# Virtualization Infrastructure at Karlsruhe

## HEPiX Fall 2007

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2) IEKP – University of Karlsruhe

# Summary

- Virtualization
- XEN / VMWare Esx
- Virtualization at IWR (FZK)
  - □ VMWare Esx
  - □ XEN
- Virtualization at IEKP (UNI)
  - □ Server Consolidation / HA
- Virtualization in Computing Development:
  - □ Dynamic cluster partitioning
  - □ Grid Workflow Systems on virtual machines (VMs)

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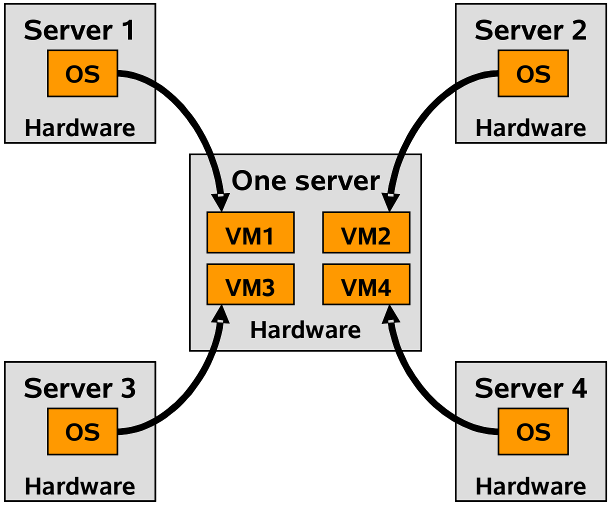
# Virtualization

- Possible Definition:
  - □ Possibility to share resources of one physical machine between different independent operating systems (OS) in Virtual Machines (VM)
- Requirements:
  - □ Support multiple OS like Linux and Windows on commodity hardware
  - □ Virtual machines have to be isolated
  - □ Acceptable performance overhead

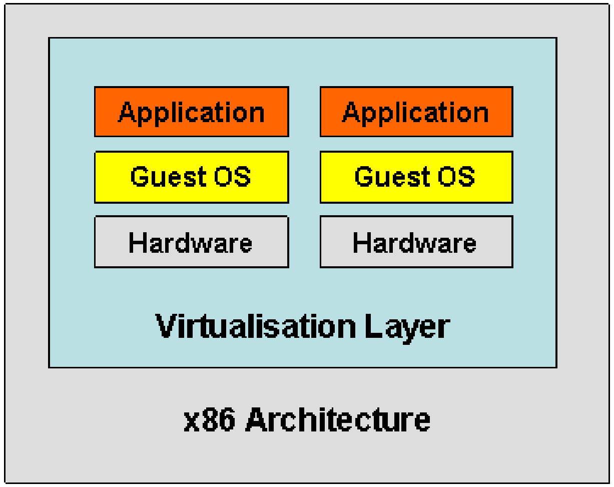


# Why Virtualization

- Load balancing / Consolidation
  - Server load is often less than 20%
  - Economization of energy, climate and space
- Ease of Administration
  - Higher flexibility
    - **Templates** of VMs
      - Fast setup of new servers and test machines
    - Backups of VMs  / **Snapshots**
    - Interception of short load peaks (CPU / Memory) through **Live Migration**
    - Support for older operation systems on new hardware (SLC 3.0.x)
    - High reliability through hardware redundance (Desaster Recovery)

# VMWare ESX

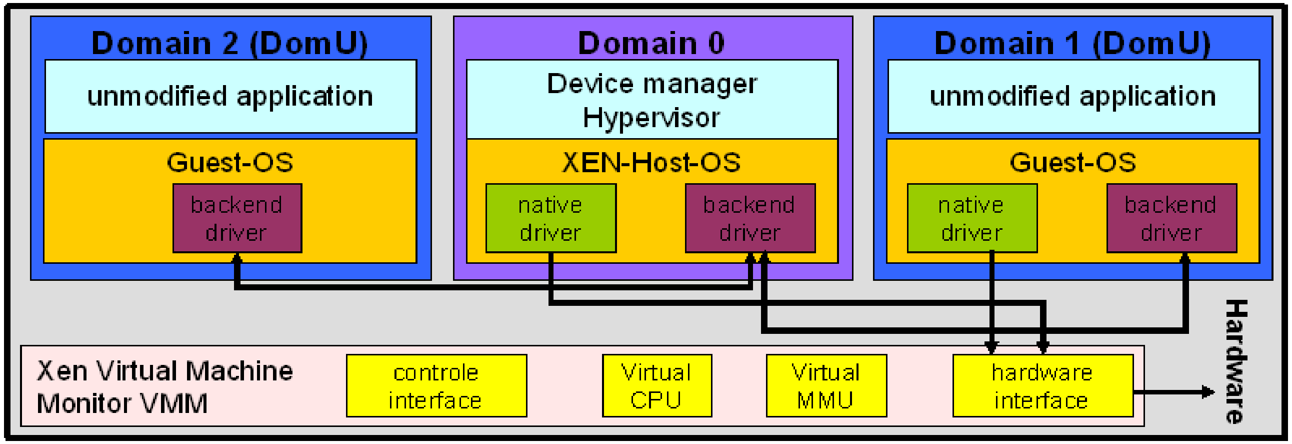
- Full Virtualization
- Virtualization layer is directly installed on the hardware host
- Optimized for certified hardware
- Provides advanced administration tools
- Near native performance while emulating hardware components
- Some Features:
  - Memory ballooning
  - Over-commitment of RAM
  - Live migration of VMs



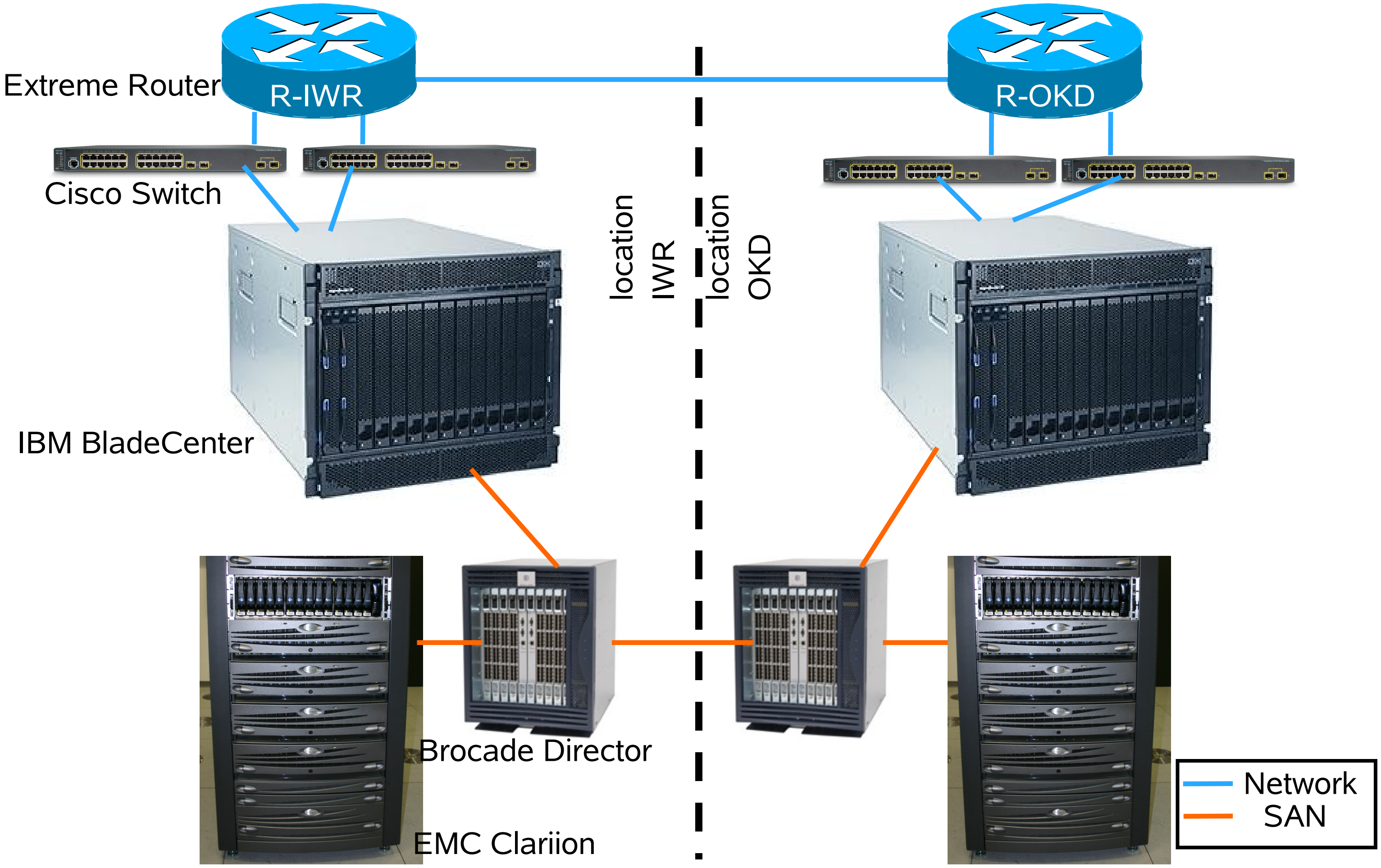
Schematic overview of VMware ESX-Server

# XEN (Open Source)

- Paravirtualization (or full virtualization – CPU support needed)
  - □ Hardware is not fully emulated ⇒ Small performance loss
- Layout:
  - □ Hypervisor (xend) runs on the privileged host system (dom0)
  - □ VMs (domUs) work cooperatively
- Host and Guest Kernels have to be adopted in Kernel < 2.6.23. But most of common Linux distributions provide XEN packages (XEN-kernel / XEN tools)
- Some Features:
  - □ Memory ballooning
  - □ Live-migration



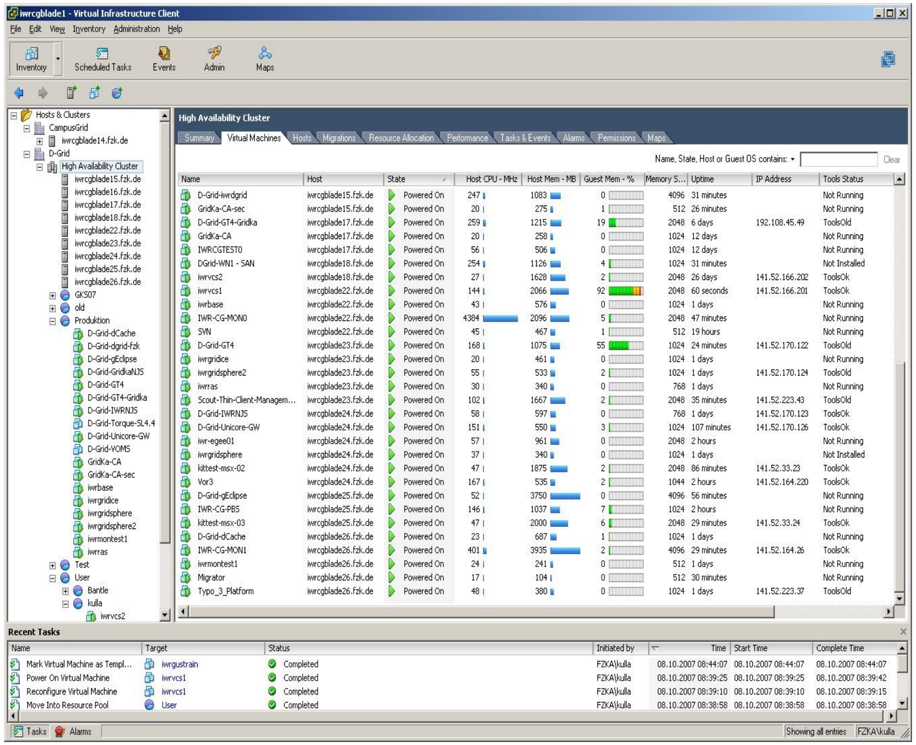
# Virtualization at IWR (FZK) – The Hardware



by Fabian Kulla

# Virtualization at IWR (FZK) – VMWare ESX

- Two ESX Environments:
  - Production:
    - 10 hosts (Blades) used
    - 30 VMs running D-Grid servers
    - 50 VMs others
  - Test:
    - 4 hosts used
    - 40 VMs
- ESX @ Gridka-School 07
  - ~50 VM for the workshops
    - gLite Introduction Course (UIs)
    - Unicore
    - …



Hosts & Clusters
CampusGrid
iwrcgblade14.fzk.de
D-Grid
High Availability Cluster
iwrcgblade15.fzk.de
iwrcgblade16.fzk.de
iwrcgblade17.fzk.de
iwrcgblade18.fzk.de
iwrcgblade22.fzk.de
iwrcgblade23.fzk.de
iwrcgblade24.fzk.de
iwrcgblade25.fzk.de
iwrcgblade26.fzk.de
GKS07
old
Produktion
D-Grid-dCache
D-Grid-dgrid-fzk
D-Grid-gEclipse
D-Grid-GridkaNJS
D-Grid-GT4
D-Grid-GT4-Gridka
D-Grid-IWRNJS
D-Grid-Torque-SL4.4
D-Grid-Unicore-GW
D-Grid-VOMS
GridKa-CA
GridKa-CA-sec
iwrbase
iwrgridice
iwrgridsphere
iwrgridsphere2
iwrmontest1
iwrras
Test
User
Bantle
kulla
iwrvcs2

High Availability Cluster

Name, State, Host or Guest OS contains:

| Name | Host | State | Host CPU - MHz | Host Mem - MB | Guest Mem - % | Memory S... | Uptime | IP Address | Tools Status |
|---|---|---|---|---|---|---|---|---|---|
| D-Grid-iwrdgrid | iwrcgblade15.fzk.de | Powered On | 247 | 1083 | 0 | 4096 | 31 minutes | | Not Running |
| GridKa-CA-sec | iwrcgblade15.fzk.de | Powered On | 20 | 275 | 1 | 512 | 26 minutes | | Not Running |
| D-Grid-GT4-Gridka | iwrcgblade17.fzk.de | Powered On | 259 | 1215 | 19 | 2048 | 6 days | 192.108.45.49 | ToolsOld |
| GridKa-CA | iwrcgblade17.fzk.de | Powered On | 20 | 258 | 0 | 1024 | 12 days | | Not Running |
| IWRCGTEST0 | iwrcgblade17.fzk.de | Powered On | 56 | 506 | 0 | 1024 | 12 days | | Not Running |
| DGrid-WN1 - SAN | iwrcgblade18.fzk.de | Powered On | 254 | 1126 | 4 | 1024 | 31 minutes | | Not Installed |
| iwrvcs2 | iwrcgblade18.fzk.de | Powered On | 27 | 1628 | 2 | 2048 | 26 days | 141.52.166.202 | ToolsOk |
| iwrvcs1 | iwrcgblade22.fzk.de | Powered On | 144 | 2066 | 92 | 2048 | 60 seconds | 141.52.166.201 | ToolsOk |
| iwrbase | iwrcgblade22.fzk.de | Powered On | 43 | 576 | 0 | 1024 | 1 days | | Not Running |
| IWR-CG-MON0 | iwrcgblade22.fzk.de | Powered On | 4384 | 2096 | 5 | 2048 | 47 minutes | | Not Running |
| SVN | iwrcgblade22.fzk.de | Powered On | 45 | 467 | 1 | 512 | 19 hours | | Not Running |
| D-Grid-GT4 | iwrcgblade23.fzk.de | Powered On | 168 | 1075 | 55 | 1024 | 24 minutes | 141.52.170.122 | ToolsOld |
| iwrgridice | iwrcgblade23.fzk.de | Powered On | 20 | 461 | 0 | 1024 | 1 days | | Not Running |
| iwrgridsphere2 | iwrcgblade23.fzk.de | Powered On | 55 | 533 | 2 | 1024 | 1 days | 141.52.170.124 | ToolsOld |
| iwrras | iwrcgblade23.fzk.de | Powered On | 30 | 340 | 0 | 768 | 1 days | | Not Running |
| Scout-Thin-Client-Managem... | iwrcgblade23.fzk.de | Powered On | 102 | 1667 | 2 | 2048 | 35 minutes | 141.52.223.43 | ToolsOld |
| D-Grid-IWRNJS | iwrcgblade24.fzk.de | Powered On | 58 | 597 | 0 | 768 | 1 days | 141.52.170.123 | ToolsOk |
| D-Grid-Unicore-GW | iwrcgblade24.fzk.de | Powered On | 151 | 550 | 3 | 1024 | 107 minutes | 141.52.170.126 | ToolsOk |
| iwr-egee01 | iwrcgblade24.fzk.de | Powered On | 57 | 961 | 0 | 2048 | 2 hours | | Not Running |
| iwrgridsphere | iwrcgblade24.fzk.de | Powered On | 37 | 340 | 0 | 1024 | 1 days | | Not Installed |
| kittest-msx-02 | iwrcgblade24.fzk.de | Powered On | 47 | 1875 | 2 | 2048 | 86 minutes | 141.52.33.23 | ToolsOk |
| Vor3 | iwrcgblade24.fzk.de | Powered On | 167 | 535 | 2 | 1044 | 2 hours | 141.52.164.220 | ToolsOk |
| D-Grid-gEclipse | iwrcgblade25.fzk.de | Powered On | 52 | 3750 | 0 | 4096 | 56 minutes | | Not Running |
| IWR-CG-PBS | iwrcgblade25.fzk.de | Powered On | 146 | 1037 | 7 | 1024 | 2 hours | | Not Running |
| kittest-msx-03 | iwrcgblade25.fzk.de | Powered On | 47 | 2000 | 6 | 2048 | 29 minutes | 141.52.33.24 | ToolsOk |
| D-Grid-dCache | iwrcgblade26.fzk.de | Powered On | 23 | 687 | 1 | 1024 | 1 days | | Not Running |
| IWR-CG-MON1 | iwrcgblade26.fzk.de | Powered On | 401 | 3935 | 2 | 4096 | 29 minutes | 141.52.164.26 | ToolsOk |
| iwrmontest1 | iwrcgblade26.fzk.de | Powered On | 24 | 241 | 0 | 512 | 1 days | | Not Running |
| Migrator | iwrcgblade26.fzk.de | Powered On | 17 | 104 | 0 | 512 | 30 minutes | | Not Running |
| Typo_3_Platform | iwrcgblade26.fzk.de | Powered On | 48 | 380 | 0 | 1024 | 1 days | 141.52.223.37 | ToolsOld |

Recent Tasks

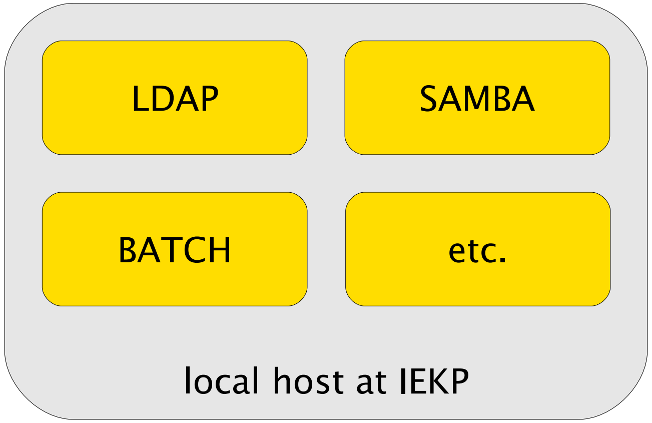
| Name | Target | Status | Initiated by | Time | Start Time | Complete Time |
|---|---|---|---|---|---|---|
| Mark Virtual Machine as Templ... | iwrgustrain | Completed | FZKA\kulla | 08.10.2007 08:44:07 | 08.10.2007 08:44:07 | 08.10.2007 08:44:07 |
| Power On Virtual Machine | iwrvcs1 | Completed | FZKA\kulla | 08.10.2007 08:39:25 | 08.10.2007 08:39:25 | 08.10.2007 08:39:42 |
| Reconfigure Virtual Machine | iwrvcs1 | Completed | FZKA\kulla | 08.10.2007 08:39:10 | 08.10.2007 08:39:10 | 08.10.2007 08:39:15 |
| Move Into Resource Pool | User | Completed | FZKA\kulla | 08.10.2007 08:38:58 | 08.10.2007 08:38:58 | 08.10.2007 08:38:58 |

# Virtualization at IWR (FZK) – XEN

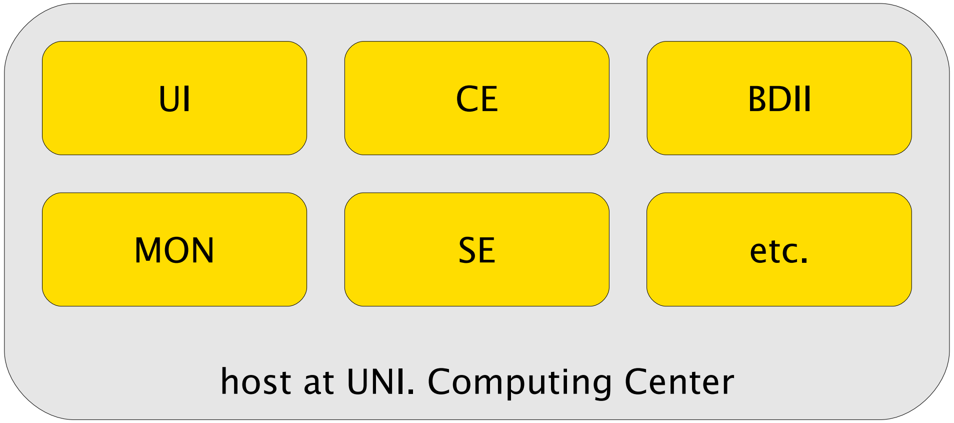
- Running on the Blade Center and on older Gridka Hardware
  - ~30 Hosts: Xen 3.0.1-3, Debian stable
- Server infrastructure for different Grid-Sites:
  - Used in former Gridka-Schools
  - 16 VMs :D-Grid site infrasturcture production and testing
  - 14 VMs : gLite test machines
  - 21 VMs: int.eu.grid site infrastructure
  - 4 VMs : EGEE training nodes
- The int.eu.grid and D-Grid sites worker nodes are running on the Gridka Cluster
  - `/opt` is mounted via nfs containing the software required by the D-Grid and int.eu.grid virtual organizations (VO)

# Virtualization at IEKP (UNI) – Server Consolidation

- Two main server infrasturctures:
  - □ local services (ldap, cups, samba, local batch system, .... )
  - □ gLite grid services of the UNI-KARLSRUHE Tier 3 site
    - moved to Computing Center of the University test cluster from local IEKP cluster

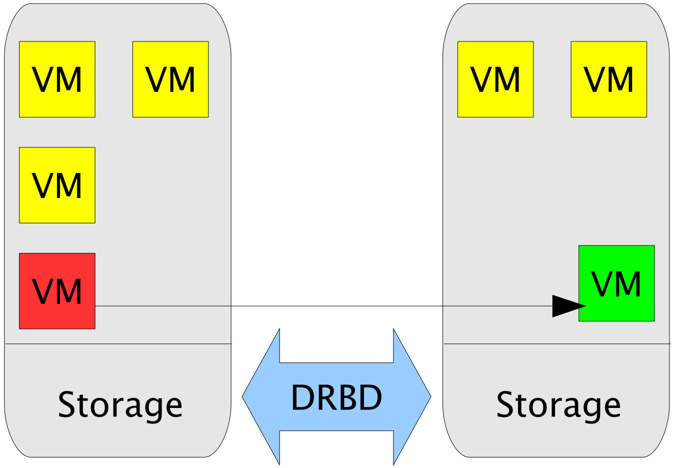


- Virtualization Hardware:
  - □ Two hosts (local IEKP):
    - AMD Athlon 64 X2 4200+
    - 6 GB RAM
    - 400 GB Raid10 disk space for VMs
  - □ Virtualization Portal at Uni. KA computing center:
    - 2x Dual-Core AMD Opteron
    - 8GB RAM
    - 400GB Disk Space



# Virtualization at IEKP (UNI) – High Availability

- Combination of spare machines and  SAN is an overkill if only a few critical services are hosted (example: IEKP)
- Solution should be without too much hardware overhead
- Possibility: Use two powerful host machines with same architecture in combination with a *Distributed Replicated Block Device* (DRBD) to mirror disk space between the machines (Raid 1 over Ethernet) for the VM images



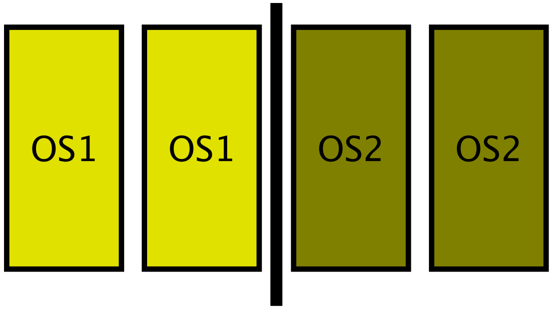
- In case of hardware problems or high load the machines can easily be migrated
- Not yet implemented:
  - □ Heartbeat: in case of complete hardware breakdown the machines will be restarted on the other host

# Dynamic Cluster Partitioning Using Virtualization

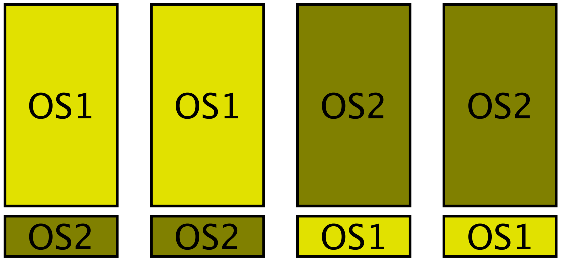
- Motivation:
  - Shared Cluster between several groups with different needs (OS, architecture)
    - Example: New shared cluster at the University of Karlsruhe computing center (in the end 2007)
      - ~ 200 worker nodes:
        - » CPU: 2x Intel Xeon quad core
        - » RAM: 32 GB
        - » Network: Infiniband
      - ~200 TB Storage:
        - » File system: Lustre
      - OS: Red Hat Enterprise 5
      - Shared between 7 different university institutes
      - IEKP relies on Scientific Linux 4 to run CMS experiment software (CMSSW) and to share the cluster in WLCG as the new UNI-KARLSRUHE Tier 3

# Dynamic Cluster Partitioning Using Virtualization

- Static partitioned cluster:
  - No load balancing between the partitions
  - changing the partitions is time consuming

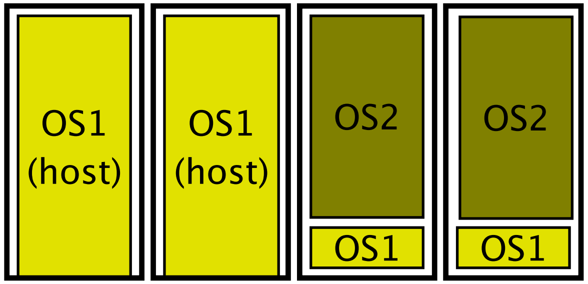


- Dynamic partitioned cluster:
  - First approach (tested on IEKP local production cluster:
    - Using XEN to host the virtualized worker nodes
    - All needed VMs are running simultaneously. Minimum memory is assigned to the not needed VM
    - Managed by additional software daemon controlling batch system and VMs
    - Tests were run for several weeks on local IEKP cluster



# Dynamic Cluster Partitioning Using Virtualization

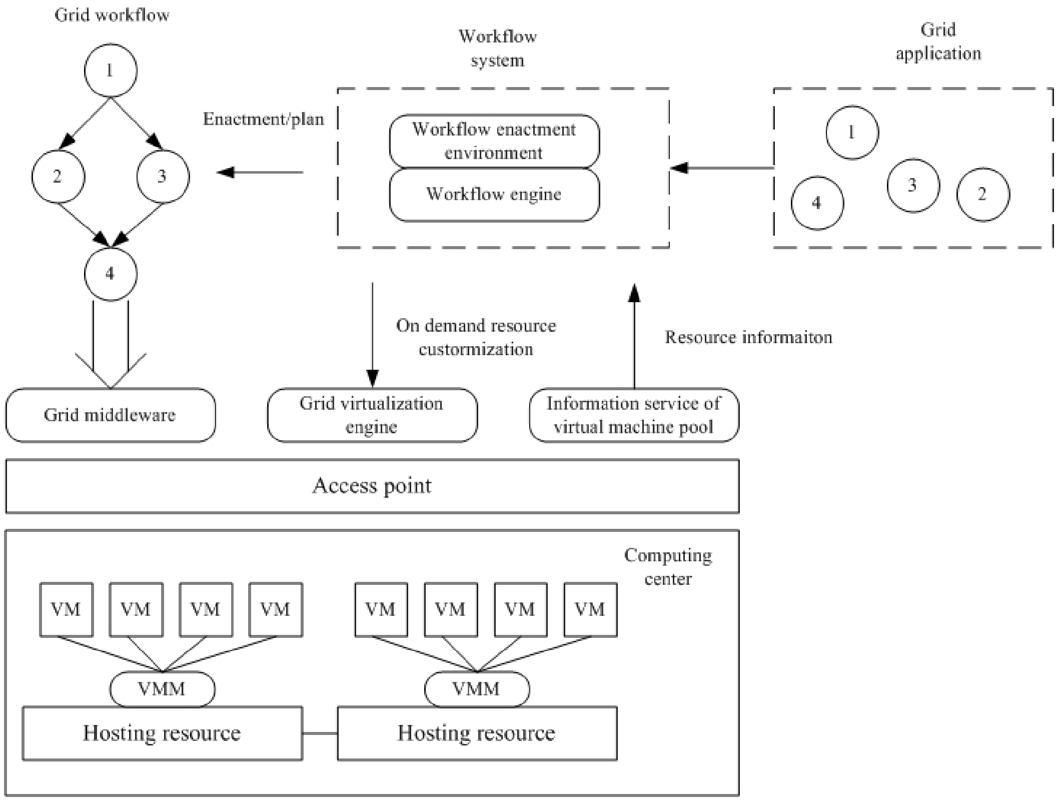
- New Approach:
  - □ Pre-configured VM Images
  - □ “wrap jobs” start the VM on the host worker node and pass the original job to the booted VM
  - □ Finishing jobs stop the VM after job output is passed out
  - □ Job cancels simply kills the VM instantly
- Main Advantages:
  - □ “Bad” grid jobs which may leave bad processes in memory are intrinsically stopped and modified VMs are removed after job
  - □ No software is needed everything is done by the batch system
  - □ VM Images could be deployed by the VO with tested software installation!!



- Performance:
  - □ measured a performance loss of about 3-5% with experiment software (CMSSW)
  - □ VM boot time: about 45s at the test cluster (old hardware)
  - □ the possiblity to participate whithin the shared cluster makes that acceptable

# Grid Workflow Systems on Virtual Machines

- Grid Workflow?
  - □ Used to model Grid applications
  - □ Execution environment is a computational Grid
  - □ Participants across multiple administrative domains
  - □ heterogeneous resource types also in kinds of Virtualization (Vmware ESX + Server, XEN)



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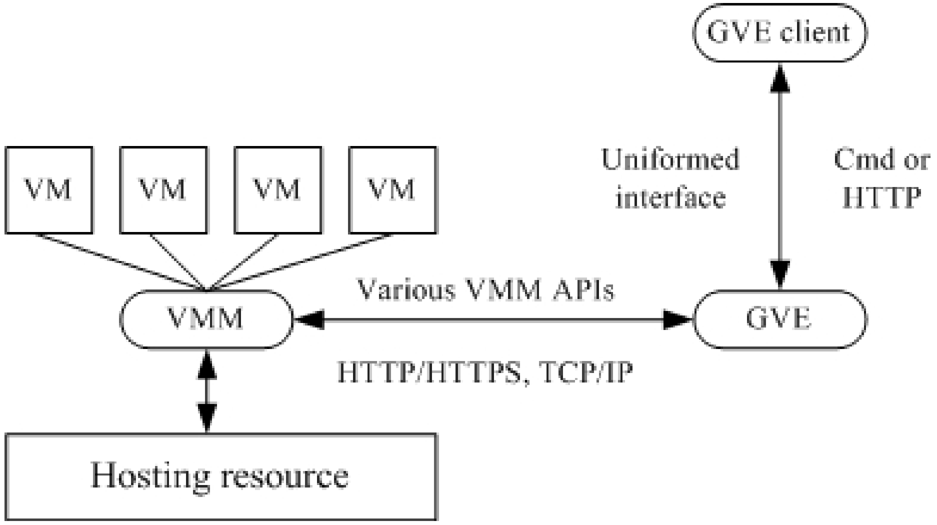
# Grid Workflow Systems on Virtual Machines

- Requirements:
  - Grid Virtualization Engine GVE
    - Interface for deployment of the VMs at the specific Grid site on the different Virtualization Infrastructures – our contribution
  - Monitor/analyze/plan virtual machines with Grid Middleware
    - Information service of VM pool (our contirbution)
    - Interface to workflow planner
  - Execute Grid applications on virtual machines
    - Workflow engine: VDS (existing work from Globus alliance)
    - Globus Toolkit + Condor

# GVE – Grid Virtualization Engine

- Definition:
  - □ Abstract layer  on varous VMMs
  - □ Remotely operation on VMs via APIs provided by VMMs
- Implementation:
  - □ VMM APIs
  - □ HTTP/HTTPS, TCP/IP
- VMM:
  - □ XEN
  - □ VMware Server
  - □ VMware ESX



# Questions?

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