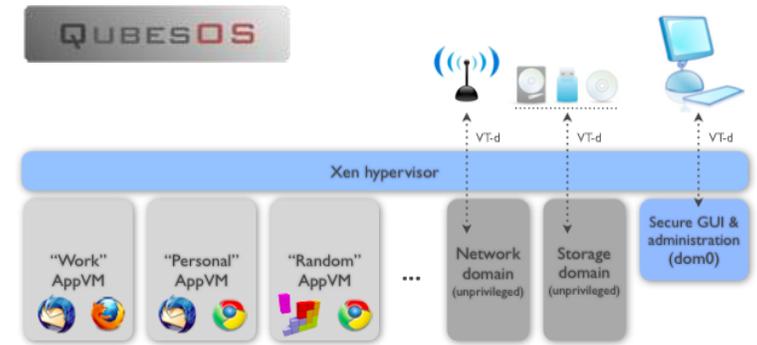
See qubes-os.org

Different windows run
in different VMs
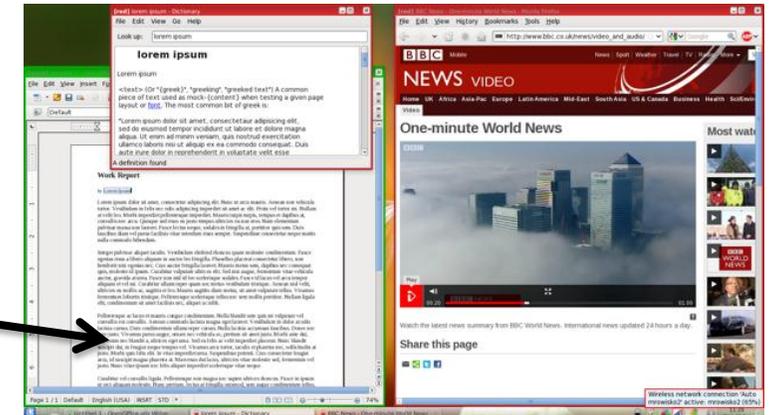
Benefits of Disaggregation

More Security

Increased serviceability and flexibility

Better Robustness

Better Performance

Better Scalability
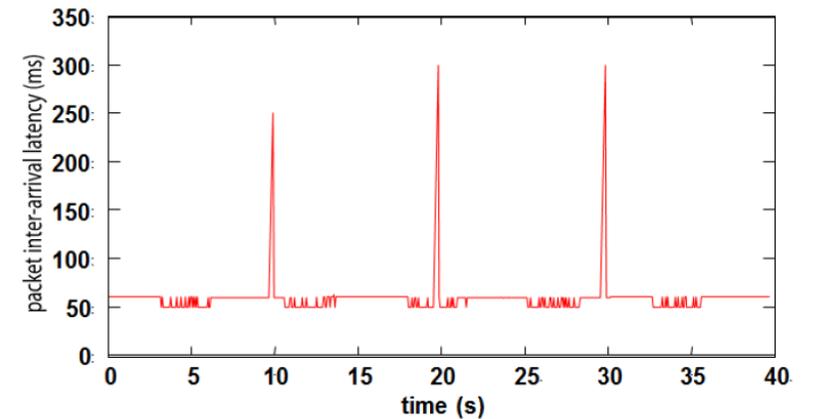
Ability to safely restart parts of the system
(e.g. just 275ms outage from failed Ethernet driver)

**Next:** XCP Architecture Diagram
Before and After Disaggregation
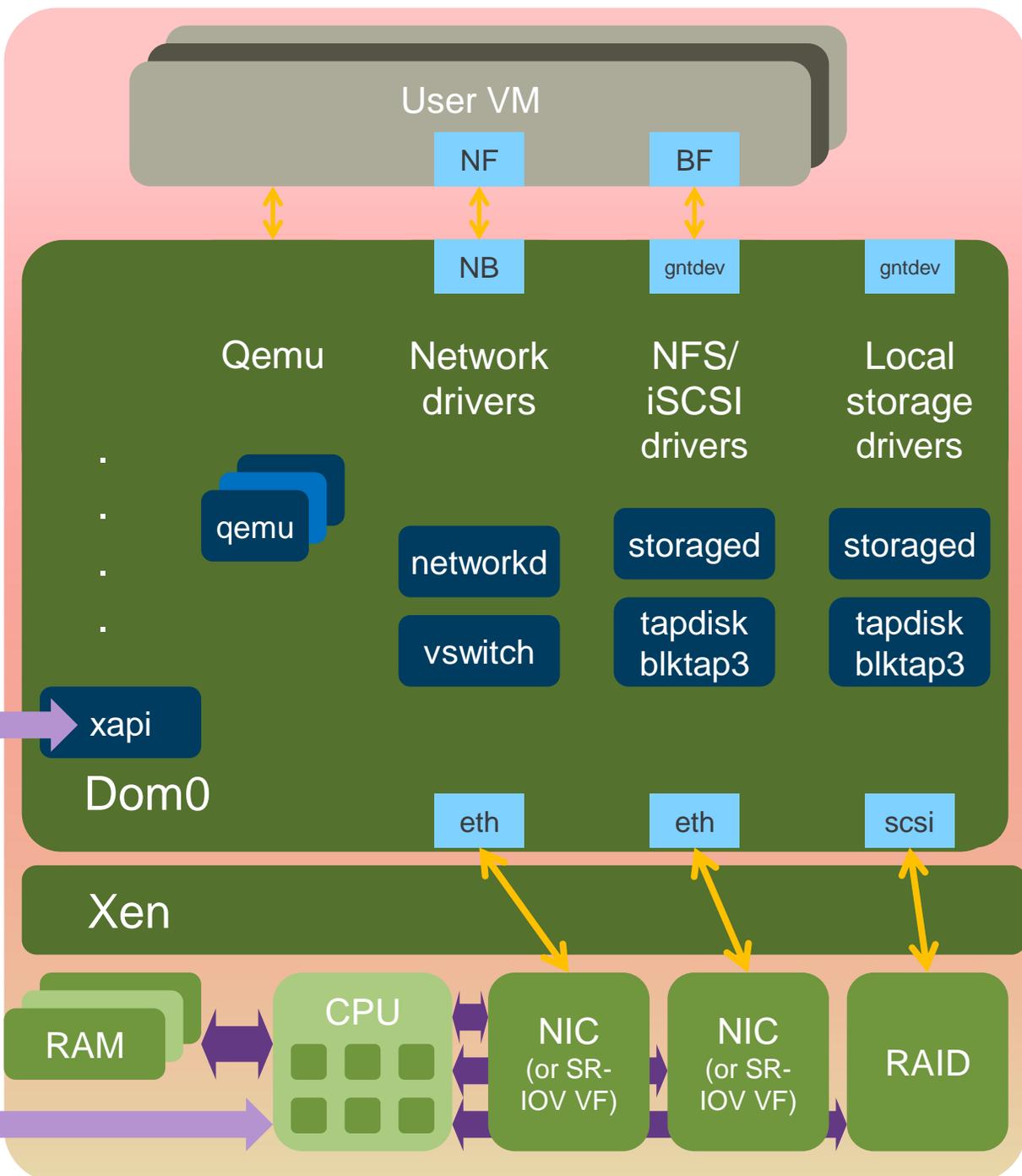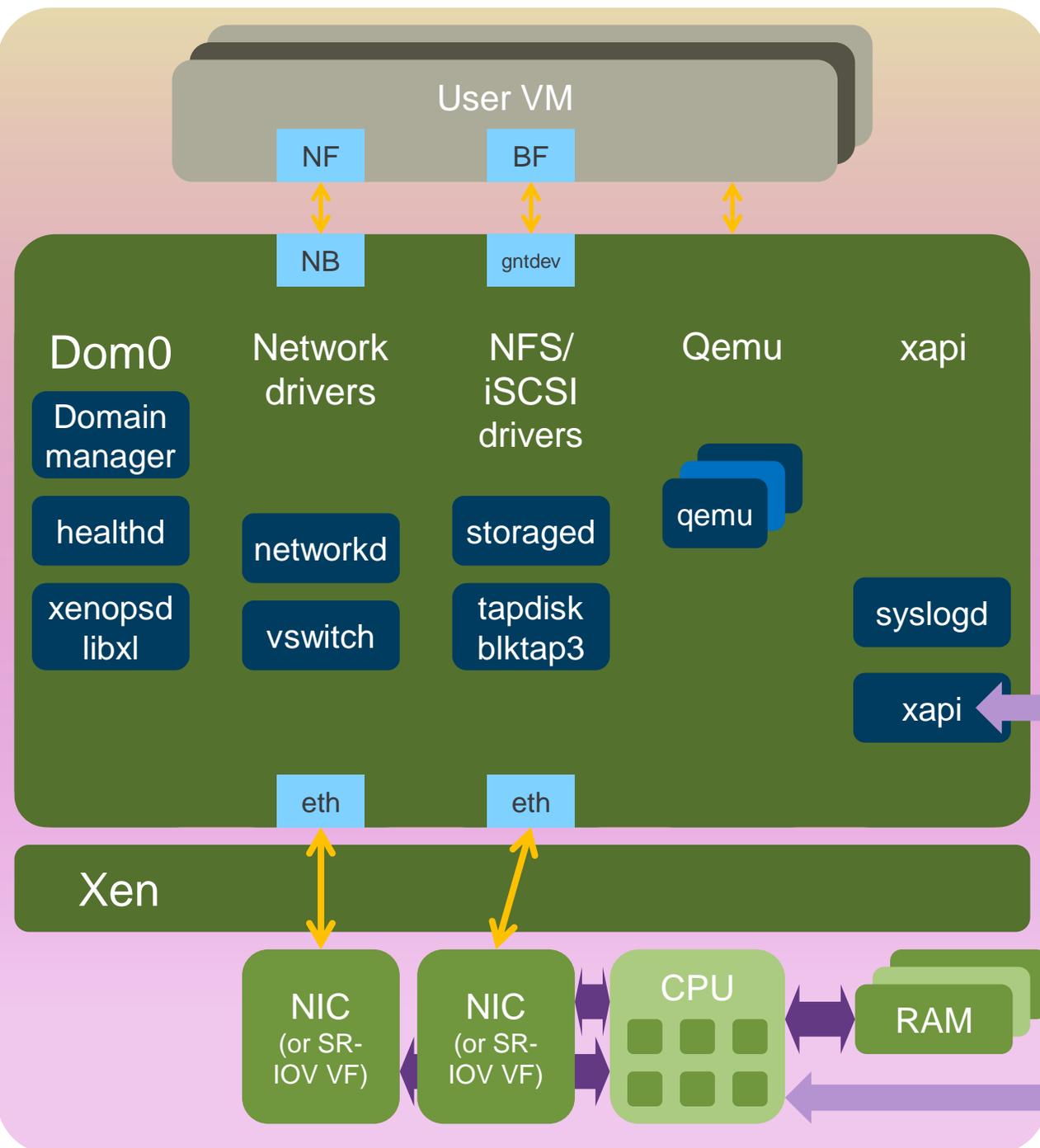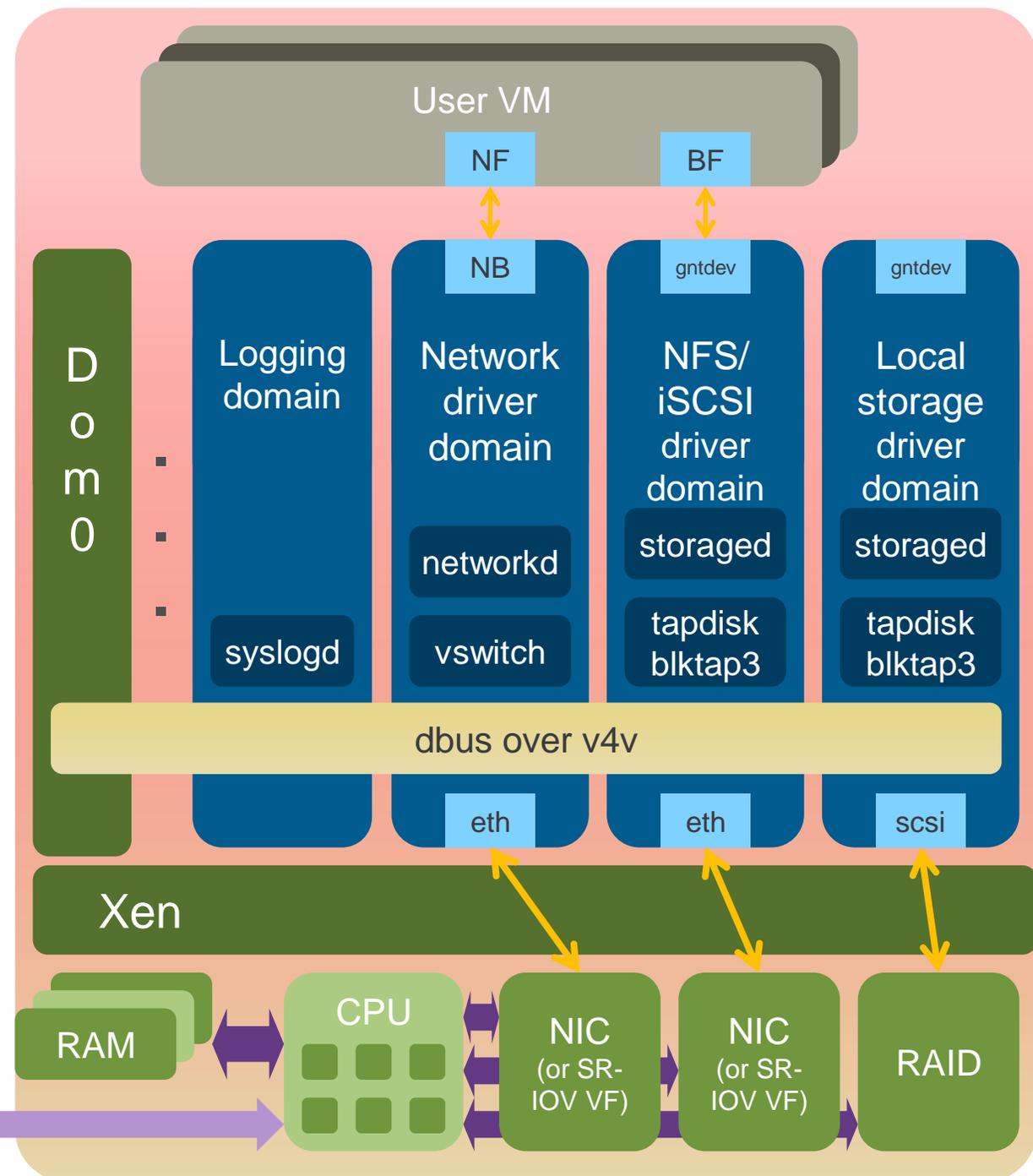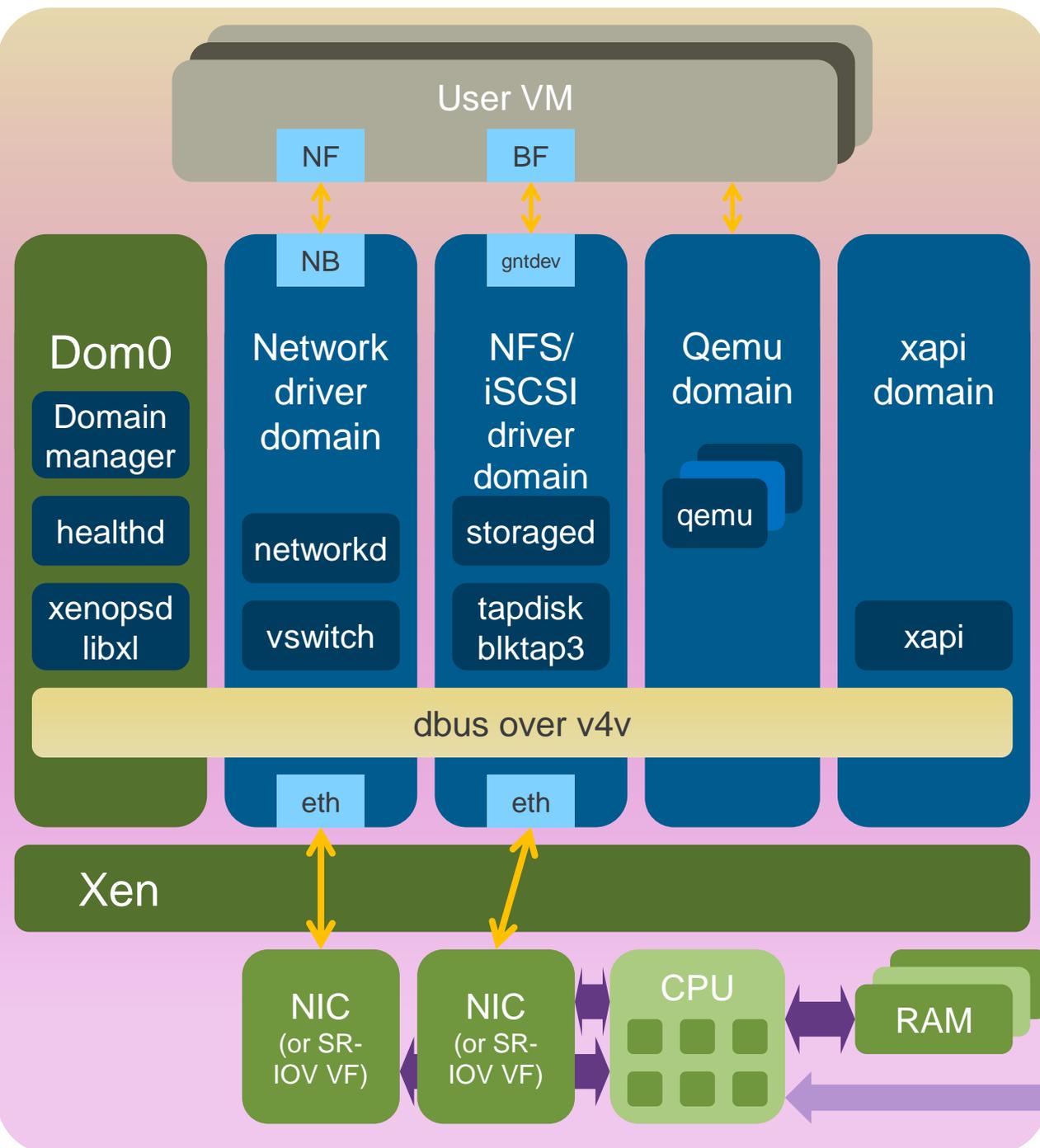
Xen Security Advantages

- Even without Advanced Security Features
  - Well-defined trusted computing base (much smaller than on type-2 HV)
  - Minimal services in hypervisor layer

- Xen Security Modules (or XSM) and FLASK
  - XSM is Xen equivalent of LSM
  - FLASK is Xen equivalent of SELinux
  - Developed, maintained and contributed to Xen by NSA
  - Compatible with SELinux (tools, architecture)
  - XSM object classes maps onto Xen features

More info: http://www.slideshare.net/xen_com_mgr/
                a-brief-tutorial-on-xens-advanced-security-features
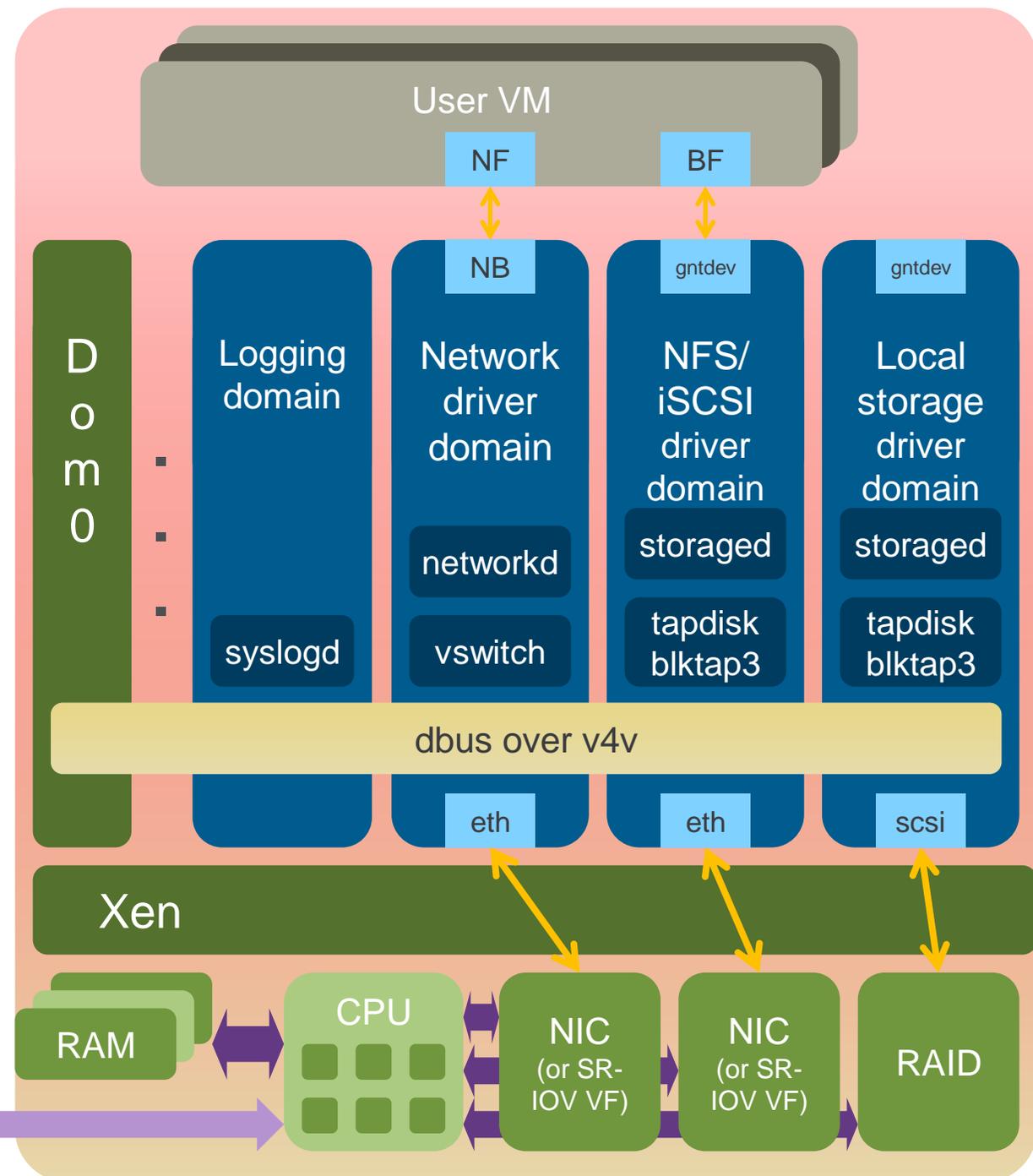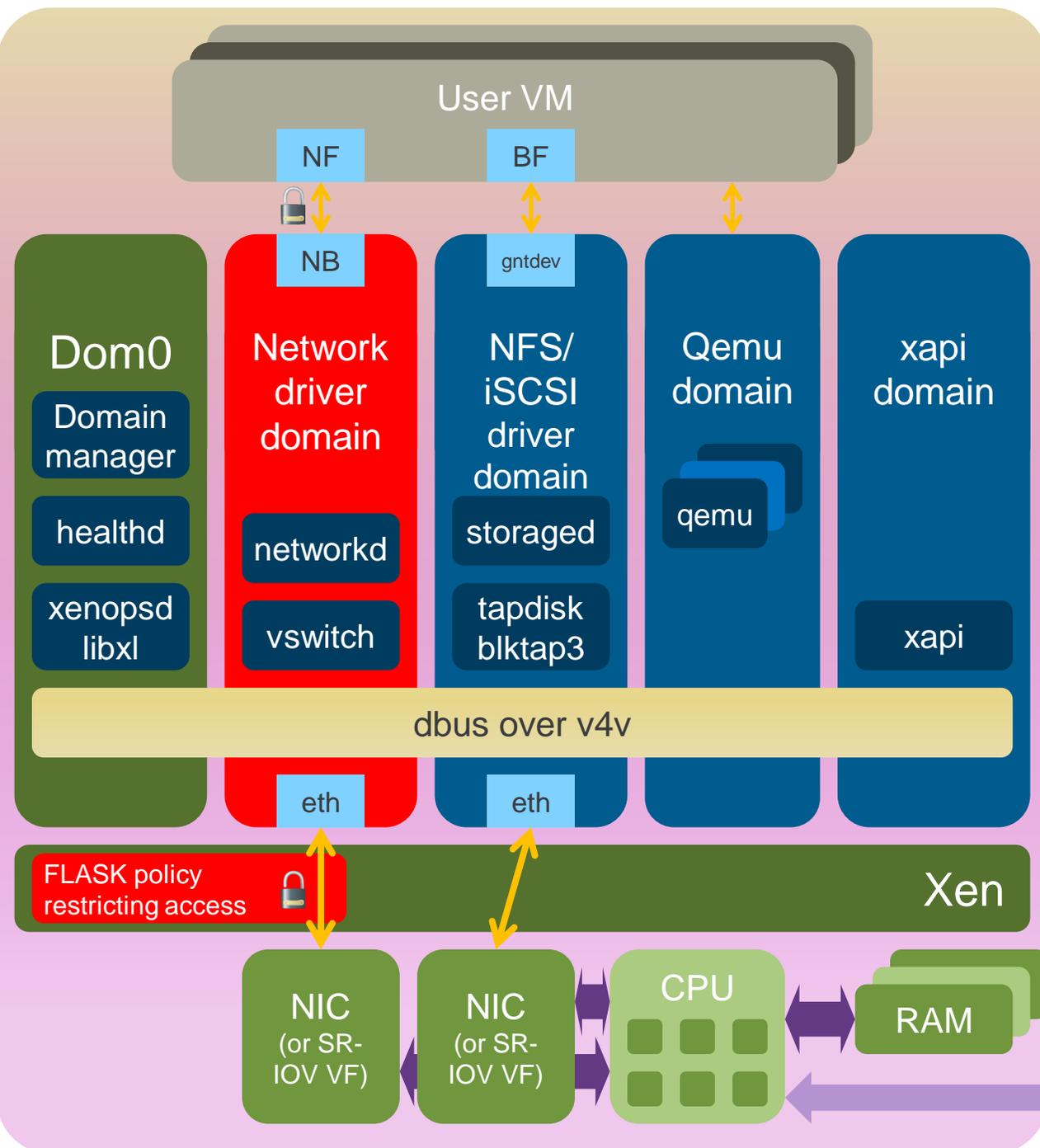
News from the Xen Community

Coming in Xen 4.3 (Q2 2013)

- PVH virtualization mode

- Extend scope of Xen Security Modules

- qxl Spice support for 3d acceleration

- Updated and improved libvirt drivers for Xen

- Lots of other stuff:
  - scalability, performance, better NUMA support, ...

More info: blog.xen.org/index.php/2013/02/11/xen-4-3-mid-release-roadmap-update

Xen 4.3 for ARM Servers

Fully functional for ARM v7 & v8

ARM v7: Versatile Express, Arndale & Samsung Chromebook

ARM v8: Fast Model

Xen and ARM : a perfect Match

ARM SOC

Device Tree describes …

I/O

| GT | GIC v2 | 2 stage MMU |

ARM Architecture Features for Virtualization

User mode : EL0

Kernel mode : EL1

Hypercall interface :HVC

Hypervisor mode : EL2

Xen and ARM : a perfect Match

One mode to rule them all

Legend:
- 🟩 Optimal performance
- 🟧 Scope for improvement

	Disk and Network	Interrupts, Timers	Emulated Motherboard, Legacy boot	Privileged Instructions and page tables	
x86: PVHVM	P	P	VS	VH	HVM mode/domain
x86: PVH	P	P	P	VH	PV mode/domain
ARM v7 & v8	P	VH	VH	VH	

Xen in CentOS 6.4+

Xen is coming back to CentOS

In semi-private beta

Planned release in CentOS 6.4

Include XAPI packages – aka XCP in CentOS

Xen Library Operating Systems

Application stacks only running on Xen APIs

Works on any Xen based cloud or hosting service

<u>Examples</u>

– ErlangOnXen.org : Erlang

– HalVM : Haskell

– OpenMirage : Ocaml

<u>Benefits:</u>

– Small footprint

– Low startup latency

– Extremely fast migration of VMs
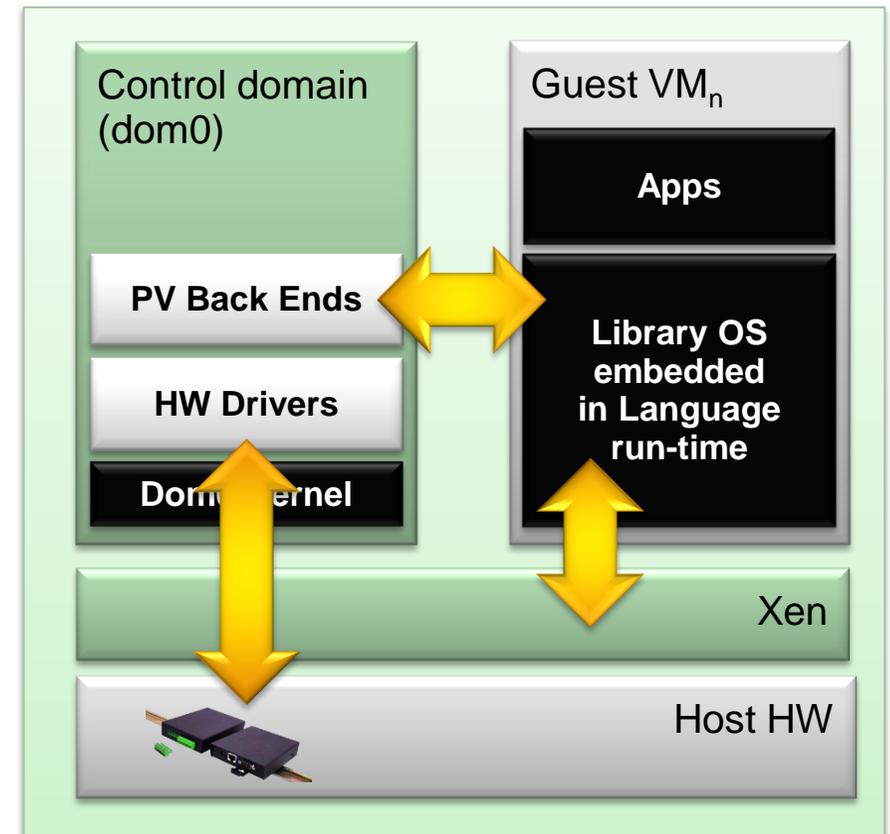
Summary: Why Xen?

- Designed for the Cloud : many advantages for cloud use!
  - Resilience, Robustness & Scalability
  - Security: Small surface of attack,
    Isolation & Advanced Security Features

- Widely used by Cloud Providers and Vendors

- XCP

  - Ready for use with cloud orchestration stacks

- Open Source with a large community and eco-system
  - Xen is still on top of the game
  - Exciting new developments and features in the pipeline

- **IRC:** ##xen @ FREENODE
- **Mailing List:** xen-users & xen-api (lists.xen.org)
- **Wiki:** wiki.xen.org
- **Ecosystem pages:**
  xen.org/community/ecosystem.html
- **Presentations & Videos:**
  xen.org/community/presentations.html

Thank You!

@lars_kurth

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