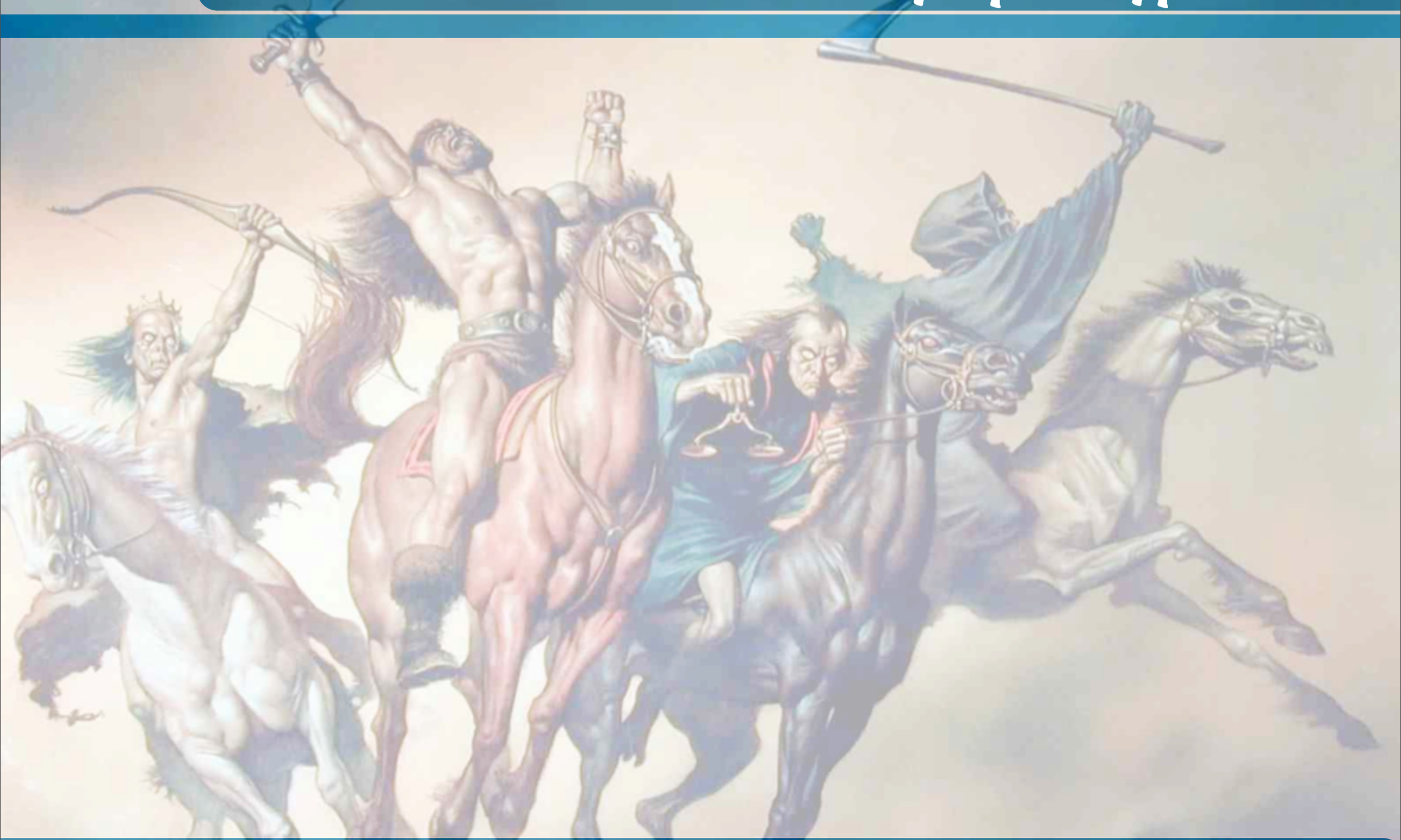
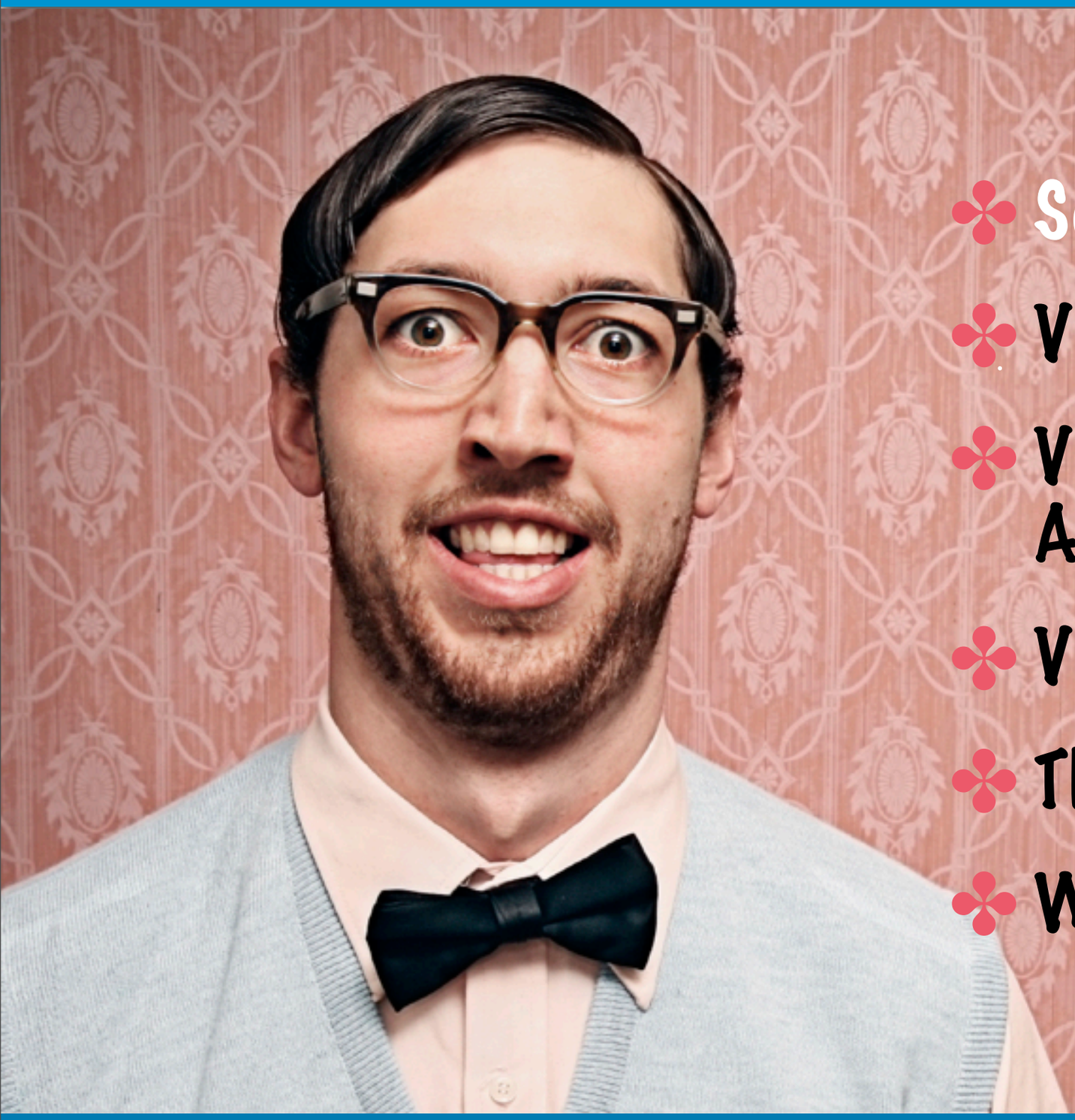
INFORMATION SECURITY DECISIONS

The Four Horsemen Of the Virtualization Security Apocalypse



Welcome To The Jungle...

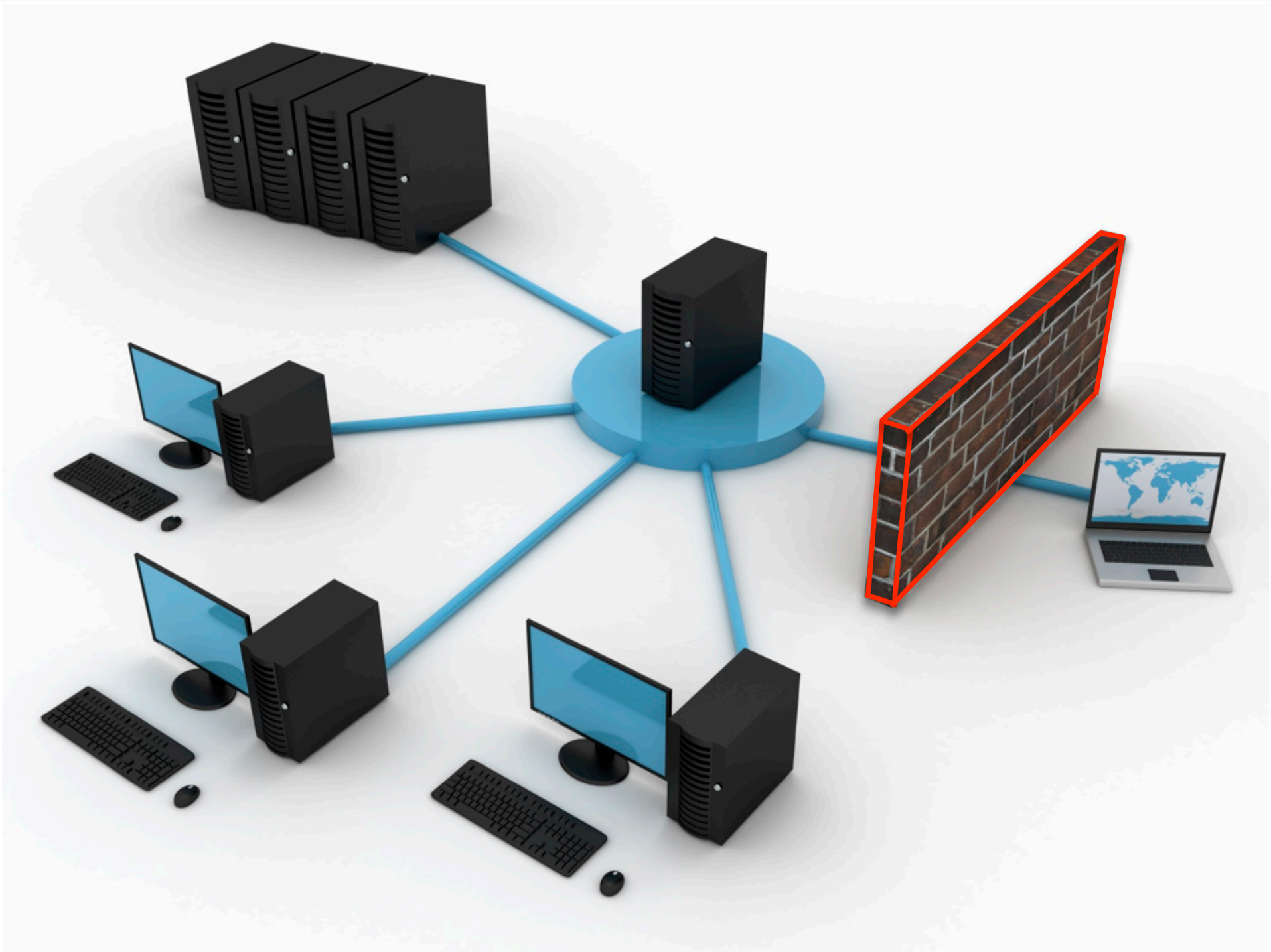


- Setup
- Virtualization In Context
- Virtual Networking Architecture
- VirtSec Solutions Landscape
- The Four Horsemen
- Wrap-Up

Topics and Goals Of Our Chat:

- Discuss the operational realities of virtualizing networking and security today: performance, scalability and resiliency
- Describe the broad impact of immaturity in VirtSec technology/solutions
- Illustrate how the melange of security in the ISV Software, hypervisor, OS, network and embedded in hardware opens a security wormhole

Status Quo = FAIL?



Status Quo = FAIL?

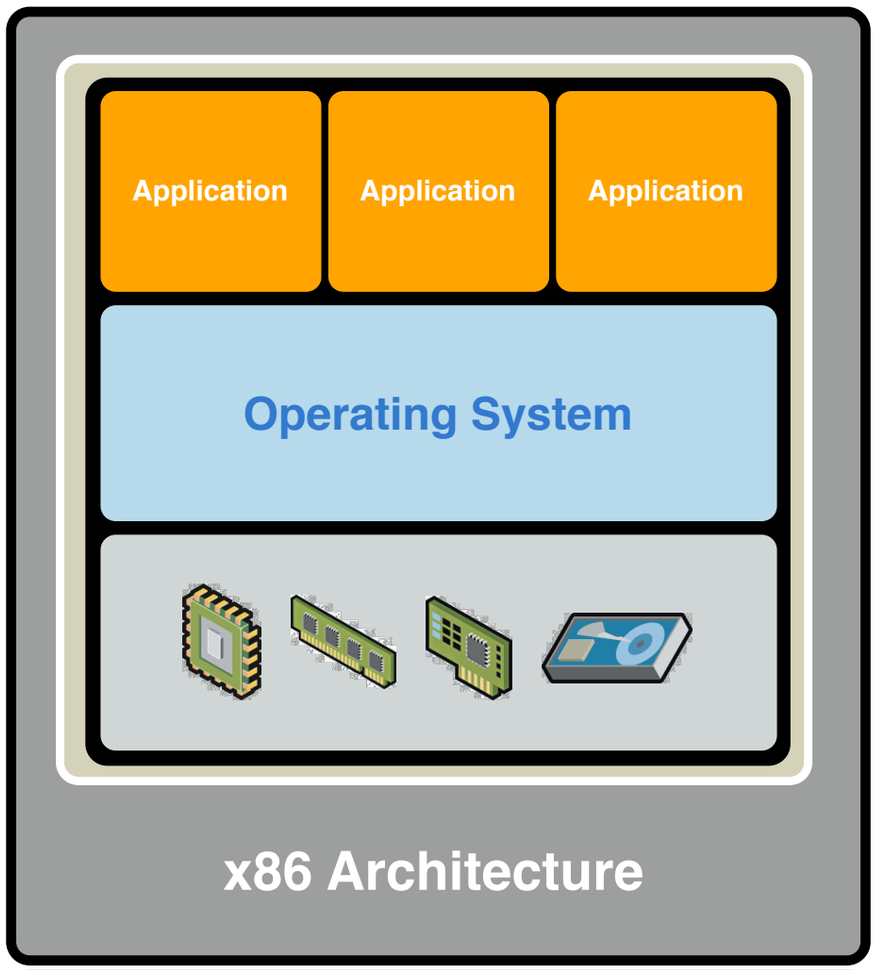
Some security things you do today are perfectly reasonable and work well in virtualized environments, others simply don't work at all

Where To Start?

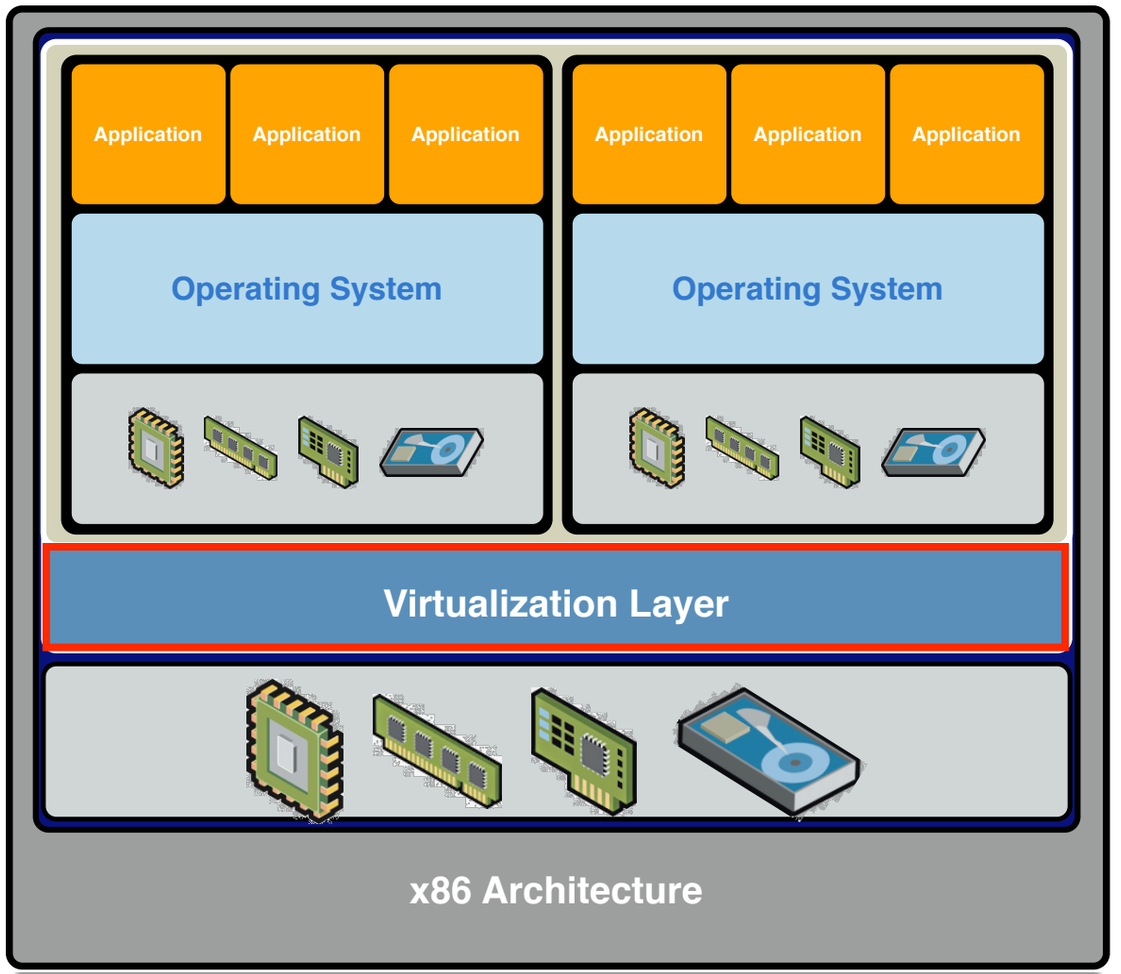
- Setup
- Virtualization In Context
- Virtual Networking Architecture
- VirtSec Solutions Landscape
- The Four Horsemen
- Wrap-Up

x86 Virtualization* Overview

From This

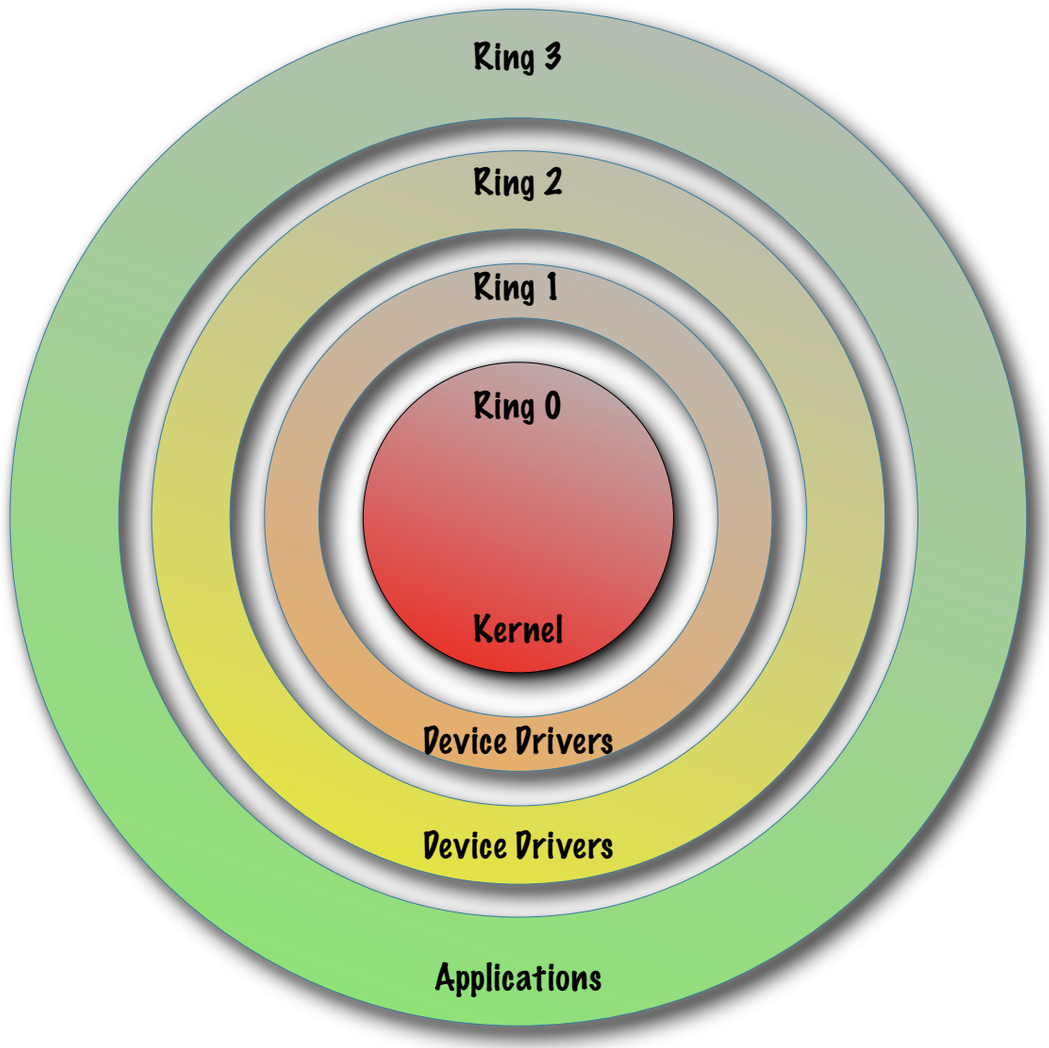


To This

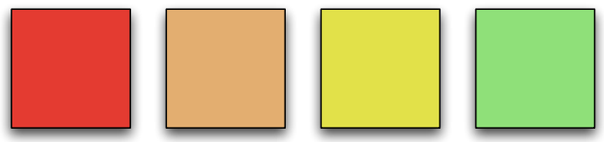


*Represents "Type 1" or Bare Metal "Server" Virtualization

x86 Hierarchical Protection Domains/Rings



Most Privileged

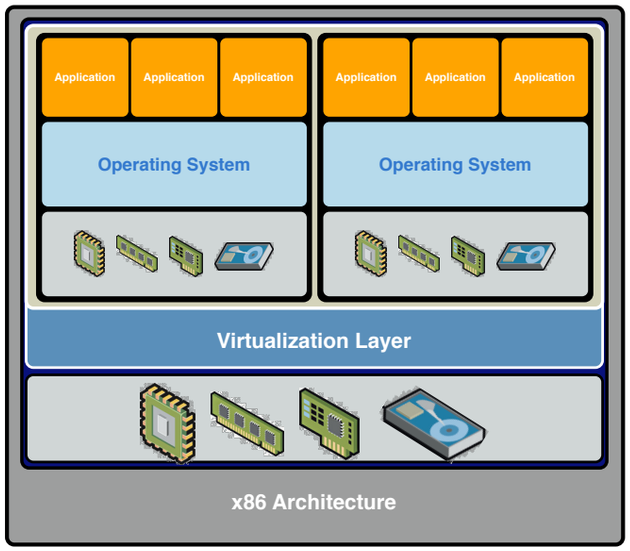


Least Privileged

Adapted from: http://en.wikipedia.org/wiki/Supervisor_mode

x86 Protection Ring Compression For Dummies

Virtualized: Software Only

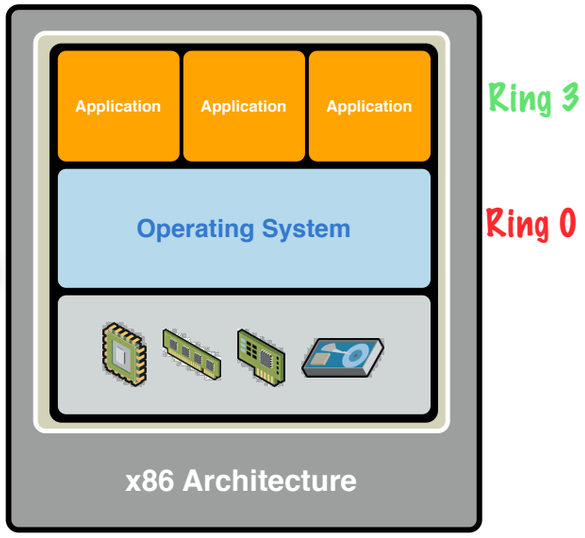


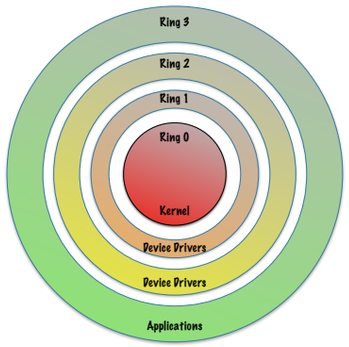
✤ The Guest OS is de-privileged into Ring 1 and the VMM takes its place in Ring 0

✤ The Guest OS still thinks it is running in Ring 0 with all the privileges thereof

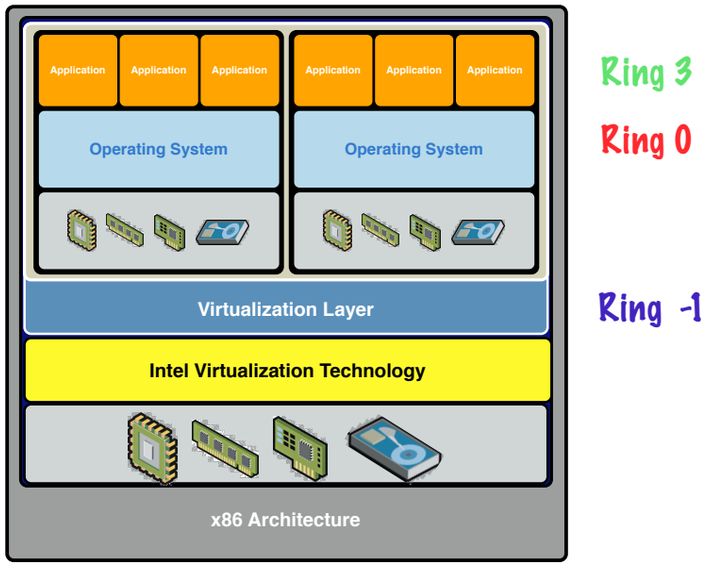
✤ Can cause issues/conflicts due to contention for the 17 x86 privileged platform control instructions

Physical/ Non-Virtualized





Virtualized: Hardware Assisted



✤ In this example, Intel VT provides the VMM with an exclusive privileged level where it resides and executes (Ring -1)

✤ The Guest OS is not de-privileged and is running in Ring 0

✤ Context switching between VMM and Guest OS's are hardware supported

*There is also para-virtualization, not covered here...

Hypervisors Are a Disruptive Commodity...

vmware®

CITRIX®

Microsoft®

IBM®

Sun microsystems

Parallels™

Xen®

ORACLE®

redhat®

*Yes, there are others, but these have pretty logos...

They're breedin' like wabbits!

...and they're showing up everywhere

No One RingO To Rule Them All!

Which means:

- Companies will likely end up with many virtualization platforms/VMM's spread out across the horizon of their enterprise

The key differentiators?

- Management, integration, extensibility and security

We need open standards for solution interoperability, management & security

- If you have issues with the "simple complexity" of a single virtualization platform, imagine when you have many

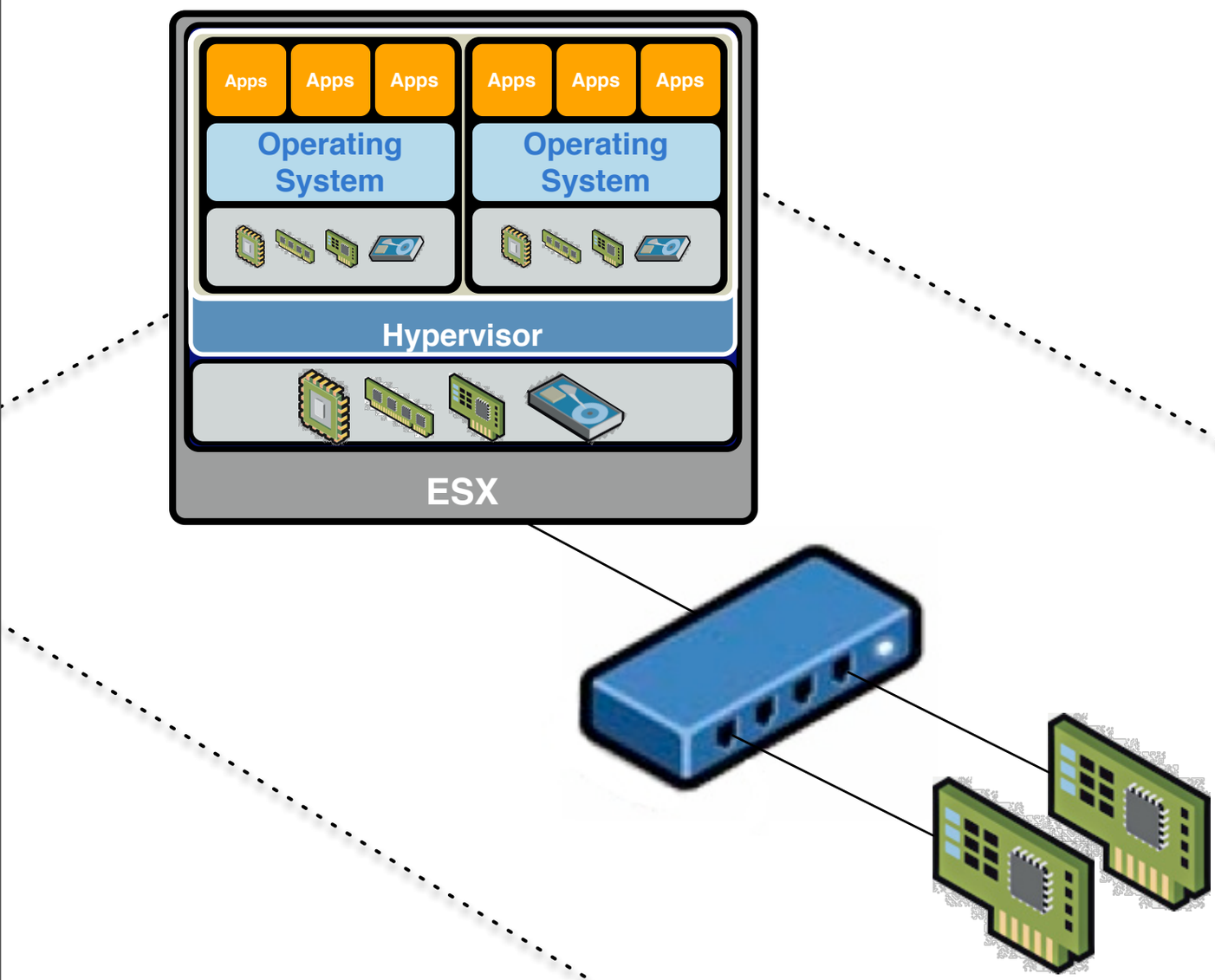
Debating Virtualization & Security

Many debates and much ado stems from the inability to distinguish between three fundamental concerns:

- Securing Virtualization
- Virtualizing Security
- Security Via Virtualization

Separate the technical, architectural, and philosophical from the functional, operational and organizational

Threat Models In Review



1. Guest to Guest
2. Guest to Host/VMM/HW
3. Guest to Self
4. External to Host/VMM/HW
5. External to Guest
6. Host/VMM to All...
7. Hardware to VMM

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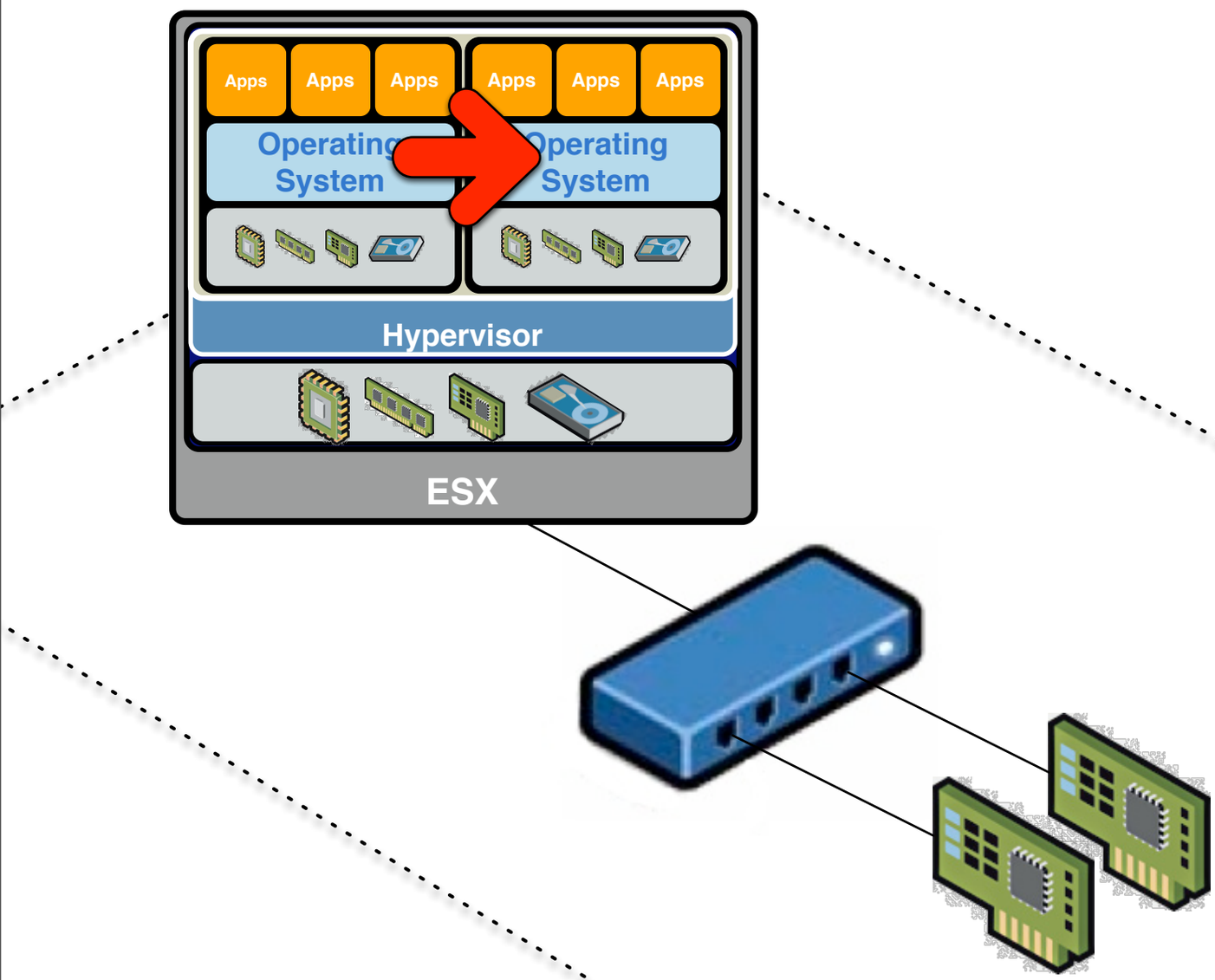

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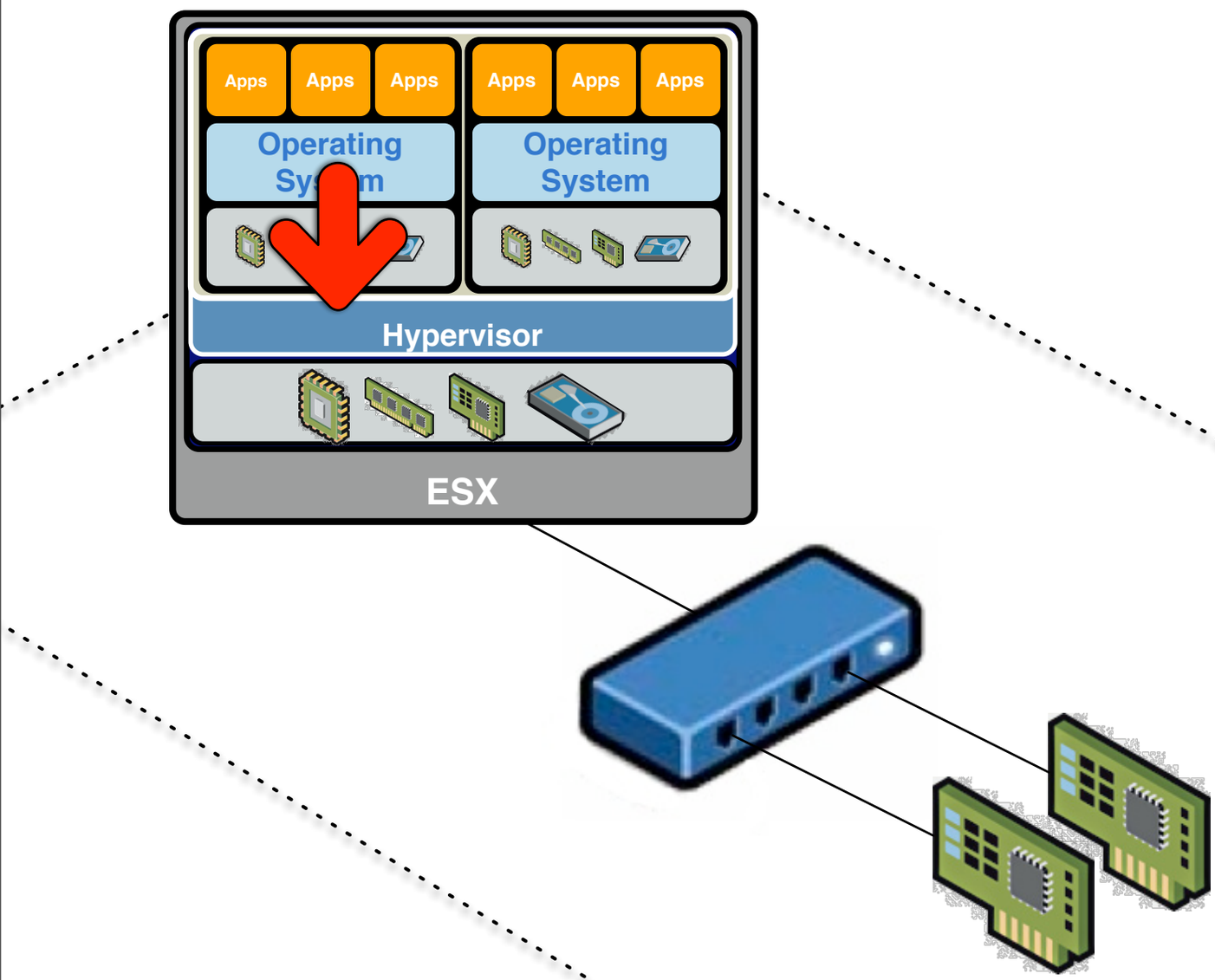

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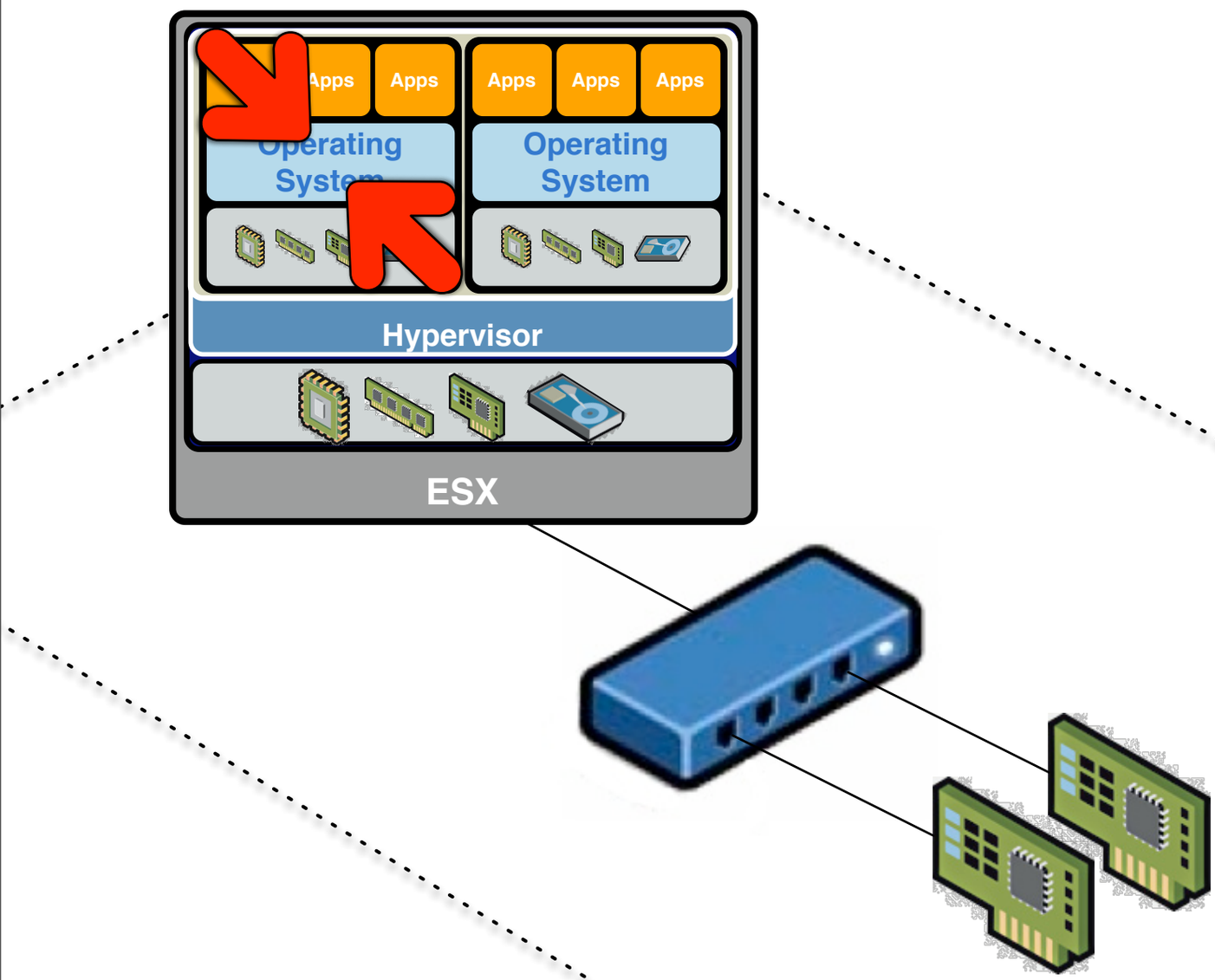

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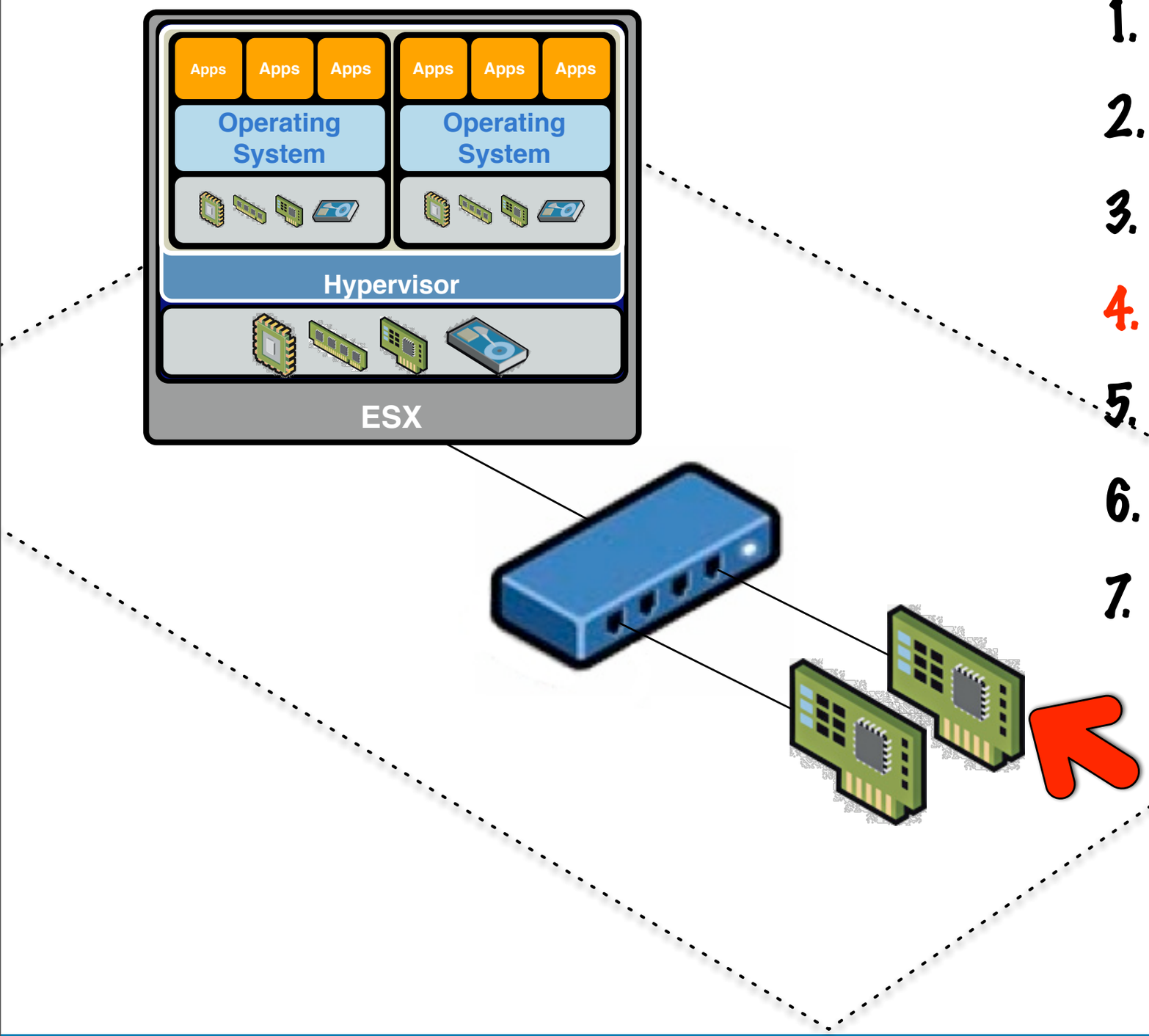

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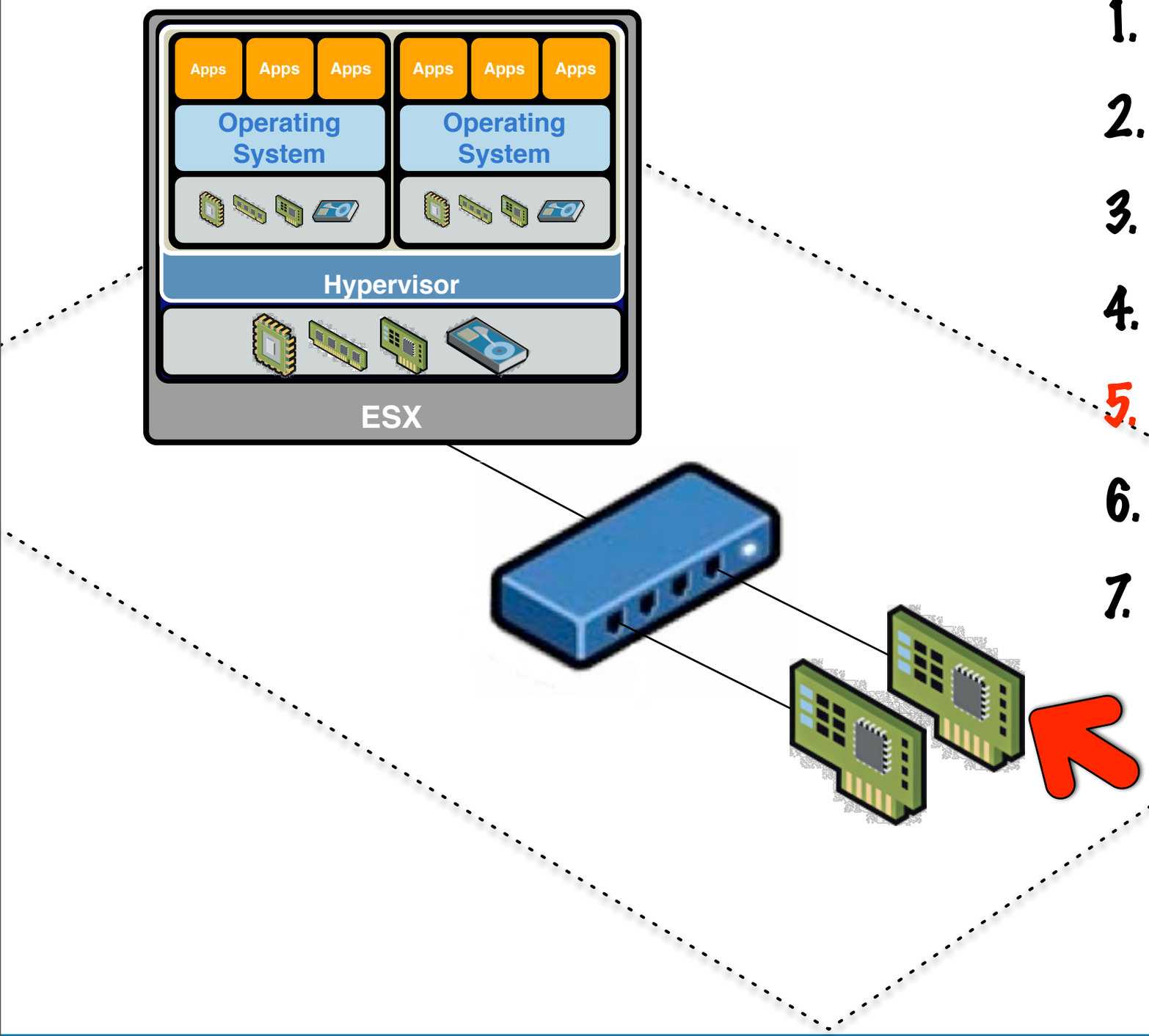

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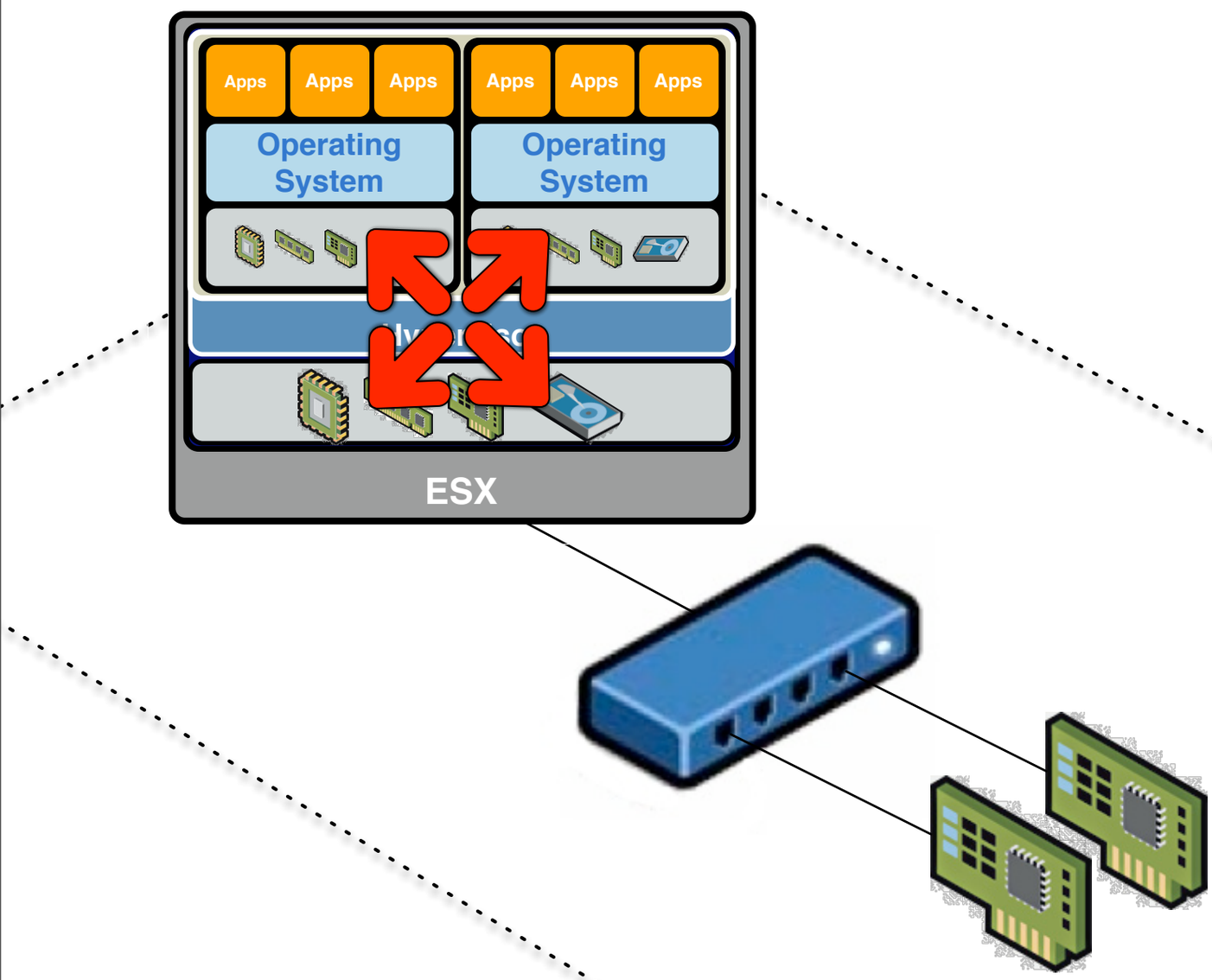

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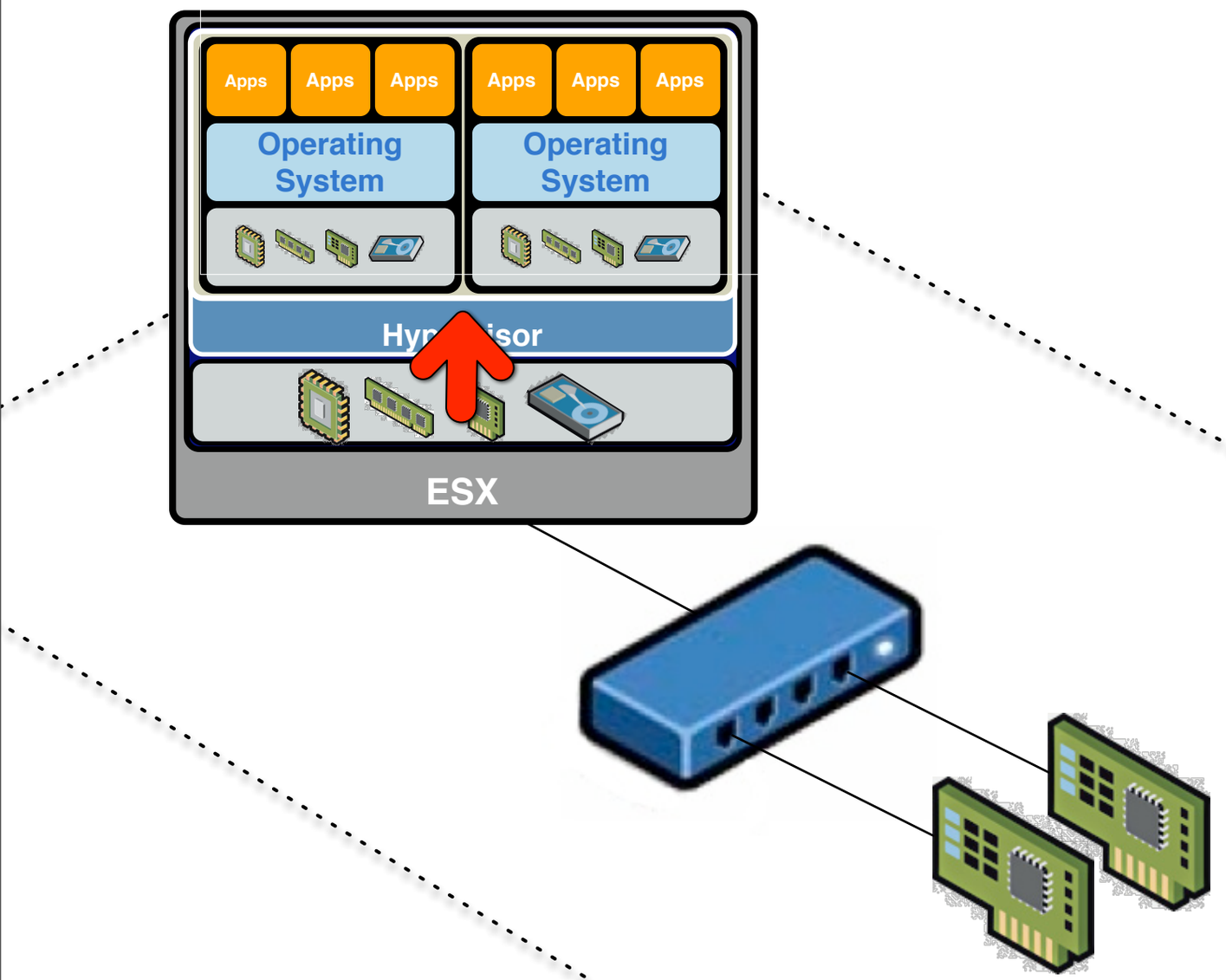

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But dOOd, What About Virtualization Malware!?

There are many really interesting topics to discuss here:

- Hypervisor malware, rootkits & hyperjacking
- Exploiting virtualization-enabled chipsets for fun and profit
- Peripheral Hardware/Firmware abuse
- Control channel manipulation

I'm neither qualified or motivated to talk about these topics and we've got much more profound and fundamental sets of issues to discuss.

There are lots of other talks featuring this stuff...

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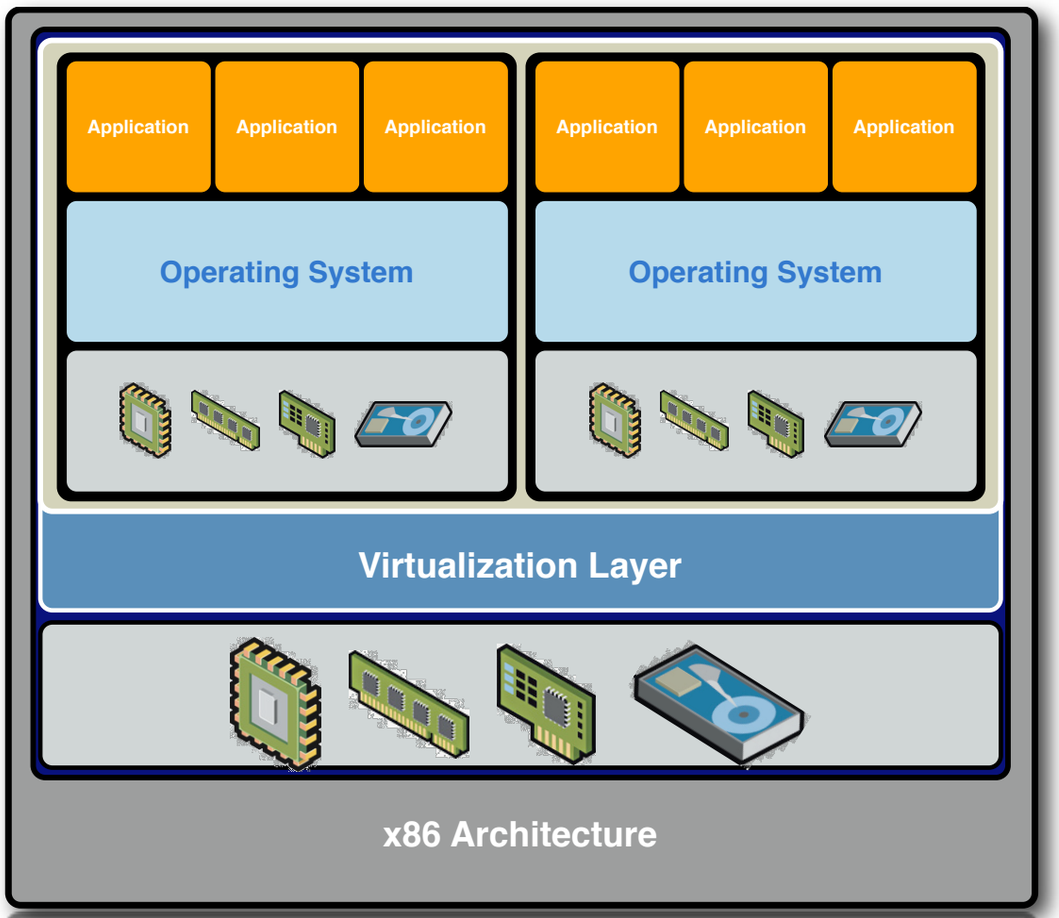
Time For Sublime Design

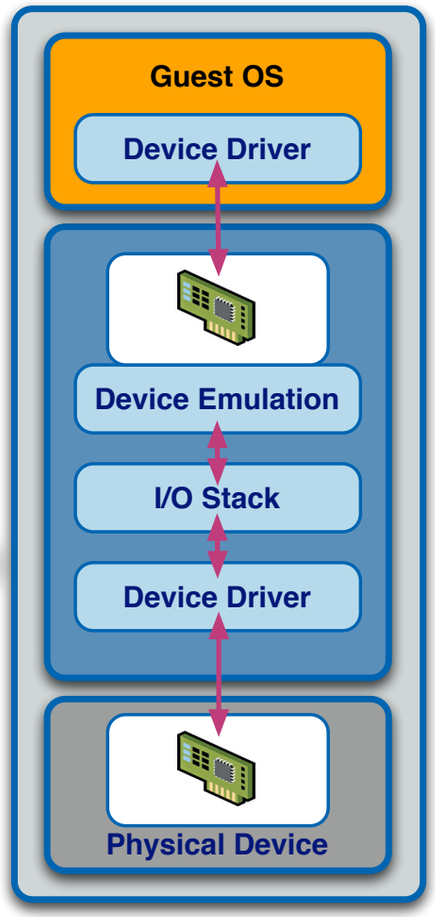
- Setup
- Virtualization In Context
- Virtual Networking Architecture
- VirtSec Solutions Landscape
- The Four Horsemen
- Wrap-Up

Virtual Networking Architecture

Virtual System



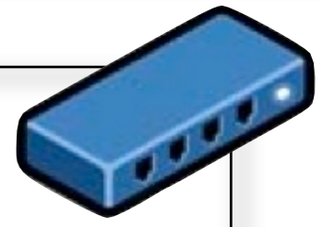
Virtual Networking



Virtual Switch

*Not shown for clarity: Service Console/VMKernel/Storage Networking

A Basic Virtual Switch Defined

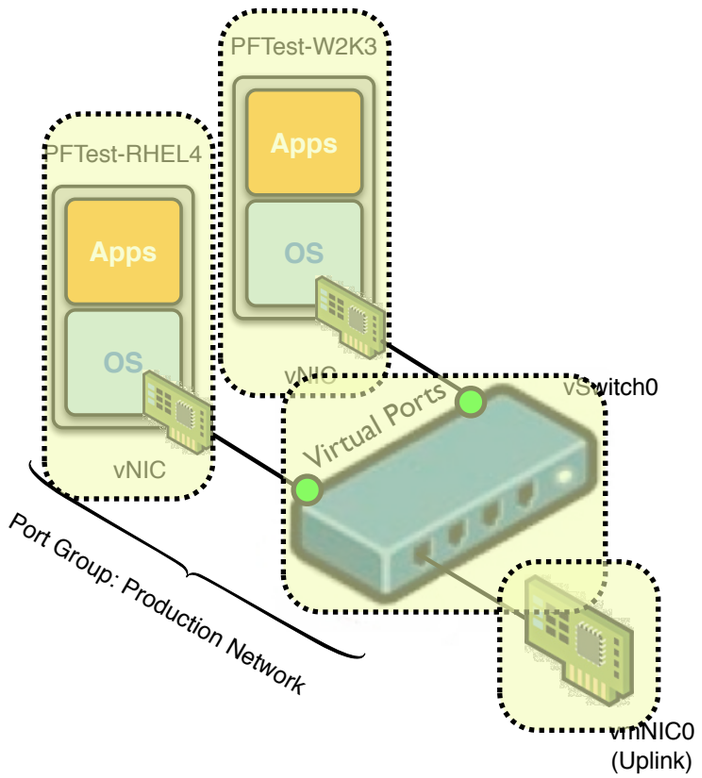


A Virtual Switch:

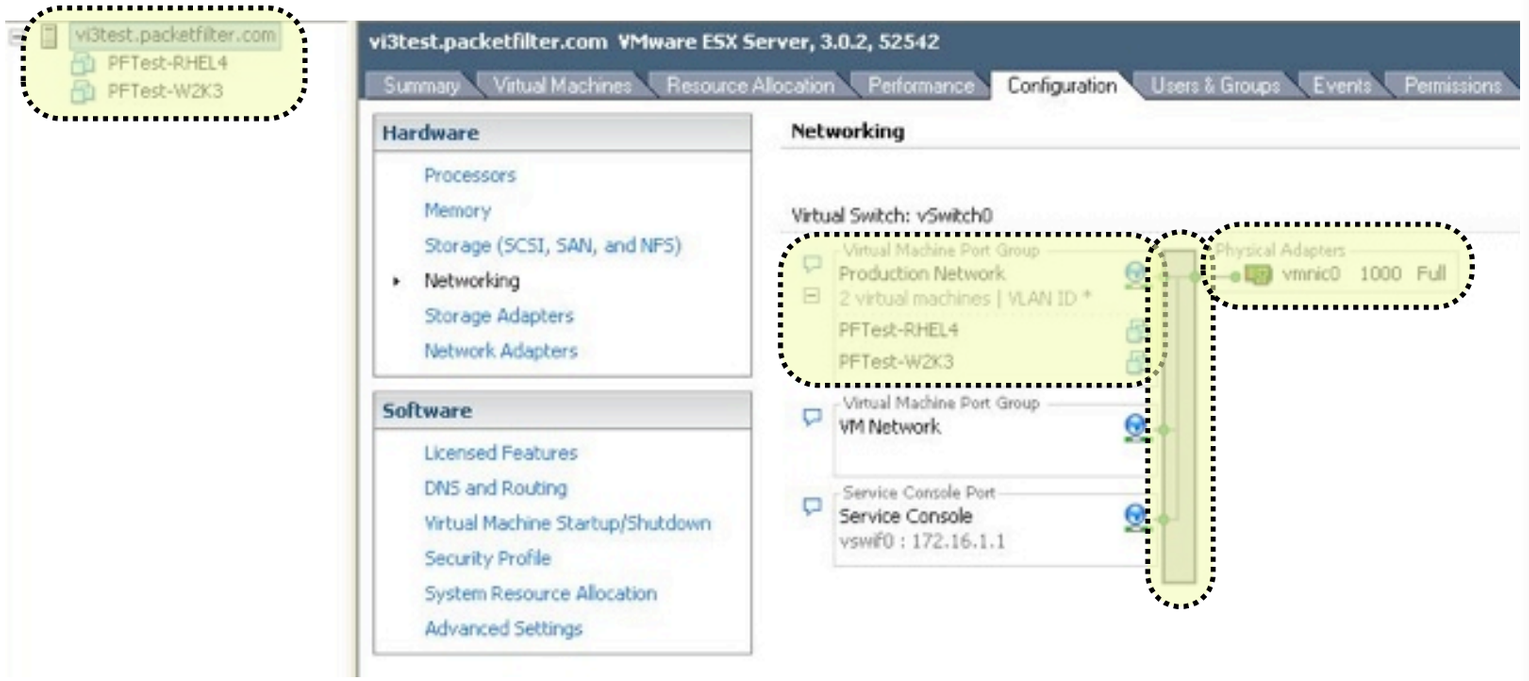
- Is a software-based networking construct that runs in the virtualization platform's kernel
- Purposely-designed layer-2 (L2) switch which is loaded dynamically at runtime with functional modules such as:
  - Core L2 forwarding engine
  - VLAN tagging, stripping & filtering
  - L2 security, checksum and segmentation offload
- Some features normally found in physical L2 switches are not present by design to provide for integrity, isolation and secure connectivity (no STP, VTP, ISL, etc...)

VMware's Virtual Switch Visualized

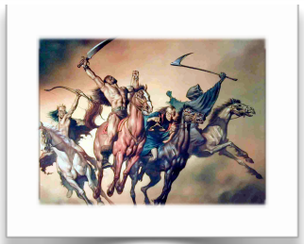
Abstracted Model



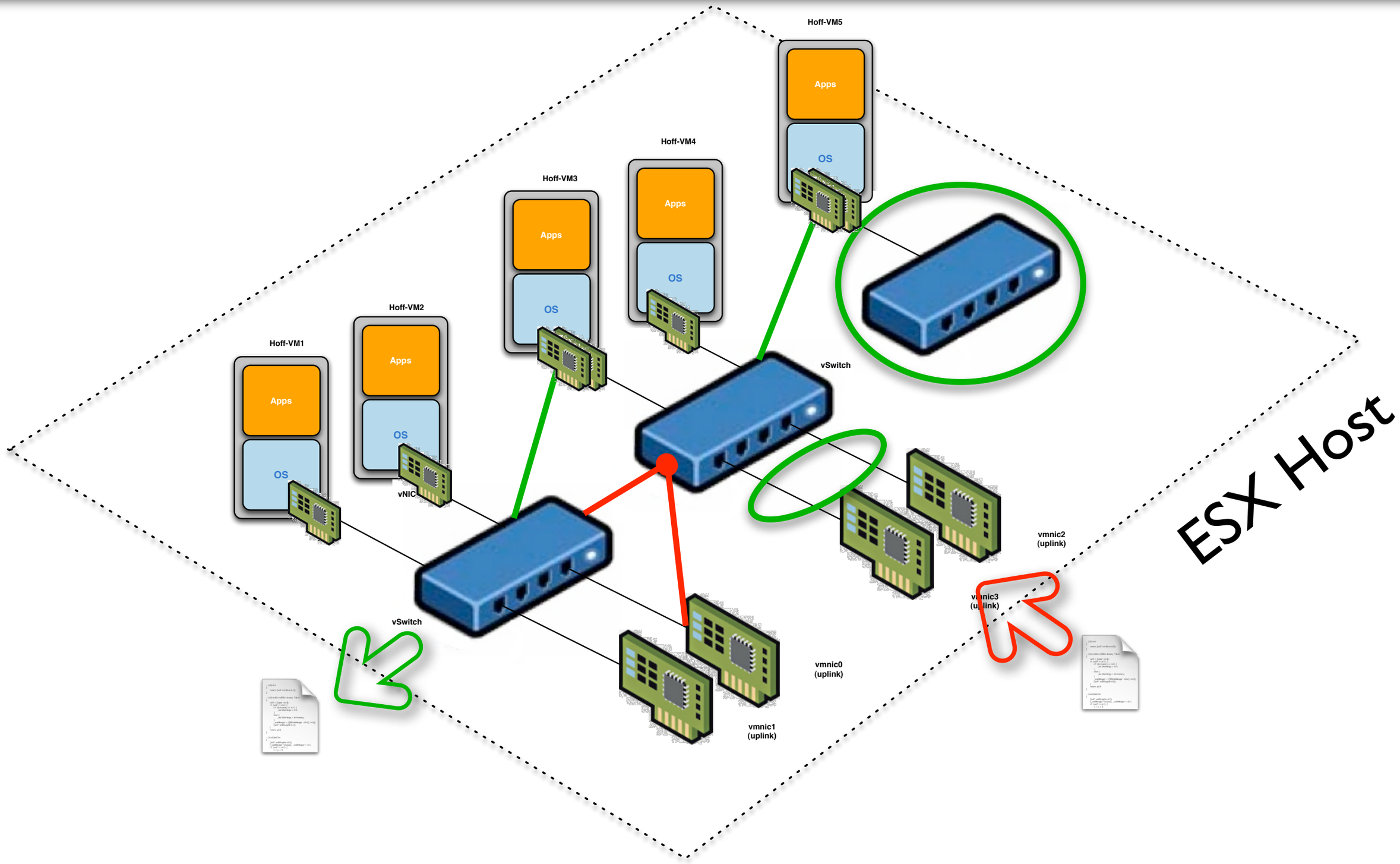
VMware Virtual Infrastructure Client View



* I purposely left off the VMotion and Service Console networks in the model for clarity



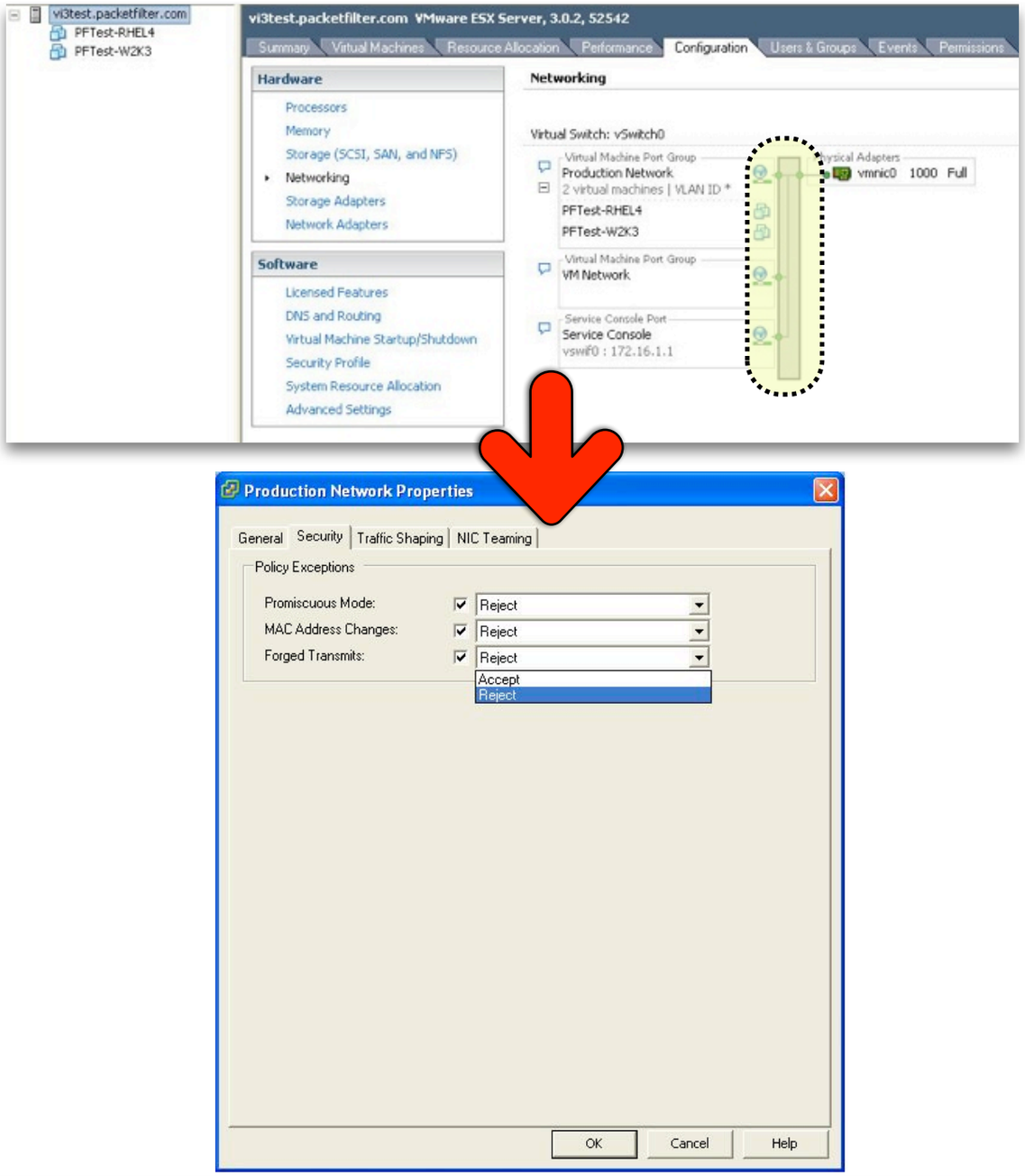
vSwitch Correctness



vSwitch Security Options

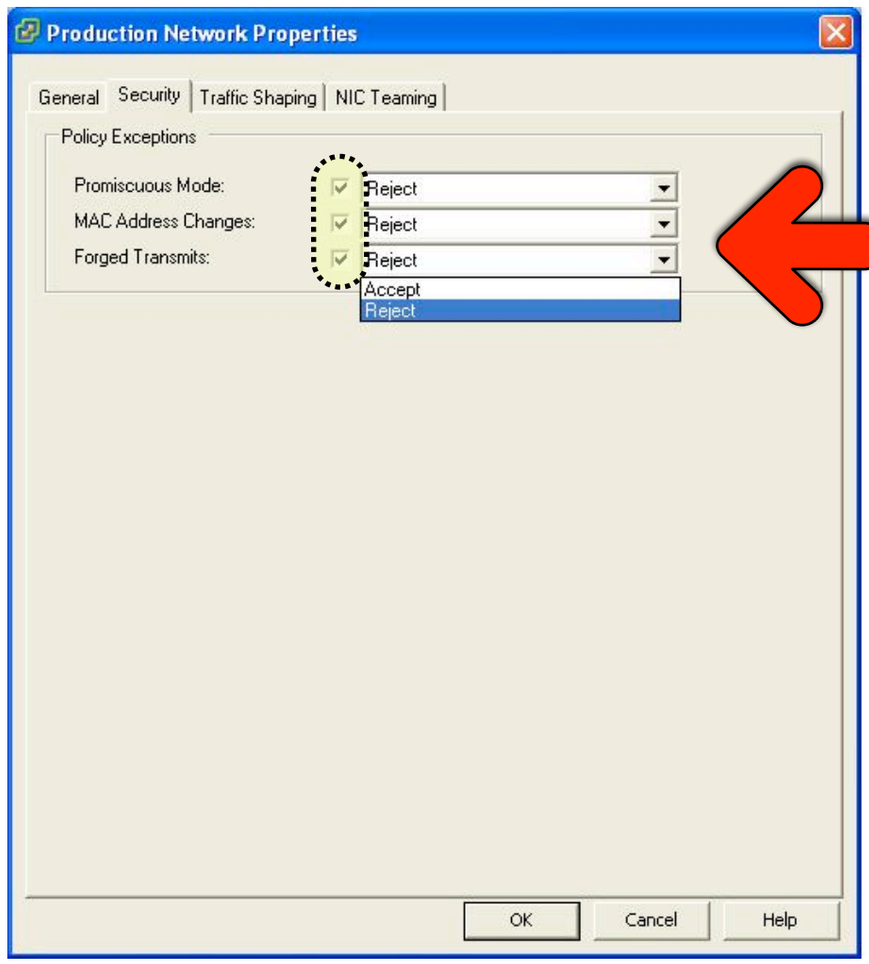
vSwitches offer some nifty security features:

- Configure promiscuous mode (per portgroup) for selective mirroring
- MAC Address changes prevents VM's from changing/ spoofing their MAC addresses
- Can restrict "forged transmissions" that would potentially allow VM's to send traffic from nodes other than themselves

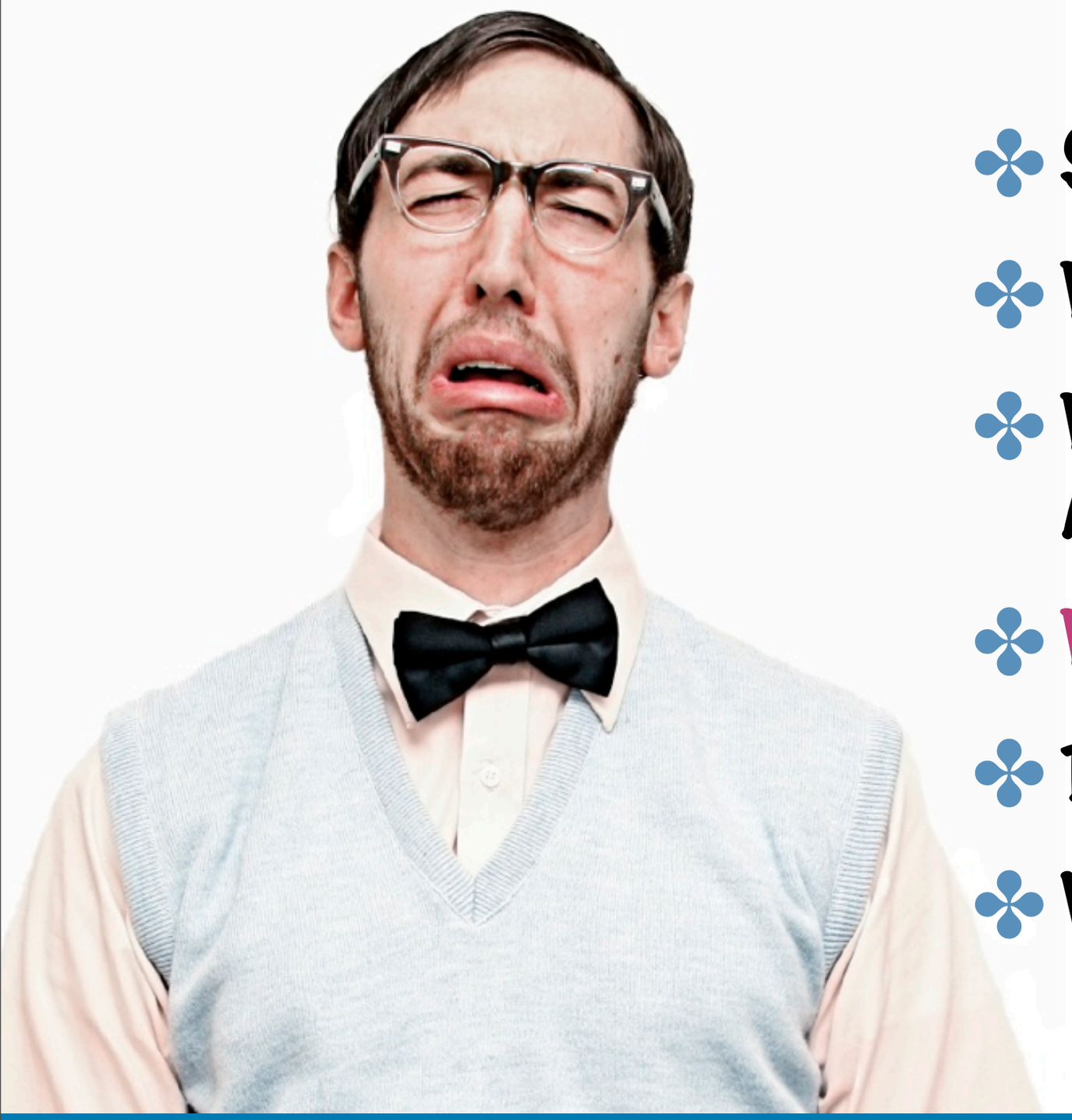


Just In Case You Missed That...

- Network Security in a VMware environment is reduced down to 3 checkboxes in VirtualCenter
- "Network Security" within the virtualized construct of a host is now administered by folks whose competency is neither networking or security
- This is the visibility we security folks have into these environments...



You're Making Me All Weepy!



- Setup & Context
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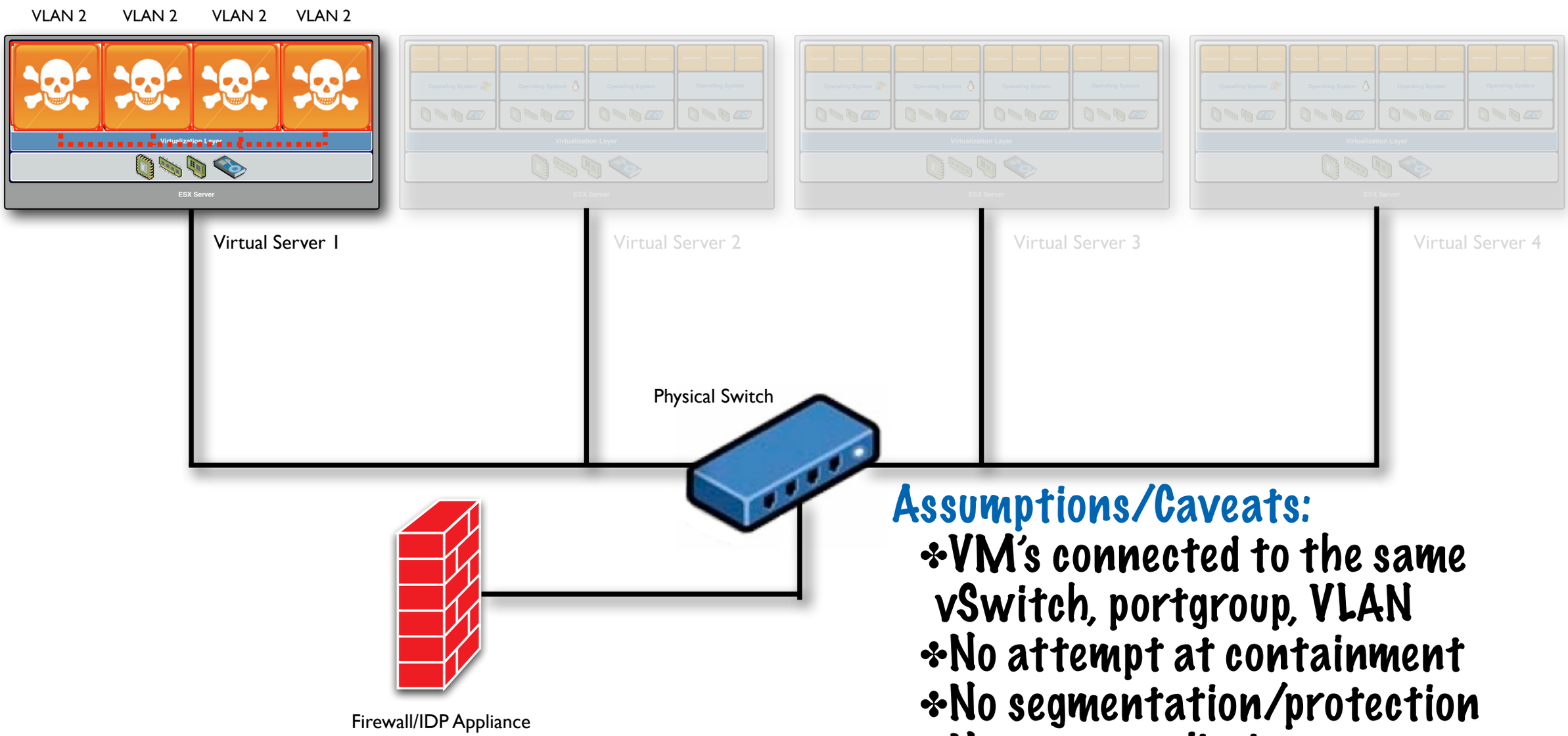
VirtSec Technology Landscape

- Evolving solutions from existing players as well as emerging startups & the virtualization platform providers
- You will need to invest differently in order to effectively manage risk in a virtualized environment
- The next 12 - 18 months will be difficult due to the gold rush effect
- There is (still) no silver bullet, just a lot of silver buckshot

Where We Are Today

VirtSec Examples: No Controls (FUD)

No Security



Assumptions/Caveats:

- VM's connected to the same vSwitch, portgroup, VLAN
- No attempt at containment
- No segmentation/protection
- Not very realistic...

Reality Check: The Intra-VM (In)Security Myth

Myth/Security Team Says:

- "Consolidating servers onto the same virtualized host is insecure because you can't secure intra-vm traffic!"

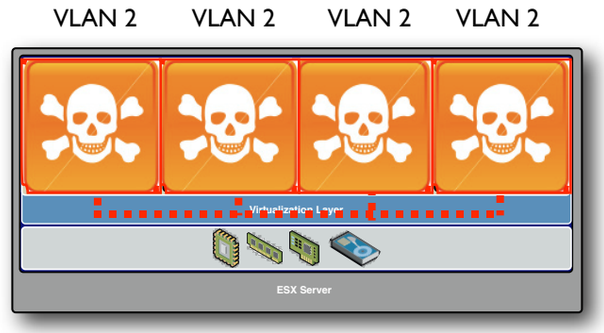
Reality/I ask:

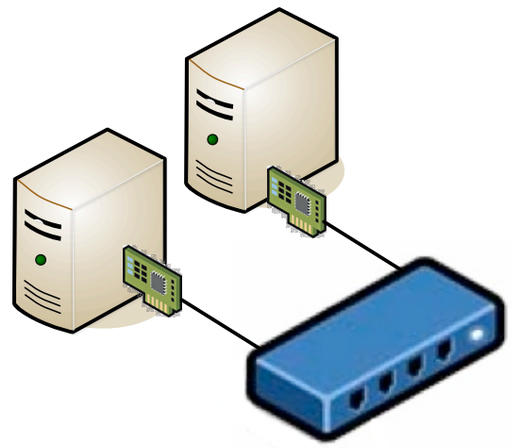
- "When you have two physical servers plugged into the same physical switch in the same VLAN, how do you secure intra-machine traffic?"

Response/Security Team Blushes:

- "Uh, we don't..."

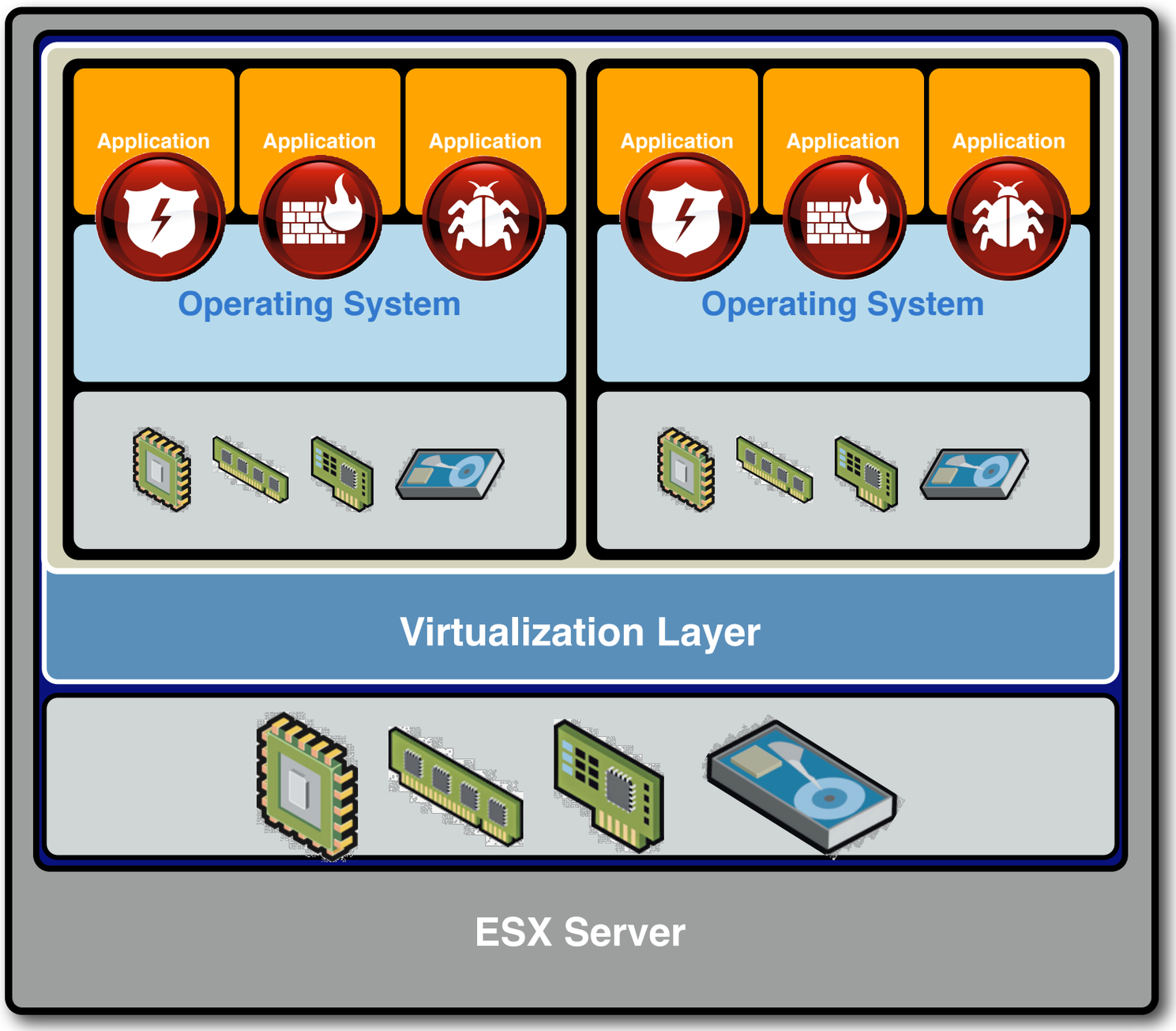
Virtualized





Real World

The Reality: Same Ol' Software In the VM



Most anything you run today in your conventional environments will work here...

- Firewalls
- HIDS
- HIPS
- Anti-virus
- NAC
- Endpoint Assurance
- Patch Management
- Inventory
- Configuration Audit & Control

Installed at the OS or Application Layers

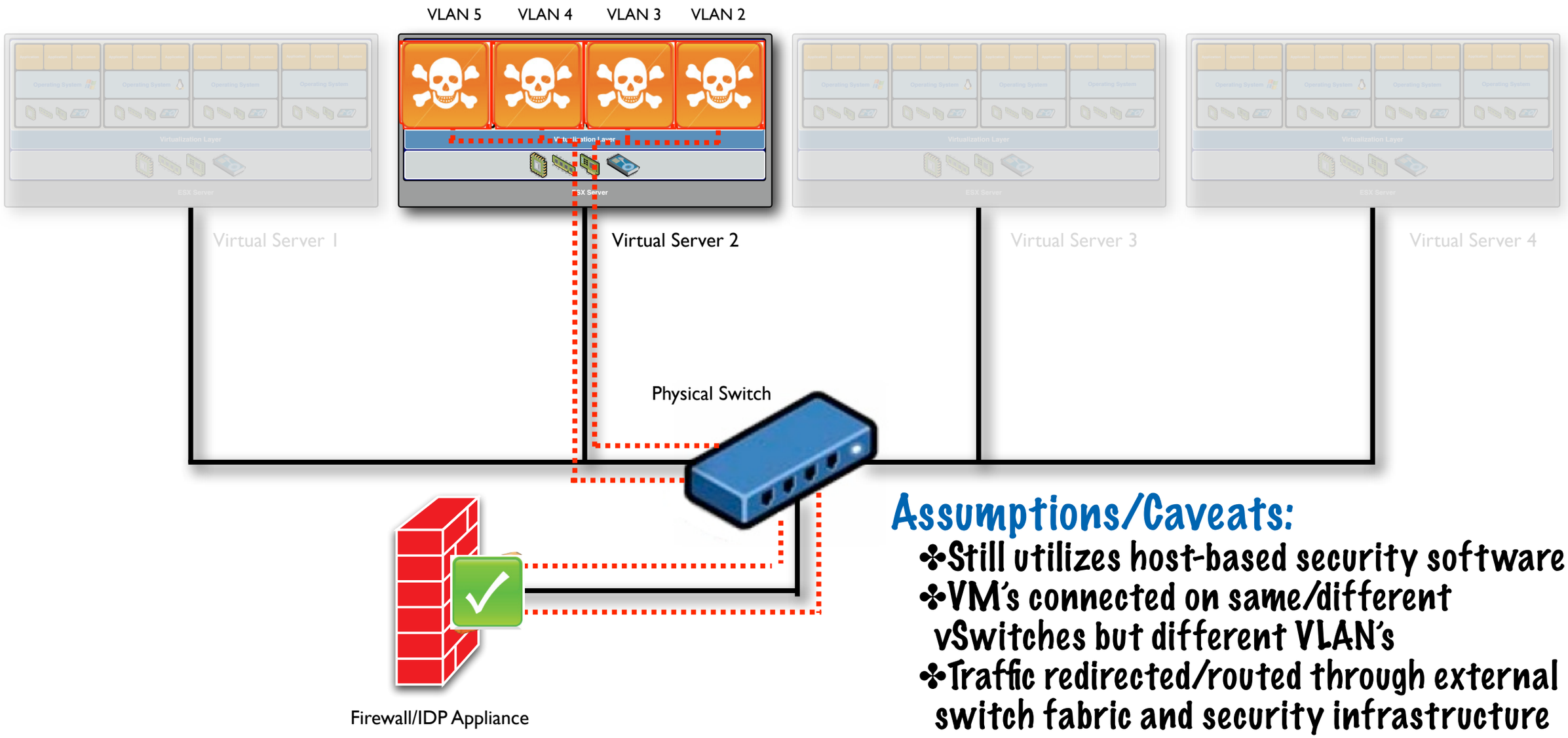
symantec. McAfee® Check Point SOFTWARE TECHNOLOGIES LTD. We Secure the Internet. CISCO

tripwire Configuresoft BIGFIX

TREND MICRO netiq Microsoft

VirtSec Examples: Interacting with External Security

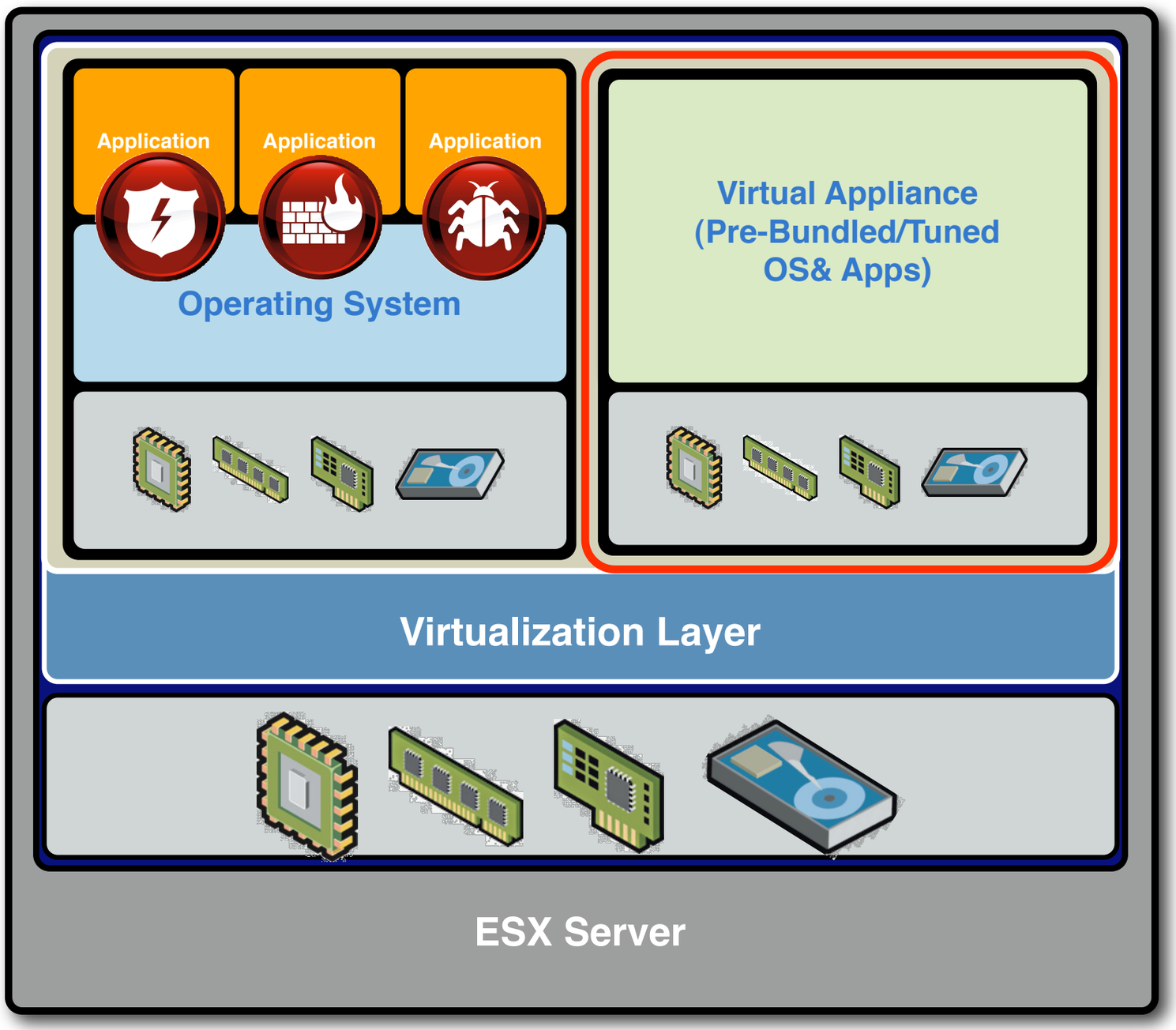
External Security



Assumptions/Caveats:

- Still utilizes host-based security software
- VM's connected on same/different vSwitches but different VLAN's
- Traffic redirected/routed through external switch fabric and security infrastructure

VirtSec Examples: Virtual Appliances

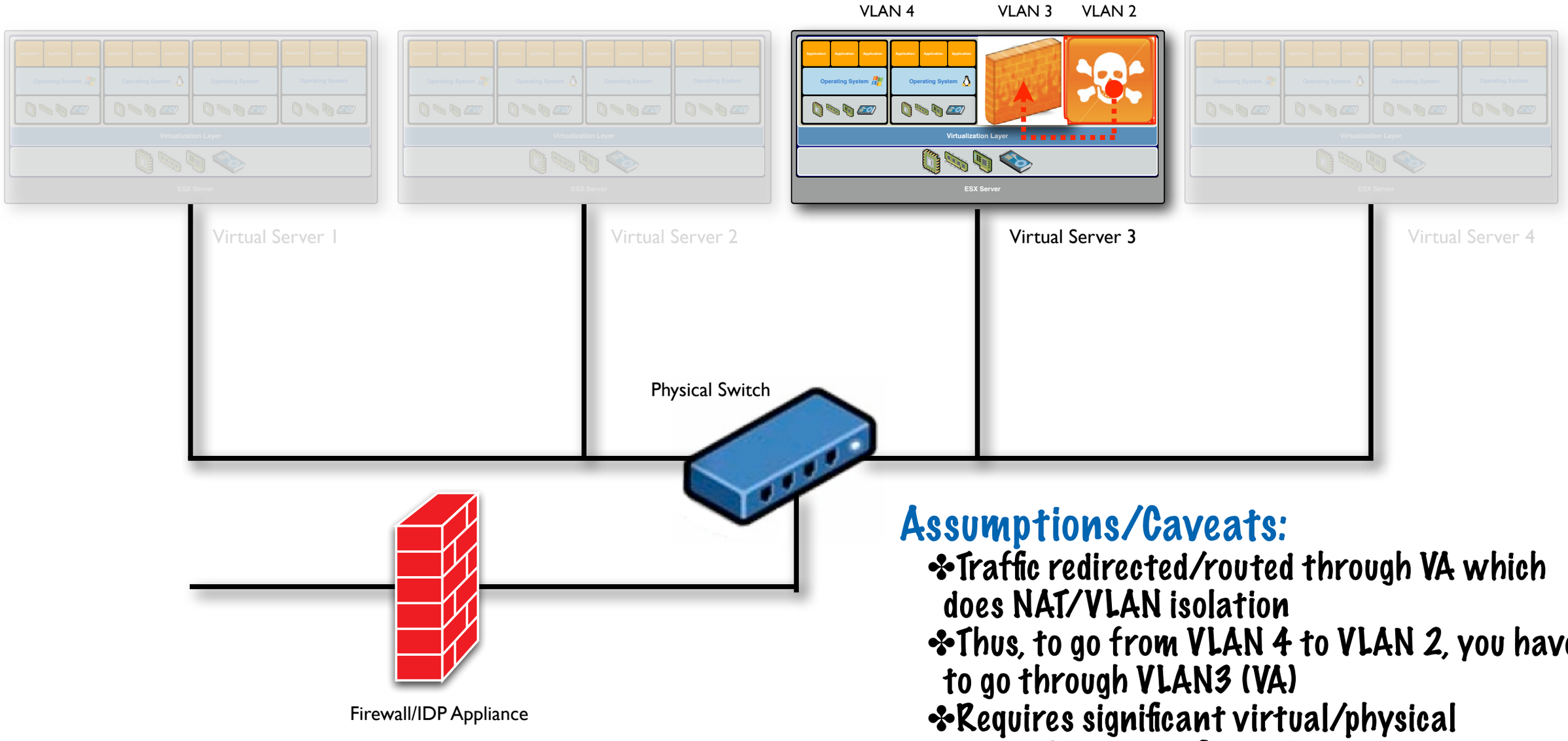


- The trick is forcing the traffic through the virtual appliances (if prevention is required) versus merely monitoring via SPAN for detection/monitoring
- Requires careful (and potentially extensive) virtual networking configuration
- Don't protect against intra-VM compromise in the same VLAN
- Does not directly protect the Hypervisor
- Many of these tools are more about visibility & vizualization than they are pure security
- Virtual Appliances are VM's! They are software & exploitable!

ALTOR networks · BlueLane · REFLEX SECURITY · catbird · Montego Networks Secure Switching for Virtual Environments

VirtSec Examples: Virtual Appliance with VM to VM On Different vSwitch/VLAN

Virtual Appliances

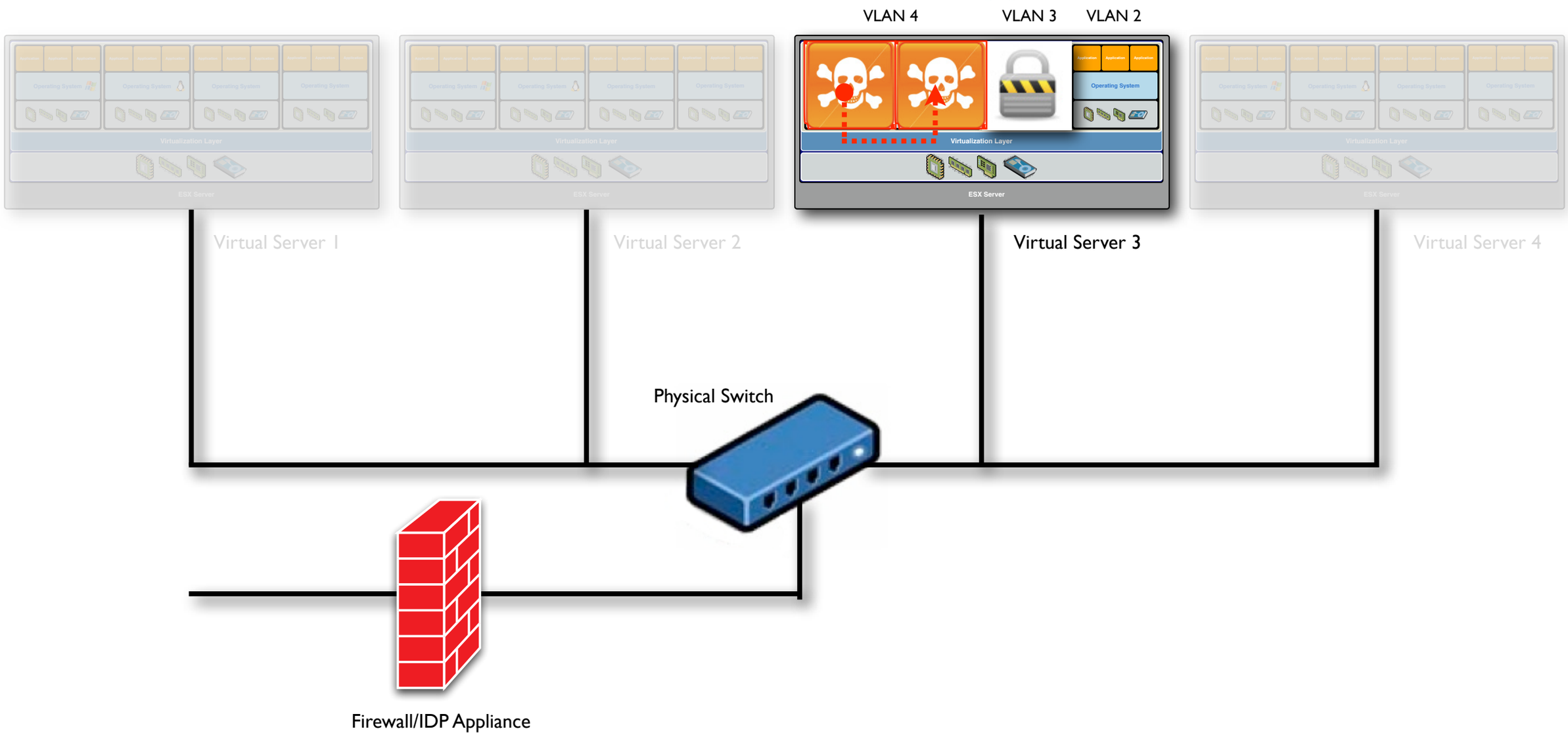


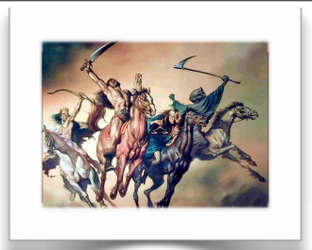
Assumptions/Caveats:

- Traffic redirected/routed through VA which does NAT/VLAN isolation
- Thus, to go from VLAN 4 to VLAN 2, you have to go through VLAN3 (VA)
- Requires significant virtual/physical networking reconfiguration

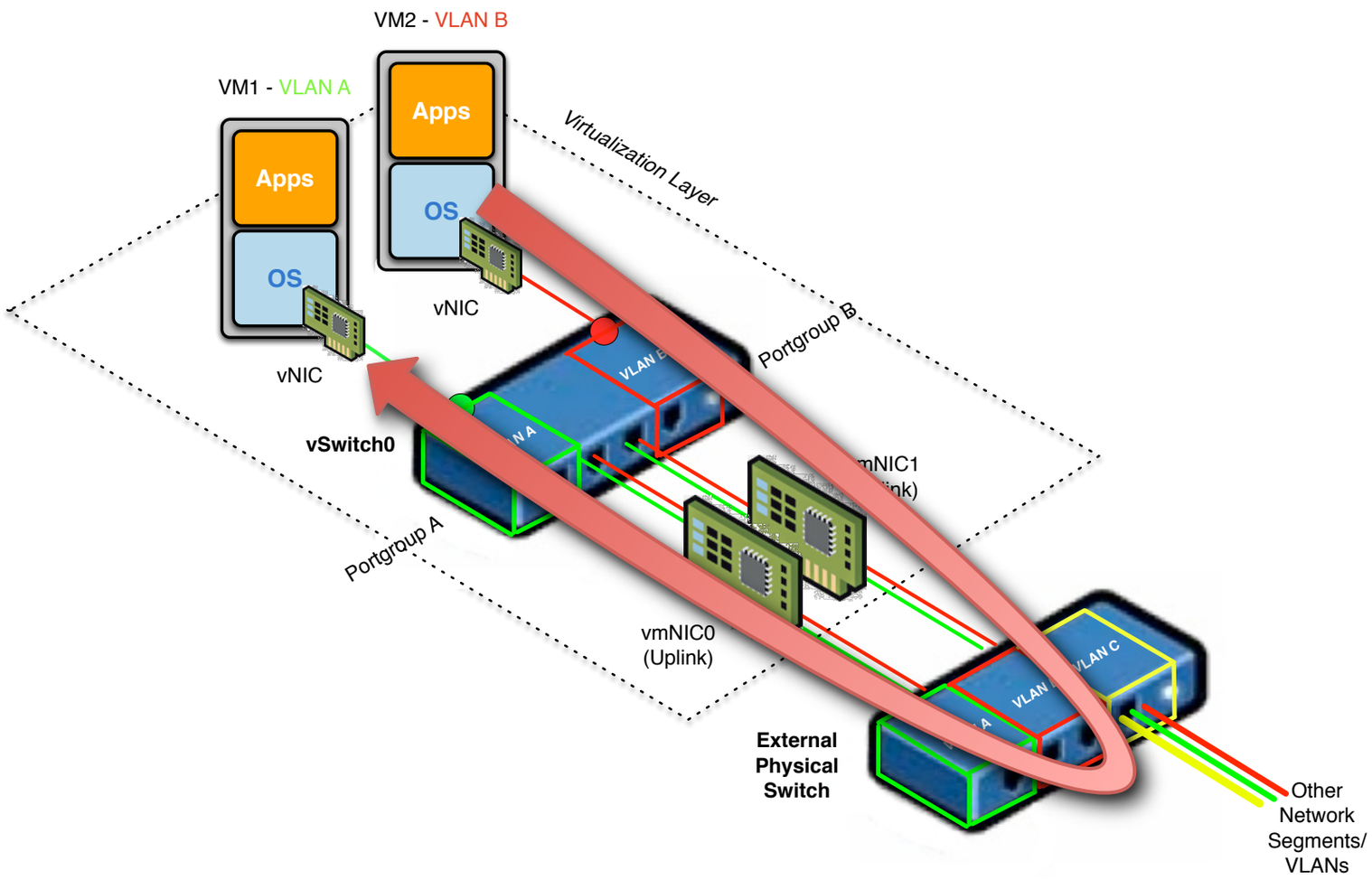
VirtSec Examples: Virtual Appliance with VM to VM On Same vSwitch/VLAN

Virtual Appliances





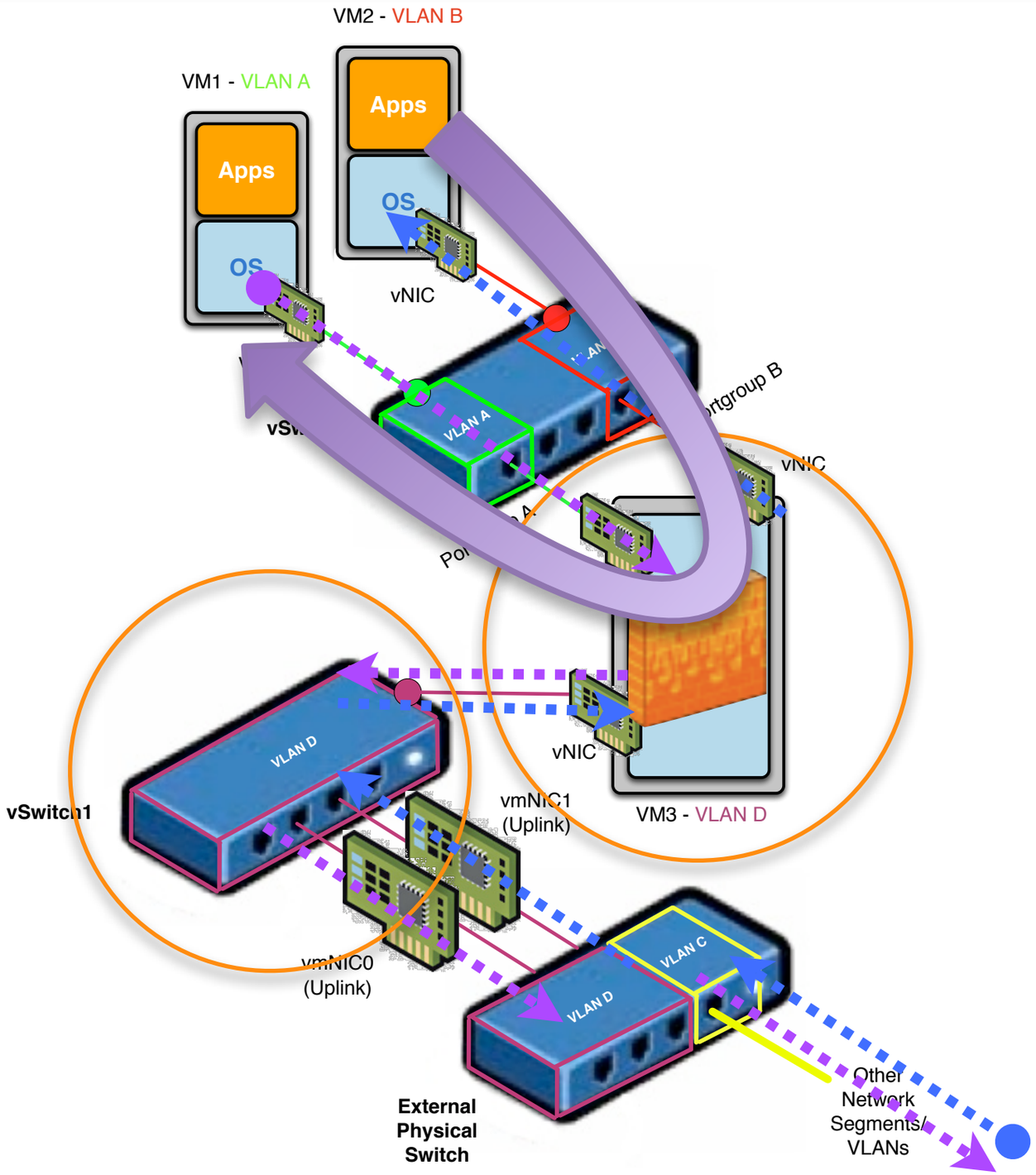
Virtual Appliances: The Devil's In the Details



Here we have a basic multi-VM configuration without a virtual security appliance:

- Two VM's, sharing a single vSwitch
- Each VM sits on its own VLAN/Portgroup
- For traffic to make it's way from VLAN A to VLAN B, the traffic must traverse the Uplinks to the external switching/routing fabric
- VLANs A and B are advertised to the rest of the network via VLAN/Subnet C

Virtual Appliances: The Devil's In the Details

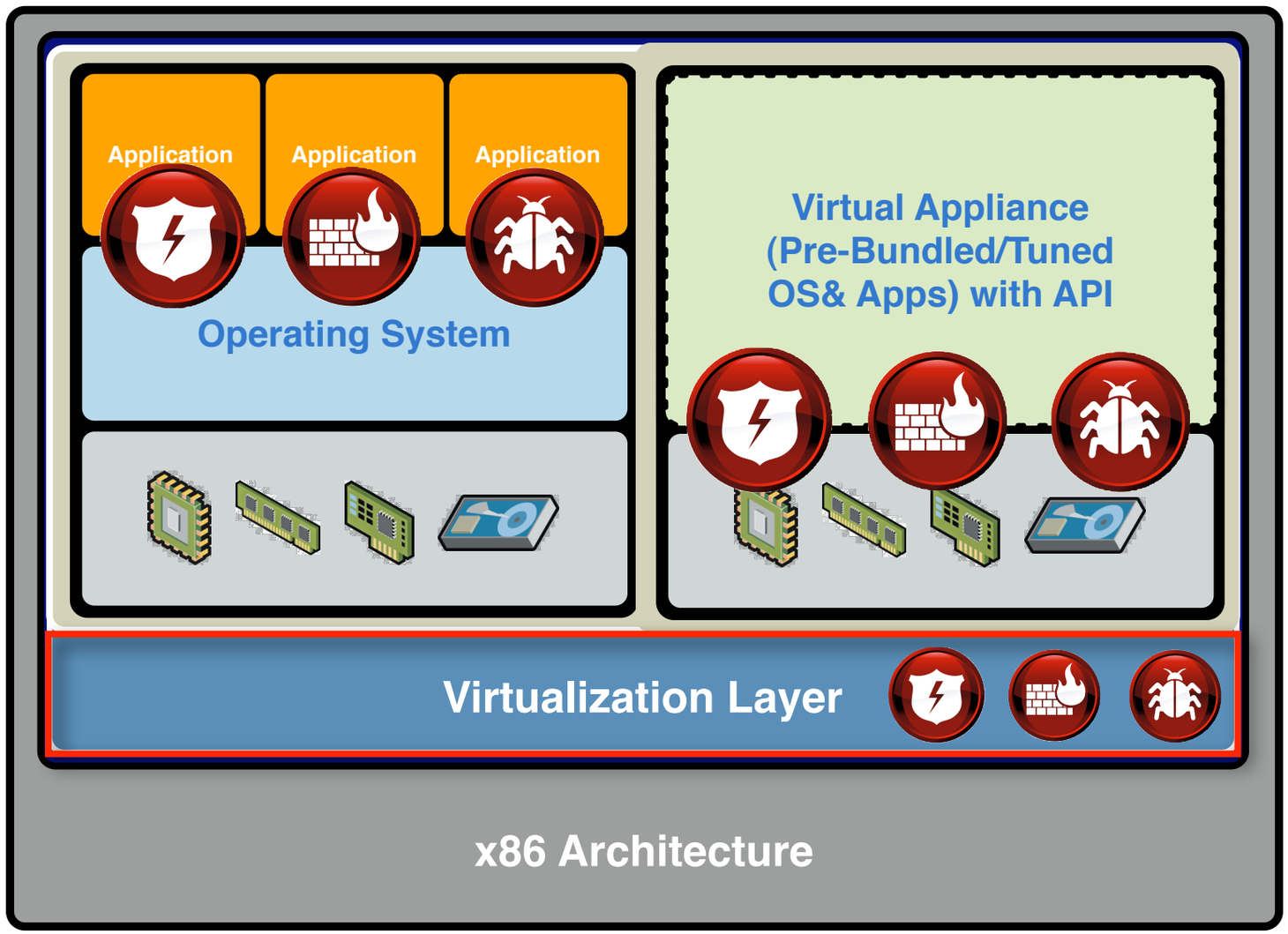


The Revised Configuration:

- VLANs A and B are now isolated on vSwitch0 with no uplinks
- VM1 and VM2 bridged/routed by VM3 (Virtual Appliance)
- VM3 also connected to vSwitch1
- For traffic to make it's way from VLAN A to VLAN B, the traffic must traverse VM3 (the virtual appliance)
- VLANs A and B are no longer advertised to the rest of the network
- VLAN D transports and thus the VA controls all intra-VM traffic and processes all externally-bound traffic

What's Coming...

VirtSec Examples: VMM/ISV API's



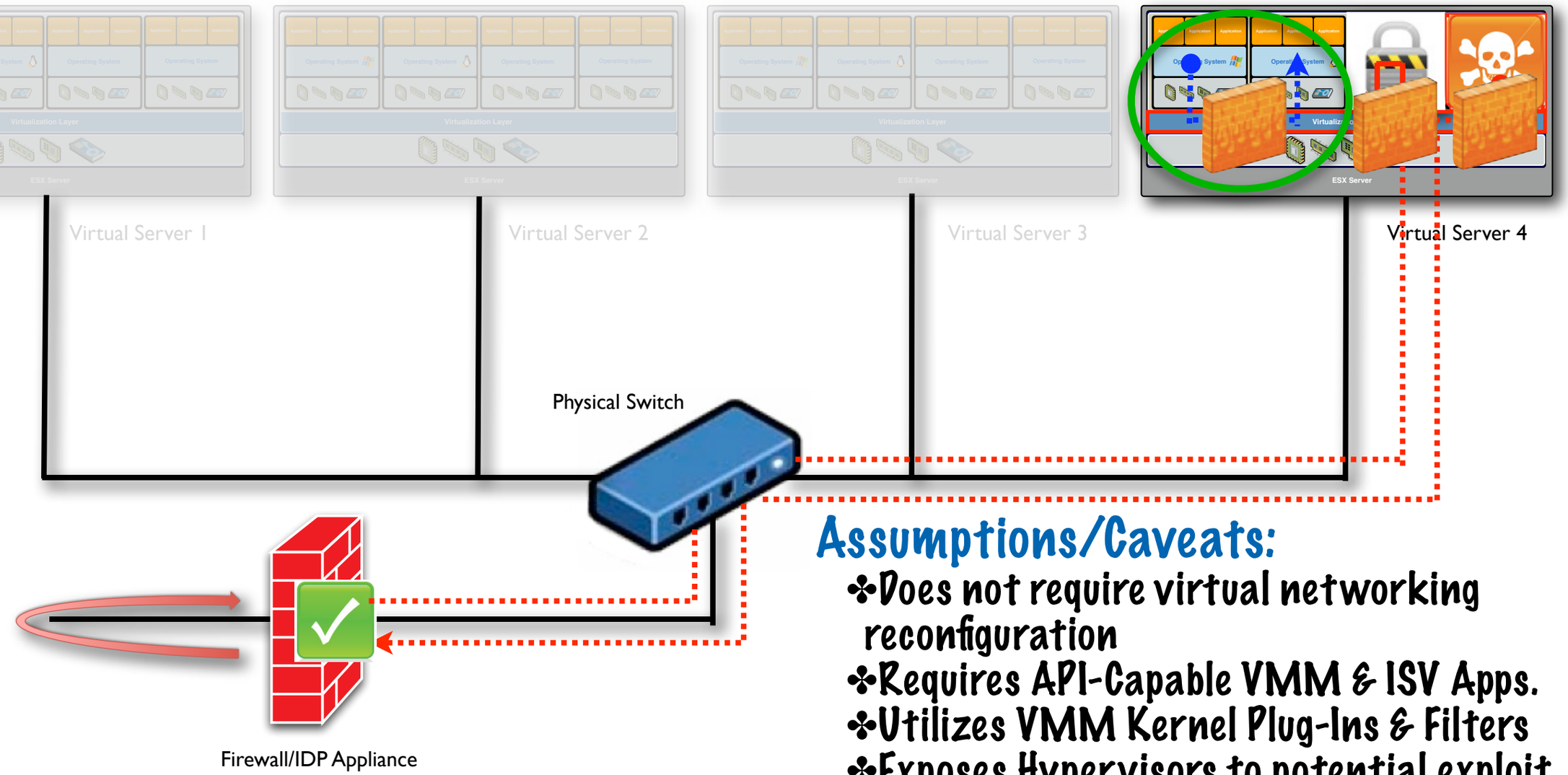
VMware VMsafe

Enables ISV partners to build security solutions in the form of a virtual appliance utilizing API's that interact with hypervisor extensions to provide for monitoring and protection of memory/CPU, networking, process execution and storage.

XenAccess

XenAccess is a library that simplifies the process of memory introspection for virtual machines running on the Xen hypervisor.

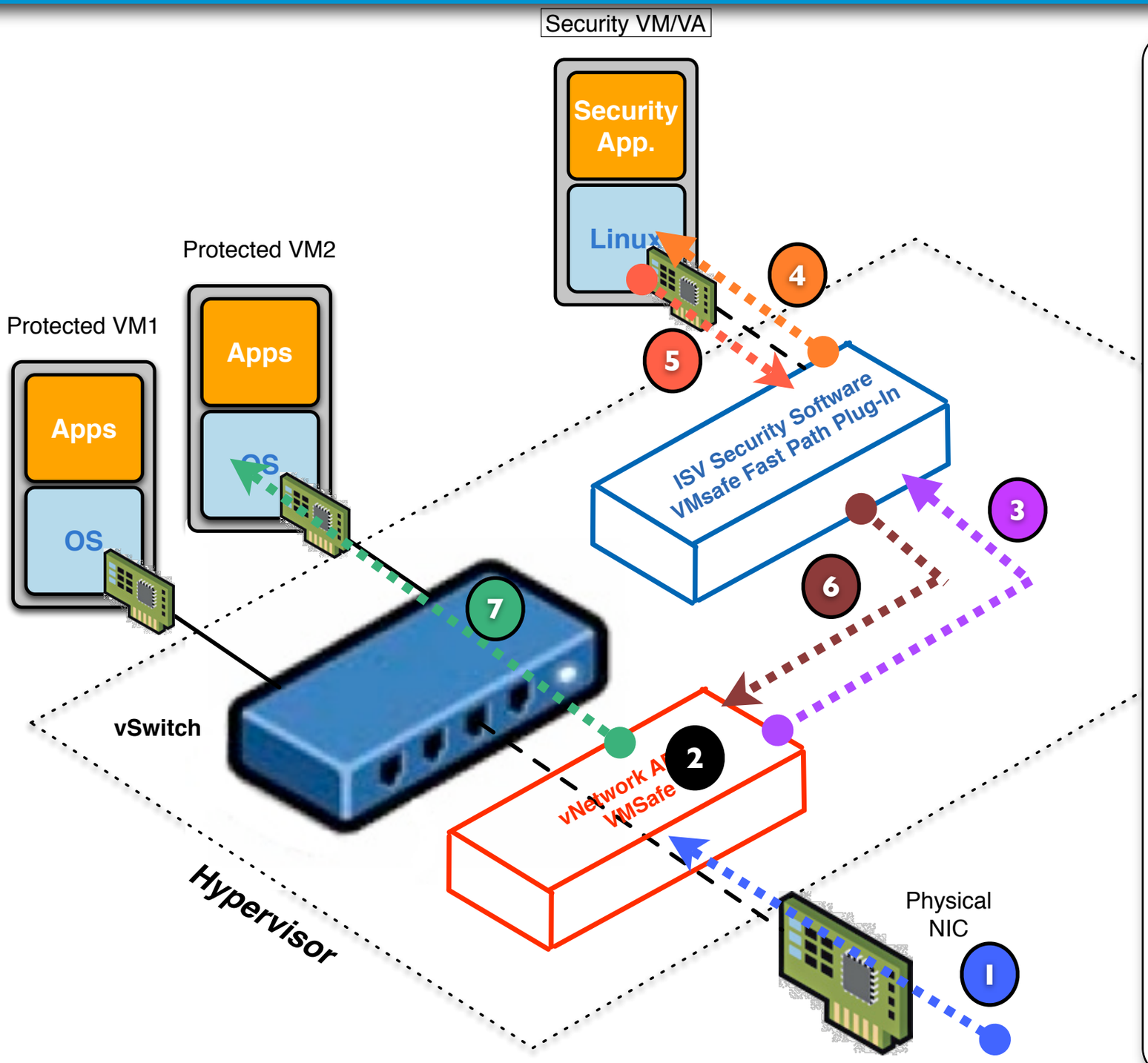
VMSafe API's: Network Introspection



Assumptions/Caveats:

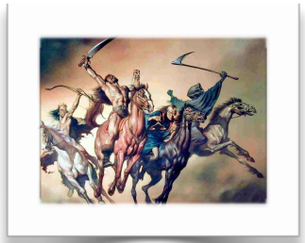
- Does not require virtual networking reconfiguration
- Requires API-Capable VMM & ISV Apps.
- Utilizes VMM Kernel Plug-Ins & Filters
- Exposes Hypervisors to potential exploit

Simplified VMSafe - Net API Example

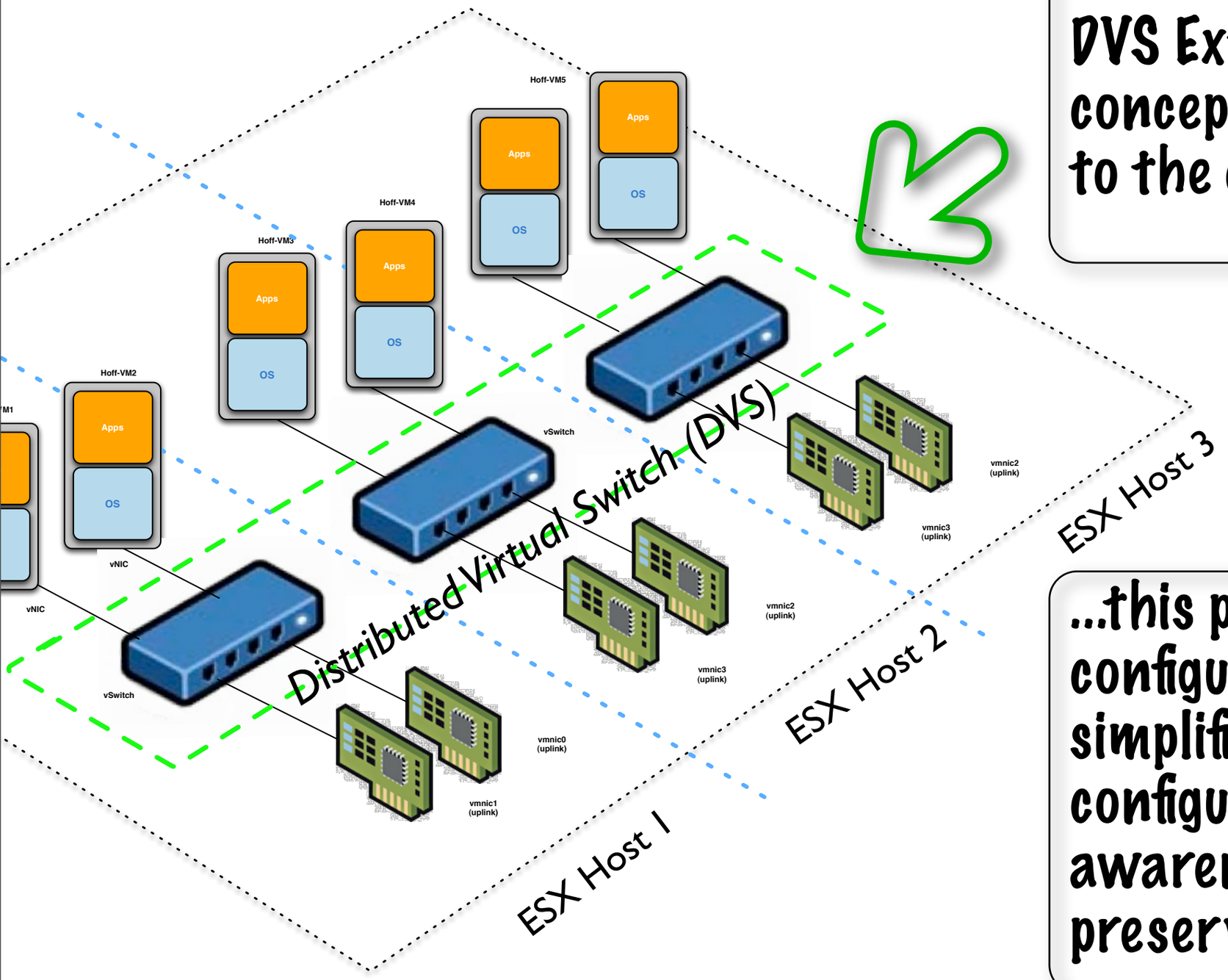


1. Traffic enters via physical NIC destined for Protected VM2 and intercepted by API-enabled VMM
2. vNetwork/VMsafe API configured via Filters to send traffic destined for PVM2 to Security VM/VA
3. API passes traffic to Security VM/VA VMM Fast-Path Plug-in Driver
4. Traffic now passed between fast-path & slow path drivers in VA/VM
5. Processing/Disposition effected by security VA/VM and passed back from slow-path to fast-path drivers
6. Traffic passed back via API/Drivers
7. Traffic sent on it's way via the virtual switching infrastructure to PVM2

PacketFilter



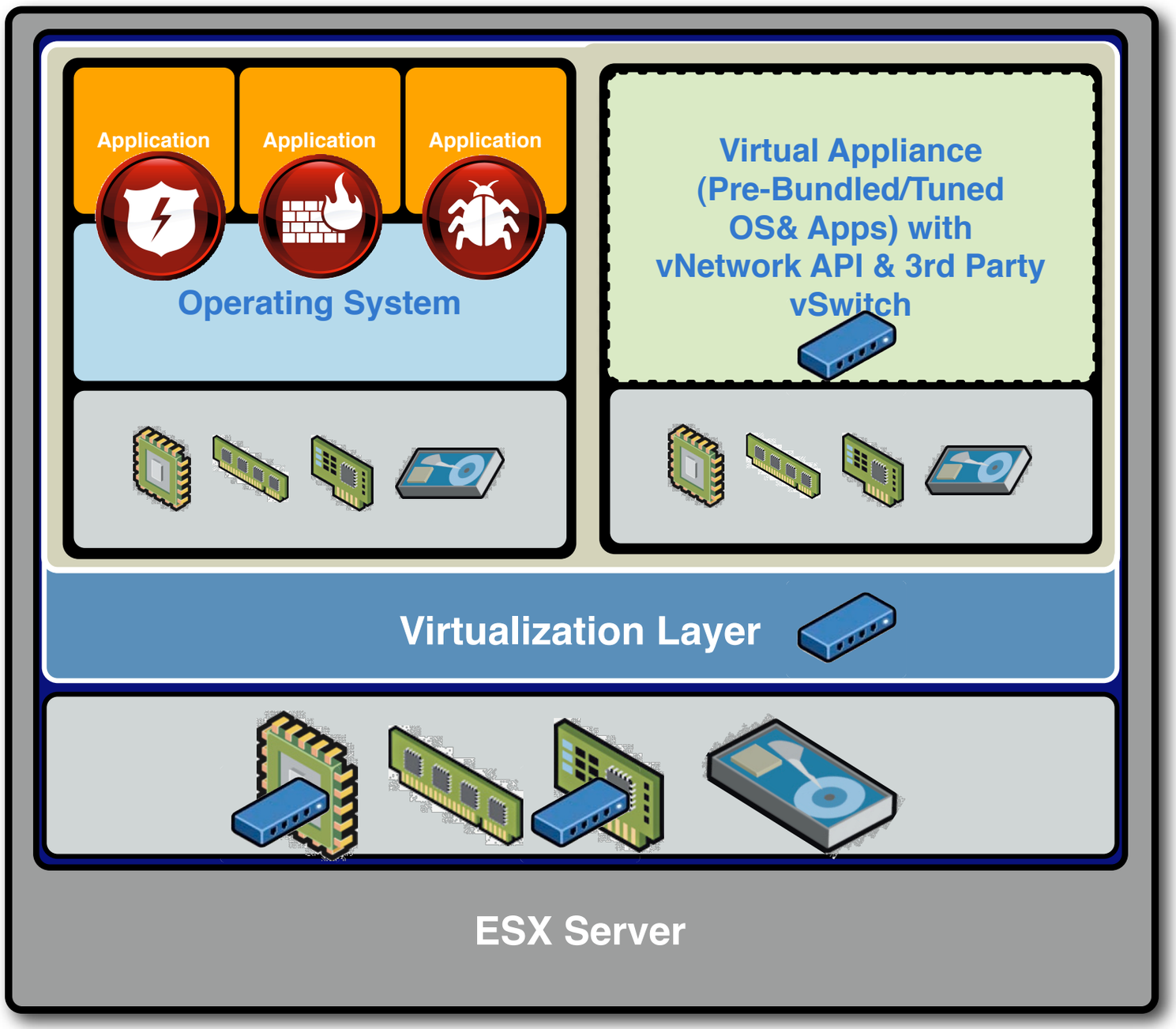
VMware vNetwork API's (Networking)



DVS Extends the virtual switch concept from the individual host to the cluster/datacenter level

...this provides for networking configurations that allow for simplified management, VM-configuration/mobility awareness & policy affinity , the preservation of VM state, and...

Third Party vSwitches

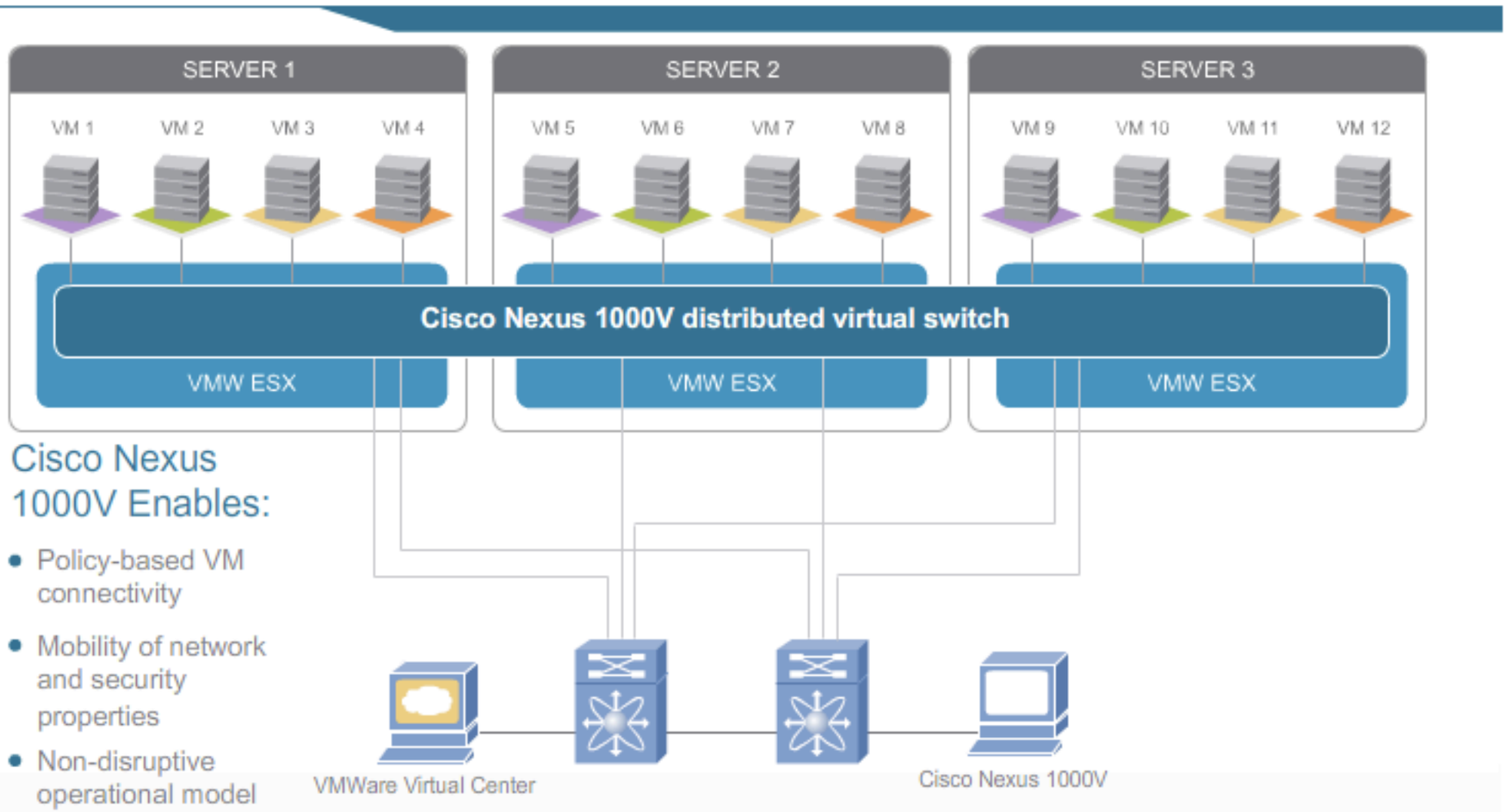


Third Party vSwitches

- Acts as a policy-driven intelligent disposition director to 3rd party security functions
- Allows integration/replication of external software, fabric capabilities and policy
- Consistency in networking capabilities
- Additional networking functionality (load-balancing, QoS, L3-7, etc...)
- Starting to appear in some very interesting places
- ...and will introduce some very interesting security and management challenges

Example: The Cisco Nexus 1000v

Cisco Nexus 1000V Architecture



Cisco Nexus 1000V Enables:

- Policy-based VM connectivity
- Mobility of network and security properties
- Non-disruptive operational model

Policy Based VM Connectivity	Mobility of Network and Security Properties	Non-Disruptive Operational Model

Virtualizing the Network Domain

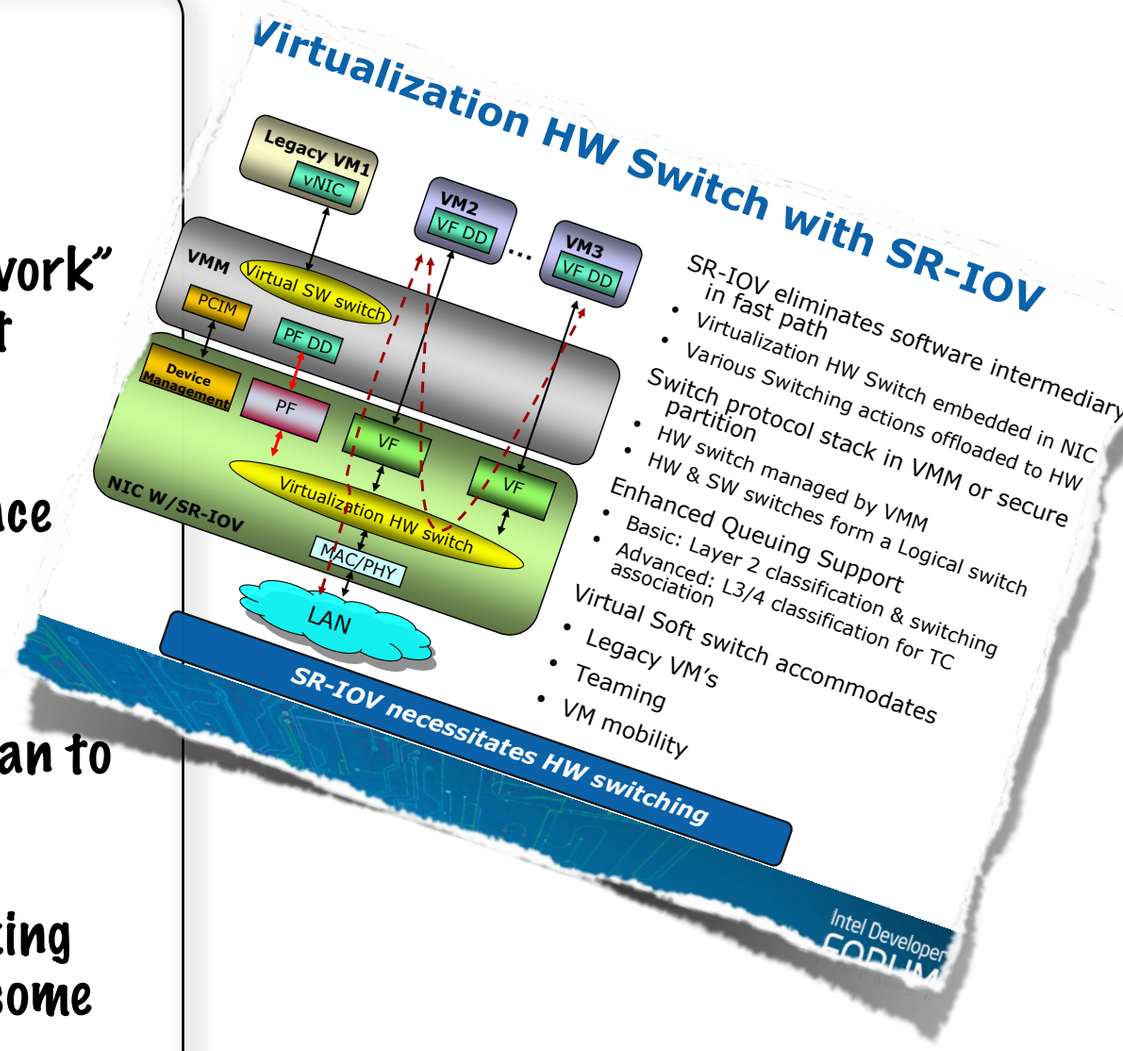
A Fly In the (Virtual) Ointment

I/O Virtualization

Virtualizing Soft Switches Into Hardware: Example Of a Virtual Security Headache

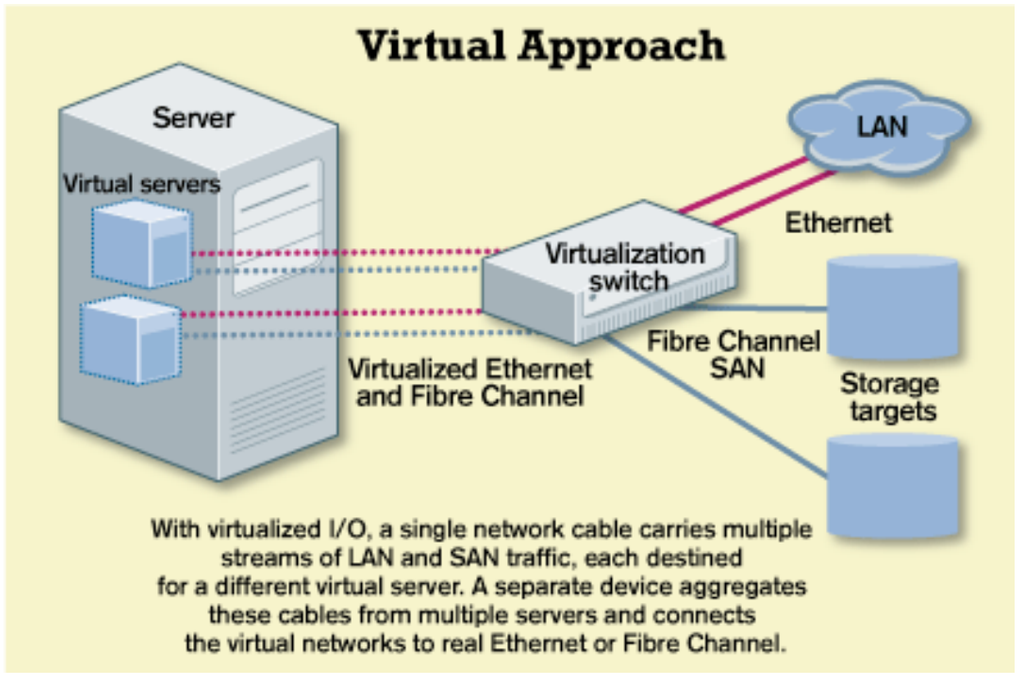
IOV is great for solving performance/scalability issues, but how will it affect security?

- It's already becoming difficult to grasp where "the network" is, who owns it, how we manage it and how to secure it
- A mélange of components providing the networking functions will add complexity, expand the attack surface and potentially limit visibility further
- What will technologies/approaches such as direct assignment bypassing the VMM and SR-IOV in NICs mean to security virtual appliances running on the hosts?
- Crossing the streams is "bad." Allowing some networking via vSwitches, some in the CPU, some in software and some in the NIC sounds awfully messy.
- What happens when the hardware is not homogenous? It's great to see partnerships that deliver things like VMDirectPath, but what about Citrix, Hyper-V, etc...?



NetEffect · Neterion · intel · Mellanox Technologies

IOV Appliances: Just To Make It More Fun!



w00t! World Domination!

- Single network connection provides virtualized fabric interconnectivity for LAN & SAN
- Claws the Access Layer back to the network switches
- All your VM's (and security) are belong to us!

- Cisco 5000/7000 Nexus
- Brocade DXC Backbone
- 3Leaf V-8000 Virtual I/O Server
- Xsigo I/O Director

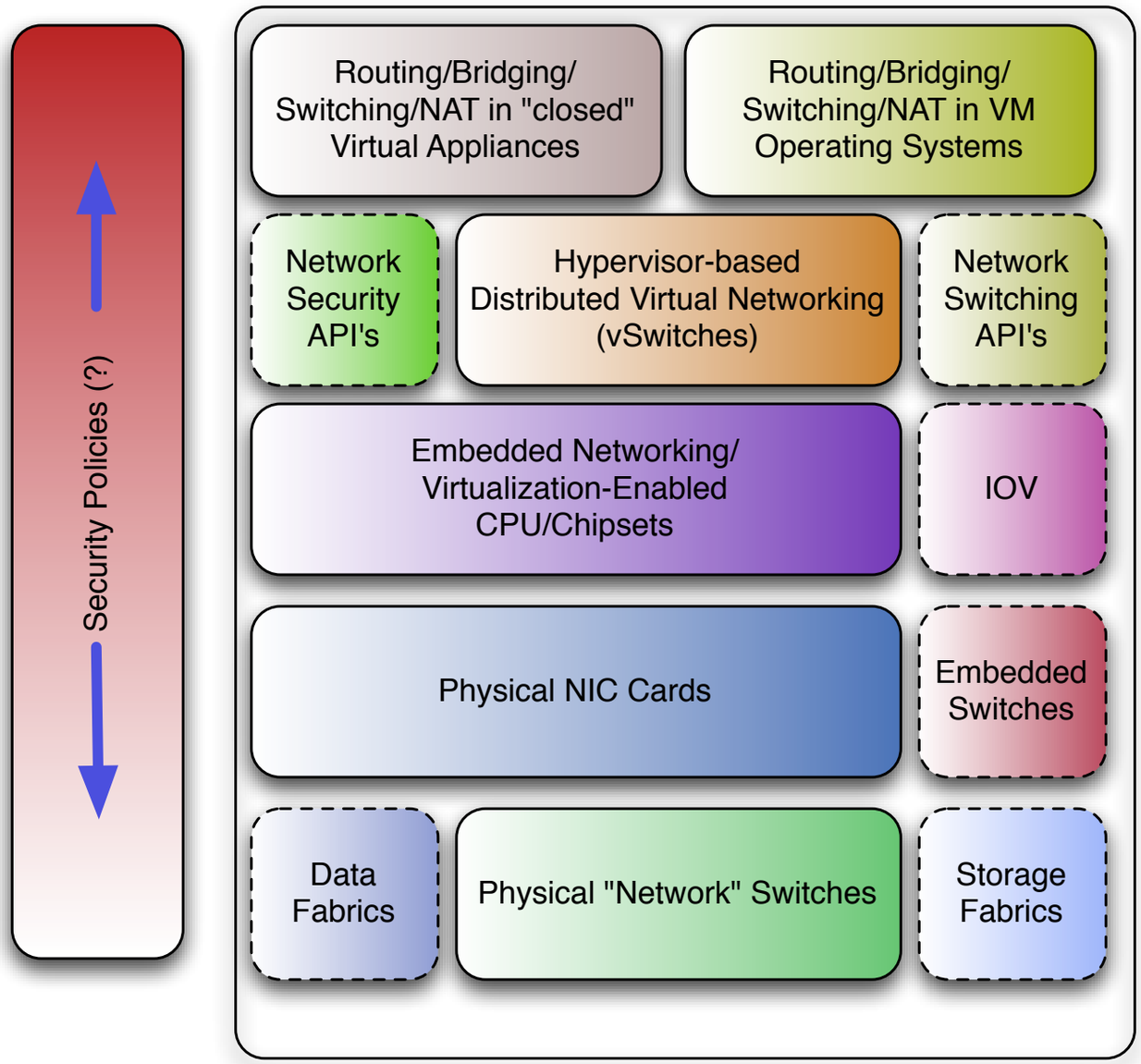
3LEAFSYSTEMS

xsigo systems

BROCADE

Where Isn't the Network?

"Networking" Element Stack



Examples

- Customized networking stacks/slowpath driver/ network stacks in virtual appliances and IPv4/6 network stacks with iptables/brctl (e.g. Linux)
- vNetwork VMsafe & Switching API's across distributed virtual switches using fastpath kernel modules integrated with VMware vSwitch and Cisco Nexus 1000V
- Intel CPU's with VT-d and SR-IOV
- Converged Network/Storage Adapters and/or NICs with embedded switching and offload
- Physical Cisco Catalyst/Nexus Switches for both networking and storage

...and the hits keep comin'

- Virtualization is simply the platform enabler
- Real Time Infrastructure (RTI) with self-governing adaptation, provisioning and autonomics is here
- MSSP/IaaS/SaaS/Clean Pipes/Cloud/Grid/Utility/Distributed computing is maturing
- How are we going to secure the abstraction of a cloud-based, dispatched virtualized set of processes, memory space, storage and I/O?

The End Is Nigh! Run Away!

- Setup
- Virtualization In Context
- Virtual Networking Architecture
- VirtSec Solutions Landscape
- The Four Horsemen
- Wrap-Up

Bring On the Pwnies!

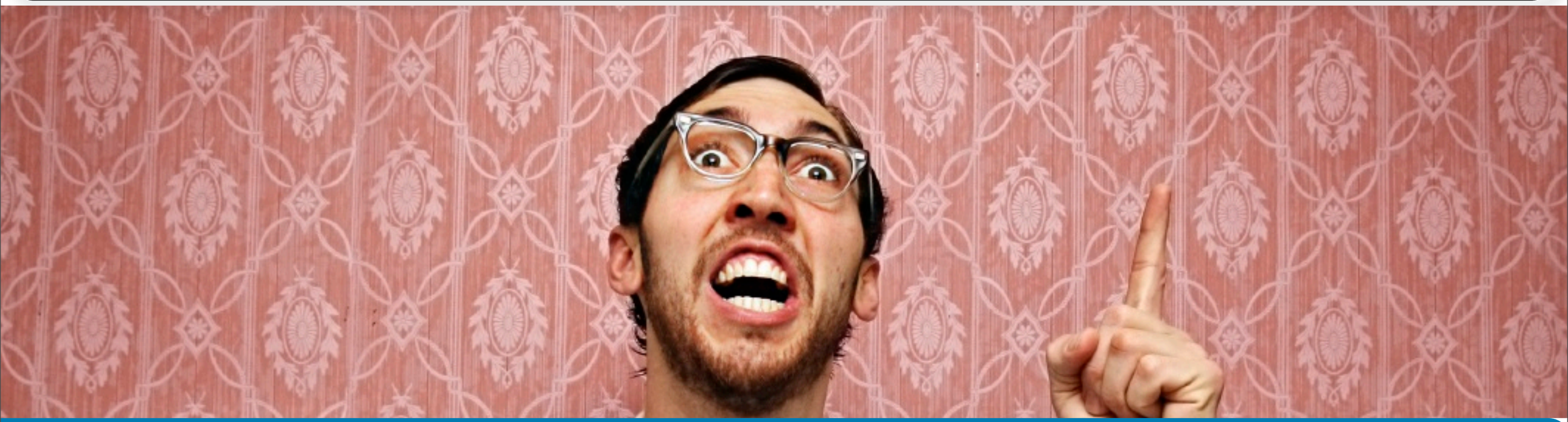
The Four Horsemen of the Apocalypse represent the "...forces of man's destruction described in the Bible in the Book of Revelations" and are "...named after the powers they represent"*

- War
- Pestilence
- Death
- Famine

*Wikipedia

Vini, Vidi, Wiki...

1. Monolithic security vendor virtual appliances are the virtualization version of the UTM argument
2. Virtualized Security can seriously impact performance, resiliency and scalability
3. Replicating many highly-available security applications and network topologies in virtual switches don't work
4. Virtualizing security will not save you money, it will cost you more



Example: Virtualizing the DMZ*

Typical Screened-Subnet DMZ:

- Trust zones separated by physical controls on separate switches & host groups/ clusters

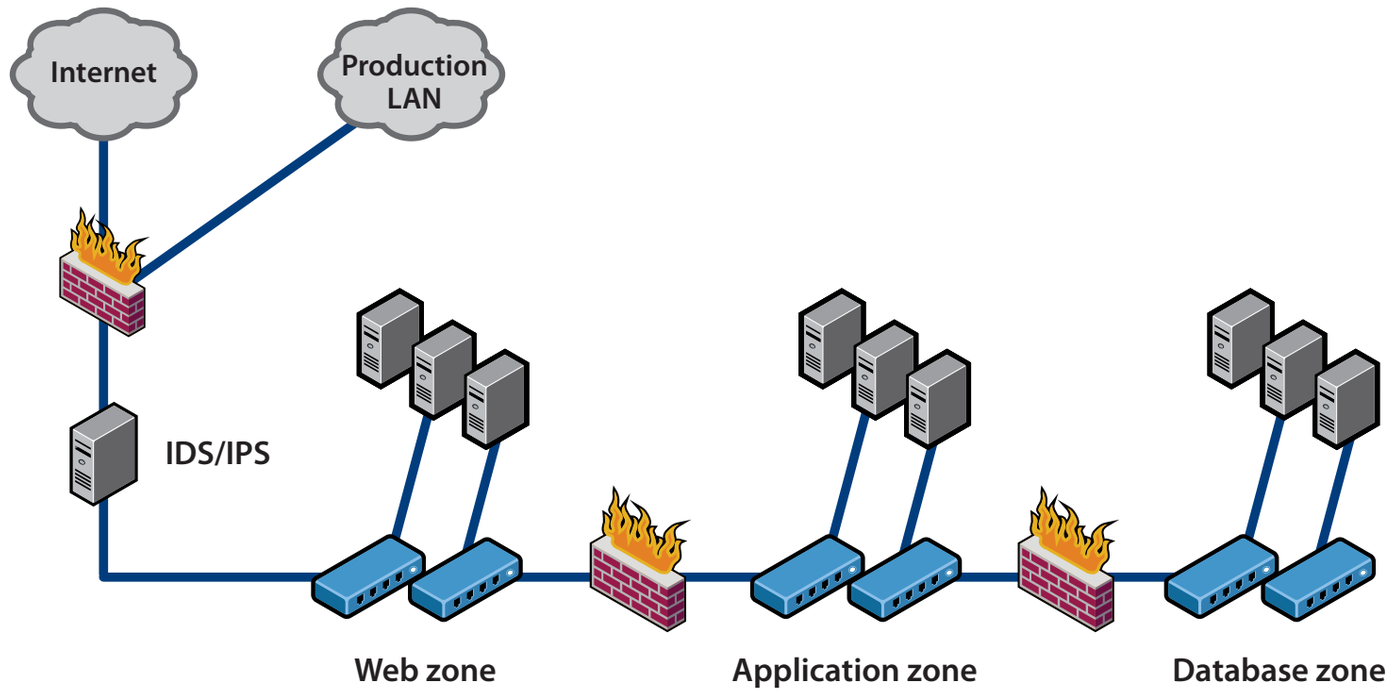


Figure 1 — A typical DMZ in a physical environment

*Images/Concept from VMware Whitepaper: DMZ Virtualization with VMware Infrastructure

Example: Virtualizing the DMZ*

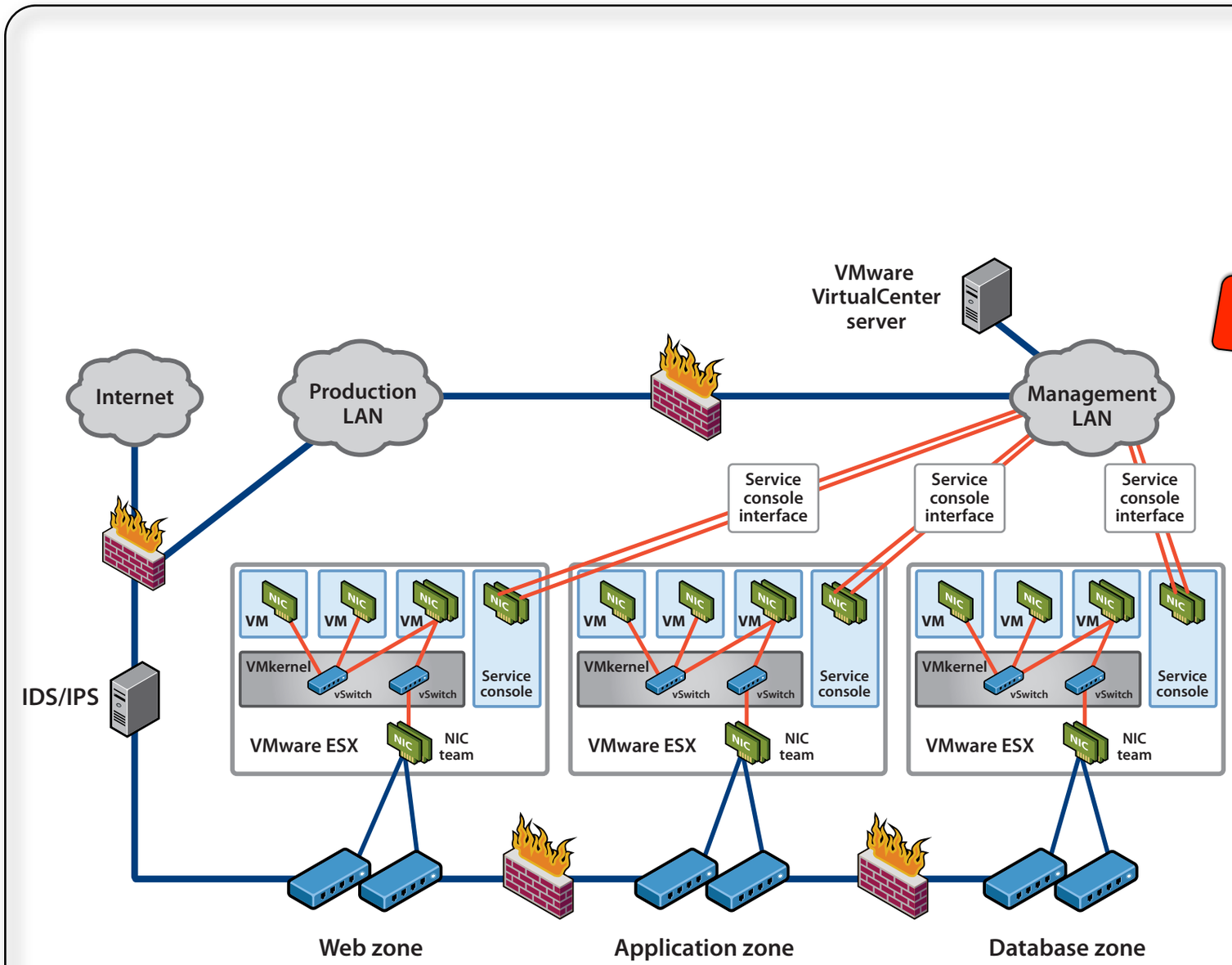


Figure 3 — Partially collapsed DMZ with separate physical trust zones

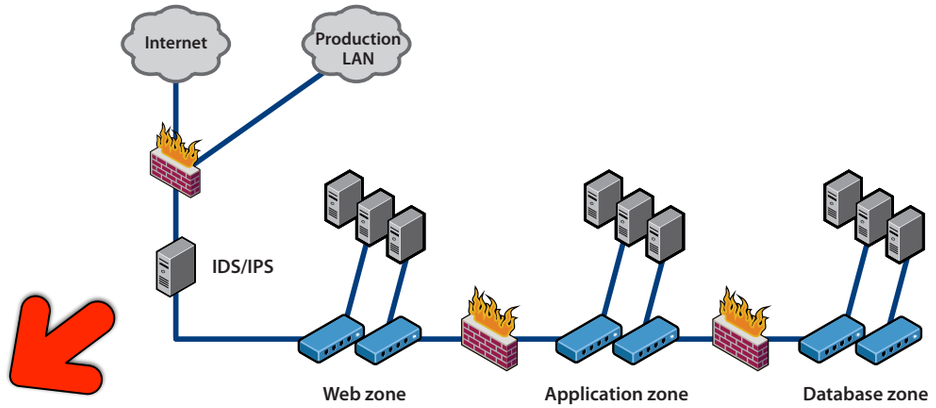


Figure 1 — A typical DMZ in a physical environment

Partially Virtualized Screened-Subnet DMZ:

- Trust zones separated by both physical controls but VM's on multiple ESX clusters

*Images/Concept from VMware Whitepaper: DMZ Virtualization with VMware Infrastructure

Example: Virtualizing the DMZ*

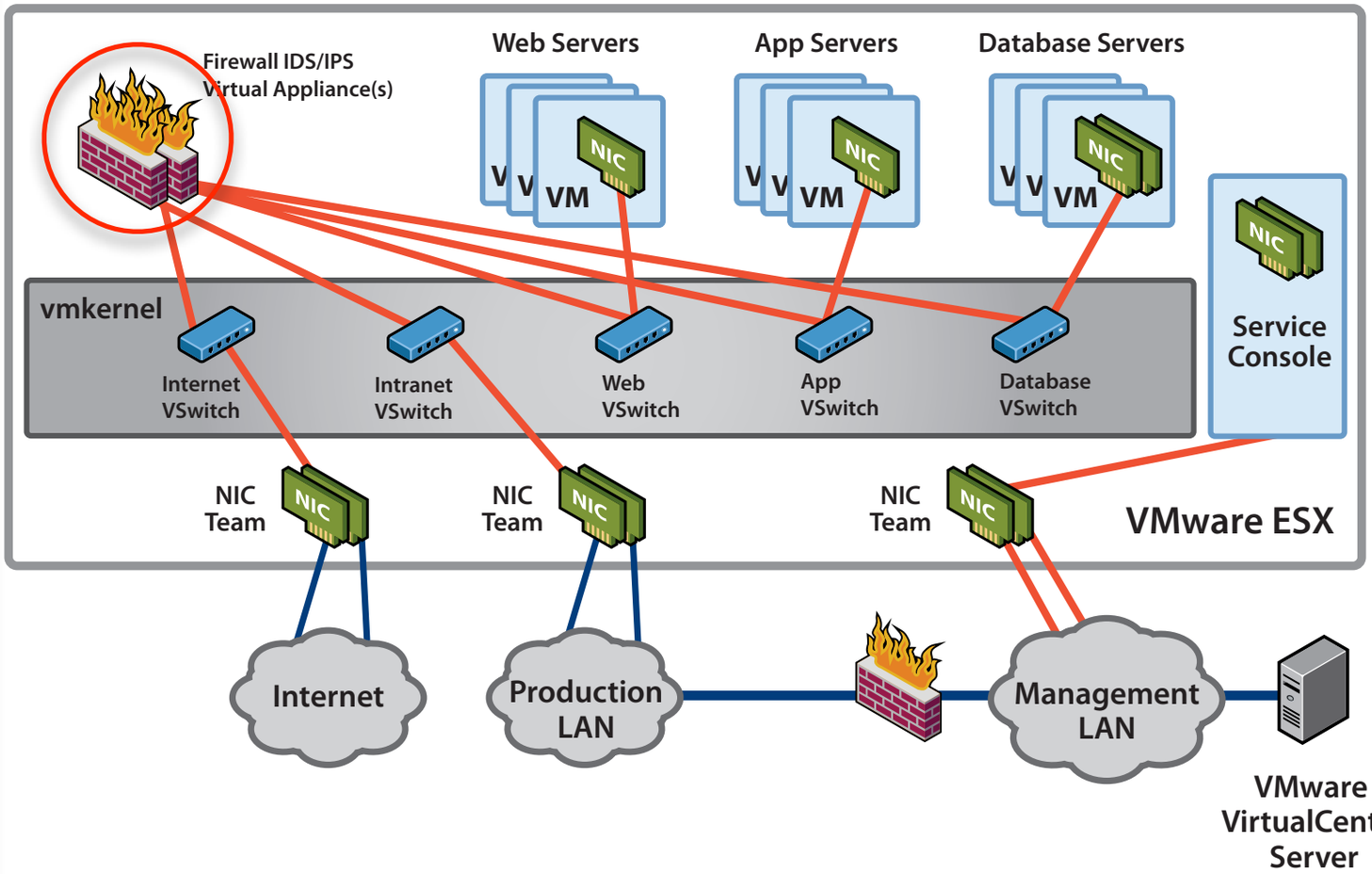


Figure 5 — Fully collapsed DMZ

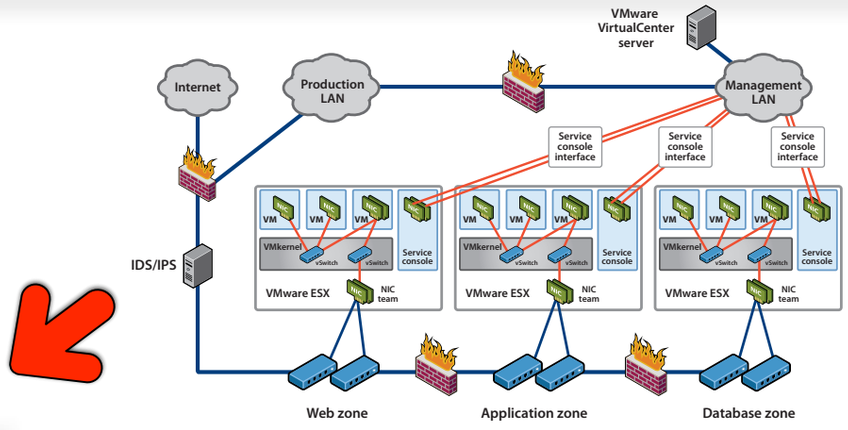


Figure 3 — Partially collapsed DMZ with separate physical trust zones

Completely Virtualized Screened-Subnet DMZ:

- Trust zones separated by virtual controls on a single ESX Cluster

*Images/Concept from VMware Whitepaper: DMZ Virtualization with VMware Infrastructure

Pwnie #1: War

Image: Mari Kasurinen | spippodeviantart.com

War I Episode 7: Revenge Of the UTM Clones

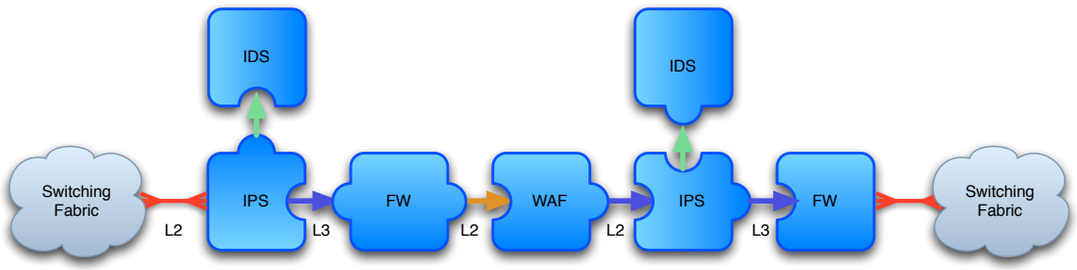
Monolithic security vendor virtual appliances are the virtualization version of the UTM argument:

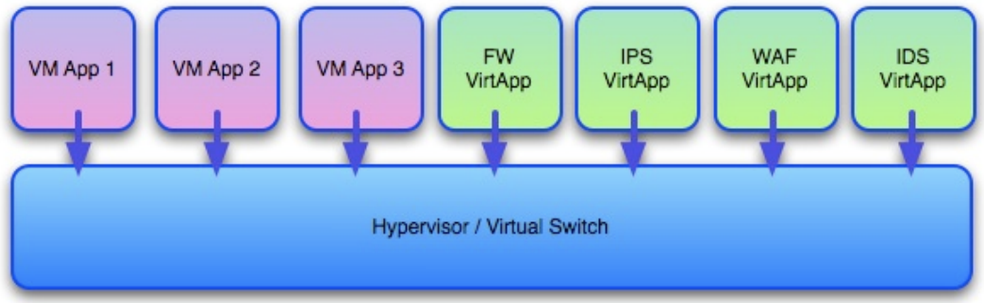
- The notion that we will deploy a single vendor/monolithic security VA in each host is silly
- If you're still stuck on "defense in breadth," you're going to deploy more than one security virtual appliances on each host
- UTM performance sucks when you flip all the switches

The VAUTM Conundrum

- How do you ensure that traffic is statefully directed to the appropriate individual in-line security bumps in the stack?

- The more security VA's you add, the less VM's you can service





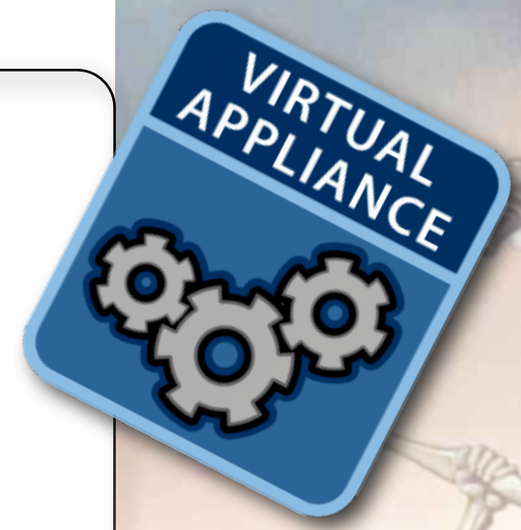
Pwnie #2: Pestilience

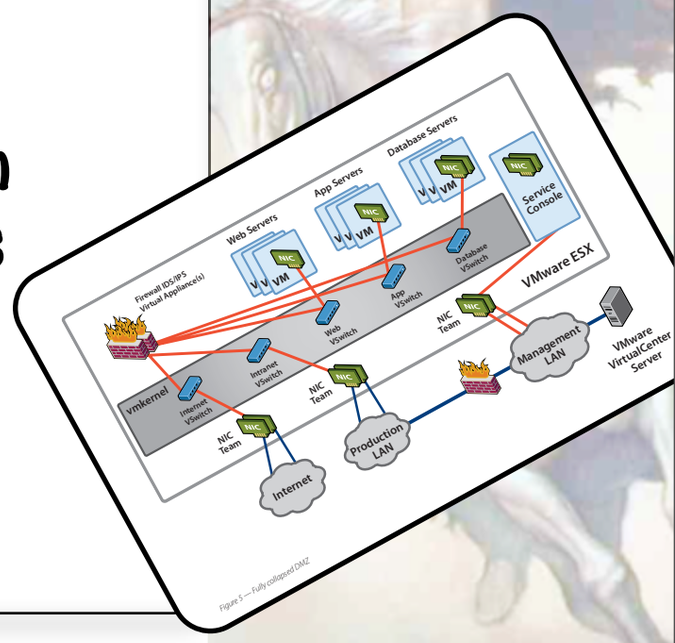
Image: Mari Kasurinen | spippodeviantart.com

Pestilence | VirtSec Screws the Capacity Planning Pooch!

Virtualized Security can seriously impact performance, resiliency and scalability

- Performance overhead of in-line security VA/VMs & API's is extremely difficult to predict
- Today we rely on multiple load-balanced high-performance multi-core COTS H/W or dedicated ASIC/FPGA equipped appliances for acceptable throughput/low latency...
- We're now going to expect that software based VA's which are not optimized or do not utilize paravirtualized drivers to perform the same?
- Security functions are competing for the same resources as the VM's you're trying to protect

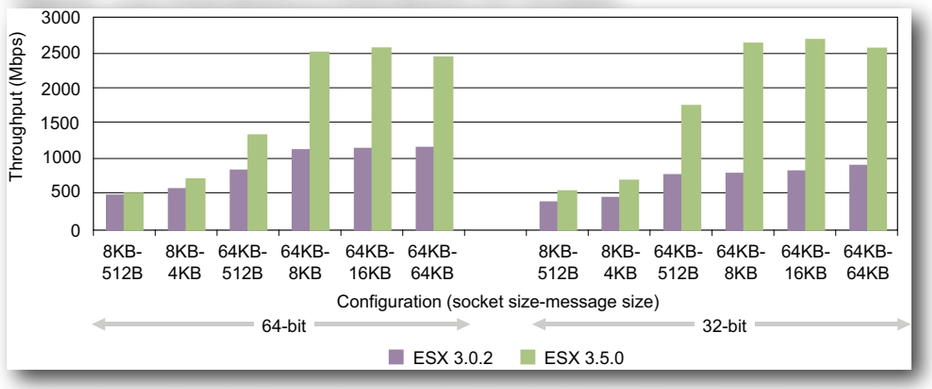




Drinking From the Firehose

- VMware showed tests* with linux-based VM-VM throughput on the same vSwitch of ~2.5Gb/s
- Most dedicated hardware appliances have trouble at those rates at small packets/low latency
- What happens when you try to choke every flow through a non-optimized, software-only virtual appliance in/out of every VM?
- What happens when we add multiple 1Gb/s or 10Gb/s bonded pipes feeding our servers?

Figure 9. Linux Virtual Machine to Virtual Machine TCP Throughput



Thus, the virtual machine to virtual machine TCP throughput on ESX Server 3.5 can exceed 2.5 Gbps for some operating systems while speeds of physical networks with 1 Gbps NICs are limited to approximately 950 Mbps.

*Networking Performance VMware® ESX Server 3.5

Public Service Announcement

Every time you deploy a security virtual appliance...

God kills a kitten.

Pwnie #3: Death

Image: Mari Kasurinen | spippodeviantart.com

Death I The Network Is The Computer?

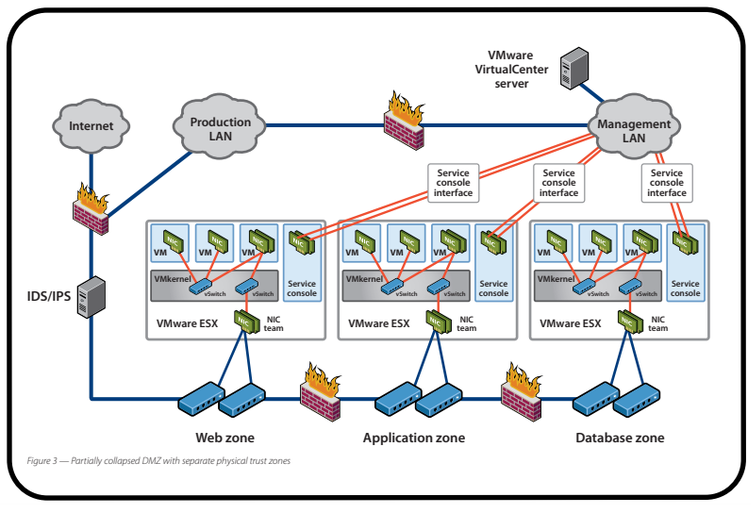
Replicating many highly-available security applications and network topologies in virtual switches don't work

- Security applications are incredibly topology sensitive
- Affinity between the physical, logical and policy elements breaks when things move
- It's not that you can't get network-based HA to work, it's the support of the applications and their secret sauce that breaks.
- Most physical appliances use heavily tweaked kernels and drivers which aren't supported natively in virtualization stacks; performance suffers and HA may no longer work
- Failover and HA/LB options for stateful security applications currently suck

...But the Security Application Failure Recovery Options Suck*

What happens when these security virtual appliances fail?

- Application-level and VMware HA clustering do not take into consideration the network topology sensitivities of security applications
- Security applications and the networking stacks are not stateful and do not exchange telemetry
- Moving the security VA to another box leaves the VM's unprotected or disconnected/isolated on the original
- Failing over an entire cluster-member's inventory of VM's due to the failure of a security component is ludicrous



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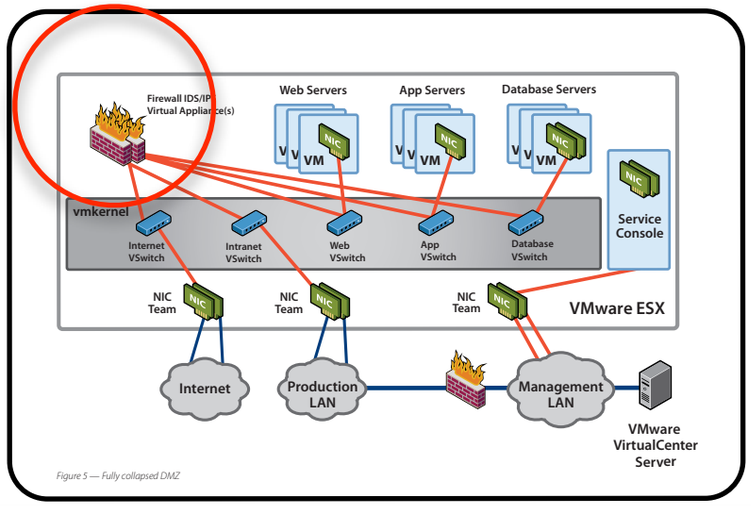


Figure 5 — Fully collapsed DMZ

*The upcoming distributed virtual switching (vNetworking) and Cisco Nexus 1000v will change things

Run...It's the Fuzz!

I would really have liked to show you a cool demo with the help of my friends from ERNW (Germany) using their modified L2 Sulley fuzzing framework, abusing the HA protocols of a few security software vendors to show you how fragile these security virtual appliances are in terms of performance/ resiliency.

We set up our test bed to compare the physical appliance versions with the virtual but quickly stopped when we realized:

- Most vendors still don't offer production-ready security virtual appliances for lots of interesting reasons...
- Most of them do not offer active/active, load-balanced HA in their products
- When they do, they are loaded with untenable caveats that make the products impractical

...and yet we're being told that virtual appliances are the centerpiece of the security portfolios in these environments?

Reality Distortion Field

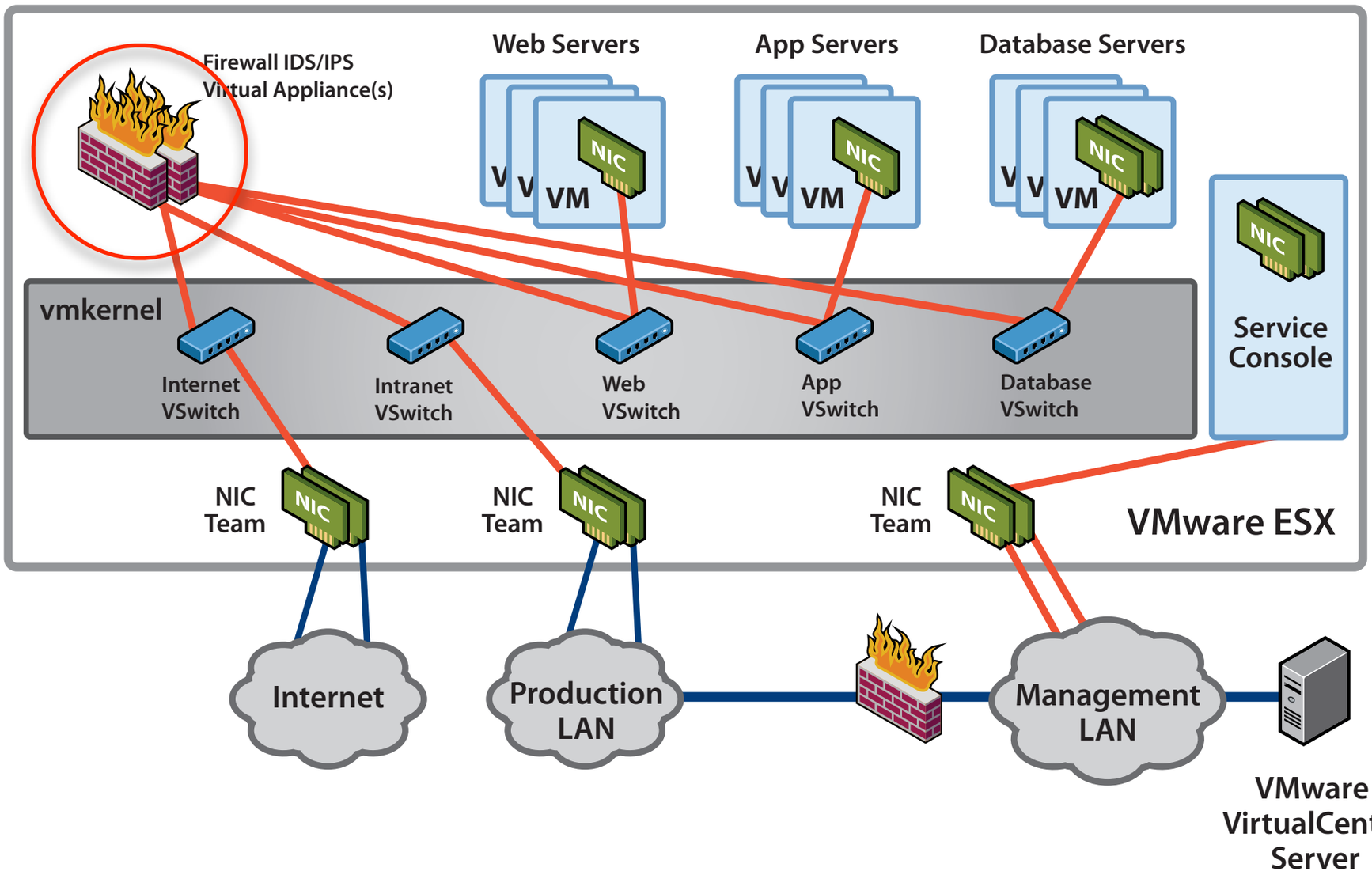


Figure 5 — Fully collapsed DMZ

*Images/Concept from VMware Whitepaper: DMZ Virtualization with VMware Infrastructure

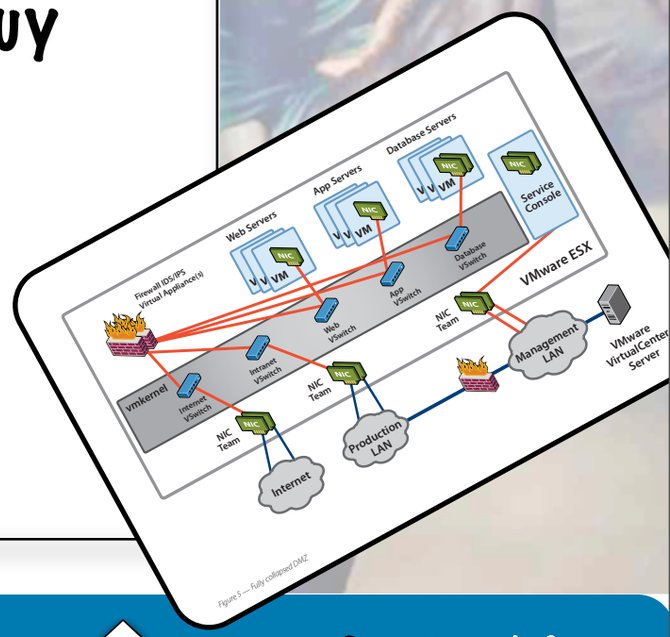
Pwnie #4: Famine

Image: Mari Kasurinen | spippodeviantart.com

Famine I Spinning VM Straw Into Budgetary Gold

Virtualizing security will not save you money, it will cost you more

- For most of this to work, we need to buy new hardware with virtualization-aware chipsets, more memory, faster/more CPU's, new vSwitches, extended management...
- We won't get rid of host-based security software
- We won't get rid of physical appliances or security line cards in switches, in fact, we'll probably have to buy more and buy bigger/more powerful switches with converged I/O
- That means that when we add VirtSec solutions, these solutions & their licenses are cost-additive
- As we add more solutions, we add complexity



Parting Is Such Sweet Sorrow

- Setup
- Virtualization In Context
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- Wrap-Up

Vini, Vidi, Wiki...

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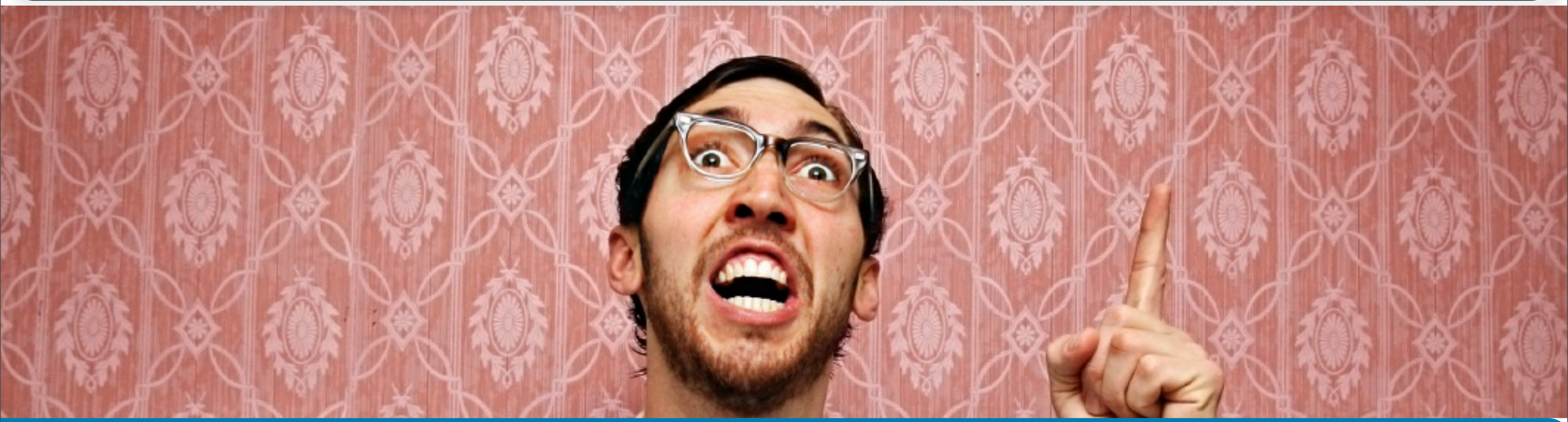

Hope Is Not a Strategy, But It Doesn't Hurt

- We need a unified approach toward virtualization with a consolidated trust model in hardware & software
- We need affinity between the VM and protection schemes/policies
- Comprehensive discovery, profiling, dynamic configuration & security management of all VM's -- online or offline
- Centralized VM registration providing telemetry that controls spin-up, state and mobility capabilities regardless of vendor based upon policies
- Intelligent networking capabilities within the virtual switching infrastructure for consistency, visibility and security including integrated virtual network admission control & access Control (vNAC)
- Correlation of telemetry between VM Management and internal/external security planes to tie in virtualization, network and security provisioning/ management into a consolidated single pane of glass

What Does This All Mean?

- Networking & Security are supposed to be getting easier, simpler and cheaper with virtualization...
- Security is going to get harder and our solution portfolios are immature at best
- We're in the midst of the cyclic flip-flop between the virtualization-powered abstraction of resources as a software-enabled layer and the realities that hardware isn't going away and is flexing its muscle
- We can't afford virtualization to continue to be siloed; the compute, security, networking, and storage fiefdom approach is dangerous

INFORMATION SECURITY DECISIONS

Thank You Cleveland!