Grid deployment using virtual machines

MetaCenter use-case

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MetaCenter

- academic grid infrastructure in Czech Republic
- consists of centers at different universities
    - Masaryk University in Brno
    - Charles University in Prague
    - West Bohemian University in Pilsen
    - and at CESNET
- hardware – around 750 CPUs
    - mostly Xeon/Opteron SMP clusters
    - SGI Altix servers
    - Opteron 16way servers
- dedicated network between sites
    - 10Gbps ethernet
    - DWDM – optical network
- participating in EGEE/EGEEII with another 250 CPUs

MetaCenter II

- software – production grid
  - shared filesystem – AFS
  - shared batch system – PBSPro
  - uniform environment – modules
  - common user management tools – Perun
  - integrated monitoring – Ganglia
- usual grid motivation
  - sharing resources
  - load balancing of jobs
  - redundancy and robustness
  - allow cooperation among scientists from different universities
  - allow experiments which exceed borders of one site

Virtual machines

- virtual machines can provide
  - several machines, with different OS or Linux flavor on the same machine
  - migration
  - suspend/resume
- could enhance MetaCenter (or general grid) in several ways
  - migration ⇒ better scheduling, robustness
  - suspend/resume ⇒ checkpointing
  - CPU/memory allocation ⇒ interactive jobs
  - several virtual domains ⇒ possibility to run different images for different groups, support different grid middleware
  - isolation ⇒ provide illusion of dedicated cluster

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1 Motivation
- MetaCenter
- Virtual machines

2 Current usage of virtual machines
- Elementary usage
- Service consolidation
- EGEE/MetaCenter integration
- Job preemption, interactive jobs

3 Future plans
- Deployment issues
- Short term plans
- Long term plans

Studied use-cases

- portability tests, running services in different Linux distributions
- sharing of one machine by several services – service consolidation
- different Linux flavors running on the same worker node – EGEE/MetaCenter integration
- preemption, interactive jobs

Elementary usage

- running different Linux distributions on the same machine
  - environment for software development
  - for portability tests (EGEE LB service)
  - for simulation of distributed environment
  - some software may require specific Linux distribution
- usually first use-case, very useful to familiarize with virtual machines tools
- in our case Xen, Vserver and OpenVZ

Xen vs. Vserver

- Xen – paravirtualization
  - useful for complete encapsulation
  - support for complete Linux distributions
  - perfect solution for service consolidation
  - may not be necessary for worker nodes, but currently used for EGEE/MetaCenter integration
- Vserver – one kernel space
  - higher number of virtual machines with small overhead
  - useful when just one or few services must be running – perfect for development machine
  - may be better solution for preemptive use-case (two domains of the same flavor)
  - better on NUMA architecture
- adoption curve similar, with slightly different problems
  - Xen – kernel modules, AFS
  - Vserver – standard system daemons, INADDR_ANY binding, loopback

Xen performance results

- good results on small SMP machines – minimal delay for CPU, memory, disk intensive applications
- bad results for fast networks – one CPU is required for bridging on full speed gigaethernet
- bad NUMA support – on 16way Opteron machine slowdown from 5 to 13 minutes
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Xen overhead

- active use of memory
  - dom0
  - every running domU needs at least 100MB
- disk partitions dedicated to different VMs
  - not easy (read-only) sharing of root filesystems
  - required splitting of scratch partitions
- fast network can be dedicated to one domU or bridged

Service consolidation

- primary motivation – efficient use of hardware
  - EGEE in a box
  - 7 domains running all EGEE services in different VM (WMS, LB, Myproxy, VOMS, CE, WN . . .)
  - different EGEE service require different setup, packages, are not compatible
  - used for certification and pre-production testbed
  - but also for production WMS for the VOCE
- 2xXeon 3.0GHz (4 CPUs with HT), 6 GB RAM, 2x150GB disk
- Xen is perfect solution, overhead is minimal
  - all services running all the time, statical splitting of memory is OK
  - root filesystem is different for different domains

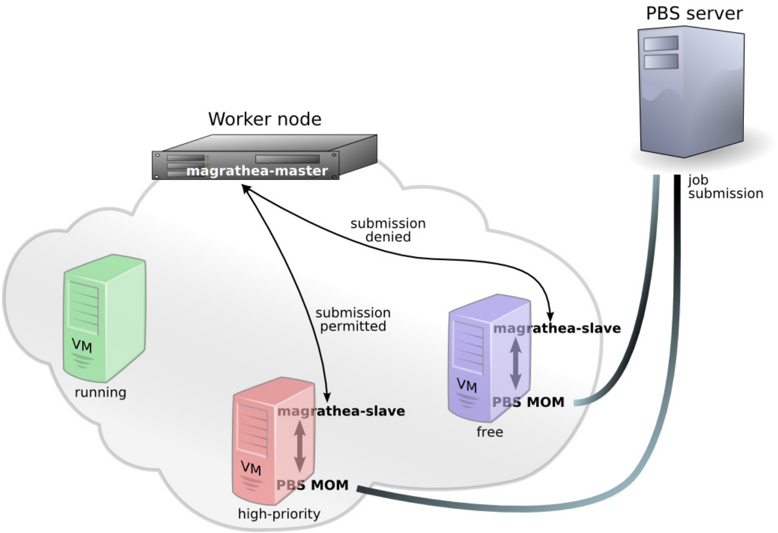
EGEE/MetaCenter integration

- primary motivation – allow coexistence of EGEE and MetaCenter environments
- two images running all the time – Debian/OpenSuse (MetaCenter) and SLC (EGEE)
- EGEE gateway (Computing Element) submits to standard PBS, but to special queue
- dynamic allocation of resources to EGEE and MetaCenter maintained by PBS
- PBS must be aware that two VMs share the same node, but with minimal changes on PBS side ⇒ Magrathea project
- no changes to EGEE software

Magrathea

- integrating virtual machines and PBS
  - each node can run several VMs at a time
  - at most one VM on each node is active
  - however, a VM can be activated even if another one is active – preemption
  - active VM is provided with “all” physical memory and CPU power
- implementation
  - PBS cannot recognize real machines from virtual ones
  - special PBS attribute to distinguish amongst free, running and occupied machines
  - modified PBS scheduler schedules jobs to free machines only
  - current state of VMs is maintained by a daemon running on each physical machine

Magrathea – implementation



Job preemption, interactive jobs

- primary motivation – adding support for interactive jobs to MetaCenter
  - new class of users who cannot use batch mode
  - new functionality for current users
- two Debian/OpenSuse images running all the time, second accessible only by privileged jobs
- when privileged job is coming, standard domain is
  - suspended – not used now
    - node/job is down for PBS
    - problem with parallel jobs
  - given only small fraction of CPU, small real memory
    - currently usable only for sequential jobs, support for parallel jobs will require migration and support on scheduler

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Deployment issues ⇒ motivation for new research

- imagine, that number of your machines grow 5x
  - you will be out of public IP address ⇒ IPv6 deployment, (private network, VPN)
  - any solution with scalability problems will become bottleneck
    - installation/management tools for clusters
    - monitoring
    - user management
  - you may find problem with licensed software
- image management ⇒ Workspaces integration?
- Infiniband available only in one virtual machine ⇒ ??
- security implications – separation of different domains, user supplied images
- monitoring/benchmarking

Short term future plans

- Magrathea extensions
  - more then two virtual domains
  - not all domains running
  - fine-grained resource allocation – virtual domains per job
- improved support for job preemption – parallel jobs
- more flexible EGEE/MetaCenter integration
- better integration with batch system – management of virtual machines
- minimization of overhead
  - Xen
    - memory
    - shared filesystem for several domains
  - shared scratch filesystem – PVFS2?
- Vserver and IPv6

Long term future plans

- efficient sharing of high speed interfaces
- monitoring
  - monitoring and management of hosting VM (dom0)
  - monitoring of services in user VMs, including their batch system
- scheduling support
  - scheduling using features provided by VMs – suspend, checkpointing, migration
  - hierarchy of schedulers is more complicated (meta, batch, workspace, VM, OS scheduler)
- migration
  - local filesystem
  - cooperation with scheduling
- model
  - two planes – real and virtual
  - dynamic mapping of virtual machines to real resources

Thank you for your attention.