



Virtualization & Cloud Computing

Corso di: Big Data Architectures

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Handwritten red circle around a green cooling unit on the ceiling.

Handwritten red scribble on the right server rack.

Handwritten red number '18' in the center aisle.

Handwritten red number '10100' near the bottom right rack.



Structure

- | Elements of cloud Computing
 - ♣ Motivation and definitions
- | Virtualization
- | Cloud Computing
- | High Availability
- | vSphere Infrastructure
- | Security on the Cloud
- | Conversions among VM and physical machines
- | vCenter, datacenters and cluster management
- | Comparison among virtual computing solutions
- | How to work with Virtual Machines
- | IaaS solutions
- | PaaS Solutions
- | SaaS Solutions
- | ICARO project
- | Container





Datacenter, definition

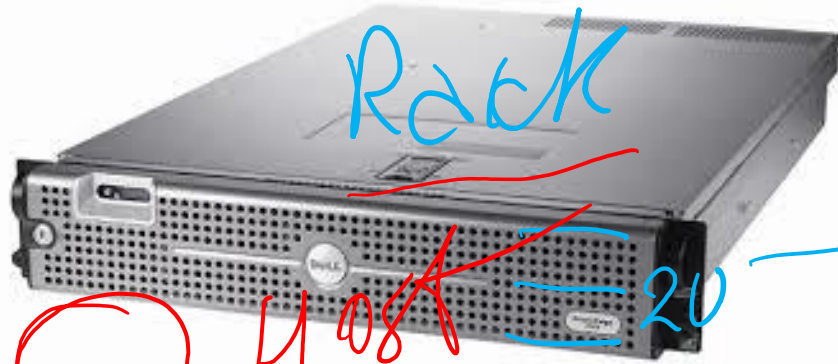
| Datacenter

- ❖ A computer factory/farm in which servers/computers are called HOSTS and are hosted and organized:
 - ➔ power, net maintenance, etc.
 - ➔ As: industrial computers, blades
- ❖ They can be exploited for private purposes, grid, cloud computing, renting/hosting, etc.





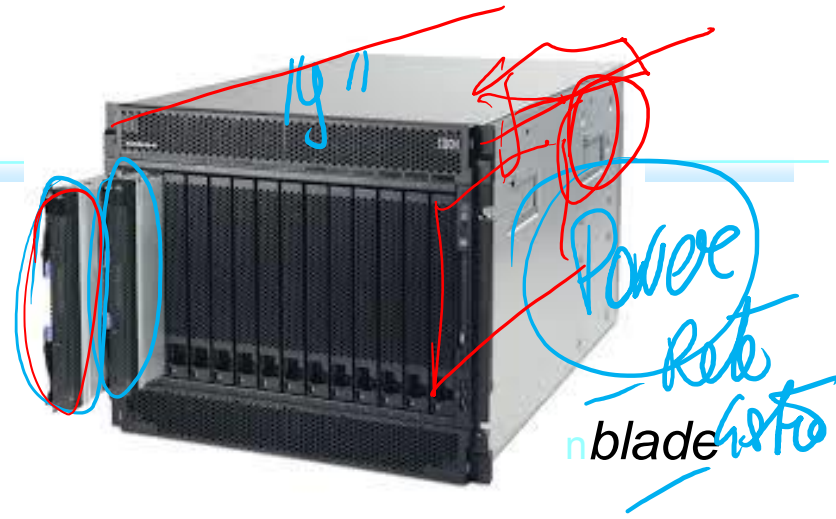
Server



Rack

server

1108 20



19"

Power

Ret

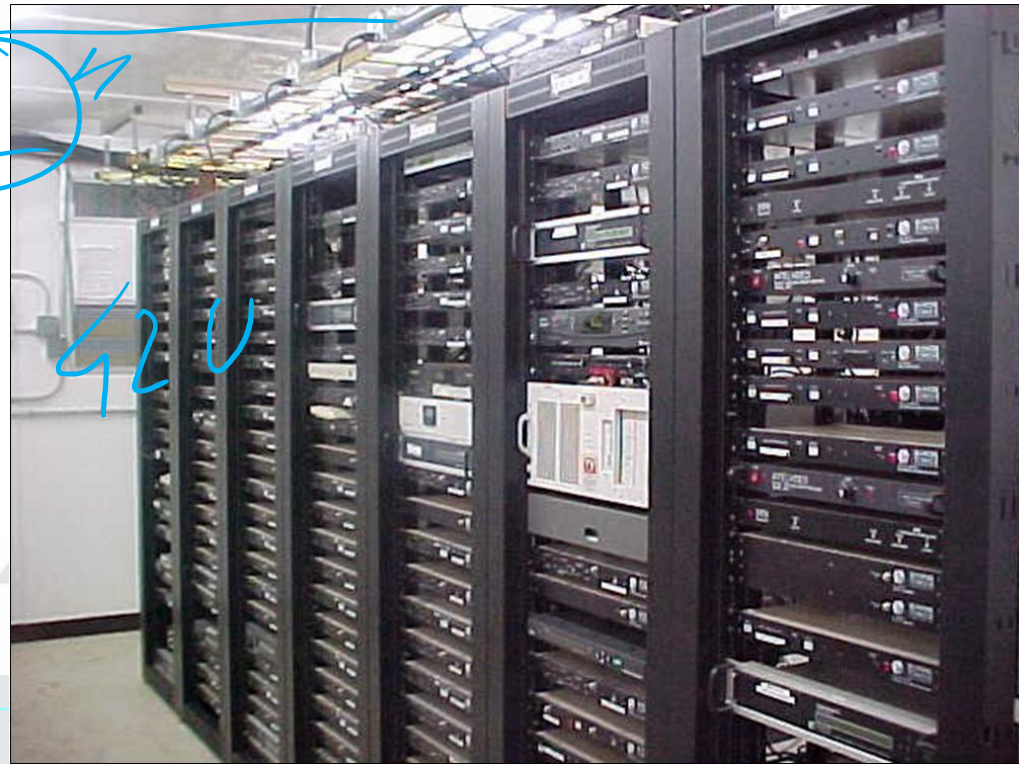
blade

foto



Storage

Rete

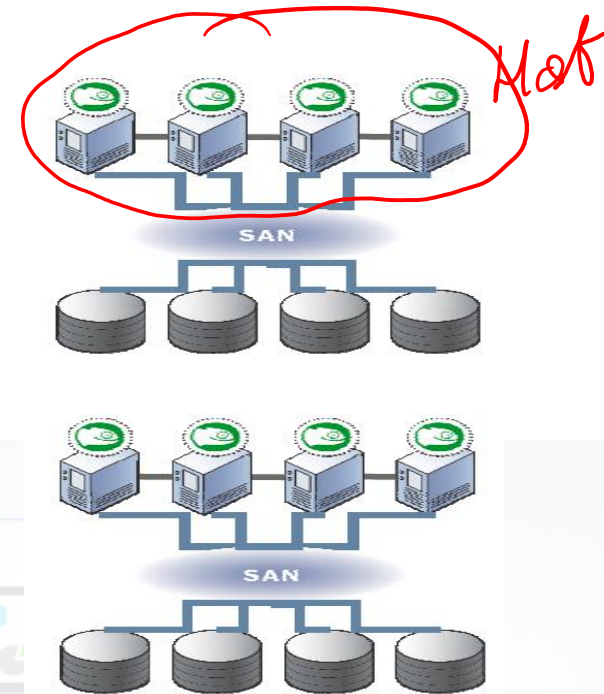


42 U



Infrastructure, definition

- | A set of datacenter and clusters
 - ♣ Cluster: group of servers plus storage (if any)
- | A storage as a set of
 - ♣ NAS: Network Area Storage
 - ♣ SAN: Storage Area Network



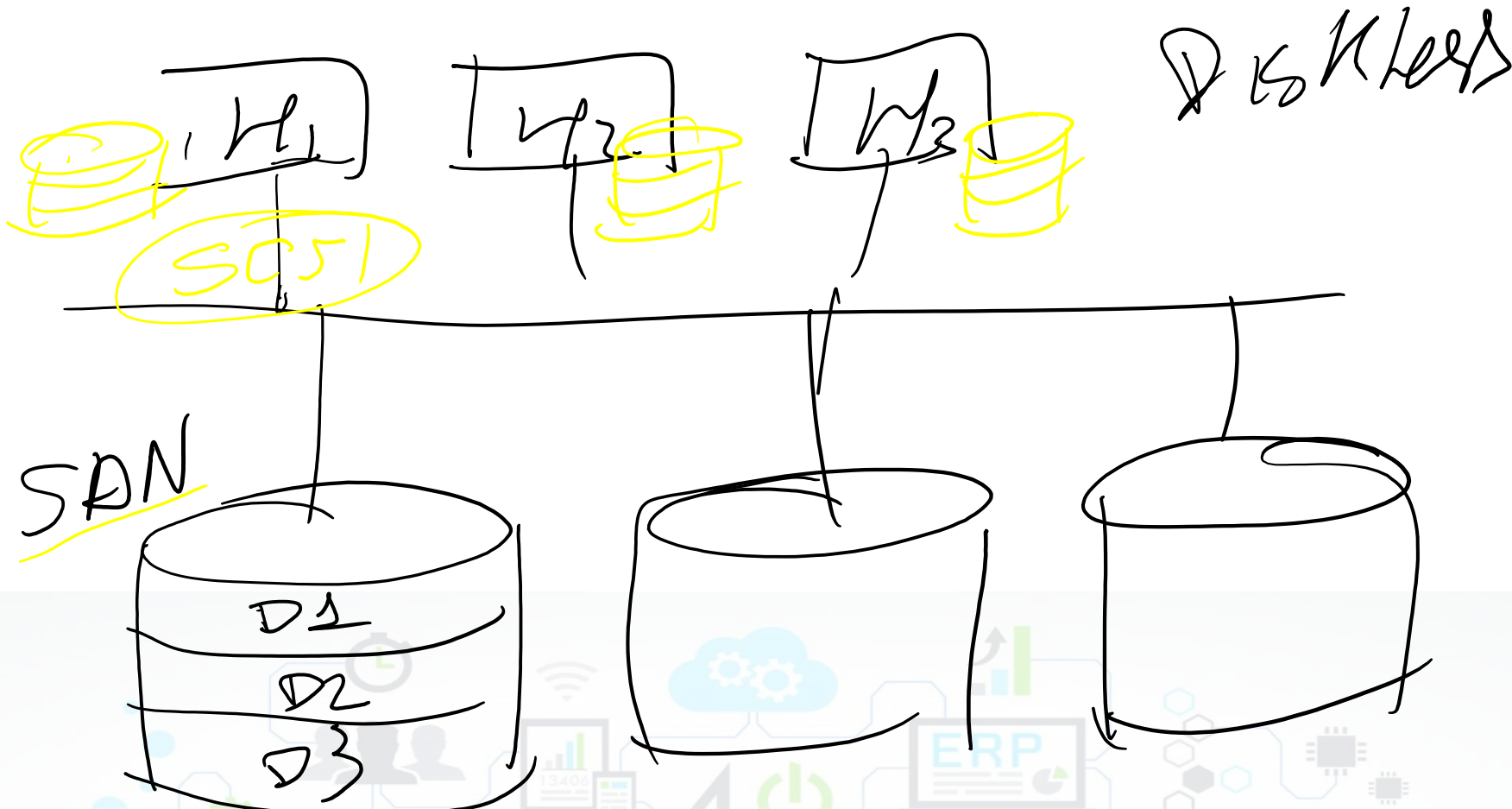
Etc..





SAN vs NAS

- In most cases they are wrongly considered the same staff
 - It is true that: NAS/SAN typically are HD in Raid connected/shared to/by Servers
- | **NAS: Network Area Storage**
 - Network HD sharing content at level of File via TCP/IP, HTTP, NFS, CIFS, etc., protocols
 - Multiple servers may access to them, the HD can be easily mounted, and see on the OS
 - Reduced performances with respect to SAN
- | **SAN: Storage Area Network**
 - HD system segmented in LUN, mounted by the Server(host)/VM OS at level of disk block
 - The OS accessing to them has to format with its own file system
 - Multiple server may access to them
 - Possible protocols: low level IP, iSCSI, Fiber, etc.

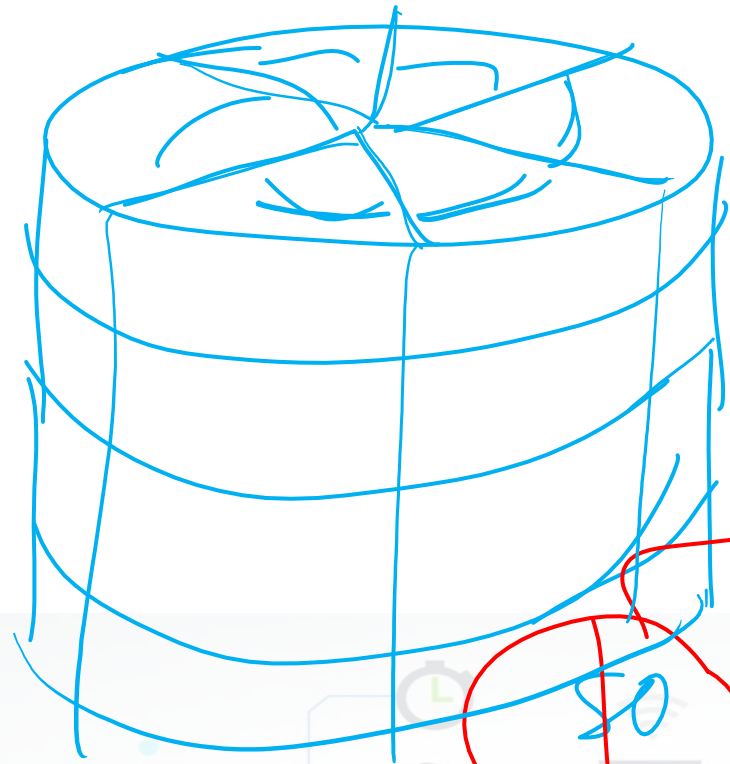




10TB

Sector/Cilindrone / Disk
3000 / 1000 / 10 ⇒ 1000000

→ Performance 8MB



LUN 2 5 TB

LUN 2 6 TB

SO
WVU



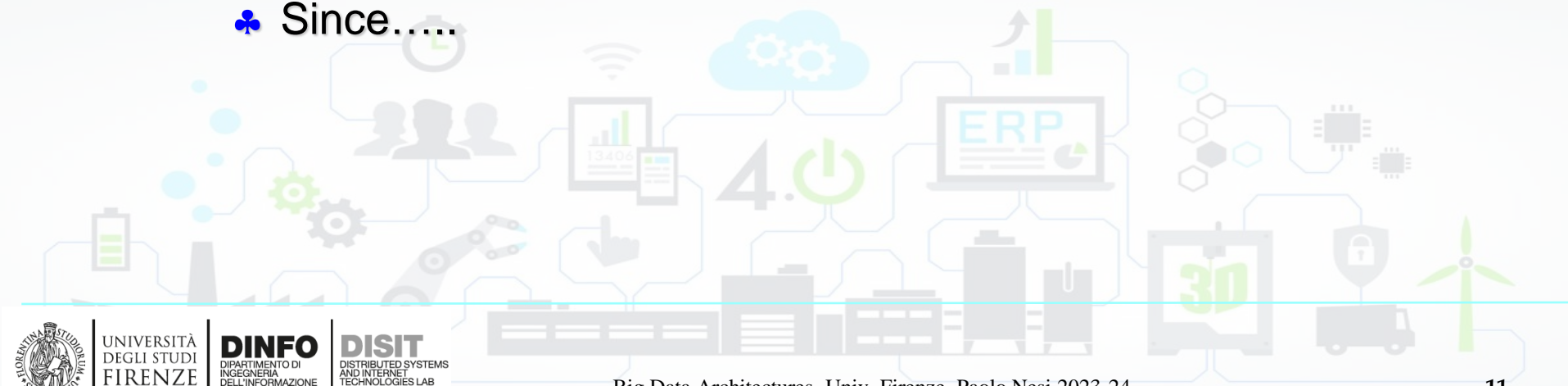
RAID



Consideration

- | The fact that we have servers and storage is not a key for cloud
- | Cloud is not a synonymous of data center
- | Since 60' **John McCarthy supposed to have a number of servers providing services for all**
- | Servers have been typically used
- | Close to the end of the 90', the first Software as a Service, SaaS, started.

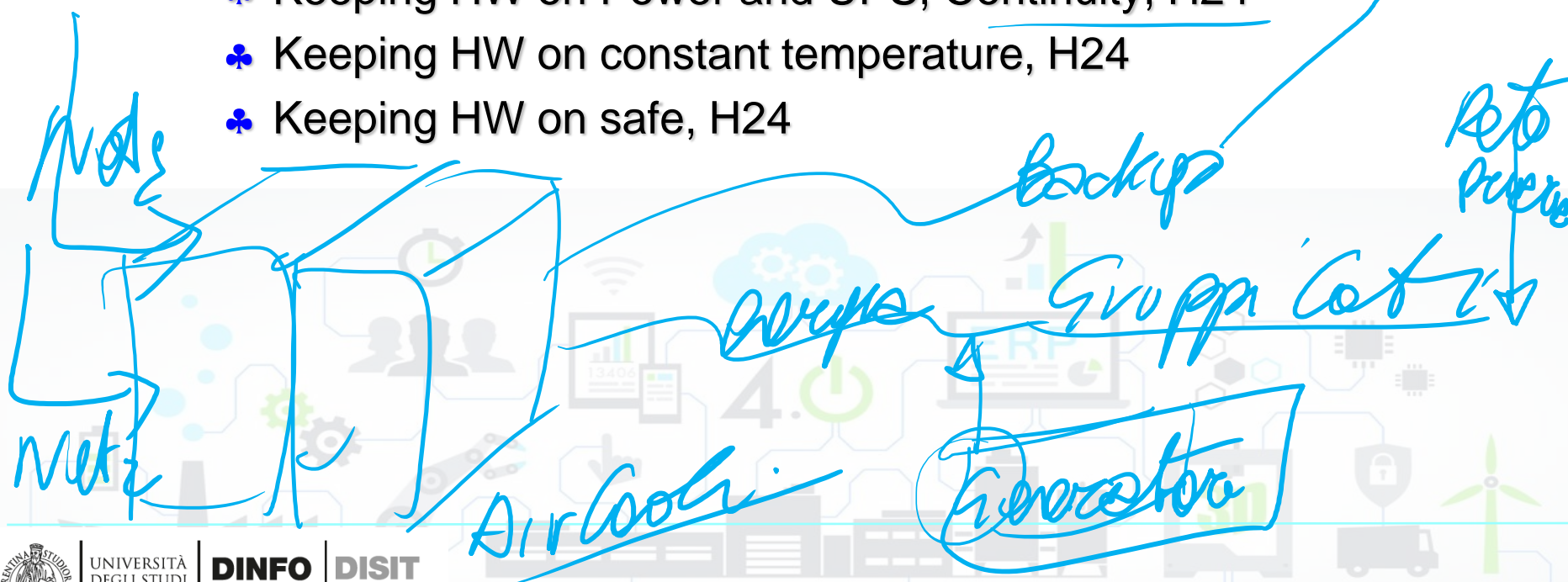
✿ Since.....





Housing

- | Moving HW, Moving servers from local premise to an infrastructure:
- | Buying HW and finding a safe location to placing,
 - ♣ Keeping HW on maintenance, H24
 - ♣ Keeping HW on Power and UPS, Continuity, H24
 - ♣ Keeping HW on constant temperature, H24
 - ♣ Keeping HW on safe, H24





Motivations for

Cloud computing and Virtualization

| **Computer Based Physical Systems (servers) are**

♣ not flexible:

➔ The HW/SW has to be dimensioned for the workload worst case and not for the real/typical one

➔ HW/SW can be hardly reused for different purposes since specific allocation is performed

♣ subjected to HW failure, and thus:

➔ Software has to be installed again when changing hardware

➔ OS has to be reinstalled in most cases



Motivations for

Cloud computing and Virtualization

Computer Based Physical Systems (servers) are

- Subjected to high costs of setup, installation and use:

 - Power, conditioning, network connection, etc.

- not scalable, to scale up frequently implies hardware change/re-engineering, (it was the gold period of the Moore's Law, of performance duplication every two years)

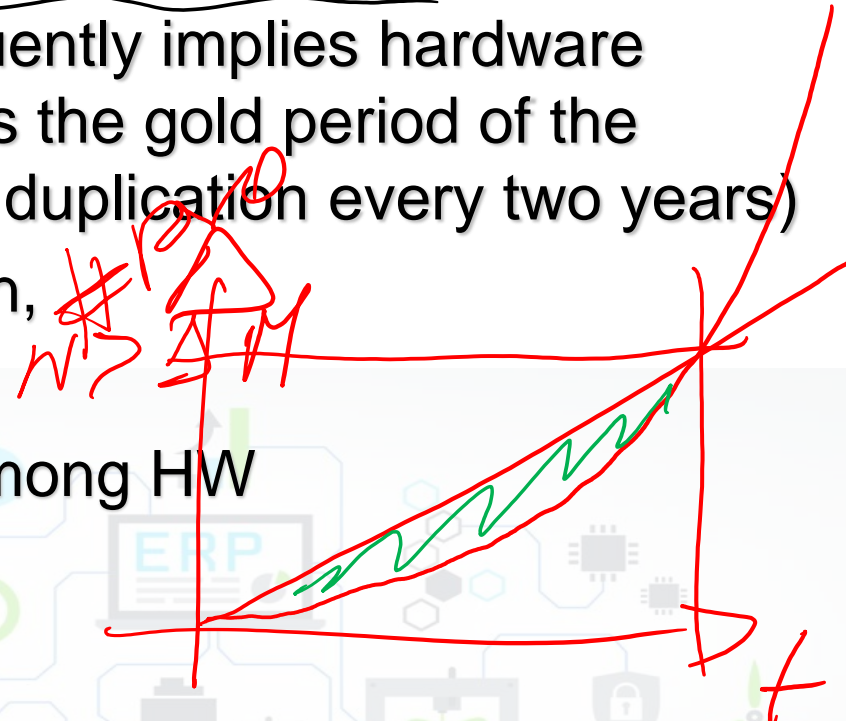
 - Data duplication, migration,

 - sharing databases, etc.

 - Distribution of activities among HW

 - Balancing or workload,

 - Add more HW,





Final Motivations

I Reduction of costs for HW and operating system SW maintenance.

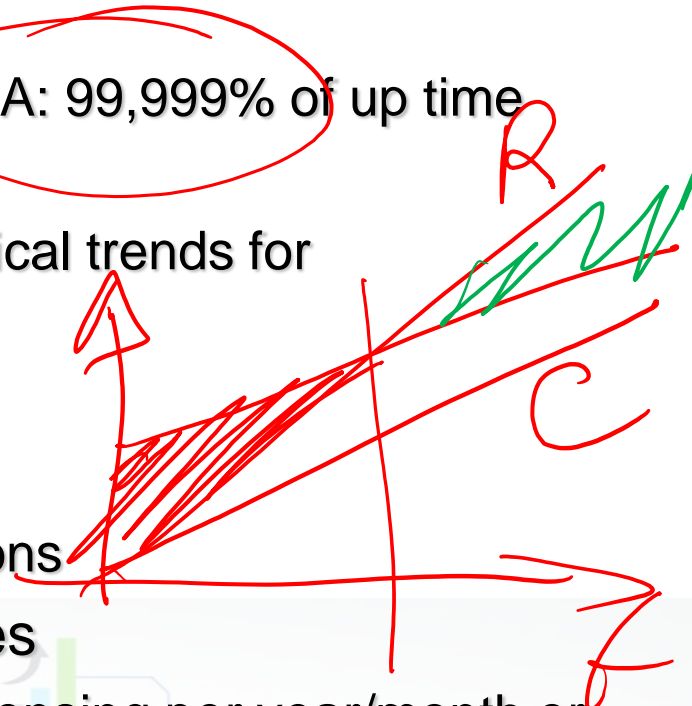
- ♣ High costs to guarantee high availability, HA: 99,999% of up time
- ♣ High costs to guarantee high reliability
- ♣ High costs to follow the HW/SW technological trends for performances, computational needs
- ♣ Critical mass is needed to justify HW costs

I Sharing resources

- ♣ Among for multiple applications and solutions

I Needs of High flexibility in terms of features

- ♣ Most of the SW is becoming a services (licensing per year/month or users) and not anymore a product.
- ♣ Many vendors provide complex SW systems in terms of services, on the basis of their consumption via network connection





Hosting, definition

HPC: high performance computing

- ♣ Solution based on cloud/grid for parallel execution of algorithms and tools.

Hosting web portal into a datacenter/cluster *SLA*

- ♣ Renting a web space via some *SLA* (service level agreement), contract, monthly rate to publishing web pages: service httpd
- ♣ Additional services: mysql, php, asp, ftp, ssh, https, etc..
- ♣ Features:
 - ➔ Space on disk, networking
 - ➔ Domain space, etc.

Hosting a machine (computer/VM) into a datacenter

- ♣ According to some SLA, contract...
- ♣ Renting a Computer/VM/Cluster into a data center





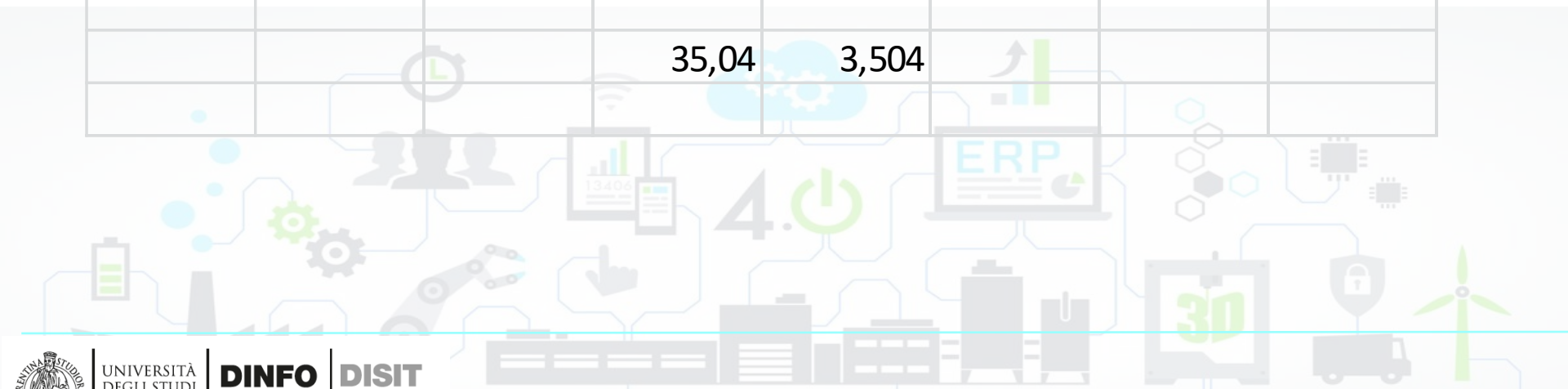
Service Level Agreement

Availability % ▲	Downtime per year ^[2] ◆	Downtime per month ◆	Downtime per week ◆	Downtime per day ◆
55.555555% ("nine fives")	162.33 days	13.53 days	74.92 hours	10.67 hours
90% ("one nine")	36.53 days	73.05 hours	16.80 hours	2.40 hours
95% ("one and a half nines")	18.26 days	36.53 hours	8.40 hours	1.20 hours
97%	10.96 days	21.92 hours	5.04 hours	43.20 minutes
98%	7.31 days	14.61 hours	3.36 hours	28.80 minutes
99% ("two nines")	3.65 days	7.31 hours	1.68 hours	14.40 minutes
99.5% ("two and a half nines")	1.83 days	3.65 hours	50.40 minutes	7.20 minutes
99.8%	17.53 hours	87.66 minutes	20.16 minutes	2.88 minutes
99.9% ("three nines")	8.77 hours	43.83 minutes	10.08 minutes	1.44 minutes
99.95% ("three and a half nines")	4.38 hours	21.92 minutes	5.04 minutes	43.20 seconds
99.99% ("four nines")	52.60 minutes	4.38 minutes	1.01 minutes	8.64 seconds
99.995% ("four and a half nines")	26.30 minutes	2.19 minutes	30.24 seconds	4.32 seconds
99.999% ("five nines") HA	5.26 minutes	26.30 seconds	6.05 seconds	864.00 milliseconds
99.9999% ("six nines")	31.56 seconds	2.63 seconds	604.80 milliseconds	86.40 milliseconds
99.99999% ("seven nines")	3.16 seconds	262.98 milliseconds	60.48 milliseconds	8.64 milliseconds
99.999999% ("eight nines")	315.58 milliseconds	26.30 milliseconds	6.05 milliseconds	864.00 microseconds
99.9999999% ("nine nines")	31.56 milliseconds	2.63 milliseconds	604.80 microseconds	86.40 microseconds





			99,8	99,98	99,998	99,999	
			0,2	0,02	0,002	0,001	
	60						
ore	24		17,52	1,752	0,1752	0,0876	ore anno
	365						
minuti	525600		1051,2	105,12	10,512	5,256	minuti
	100	0,2					
	525600 X						
			35,04	3,504			





Infrastructure as a Service, IaaS

I the provision of infrastructure with a relevant processing power, storage, network and other basic resources independently of application services of any type.

♣ Example: a server in rent, a VM for rent

I Thus, it is possible to use an infrastructure of a provider to run your application, against a payment based on the renting (consumption) of the infrastructure, leaving the responsibility of the HW, OS, and SW (libraries, middleware, backup, storage, network, etc.) as well as of the application itself to the provider.

♣ Amazon EC2 is an example of IaaS service.

Nec CPU

Yes

App #

#Scale
#Res

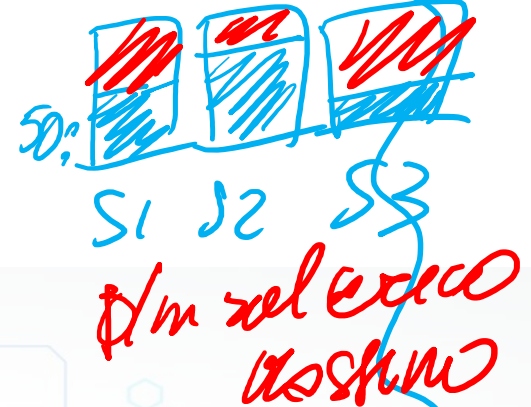


100.000 + Mem + Core + RA + Rob



Motivations for Applications on the Cloud


- Single-tier applications, such as small web portals, do not demand a complex system, and
 - do not justify the acquisition of a host server !!!???
- Multi-tier applications have multiple servers, such as:
 - High performance web server, high number of users
 - SN: Social networks
 - CMS: content management systems
 - CRM: customer relationship management
 - CDN: Content delivering network
 - ERP: enterprise resource planning
 - P2P torrent tracker: see Piratebay
- All typically parallel applications that may need grid, computation, storage, etc. may run on cloud, etc.



Acc solo quello che serve !!



Structure

- | Elements of cloud Computing
- | Virtualization 
 - ♣ emulation, para-virtualization
 - ♣ virtual resources
 - ♣ snapshots
- | Cloud Computing
- | High Availability
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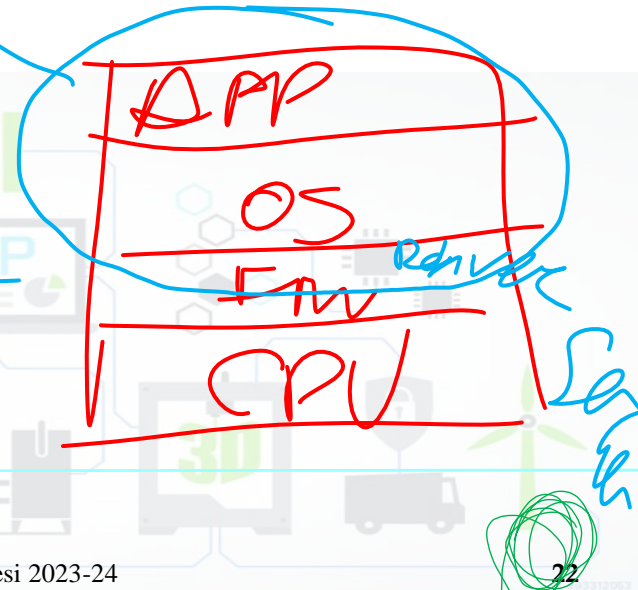
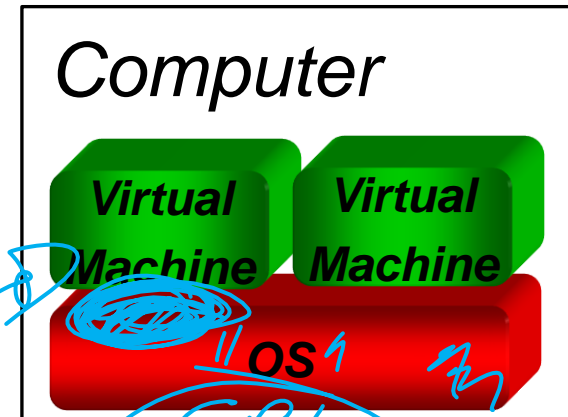
Concept of Virtual Server

I Hyp:

- ♣ you can make the image (in a file) of the HD of a Physical Server (with its Operating System and files) and
- ♣ put in execution the OS from the HD (file) by a program of "emulation"

I Thus we have:

- ♣ a computer with an operating system OS
- ♣ that hosts a program of "emulation",
- ♣ which in turn, it is capable to run in separate processes the images of the corresponding OS VM





Typical Features for renting a Computer or a Virtual Machine into a Datacenter

(1/2)

X

Requesting to have one or more Computers/Hosts and/or VMs

Hardware:

- CPU: 32/64 bit, number of cores/CPU, frequency of work, intel/amd, etc.
- RAM memory: size and frequency of work
- ~~Power supply: fault-tolerant or not; with UPS or not, etc..~~
- HD: space, speed (7.2, 15Kgiri), security level/RAID, type SAS/SATA, SCSI
- NAS/SAN, Network area storage/SAN, fiber/internet: size, RAID, etc.
- Network features:
 - Number of connections/cards, NICs
 - number of IP addresses, static/DHCP
 - Transfer rate: minimum guaranteed, maximum possible, down/upload
 - Maximum transferred bytes: per day, per month, etc.

Host/Network

SLA
Mbps



Typical Features for renting a Computer or a Virtual Machine into a Datacenter

(2/2)

I Software:

- ♣ Operating systems: versions, with maintenance, etc.
- ♣ Software preinstalled into the Computer/VM, see in the following

I Services:

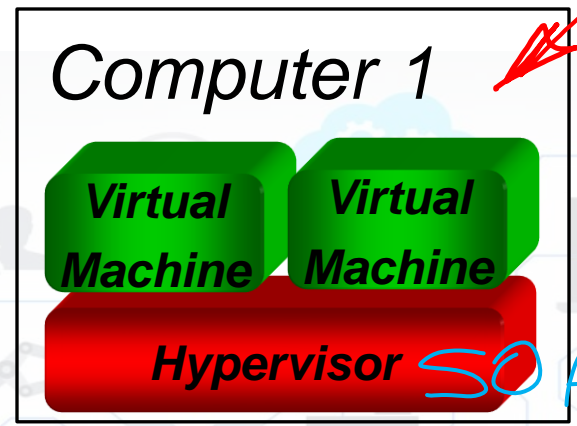
- ♣ Periodic back up: details on HD space
- ♣ Access to VM/Computer: remote desktop or KVM tool
- ♣ Reboot or not of the Server, for example via Plesk.



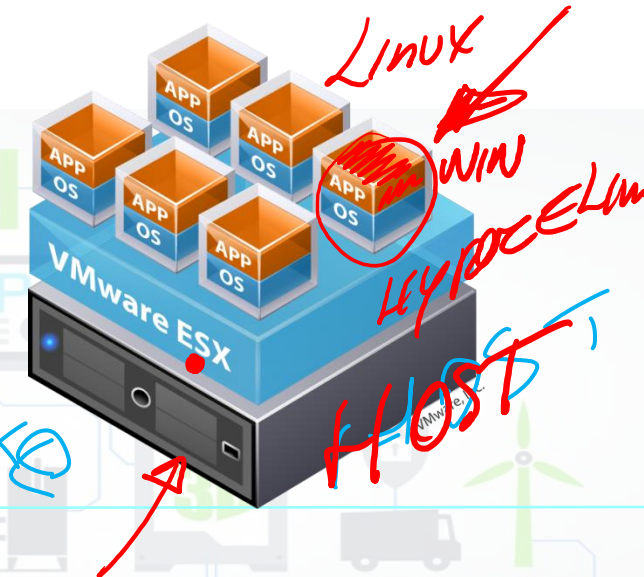


Virtual Machine, Virtualization

- | **Virtual Machine:**
 - ♣ An image of an operating system that can be put in execution into a real host/computer creating a virtual computer that exploits a part of all of the host resources
 - | E.g.: Host may be Linux-like while the VM may be Window, Mac, Linux, ...
- | **Virtualization**
 - ♣ Transforming a physical computer into a VM, virtual machine, hosted on some Host computer
- | **Hypervisor** (VM Monitor) to manage the several VMs on the host



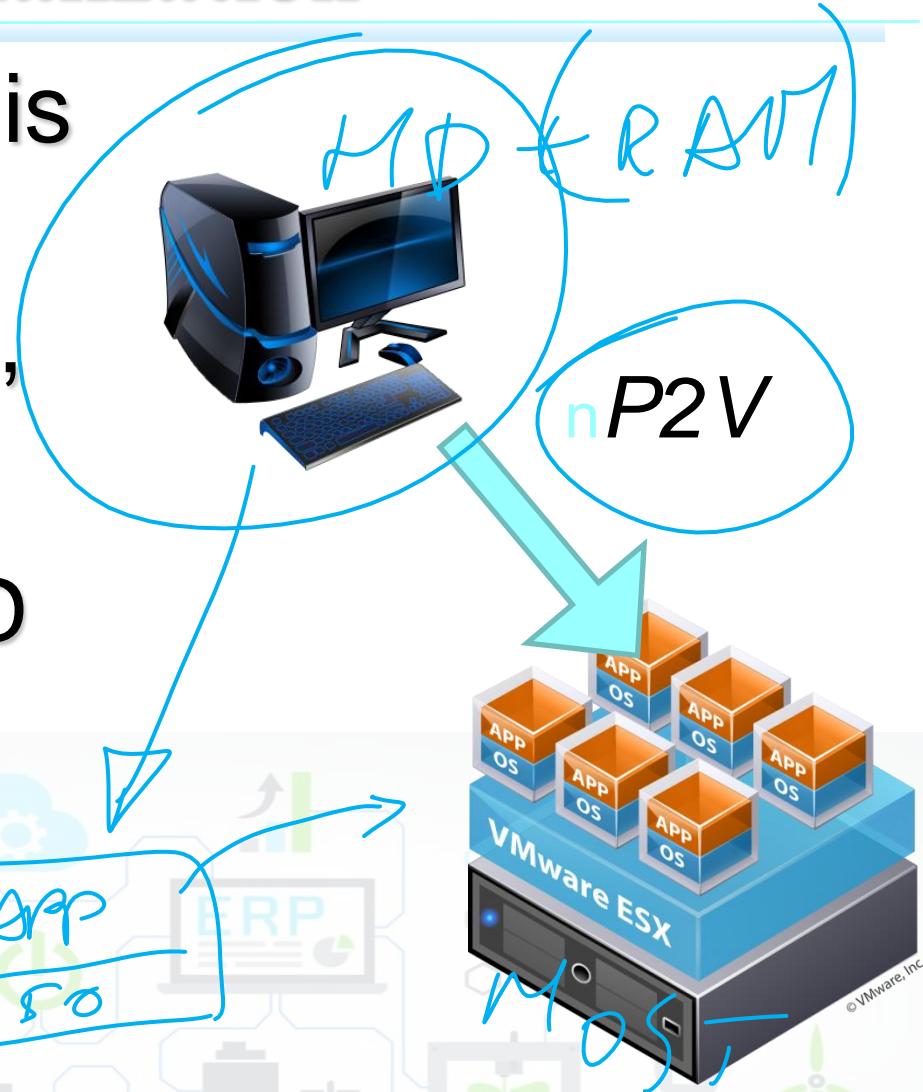
HOST





The Virtualization

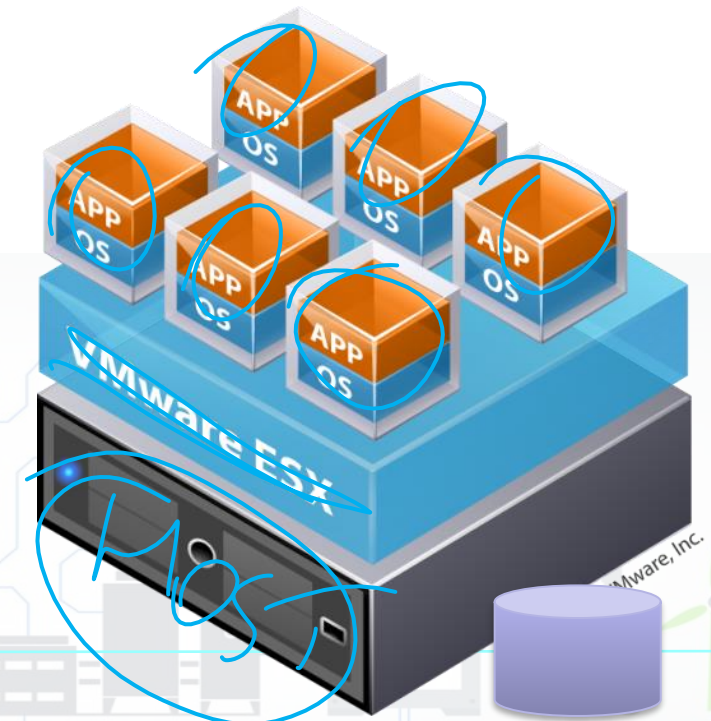
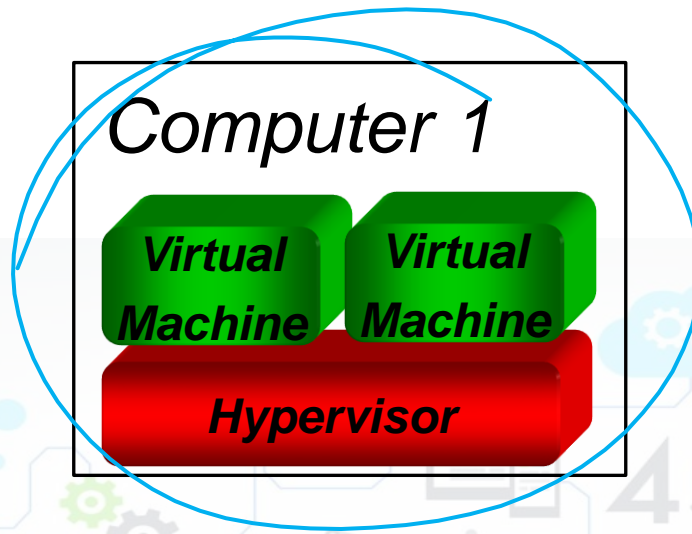
- | Process by which it is possible to create a virtual machine, VM,
- | For example by:
 - ♣ An installation DVD
 - ♣ Cloning a physical machine (P2V)
 - ♣ Clone from VM
 - ♣ Template from..





The Hypervisor

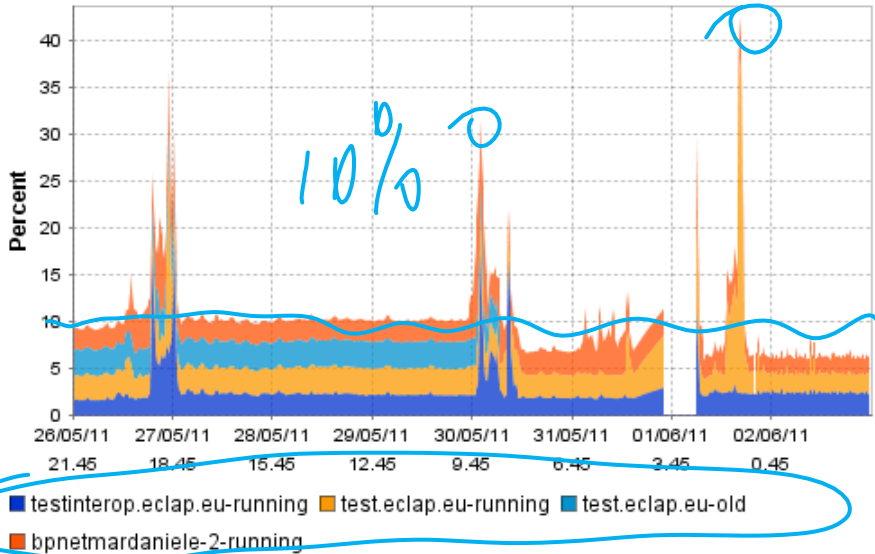
- | It is the essential OS, that can be installed in a Host and can put in execution and manage one or more VM
- | The Host is a server HW that host the Hypervisor
- | ESX of VMware is an Hypervisor.



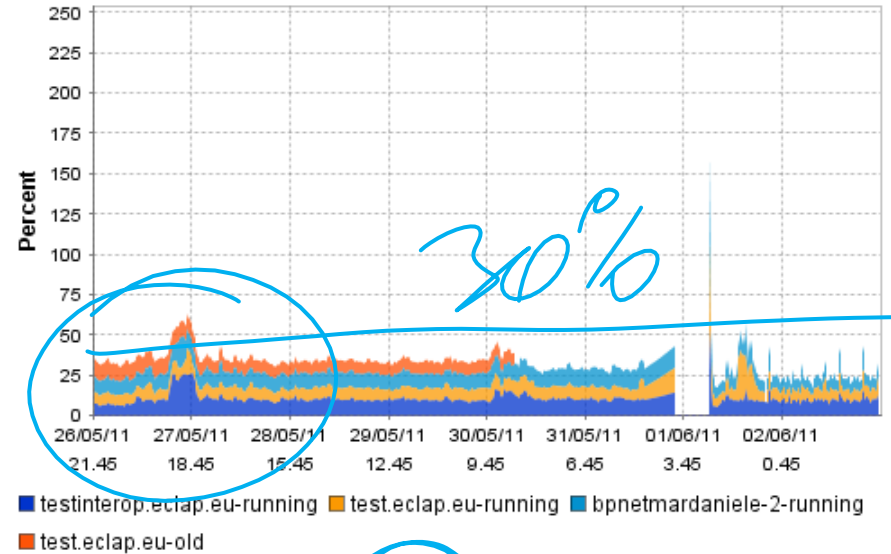


Performance Analysis of VM on the Host

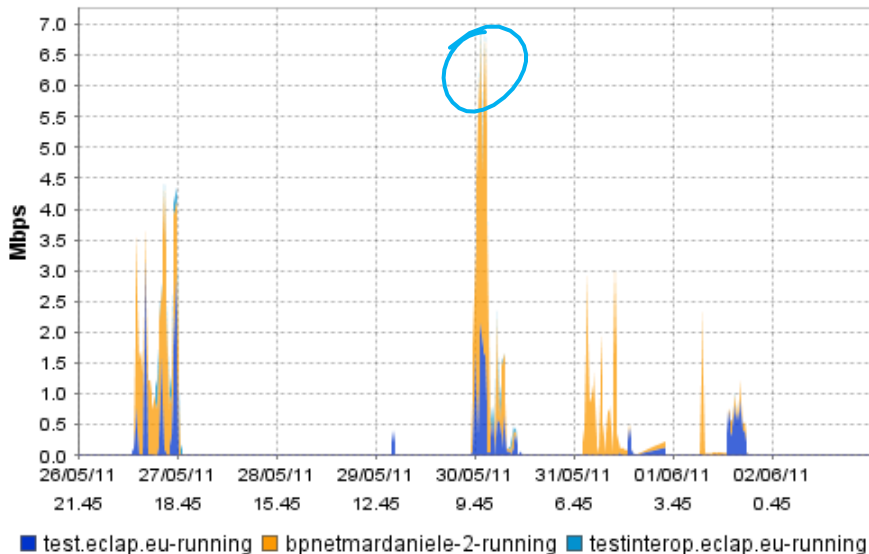
CPU Usage (Top 10)



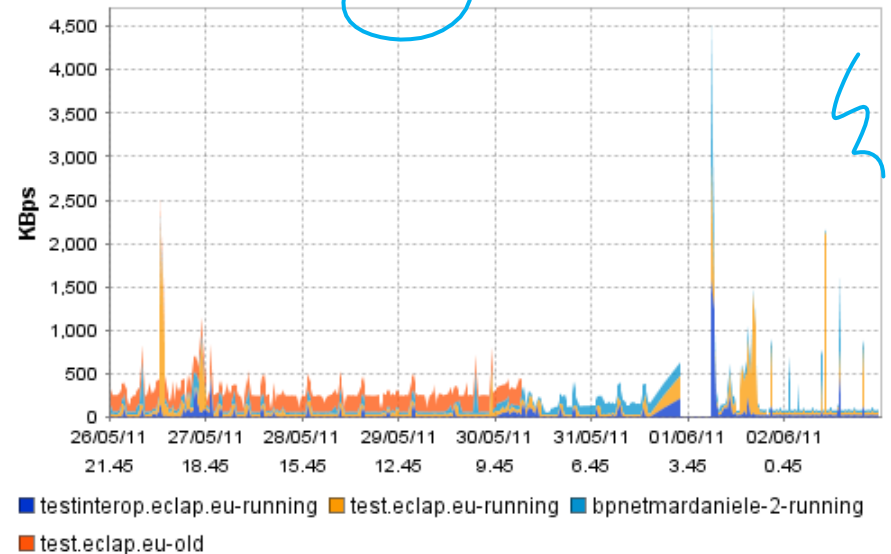
Memory Usage (Top 10)



Network (Mbps) (Top 10)



Disk (KBps) (Top 10)





Motivations for Cloud computing and Virtualization

- | **Most of the Host/datacenter capabilities** are not exploited at 100% in every time instant
 - ♣ They are typically present in large industries/institutions or in large services: google, amazon, tiscali, Dada, ibm, cnr, etc
 - ♣ Their size is typically defined on the basis of the workload worst case
- | ***If they are big***: the exploitation of the remaining resources for cloud/hosting is a solution to recover money, since a non working machine (like a caw) is a costs without any return.
- | ***If they are small***: it could be a solution to host machines on a professional infrastructure to reduce annual costs for HW/SW
 - ♣ Delegating to cluster owners the costs for *maintenance, renovating hardware, renovating software, network costs, back up costs, power supply, etc.*



Benefits of Virtual Machine

Main benefits:

- ♣ Separation of OS+SW with respect to the needed HW
- ♣ Exploiting legacy solutions which can be wrapped into a VM and protected with a physical firewall without reinstalling and recompiling old applications.
- ♣ The simple upgrade can be obtained by giving more CPU instead of changing HW and reinstalling all SW elements.

For example:

- ♣ An old Linux Server hosting several web portals with a old versions of: MySQL, PHP, etc.. and many configuration aspects: users, mailing lists, etc. very time consuming to port on a new server
- ♣ An old Cobol application running only on an old Windows 2000 Server, which cannot be recompiled into a new Windows Server 2008 at 64 bits without spending months of work.
- ♣ A Cobol application running on machine based on an IBM system 36....
- ♣ Etc.



VM on PC workstations

- | On a single Computer it is possible to put in execution a VM by using a standalone Hypervisor
- | **VMware Workstation** can play on Windows:
 - ♣ VMware Virtual Machines with: MS Win, Linux, Mac, ChromeOS, etc.
- | **VMware Player** can play on Windows or Linux
 - ♣ Free of charge
 - ♣ VMware Virtual Machines with: MS Win, Linux, Mac, ChromeOS, etc
- | **VMware Fusion** can play on MAC:
 - ♣ VMware Virtual Machines with: MS Win, Win 7, ChromeOS, etc.
- | **Microsoft Virtual PC** on Windows 7:
 - ♣ Free of charge
 - ♣ Create VM with Win XP, Linux Ubuntu,



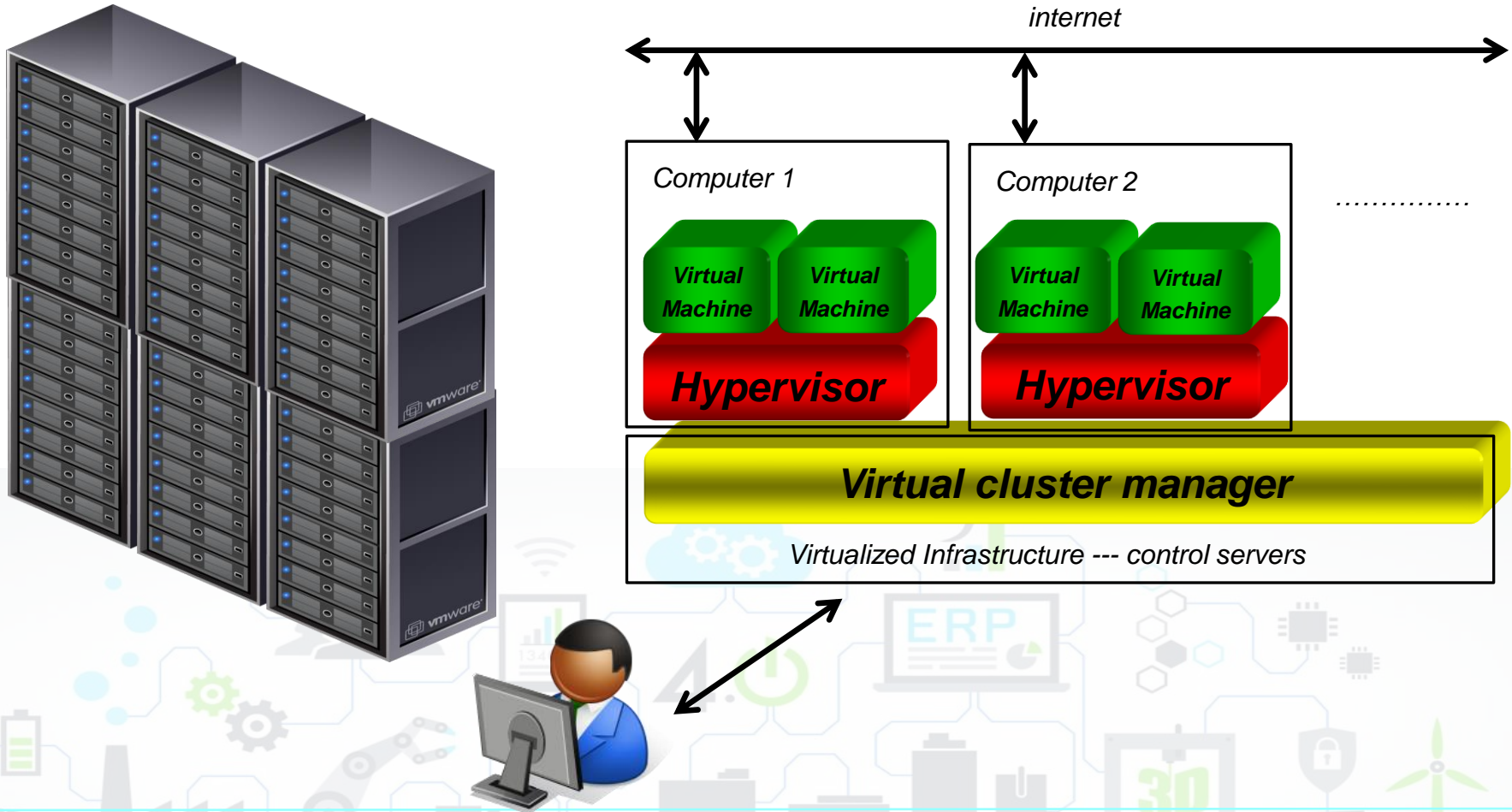
Software/Components preinstalled into rented Computers/VMs

- | **Several kinds of software components/tools** that can be accessible on rented VM and/or Computers.
- | **Availability of HW/SW:** for example at 98% or 99.999%
- | **Typical components** that could be requested:
 - ♣ DB: MySQL
 - ♣ FTP: server and client
 - ♣ Web Server: Apache, IIS
 - ➔ Add-on: PHP, Perl, Python, cache tools on several levels
 - ♣ SMTP address, antispam
 - ♣ Web Application Server: TomCat,
 - ♣ And: Antivirus, backup, email, Drupal, Joomla, etc...
- | **A full server can be customized, so that any other tool can be installed as well from the user**



Cloud Computing with VMs

Several Hypervisors on a Clusters

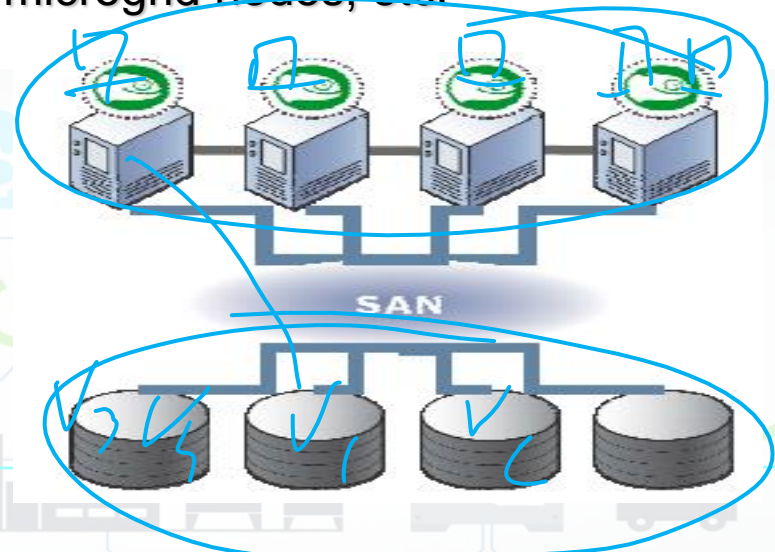




Clusters, generic definition

For Cluster, it is typically intended:

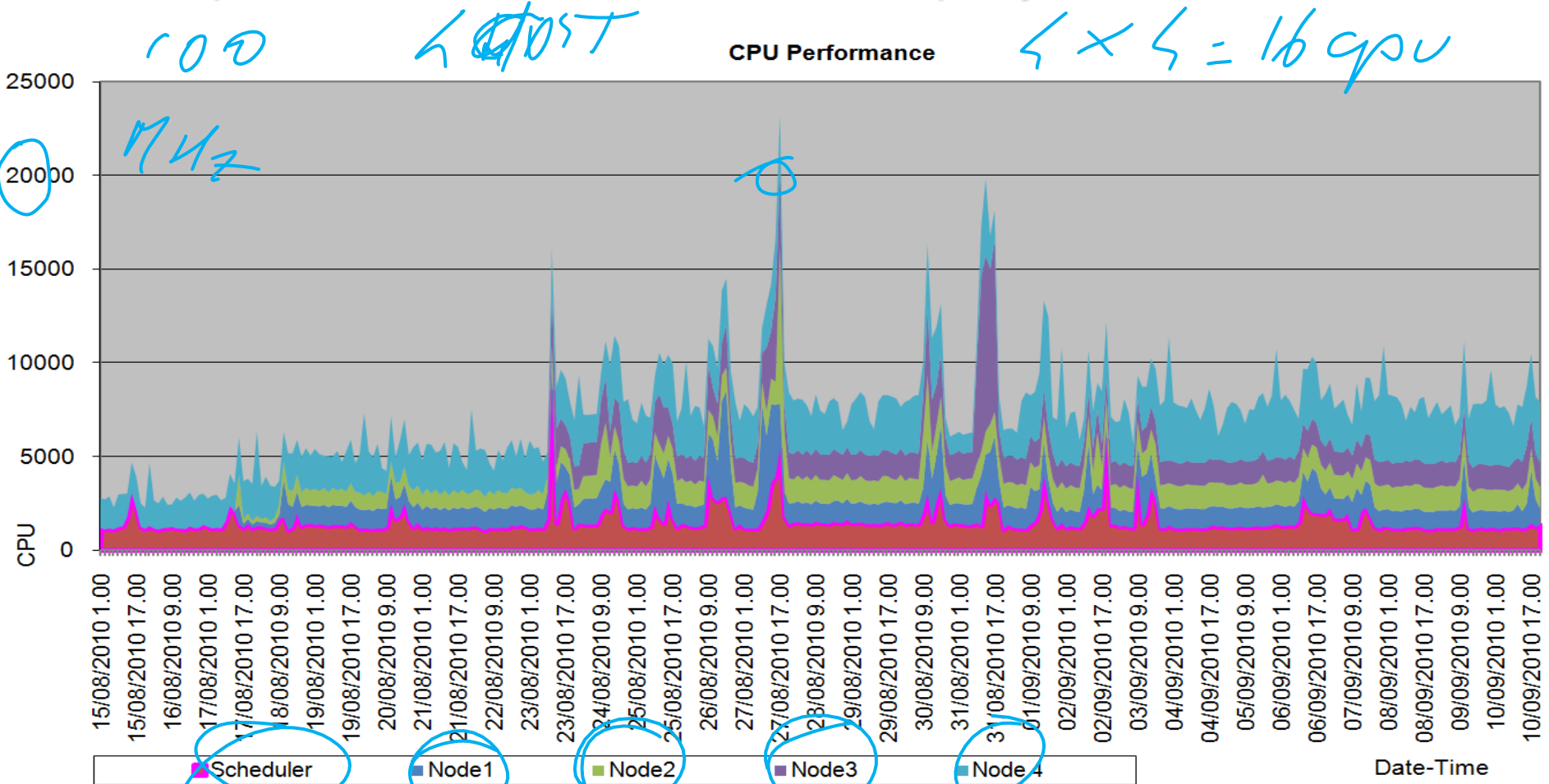
- Several kinds of computers and/or VMs used to compose a group of resources, that can be managed together, and may be sharing the same domain or not.
- a set of computers/VMs into a datacenter which are dedicated to a unique problem, for example:
 - ➔ A microgrid, an Hadoop cluster,
 - ➔ A social network.....
 - ➔ A web portal with its multi-tier servers: front-end portals, balancer, database computers, backoffice microgrid nodes, etc.





From Clustering VM to Cloud

- The first step has been the exploitation of unused resources to provide them as a service to third party.





Approaches for Virtualization

I Hardware Emulation

- ❖ Full emulation of Hardware devices and features
- ❖ It is possible to use an original OS without changes, may be with some drivers installed, but **not kernel** changes
- ❖ Higher isolation among VMs, strong robustness, limited efficiency.
- ❖ **Used by** Vmware core
- ❖ Typically 10% of overhead

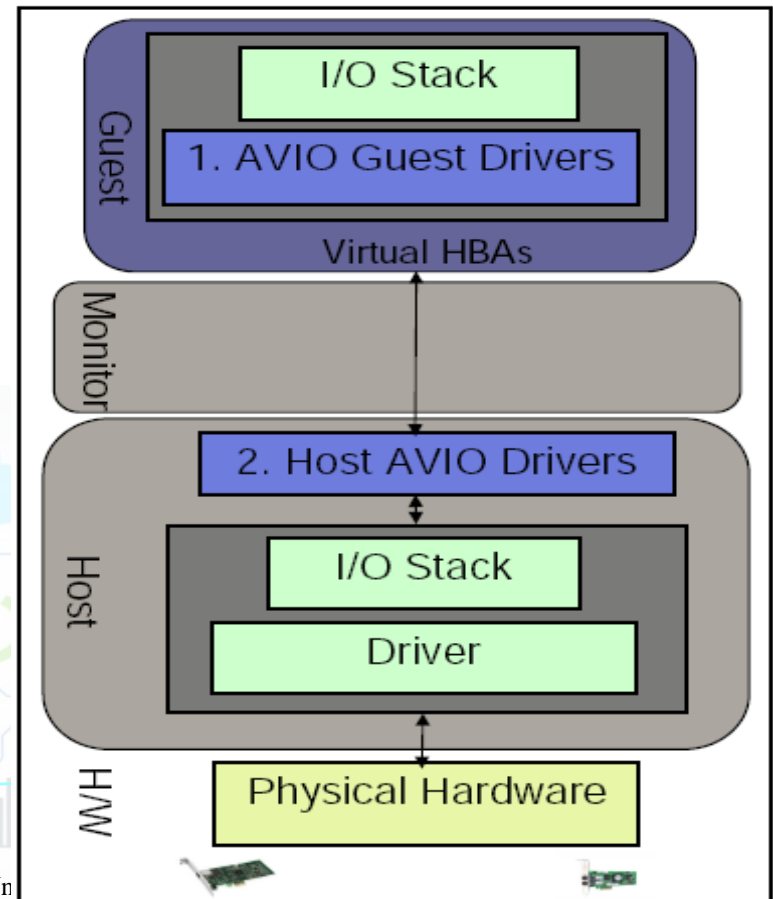
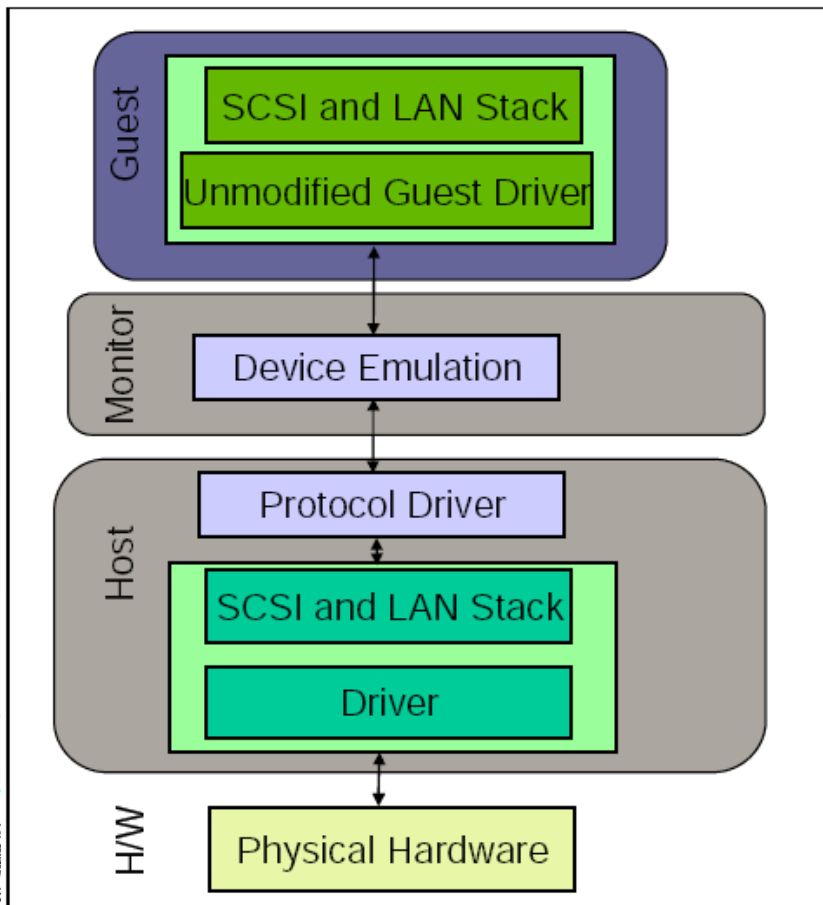
I Paravirtualization (total or only on some devices)

- ❖ The execution is performed via specific API and the hosted OS has to be modified to use them instead of the original HW
- ❖ Lower isolation, higher efficiency
- ❖ Lower robustness: VM crashes may crash the whole system
- ❖ **Used by:** HP-VM, Xen (both of them which can also go in emulation mode)
- ❖ **Used by VMware:** VMXNET (100 Gbps net), PVSCSI in vSphere4
- ❖ Typically 2% of overhead



Para-virtualization

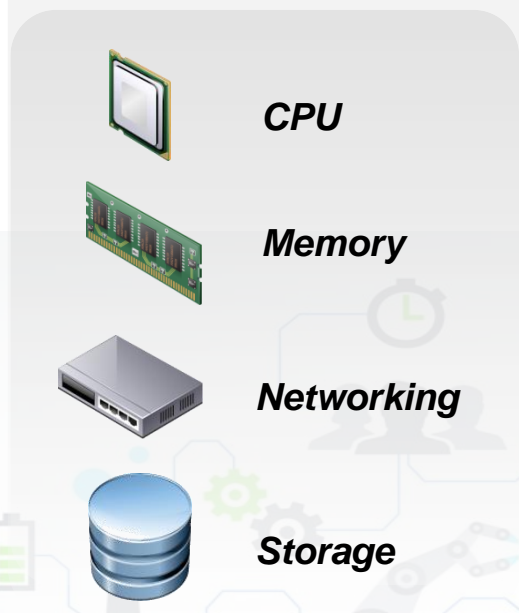
- | It is intended as a solution to cut out a part of the I/O stack, for example for the HD access or network.
- | The following example is related to HP VM v. 3.5





“Speeds and Feeds”

Optimization for the Highest Consolidation Ratios



- VM Scale Up

- 8-way vSMP and 255 GB of RAM per VM

- Hardware Scale Up

- 64 cores and 512GB of physical RAM

- Hardware Assist
- Purpose Built Scheduler

- Lowest CPU overhead

- Hardware Assist
- Page Sharing
- Ballooning

- Maximum memory efficiency

- VMXNET3
- VMDirectPath I/O

- Wirespeed network access

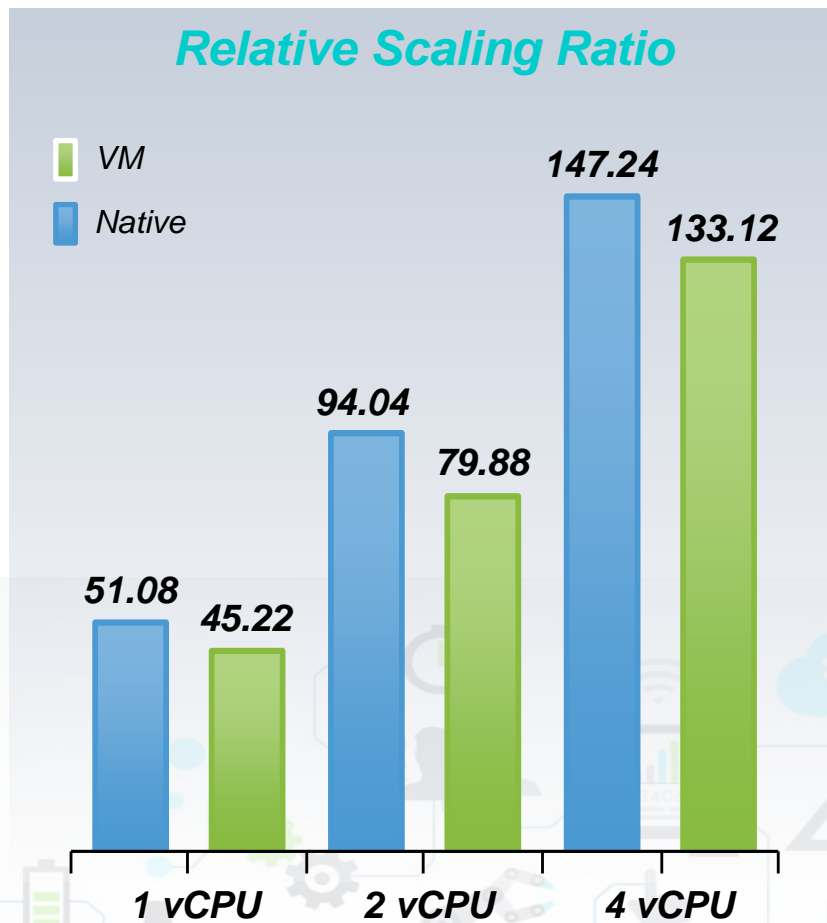
- Storage stack optimization
- VMDirectPath I/O

- Greater than 360k iops per second
- Lower than 20 microsecond latency

Current NEW



ESX 4.0 Performance with SQL Server 2008



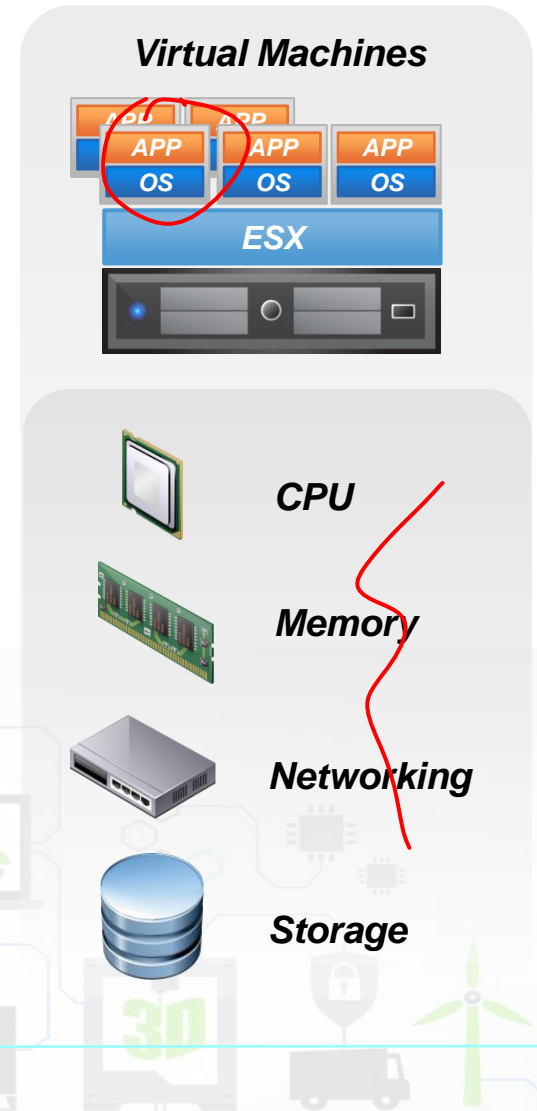
- | ESX achieves 90% of native performance on 4.0 vCPU VM
- | Workload transaction latency unchanged between ESX 4.0 and Native



Host: risorse primarie





Host Profile

- ♣ Memory Reservation
- ♣ Storage
- ♣ Networking
- ♣ Date and Time
- ♣ Firewall
- ♣ Security
- ♣ Services
- ♣ Users and User Groups
- ♣ Security



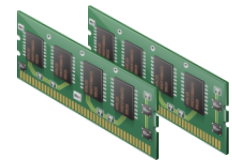


Limiting VM Resources

- | **VM Resources** (CPU, Mem, HD, net.) consists also in providing support for:
 -    
 - ♣ Dynamically providing resources over the reserved values that can be negotiation into the SLA/ contract.
- | **Controlling and limiting** access/cost and the exploitation of HW resources:
 - ♣ A limit on the number of CPUs
 - ➔ A limit on the number of Clocks, over of a reserved number of clocks
 - ♣ A limit on the maximum size of the RAM, over of the reserved number of Mbytes
 - ♣ A limit on the size of the HD, SAN/NAS access
 - ♣ A limit on the number of network cards, number of Mbps, etc.



Model for Memory



I Memory

♣ Total host memory

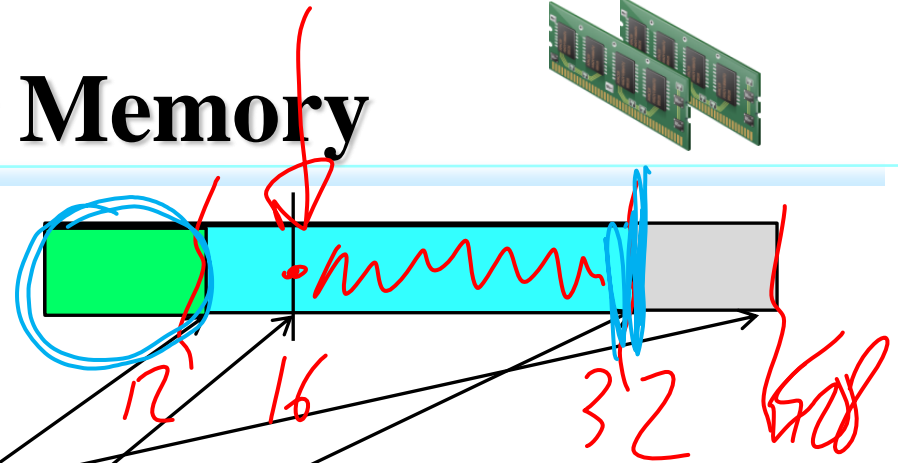
♣ For each VM

➔ Max memory for the OS

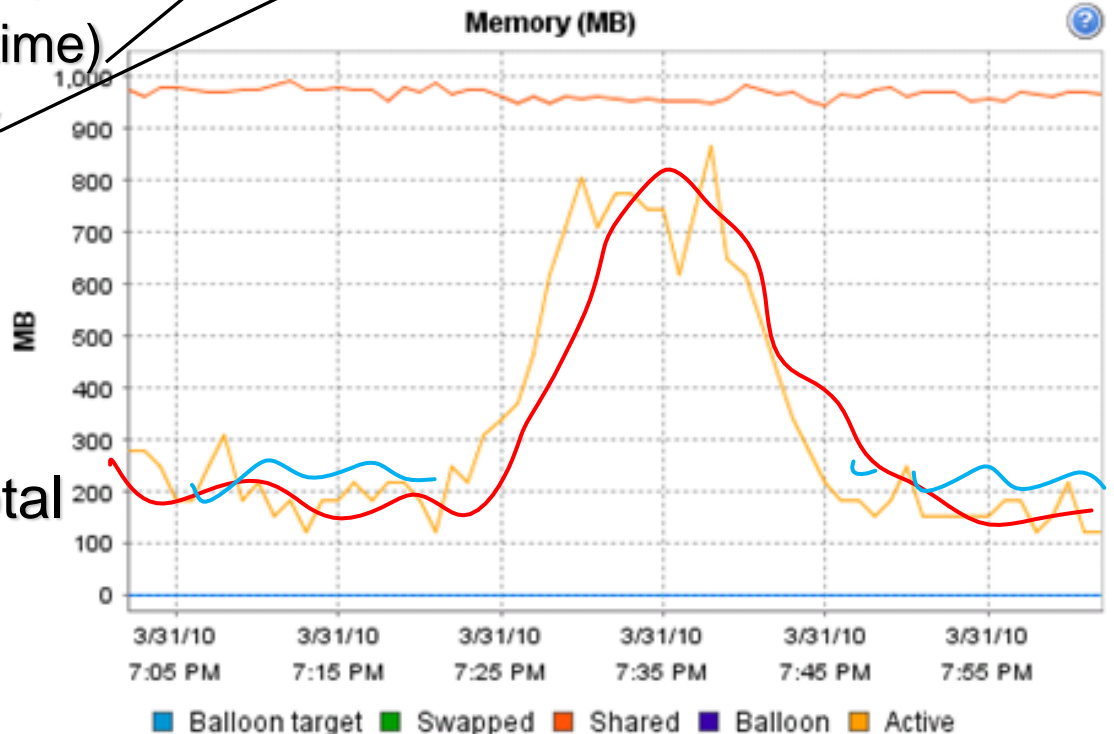
➔ Reserved Memory

➔ Used Memory (time)

➔ Limited memory

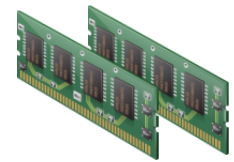


I Be carefull to overcommitted resources on the Host respect to the total CPU and Mem of the hosted VMs





VM: Memory Definitions

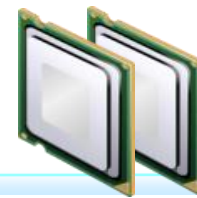


- | **Reserved:** not available for the other VM on the same host!!

- | **Active:** memory actually used
- | **Ballon:** Memory requested by the VM to the host
 - ♣ This memory is shared among several hosts
- | **Shared:** memory available for sharing
- | **Swapped:** amount of memory that has been swapped into the HD by the VMKernel of the host
 - ♣ This parameter has to be low as much as possible
 - ♣ Increase the reserved to make it low or reduce the number of VM on the host



Model for CPU



Memory

♣ Total host Clock

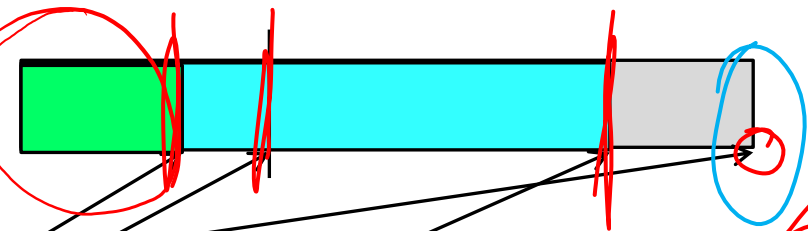
♣ For each VM

➔ Max #cks/s host

➔ Reserved #cks/s

➔ Used #cks/s

➔ Limited #cks/s



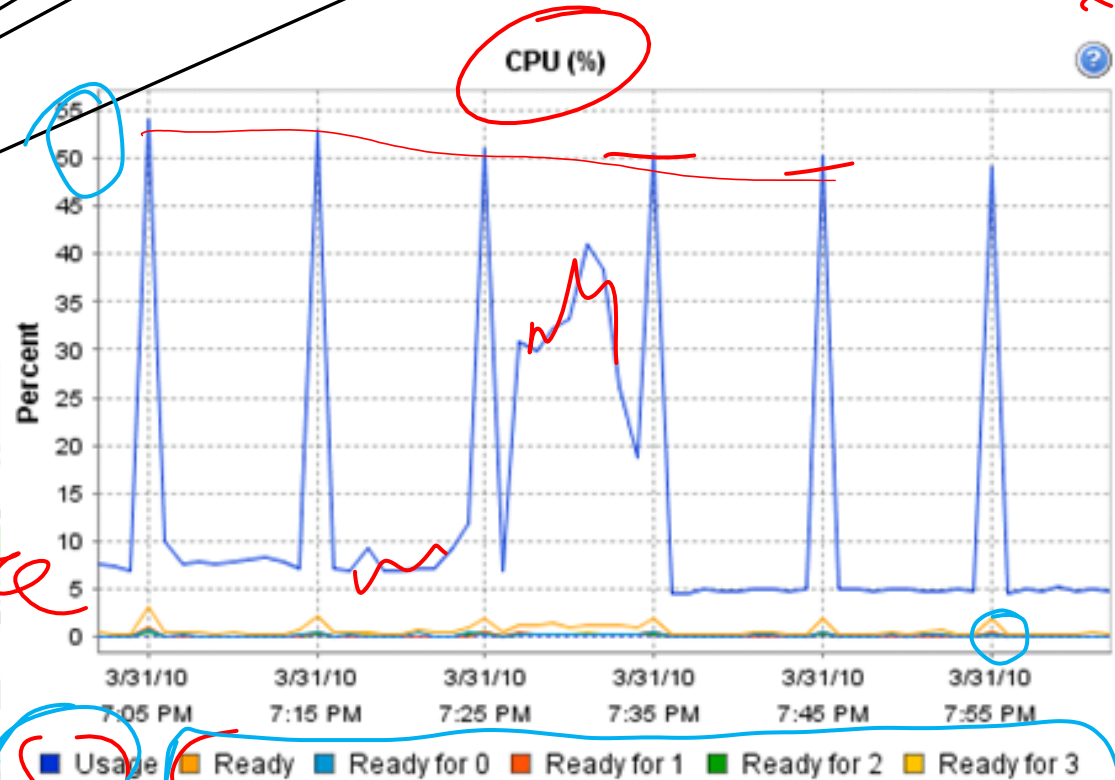
4 85 Hz

Ck/s → Hz

1 GHz → 1000 MHz

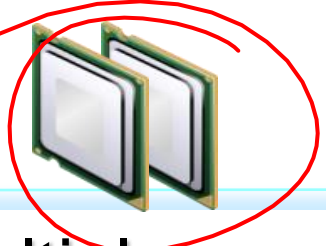
Xoom #1 CPU core

25 GHz

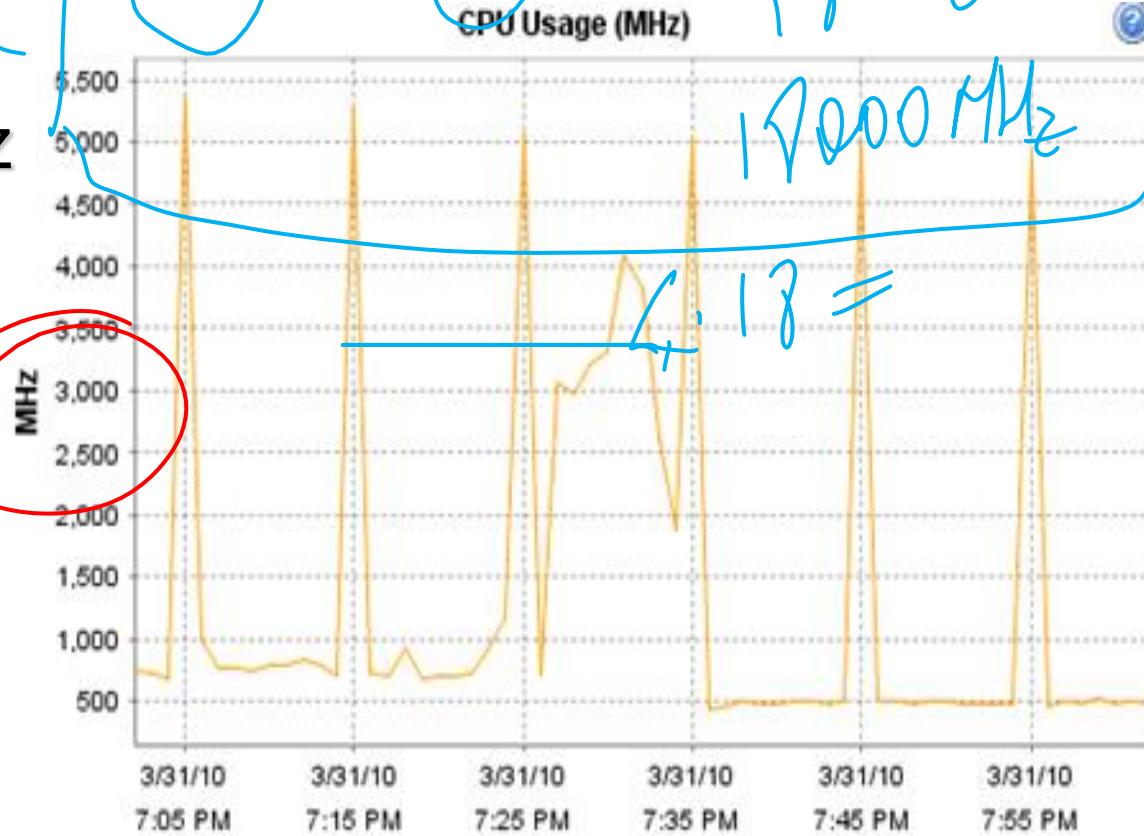




Model for CPU



- An host may have multiple CPU with multiple Core
- An host with 4 CPU at 3Ghz and 6 core each has
 - 24 cores at 3Ghz
 - 72.000 MHz
- VMs share this amount





Virtual Resources, 1/2

The idea of Virtual Resources (CPU, Mem, HD, net.) consists in providing a number of resources larger than those that physically available and manage them virtually and/or dynamically

For example, one Host may have 2 VM and HW resources:

- ♣ 2 cores at 1300 Mhz

- ♣ 1.8 Gbyte RAM

- ♣ 2 network cards

- ♣ Best case:

- CPU=400+800 Mhz

- RAM=400+400 Mbyte

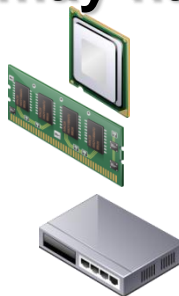
- 2 Network cards shared

- ♣ Worst case → no resources enough:

- CPU=3 cores at 1300 Mhz

- RAM=2 Gbyte

- 2 Network cards shared



VM1:

- n 1 CPU 1300 Mhz, 400 Mhz reserved

- n 1 Gbyte RAM max, 400 Mbyte reserved

- n 2 network cards, 2 IPs

VM2:

- n 2 CPU 1300 Mhz, 800 Mhz reserved

- n 1 Gbyte RAM max, 400 Mbyte reserved

- n 2 network cards, 2 IPs



Virtual Resources, 1/2

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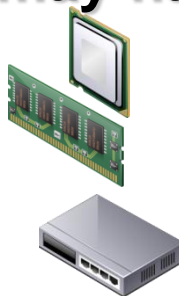
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- n 2 CPU 1300 Mhz, 800 Mhz reserved

- n 1 Gbyte RAM max, 400 Mbyte reserved

- n 2 network cards, 2 IPs



Virtual Resources, 2/2

I The server hosting the VMs

♣ Min Mhz:

→ 400Mhz + 800Mhz

♣ Max Mhz:

→ 1300Mhz + 2*1300Mhz

♣ Min RAM:

→ 400Mbyte + 400Mbyte

♣ Max RAM:

→ 1000Mbyte + 1000Mbyte

♣ Network:

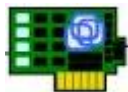
→ No limits on the number of virtual IP addresses/cards

VM1:

- n 1 CPU 1300 Mhz, 400 Mhz reserved
- n 1 Gbyte RAM max, 400 Mbyte reserved
- n 2 network cards, 2 IPs

VM2:

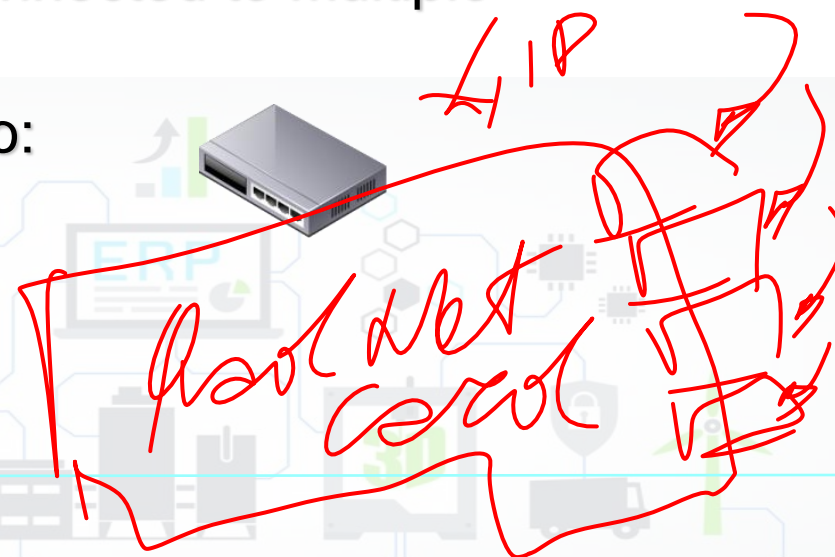
- n 2 CPU 1300 Mhz, 800 Mhz reserved
- n 1 Gbyte RAM max, 400 Mbyte reserved
- n 2 network cards, 2 IPs



Model for network



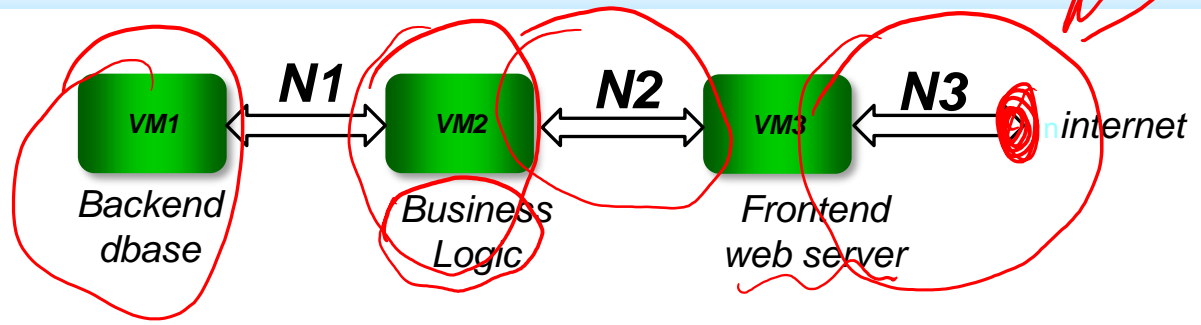
- | An host may have multiple network cards with one physical IP each or some of them bridged
- | Each single VM may have:
 - ♣ access to a number of networks (physical or virtual)
 - ♣ Installed multiple network cards
 - ➔ Each card can have one IP and may be connected to a network
- | This means that an host may be connected to multiple networks with multiple IP
- | Network cards may be connected to:
 - ♣ Physical switch
 - ♣ Virtual switch



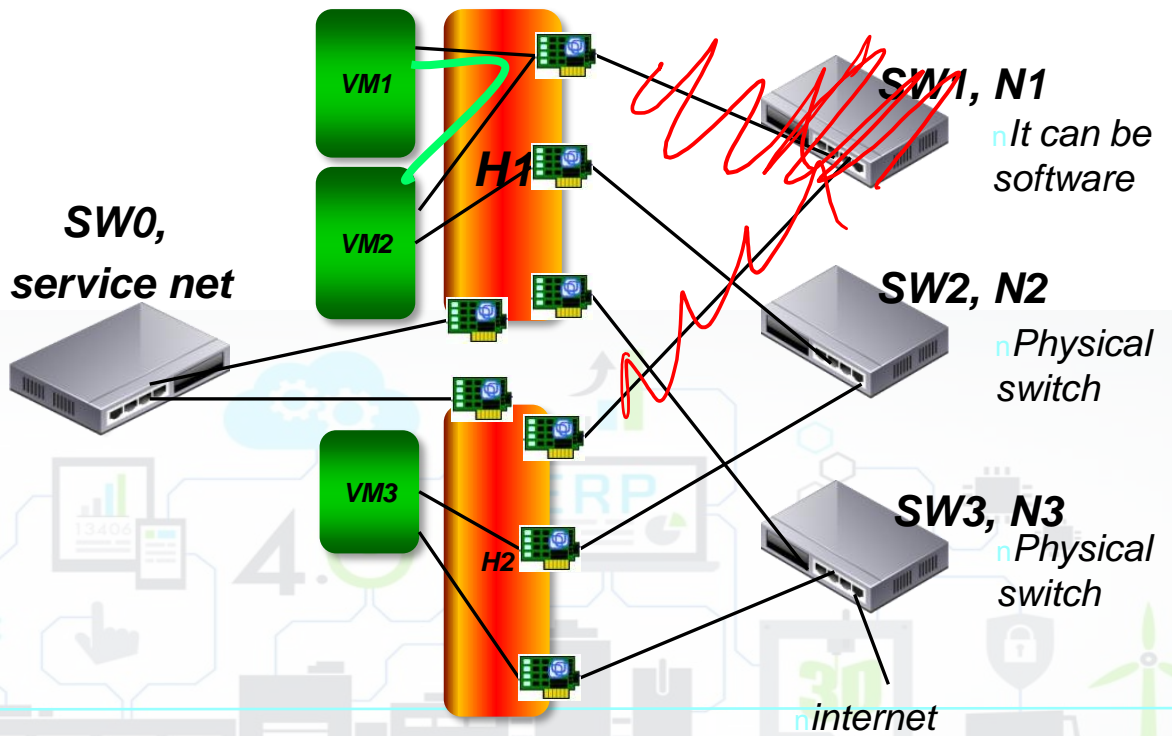


Example of Cloud Networking

- Example of allocation of a three tiers solution
- 3 different networks (N1, N2, N3)
- 2 Host: H1, H2
- 3 VM: VM1, VM2, VM3



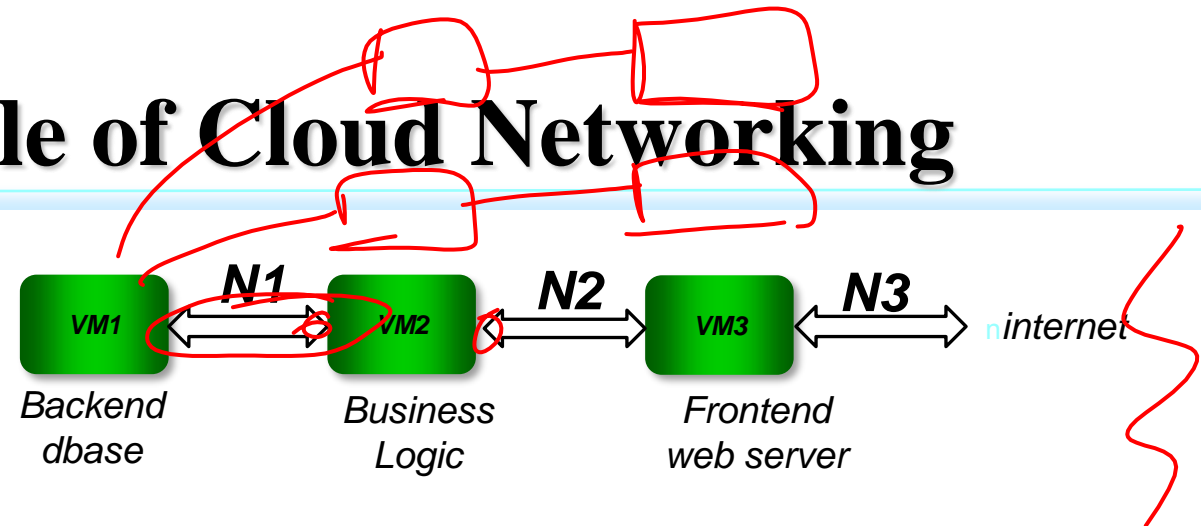
- SW1 is convenient to be software (full virtual). If it is HW, the VM1 can be moved from H1 to H2, dynamically
- SW2 could be fully virtual if VM3 is moved on H1



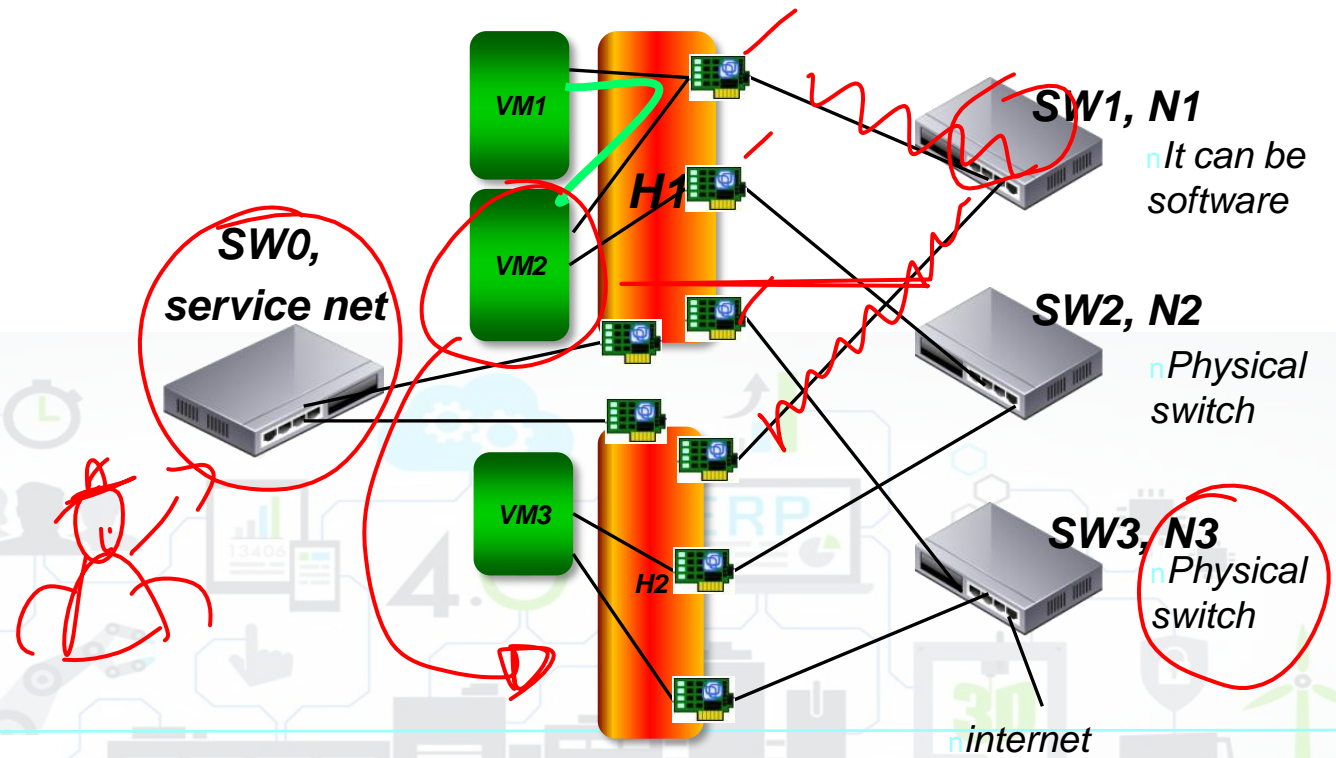


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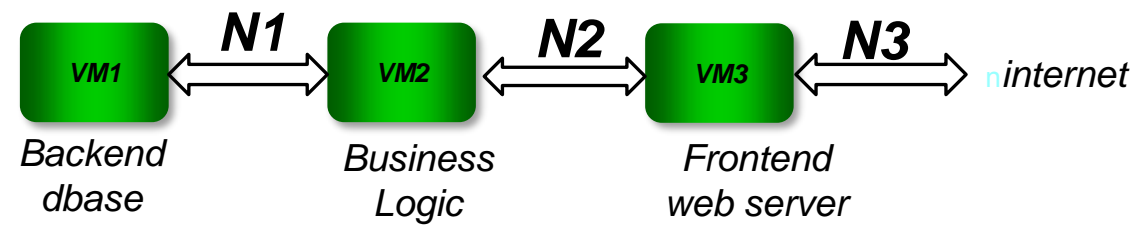
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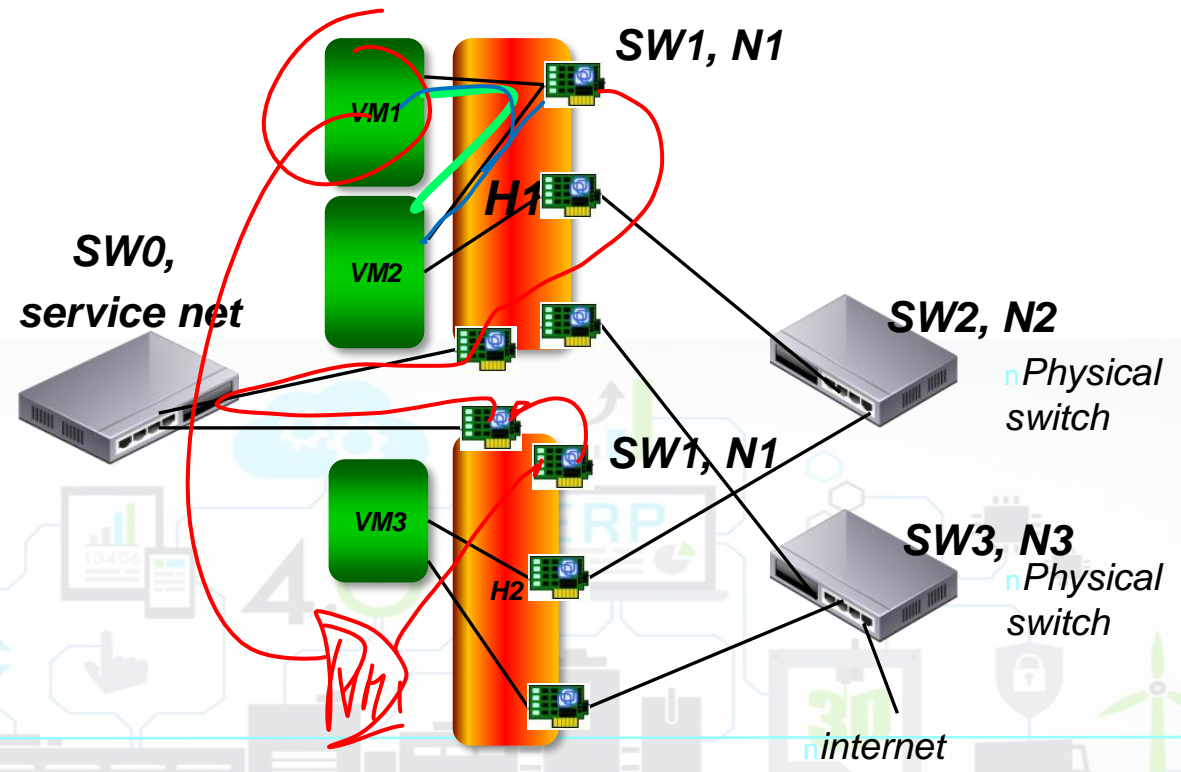


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- SW2 could be fully virtual if VM3 is moved on H1





Network and Virtual Networks

Virtual Switch: vSwitch0

Virtual Machine Port Group

- VM Network
- 10 virtual machine(s)
 - mobmed.axmedis.org-d6-back-28-07-2010
 - mobmed.axmedis.org-running
 - musicnetwork.dsi.unifi.it-back-01-06-201...
- Service Console Port
- Service Console
- vswif0 : 192.168.0.147

Physical Adapters

- vmnic1 1000 Full

The same VM with access to 2 different network via real network adapters

Virtual Switch: vSwitch1

Virtual Machine Port Group

- Mydbnetwork
- 1 virtual machine(s)
 - backdb

Physical Adapters

- No adapters

A virtual network

Virtual Switch: vSwitch2

Virtual Machine Port Group

- Virtual Machine Network
- 8 virtual machine(s)
 - mobmed.axmedis.org-d6-back-28-07-2010
 - mobmed.axmedis.org-running
 - openmind.axmedis.org-running
 - musicnetwork.dsi.unifi.it-back-01-06-201...

Physical Adapters

- vmnic0 1000 Full





Model for HD, Storage



I Storage:

- ♣ HD contained into VM
- ♣ SAN: External to VM and mounted for their usage
- ♣ In any case connected with some Operating Systems (may be dedicated)

NAS host

I HD with fault tolerant solution:

- ♣ Redundancy: replications into the Storage
- ♣ Distributed/federate/replicated: replications into multiple storage



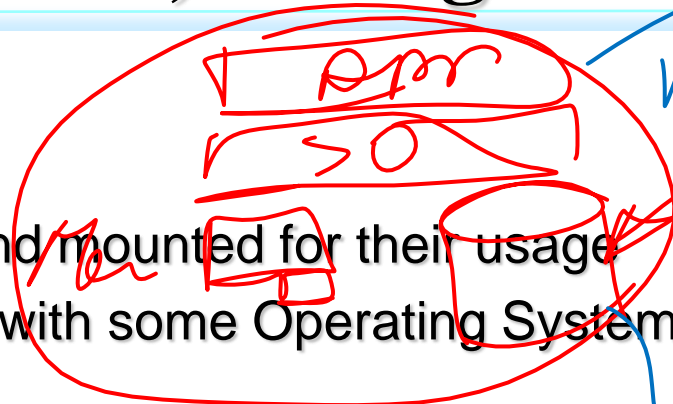


Model for HD, Storage



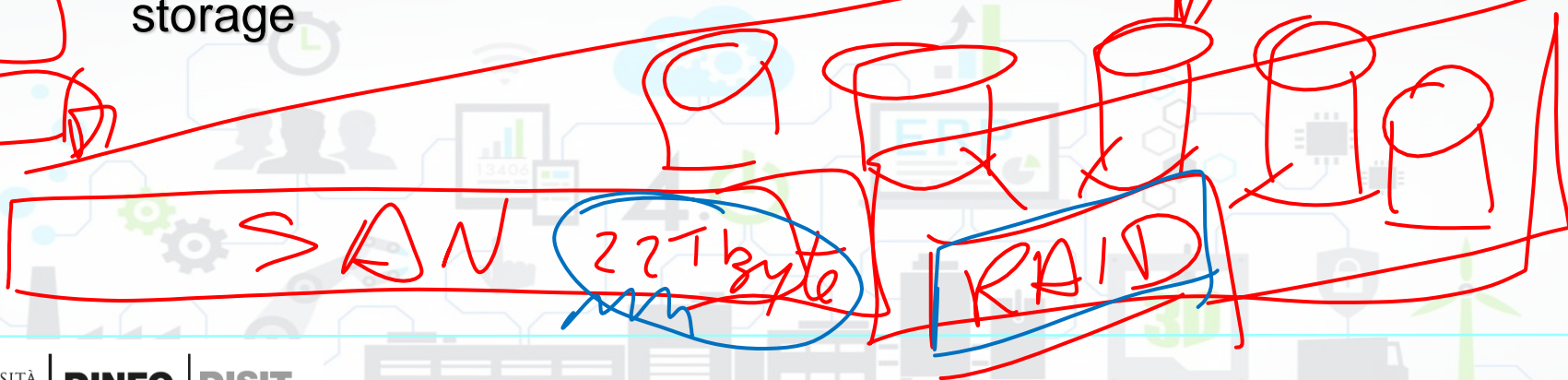
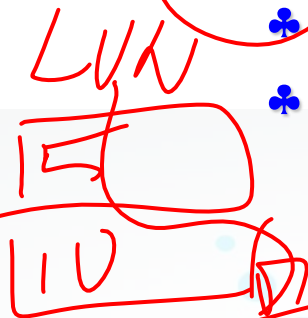
Storage:

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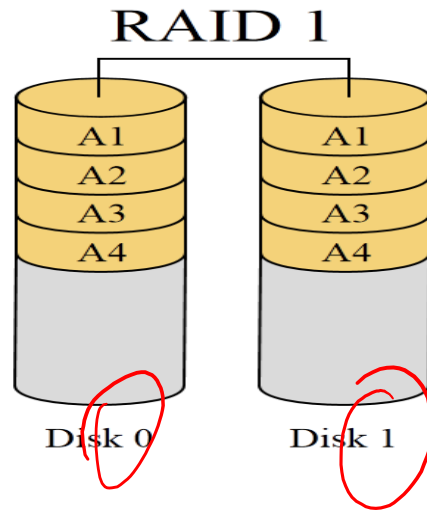
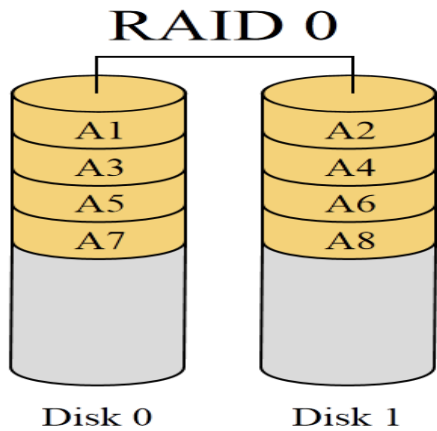
HD with fault tolerant solution:

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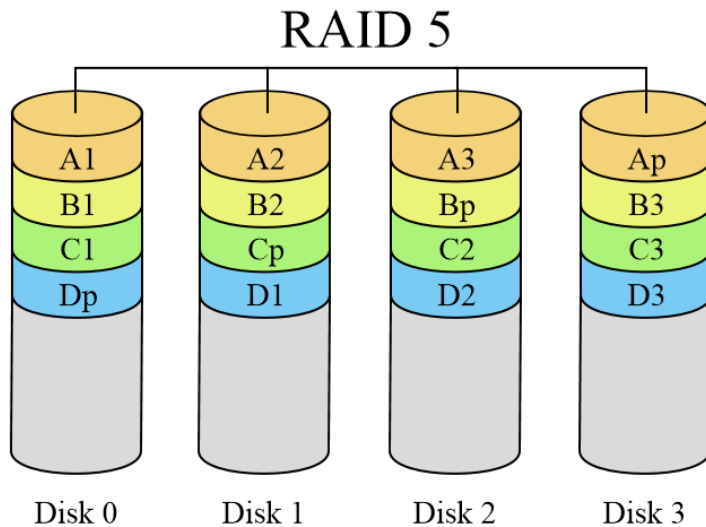


Internal replications: HD RAID



n RAID 0: HD0+HD1

n RAID 1: HD0 cloned on HD1



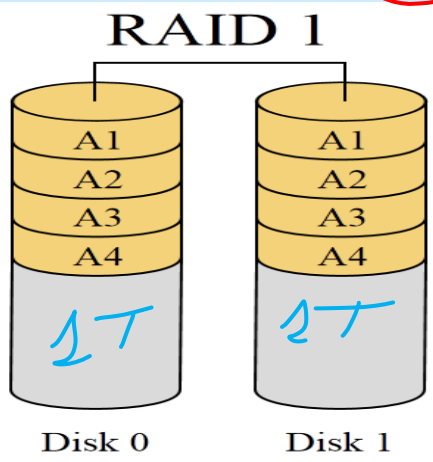
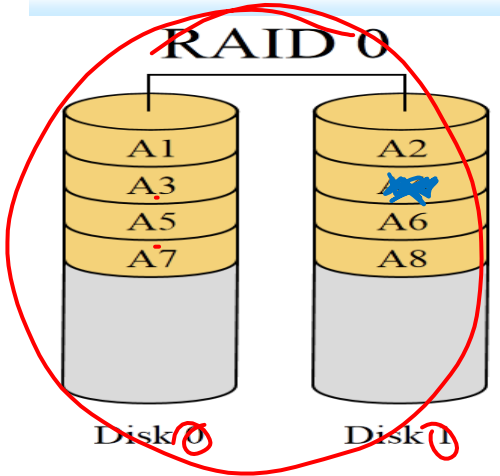
n RAID 5: gestione del guasto di un disco

n valido fino a 14

n per la doppia parità
→ RAID 6

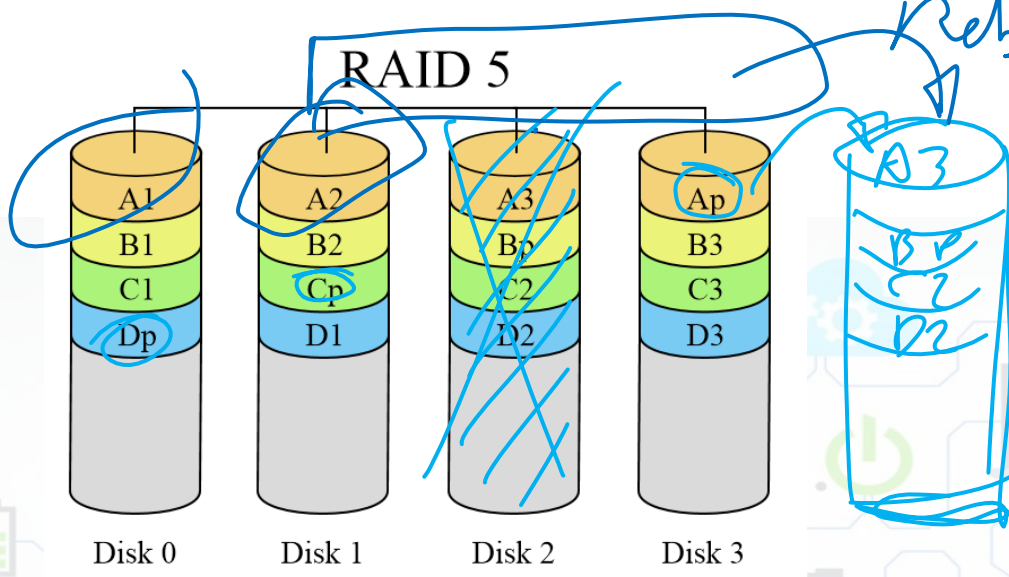


Internal replications: HD RAID



RAID 0: HD0+HD1 $2T$
 $1T + 1T = 2T$

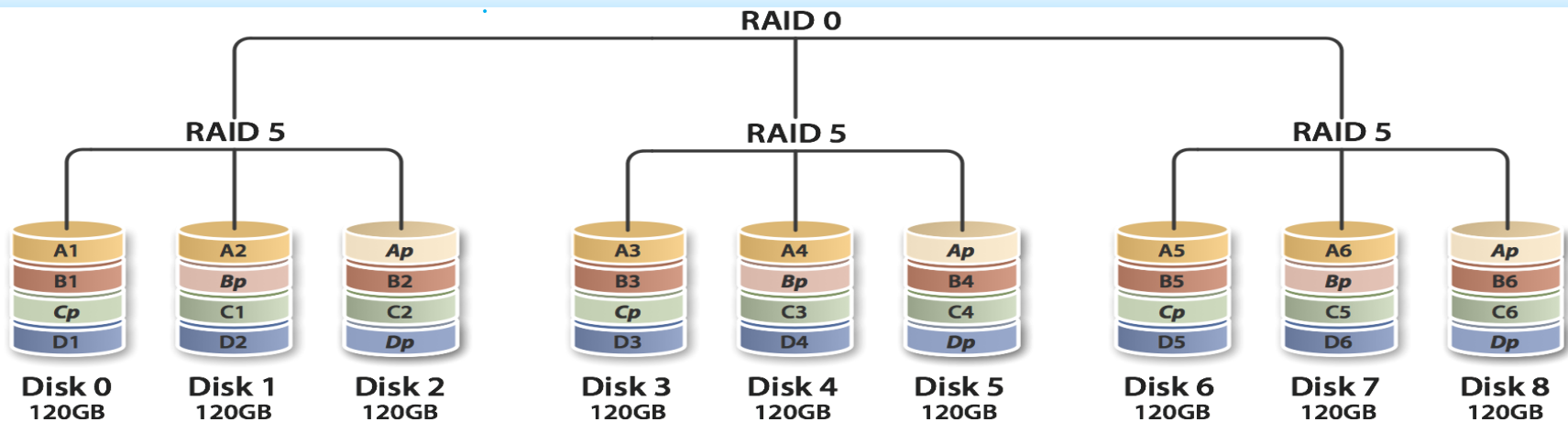
RAID 1: HD0 cloned on HD1



RAID 5: gestione del guasto di un disco
 valido fino a 14
 per la doppia parità
 → RAID 6



Internal replications: RAID 50



RAID 50: A1,A2,A3,A4,A5,A6 and three Parities

- ♣ Min 9HD, can support failures of three HDs
- ♣ improves upon the performance of RAID 5

In this case:

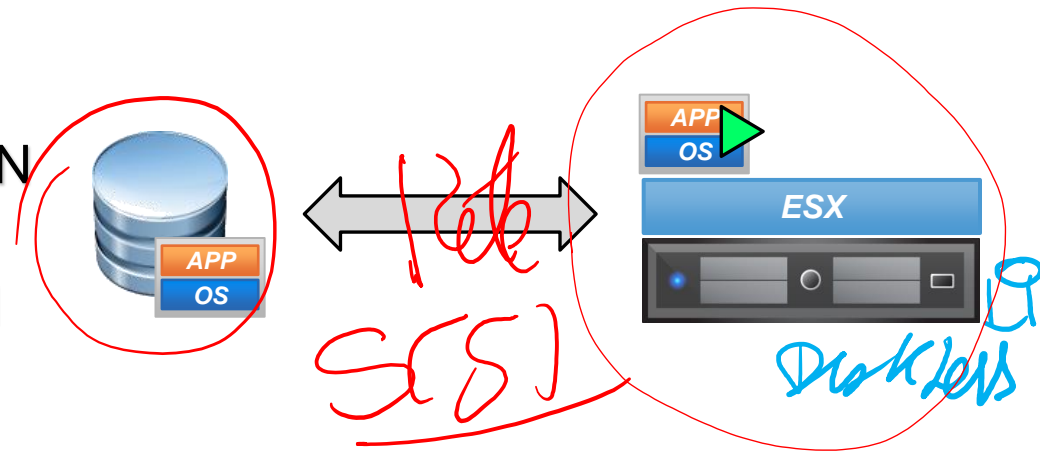
- ♣ Size: 6 over 9 HD, you lose a HD per R5
- ♣ Read/Write speed up: $n(m - 1) \times \text{HD}$
→ $n=3, m=3 \rightarrow 6x$ in this case



Simple configuration

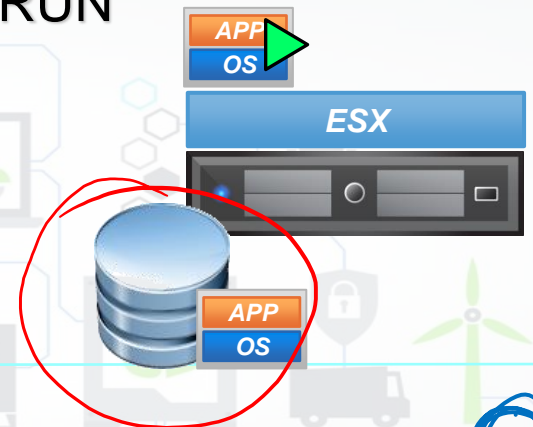
VM stored on a storage and executed on a remote hypervisor host

- At the start is uploaded on ESX memory and RUN
- Each write is passed back to the storage, SAN
- All via network



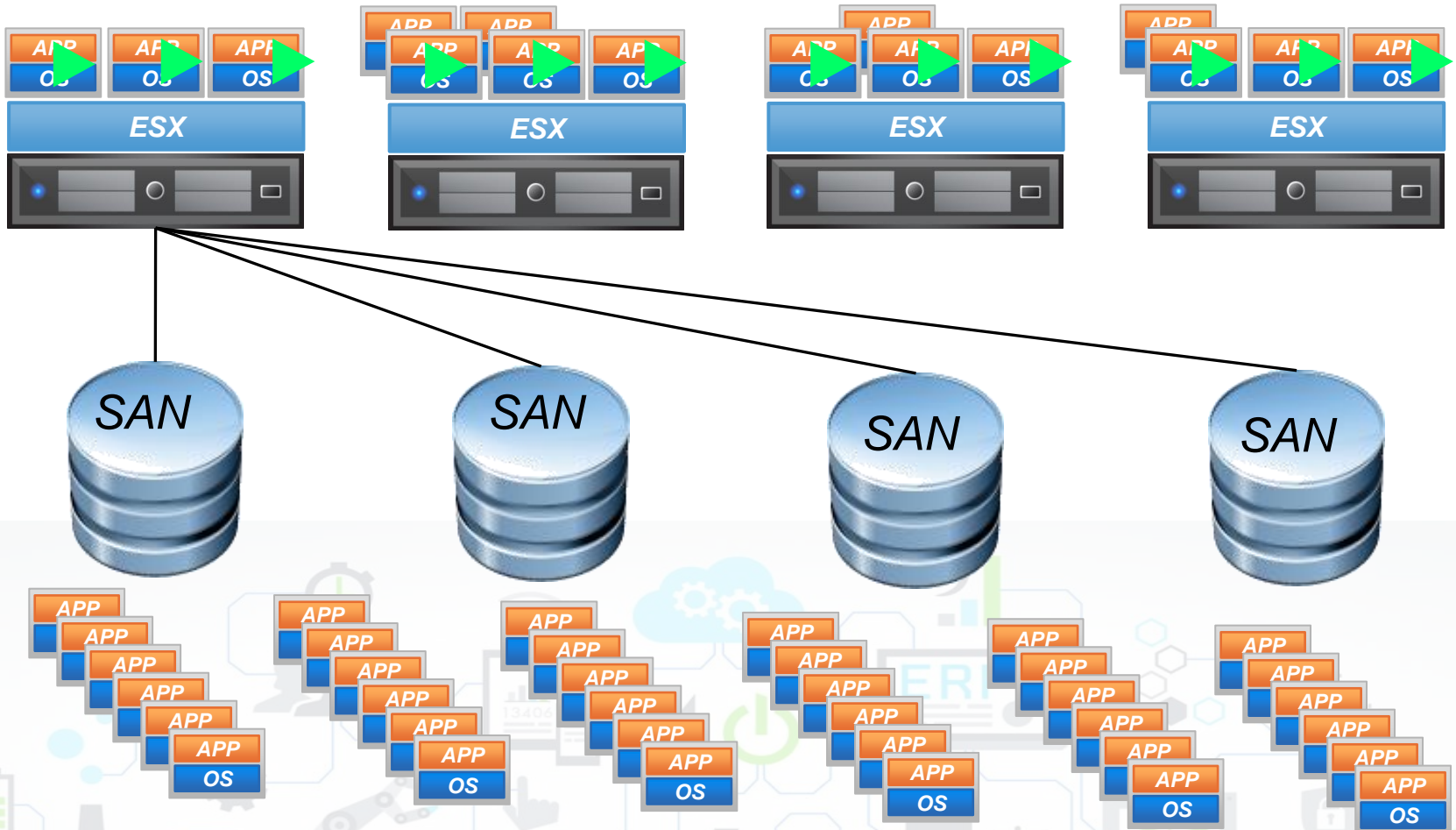
VM stored and executed on the same hypervisor host

- At the start is uploaded on ESX memory and RUN
- Each write is passed back to the storage
- All via internal communication
- higher performances
- lower flexibility



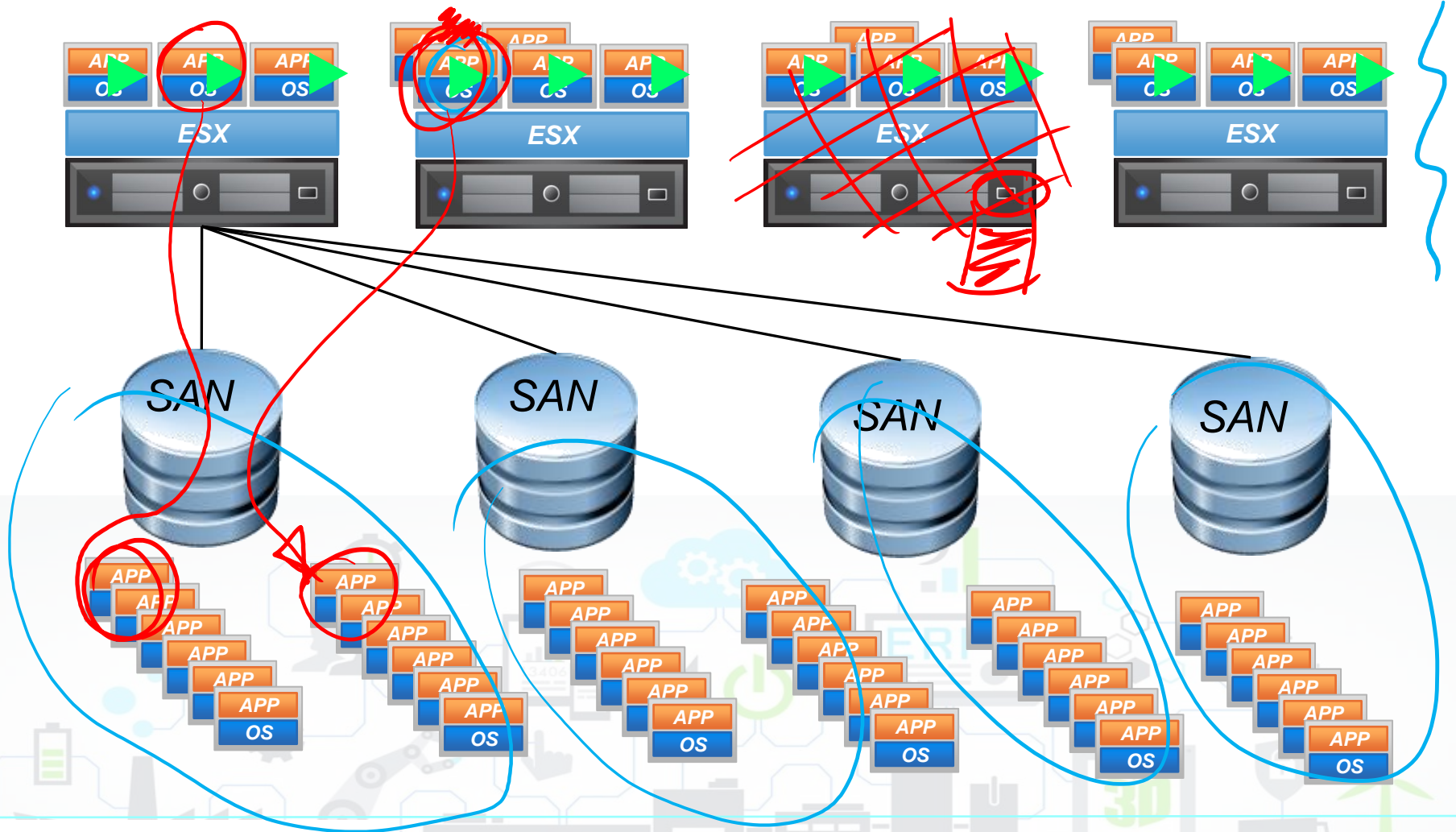


Cluster of Hosts in DRS





Cluster of Hosts in DRS





Model for storage consumption



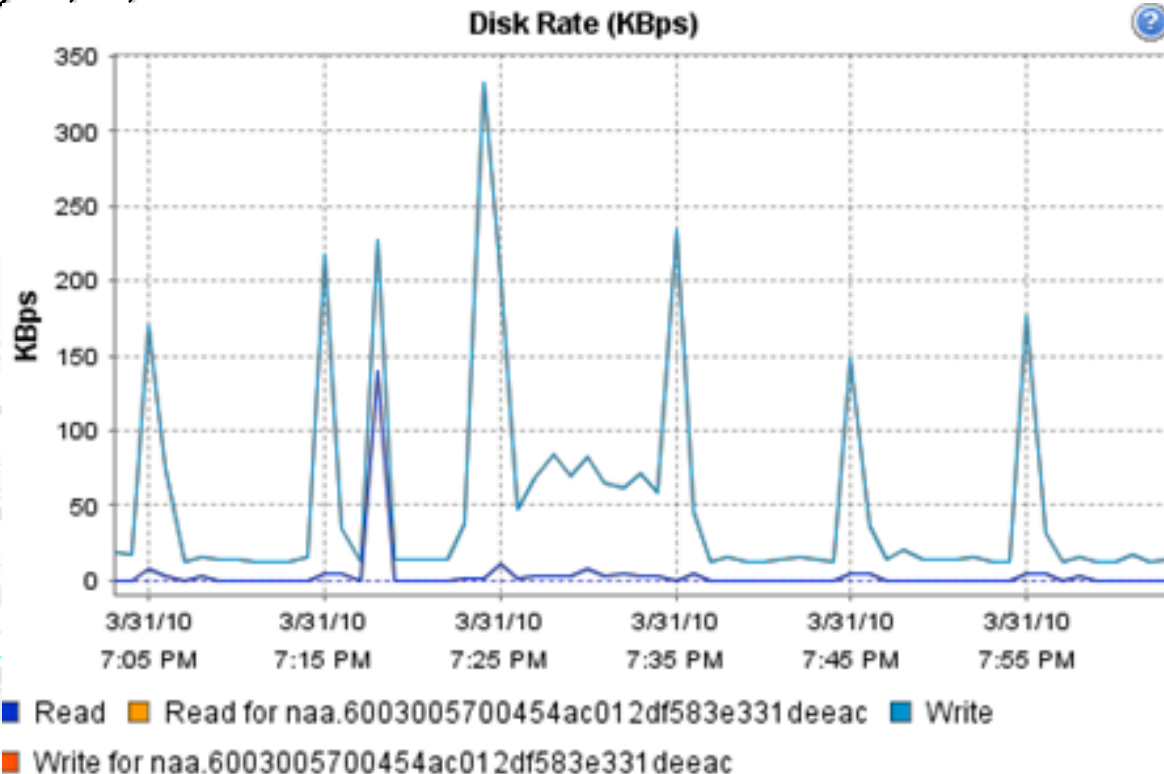
HDD Typical:

- ♣ 100 Mbyte per sec. (high/max value) *DMA*
- ♣ Seek time 5-7 Msec.
- ♣ 5000-7500-10000-15000 rpm (revolution per minute), spindle
- ♣ Thus latency: (5.56, 4.17, 3.00, 2.00) respectively *ms*
- ♣ Format Block size: 2Mbyte, 4, ..8

Cache, no cache;
different kind:

SSD:

- ♣ 30% faster

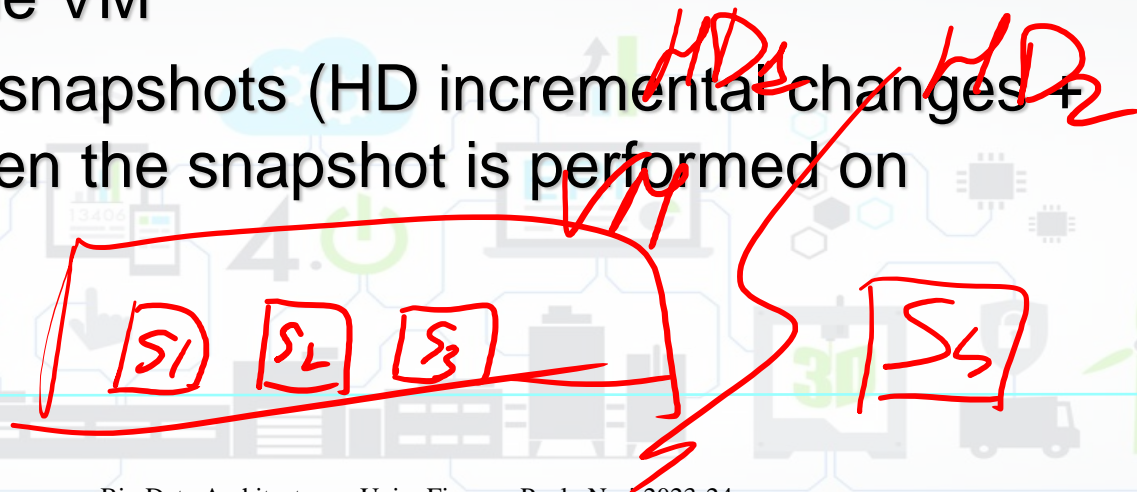




Storage Consumption



- | Each host may have
 - ♣ internal Storage one or more HD
 - ♣ External storage may be mounted (SAN or NAS)
- | External storage may be shared or reserved for a specific Host
- | Each VM has its permanent memory consumption:
 - ♣ Image for the VM
 - ♣ + space for snapshots (HD incremental changes + memory when the snapshot is performed on running)





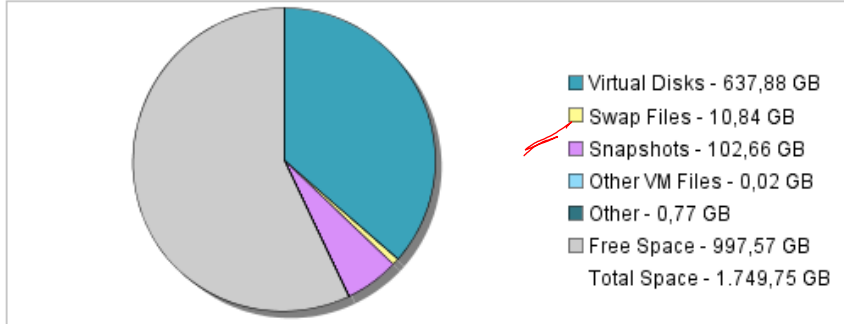
Examples



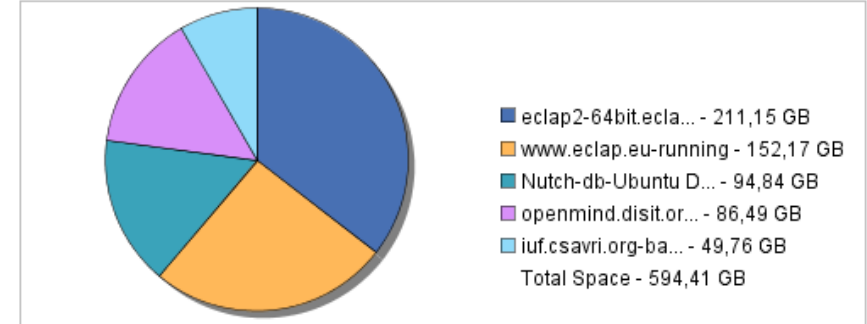
n Host

Space Utilization for 145-Storage-A-4

By File Type

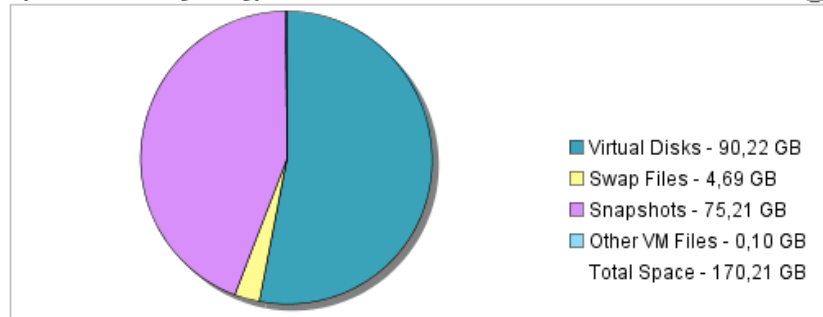


By Virtual Machines (Top 5)

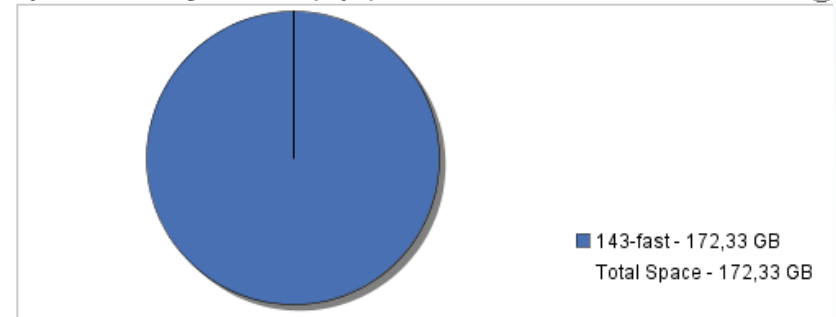


n Virtual Machine

Space Utilization By File Type



Space Utilization By Datastores (Top 5)





Virtual Machine: Snapshots



Working on VM Snapshots

Creating a Snapshot:

- A point from which it is possible to **reboot, restart**
- Consuming HD space
- Making back up since the core image of the VM is not changed, changes are confined in the files representing the last status “you are here” and not the previous conditions

Restarting from a past snapshot

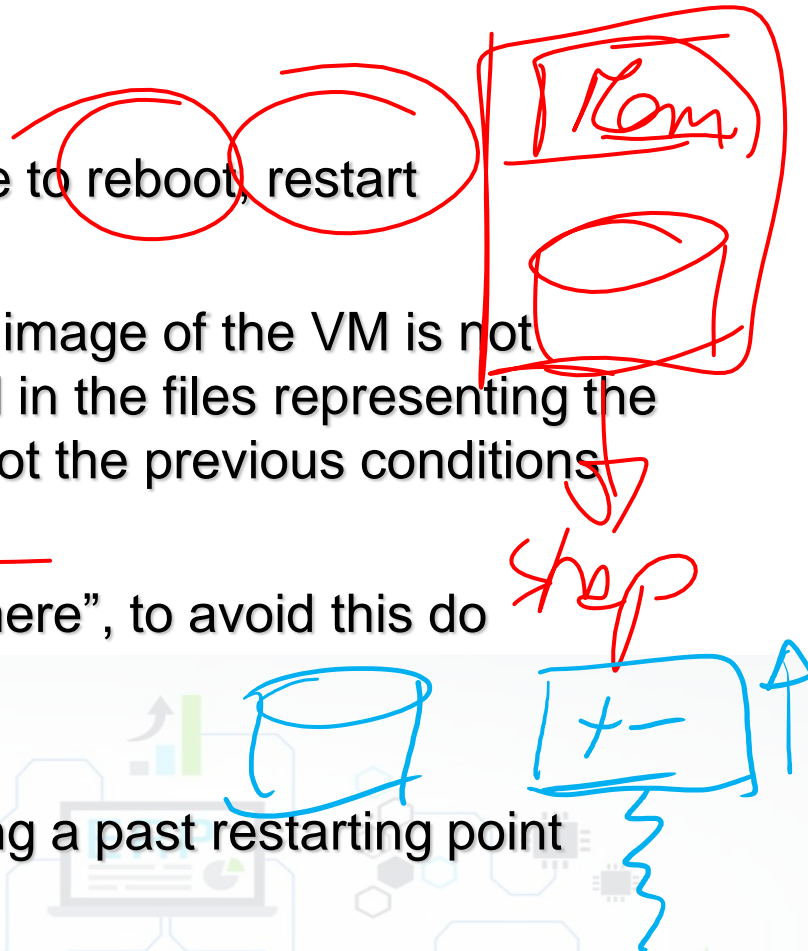
- Losing current point: “you are here”, to avoid this do another snapshot!!

Deleting a past snapshot

- Recovering HD space, removing a past restarting point

Removing all snapshots

Defragmenting images of the HDs into the VM





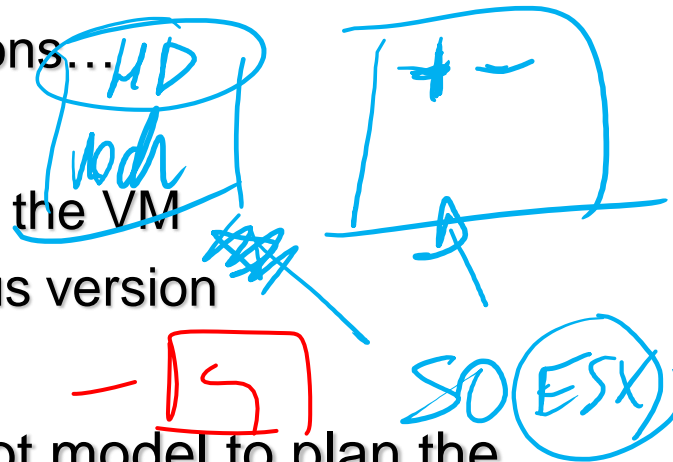
VM Snapshots

VM Snapshots can be at VM Off or ON

- Snapshots of running VM have implications...

Removing Snapshots

- Defragmenting images of the HDs into the VM
- Consolidating the changes in the previous version



VMware WS has an automated Snapshot model to plan the periodic snapshotting of the VM, for example:

- every hour, day, week, ...

A way to make back up

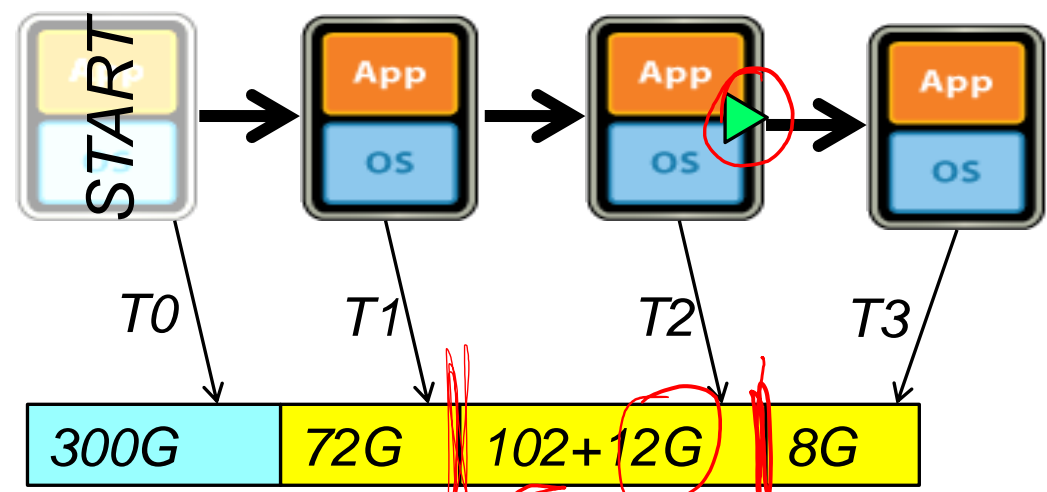
- A different way can be to clone the VM on different host or NAS. In most cases, the cloning implies the lost of performed snapshots



Snapshot process

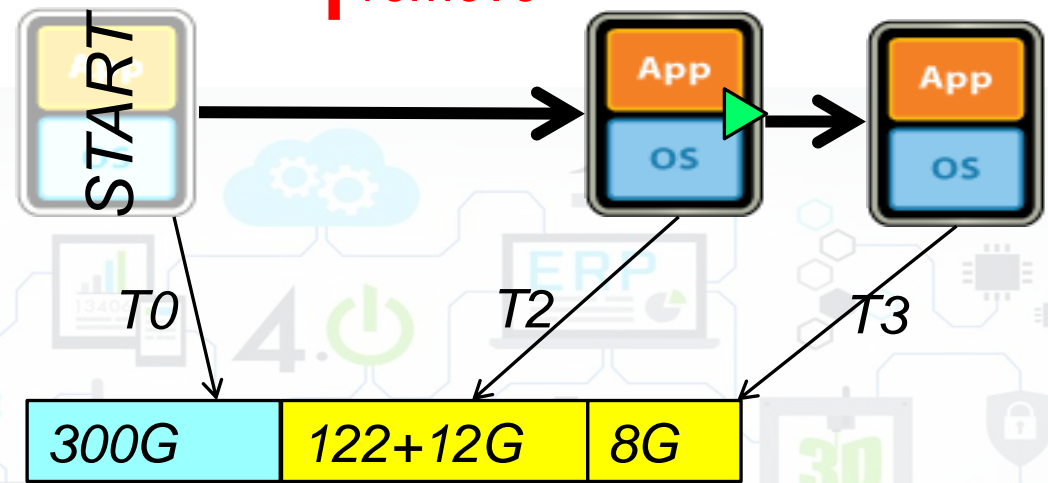
Original version

- 1 VM
- 12 Gb ram
- 300Gbyte hd
- 72+102+12+8 Gbyte snapshots



After T1 Rimoval

- 1 VM
- 12 Gb ram
- 300Gbyte hd
- 72+122+12+8 Gbyte snapshots



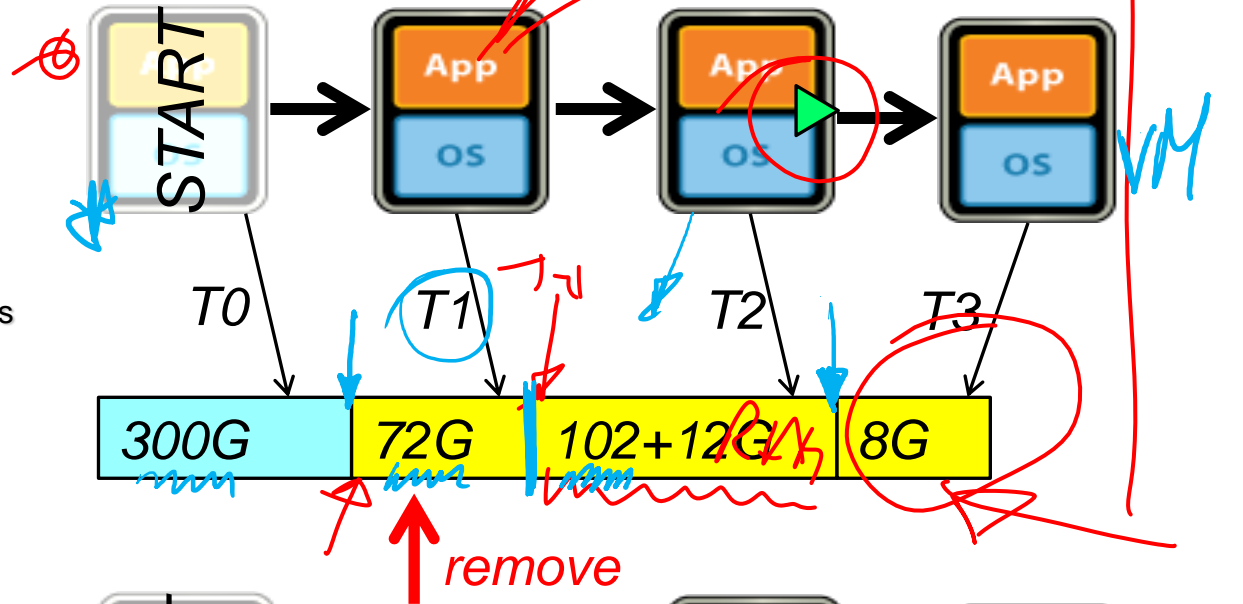


Snapshot process

Original version

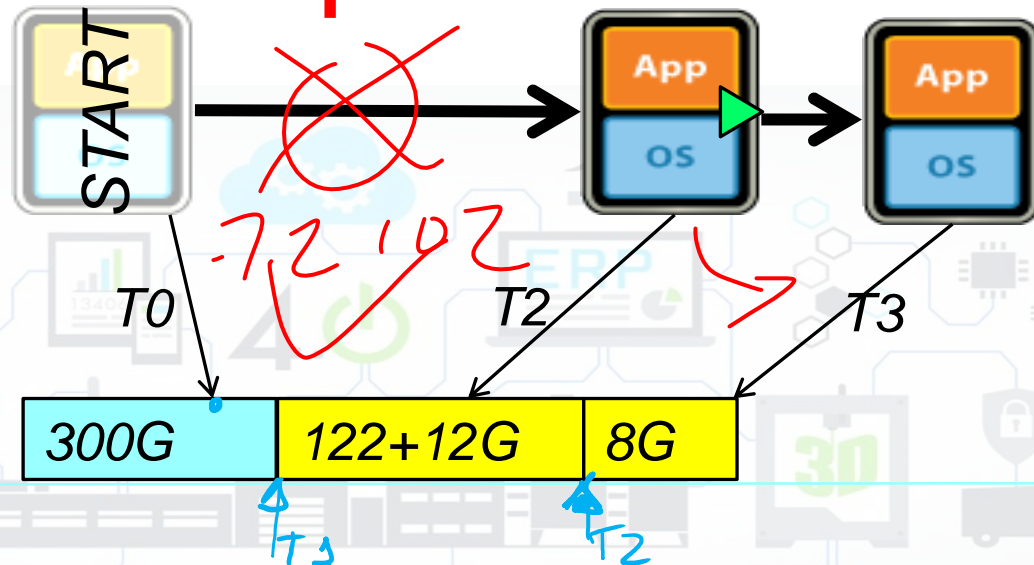
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72005



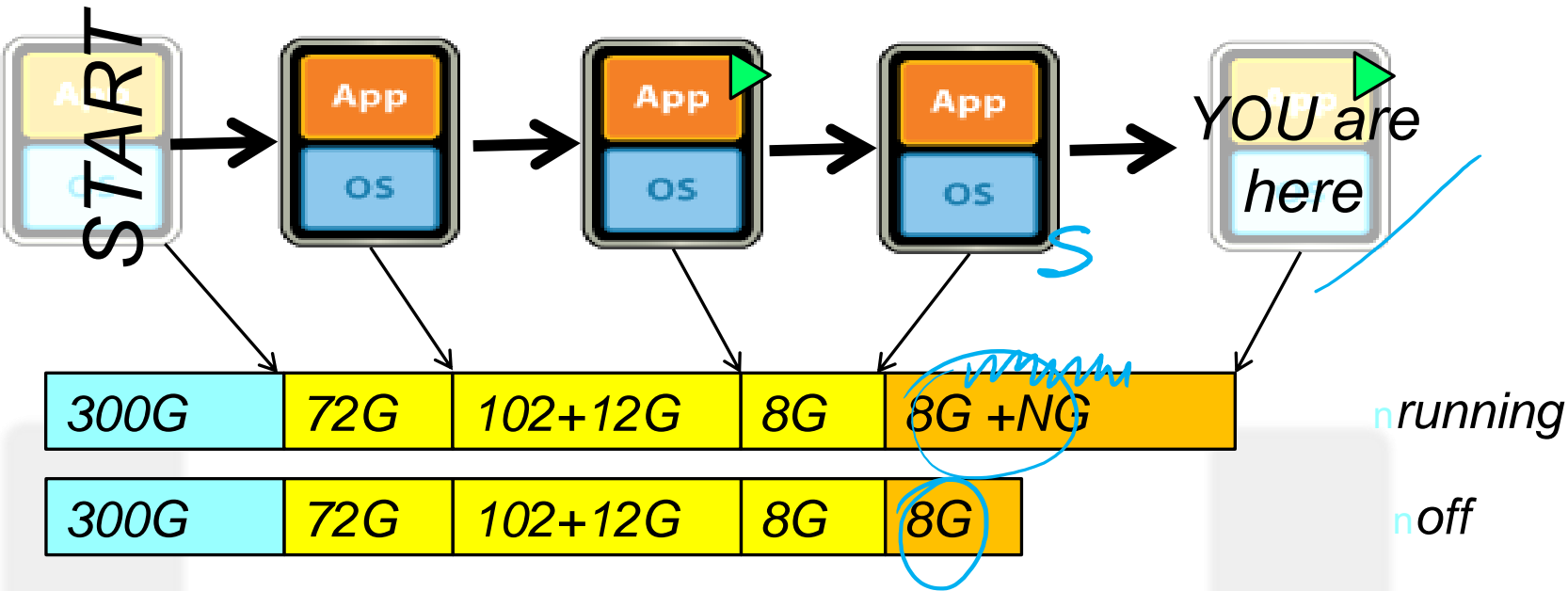
After T1 Removal

- 1 VM
- 12 Gb ram
- 300Gbyte hd
- 72+122+12+8 Gbyte snapshots





Virtual Machine: Snapshots, 1/3

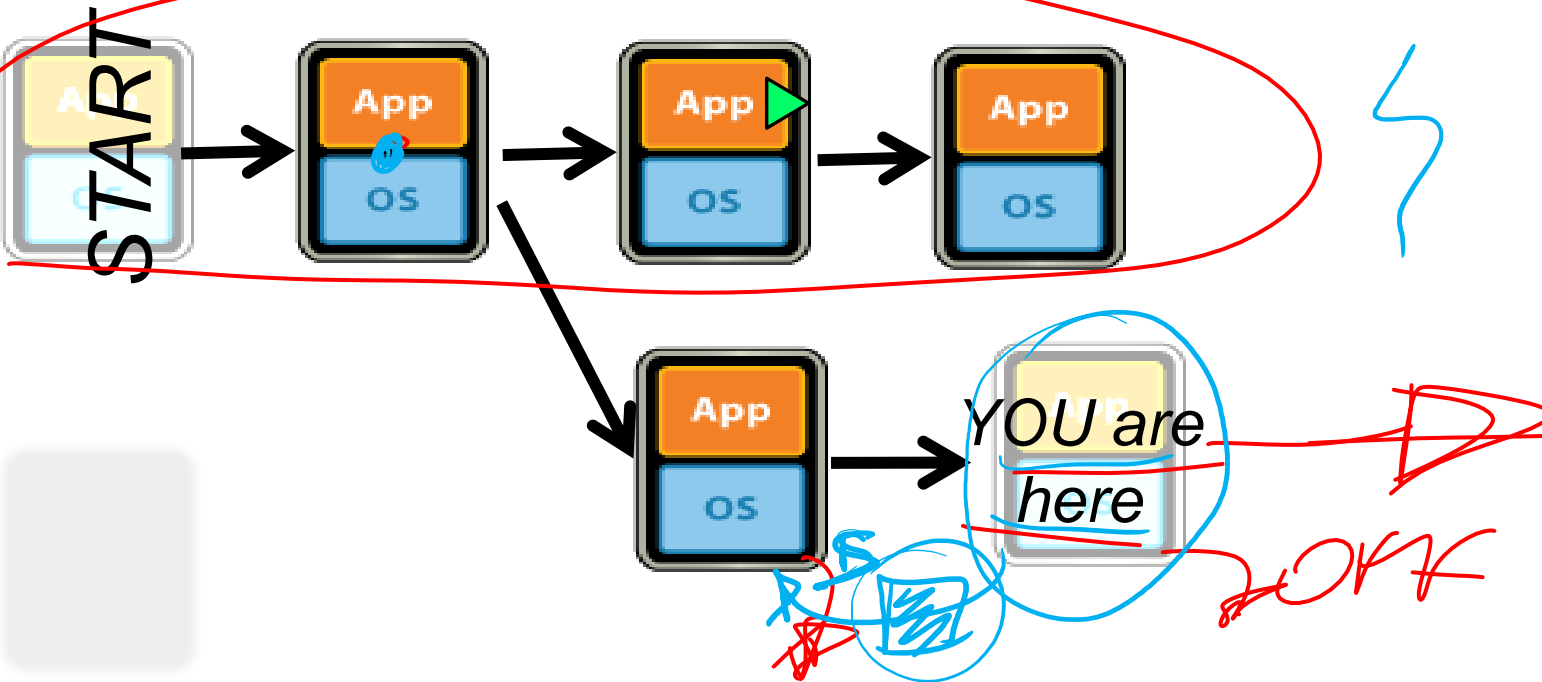


n When a number of snapshots are in place:

n the access to HD is deteriorating since the data are not contiguous, the data access implies multiple seek for multiple accesses at different segments of the same data in different file representing the different progressive snapshots!



Virtual Machine: Snapshots, 2/3





Structure

- | Elements of cloud Computing
- | Virtualization
- | Cloud Computing ←

 - ♣ cloud vs grid
 - ♣ goals of cloud computing
 - ♣ Solutions as a Service

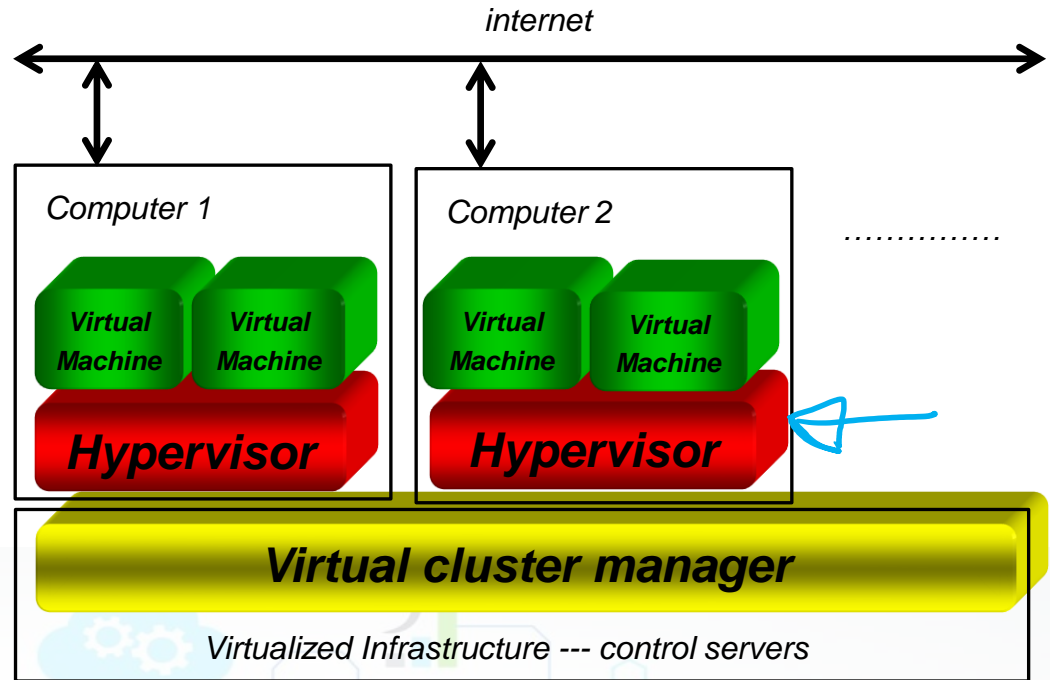
- | High Availability
- | vSphere Infrastructure
- | Security on the Cloud
- | Conversions among VM and physical machines
- | vCenter, datacenters and cluster management
- | Comparison among virtual computing solutions
- | How to work with Virtual Machines
- | IaaS solutions, SaaS Solutions, PaaS Solutions
- | Progetto ICARO





Cloud Computing with VMs

Several Hypervisors on a Clusters





Cloud Computing

- | **A Cloud:** a type of parallel and distributed system consisting of a collection of interconnected and virtualized computers, VMs
 - ♣ They are dynamically provisioned and presented as one or more unified computing resources
 - ♣ based on service-level agreements, SLA, established through negotiation between the service provider and consumers
- | Subset of grid computing where the allocated processes are virtual computers
- | **Implies**
 - ♣ An alternative way to have local servers or GRIDs
 - ♣ Outsourcing: HW and SW tools, they may be grid elements
 - ♣ Outsourcing: network, CPU, memory, HD, etc.
 - ♣ Definition of some service agreement, monthly rate, minimum network capability, kind of HW, mem space, minimum level of CPU/mem, etc.



Abstraction of Cloud Computing, (Buyya & Yeo)

Users/
Brokers

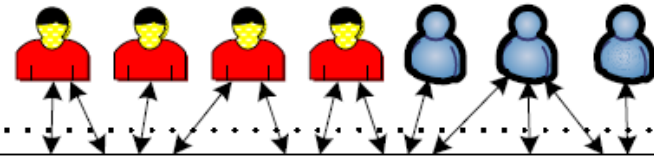
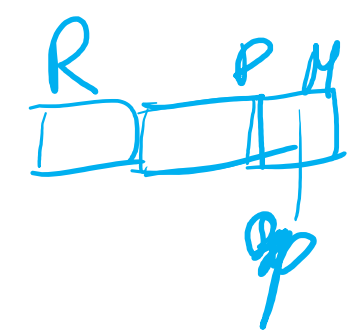
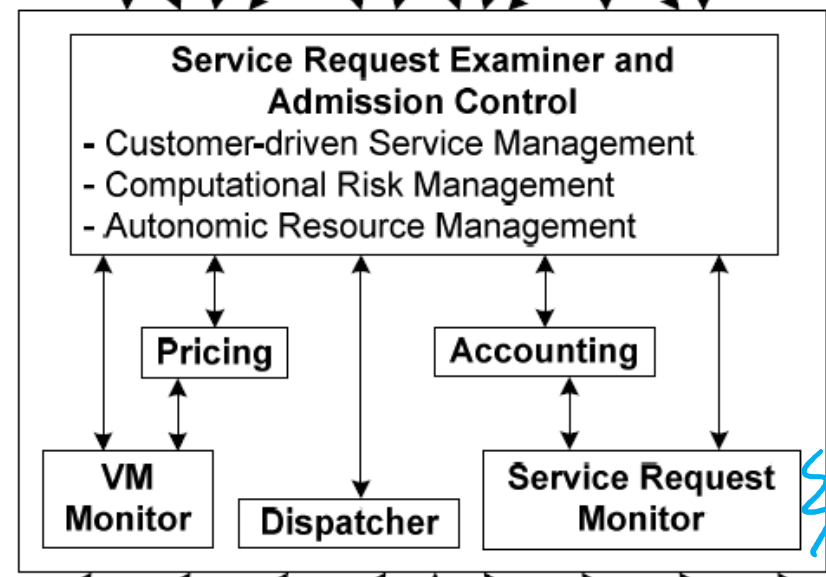
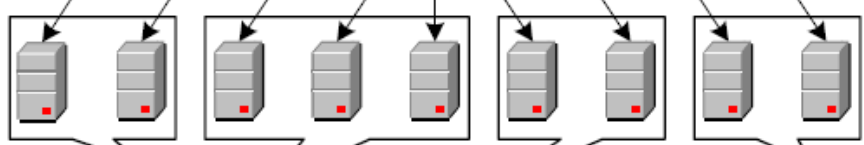


diagram
CSP

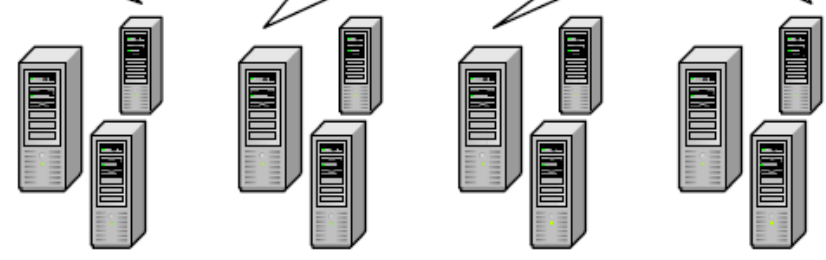
**SLA
Resource
Allocator**



Virtual
Machines
(VMs)



Physical
Machines



High-level market-oriented cloud architecture.



Cloud vs GRID computing, HPCN

- | **Cloud computing** is an evolution of GRID computing
- | **Renting a GRID** service means:
 - ♣ Parallelize the algorithm, demand the execution, wait for the results, etc.
 - ♣ To do no know where the processes are executed. In most cases batch processing such as on Globus
- | **Renting a VM/Computer** into a Cloud means:
 - ♣ Simple contracts, remote access to servers
 - ➔ Get access to virtual or physical resources at 100%
 - ♣ Privacy of the allocated processes in your VM/Host
 - ♣ Processes running on your preferred OS and do not have to be recompiled as in most Grid solutions.
 - ♣ Scalability in terms of number of CPU, Mem, network performance, computers, etc. OR you have to change your OWN architecture
 - ➔ Simple creation and reconfiguration of multitier solutions
 - Creating fault tolerant solutions
 - Balancing load of CPU, Memory, network, etc.



Cloud vs SuperComputers

Cloud Computing is based on a set of Hosts for hosting VM or providing access to single/multiple Servers fully at disposal of the customers accessing to the cloud via remote access (see later).

- ♣ They are MIMD computers
- ♣ Hosts may contains hypervisors to host VM of diff. OSs.
- ♣ Hosts may be single computers with Linux, Windows,...

Super Computers, such as Blue Gene/P:

- ♣ Processor PowerPC 450 with 4 cores, 850 Mhz
- ♣ Each board: 32 CPU processors
- ♣ Each Rack: 32 boards
- ♣ [Jülich Research Centre](#) in Germania has a Blue Gene with 65536 processors → 167 teraFlops, the strongest computer in the world!





Comparing Computing Services

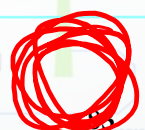
System	<u>Amazon</u> Elastic Compute Cloud (EC2)	<u>Google</u> App Engine	<u>Microsoft</u> Live Mesh	<u>Sun</u> Network.com (Sun Grid)	<u>GRIS Lab</u> Aneka
Property					
Focus	Infrastructure	Platform	Infrastructure	Infrastructure	Software Platform for enterprise Clouds
Service Type	Compute, Storage (Amazon S3)	Web application	Storage	Compute	Compute
Virtualisation	OS Level running on a Xen hypervisor	Application container	OS level	Job management system (Sun Grid Engine)	Resource Manager and Scheduler
Dynamic Negotiation of QoS Parameters	None	None	None	None	SLA-based Resource Reservation on Aneka side.
User Access Interface	Amazon EC2 Command-line Tools	Web-based Administration Console	Web-based Live Desktop and any devices with Live Mesh installed	Job submission scripts, Sun Grid Web portal	Workbench, Web-based portal
Web APIs	Yes	Yes	Unknown	Yes	Yes
Value-added Service Providers	Yes	No	No	Yes	No
Programming Framework	Customizable Linux-based Amazon Machine Image (AMI)	Python	Not applicable	Solaris OS, Java, C, C++, FORTRAN	APIs supporting different programming models in C# and other .Net supported languages





Comparing Computing Services

- | In the previous table, different solutions for computing services in the network are compared.
- | They are mainly: cloud computing, grid services, application services,
- | The solutions taken have been selected as representative of their category
 - ✿ Please see the slides on GRID for more details and a wider comparison on the grid solutions
 - ✿ Please see the slides regarding the general distributed systems for multitier applications





Advantages of Cloud Computing

Grids are difficult to use and to maintain:

- GRID customers have too many different needs that make the creation of fully open grid very difficult.

Cloud computing

- HW/SW is hosting virtual computers that can be moved to other solutions with low costs
- Lower costs since the HW/SW is seen as a service
 - No maintenance, centralized services such as back up, scaling, etc.
- Lower costs for Small Business:
 - Reduction of costs since the admortment can be performed by who is exploiting the computer
- Scalability similar to grid:
 - Horizontal scaling
 - Parallelization as MIMD





Goals of Cloud Computing

I **Scalability.**

- ♣ scaling with workload demands so that performance and compliance with service levels remain on target

I **Availability.**

- ♣ users of Internet applications expect them to be up and running every minute of every day, i.e.: h24, 24/7

I **Reliability**

- ♣ physical system components rarely fail, but it happen. So that, they can be replaced without disruption.
- ♣ Today, reliability means that applications do not fail and most importantly they do not lose data, and the service is not stopped.

I **Security.** *Privacy*

- ♣ Applications need to provide access only to authorized, authenticated users, that need to be able to trust that their data is secure.



Goals of Cloud Computing

| ***Flexibility and agility:***

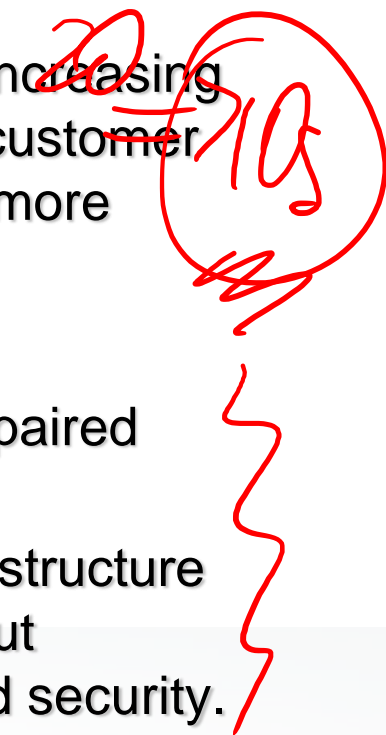
- ❖ Adapt rapidly to changes of business conditions by increasing the velocity at which applications are delivered into customer hands. E.g.: more CPU, more clock, more memory, more network cards, etc.

| ***Serviceability:***

- ❖ In the past this meant using servers that could be repaired without, or with minimal, downtime.
- ❖ Today it means that an application's underlying infrastructure components can be updated or even replaced without disrupting its characteristics including availability and security.

| ***Efficiency:***

- ❖ differentiates the cloud computing. The process allocation and costs have to be very effective with respect to the investment.





Definizioni

XaaS

Classificazione NIST

- ♣ Software as a Service (SaaS)
- ♣ Platform as a Service (PaaS)
- ♣ Infrastructure as a Service (IaaS)

Cloud Application
Software as a service

Cloud Platform
Platform as a service

Cloud Infrastructure
Infrastructure as a service

SW
ITW

Business Process as a Service (BPaaS)

- ♣ Aggiunto in seguito

Everything as a Service (XaaS)

- ♣ Middleware as a Service !!!!

MaaS



Infrastructure as a Service (IaaS)

CSP

- | erogazione di servizi infrastrutturali relativi a capacità elaborativa, storage, rete e altri elementi di base assolutamente indipendenti da servizi applicativi di qualunque tipo.
- | Si utilizza quindi l'infrastruttura messa a disposizione dal provider per eseguire la propria applicazione,
 - ♣ pagamento in base al consumo dell'infrastruttura
 - ♣ lasciando sotto la responsabilità dell'utente la gestione del sistema operativo, dell'eventuale middleware e della parte di runtime, oltre che dell'applicazione stessa.
- | Amazon EC2 è un esempio di servizio IaaS.

Host
Host
VM



Platform as a Service (PaaS)

- | erogazione di servizi applicativi di base come sistemi operativi, middleware, linguaggi, tecnologie di base dati e l'ambiente runtime necessari per eseguire l'applicazione,
- | L'applicazione rimane l'unica cosa sotto la responsabilità dell'utente, oltre alla definizione del modello (e.g., numero e dimensione dei server, datacenter, caratteristiche del networking) da utilizzare per l'esecuzione dell'applicazione.
- | Google AppEngine è un esempio di Platform as a Service.
- | A livello PaaS viene anche collocato l'insieme dei servizi MaaS, Middleware as a Service.



Software as a Service (SaaS)

- | erogazione di servizi applicativi di qualunque tipo, accessibili indipendentemente dalla collocazione e dal tipo di device utilizzato.
- | Non è eseguita un'applicazione proprietaria del cliente, ma il cliente stesso paga il diritto (mediante licenza o canone di affitto) di utilizzo di un'applicazione messa a disposizione dal provider, senza preoccuparsi di come essa venga realizzata e gestita nel cloud.
- | L'unica preoccupazione del cliente in questo caso, oltre ovviamente alla scelta della corretta applicazione che soddisfi le sue necessità, è gestire il numero di licenze richieste in funzione del numero di utenti.
- | Salesforce.com Customer Relationship Management (CRM) è un esempio di soluzione in cui il software è venduto in modalità as a service.



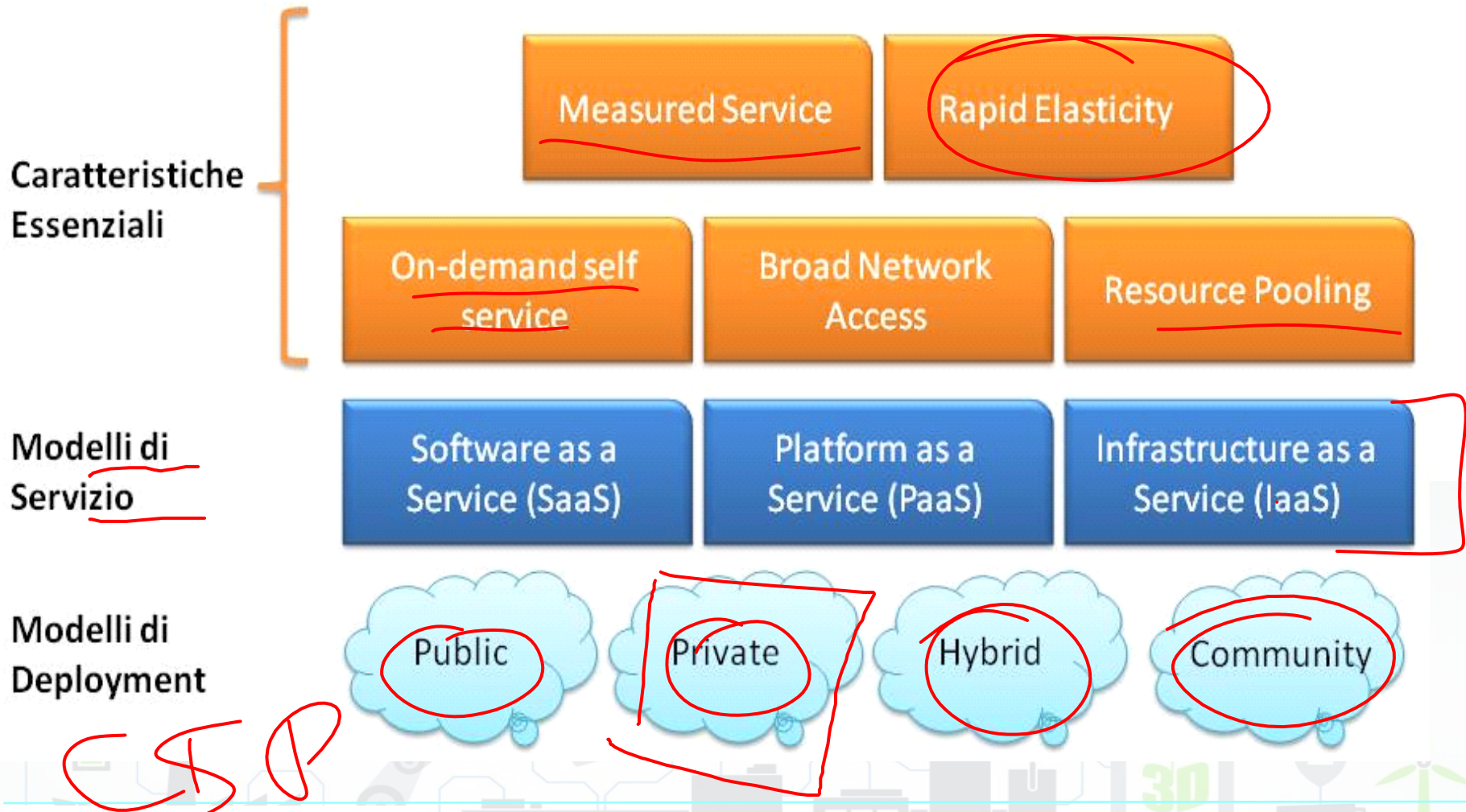
Business Process as a Service (BPaaS):

- | erogazione di servizi non esclusivamente riferiti ad ambiti applicativi ma direttamente alle funzionalità di business o di processo, potenzialmente trasversali rispetto alle piattaforme applicative.
- | un processo di business mappato interamente nel cloud (composto da servizi, applicazioni web, applicazioni legacy, servizi di integrazione, etc.).
- | Il processo di business è un pattern di servizi ed include problemi di sicurezza, costi, scalabilità connessione fra local e cloud bidirezionale, il cloud può essere un burst per l'azienda, e può sgravare i costi nel momento del bisogno.





Modello Generale






Definizioni

- | **Private Cloud.** abilitata per operare soltanto per un'organizzazione. può essere gestita dalla stessa organizzazione o da parte di terzi.
- | **Community Cloud.** condivisa da più organizzazioni a supporto di una singola community che ha interessi e obiettivi comuni. Questa può essere gestita dalle stesse organizzazioni o da terzi in modalità on-premise e off-premise.
- | **Public Cloud.** resa disponibile in maniera pubblica ed è di proprietà di un'organizzazione che vi gestisce la vendita di servizi cloud.
- | **Hybrid Cloud.** Infrastruttura composizione di due o più cloud (siano essi private, community o pubblici), rimangono entità separate, ma comunque accomunate da standard o tecnologie proprietarie che abilitano un certo livello di portabilità di dati e/o applicazioni di migrazione e/o bursting.



Structure

- | Elements of cloud Computing
- | Virtualization
- | Cloud Computing
- | High Availability 
 - ♣ Workload Balancing
 - ♣ RAID on HD
 - ♣ SAN/NAS
- | vSphere Infrastructure
- | Security on the Cloud
- | Conversions among VM and physical machines
- | vCenter, datacenters and cluster management
- | Comparison among virtual computing solutions
- | How to work with Virtual Machines
- | IaaS solutions, SaaS Solutions, PaaS Solutions
- | ICARO project



High Availability

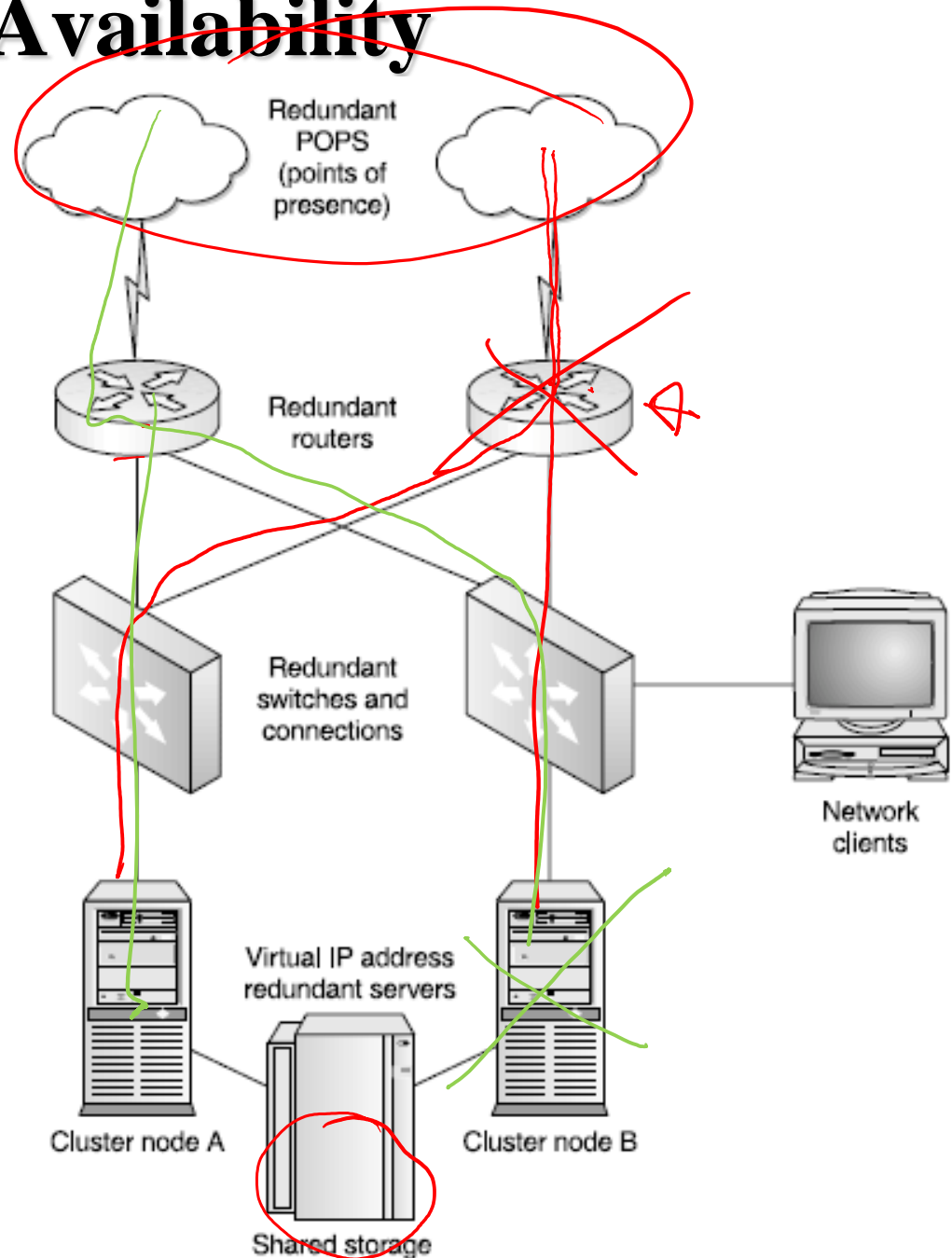
- | The high availability has to be guaranteed only by the integration of features of:
 - ♣ **High Reliability**
 - ♣ **High Serviceability**
 - ♣ **Fault tolerance**
 - ♣ **Migration of VM to different HW**
 - ♣ **Disaster recovering**





High Availability

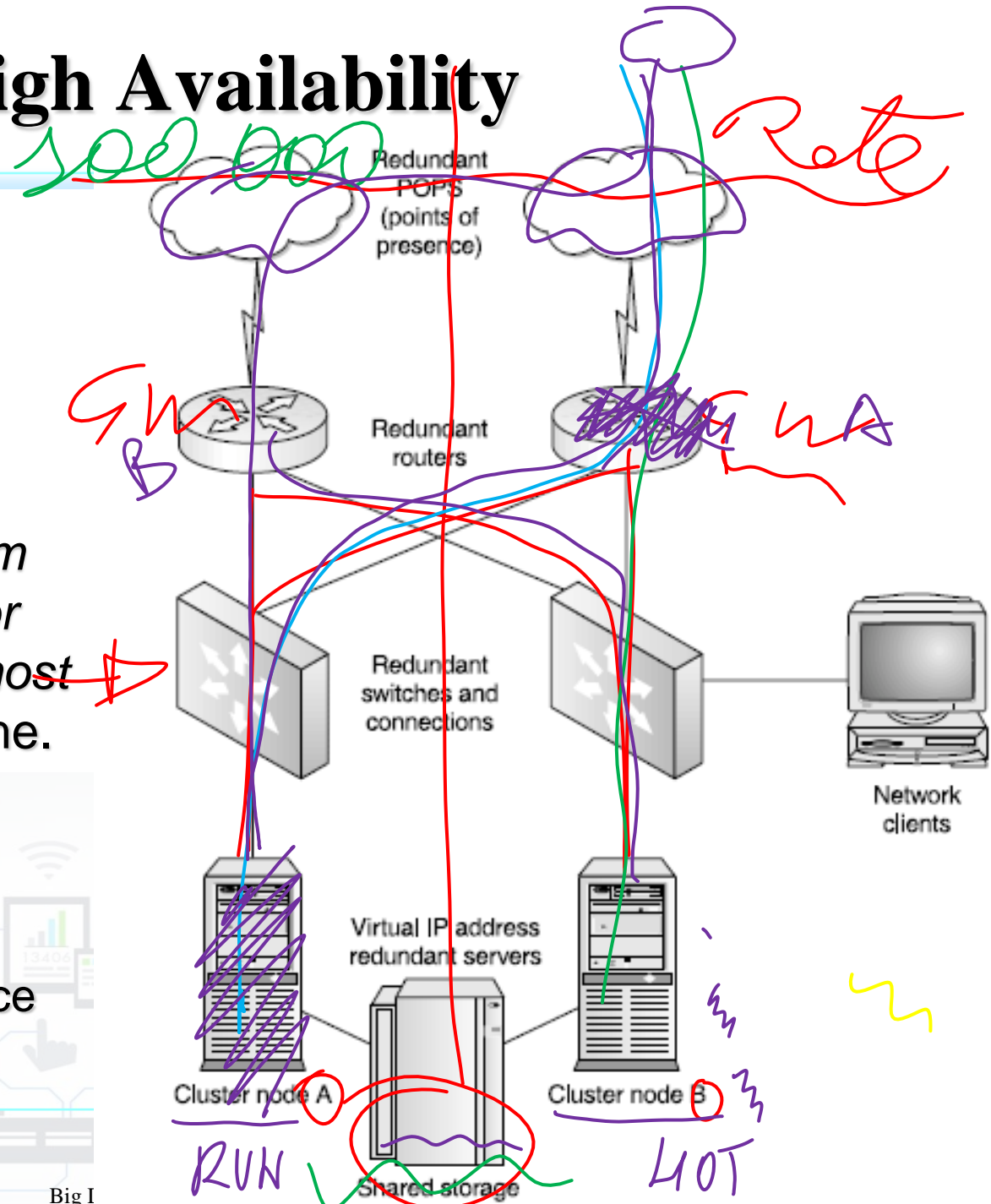
- | **High Availability**, available 99.999 % (called "Five Nines") percent of the time.
- | **Five Nines** is the term for saying a service or system will be up almost 100 percent of the time.
- | In case of failure:
 - ♣ the path changes to guarantee the service





High Availability

- High Availability, available 99.999 % (called "Five Nines") percent of the time.
- Five Nines is the term for saying a service or system will be up almost 100 percent of the time.
- In case of failure:
 - the path changes to guarantee the service





High Availability

May be achieved by redundancy of :

→ Servers and Services (hot spare or balancing)

- VM based architectures

→ HW/SW: power supply, network connections, etc.

♣ **Load Balancing/Balancer** according to server traffic/requests

→ Server Clustering, multitier solution

♣ **Hot Spare:**

→ Server: cloned server to be used when the main is not functioning: heartbeat to detect the server availability and thus failover. (heartbeat signal to communicate the correct running of a process/CPU)

→ HD: Raid based on SAN/NAS, LUN, in host

♣ **Mixed: balancing and hot spare**



High Availability: Load Balancing

Service distributed/cloned on more servers

According to different policies

→ Round robin

→ Network traffic

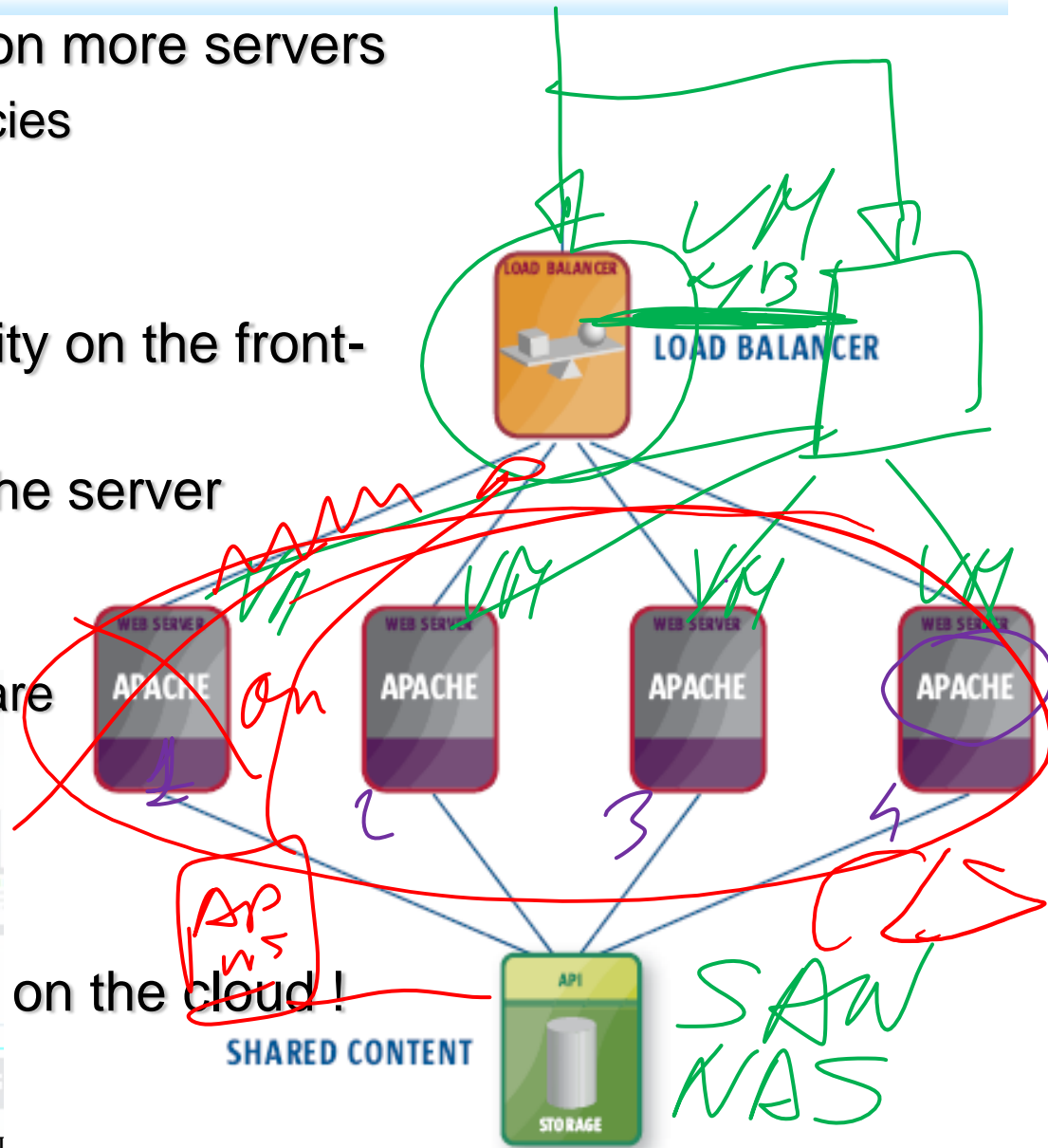
Single transfer rate capability on the front-end of the load balancer

Sensing the availability of the server on balancer +

heartbeat solutions to understand if the servers are alive or not

Common NAS/SAN

That is a Cluster of servers on the cloud!





Balancing multi-tier, 3-tier

Presentation layer

Business logic layer

Data layer

NLB IIS web servers

CLB cluster

Clustered SQL servers

Handwritten: Network
SW
B
E

Handwritten: 1000

Handwritten: 1000

Handwritten: 500

Handwritten: 500

Handwritten: VM

Handwritten: B

Handwritten: VM

Handwritten: SAN

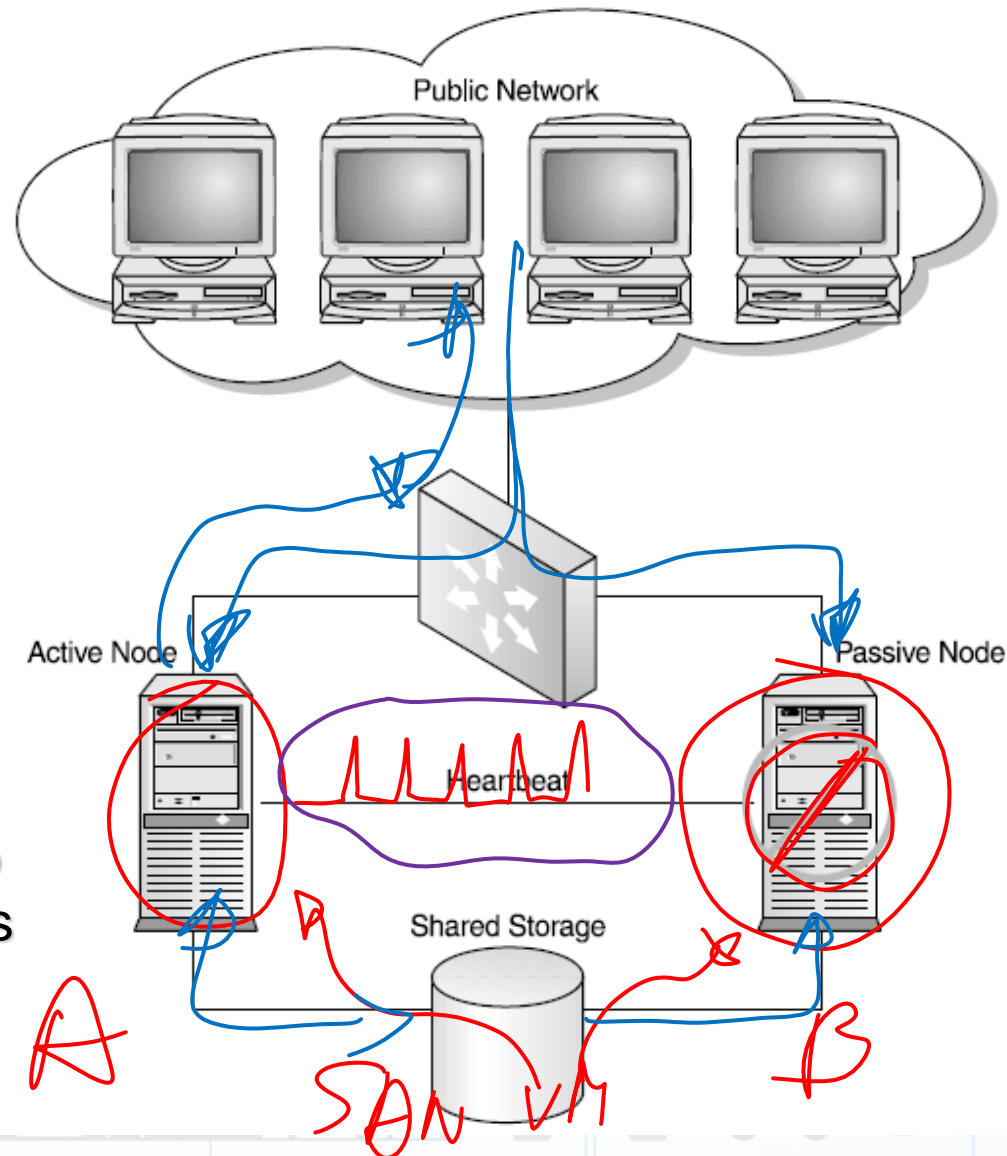


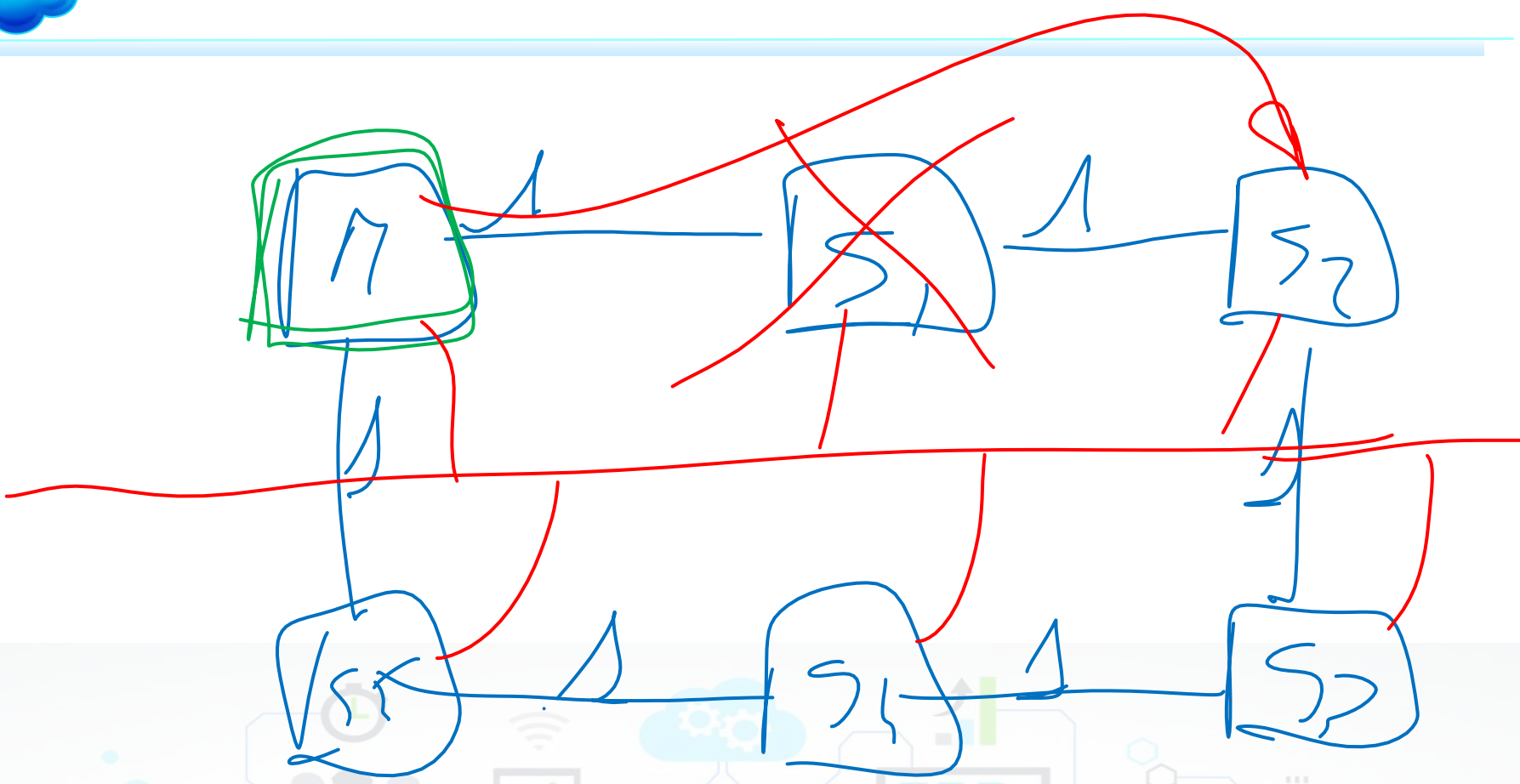
High Availability: Hot spare

Fully cloned servers to be alternatively used when the running one fails

Internal Network

- ♣ *Heartbeat* to detect the server availability and thus failover.
 - ♣ *[To keep servers aligned on context and data]*
- Shared data storage is a simplification and optional.
- ♣ A different solution may be to have a cloned storage to keep aligned among the two servers







High Availability: Hot spare, hw

Three separate networks cards

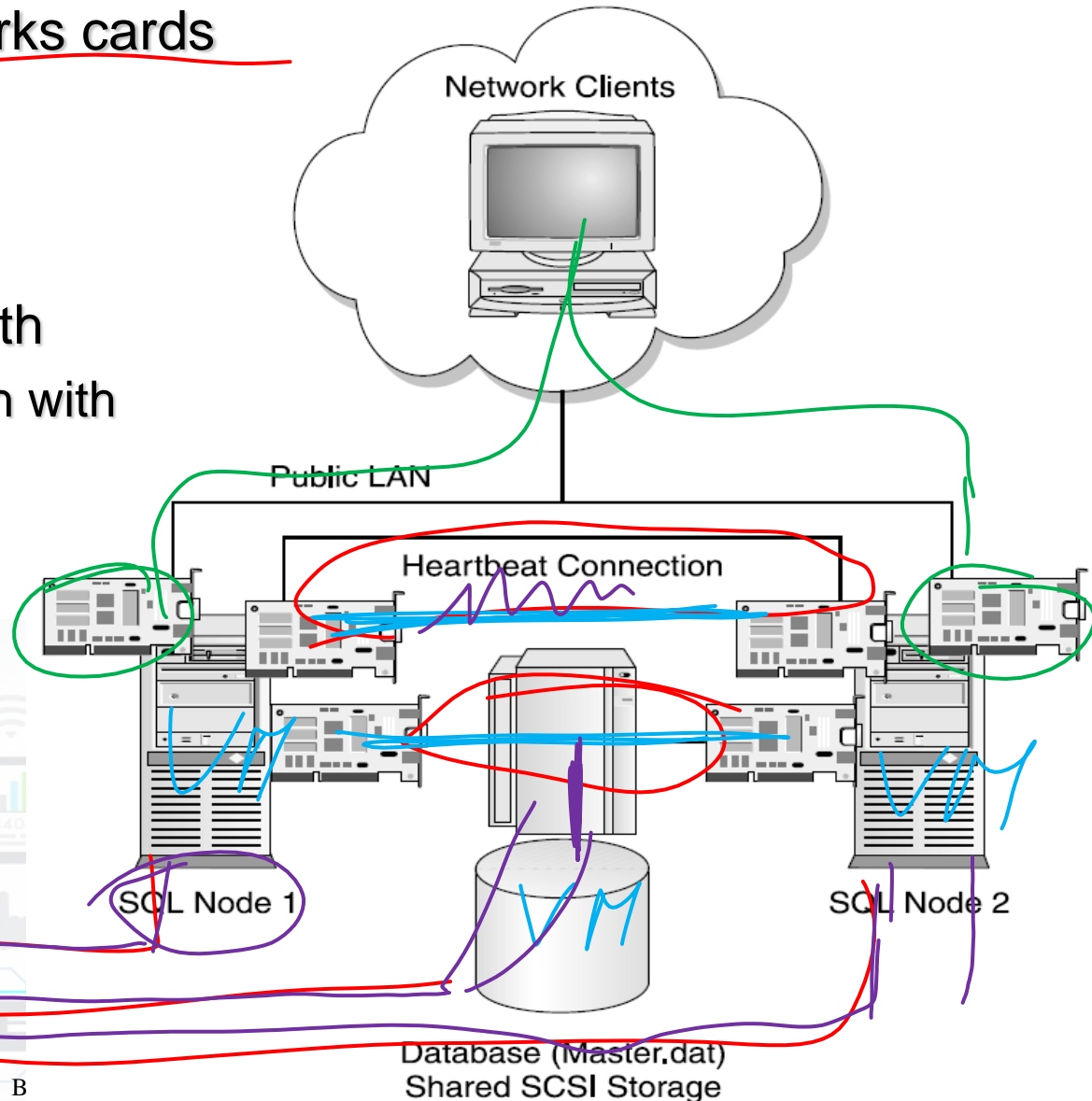
- ♣ Front end
- ♣ Heartbeat
- ♣ Database NAS/SAN

UPS/APC solutions with

- ♣ 2 UPS, each of which with network card

NAS/SAN

- ♣ Raid 5 or 6, 60
- ♣ Fiber connection



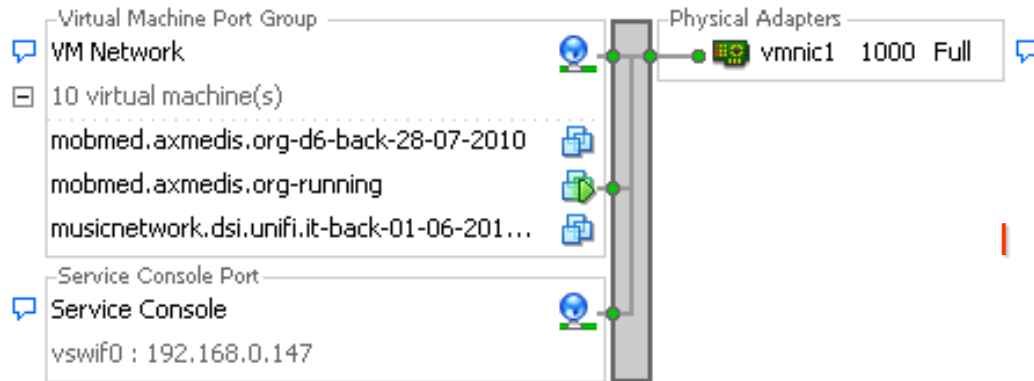
UPS



Network and Virtual Networks

Virtual Switch: vSwitch0

Remove... Properties...



| The same VM with access to 2 different network via real network adapters

Virtual Switch: vSwitch1

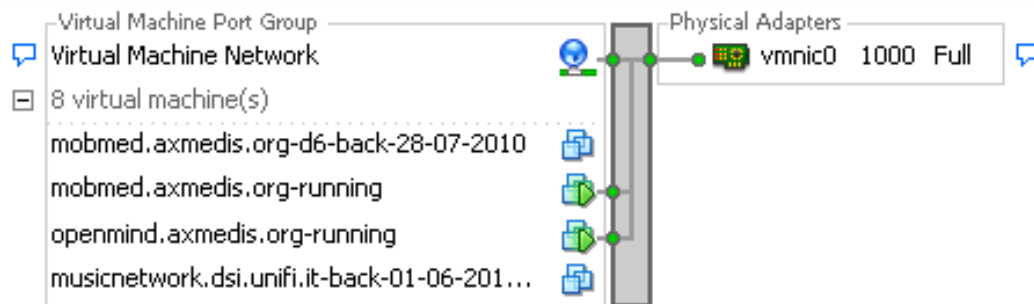
Remove... Properties...



| A virtual network

Virtual Switch: vSwitch2

Remove... Properties...



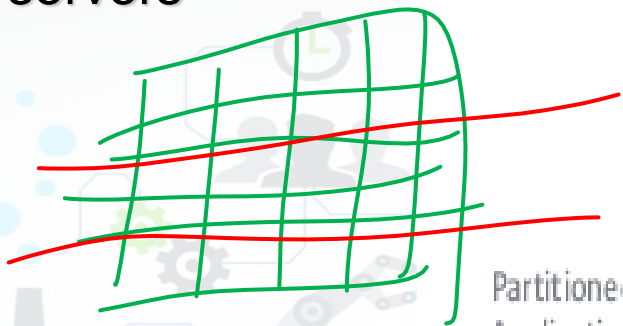


Partitioning the database

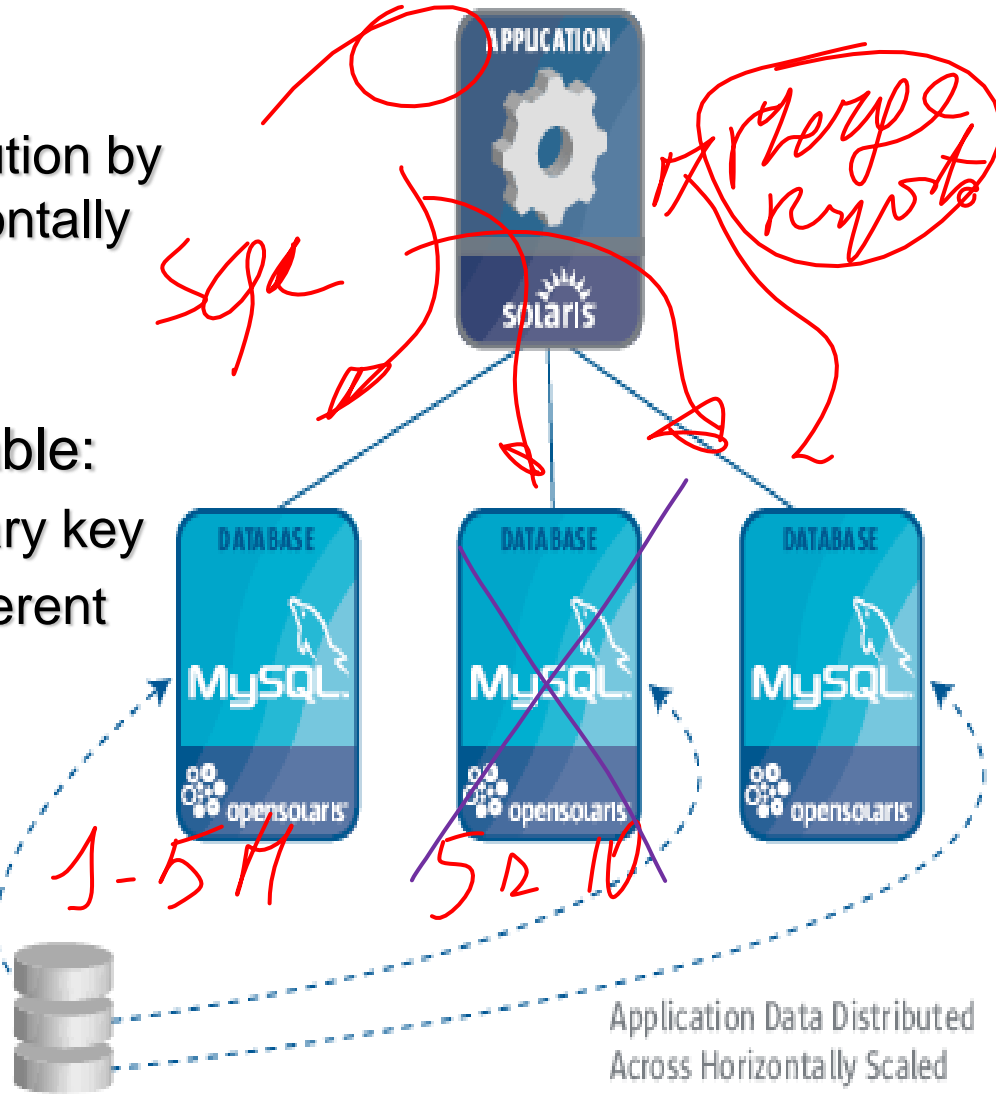
- The database may be
 - stored in a single NAS
 - stored into a distributed solution by partitioning the tables horizontally or vertically

Horizontal partitioning of a table:

- According to a certain primary key
- Distributing the table on different servers




Partitioned Application Data



Application Data Distributed Across Horizontally Scaled Database Instances



Structure

- | Elements of cloud Computing
- | Virtualization
- | Cloud Computing
- | High Availability
- | vSphere Infrastructure 
 - ♣ Vmotion
 - ♣ Power Management
 - ♣ Resource Scheduling
 - ♣ Fault Tolerance
- | Security on the Cloud
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vSphere 4 infrastructure of VMware

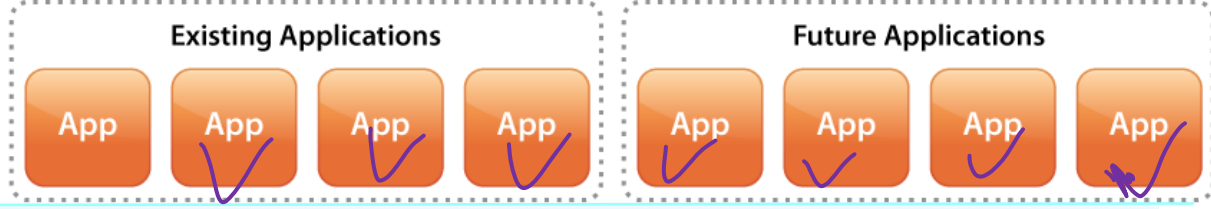
V65

I High level features:

- ♣ HA: high availability
- ♣ DRS: Distributed Resource Scheduling
- ♣ Creating Fault Tolerance architectures
- ♣ DPM: datacenter power management, based on VMotion
- ♣ Converting VM into VM for infrastructure, from physical to VM
- ♣ vApp: are Virtual Application Services
- ♣ Cloning and Moving VM
- ♣ Making Templates for VM
- ♣ Backup VM and thus virtual servers

I Low level features:

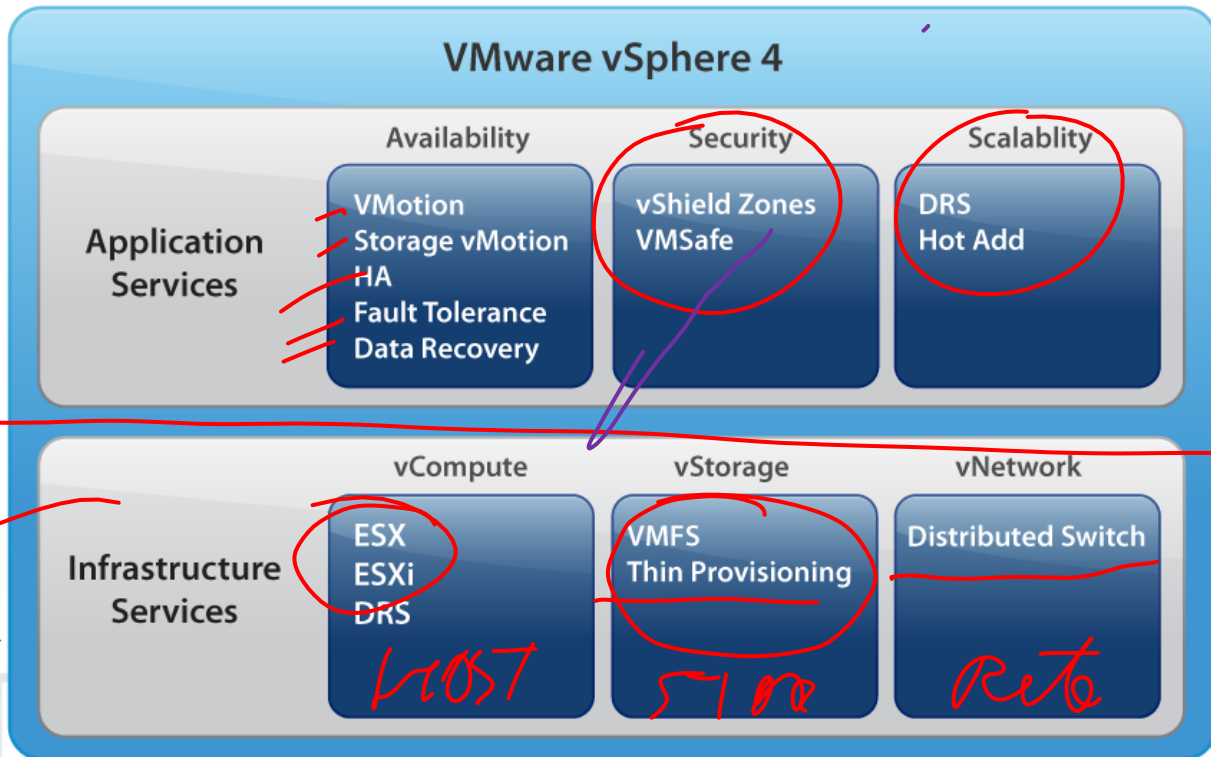
- ♣ VMotion: VM moving among Hosts
- ♣ Dynamic increment of: CPU ck, MEM, net...



Summary of VMware vSphere 4.0

Vsphere

Host





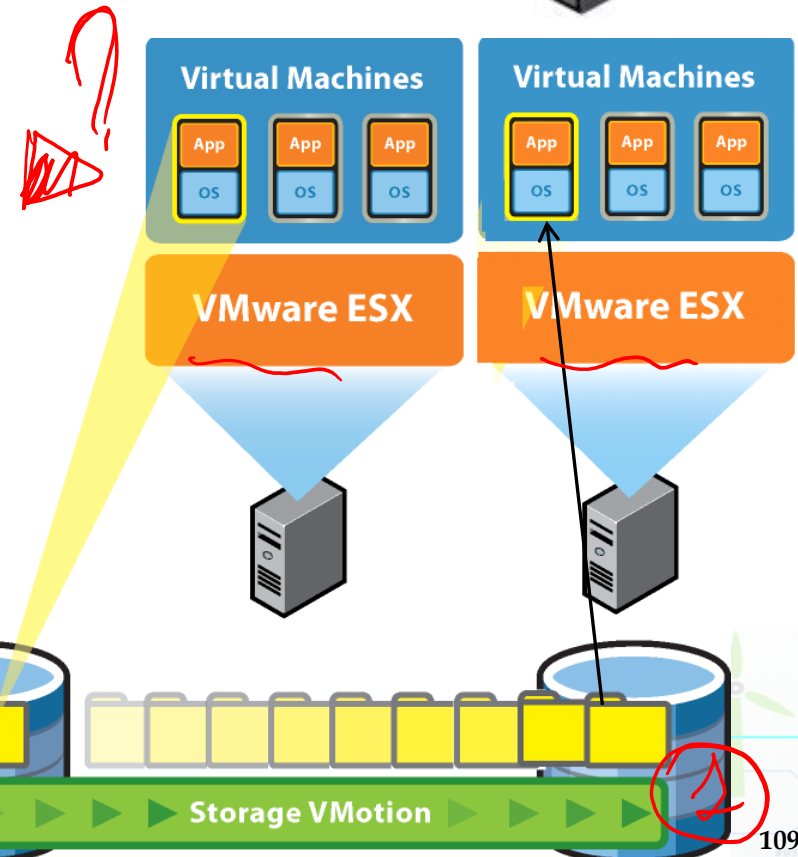
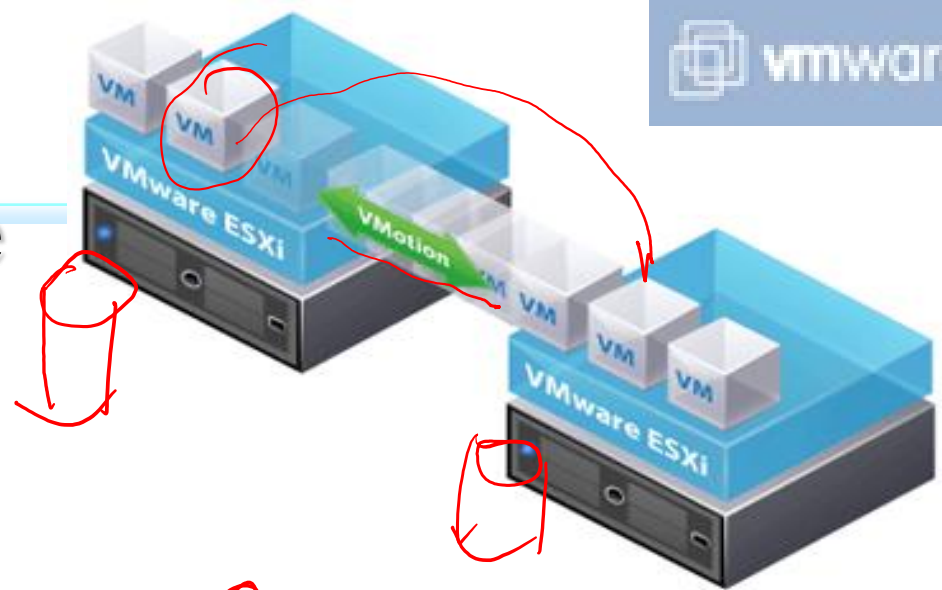
VMotion of VMware vSphere

you need:

- ❖ VM without snapshots
- ❖ VM must be powered off to simultaneously migrate both host and datastore
- ❖ Compatibility among host CPU and VMs
- ❖ Dedicated virtual network
- ❖ **The VMs can be ON**

Steps:

1. moving HD images
2. aligning OS and CPU status
3. off-the old and then on-new





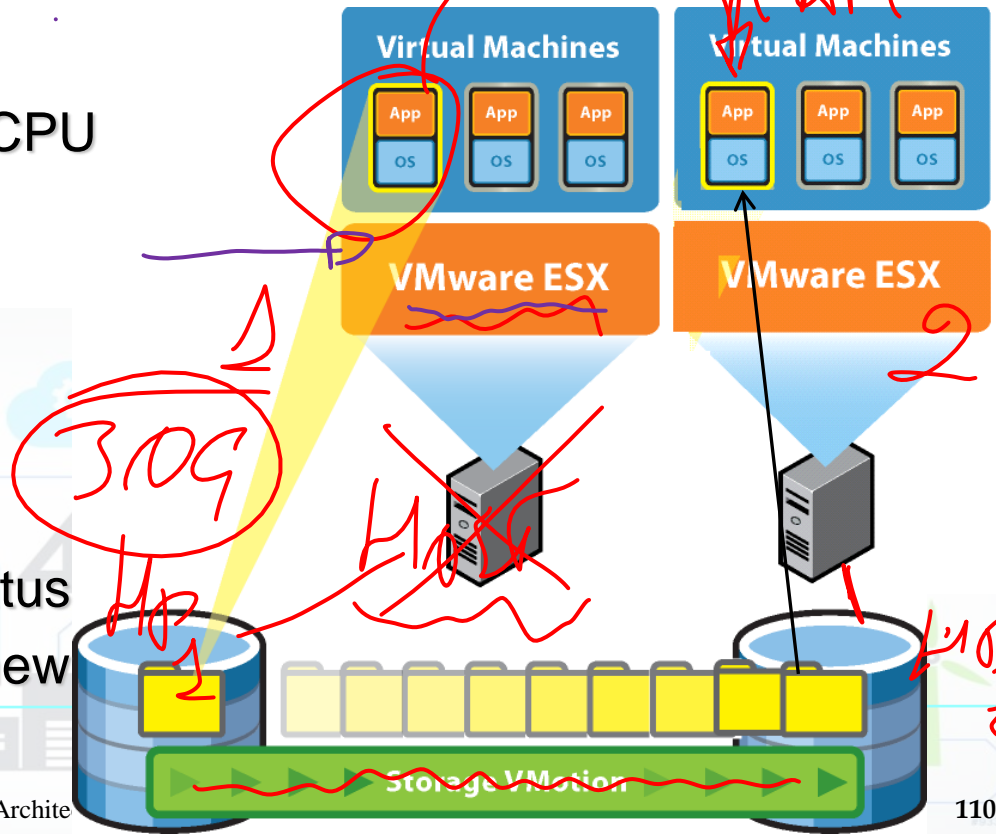
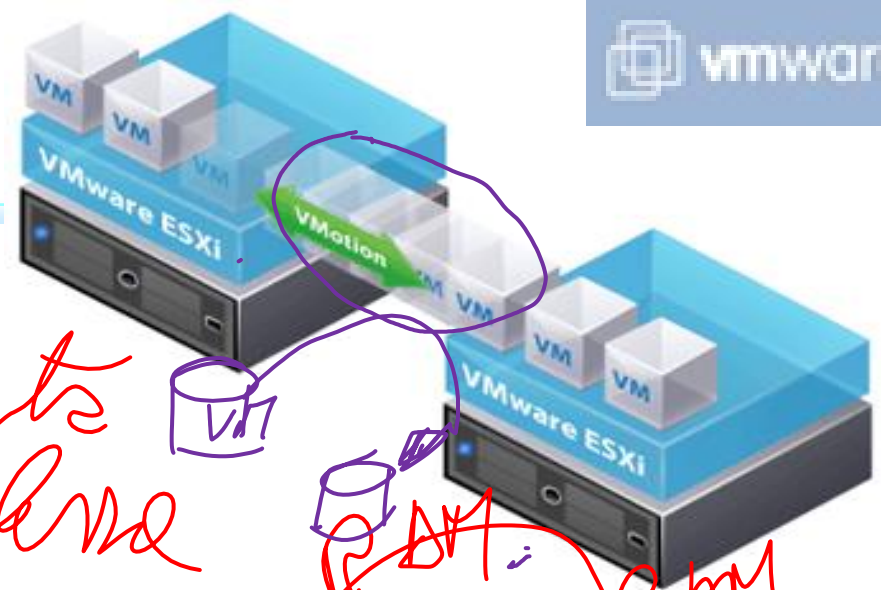
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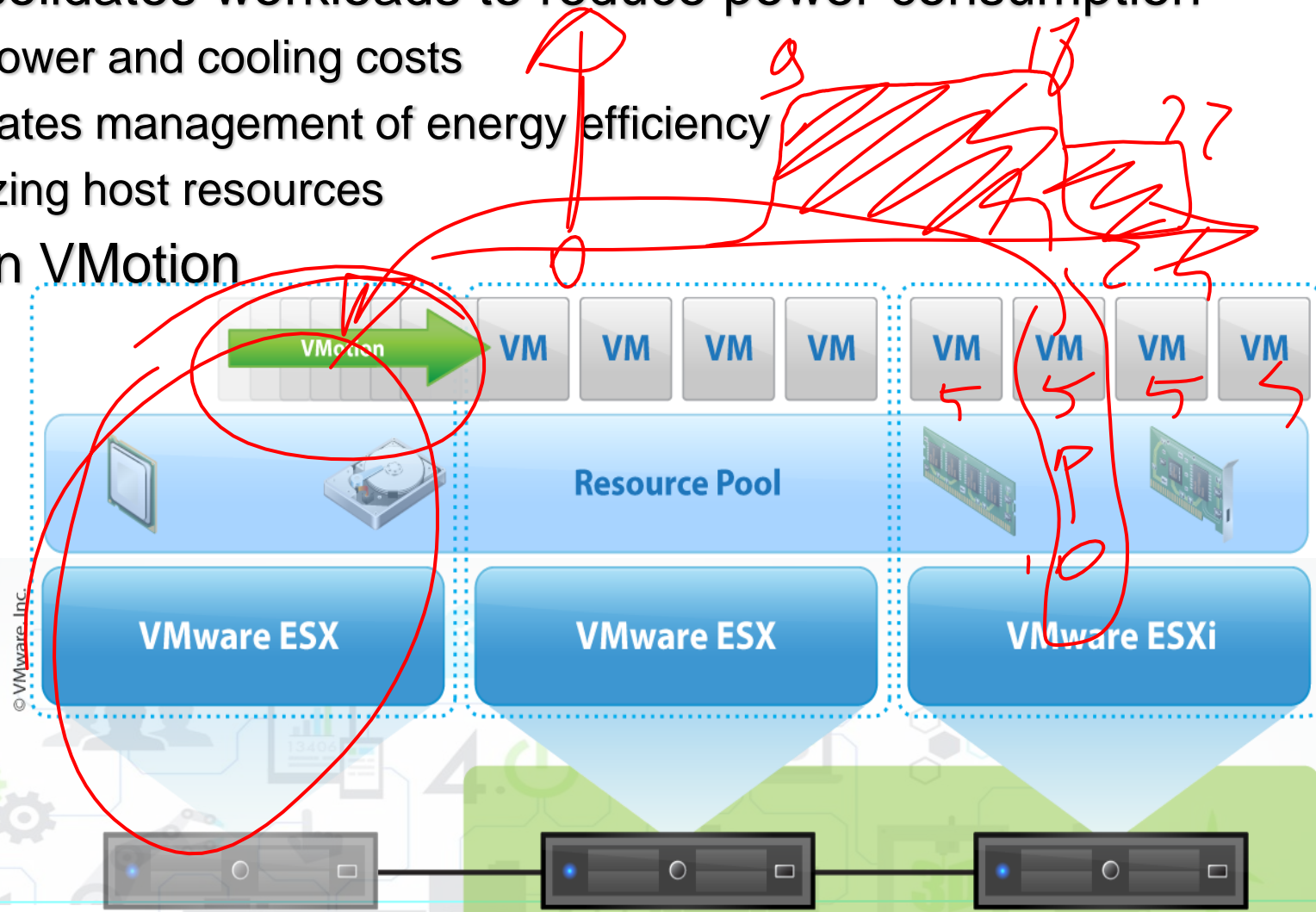
VMware DPM, Power Management

DPM consolidates workloads to reduce power consumption

- Cuts power and cooling costs
- Automates management of energy efficiency
- optimizing host resources

Based on VMotion

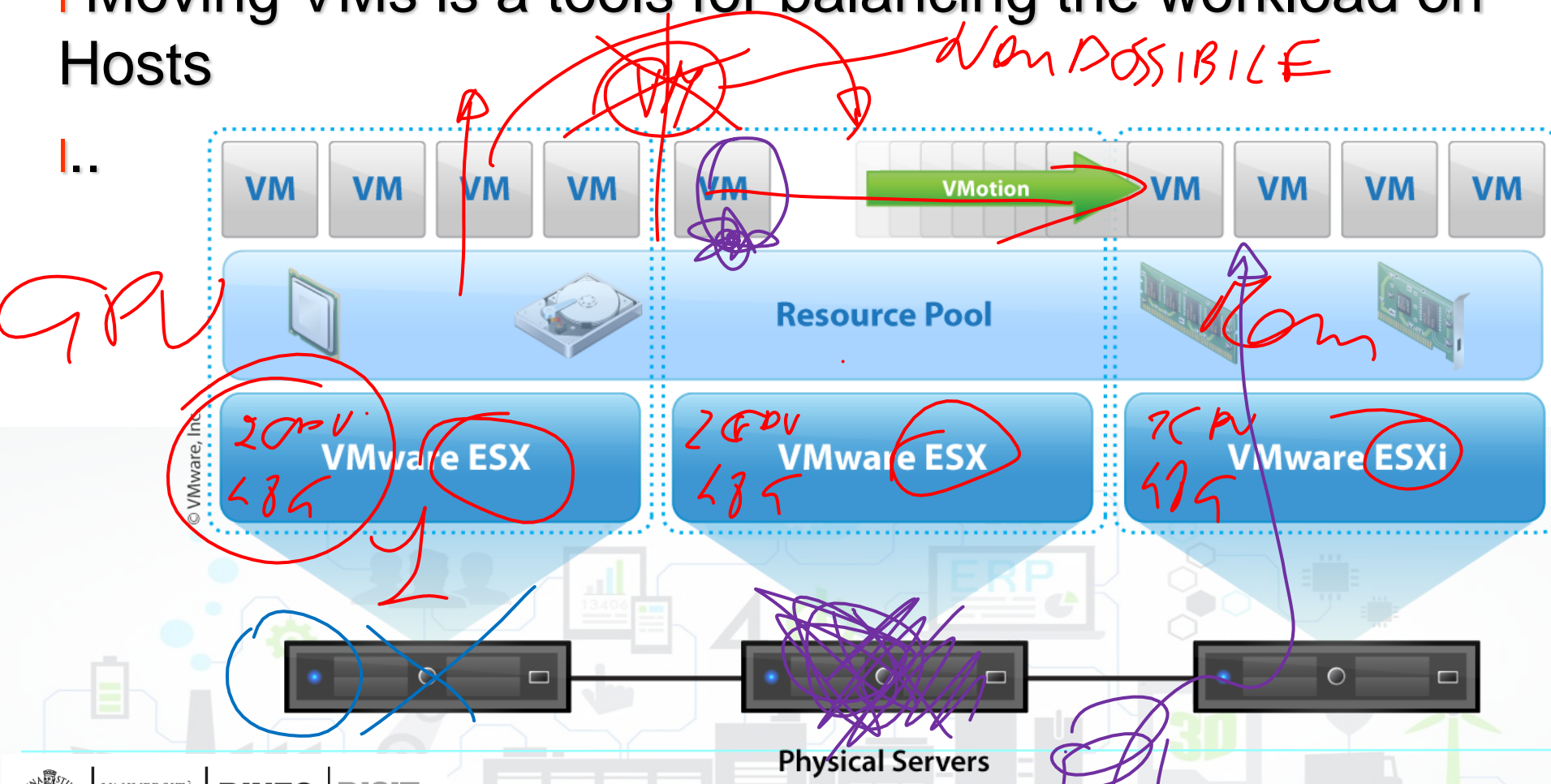
RAM





VMware DRS, Distrib. Res. Scheduling

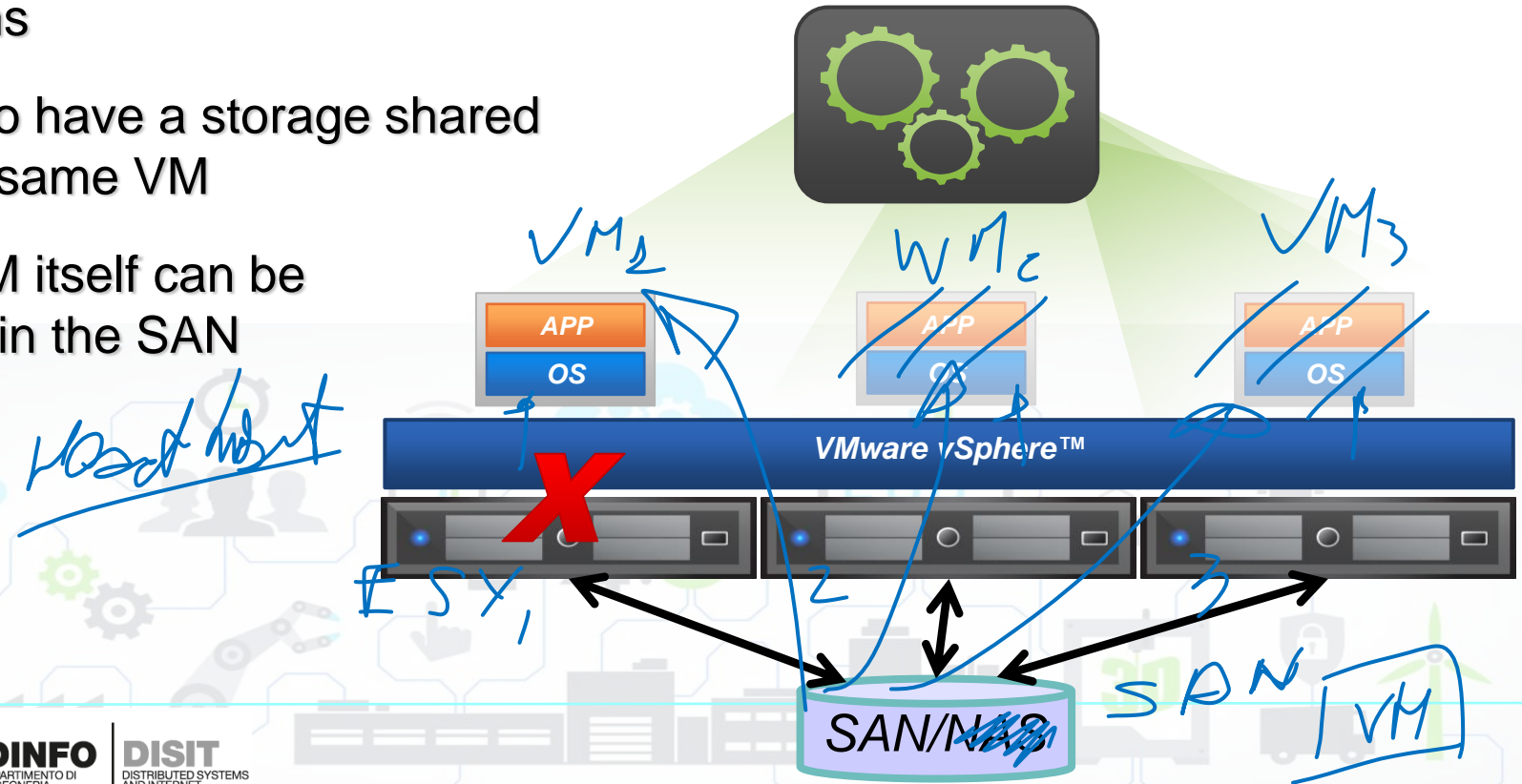
- DRS is used to balance the workload among Hosts
- Moving VMs is a tools for balancing the workload on Hosts





VMware Fault Tolerance, FT

- Single identical VMs running in lockstep on separate hosts
- Zero downtime, zero data loss failover for all virtual machines in case of hardware failures
- Single common mechanism for all applications and Operating systems
- Need to have a storage shared by the same VM
- The VM itself can be stored in the SAN

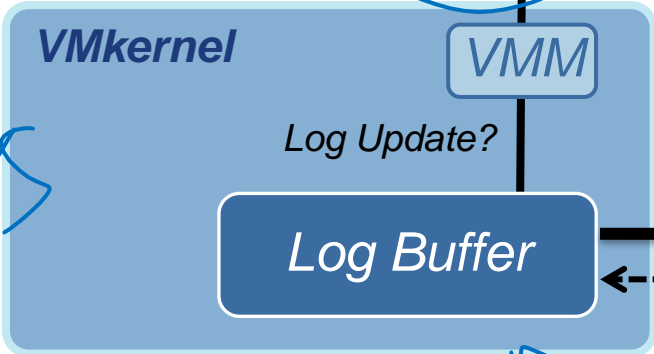




How VMware FT Works

Primary Virtual Machine

Secondary Virtual Machine

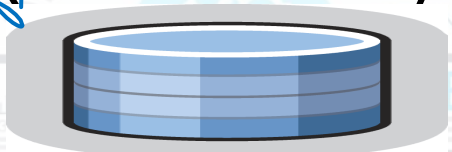


Record Logs

Heartbeat?

Read/Write

Read



Single Copy of Disks on Shared Storage (SAN)

2 Core

Update



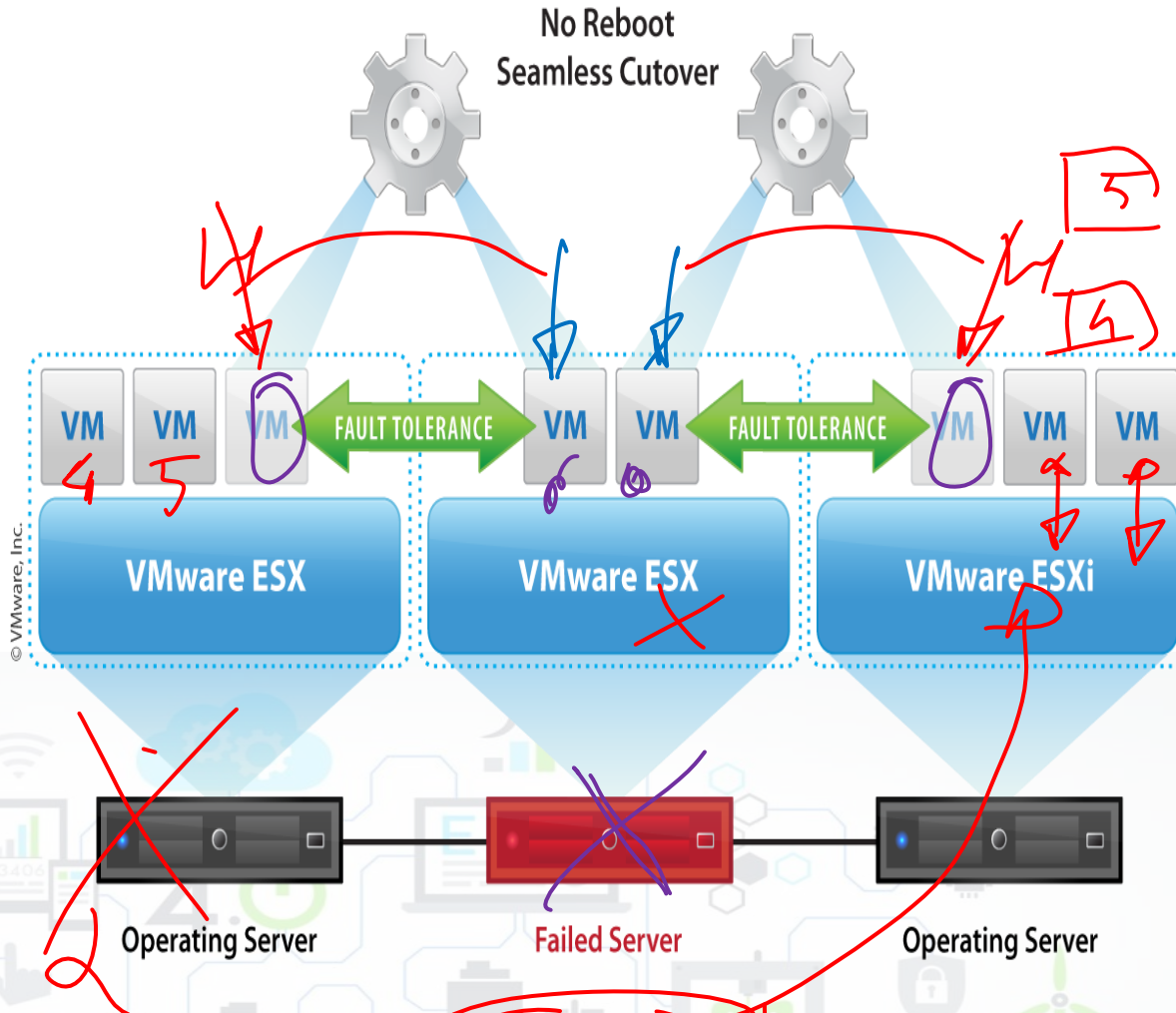
HA: High Availability of vSphere

When a host fails, the running VM on the host may be turned ON on another hosts

- Just the time to turn on again the host

HOT Spare solution:

- It is also possible to keep aligned 2 distinct hosts to make a faster switch OFF→ON of the VM on the faulty host
- implies to have duplicated resources: Host, CPU etc.





VM w auto Reboot

- VM che può lavorare in DRS

- Riarsese



- SO abbe data. con
1 process in autoreboot

- SO della VM deve avere
inbuilt il numero 1

AVM TOOLS



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Security on the cloud

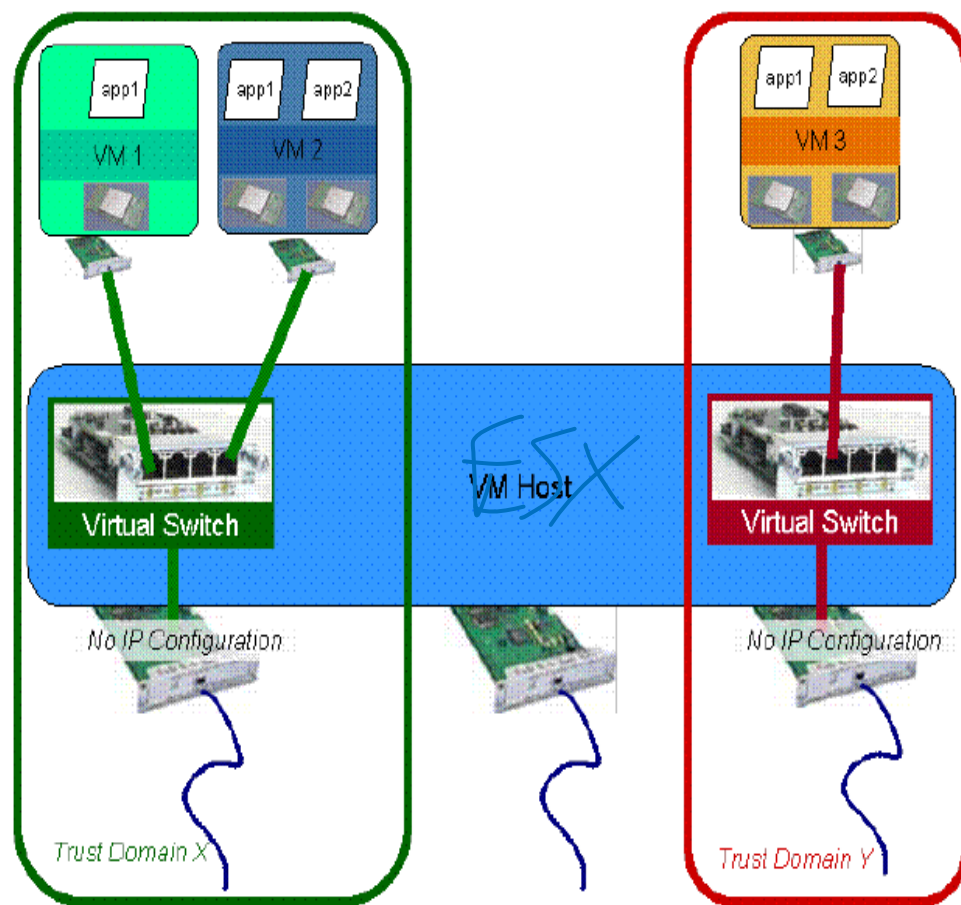
- | Protecting VMs from external access
- | Protecting VMs each other in the cloud
- | Technologies:
 - ♣ Accessing to other VM via dedicated virtual networks, using Virtual Networking, Virtual Switch
 - ♣ Avoiding shared disk, at least using authenticated connections
 - ♣ Using Firewall
 - ♣ Communicating with other VMs via protected connections: protected WS, HTTPs, SSL, SFTP, etc.



Virtual Networking

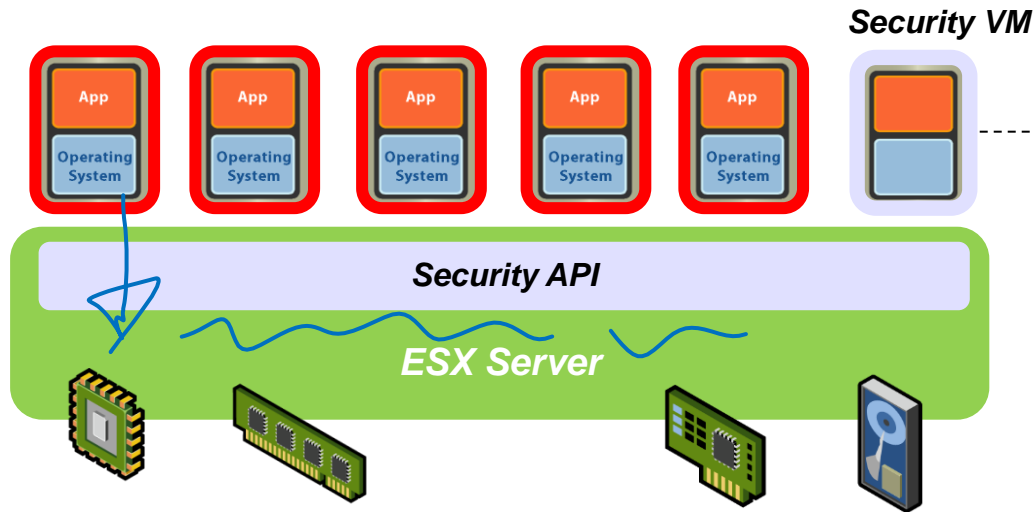
- Per isolare meglio dei guest OS da altri che non sono nello stesso trust domain
- isolare i virtual switch dei singoli trust domain.
- Solo i guest che condividono lo stesso domain hanno schede di rete virtuali sullo stesso virtual switch.
- virtual switch su porte logiche del sistema host che non hanno indirizzo ip configurato.

Figure 1 - Isolating virtual machines to separate network trust domains





Vmware Vsphere VMsafe



- **HIPS**
- **Firewall**
- **IPS/IDS**
- **Anti-Virus**

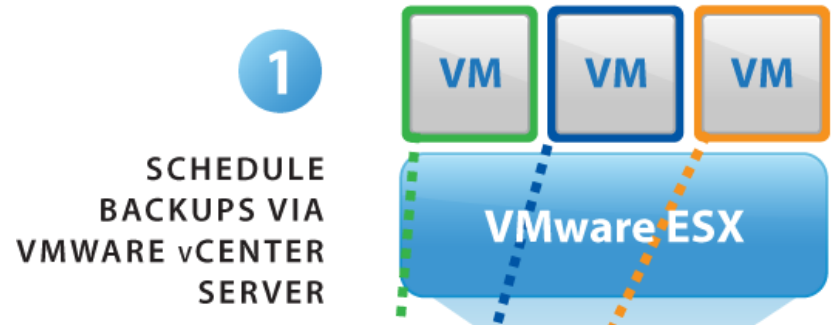
- Creates a new, stronger layer of defense – fundamentally changes protection profile for VMs running on VMware Infrastructure
- Protect the VM by inspection of virtual components (CPU, Memory, Network and Storage)
- Complete integration and awareness of VMotion, Storage VMotion, HA, etc.
- Provides an unprecedented level of security for the application and the data inside the VM



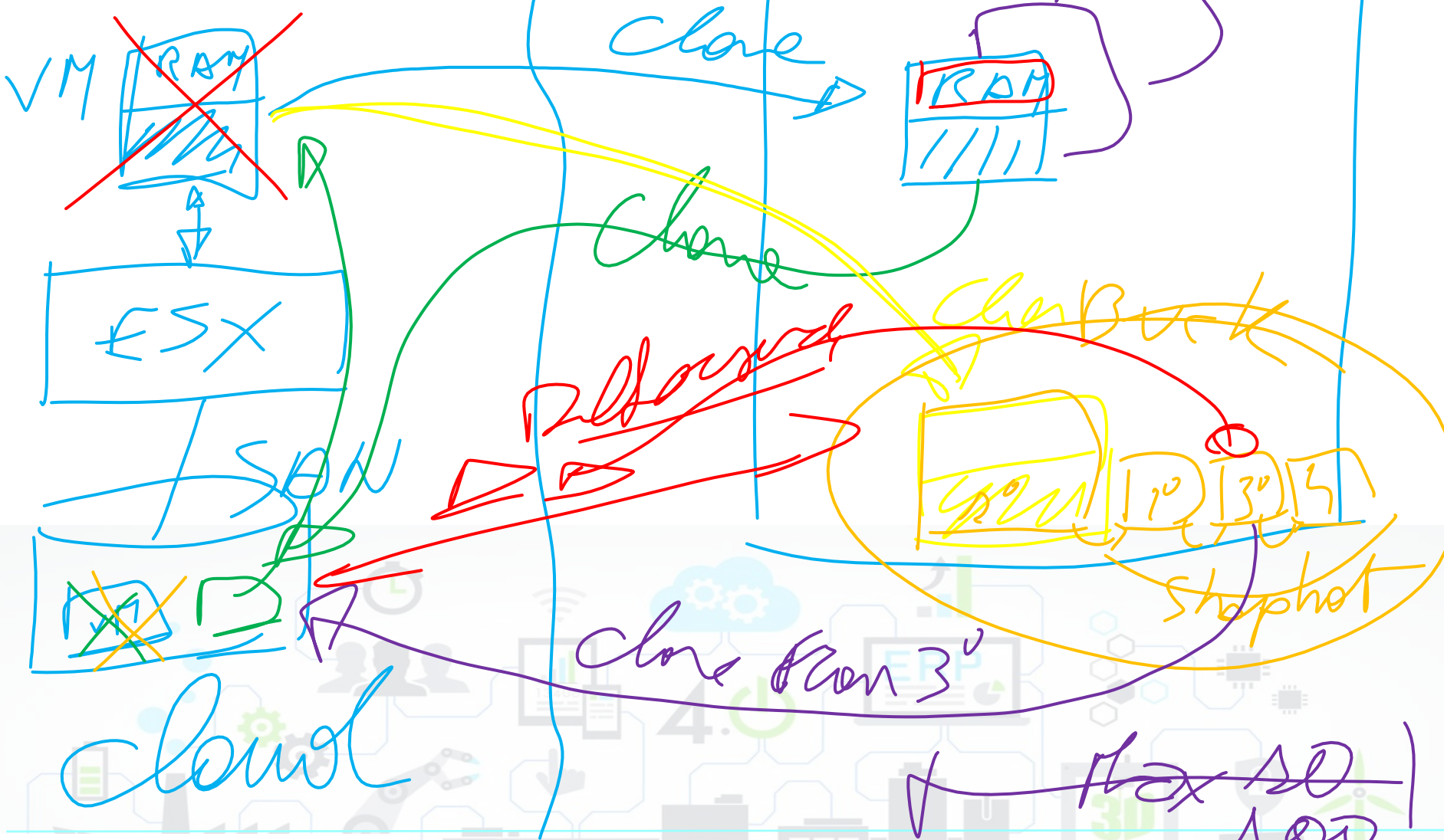
VMware vSphere

Data Recovery

Backup Only



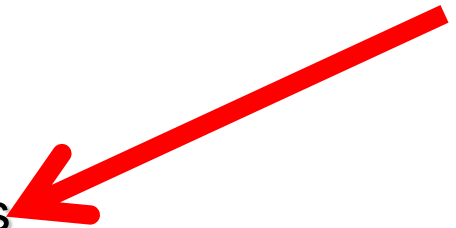
Scrubbing





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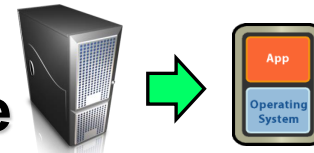




VM Converter, the migration

Conversion possibilities, migration possibilities

P2V, from Physical → Virtual machine



- Reusing legacy servers into stronger and new HW machines
- From ISO CD of an OS → VM

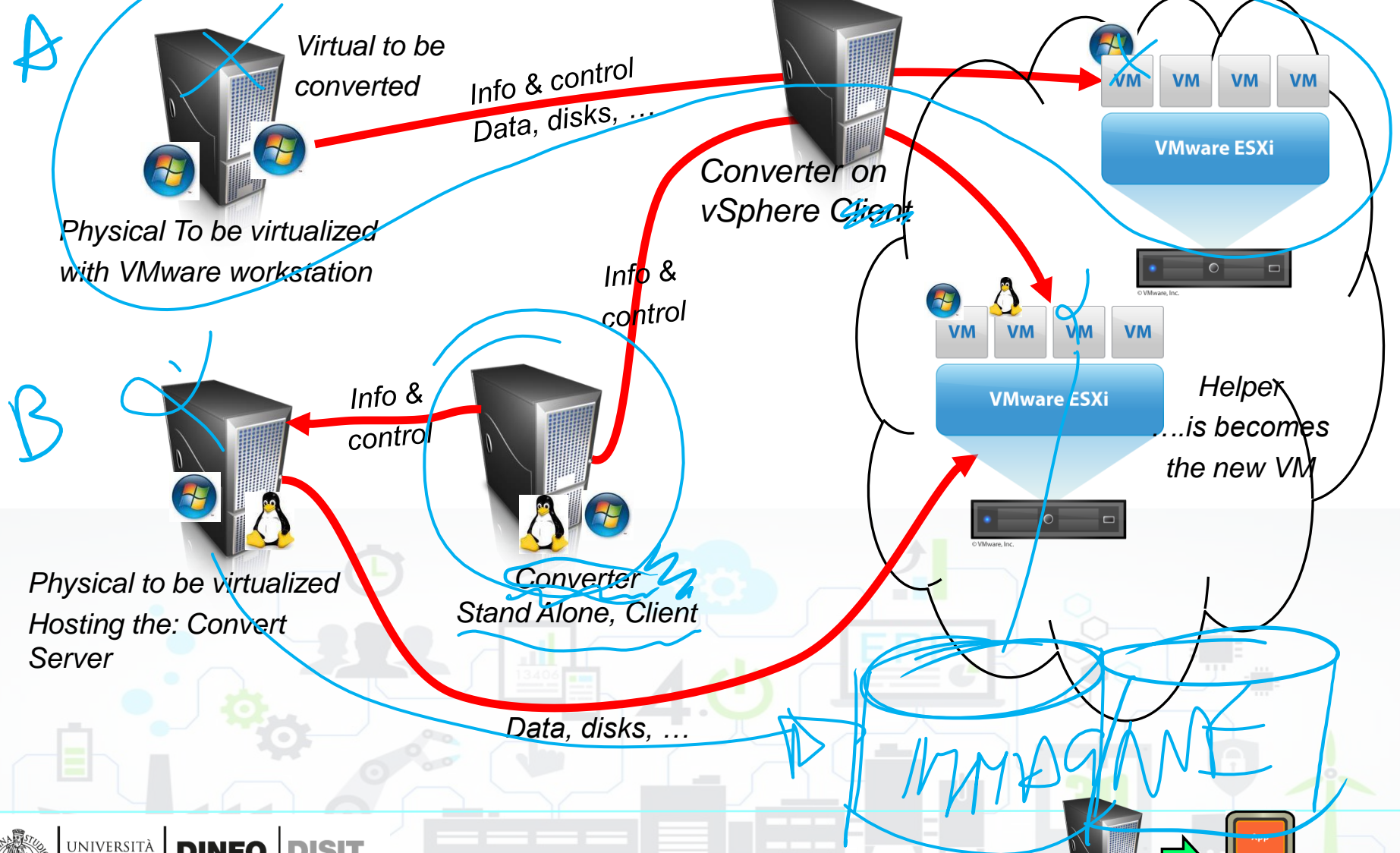
V2V, from Virtual → to Virtual



- Import/export a VM from/to different standards
- From VM Workstation → Infrastructure VM
- From Infrastructure VM → template for VM with some parameters
- From Infrastructure VM → VM Workstation
- From Infrastructure VM → Infrastructure VM changing parameters
-

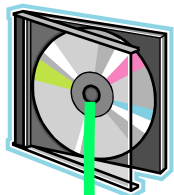


P2V, vConverter vSphere





P2V, OpenCD vConverter vSphere



Boot from CD with OpenCD Converter containing the: Convert Stand Alone Client and Converter Server



Physical To be virtualized

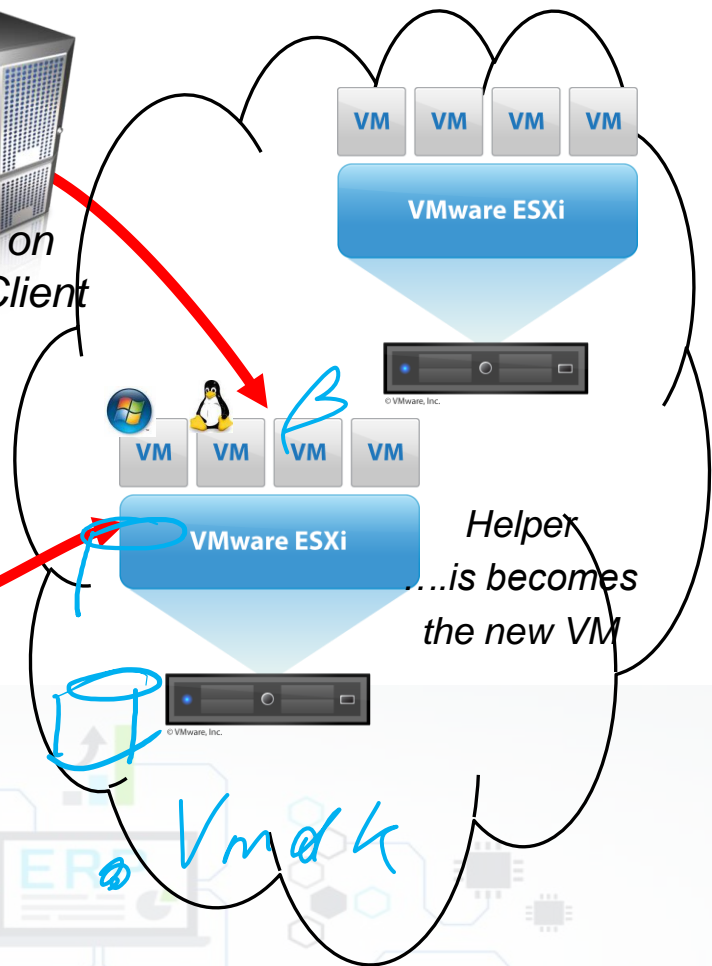
Cloning HD physically:
No resize (+-)
No partitions
RAID drivers needed



Converter on vSphere Client

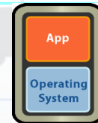
Info & control

Data, disks, ...



Handwritten notes: K, V, AP

Handwritten note: Vmtoolsd





P2V conversion

How to convert, typically:

- ♣ From **VM Converter Stand Alone** on Windows or Linux
 - ➔ it includes a Server side and a client consol,
 - server side has to be installed on the P machine to be converted.
 - Client side is a consol
 - ➔ From Linux to VM on ESX Host
 - ➔ From Windows to CM on ESX Host
- ♣ From **VM converter as plugin of vCenter**, via vCenter Client
 - ➔ From Windows to VM on ESX Host
- ♣ From **OpenCD**, with included VM Converter and alone
 - ➔ From Windows to CM on ESX Host
- ♣ From **VMware Workstation**
 - ➔ From Windows to CM on ESX Host



P2V conversion

I Hypothesis:

- ♣ Converter server installed on Physical machine
- ♣ Converter in third machine or on the physical (windows)
- ♣ All snapshots are removed and the disks re-compacted.

I First step:

- ♣ The Converter Client is launched
- ♣ The Converter Client creates an Helper VM on the vCenter Host

I Second step:

- ♣ The Helper VM works independently to transfer the data from VM Converter Server to the new VM via the Helper VM, under the control of Client.
- ♣ The Converter Client provides commands to close and destroy the Helper VM and put in execution the new VM with the final shape



P2V conversion

Third step:

- ♣ Reboot the new machine as Virtual machine

- ➔ Then install the VMware tools on the VM from the vCenter or from the VMware Workstation hypervisor.
- ➔ Revise the general config, network, etc.
- ➔ See if it possible to use paravirtualized drivers instead of physical drivers.

- ♣ If the converted VM is not booting

- ➔ Verify the VM setting: disk, operating system, disk drivers, etc.
- ➔ Regenerate the VM tools on the VM and try again



Structure

- | Elements of cloud Computing
- | Virtualization
- | Cloud Computing
- | High Availability
- | vSphere Infrastructure
- | Security on the Cloud
- | Conversions among VM and physical machines
- | vCenter, datacenters and cluster management
- | Comparison among virtual computing solutions
- | How to work with Virtual Machines
- | IaaS solutions, SaaS Solutions, PaaS Solutions
- | ICARO project



vCenter vSphere

- | The so called Inventory
- | Datacenter

❖ Cluster00

➔ Host....

➔ Host....

➔ Application:

- VM1
- VM2

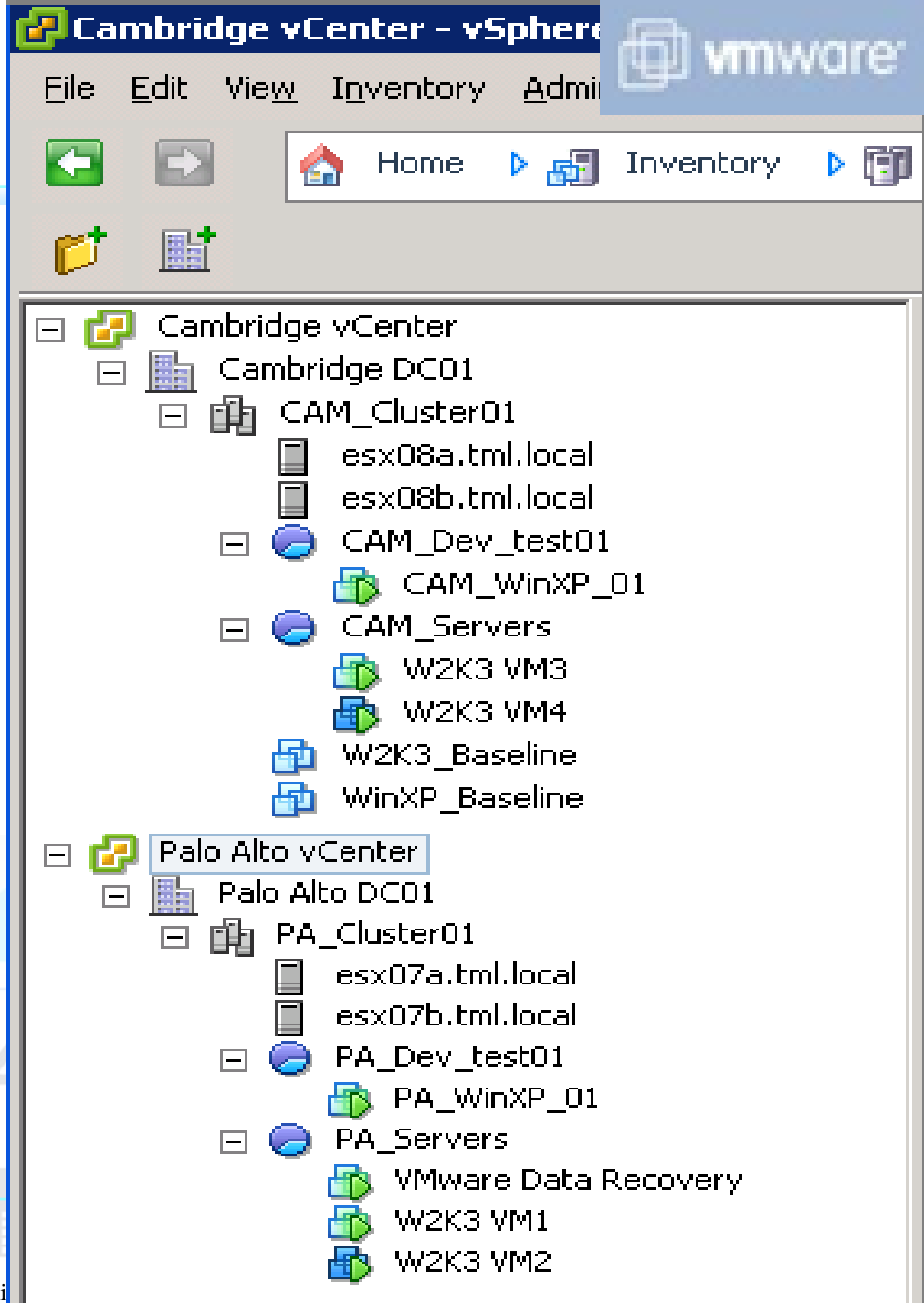
➔ VM3

➔ VM4

❖ Cluster01

➔ H2..

➔ ...



The screenshot shows the VMware vCenter console interface. The title bar reads "Cambridge vCenter - vSphere". The menu bar includes "File", "Edit", "View", "Inventory", and "Admin". The breadcrumb navigation shows "Home" and "Inventory". The main content area displays a tree view of the vCenter inventory:

- Cambridge vCenter
 - Cambridge DC01
 - CAM_Cluster01
 - esx08a.tml.local
 - esx08b.tml.local
 - CAM_Dev_test01
 - CAM_WinXP_01
 - CAM_Servers
 - W2K3 VM3
 - W2K3 VM4
 - W2K3_Baseline
 - WinXP_Baseline
- Palo Alto vCenter
 - Palo Alto DC01
 - PA_Cluster01
 - esx07a.tml.local
 - esx07b.tml.local
 - PA_Dev_test01
 - PA_WinXP_01
 - PA_Servers
 - VMware Data Recovery
 - W2K3 VM1
 - W2K3 VM2



vCenter vSphere

- | The so called Inventory
- | Datacenter

Cluster00

- Host....
- Host....
- Application:
 - VM1
 - VM2

→ VM3

→ VM4

Cluster01

→ H2..

→ ...



see

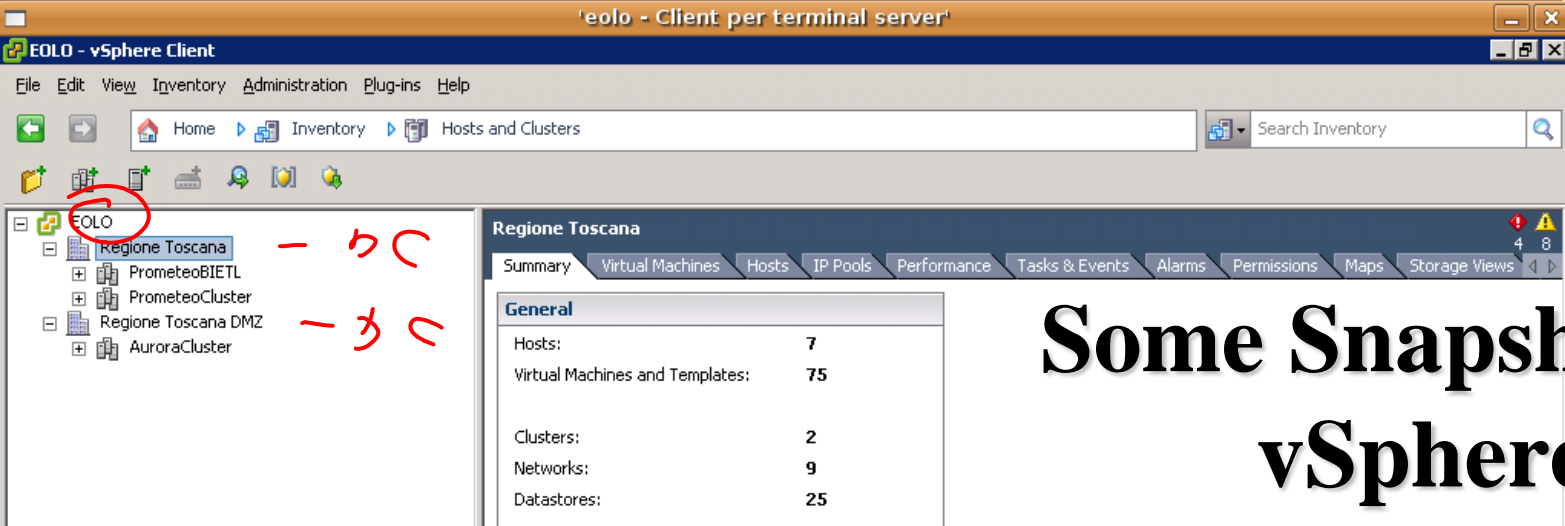
The screenshot shows the vSphere inventory tree for two vCenters: Cambridge vCenter and Palo Alto vCenter. The Cambridge vCenter tree includes:

- Cambridge DC01
 - CAM_Cluster01 (circled in red)
 - esx08a.tml.local (with red arrow and "U OLT" note)
 - esx08b.tml.local (with red arrow)
 - CAM_Dev_test01
 - CAM_WinXP_01 (checked)
 - CAM_Servers (circled in blue)
 - W2K3 VM3 (checked)
 - W2K3 VM4 (checked)
 - W2K3_Baseline
 - WinXP_Baseline

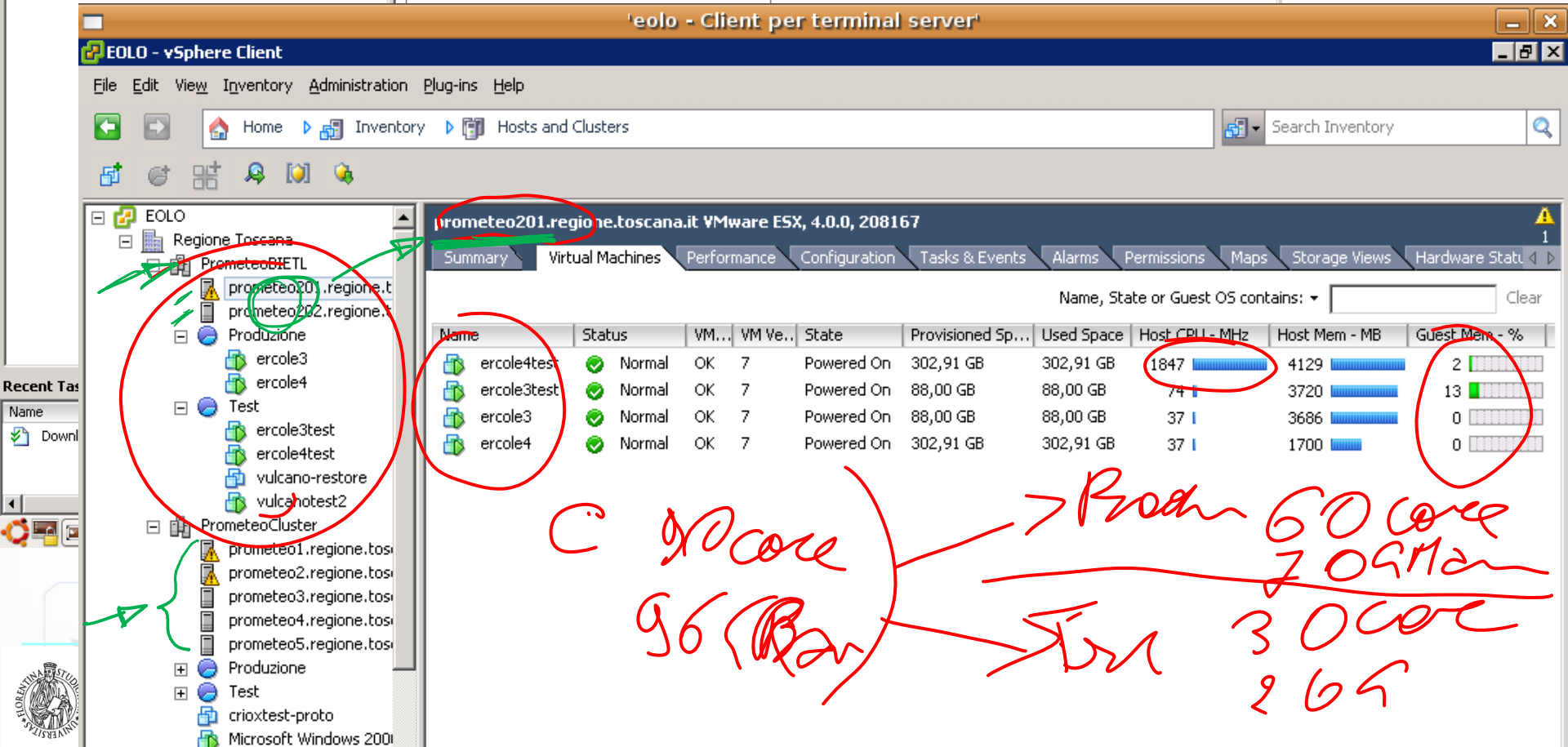
Handwritten annotations include "SAN" with a red arrow pointing to the CAM_Servers folder, and a blue circle containing "10G" and "10G" with a red arrow pointing to the W2K3 VMs. The Palo Alto vCenter tree includes:

- Palo Alto DC01
 - PA_Cluster01
 - esx07a.tml.local
 - esx07b.tml.local
 - PA_Dev_test01
 - PA_WinXP_01
 - PA_Servers
 - VMware Data Recovery
 - W2K3 VM1
 - W2K3 VM2

Other annotations include a red arrow pointing to the Palo Alto DC01 folder and a red squiggle to the right of the Palo Alto tree.



Some Snapshots of vSphere





Storage View

Getting Started | Summary | Virtual Machines | Performance | Configuration | Tasks & Events | Alarms | Permissions | Maps | **Storage Views** | Hardware St

View: Reports | Maps | Last Update Time: 2/23/2009 11:56:25 PM [Update...](#)

SharedTMPLs | 02001f000... | 02001e000... | 02000b000... | 02000c000... | 02001d000... XP Template | 00000... | 02001a000... | 50:06:050:06:01... | 020000000... | 020001000... | 020000000... | 02001b000... | vmhba1 | 020019000... | W2K3 Temp... | Training0... | SharedVMs | VM4-RHEL5 | VM2-W2K3 | VM2-XP

Controls

Show

- Datacenter
- Cluster
- Host
- Virtual Machine
- Datastore**
- SCSI Volume (LUN)
- NAS Mount
- SCSI Adapter
- SCSI Target (Array Port)

Update View

Zoom

Virtual Machines | Performance | Configuration | Tasks & Events | Alarms | Permissions | Maps | **Storage Views**

View: Reports | Maps | Last Update Time: 2/23/2009 11:16:05 PM

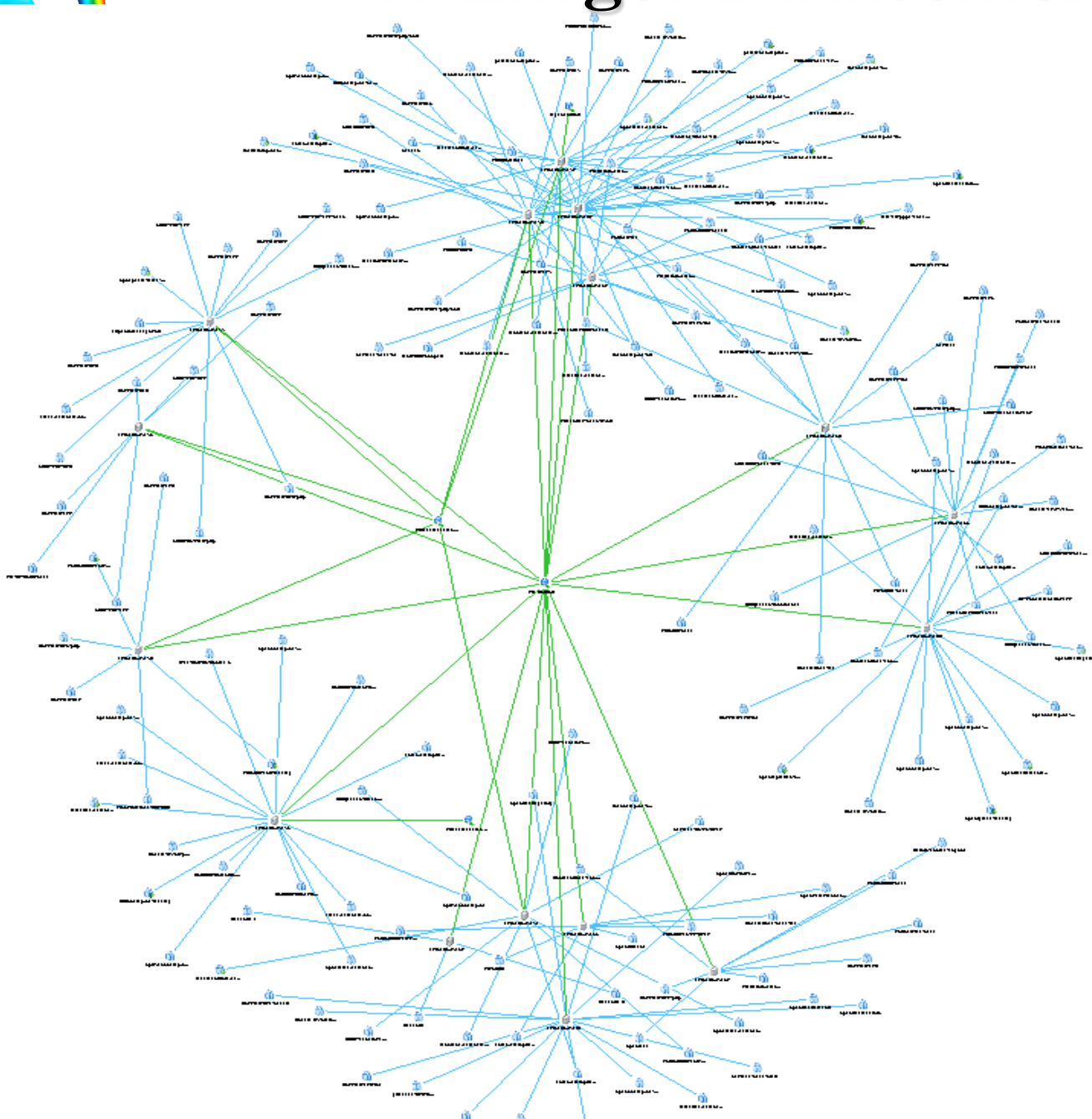
Show all Virtual Machines ▾ | VM or Multipathing Status contains: ▾

VM	Multipathing Status	Space Used	Snapshot Space
Train01_WindowsXP_01	Partial/No Redundancy	1.94 GB	0.00 B
VM2-XP	Partial/No Redundancy	3.38 GB	0.00 B
VM4-RHEL5	Partial/No Redundancy	8.10 MB	0.00 B
VM2-W2K3	Partial/No Redundancy	4.50 GB	256.07 MB
W2K3 Template	Partial/No Redundancy	4.00 GB	0.00 B
XP Template	Partial/No Redundancy	3.00 GB	0.00 B



A Larger Datacenter

Time since last data update: 01:02 [Refresh](#)



Overview

Map Relationships:

Custom Map

Host Options

- Host to VM
- Host to Network
- Host to Datastore

VM Options

- Fault Tolerance relationships
- VM to Network
- VM to Datastore
- Show only powered on VMs

[Apply Relationships](#)



Partially Collapsed with Separate Physical Trust Zones

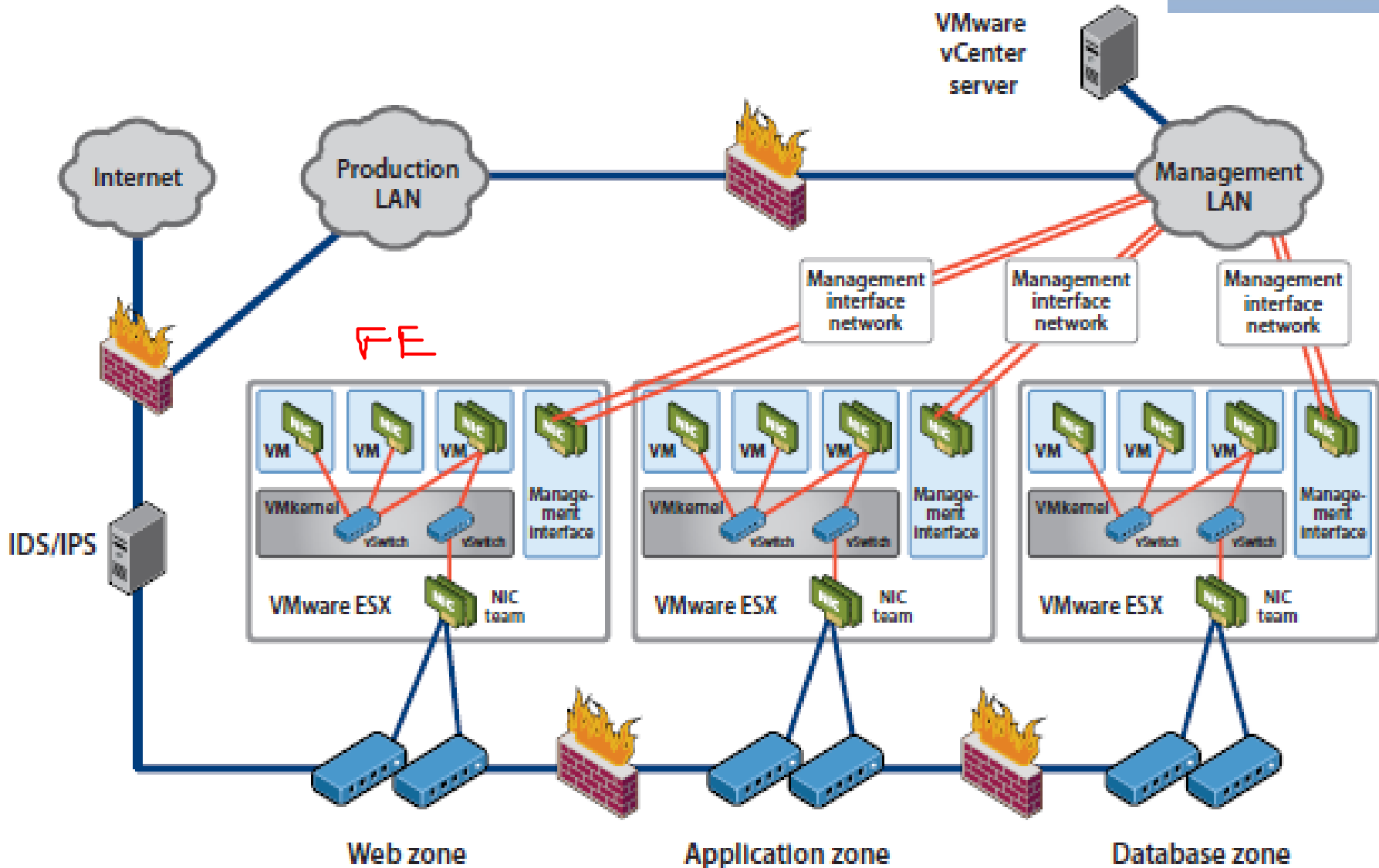


Figure 2 — Partially collapsed with separate physical trust zones



Partially Collapsed with Separate Physical Trust Zones

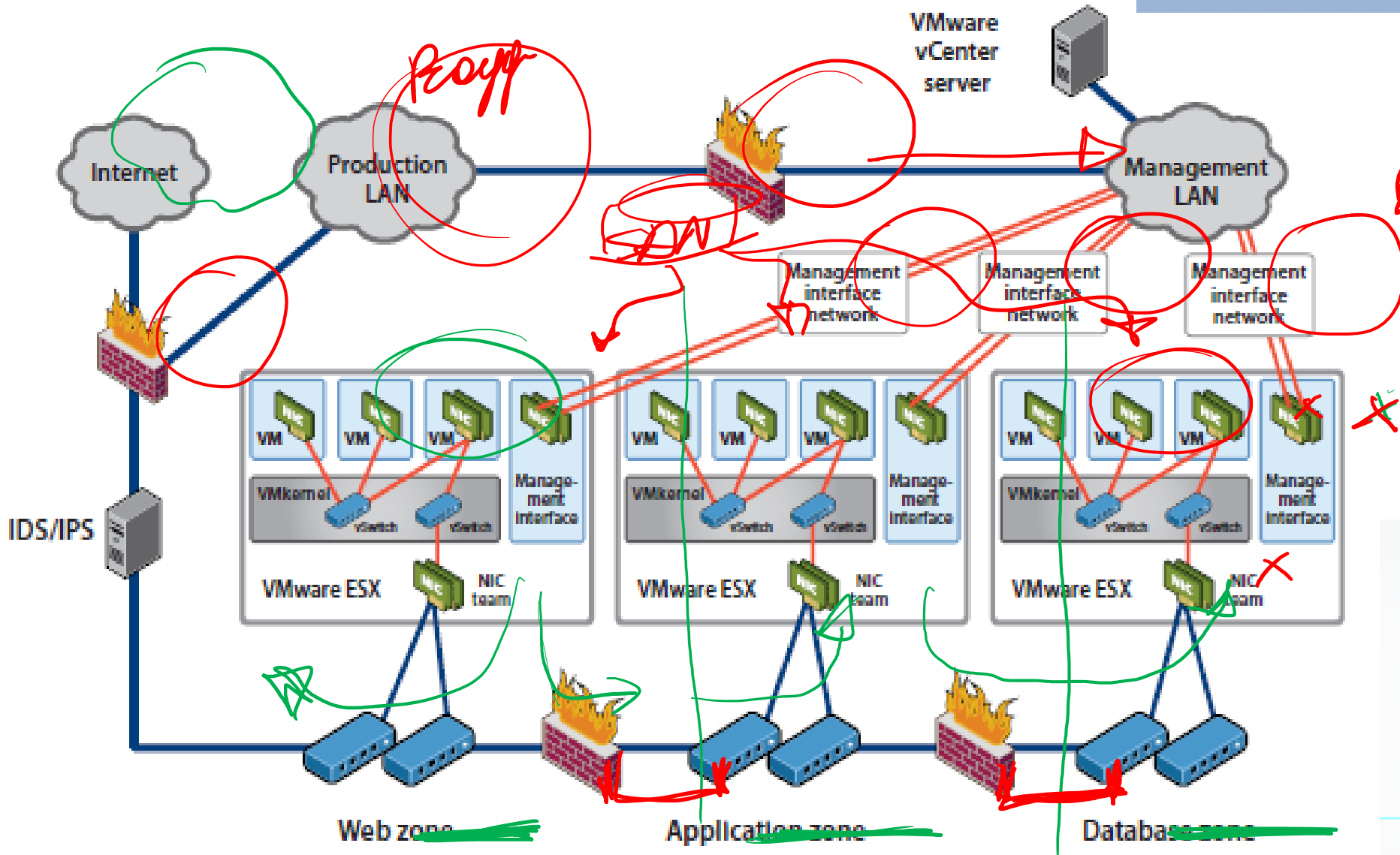


Figure 2 — Partially collapsed with separate physical trust zones



Partially Collapsed with Separate Physical Trust Zones

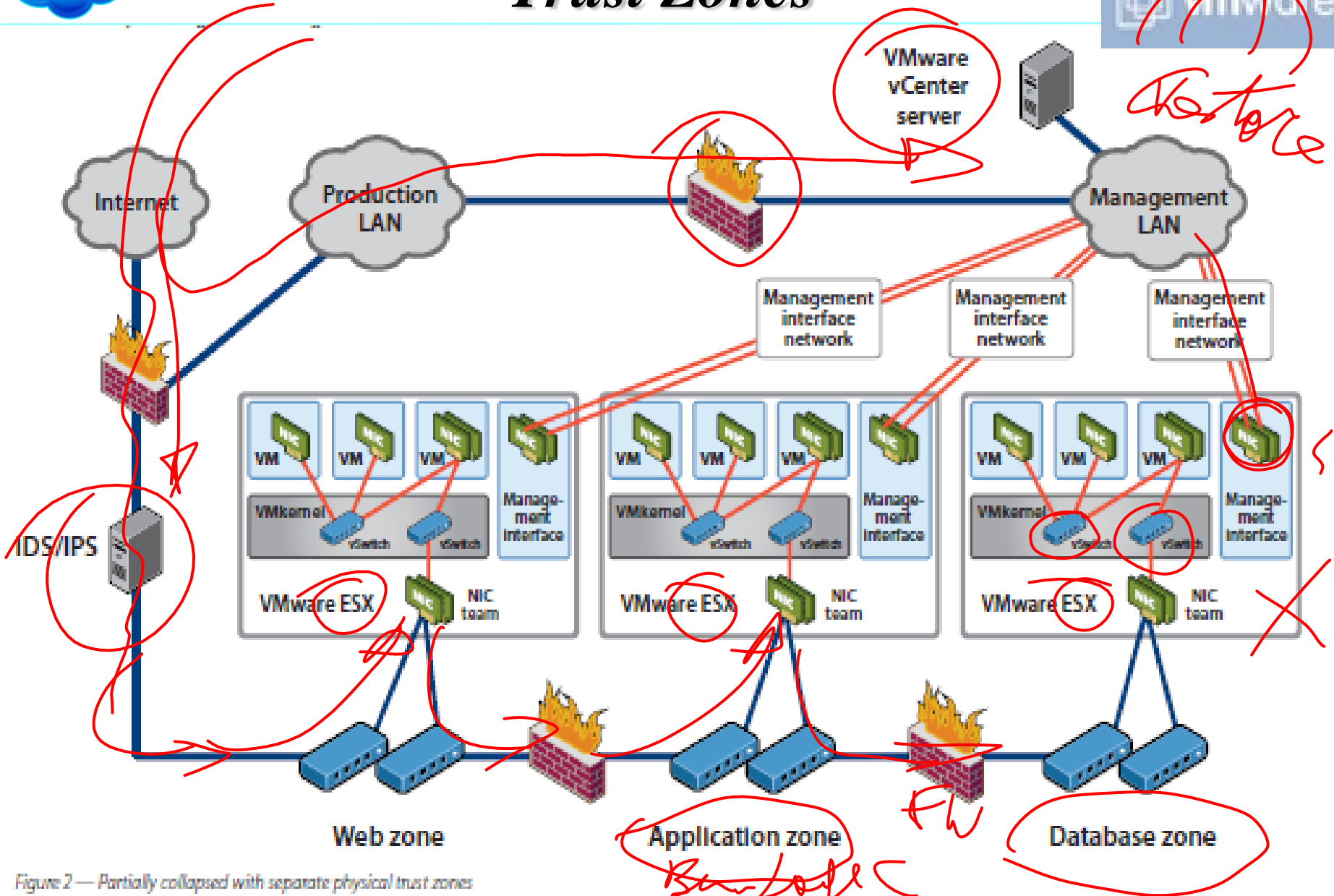


Figure 2 — Partially collapsed with separate physical trust zones



Monitoring the Solution

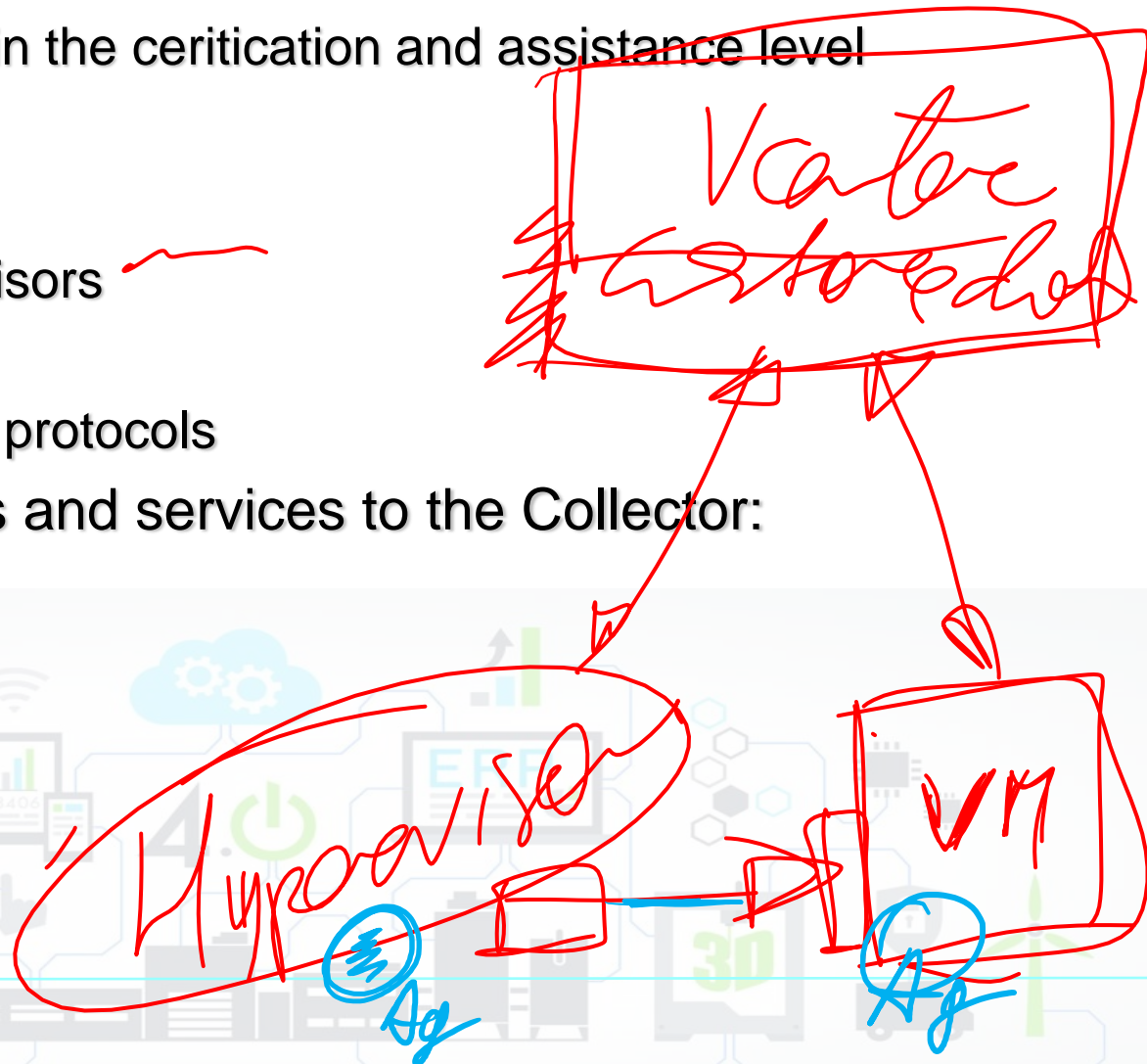
- | Monitoring and assessing performance at level of:
 - ♣ Datacenter, Cluster, Host
 - ♣ Virtual Machine from outside

 - ♣ Virtual Machine inside:
 - ➔ this has to be performed by using tools inside the VM operating system
 - ➔ Windows:
 - System monitoring hosts, detailed performances
 - ➔ Linux:
 - Top or other tools



Main Monitoring methods

- | Agent and Agentless
 - ♣ Problems to maintain the certification and assistance level
- | Protocols:
 - ♣ SSH
 - ♣ API of hosts hypervisors
 - ♣ Storage protocols
 - ♣ Network monitoring protocols
- | Call from applications and services to the Collector:
 - ♣ Call REST
 - ♣ Call to WebService
 - ♣ Write on database





Performance Analysis, Cluster/DC

'eolo - Client per terminal server'

EOL0 - vSphere Client

File Edit View Inventory Administration Plug-ins Help

Home Inventory Hosts and Clusters

Search Inventory

- ercole3
- ercole4
- Test
 - ercole3test
 - ercole4test
 - vulcano-restore
 - vulcanotest2
- PrometeoCluster
 - prometeo1.regione.tos...
 - prometeo2.regione.tos...
 - prometeo3.regione.tos...
 - prometeo4.regione.tos...
 - prometeo5.regione.tos...
- Produzione
- Test
 - crioxtest-proto
 - Microsoft Windows 200...
 - Microsoft Windows 200...
 - neraide2test
 - ubuntu-dsk
- Regione Toscana DMZ
 - AuroraCluster
 - aurora.regione.toscane...
 - aurora1.regione.toscar...
 - Produzione
 - Test
 - baccotest_bk
 - cassiopea3test
 - cassiopeatest
 - cerbero?

prometeo1.regione.toscana.it VMware ESX, 4.0.0, 208167

Summary Virtual Machines Performance Configuration Tasks & Events Alarms Permissions Maps Storage Views Hardware Stati

Name, State or Guest OS contains: Clear

Name	Status	VMware Tools Status	VM Version	State	Provisioned Sp...	Used Space	Host CPU - MHz	Host Mem - MB
crio8	Normal	OK	7	Powered On	75,00 GB	75,00 GB	198	7458
saturnotest	Normal	OK	7	Powered On	35,15 GB	35,15 GB	0	869
crio2	Normal	OK	7	Powered On	79,00 GB	79,00 GB	1127	10966
carontex	Normal	OK	7	Powered On	12,00 GB	12,00 GB	265	1131
azan	Normal	OK	7	Powered On	15,50 GB	15,50 GB	88	483
crio4test	Normal	OK	7	Powered On	48,00 GB	48,00 GB	884	7747
elio6test	Normal	OK	7	Powered On	43,00 GB	43,00 GB	176	1971
elio6	Normal	OK	7	Powered On	43,00 GB	43,00 GB	154	508
crio7	Normal	OK	7	Powered On	48,00 GB	48,00 GB	66	6196
ganimede	Normal	Out of date	4	Powered On	99,66 GB	99,66 GB	22	1883
giapeto	Normal	Out of date	4	Powered On	53,02 GB	53,02 GB	44	2688



Recent Tasks

Name	Target	Status	Initiated by	vCenter Server	Requested Start Ti...



Performance Analysis, Cluster/DC

'eolo - Client per terminal server'

EOLO - vSphere Client

File Edit View Inventory Administration Plug-ins Help

Home Inventory Hosts and Clusters Search Inventory

ercole3 ercole4 Test ercole3test ercole4test vulcano-restore vulcanotest2 PrometeoCluster prometeo1.regione.tos... prometeo2.regione.tos... prometeo3.regione.tos... prometeo4.regione.tos... prometeo5.regione.tos... Produzione Test criotest-proto Microsoft Windows 200... Microsoft Windows 200... nereide2test ubuntu-dsk Regione Toscana DMZ AuroraCluster aurora.regione.toscane aurora1.regione.toscar... Produzione Test baccotest_bk cassiopea3test cassiopeatest cerbero?

prometeo1.regione.toscana.it VMware ESX, 4.0.0, 208167

Summary Virtual Machines Performance Configuration Tasks & Events Alarms Permissions Maps Storage Views Hardware Status

Name, State or Guest OS contains: [] Clear

Name	Status	VMware Tools Status	VM Version	State	Provisioned Sp...	Used Space	Host CPU - MHz	Host Mem - MB
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giapeto	Normal	Out of date	4	Powered On	53,02 GB	53,02 GB	44	2688

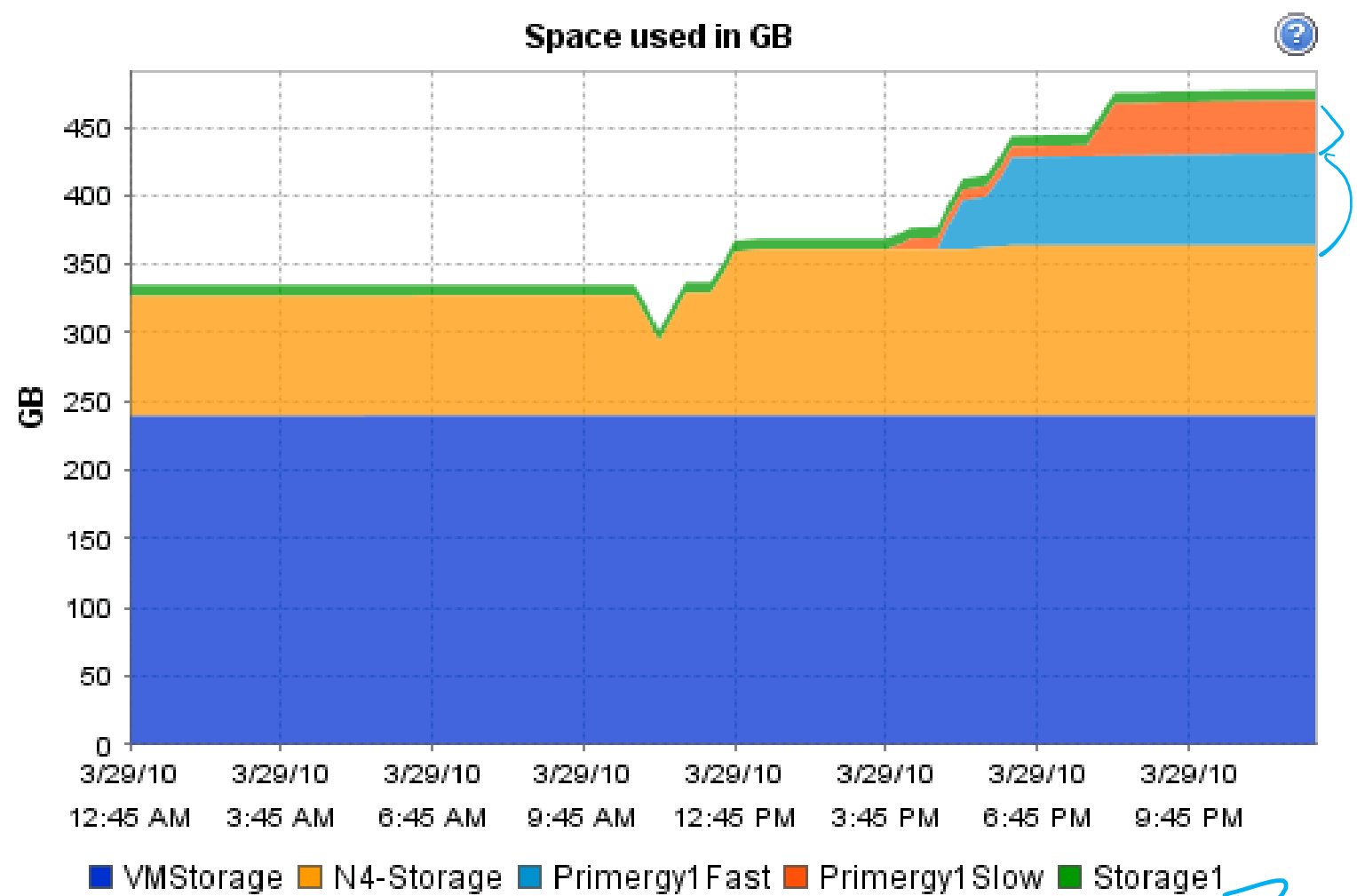
Handwritten notes and diagrams: Blue circles around VM versions 7 and 4. Blue arrows pointing to CPU and Mem columns. Blue sketches of storage disks with labels like '500g' and 'minio eg'. A VMware logo is present in the bottom right.

Recent Tasks

Name	Target	Status	Initiated by	vCenter Server	Requested Start Ti...



Datacenter space consumed again time





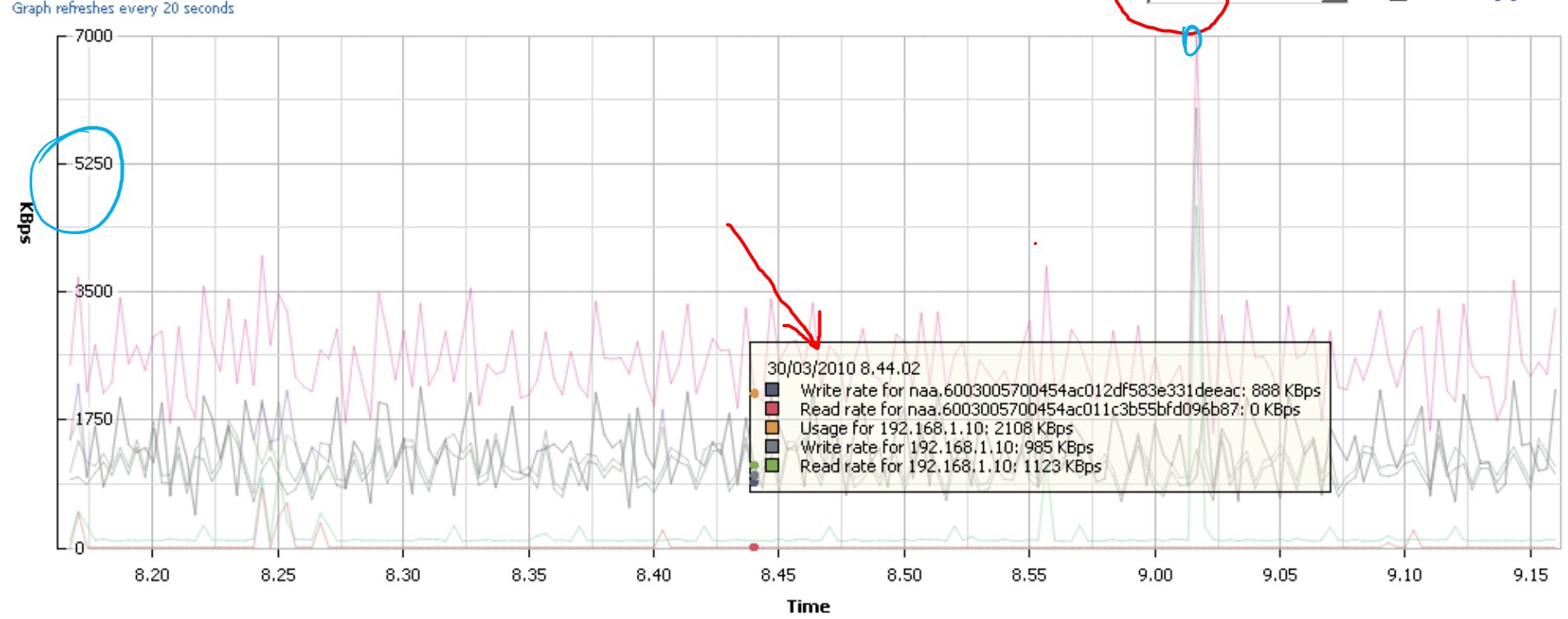
Performance Analysis, Single VM

Getting Started Summary Virtual Machines Resource Allocation Performance Configuration Tasks & Events Alarms Permissions Maps Storage Views Hardware Status

Overview **Advanced**

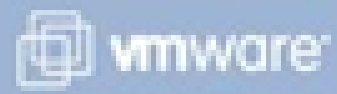
Disk/Real-time, 30/03/2010 8.16.12 - 30/03/2010 9.16.12 [Chart Options...](#)

Switch to: **Disk**



Performance Chart Legend

Key	Object	Measurement	Rollup	Units	Latest	Maximum	Minimum	Average
■	naa.600300570...	Write rate	Average	KBps	1001	1727	626	1058,693
■	naa.600300570...	Read rate	Average	KBps	0	820	0	18,045
■	192.168.1.10	Usage	Average	KBps	3281	6992	1564	2594,006
■	192.168.1.10	Write rate	Average	KBps	1110	6019	716	1218,615
■	192.168.1.10	Read rate	Average	KBps	2170	2279	446	1374,872
■	naa.600300570...	Read rate	Average	KBps	2170	2279	446	1356,693
■	naa.600300570...	Write rate	Average	KBps	1001	1727	626	1058,693





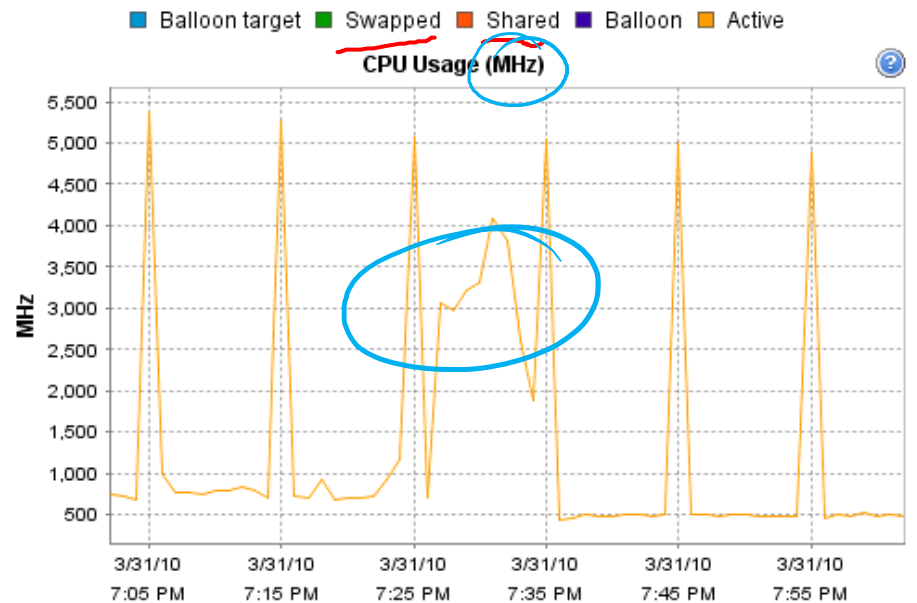
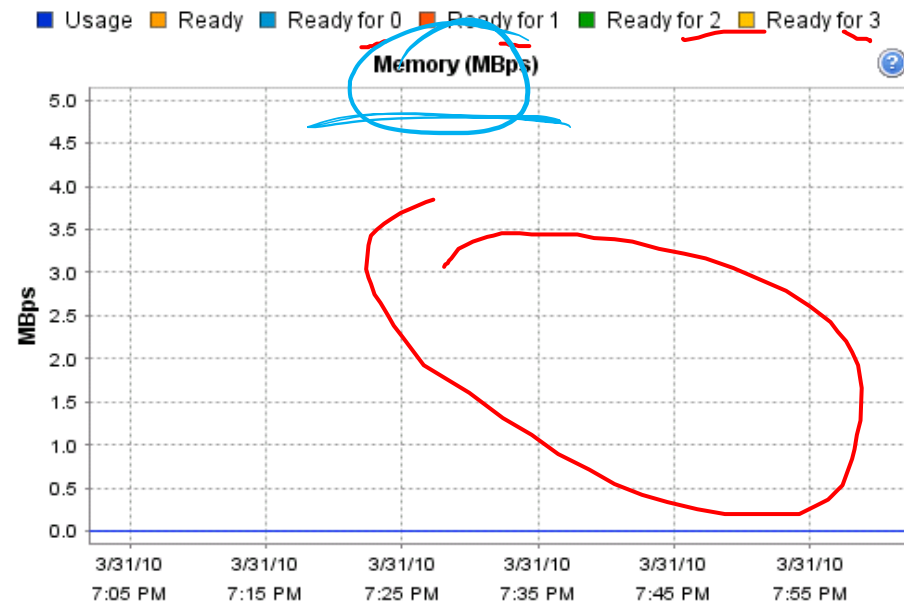
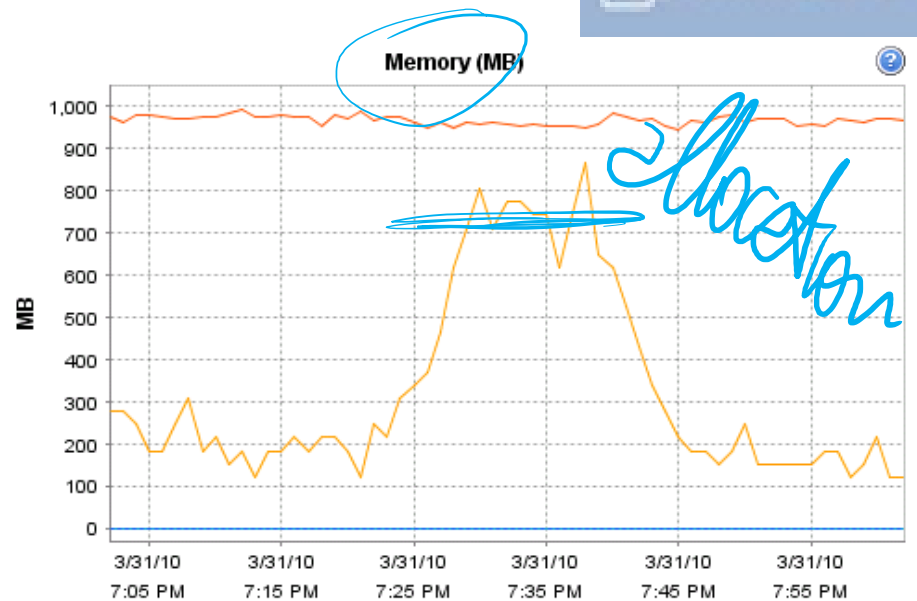
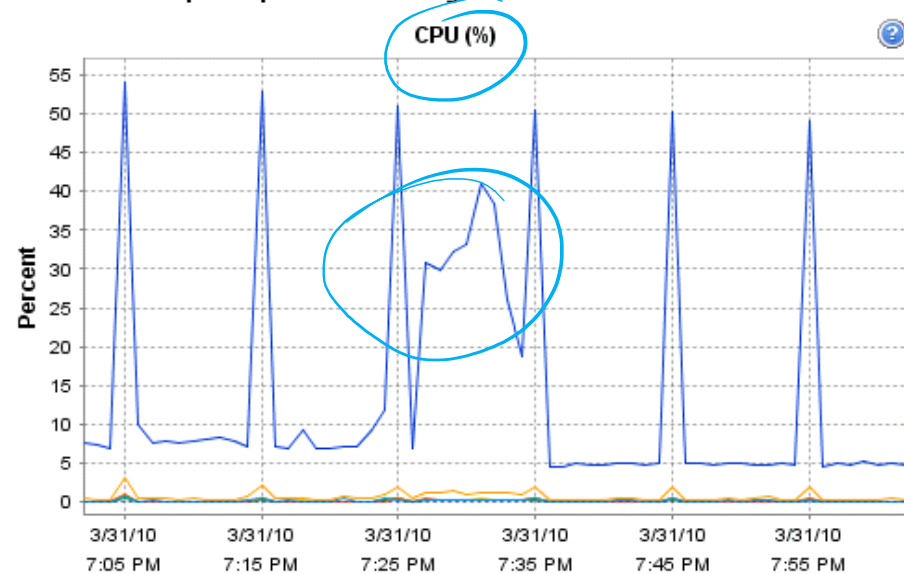
Performance Analysis, Single VM



Getting Started Summary Resource Allocation Performance Tasks & Events Alarms Console Permissions Maps Storage Views

Overview **Advanced**

Realtime Summary for **opnet.axmccis.org**





Performance Analysis, Single VM

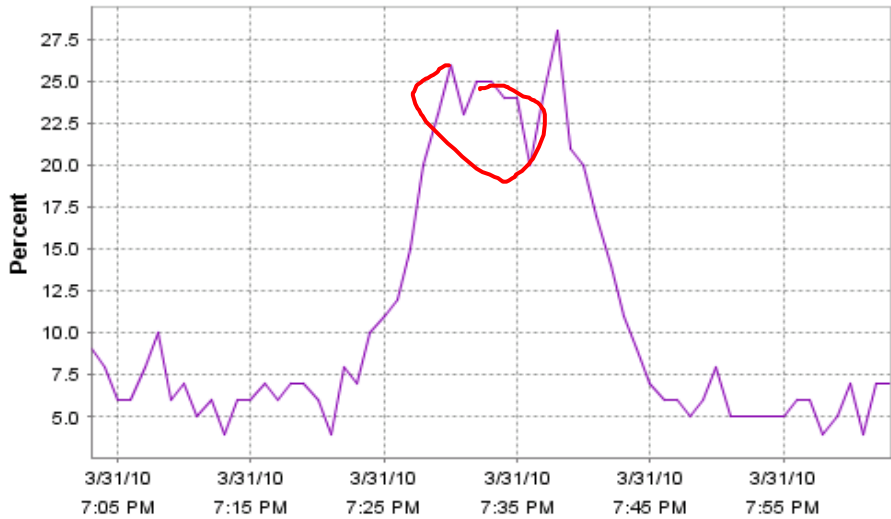


Getting Started Summary Resource Allocation Performance Tasks & Events Alarms Console Permissions Maps Storage Views

Overview Advanced

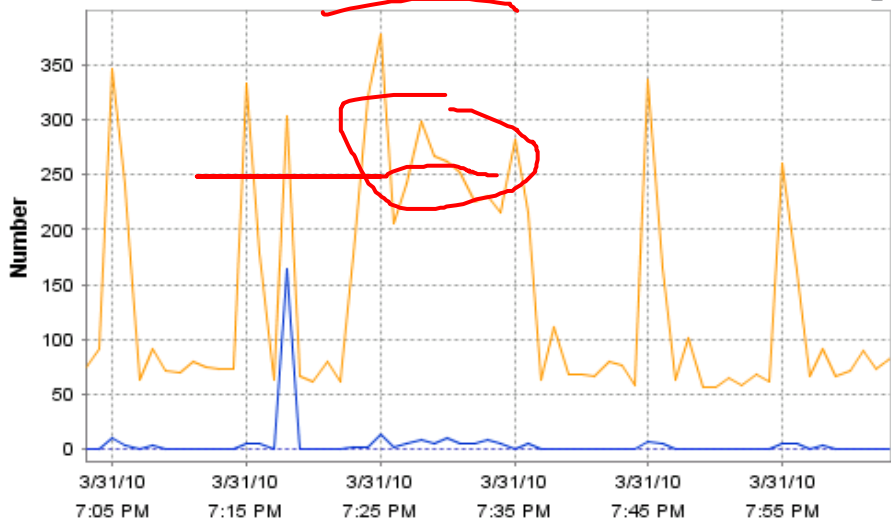
■ Swap in rate ■ Swap out rate

Memory (%)



■ Usage

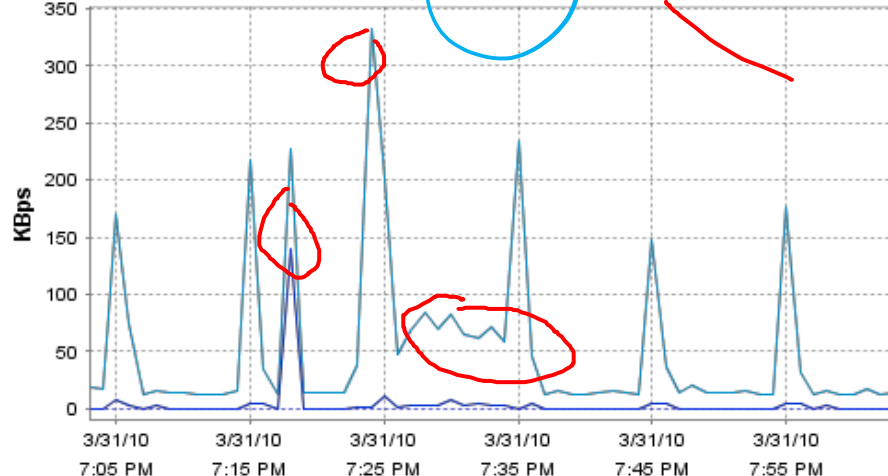
Disk Requests (Number)



■ Read ■ Write

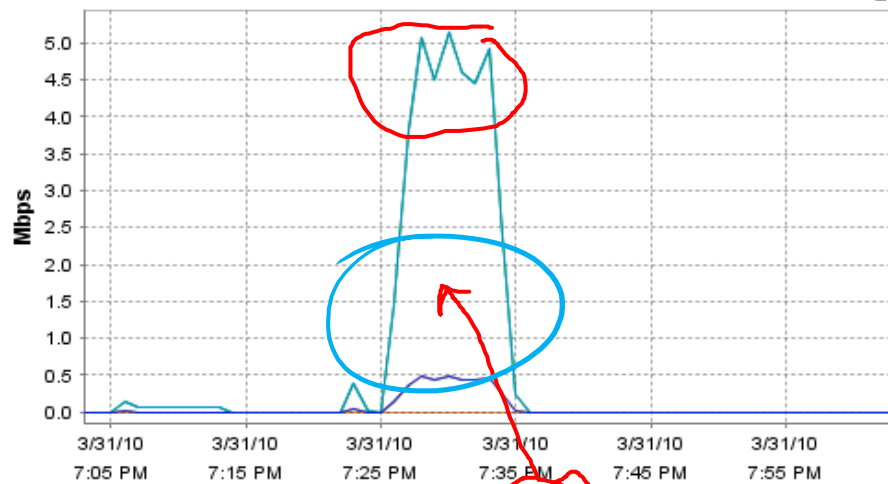
■ Usage in MHz

Disk Rate (KBps)



■ Read ■ Read for naa.6003005700454ac012df583e331deaac ■ Write
■ Write for naa.6003005700454ac012df583e331deaac

Network Rate (Mbps)

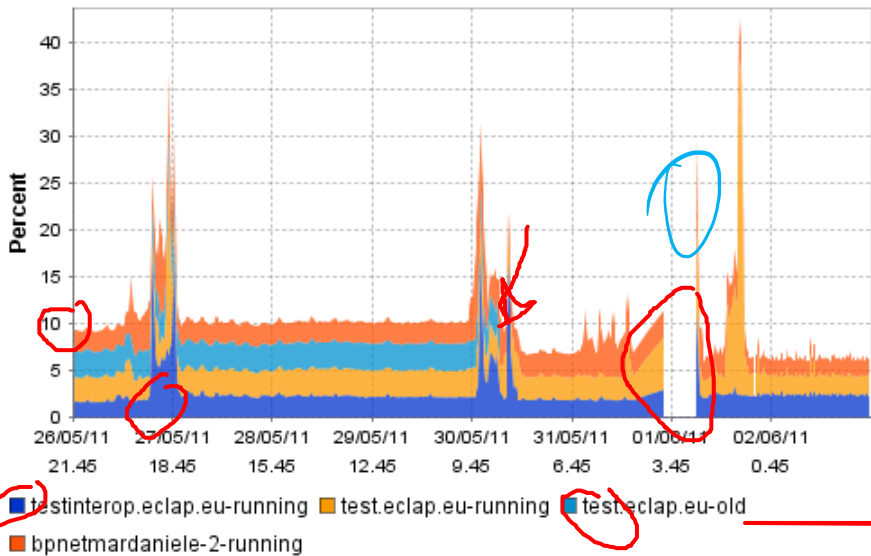


■ Transmitted for 4000 ■ Transmitted for 400 ■ Received ■ Transmitted
■ Received for 4000 ■ Received for 4001

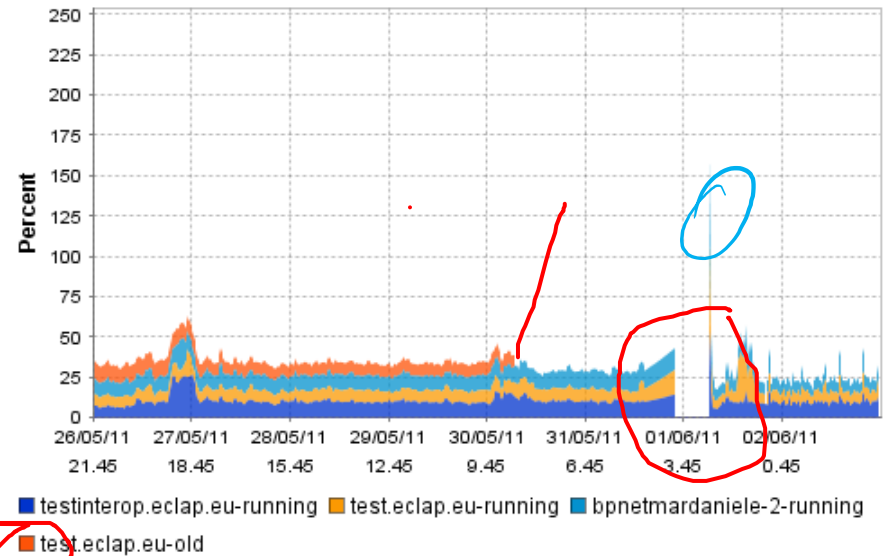


Performance Analysis of VM on the Host

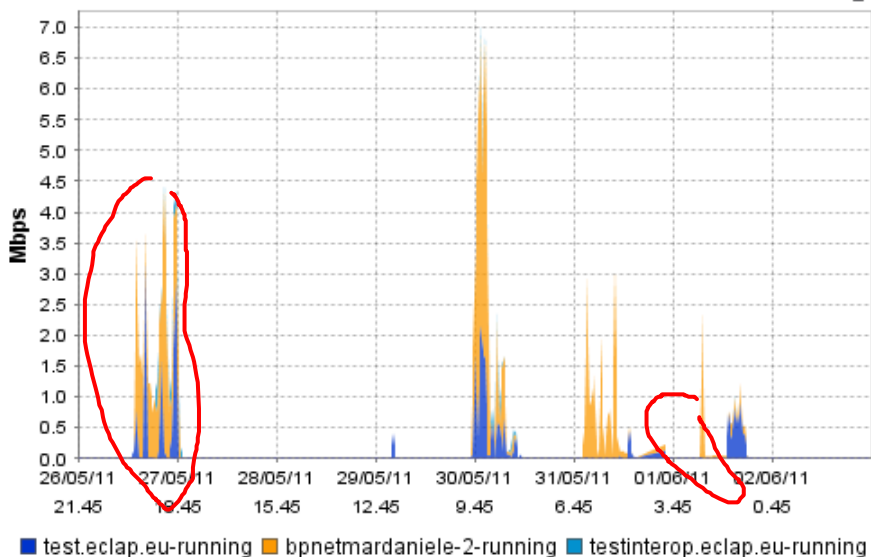
CPU Usage (Top 10)



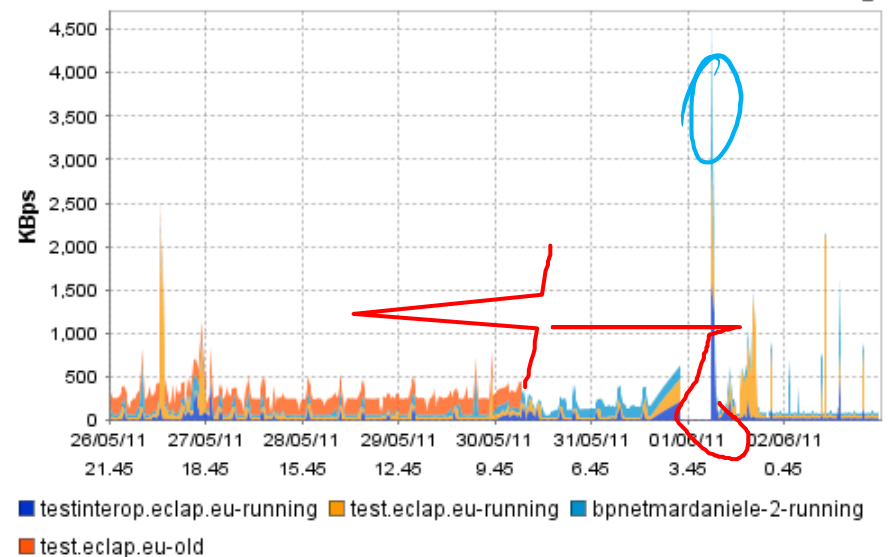
Memory Usage (Top 10)



Network (Mbps) (Top 10)



Disk (KBps) (Top 10)





Problematiche del Monitoraggio

I Parametri da monitorare: IaaS, PaaS, e SaaS:

- ♣ Condizioni e parametri di stato degli HOST
- ♣ Parametri di consumo degli HOST
 - ➔ Spazio storage, snapshots, etc.
- ♣ Condizioni e parametri di stato delle VM e del sistema operativo
- ♣ Parametri di consumo delle VM
 - ➔ Spazio disco, memoria, connessione

♣ Condizioni e parametri di stato delle applicazioni e dei servizi dentro le VM

♣ Parametri di consumo delle applicazioni e dei servizi dentro le VM:

➔ E.g.: Numero di fatture, numero di utenti

HL



SaaS





Monitorare perché'

I Actions:

- ♣ Allarmi gialli/rossi (75%/90%) se si superano soglie definite
- ♣ Invio di: email, sms, etc.
- ♣ Attivazione di riconfigurazioni, cambi di configurazione, estensioni di risorse
- ♣ Attivazione di moving → DRS / HA / FT
- ♣ Shutdown di emergenza
- ♣ Network off/on
- ♣ Cambio di billing in base alla SLA
- ♣ Etc. etc.





Confronto fra sistemi di monitoring

Requisiti	Nagios (core)	Ganglia (core)	Zenoss (core)	Zabbix 2.2.0	Hyperic HQ 4.6.6
PaaS/SaaS					
Monitoraggio Virtual Machine (Low level Metrics)	X	X	X	X	X
Monitoraggio Applicazioni/Servizi Agent-Based	X	X	X(M)	X	X
Monitoraggio Applicazioni/Servizi Agent-Less	X	-	X	X	X
Agent WIN OS	X	X	X(M)	X	X
Agent/daemon Linux OS	X	X	X(M)	X	X
IaaS					
Monitoraggio Host (Low level Metrics)	X	X	X	X	X
Monitoraggio Hypervisor (Low level Metrics)	X	X (+)	X(^)	X(\$?)	X(°)
Agent per Hypervisor Notifiche	X	X (+)	X(M)	X(\$\$)	X(°)
Eventi e notifica allarmi	X	X	X	X	X
High Level Metrics					
Definizione HLM	X (**)	X (+++)	X(M)	X(\$)	X(°)
Calcolo HLM	X (**)	X (+++)	X(M)	X(\$)	X(°)
Storage HLM	X (**)	X (+++)	X(M)	X	X(°)
Interoperabilità					
SDK /API accesso dati	X	X	X	X	X
Plugin	X	X	X	X(\$)	X
Integrazione Linguaggio	C/CGI	C, Perl, PHP, Python	Python under Zope	PHP,	Java/C
DB Data Storage	MySQL (via event broker con NDOutils o Merlin)	MySQL (++)	MySQL	MySQL, Oracle, PostgreSQL, SQLite, IBM DB2	MySQL, Oracle, PostgreSQL
FS Data Storage	RRD tool	RRD tool	-	-	-
Linux OS	X	X	X	X	X
Win OS	X (***)	X	-	X	X
Licenza	GPL	BSD	GPL	GPL	GPL
Web GUI	Nagios XI (*)	Ganglia Web 2.2.0+	X	X	X

Handwritten notes:
 A
 Jp





Structure

- | Elements of cloud Computing
- | Virtualization
- | Cloud Computing
- | High Availability
- | vSphere Infrastructure
- | Security on the Cloud
- | Conversions among VM and physical machines
- | vCenter, datacenters and cluster management
- | Comparison among virtual computing solutions
- | How to work with Virtual Machines
- | IaaS solutions, PaaS Solutions, SaaS Solutions
- | ICARO project





Virtualization Solutions

| VMware vSphere

- ♣ Datacenter and VM management, a large range of OS

| Microsoft Hyper-V

- ♣ Based on Microsoft Windows Server 2008

| HP Integrity

- | Datacenter and VM management, x86, linux, etc.
- | No GUI for monitoring

| XEN

- ♣ Virtual machine monitor, hypervisor: Suse, RedHat, Sun Solaris, Debian
- ♣ X86, 64, PowerPC 970
- ♣ GPL licensing

| others

- ♣ SWsoft with its Virtuozzo
- ♣ IBM Power VM
- ♣ VirtualBox of Sun, open source



Comparison (www.ctistrategy.com)

Aspect	VMware vSphere 4	Microsoft Hyper-V R2
Hosts		
CPUs supported	Recent AMD, Intel	Recent AMD, Intel
# CPU cores supported	64	64
Memory supported	Unlimited	2TB
I/O devices supported	IDE, SCSI, SAS, SATA, FC, 1Gb and 10Gb Ethernet, iSCSI, NFS, FCOE, Infiniband	IDE, SCSI, SAS, SATA, FC, 1Gb and 10Gb Ethernet, iSCSI, CIFS, FCOE, Infiniband
Memory optimization	Over-commit, transparent page sharing, ballooning, large memory pages	Standard Windows Server 2008 features
Platform support	Fewer vendors	More vendors
Supported storage of guest VMs	Direct, <u>SAN</u> , NAS, iSCSI	Direct, <u>SAN</u> , iSCSI
Number of nodes in a cluster	32 nodes if < 40 VMs per node	16



Comparison, 2

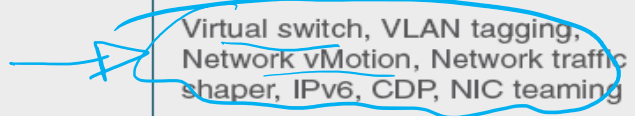
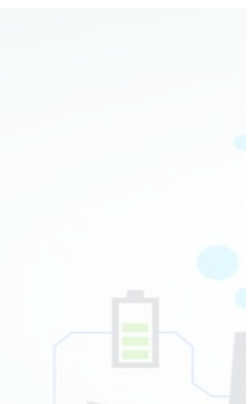
Aspect	VMware vSphere 4	Microsoft Hyper-V R2
Guest		
Operating systems supported	Asainux, CentOS, Debian, FreeBSD, OS/2, Solaris 10, SCO OpenServer, SCO Unixware, Windows Server, RHEL, SUSE, MS-DOS, Netware - <i>XP, Vista</i>	Windows Server, Vista, XP, SUSE Linux
Operating systems tools provided (per OS)	Yes, for most guests	Yes, for most guests
# virtual CPUs supported	8	4
# guests per host	256 running	512 (192 running)
# Amount virtual memory	255GB	64GB
Virtual NICs	10	Yes, limit unknown
# of snapshots	32 per VM (?)	50 per VM
Types of guests supported	32-bit, 64-bit, simultaneously	32-bit, 64-bit, simultaneously
Ability to hot-add disk images and external storage	Yes	Virtual SCSI devices only, not IDE

x CPU / HOST

x CPU / HOST



Aspect	VMware vSphere 4	Microsoft Hyper-V R2
Features		
VM move	Live	Live
Direct I/O	VMDirectPath I/O	-
VM synchronization	With limits (1 vCPU, many features disabled)	No
Directly boot from VM image	Only if ESXi installed	Yes
P to V	Included	Included
V to P	Included	Included
H/A via clustering and failover	Yes	Yes
Replication	Integration with 3rd party storage products	Yes (DFS-R)
Performance monitoring	Yes, vCenter Server	Yes, SC Operations Manager
Network features	Virtual switch, VLAN tagging, Network vMotion, Network traffic shaper, IPv6, CDP, NIC teaming	Standard Windows Server 2008 features
Storage features	Thin provisioning, consumption-based monitoring, reports and topology maps, LUN discovery, adaptive block sizing, storage vMotion	Standard Windows Server 2008 features
Patching of guests	vCenter Update Manager (both running and halted guests, Windows and some Unix)	Standard Windows Server 2008 features for booted Windows guests, Offline Machine Servicing Tool for halted Windows guests
Security	Layer 2 security policies, vShield, VMsafe 3rd party security products	Native firewall, 3rd party security products
Backups	Native via VMware Data Recovery, Support from major vendors	Native, Support from major vendors
Resource management	Yes, many options	Yes, some options
Physical server power on / off as needed	Via VMware DRS / DPM	No





Standards in Virtual Machine formats

| Virtual Machine formats on the HD

| **OVF**: Open Virtualization Format, on the push of VMware

✿ Format for VM

| VM disk format of VMware is a standard which is supported by:

✿ VMware workstation

✿ vSphere VMware

✿ VirtualBox of SUN





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- | IaaS solutions, PaaS Solutions, SaaS Solutions
- | ICARO project



How to WORK with VMs in the Cloud

| KVM solutions

- ♣ Local access via local KVM
- ♣ Local server access via HTTP

| Windowing Terminal

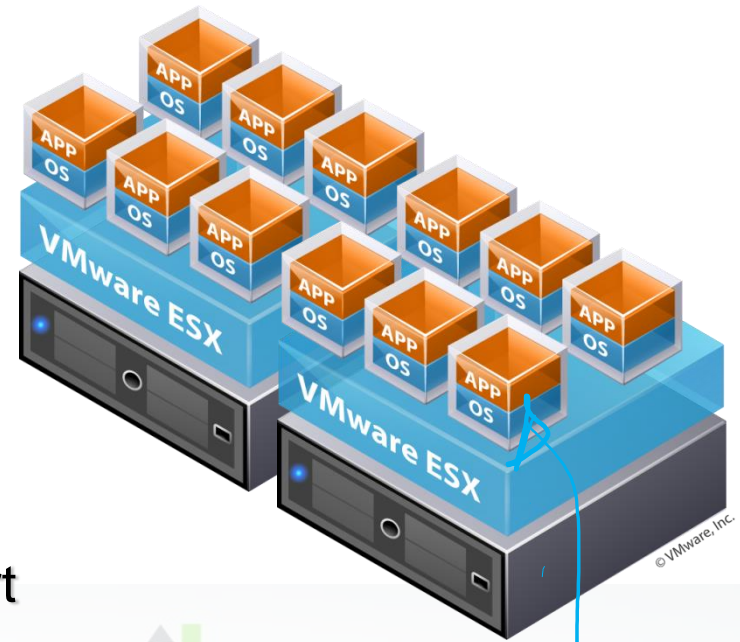
- ♣ MS Windows Remote Desktop
- ♣ X Terminal to linux

| Remote Solutions:

- ♣ VNC, Radmin, etc.
- ♣ VNC: Also possible via HTTP port

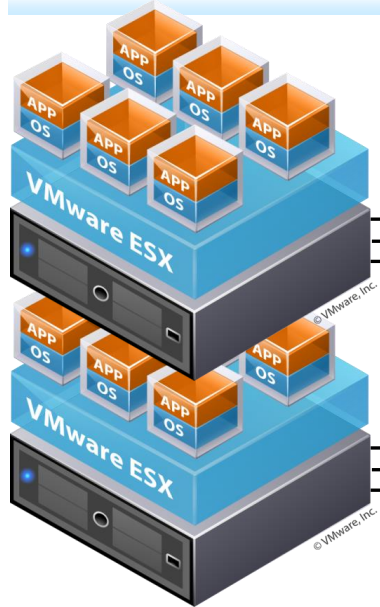
| Telnet, char based consol, SSH

VT100 terminal for example



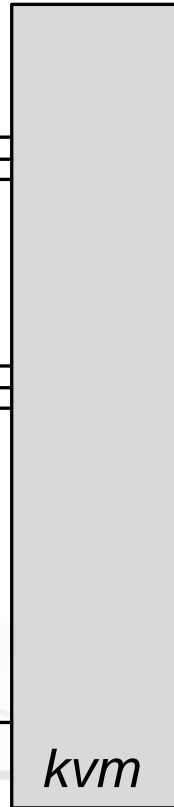


KVM



Keyboard, Video, Mouse

Keyboard, Video, Mouse



Network:

- control
- remote access/desktop



VGA





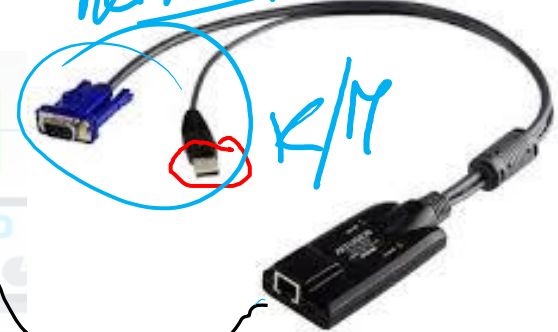
RJ45 KVM



K/M

RJ45

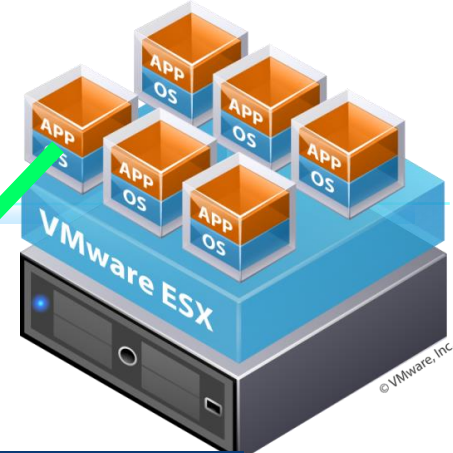
*È un caso di rete
Ma non porta sepolchi
rete*



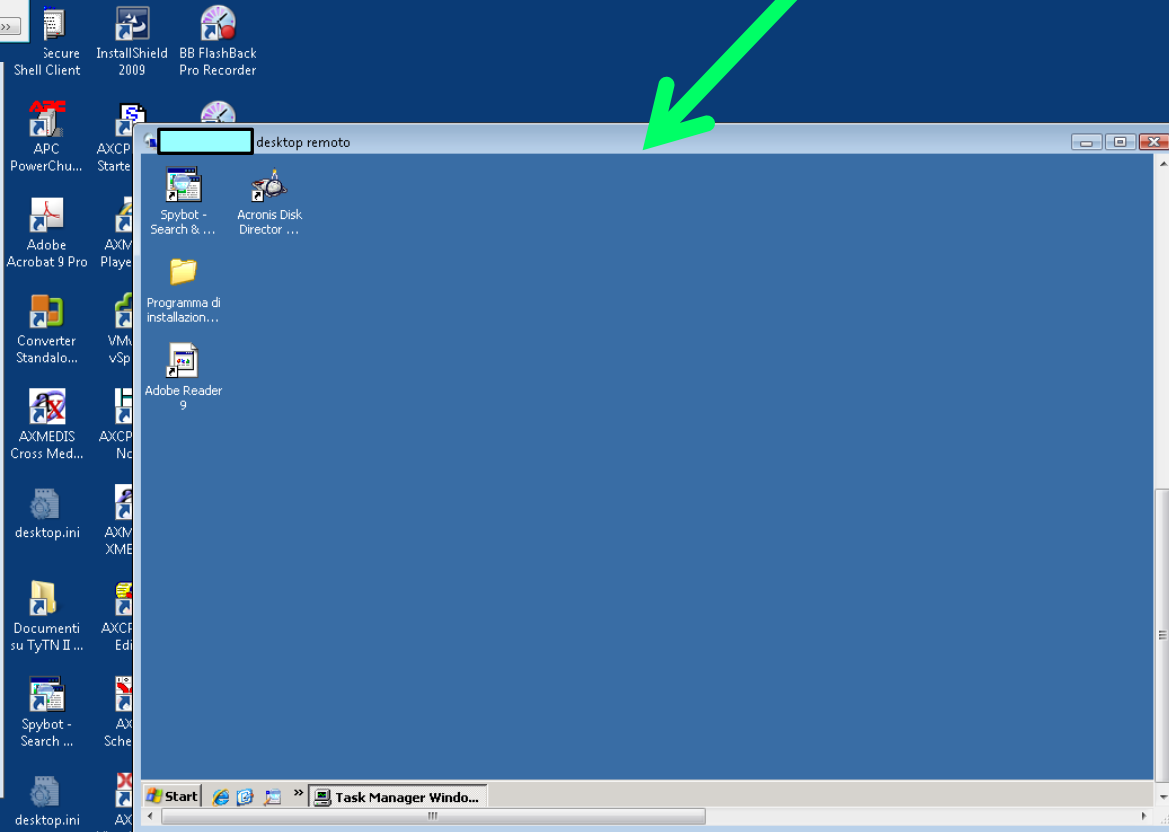
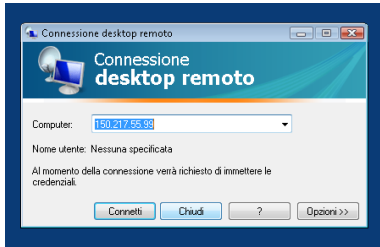
K/M



Windows Remote Desktop



n Remote machine
n Windows 2003

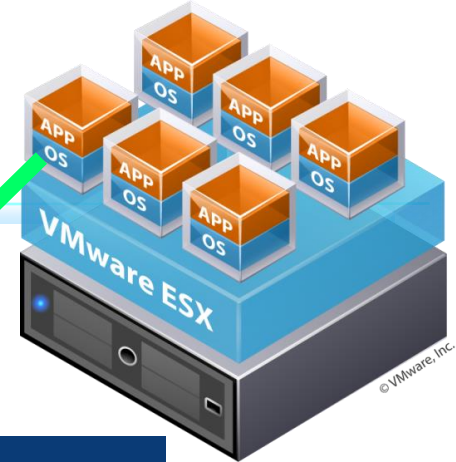


n Local machine
n Windows Vista

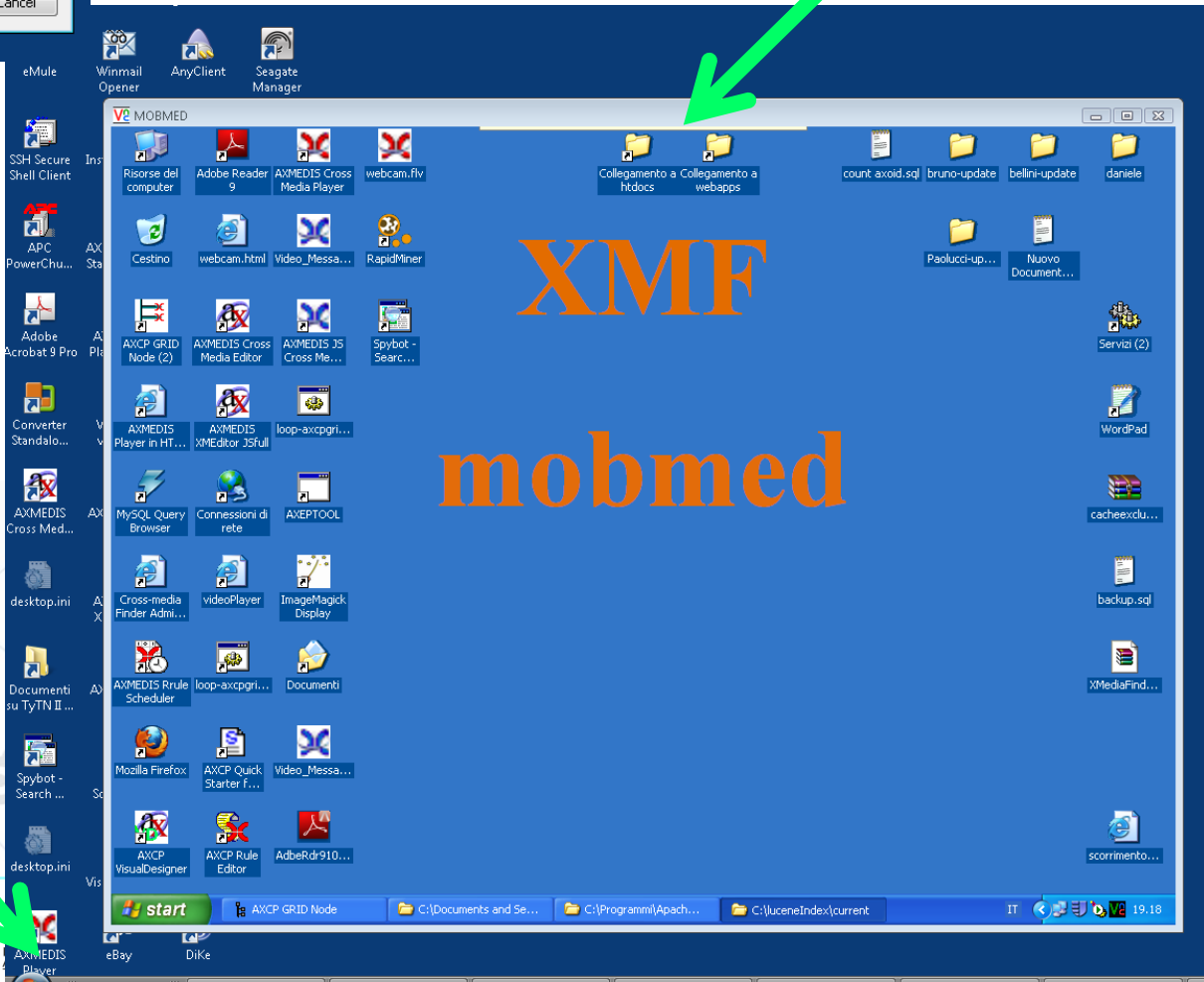
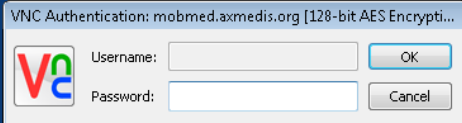




VNC remote connection



Remote machine
Windows XP



Local machine
Windows Vista





- | Targhet
- | Come si lavora a caldo





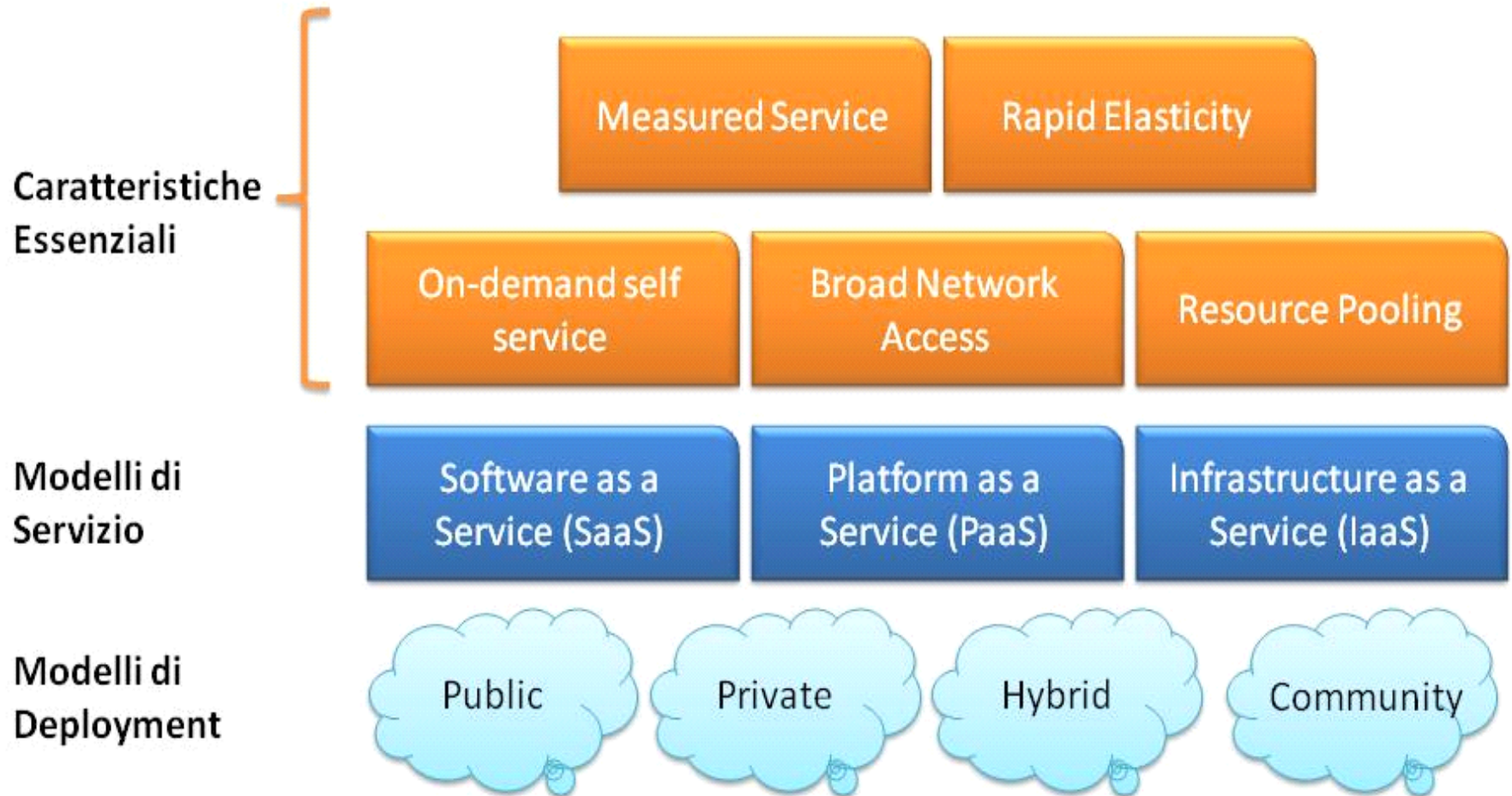
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Modello Generale





Infrastructure as a Service (IaaS)

- | erogazione di servizi infrastrutturali relativi a:
 - ♣ CPU come clock, storage as HD, rete, mem
 - ♣ altri elementi di base assolutamente indipendenti da servizi applicativi di qualunque tipo.
- | infrastruttura messa a disposizione dal provider per eseguire la propria applicazione:
 - ♣ Affitto di Server e/o macchine virtuali
 - ♣ pagamento in base al consumo dell'infrastruttura
 - ♣ lascia sotto la responsabilità dell'utente la gestione del sistema operativo, dell'eventuale middleware e della parte di runtime, oltre che dell'applicazione stessa.
- | Amazon EC2 è un esempio di servizio IaaS.



IaaS

- | Una serie di Host, VM e NAS/SAN
- | Un gestore di macchine virtuali
- | Un sistema per il deploy basato su templates
- | Un sistema di monitoring and alarm su risorse fisiche e parametri di hosts
- | Un sistema per l'accounting e il deploy automatico
- | Alcuni servizi per l'accesso diretto a Host e VM



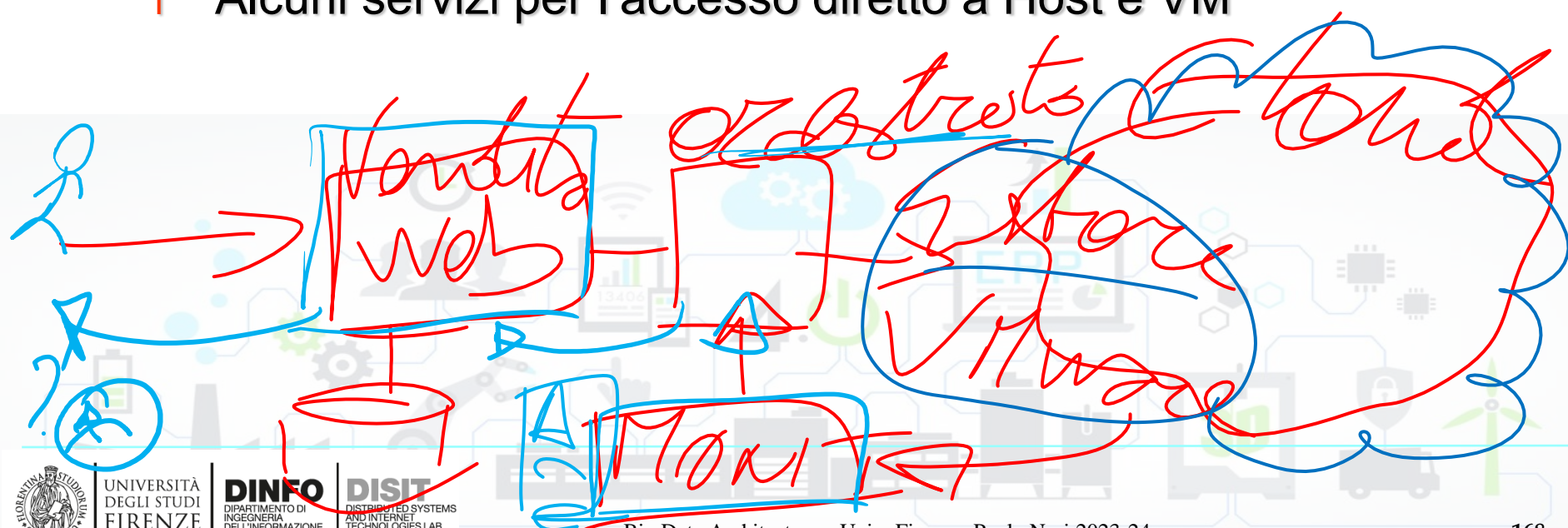


IaaS

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SAP
 IP
 Service ID

cost knowledge → Billing





IaaS Solutions

- | Based on Virtualization
- | A set of Datacenters, Hosts, NAS/SAN, networks, etc.
- | IaaS commerciali come

Cluster

*CSP
2° livello*

- Amazon's Elastic Compute Cloud (EC2) and Simple Storage Service (S3). Amazon EC2 è il leader del mercato dei provider IaaS.

- | Come Technology provider di soluzioni IaaS si hanno:

- Oracle,
- VMware: Vcenter, Vsphere, etc.;
- **Nimbus**;
- OpenNebula;
- HP;
- **Eucalyptus**; **Ubuntu Enterprise Cloud** (basato su Eucalyptus);
- GoGrid;
- Flexiscale;
- UNISYS,
- Enterprise Cloud Manager, ECM, on Hybrid.



Service Model	IaaS													
Infrastructure Feature	Amazon EC2	BitRefinery	GoDaddy	GoGrid	Hosting.com	NephoScale	OpSource	Rackspace	ReliaCloud	Softlayer	Terremark	Eucalyptus	OpenNebula	Nimbus
Pay As You Go	x		x	x		x	x	x		x	x			
Dynamic Service Level Agreement														
Certificazioni (e.g., PCI o SAS 70)	x	x			x		x	x	x	x	x			
Scale Up		x	x	x	x	x	x	x			x			
Scale Out	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Live Support		x	x	x	x	x	x	x	x					
Monitoring Tools	x		x		x		x	x		x			x	
APIs	x			x		x	x	x	x	x	x	x	x	x
Free Tier	x					x						x	x	
Highly customizable instances		x			x		x				x			
Cloud Burst													x	



IaaS confronto (legenda)

- | **Pay per use** – se si paga a consumo, in realtà molti provider hanno una filigrana di offerte più ampia, includendo anche piani mensili, sconti e promozioni ecc.
- | **Dynamic SLA** – se viene offerta la possibilità di ridefinire gli SLA.
- | **Certifications** – se il provider offer certificazioni sulla compliance/sicurezza come PCI o SAS 70.
- | **Scale Up** – se è possibile lo scale up di single istanze di server, tramite l’aggiunta di memoria, extra CPU o storage.
- | **Scale Out** – se è possibile fare il deploy veloce di nuove istanze dei server.
- | **Live Support** – può essere diviso in:
 - ♣ *Poor (n)* – solo forum di supporto for free; in alternativa a pagamento.
 - ♣ *Average (y)* – supporto 24x7 gratis (telefono, chat, forum).
 - ♣ *Extensive (y)* – offerte di supporto multiplo per ogni soluzione proposta.
- | **Monitoring** – può essere diviso in:
 - ♣ *Poor (n)* – nessuna soluzione di monitoring/alert integrata, sono necessari strumenti di terze parti da acquistare separatamente.
 - ♣ *Average (y)* – strumenti di monitoring minimali e senza servizi di alert.
 - ♣ *Extensive (y)* – soluzioni complete e integrate di strumenti di monitoring compresi nel prezzo.
- | **APIs** – se vi sono API per interagire con i server.
- | **Free Tier** – se vengono offerte soluzioni di prova per il test dei servizi



Structure

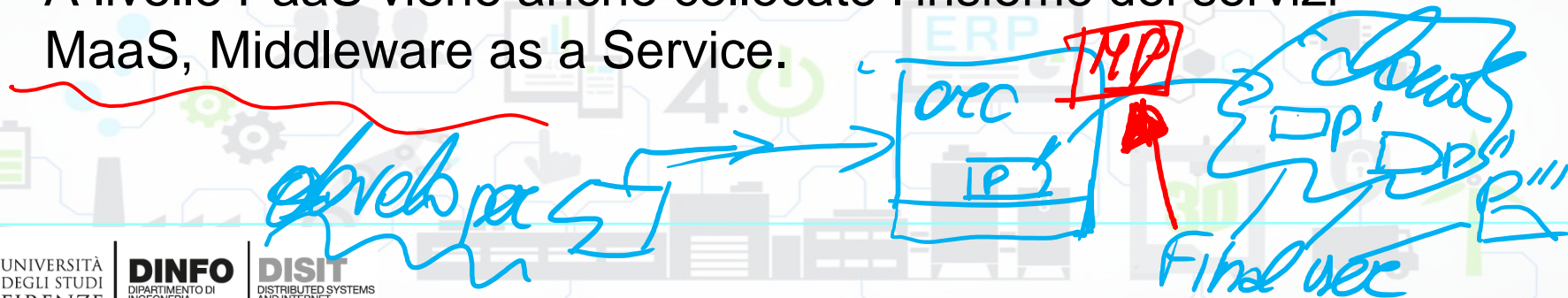
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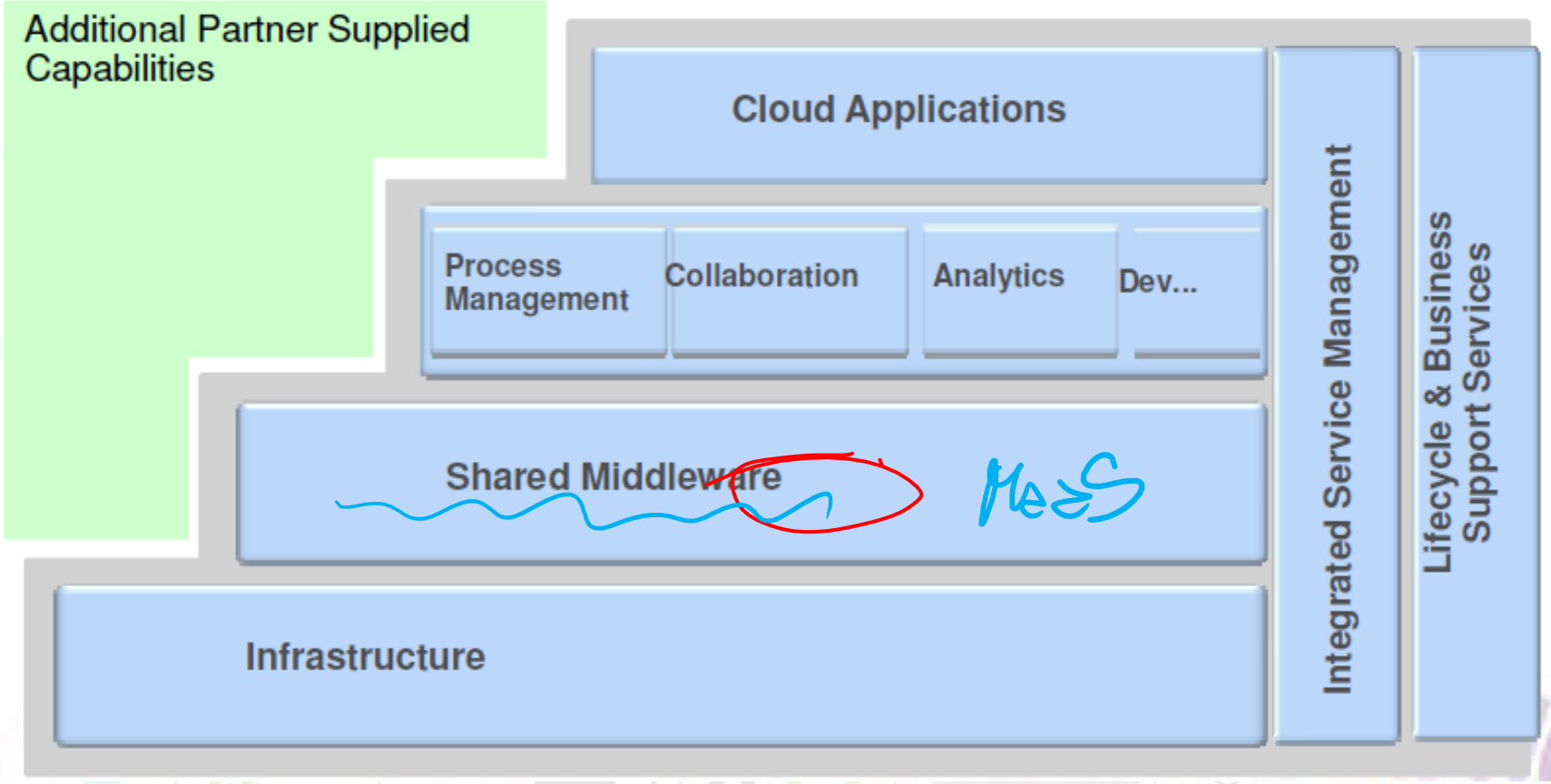




Platform as a Service (PaaS)

- | erogazione di servizi applicativi di base come:
 - ♣ sistemi operativi, middleware, linguaggi,
 - ♣ tecnologie di base dati
 - ♣ ambiente runtime necessari per eseguire l'applicazione,
- | rimane sotto la responsabilità dell'utente,
 - ♣ applicazione
 - ♣ la definizione del modello (e.g., numero e dimensione dei server, datacenter, caratteristiche del networking) da utilizzare per l'esecuzione dell'applicazione.
- | Google AppEngine è un esempio di Platform as a Service.
- | A livello PaaS viene anche collocato l'insieme dei servizi MaaS, Middleware as a Service.







PaaS

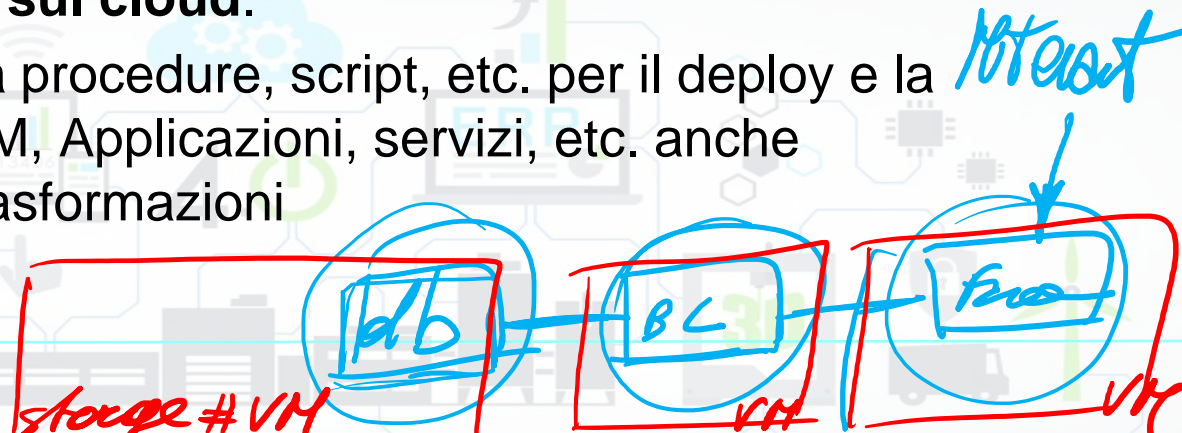
- | **Middleware per accesso ai servizi di base**
 - ♣ **Middleware as a Service, MaaS**
 - ♣ **API per accesso a questi servizi**
- | **Sistema di sviluppo** per applicazioni che possono usare le API
- | **Servizi e risorse base**



| **Business Process Modeling:**

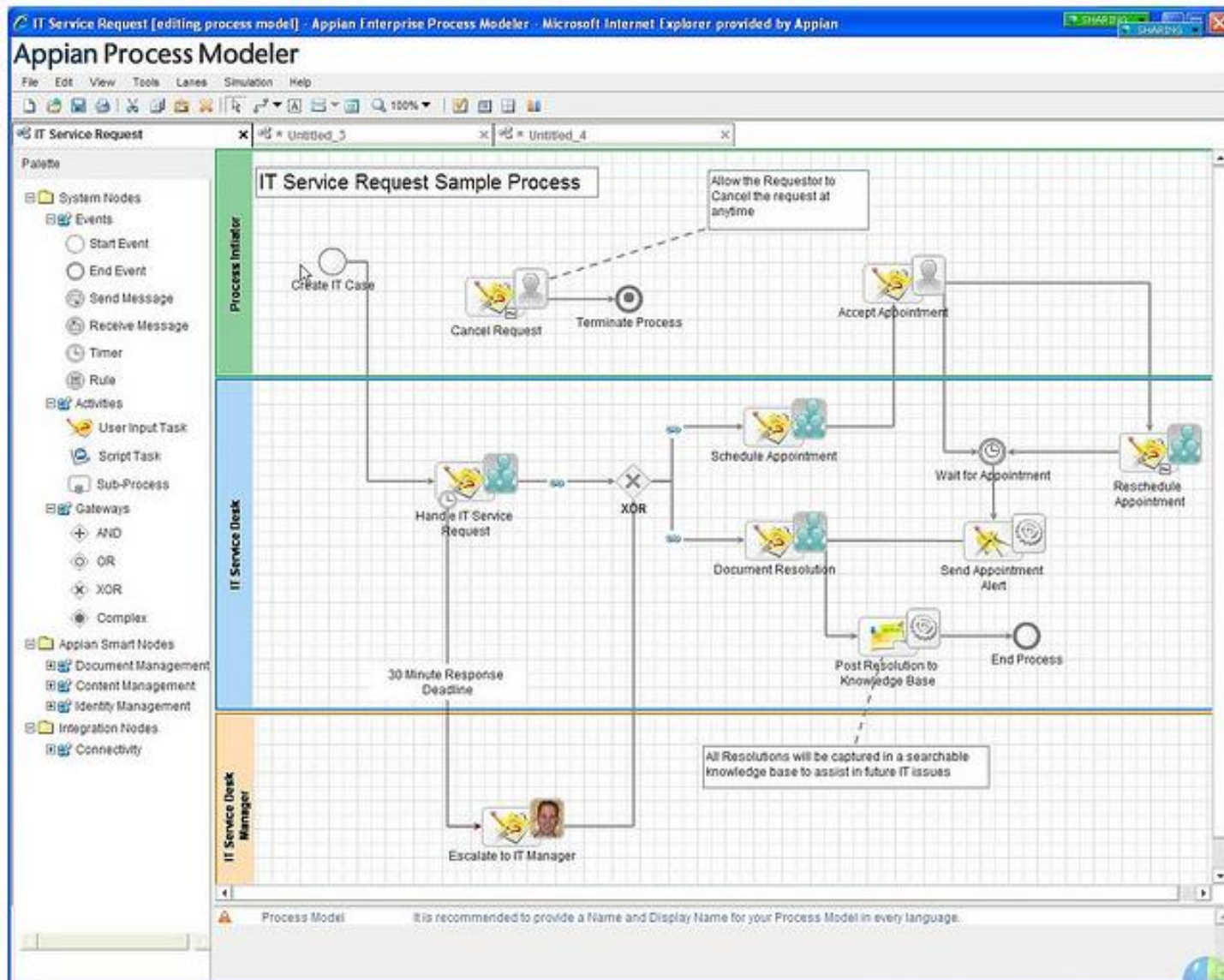
- ♣ **permette definire come allocare e configurare le macchine virtuali ed i servizi sul cloud.**
- ♣ **A livello SaaS: Crea procedure, script, etc. per il deploy e la configurazione di VM, Applicazioni, servizi, etc. anche riconfigurazioni e trasformazioni**

| **Processo di lavoro**





Appliant Process Modeler





Alcuni esempi di PaaS

- | Google App Engine (<https://appengine.google.com/>) detto anche GAE
- | Windows Azure Platform (<http://www.microsoft.com/windowsazure/>)
- | Force (<http://www.salesforce.com/platform/>)
- | Oracle Fusion Middleware (<http://www.oracle.com/it/products/middleware/index.html>)
- | Eccentex AppBase (<http://www.eccentex.com/platform/features.html>)
- | 3Tera AppLogic (<http://www.ca.com/us/cloud-platform.aspx>)



Service Model	PaaS											
Platform Feature	SalesForce Force.com	Red Hat OpenShift	Rackspace Cloud Sites	Microsoft Windows Azure	Jelastic	Heroku	Google App Engine	Cumulogic	Cloudify	CloudFoundry	CloudBees	AMS Elastic Beanstalk
Tecnologie	Java, .NET, Ruby, PHP, Python, Perl, Adobe Flex e AIR	Java, Java EE, Python, Perl, PHP, Ruby	PHP, ASP, .NET	C#, Java, PHP, Ruby	Java	Ruby	Java, Python	Java, Spring	Java, .NET, Groovy, Ruby, C++, Node.js, Spring (more soon)	Java Spring, Groovy Grails, Ruby Rails Sinatra, Node.js	Java	Java
Cloud hosting		Multi IaaS Provider (AWS, etc.)	Multi-tenant PaaS				Amazon EC2, OpenStack, CloudStack, EucaLypTus, VMware vSphere	deploy su qualsiasi IaaS e BYON (bring-your-own-nodes)				AWS Cloud
Content Delivery Network (CDN)			Rackspace Cloud Files/Akamai									
Repositories		Git, SSH, rsync	FTP/S		Maven, Git, SVN		Git, SVN	Git	Git	Git	Maven, Git, SVN	
Databases	SOQL, SOSL	MySQL, MongoDB, MemBase, Memcache	MySQL 5 & MS SQL Server 2008		Maria DB, MySQL, PostgreSQL, MongoDB, CouchDB	Amazon RDS (MySQL), MongoDB, Redis, CouchDB	Google Cloud SQL	MySQL, MySQL cluster, MongoDB	Cassandra, MongoDB, MySQL, HSOL	MongoDB, MySQL, Redis	MySQL	
APIs	REST	REST	object storage/CDN	REST			JDBC, DB-API	REST	CLI, REST, Web	CLI	REST, CLI	
Dashboard/Console centralizzata		x	x		x			x	x		x	



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- | ICARO project



Software as a Service (SaaS)

- | **erogazione di servizi** applicativi accessibili indipendentemente dalla collocazione e dal tipo di device utilizzato.
- | **Non sono eseguite** applicazioni del cliente
 - ♣ il cliente paga il diritto (mediante licenza o canone di affitto) di utilizzo di un'applicazione messa a disposizione dal provider, senza preoccuparsi di come essa venga realizzata e gestita nel cloud.
- | Il cliente deve scegliere la corretta applicazione che soddisfi le sue necessità
- | Salesforce.com Customer Relationship Management (CRM) è un esempio di soluzione in cui il software è venduto in modalità as a service.





Architetture SaaS

- | **Interfacce esterne**
- | **L'insieme di API**, rappresentano i metodi con cui le applicazioni possono venir relazionate con altri servizi o software,
 - ♣ Cloud support for mobile, come Apple
 - ♣ Push service come Apple
- | **Middleware** è lo strumento che permette all'applicazione di sfruttare tutti i servizi e le risorse di livello più basso
- | **Ci puo' essere un Business Producer** per effettuare il deploy automatizzato di Software a servizio.
 - ♣ Tali soluzioni devono tenere conto dello sviluppo dei programmatori e delle SLA (con i corrispondenti parametri di consumo da monitorare).



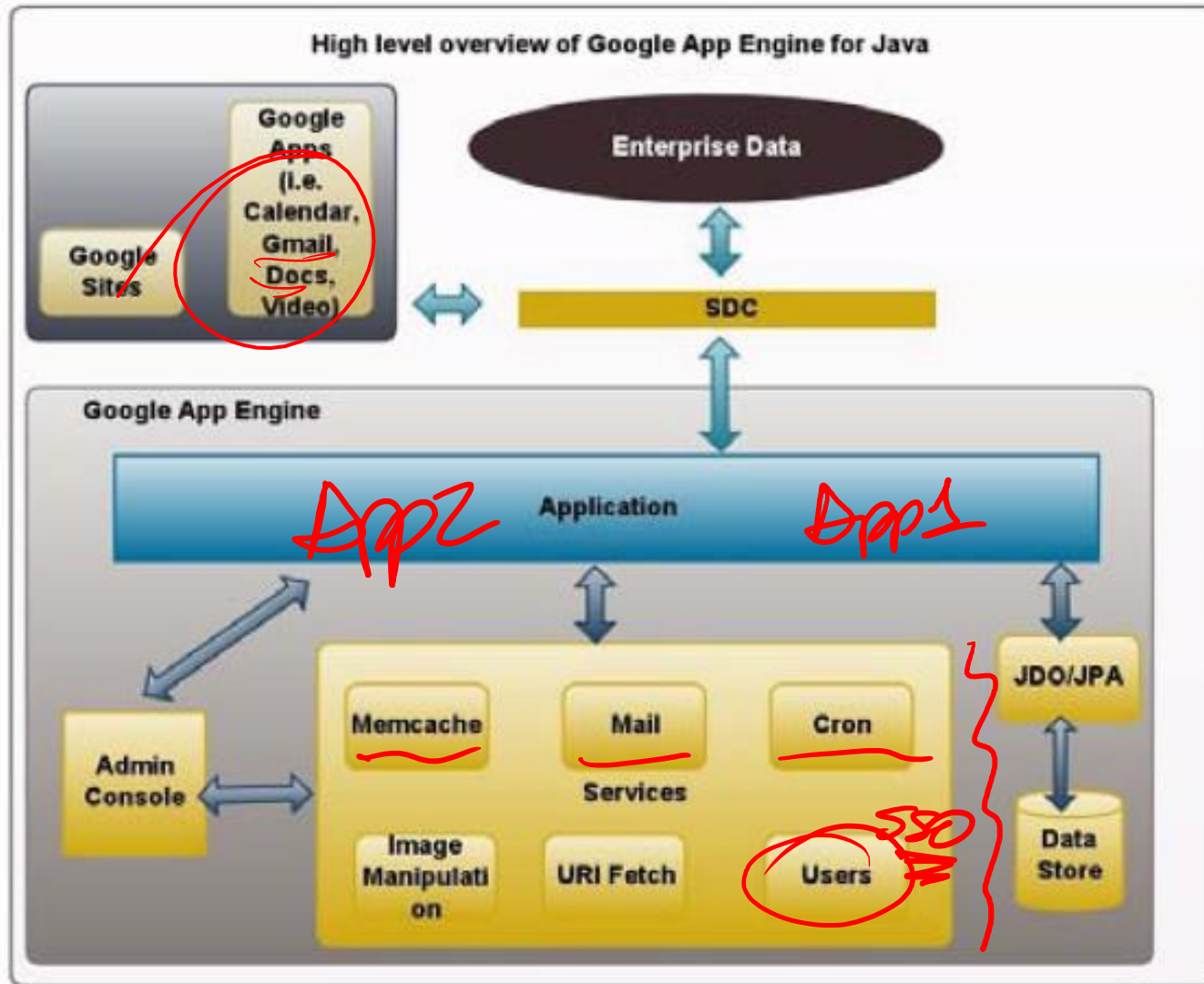
Soluzioni SaaS

- | **Google Apps** (Google) - Google offre gratuitamente ai privati i propri servizi applicativi come:
 - ♣ Google Documents, GMail, Calendars, Sites.
- | **Oracle CRM On Demand** in grado di supportare tipologie di offerta sia in multi tenancy sia in single tenancy
- | **SalesForce.com** (Salesforce) - Customer Relationship Manager.
- | **Zoho Office** (Zoho) - Propone un insieme di applicazioni mirate alle aziende. Il portfolio di servizi prevede più di 20 applicazioni tra cui ad esempio posta elettronica, office app CRM
- | **IBM LotusLive** (IBM) - Consiste di una raccolta di soluzioni di collaborazione aziendale online e servizi di social networking.

MS 365



GAP: Google App Engine



User Page



GAP: Google App Engine

- | **Datastore:** un database non relazionale distribuito e scalabile, accessibile attraverso un set di API e gestibile attraverso il pannello di controllo dell'applicazione. Il servizio di base su BigTable, un sistema proprietario per l'archiviazione di dati strutturati.
- | **Google accounts:** un set di API che permette l'autenticazione di utenti attraverso account Google.
- | **URL Fetch:** API che permette di ricavare risorse sul web.
- | **Mail:** API che permette l'invio di e-mail.
- | **Memcache:** sistema di caching di tipo chiave-valore. I contenuti di tale cache sono condivisi tra le varie istanze in esecuzione dell'applicazione.
- | **Image manipulation:** API utilizzabile per la manipolazione di immagini.
- | **Tasks:** Lo sviluppatore ha inoltre la possibilità di schedare task secondo determinati orari o utilizzare una coda di task per permettere alla propria applicazione di eseguire delle operazioni di background mentre delle richieste web vengono servite.

Service Model	SaaS					
Software	Aplicor	NetSuite	Microsoft Dynamics	RightNow	Salesforce .com	
Feature						
Campaign Management	X	X	X	X	X	
Lead management	X	X	X	X	X	
Event Management	X			X		
Pay Per Click (PPC) integration	X	X			X	
E-mail con trackable link e click-through	X	X	X	X	X	
Account Management	X	X	X	X	X	
Contact Management	X	X	X	X	X	
Opportunity Management	X	X	X	X	X	
Competitive Intelligence	X					
Sales Analytics	X	X	X	X	X	
Data Deduplication		X				
Ticket/case/incident management	X	X	X	X	X	
Email to case creation	X			X	X	
Routing	X	X	X	X	X	
Escalation	X	X	X	X	X	
Customer Surveys	X	X		X	X	
Knowledge base	X	X		X		
Self Service Portal	X	X	X	X	X	
Dashboard	X	X	X	X	X	
Ad Hoc Report Writer	X	X	X	X	X	
Data Warehouses	X				X	
OLAP	X		X		X	
Groupware Integration	X	X	X	X	X	
Partner relationship management	X	X		X		
E-commerce Suite		X				
Sales Order Processing	X	X				
Workflow Designer	X			X		
Offline Edition	X	X			X	
Enterprise Resource Planning	X	X	X			
Certifications	ISO, NIST	SAS70			SAS70	
SLA with Guarantee	X					



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iCaro

x Cloud Service Provider

Paolo Nesi (UNIFI, DISIT Lab)

Feb 2015



COMPUTER
GROSS



UNIVERSITÀ
DEGLI STUDI
FIRENZE
DINFO
DIPARTIMENTO
INFORMAZIONE
E COMUNICAZIONE





❑ IaaS, Infrastructure as a Service:

- ❑ **Business:** vendita di host a consumo
- ❑ **Gestione:** limitata al parco degli Host → **vari Gestori**
- ❑ **Monitoraggio** delle risorse → varie soluzioni di monitoraggio per gli utenti finali e per l'amministratore,
 - ❑ spesso integrate con il Gestore
 - ❑ configurazione di monitoraggio automatizzabile
 - ❑ ~~Dati di monitoraggio accessibili via API del Gestore~~
- ❑ **Costi di gestione:**
 - ❑ ~~accettabili~~ con una buona automazione se mono datacenter con Gestore monomarca, etc.. Altrimenti I costi salgono...
 - ❑ Difficili da gestire se vi sono aspetti di contrattuali stringenti da tenere sotto controllo



Contesto PaaS

❑ PaaS, Platform as a Service:

- ❑ **Business:** vendita di VM a consumo .. *Platform*
- ❑ **Gestione** di template con sistemi operativi → vari Gestori
- ❑ **Monitoraggio** delle risorse → varie soluzioni di monitoraggio,
 - ❑ spesso non molto connesse con il vostro cliente finale
 - ❑ Difficile automazione della soluzione di monitoraggio, ma possibile
 - ❑ Dati di monitoraggio accessibili via API delle piattaforme o tramite il sistema di monitoraggio
- ❑ **Costi di gestione:**
 - ❑ **accettabili** con una discreta automazione se mono datacenter e gestore monomarca, etc..
 - ❑ Non trascurabili quando vi sono aspetti di contrattuali stringenti da tenere sotto controllo





❑ SaaS: Software as a Service

❑ Business:

- ❑ vendita a consumo di soluzioni software di terzi:
 - ❑ tipicamente software con licenze standard, mensili o annuali
 - ❑ a consumo significa anche con licenze specifiche: numero di utenti, numero di fatture, etc.
- ❑ COME: Applicazioni singola VM FINO A configurazioni Multi-tier complesse
 - ❑ Le semplici applicazioni a singola VM sono vendibili con svariate configurazioni, l'uso di template è molto limitato
 - ❑ Le configurazioni complesse possono avere decine di servizi, connessioni virtuali, aspetti contrattuali complessi, spesso customizzazioni rilevanti, etc....
 - ❑ Le configurazioni two tier, sono in numero elevato e costo molto in configurazione

❑ Gestori: in questo caso sono soluzioni che

- ❑ **Aiutano** a predisporre le applicazioni in modo che possano essere gestite in modo semplice: questi vanno da quelli che fanno tutto a quelli che definiscono linee guida complesse che solo tramite una programmazione spinta permettono di automatizzare il processo, anche tramite vari step a mano
- ❑ **Allocano** (deploy) e configurano le applicazioni software in modo automatico nel cloud in base a varie pattern. Questi gestori permettono di definire delle procedure di deploy (workflow) anche con parametri, in alcuni casi hanno un sistema di monitoraggio integrato anche se non sofisticato.



❑ SaaS: Software as a Service (continua)

❑ Monitoraggio: soluzioni che dovrebbero permettere di

- ❑ **controllare** non solo il consumo delle risorse a livello IaaS, PaaS ma anche gli aspetti SaaS dell'Applicazioni a consumo, per esempio le relazioni, i servizi interni, etc..
- ❑ **Automatizzare** la configurazione del sistema di monitoraggio: sia per singole che VM che per business complessi con varie VM e Servizi collegati
 - ❑ **Definire** delle metriche di alto livello che possano mostrare il vero comportamento del sistema
 - ❑ **Valutarle** in modo automatico valori collegati al contratto
- ❑ **Esportare** i dati di monitoraggio verso gli amministratori e anche verso i clienti finali

❑ Costi di gestione: molto elevati se vengono svolte a mano le:

- ❑ operazioni di configurazione, allocazione e deploy su cloud
- ❑ operazioni di configurazione del monitoraggio: basso e alto livello, connessione fra ogni singola metrica e il contratto
- ❑ valutazioni sui cambi di configurazione, connessione fra ogni singola metrica e il contratto
- ❑ riconfigurazioni sulla base di valutazioni complesse e strategie non formalizzate
- ❑ ...



Obiettivi di ICARO

- ❑ **Ridurre i costi di gestione** in caso di configurazioni complesse: IaaS, PaaS, SaaS, PBaaS, automatizzando i processi di
 - ❑ **Vendita delle soluzioni su cloud**
 - ❑ **Configurazioni integrate: IaaS, PaaS, SaaS, PBaaS**
 - ❑ **Config e Deploy di applicazioni complesse, multitenant ...**
 - ❑ **Config e gestione di soluzioni di monitoraggio a livello di metriche integrate per aspetti: IaaS, PaaS, SaaS, PBaaS, business, SLA**
 - ❑ **Controllo e monitoraggio dei sistemi, Business Level, SLA level**
 - ❑ **Ri-configurazione sulla base della valutazione di condizioni complesse**
- ❑ Le soluzioni **Cloud attuali** sono spesso:
 - ❑ *rigide, provocano inerzie notevoli all'adattamento rispetto a nuove esigenze, ad incrementi di carico/mercato, etc.*
- ❑ **ICARO ha inteso sviluppare soluzioni per avere:**
 - ❑ *Ridurre i costi e fornire maggiore flessibilità sul Cloud*
 - ❑ *Adattare il loro parco software alle nuove esigenze*
 - ❑ *Fornire servizi a consumo: Business Process as a Service, BPaaS*



Obiettivi Tecnici, overview

- ❑ modello descrittivo per servizi e applicazioni
- ❑ sistema automatico di configurazione
- ❑ reasoner che prendere decisioni su configurazioni: consistenza e completezza
- ❑ soluzione di produzione del business, config automatica
- ❑ motore di intelligence per il cloud
- ❑ algoritmi per il monitoraggio del comportamento di servizi e applicazioni: IaaS, PaaS, SaaS,...
- ❑ soluzione PaaS di tipo evoluto → SaaS
- ❑ algoritmi per la valutazione di modelli di costo e di business
- ❑ adeguamento dell'architettura su alcune applicazioni
- ❑ algoritmi di ottimizzazione della gestione del cloud

KEPT



Cloud Orchestration

- ❑ *the ability to instantly manage, automate and streamline all elements of a cloud platform including the management of physical and virtual resources*
- Una piattaforma di orchestrazione consente ai cloud service provider di separare le risorse virtuali da quelle fisiche
- Attraverso il software, il cliente è in grado di riconfigurare un server in pochi minuti
- Se un progetto è finito o in pausa, il server può essere usato per altri compiti
- Attraverso un pannello di controllo o un API il cliente accende/spenge quello che desidera, e il software fa il resto



- **Orchestration:** è un concetto fondamentale del Cloud Computing, spesso confuso con quello di *Automation*
- L'automazione non basta
- Diventa necessario orchestrare i processi
 - si mettono assieme i vari aspetti della gestione del cloud
 - semplificare la gestione dell'automazione e trovare un bilanciamento per gestire hypervisor, l'utilizzazione delle risorse, disponibilità, scalabilità, prestazioni, sulla base dei requisiti business, con l'intento di fornire servizi velocemente e in modo efficace
 - Gestire workload tramite un'interfaccia singola, in modo da garantire efficienza, controllo e scalabilità
 - Identifica i task automatici che compongono un processo e ne assicura la riusabilità all'interno delle operazioni
 - Semplifica la produzione, il provisioning, il de-provisioning
 - Permette di non fare azioni ripetitive manualmente

Orchestration vs Automation

	Automation	Orchestration
Numero di task coinvolti	Riguarda un singolo task	Combina i singoli task in processi
Pre-requisiti per le prestazioni	I task automatici devono essere eseguiti in sequenza, in accordo alle linee guida sulla sicurezza, con gli opportuni permessi	L'orchestration assicura le prestazioni di ciascuno dei task automatici in un ordine definito, all'interno del workflow
Error-proneness (propensione all'errore)	Richiede molto lavoro di coding, con il rischio di errori nell'esecuzione manuale dei comandi	Elimina gli errori ottimizzando la quantità di codice richiesto. Riutilizza i blocchi di codice in modo da eliminare le ridondanze
Utilizzazione delle risorse	I task automatici esistono come entità autonome, e quindi sfruttano le risorse indipendentemente: spreco delle risorse	Enumera le risorse, IAM (Identity and Access Management) roles, i tipi di istanze, ecc. in modo da ridurre i tempi e fornire risultati più precisi
Esempio	Avviare o configurare un web server	Combina i task automatici in un singolo workflow in modo da soddisfare le richieste

Orchestration

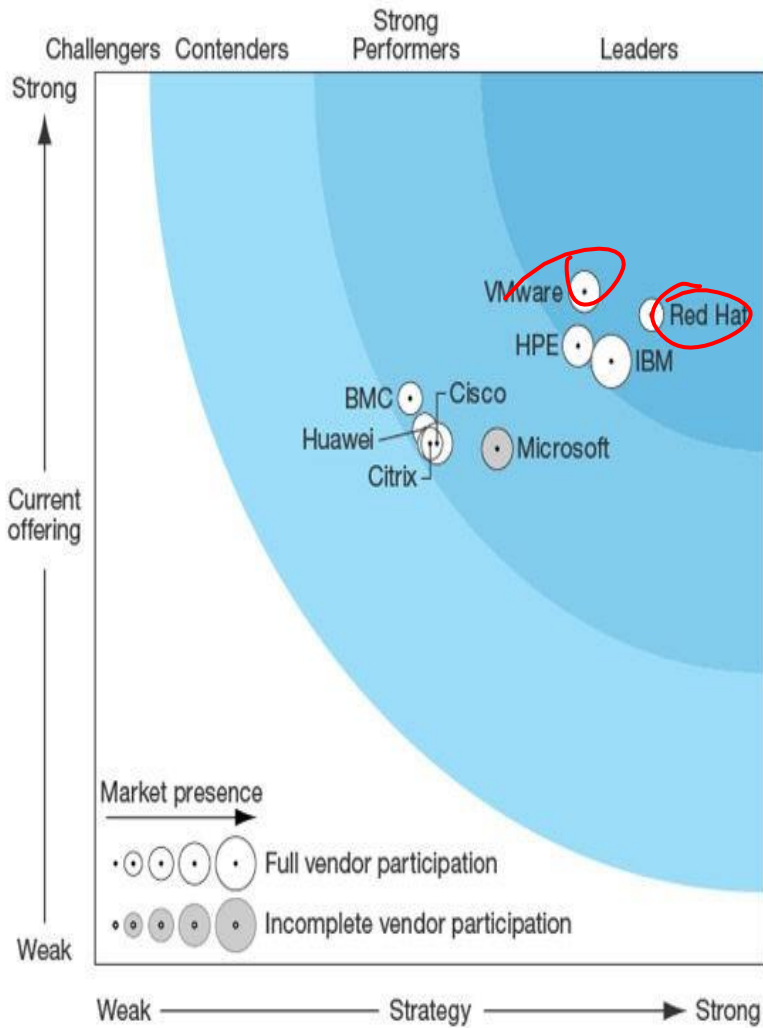
**Cloud Orchestration =
Automation + Integration
+ Best Practices**

Automation = automazione di specifici task

Orchestration = automazione di processi e workflow

Reference

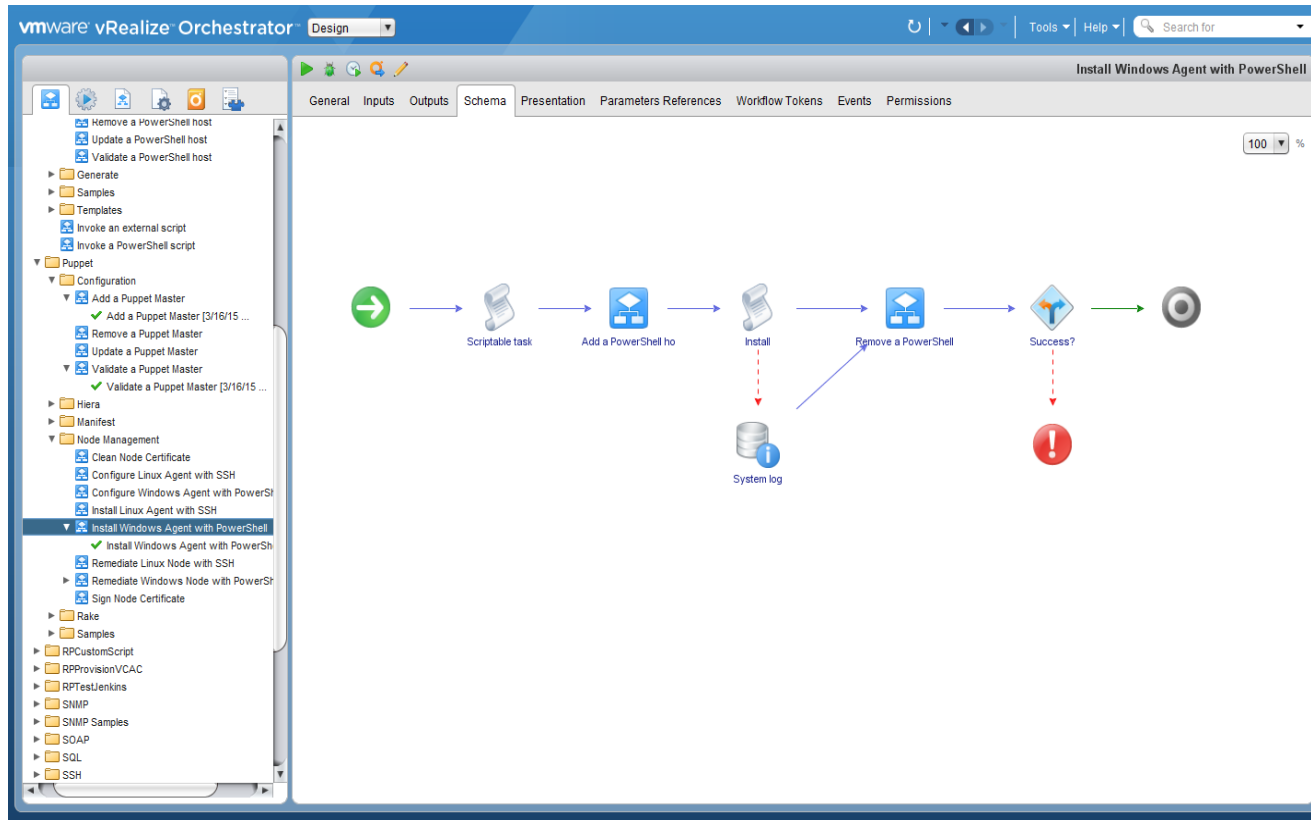
Mercato



- *In pochi anni sono state sviluppate centinaia di soluzioni per il cloud management (e molte specificamente per l'orchestrazione dei processi cloud)*
- *Però i cloud leader (quelli che si dividono la fetta maggiore del mercato) sono pochi*

vRealize: workflow schema

Workflow Schema, è una rappresentazione grafica che mostra il workflow come un diagramma che interconnette gli elementi del workflow. È l'elemento più importante di un workflow perché ne determina la logica



vmware®

vRealize: workflow schema elements



Start Workflow, il punto di inizio del workflow. Tutti i workflow contengono questo elemento (e soltanto uno). Ha un output e nessun input e non può essere ri **vmware** lo schema.



Scriptable task, task di tipo generale per la scrittura di funzioni Javascript.



Decision, una funzione booleana. Riceve un input e restituisce true/false. Il tipo di decisione che l'elemento prende dipende dal tipo di input parameter, e condiziona la direzione del flusso che il workflow prende.



Custom decision, una funziona booleana. Riceve diversi input e li processa in accordo allo script definito restituendo true/false.



Decision activity, una funzione booleana. Esegue un workflow e collega i suoi output parameter a un percorso true/false.



User Interaction, consente agli utenti di passare nuovi parametri di input al workflow. Permette di definire il modo in cui i presentare la richiesta bloccante di parametri di input e impostare vincoli (e.g., range, timeout). Consente di impostare permessi in modo da definire quali utenti possono impostare i parametri.

vRealize: workflow schema elements



Waiting timer, utilizzato per workflow che richiedono tempi di esecuzione lunghi. Quando il workflow arriva al waiting timer entra in stato di attesa. Si può impostare una data alla quale il workflow riprende l'esecuzione. Mentre è in attesa della data, il workflow è nello stato *waiting-signal*.



Waiting event, utilizzato per workflow che richiedono tempi di esecuzione lunghi. Quando il workflow arriva al waiting event entra in stato di attesa. Si può definire un trigger event che il workflow si aspetta per poter riprendere l'esecuzione. Mentre è in attesa dell'evento il workflow è nello stato *waiting-signal*.



End workflow, il punto finale di un workflow. Si possono avere end workflow multipli in uno schema, che rappresentano le possibili uscite prodotte da esso. Hanno un input e nessun output.



Thrown exception, crea un'eccezione e ferma il workflow. Può comparire molte volte in un workflow. Ha un parametro di input (solo di tipo String) e nessun output. Quando il workflow raggiunge un elemento Exception entra nello stato *failed*.

vRealize: workflow schema elements

vmware®



Workflow note, consente di annotare le varie sezioni di un workflow.



Action element, invoca un'azione dalla libreria delle azioni dell'Orchestrator. Quando il workflow raggiunge questo element esegue l'azione.



Workflow element, avvia un workflow in modo sincrono. Il workflow originario continua la sua esecuzione solo dopo che è completata quella del workflow invocato.



Foreach element, esegue un workflow da ogni elemento di un array. Per esempio, si può eseguire un'operazione di rename di tutte le Virtual Machine di una cartella.



Asynchronous workflow, avvia un workflow in modo asincrono. Il workflow originario non attende il completamento dell'esecuzione di quello invocato, ma continua la sua esecuzione.

vRealize: workflow schema elements



Schedule workflow, crea un task per eseguire il workflow a un tempo prestabilito e poi il workflow continua la sua esecuzione.



Nested workflows, esegue workflow multipli simultaneamente. Si può scegliere di annidare workflow locali o remoti, cioè che risiedono su differenti Orchestrator server. Si possono eseguire workflow con differenti credenziali. Il workflow attende il completamento di tutti i workflow prima di riprendere la sua esecuzione.



Handle error, gestisce gli errori per uno specifico elemento del workflow. Il workflow può gestire l'errore creando un exception, chiamando un altro workflow, o eseguendo uno script.



Default error handler, gestisce gli errori del workflow che non sono gestiti dallo standard error handler.



Switch, commuta verso workflow alternativi, sulla base di un parametro o di un attributo.

Chef

Chef, è un potente strumento di *configuration management* per la gestione di infrastrutture attraverso il codice. Automatizza la configurazione, il deploy, e la gestione delle applicazioni

- Utilizza *cookbook* per determinare come ogni nodo deve essere configurato
- Un cookbook consiste di molte “ricette” (recipe); una ricetta è uno script di automazione per un particolare servizio scritto in Ruby
- *Chef Client*, è un agent che gira su un nodo ed esegue i task che lo configurano
- Chef può gestire qualunque cosa può eseguire un client Chef (macchine fisiche, container, istanze cloud-based)
- *Chef server*, è il repository per tutti i dati di configurazione. Sia il client che il server Chef comunicano in modo sicuro, utilizzando una combinazione di chiavi pubbliche e private, che assicurano che il server risponda soltanto alle richieste del client

Chef

- Facile da installare (utilizza un third-party installer)
- È utilizzato particolarmente per l'automazione a livello OS, come il deploy dei server, l'applicazione di patch
- Richiede esperienza di programmazione
- Ha una curva di apprendimento molto ripida, una volta superata la quale offre potenza e flessibilità

Puppet

Puppet, è simile a Chef. Richiede l'installazione di un master server e un client agent nei nodi

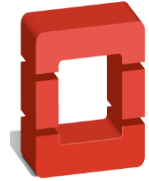
- Si possono scaricare e installare i moduli necessary tramite comandi Puppet. Come Chef, offre una versione enterprise che consente di avere funzionalità aggiuntive
- Chef e Puppet svolgono le stesse funzioni di base, ma utilizzano un approccio differente. Chef è un sistema più integrato e monolitico, mentre Puppet consiste di diversi servizi. Questo rende Chef in un certo senso più facile da configurare e gestire
- È pensato per gli amministratori di sistema che necessitano di specificare configurazioni come dipendenze, mentre Chef è fatto per gli sviluppatori che scrivono il codice per il deploy
- Dipende fortemente dal proprio Domain Specific Language (DSL) per la definizione di regole di configurazione, mentre il DSL di Chef è solo un “supplemento” a Ruby, linguaggio utilizzato per le ricette Chef
- È utilizzato per la mid-level automation (e.g., installare database, avviare Apache)

OpenStack



- *OpenStack*, è una piattaforma di cloud computing open source (licenza Apache), utilizzata principalmente come soluzione Infrastructure as a service (IaaS)
- Consiste in una serie di progetti interconnessi che controllano insieme di risorse di processing, storage, rete, attraverso un data center
- Gli utenti gestiscono le risorse attraverso una dashboard web-based, strumenti a riga di comando, oppure API RESTful
- È un progetto congiunto iniziato nel 2010 fra Rackspace Hosting e NASA. È gestito dalla OpenStack Foundation (organizzazione no-profit). Ne fanno parte più di 200 aziende (e.g., IBM, Canonical, Cisco, Dell, EMC, Ericsson, Hewlett-Packard, Huawei, Intel, Mellanox, Mirantis, Oracle, Red Hat, SUSE Linux, VMware, Yahoo)
- I componenti principali sono: Nova (compute), Cinder (block storage), Glance (image library), Swift (object storage), Neutron (network), Keystone (identity), Heat (orchestration tool)

OpenStack (Heat)



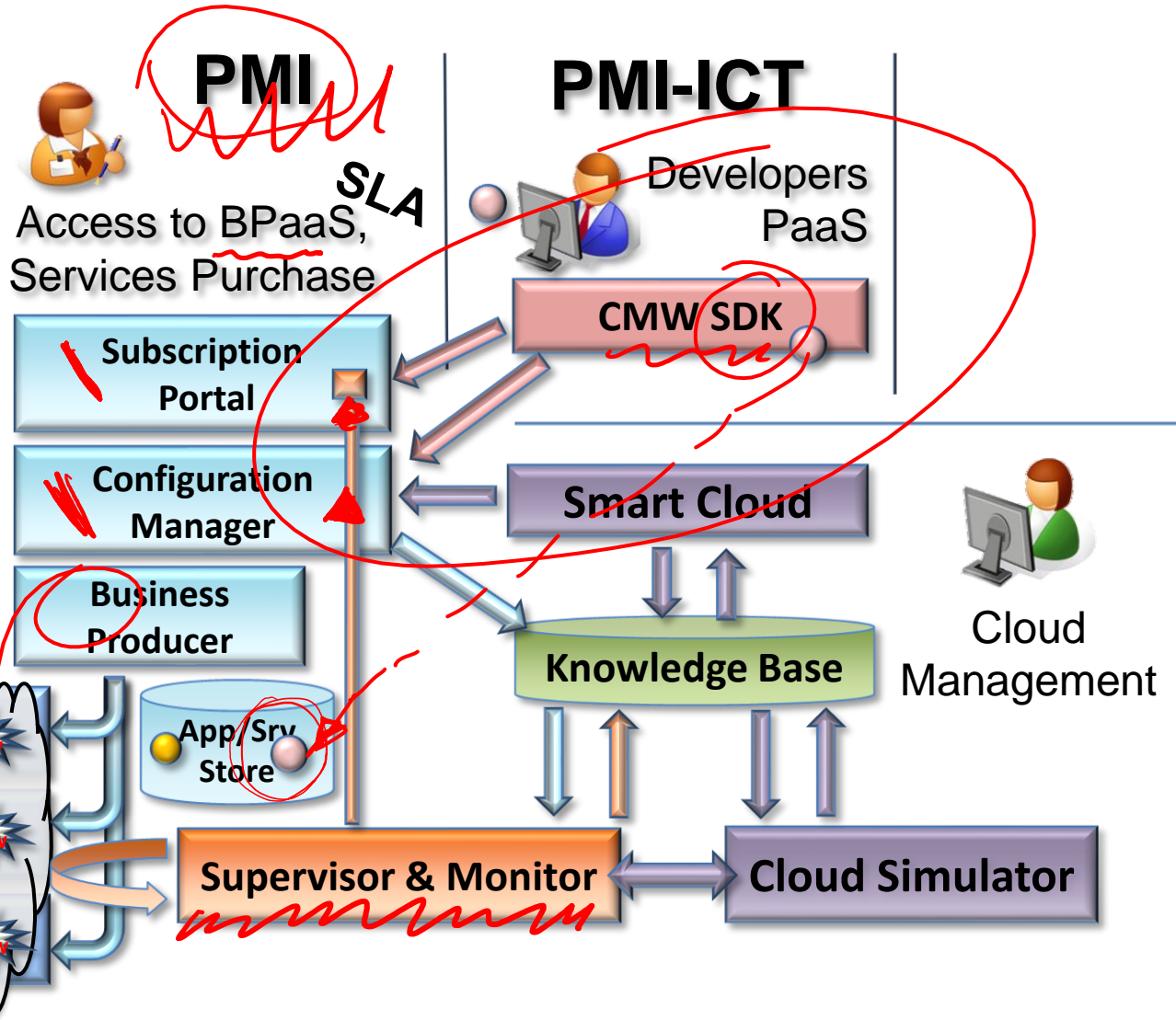
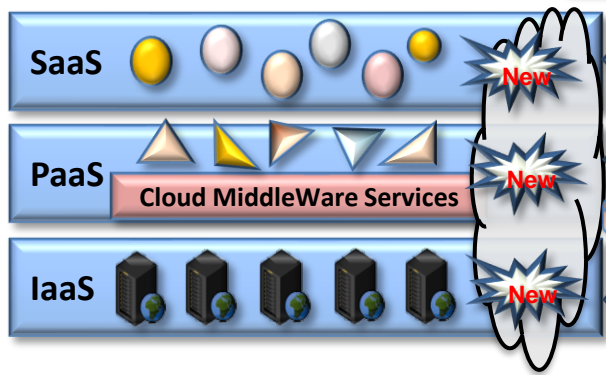
- *Heat*, è un meccanismo di orchestrazione conosciuto come progetto *Orchestration for OpenStack on OpenStack (OOO)*.
- Fornisce un'orchestrazione basata su template per descrivere un'applicazione cloud tramite l'esecuzione di appropriate chiamate alle API OpenStack, che generano applicazioni nel cloud
- Integra altri componenti core di OpenStack in un template
- I template consentono la creazione della maggior parte dei tipi di risorse OpenStack (*instances, floating IPs, volume, security group, user*) così come funzionalità più avanzate come *instance high availability, instance autoscaling, nested stack*
- Alternativo alla scrittura di uno script per la gestione delle risorse in OpenStack (setting up dei server, aggiunta volumi, gestione reti, ecc.)
 - Si crea un Heat template che specifica l'infrastruttura richiesta
 - In caso di cambiamenti futuri al servizio si può modificare il template Heat e l'engine di Heat farà i cambiamenti necessari quando il template verrà rieseguito



Architettura ICARO

Utenza Finale

Application Access on
iCaro cloud

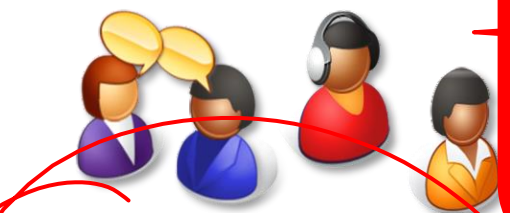




Architettura ICARO

Utenza Finale

Application Access on
iCaro cloud



PMI
 Access to BPaaS,
 Services Purchase

SLA

Subscription Portal
 Configuration Manager
 Business Producer

PMI-ICT
 Developers
 PaaS

CMW SDK

Smart Cloud
 Knowledge Base
 Cloud Management

SaaS
 PaaS
 Cloud MiddleWare Services
 IaaS

New

App/Srv Store
 Supervisor & Monitor
 Cloud Simulator



Subscription Portal

- ❑ Interfaccia di **vendita di soluzioni a consumo**, che possono andare da Host, Macchine Virtuali, applicazioni e combinazioni complesse.
 - ❑ Svariate possibili configurazioni di applicazioni: ERP, CRM, etc.,
- ❑ **Soluzioni offerte con varie tipologie di contratti di servizio** (Service Level Agreement, SLA) e relativi parametri per il calcolo dei costi a consumo: rete, disco, fatture, email, etc.
- ❑ **produzione automatica dei pattern/configurazioni** complesse composte da: VM, applicazioni Web e non solo, servizi sulla base di buone pratiche, profiling, applicazioni legacy, e servizi per connessione con applicazioni on site remote, etc.
- ❑ **Il Business Producer:**
 - ❑ evoluzione dei tradizionali orchestrator, che tramite workflow permettono di eseguire la procedura di deploy delle applicazioni sul Cloud.
 - ❑ lavora con VCO VMware,
 - ❑ può essere esteso ad altre soluzioni di mercato.



Subscription Portal

iCaro Portal
La piattaforma cloud per l'accelerazione del business delle PMI toscane

Home Offerta I Miei Servizi Partners

AREA RIVENDITORI
Benvenuto andreaschechi
LOGOUT »

Applicazione LAMP
Con questo servizio puoi attivare un sito di commercio elettronico basato su Magento o PrestaShop, oppure un CMS Drupal, un CRM VTiger o l'applicazione Ines as a Service

Una tantum	€ 180,00	Al mese	€ 78,00
Ricorrenza	Codice	Descrizione	Quantità Prz. Unitario Totale
Una tantum	MCCLSWIM-ATT	My Virtual Server Intel Start-up	1 € 180,00 € 180,00
Al mese	MCCLSWIM	My Virtual Server Intel 1Gb Ram incluso Licenza Windows Server	1 € 21,00 € 21,00
Al mese	MCCLSWIM-1GBRAM	My Virtual Server Intel 1Gb Ram aggiuntiva	2 € 15,00 € 30,00
Al mese	MCCLSWIM-1CPU	My Virtual Server Intel Virtual CPU aggiuntiva	1 € 15,00 € 15,00
Al mese	MCCLSAN1GB-CAP	My Space 1GB SAN per VM @High Capacity & Availability	120 € 0,10 € 12,00

ICARO

Home Offerta Control Panel Blog Launchers

Launchers / Generic Launcher

Login
Benvenuto UtenteX
Logout

Generic Deployment Portlet

JOOMLA

Joomla è uno strumento che permette la creazione e la pubblicazione di siti Internet dinamici, in maniera semplice e veloce, ma anche con grandi potenzialità e sicurezza. Un pannello di controllo ricco di icone e con grafica accattivante ti guida nell'inserimento dei contenuti e nella configurazione delle caratteristiche del sito, fra sondaggi e notizie, gallerie fotografiche, blog e molto altro. Tutte queste operazioni possono essere effettuate senza scrivere o modificare una riga di codice.

Media sessioni contemporanee:

Massimo sessioni contemporanee:

Dimensioni Storage File:

Domínio del sito:

e-mail amministratore:

Tempo medio di risposta atteso:

iCaro Subscription Portal Sign In

Home Offerta I Miei Servizi

Contratto	Servizio	Cod. Cliente	Nome Cliente	Data Richiesta	Data Consegna	Stato	
30257	Dummy Joomla Farm	CC001	Nome cliente	27/06/2014 12:45	27/06/2014 12:46	DEPLOYED	MON
30256	Dummy Joomla Farm	CC001	Nome cliente	27/06/2014 12:43	27/06/2014 12:43	DEPLOYED	MON
30255	Dummy Joomla Farm	CC001	Nome cliente	27/06/2014 12:42	27/06/2014 12:42	DEPLOYED	MON
30254	Dummy Joomla Farm	CC001	Nome cliente	27/06/2014 12:39	27/06/2014 12:39	DEPLOYED	MON
30253	Dummy Joomla Farm	CC001	Nome cliente	27/06/2014 12:37	27/06/2014 12:38	DEPLOYED	MON
30252	Dummy Joomla Farm	CC001	Nome cliente	27/06/2014 12:30	27/06/2014 12:30	DEPLOYED	MON
30251	Dummy Joomla Farm	CC001	Nome cliente	27/06/2014 12:28	27/06/2014 12:28	DEPLOYED	MON

Accesso al BPaaS



- ❑ Strumento tecnico per la **generazione e gestione automatizzata delle configurazioni**
- ❑ **Configurazioni e SLA complesse** con regole di adattamento che includono la gestione automatizzata delle operazioni di deploy e update sul cloud tramite Business Producer.
 - ❑ Business Producer può essere un cloud manager di mercato.
- ❑ **Il Configuration Manager, CM**
 - ❑ comunica le configurazioni e le SLA allo Smart Cloud che le verifica, e che eventualmente provvede a suggerire al CM eventuali modifiche ed adattamenti.
 - ❑ richiede grafici e dati al sistema di monitoraggio, S&M.



Configuration Manager

Backoffice del Business

System Overview Dashboard:

- Utilizzo Sistema:** CPU % (62), Mem. % (69), Banda % (96)
- Coda Lavori:**

Codice	Descrizione	Inizio	Stato
004	Workbook W004	13-12-2013 12:00:01	Completed
005	Workbook W005	13-12-2013 12:10:01	Completed
006	Workbook W006	13-12-2013 13:00:01	Completed
- Giornale Sistema:** Log of system events including GetServiceParameters, GetServiceFeatures, and LoadDashboard.
- Utilizzo CPU Servizi:** Bar chart showing CPU usage for various services (VDC01 to VDC07).

Service Configuration Interface (ServiceEdit):

URL: 10.254.101.217/CM/EditService?pServiceId=9

Fields:

- Provisioning Workflow ID: 283a09da-b2b1-4dd1-a208-c5745d86454d
- Deprovisioning Workflow ID: [Empty]
- Recupera button

N. Codice	Descrizione	Q.tà	Prezzo	Valuta	Caratteristiche
1	SW005 Joomla Farm Joomla Farm	1	1	EUR	<ul style="list-style-type: none"> Condizioni di vendita Prezzo unitario: 350 Valuta: EUR Tarifazione: FIXED

Parametri del servizio:

Nome	Parametro	Valore	Modifica	Elimina
nfsSize	Dimensioni Storage File (GB)	30	[Modifica]	[Elimina]
NFSVmlpAddress	NFS Fixed, valid IP Address		[Modifica]	[Elimina]
webFrontend	Nodi Front-End	1	[Modifica]	[Elimina]
dbSize	Dimensione Database Server	20	[Modifica]	[Elimina]
farmId	Identificativo della farm	MyFarm001	[Modifica]	[Elimina]
nfsVmlpAddress	IP della macchina virtuale	10.254.101.82	[Modifica]	[Elimina]
mysqlVmlpAddress	IP del DB MySQL	10.254.101.83	[Modifica]	[Elimina]
haproxyVmlpAddress	IP del proxy HA	10.254.101.84	[Modifica]	[Elimina]
joomlaWebVmlpAddress	IP della macchina Joomla	10.254.101.85	[Modifica]	[Elimina]
resourcePool	VMWare Resource Pool		[Modifica]	[Elimina]
haproxyPublicIpAddress	IP pubblico della macchina HA proxy	212.19.117.149	[Modifica]	[Elimina]
haproxyPublicSubnetMask	Subnet Mask relativa a IP pubblico di HA Proxy	255.255.255.240	[Modifica]	[Elimina]



- ❑ **produzione automatica dei pattern/configurazioni**
complesse composte da: VM, applicazioni Web e non solo, servizi sulla base di buone pratiche, profiling, applicazioni legacy, e servizi per connessione con applicazioni on site remote, etc.
 - ❑ Il Business producer è un'evoluzione dei tradizionali orchestrator, che tramite workflow permettono di eseguire la procedura di deploy delle applicazioni sul Cloud.
- ❑ **Il Business Producer:**
 - ❑ nella sperimentazione ICARO lavora con VCO VMware,
 - ❑ può essere esteso ad altre soluzioni di mercato.



Architettura ICARO

Utenza Finale

Application Access on
iCaro cloud



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Configuration Manager

Business Producer

PMI-ICT

Developers
PaaS

CMW SDK

code + workflow

Smart Cloud



Cloud Management

Knowledge Base

App/Srv Store

Supervisor & Monitor

Cloud Simulator

Cloud MiddleWare Services

New

New

New



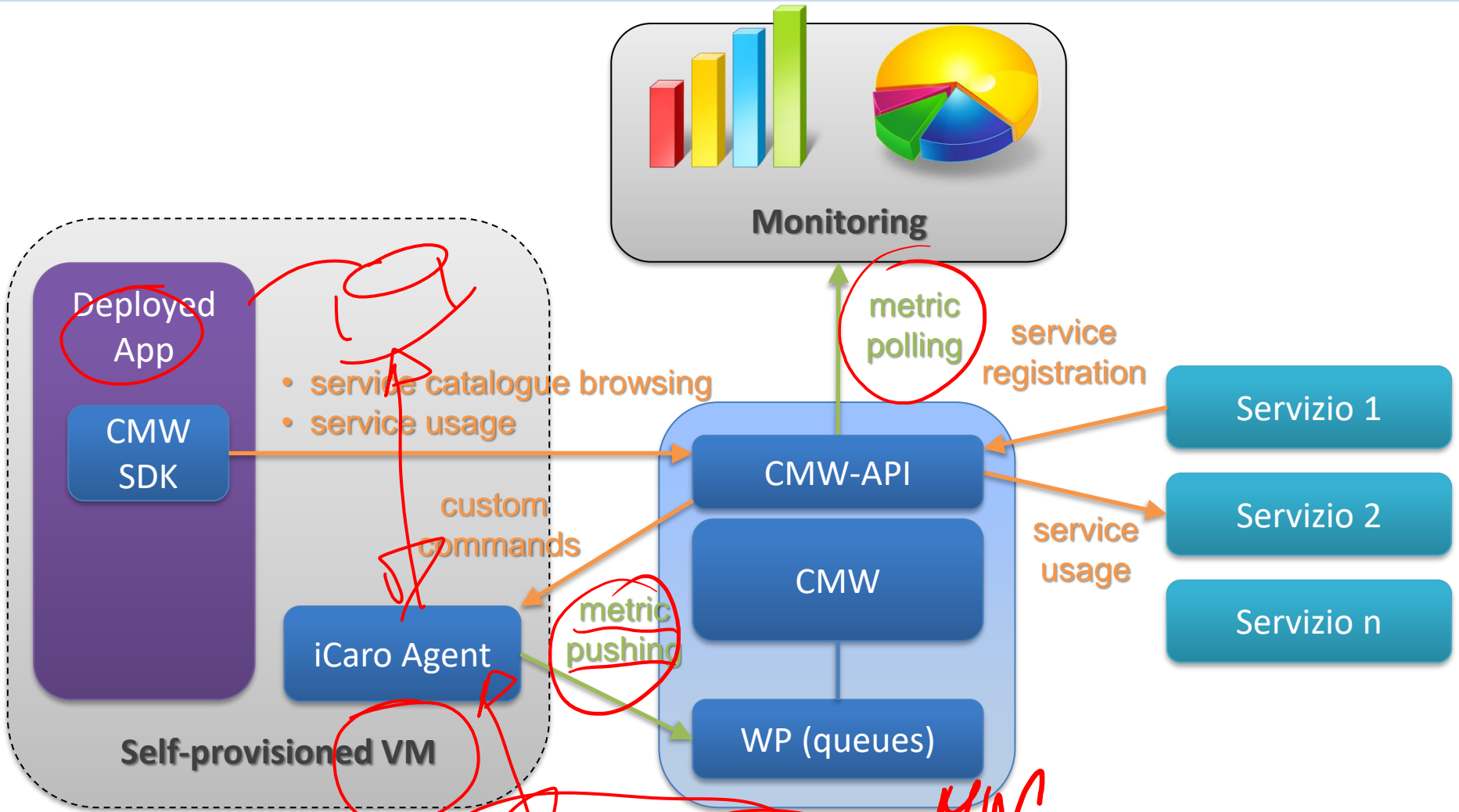
Cloud Middleware &

Cloud Middleware SDK

- ❑ **Supporto per lo sviluppo** (in Java e PHP) che consente a Sviluppatori di Applicazioni ICT di:
 - ❑ **Adattare le applicazioni** per essere gestite, vendute in ottica di consumo su ICARO.
 - ❑ utilizzare, mediante un sistema di messaggistica asincrona, uno o più servizi presenti nel catalogo gestito dal modulo CMW (es. postgresSQL, SQL Server, SMTP server, Object Storage).
 - ❑ recuperare i valori attuali delle "metriche applicative" inerenti i servizi offerti da CMW (es. dimensione di un database, numero mail inviate, ecc.).



CMW, CMW-SDK, WP: Architettura

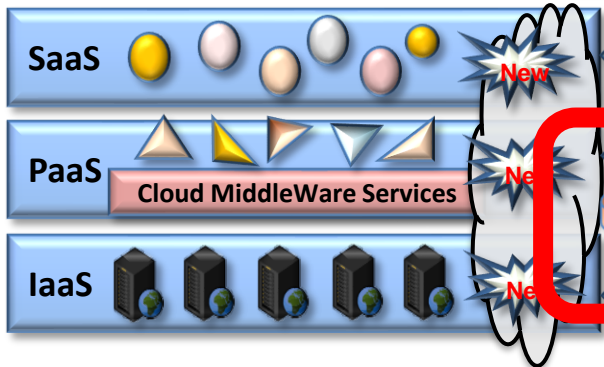




Architettura ICARO

Utenza Finale

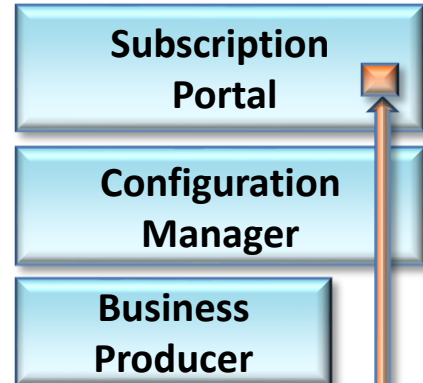
Application Access on
iCaro cloud



PMI

Access to BPaaS,
Services Purchase

SLA



PMI-ICT

Developers
PaaS



Cloud
Management



Supervisor & Monitor

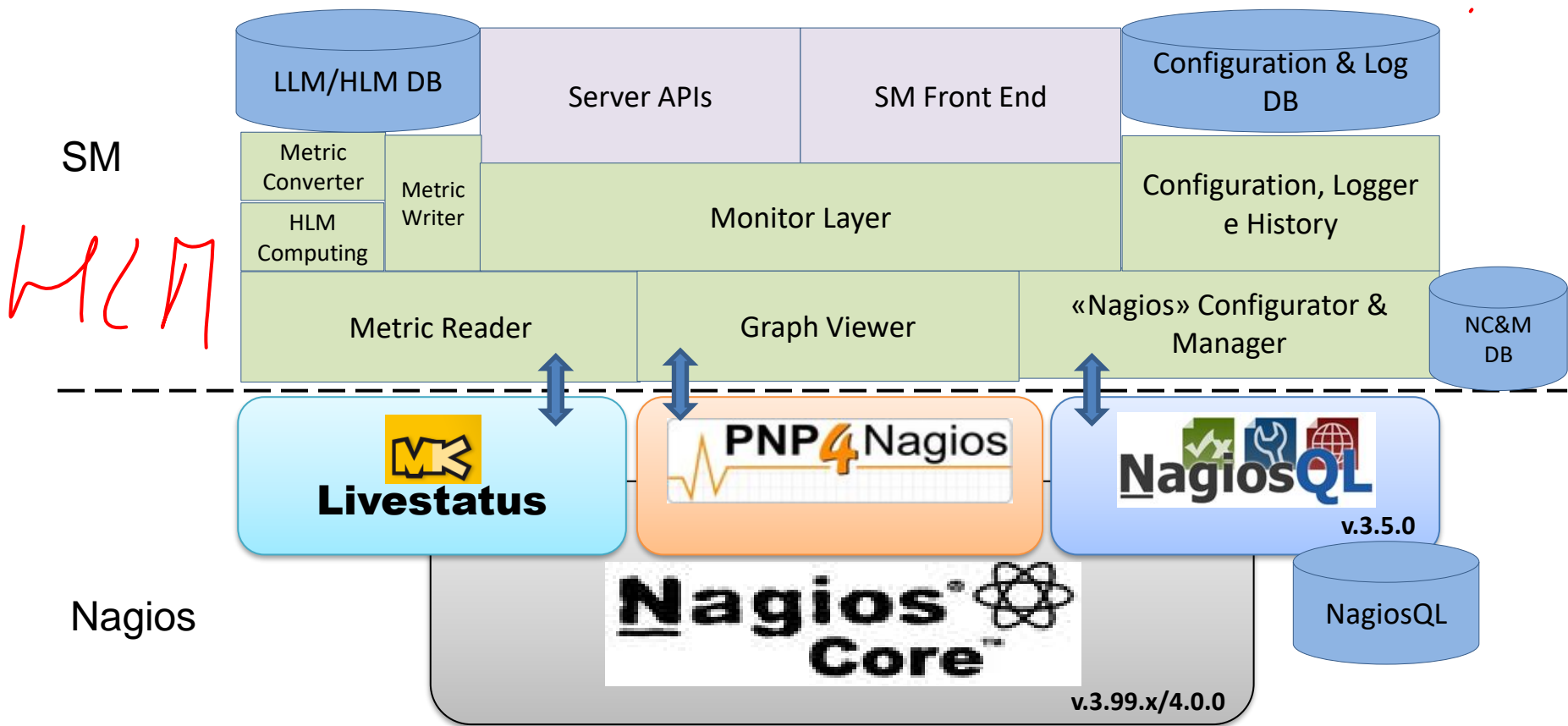
- ❑ **Supervisione e monitoraggio delle risorse e dei consumi in modo integrato analizzando e tenendo sotto controllo:**
 - ❑ risorse cloud ai livelli: IaaS, SaaS, PaaS, BPaaS,
 - ❑ metriche applicative di Applicazioni e Servizi single/multi-tier: standard e caricati tramite il PaaS;
 - ❑ metriche definite in relazione alle SLA;
 - ❑ servizi interni ed esterni anche locati in altri cloud e sistemi, come supervisione dello stato dei processi: http, ftp, reti, server esterni, Web App Server, etc.

- ❑ **Il Supervisor & Monitor:**
 - ❑ è configurato in modo automatico dalla Knowledge Base
 - ❑ in ICARO utilizza il tool Nagios ed è in grado di controllare e configurare Nagios in modo automatizzato e di accedere in remoto alle funzionalità dei suoi componenti
 - ❑ Livello di astrazione del monitoraggio: possibilità di utilizzare differenti sistemi di monitoraggio di basso livello

WORKFLOW
↳ Self Monitor

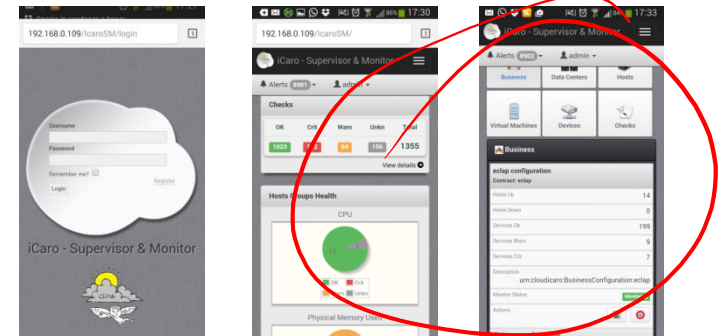
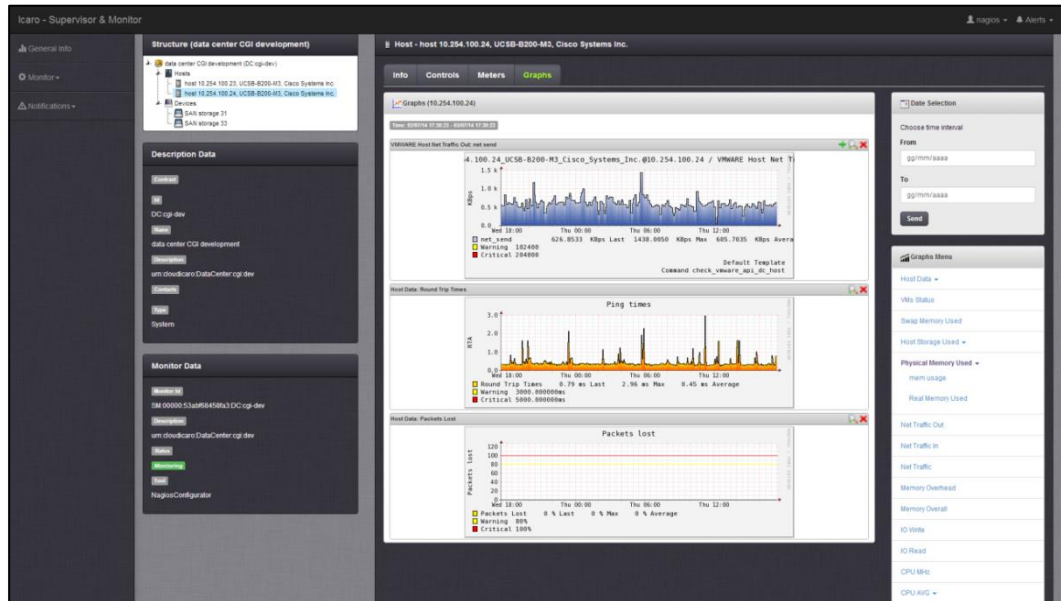


SM – Architettura & Nagios

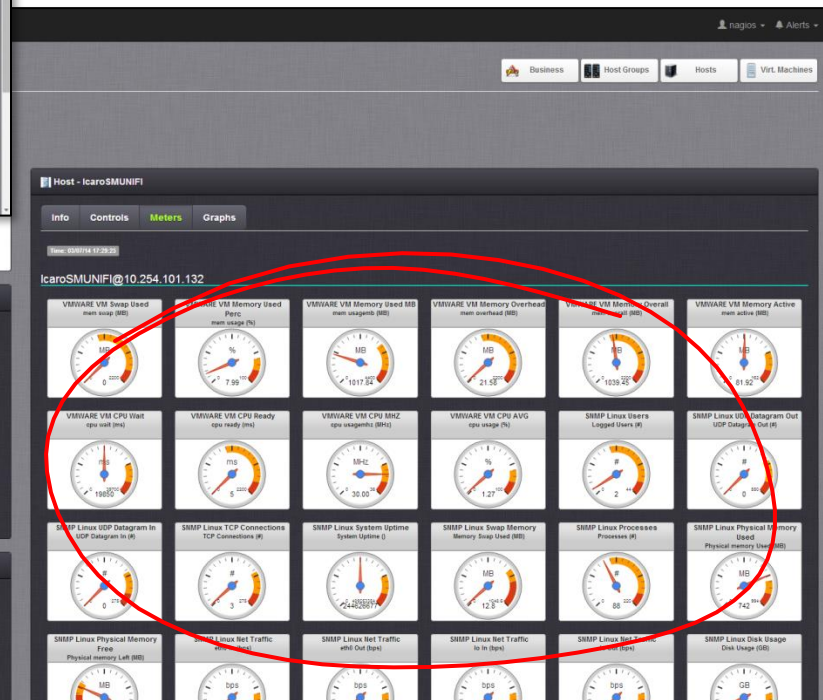




Supervisor & Monitor Front-End



...on Mobile Devices



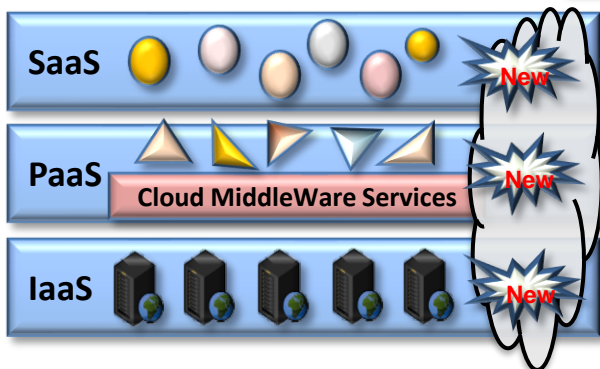
- Monitoraggio del Business
- Su PC e Mobile
- Completamente automatizzato



Architettura ICARO

Utenza Finale

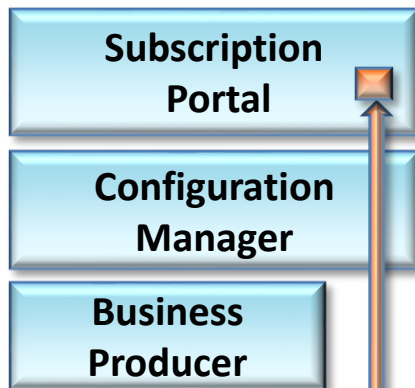
Application Access on iCaro cloud



PMI

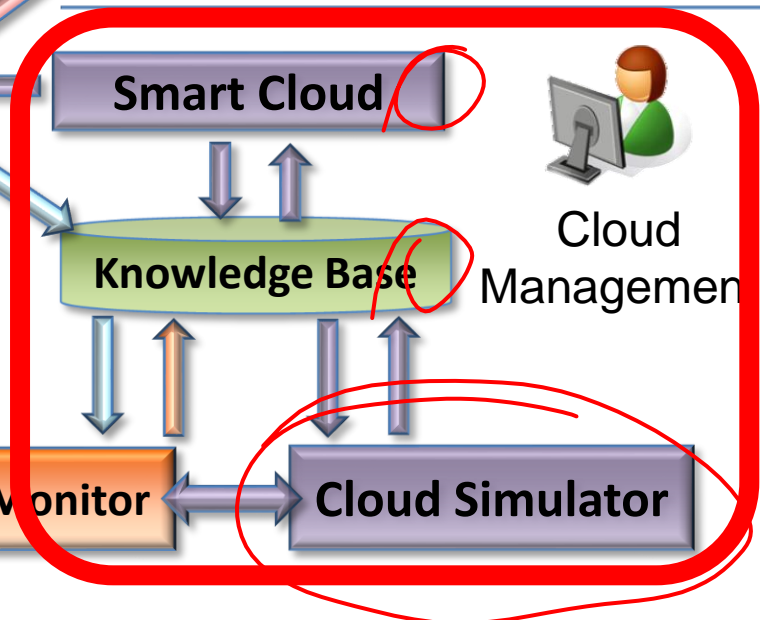
Access to BPaaS, Services Purchase

SLA



PMI-ICT

Developers PaaS



Cloud Management



Smart Cloud Engine

- ❑ **Processi AUTOMATICI per**
 - ❑ Verifica e validazione di consistenza e completezza delle configurazioni
 - ❑ Controllo della salute e del comportamento IaaS, PaaS, SaaS, Business, SLA con metriche complesse
 - ❑ Supporto alle decisioni per Scaling, cloning, migrazione e riconfigurazione
 - ❑ Processi di ottimizzazione
- ❑ Usa come modello la KB

SCE	...	71418386601350	...	9	9	#slid=um.cloudicar...	...	9	9
SCE	21252	ubuntu141833030107 71418386601349	2014-12-12 18:47:08	um.cloudicar:Service LevelAgreement:3063	um.cloudicar:Service LevelAgreement:3063	#isNonConcurrent=1 also, #slid=um.cloudicar...	- SUCCESS	um.cloudicar:Service LevelAgreement:3063	um.cloudicar:Ser LevelAgreement:3
SCE	21251	ubuntu141833030107 71418386601349	2014-12-12 18:47:08	um.cloudicar:Service LevelAgreement:3035	um.cloudicar:Service LevelAgreement:3035	#isNonConcurrent=1 also, #slid=um.cloudicar...	- SUCCESS	um.cloudicar:Service LevelAgreement:3035	um.cloudicar:Ser LevelAgreement:3
SCE	21250	ubuntu141833030107 71418386601347	2014-12-12 18:46:32	um.cloudicar:Service LevelAgreement:3065	um.cloudicar:Service LevelAgreement:3065	#isNonConcurrent=1 also, #slid=um.cloudicar...	- SUCCESS	um.cloudicar:Service LevelAgreement:3065	um.cloudicar:Ser LevelAgreement:3
SCE	212...	ubuntu141833030107 71418386601342	2014-12-12 18:46:08	um.cloudicar:Service LevelAgreement:3055	um.cloudicar:Service LevelAgreement:3055	#isNonConcurrent=1 also, #slid=um.cloudicar...	- SUCCESS	um.cloudicar:Service LevelAgreement:3055	um.cloudicar:Ser LevelAgreement:3

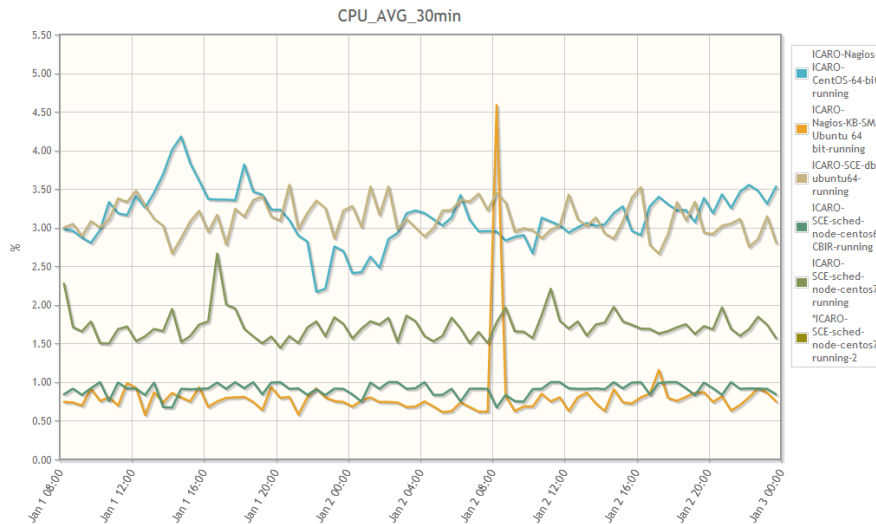
Current monitoring jobs: 1 jobs: 0 job: 0 supports persistence: yes Run: 0 of job executed: 0/0 Retries Scheduler: 0 Running since: Fri Dec 12 18:46:01 CET 2014 Scheduler: instance id: libata1418386601347 Scheduler name: SCE Scheduler: shutdown: no Scheduler: startid: yes Standby mode: no	CPU load: 0.07:48572852010303 CPU load: 0.07:48572852010303 Committed virtual memory: 2084482768 Free physical memory: 1007314162 Free swap space: 620283048 Number of processes: 4 Operating System architecture: amd64 Operating System name: Linux Operating System version: 3.13.0-24-generic Process CPU time: 845200000 System Load average: 3.0 Total physical memory: 14622872608 Total swap space: 4202830488
---	--

do in template



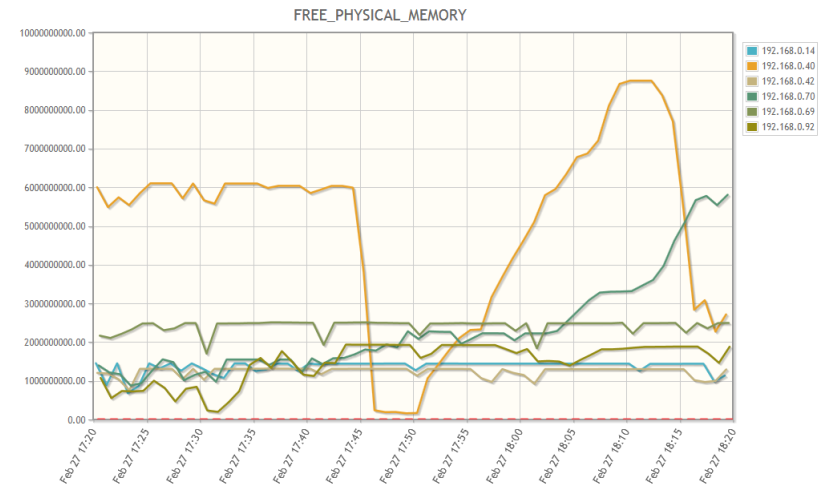
Smart Cloud Engine

- Report degli allarmi relativi alle singole SLA;
- Grafici delle metriche combinati per SLA o singoli;



- Notifica delle VM che non producono dati in legenda;
- Definizione intervalli temporali;

- Visualizzazione dello stato del cluster sia in forma aggregata che per singolo parametro (memoria, cpu, swap ecc.);





Smart Cloud Engine

- Visualizzazione eventi di allarme sia in forma aggregata che per singola metrica (data, soglia, valore misurato, configurazione ecc.)
- Strategy Condition Editor per l'Elastic Cloud
 - definizione di regole booleane di complessità arbitraria per l'attivazione di procedure di scaling, controllo, autoregolazione ecc.
 - vincoli su metriche e SLA, VM, Business Configuration con impostazione di soglie (%)

Timestamp	SlA	Metric	Metric Name	Metric Unit	Metric Timestamp	Vm	Vm Name	Host Machine	Value
2015-02-27 18:13:57	urn:cloudicaro:ServiceLevelAgreement:icaro-distit	urn:icarocloud:ServiceMetric-d8b284f0-d4e6-4420-806b-0712afe5d29c	Network Traffic AVG 30min	bps	2015-02-27 18:09:03	urn:cloudicaro:VirtualMachine:vm-966	DISIT-ICARO-Nagios-64-bit-running	urn:cloudicaro:HostMachine:distit-143	516437.77449260856
2015-02-27 17:43:56	urn:cloudicaro:ServiceLevelAgreement:icaro-distit	urn:icarocloud:ServiceMetric-f53287db-d922-40d3-83ac-7057a174e040	Network Traffic AVG			urn:cloudicaro:VirtualMachine:vm-966	DISIT-ICARO-Nagios-64-bit-running	urn:cloudicaro:HostMachine:distit-143	
2015-02-27 17:13:55	urn:cloudicaro:ServiceLevelAgreement:icaro-distit	urn:icarocloud:ServiceMetric-4fb07e53-e182-42f7-81d3-8b236cedce9							
2015-02-27 16:43:57	urn:cloudicaro:ServiceLevelAgreement:icaro-distit	urn:icarocloud:ServiceMetric-1b683b27-872c-4c21-8a1e-ee39017de7e9							

Add Elastic Job Constraints

Match ALL

IF Metric CPU AVG 30min of SLA urn:cloudicaro:ServiceLevelAgreement:distit-hab IS 10 % ABOVE THE THRESHOLD FOR 30 min

Match ANY

IF Metric Disk Usage AVG 30min of VM eclap-bp64net:eclap.eu-running IS 20 % ABOVE THE THRESHOLD FOR 30 min

IF Metric Memory Used AVG 30min of SLA urn:cloudicaro:ServiceLevelAgreement:distit-org IS 30 % ABOVE THE THRESHOLD FOR 1 week

Match ANY

IF Metric Network Traffic AVG 30min of BC urn:cloudicaro:context:BusinessConfiguration:icaro-dev IS 40 % ABOVE THE THRESHOLD FOR 4 day

IF Metric CPU AVG 30min of SLA urn:cloudicaro:ServiceLevelAgreement:eclap IS 50 % BELOW THE THRESHOLD FOR 1 h

IF Metric CPU AVG 30min of SLA urn:cloudicaro:ServiceLevelAgreement:log IS 60 % ABOVE THE THRESHOLD FOR 3 h

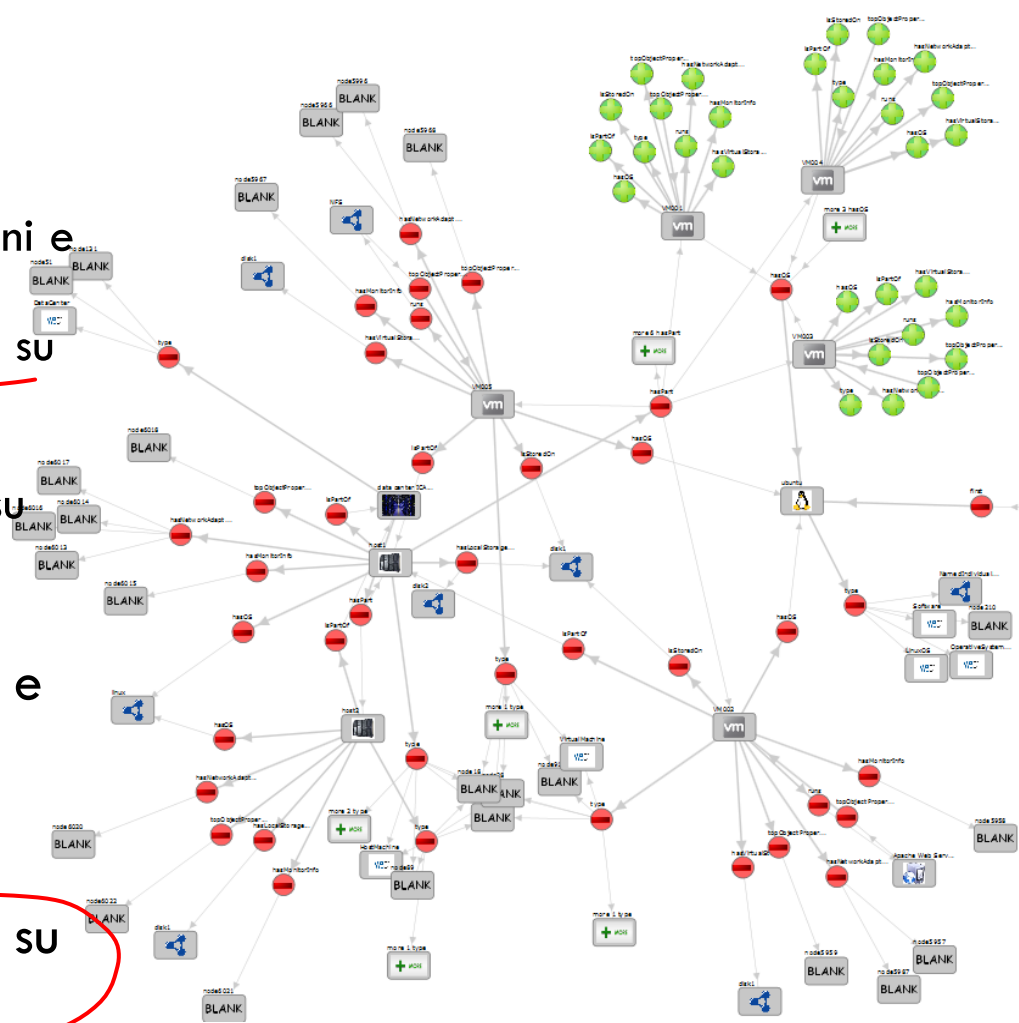
IF Metric CPU AVG 30min of SLA urn:cloudicaro:ServiceLevelAgreement:simobility IS 70 % ABOVE THE THRESHOLD FOR 1 month

Confirm



Knowledge Base & Tools

- ❑ **Via API Rest riceve le configurazioni e le variazioni**
- ❑ **Modello di Cloud intelligence**
 - ❑ Formalizzazione di configurazioni e SLA (Service Level Agreement)
 - ❑ reasoner supporto alle decisioni su configurazioni: consistenza e completezza
 - ❑ adeguamento dell'architettura su alcune applicazioni
- ❑ **Tecnologia**
 - ❑ Knowledge base: RDF store e inference engine
 - ❑ Smart Cloud Ontology: <http://www.disit.org/5604>
 - ❑ Esempio di dato accessibile su <http://log.disit.org>



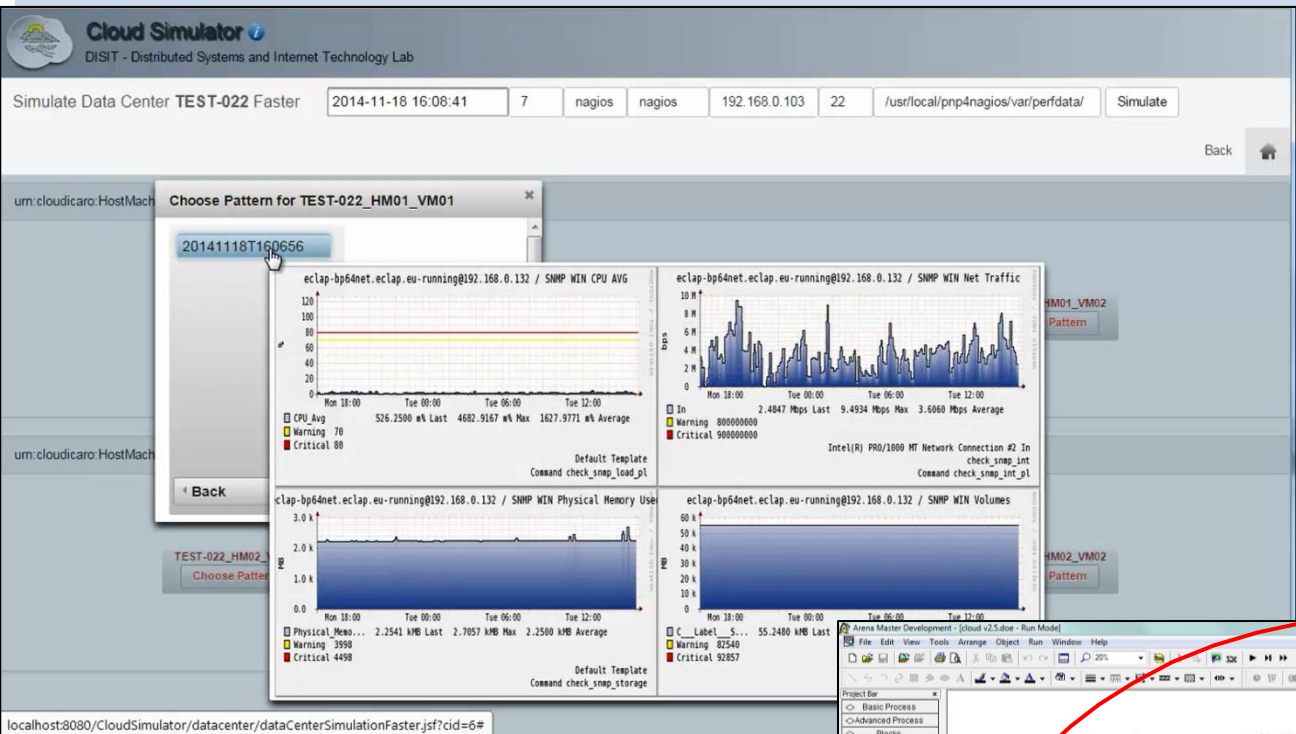


Cloud Simulator

- ❑ **Permette di**
 - ❑ **Simulare** il comportamento di carico di datacenter complessi
 - ❑ **creare situazioni di carico** partendo da andamenti di carico reali dallo storico del sistema di monitoraggio
 - ❑ **studiare** gli effetti del carico sulle risorse di base a livello IaaS
- ❑ **Produce andamenti Simulati** accessibili e analizzabili da Supervisor & Monitor come dallo Smart Cloud Engine
- ❑ **Si integra** con
 - ❑ Lo Smart Cloud Engine per l'esecuzione di processi di controllo e valutazione e
 - ❑ la Knowledge Base per gestione delle configurazioni e dei dati, navigazione nella rappresentazione complessa del cloud
 - ❑ Il Supervisor & Monitor per l'accesso ai dati di monitoraggio, e la produzione di grafici

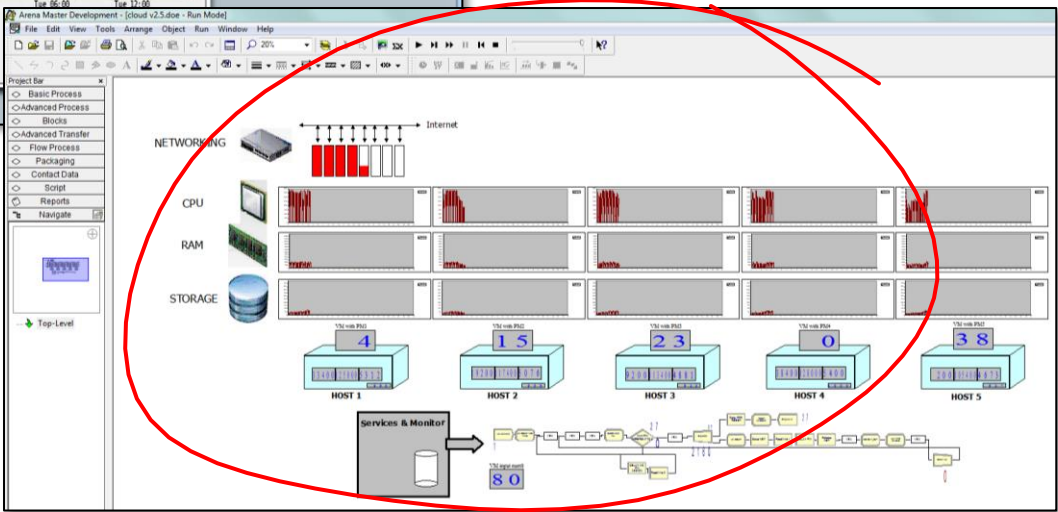


Cloud Simulator



Simulare il
 comportamento
 di carico di
 datacenter
 complessi

Identificare
 allocazioni ottime
 delle risorse





Vantaggi di ICARO

- ❑ **Automazione** di svariati aspetti di gestione cloud
 - ❑ gestire con: SM, KB, SCE, gestori e data center diversi
 - ❑ allocare applicazioni in modo automatizzato
 - ❑ Vendere configurazioni complesse con costi di produzione e gestione ridotti.
- ❑ **Ridurre i costi** automatizzando i processi di
 - ❑ **Vendita delle soluzioni su cloud**
 - ❑ **Configurazione, integrando: IaaS, PaaS, SaaS, PBaaS**
 - ❑ **Config e Deploy di applicazioni SaaS anche complesse...**
 - ❑ **Config e gestione di soluzioni di monitoraggio a livello di metriche integrate: IaaS, PaaS, SaaS, PBaaS, business, SLA**
 - ❑ **Controllo e monitoraggio dei sistemi, Business Level, SLA level**
 - ❑ **Ri-configurazione sulla base della valutazione di condizioni complesse**



Portabilità e Interoperabilità

- ❑ La soluzione CM e SP vanno calate sul particolare Orchestrator anche se sono in larga parte indipendenti da questo ma sono dipendenti dai modelli di business del Cloud Service provider.
- ❑ La parte CMW è agnostica rispetto ai processi di deploy
- ❑ La soluzione di monitoraggio, SM, è trasportabile su altri monitor di basso livello, oggi usa Nagios
- ❑ La soluzione Smart Cloud, SCE-KB, è agnostica rispetto al gestore e completamente integrata con SM



- ❑ Versione completa della slide:
<http://www.disit.org/6587>
- ❑ ICARO project official web page dove in documenti vi sono documenti accessibili e video:
<http://www.cloudicaro.it/>
- ❑ Altra documentazione accessibile su
 - ❑ Video overview: <http://www.disit.org/6558>
 - ❑ Page with Smart Cloud Videos: <http://www.disit.org/6544>
 - ❑ ICARO page at DISIT <http://www.disit.org/5482>





References

- | **VMware:** <http://www.vmware.com>
- | **HP:** www.hp.com/go/integrityvm
- | **Microsoft Hyper-V:** <http://www.microsoft.com/hyper-v-server/en/us/default.aspx>
- | **“Windows Server 2008 Hyper-V Technical Overview”-**
<http://download.microsoft.com/download/4/2/b/42bea8d6-9c77-4db8-b405-6bffe59b157/Hyper-V%20Technical%20Overview.docx>
- | **Comparison of Hypervisors by VMware -**
<http://www.vmware.com/technology/whyvmware/architectures.html#c132894>
- | **“VMware vSphere 4” Datasheet -** <http://www.vmware.com/products/vsphere/>
- | ICARO project: <http://www.disit.org/5482>, <http://www.cloudicaro.it/en/>

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