Science Computing Clouds

December 9, 2008

Chan-Hyun Youn

School of Engineering/ Grid Middleware Research Center
Information and Communications University

Table of Contents

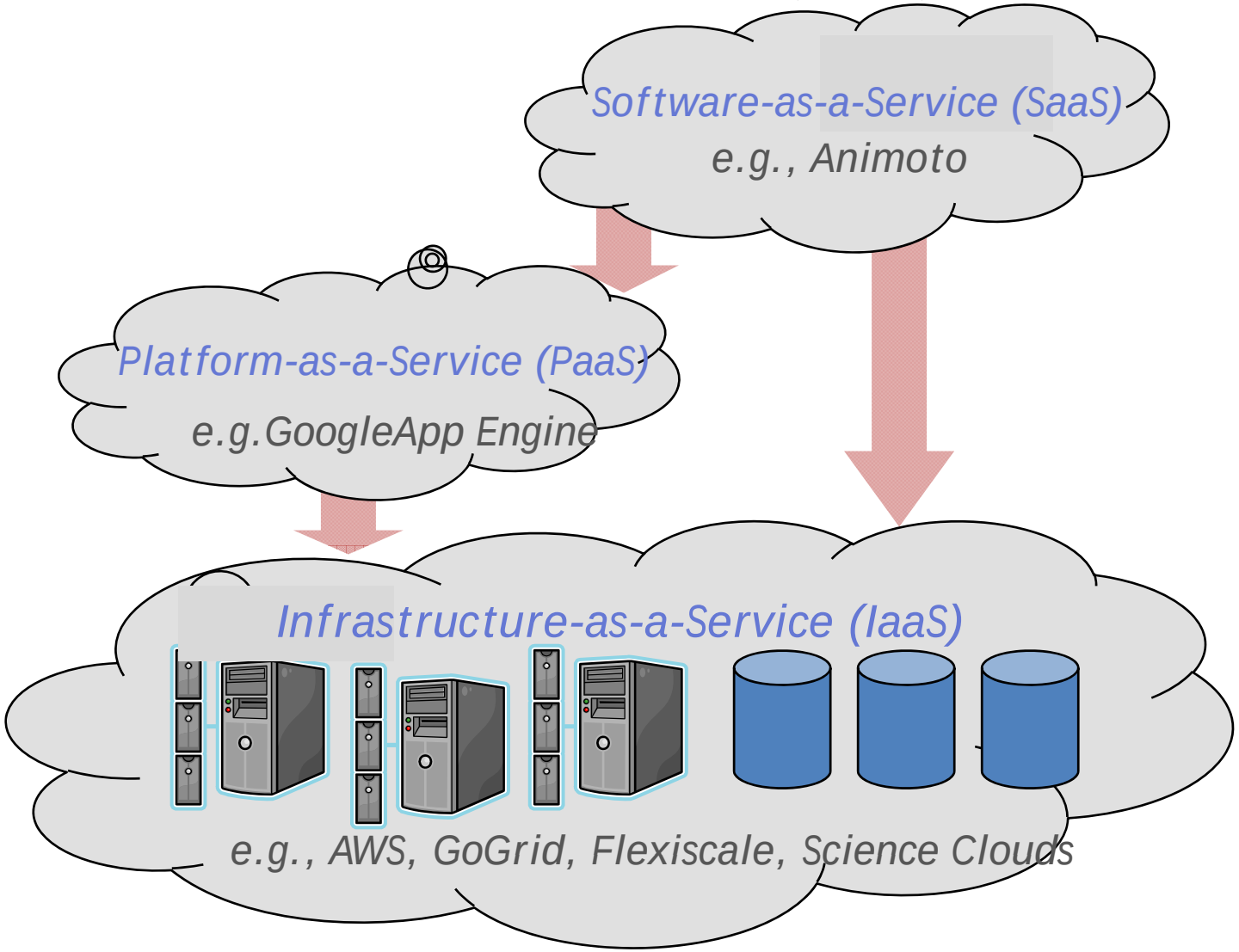
Cloud Computing :Definition (1/2)

- **Definition**
  - *"A paradigm in which **information is permanently stored in servers on the Internet** and cached temporarily on clients that include desktops, entertainment centers, table computers, notebooks, wall computers, handhelds, etc.*" [1]
  - Three Different Level of Cloud computing [2]
    - ✓ Application in the Cloud (ex. Google Web Doc, SalesForces.com)
    - ✓ Platform in the Cloud (ex. Google App Engine)
    - ✓ Infrastructure in the Cloud (ex. Amazon EC2, GoGrid)

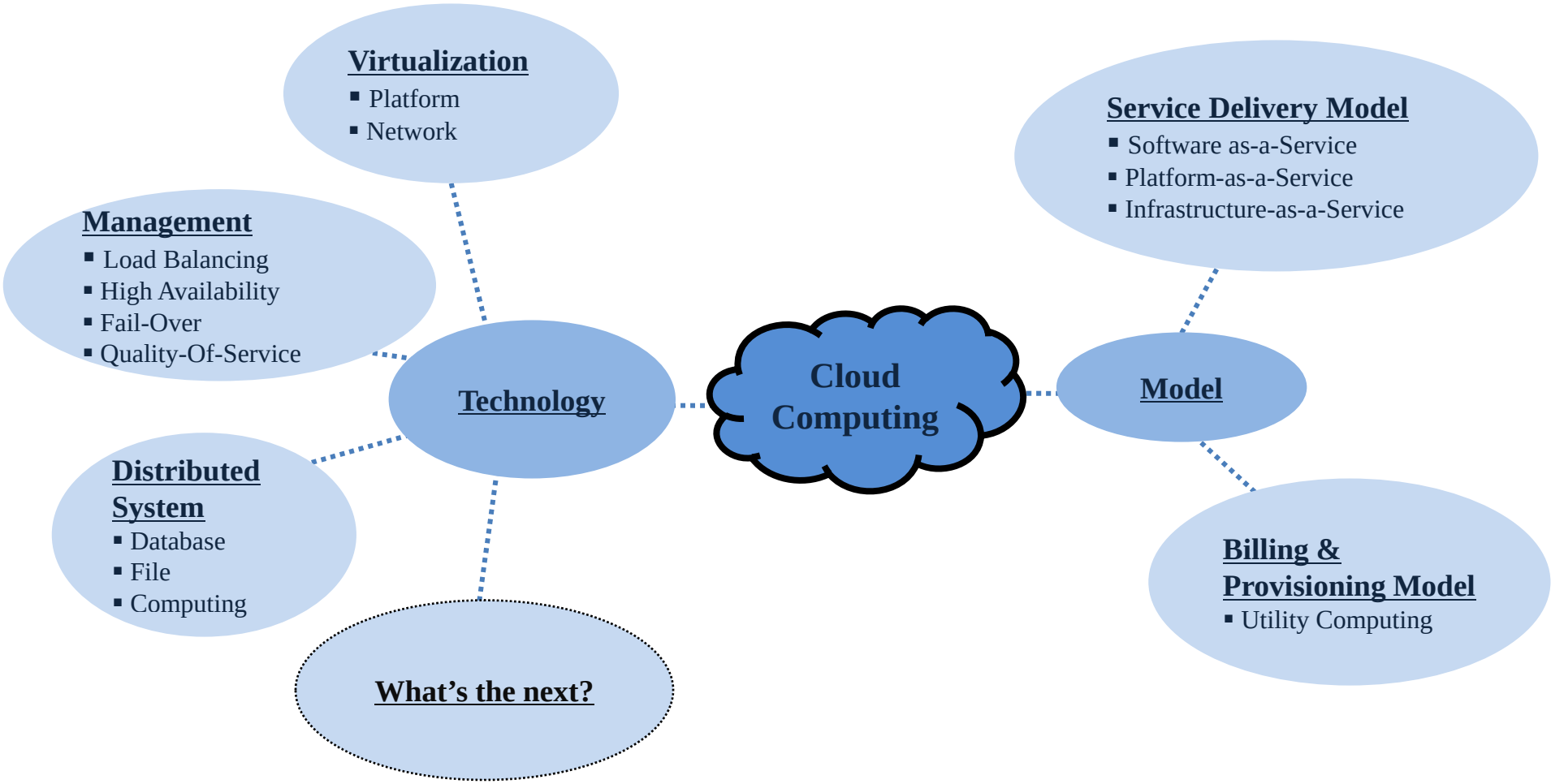
- **Comments**
  - Cloud Computing**에 대한 정의가 여럿 존재하지만 구체적으로 무엇을 빌려쓰는가에 따라 3가지**(SaaS, PaaS, IaaS)**로 나누어 생각하는 것에 많은 사람들이 동의함**
  - **각각의 3가지** Cloud**들을 구현하기 위한 방법들이 서로 다름**.

[1] The Definition of cloud computing used in IEEE Computer Society
[2] http://blog.rightscale.com/2008/05/26/define-cloud-computing/, Define Cloud Computing

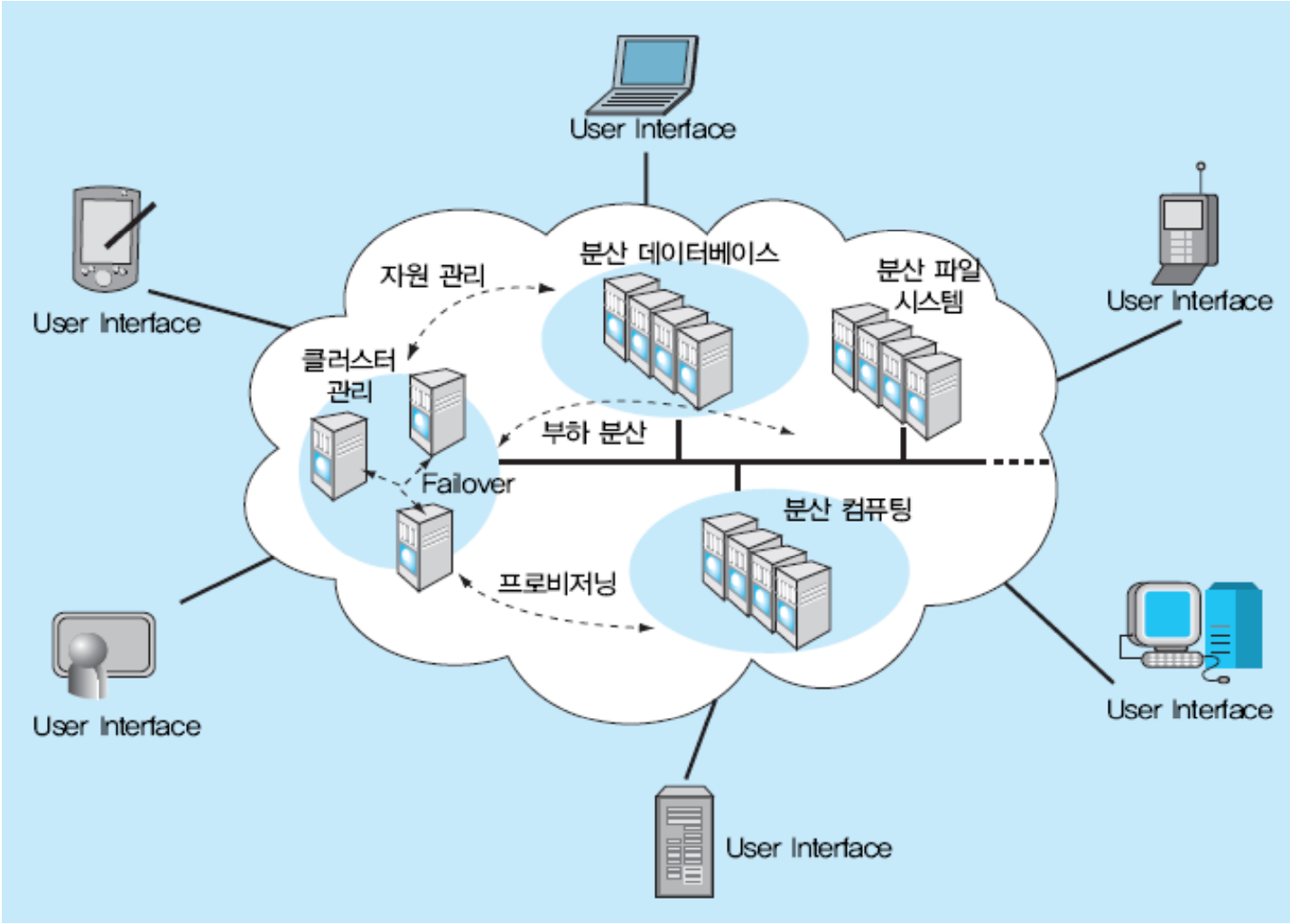
Cloud Computing :Definition (2/2)



Deep Inside Cloud Computing : Technologies and Models



Deep Inside Cloud Computing : Management



[3] Cloud Computing Management, Microsoft ware, 2008년 3월

Case Study I .
Autonomic Resource Management in Virtualized Data Center [4]

[4] J. Xu, M. Zhao, J. Fortes, R. Carpenter, M. Yousif, “Autonomic Resource Management in Virtualized Data Centers” in press, Cluster Computing: The Journal of Networks, Software Tools and Applications, July 2008.

Traditional Data Centers

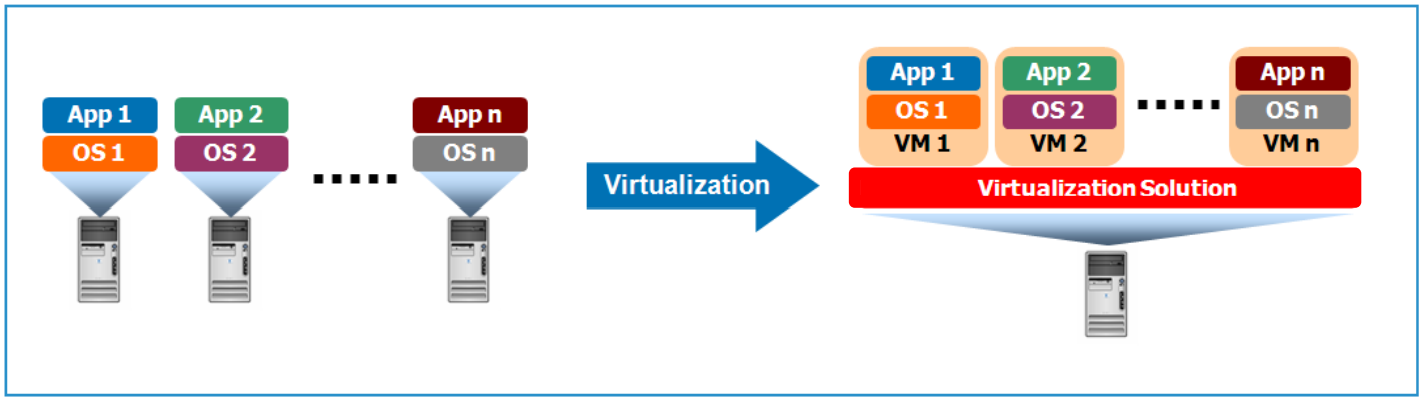
- **Static Resource Allocation**
- **Setup and Maintenance are very costly**
- **Pay-as-you-go model is more attractive**

Overview

- **Goal**
  - **Automatic, SLA-compliant, cost-effective Resource Allocation**
- **Challenges**
  - Dynamically changing application workload and workload mixes
  - On-demand resource allocation
- **Solution**
  - Virtual resource containers
    - ✓ Flexible resource allocation for application-specific execution environment
  - Two-level resource control
    - ✓ SLA-driven optimization at both application level and data center level
  - Fuzzy-logic-based application-level controllers

Virtualized Data Center

- **Virtual Container**
  - **VMWare[5] or Xen[6]**

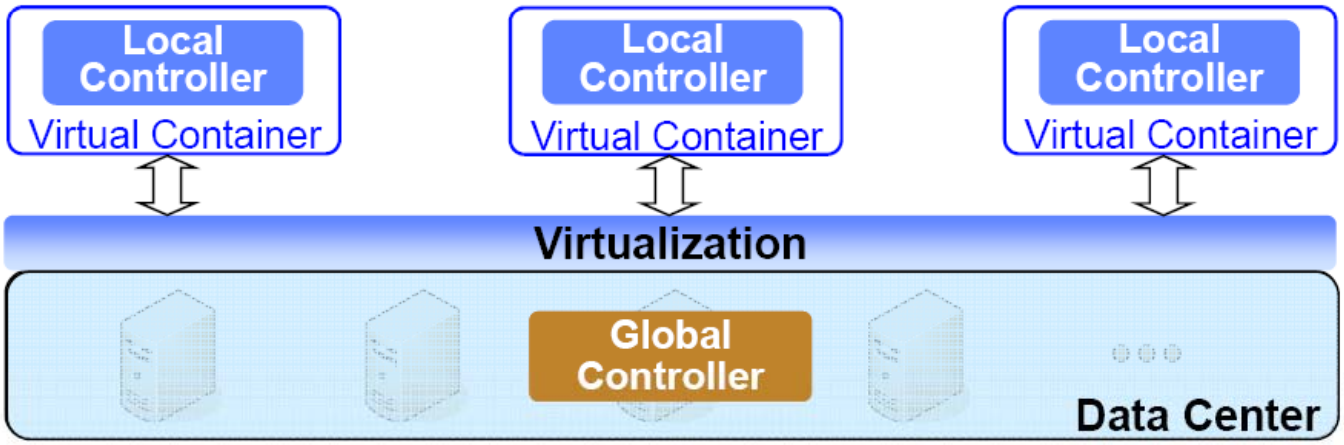


  - Application-tailored execution environment
    - ✓ Isolation, Security, Customization
  - Fine-grained Dynamic Resource Allocation

[5] www.vmware.com, VMware : Virtualization via Hypervisor, Virtual Machine & Server Consolidation
[6] www.xen.org, Home of the Xen hypervisor, the powerful open source industry standard for

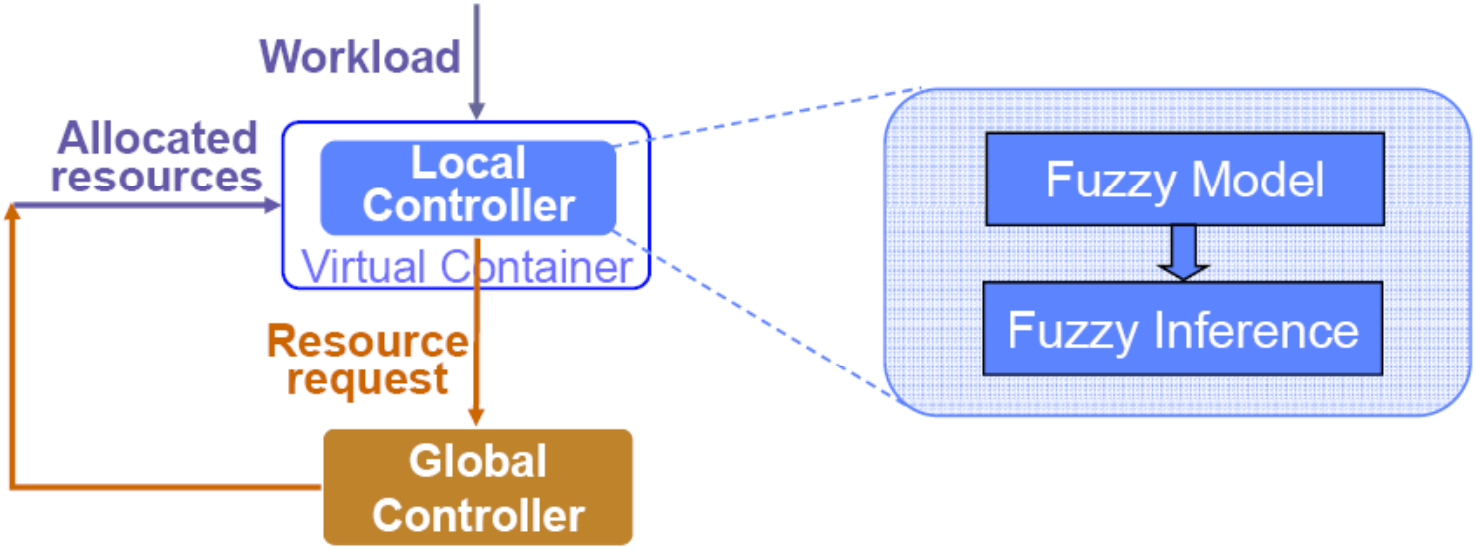
Two-level Control

- **Local Controller**
  - Employed at each virtual container
  - Determines resource needed by the application
  - Makes resource request to data center
- **Global Controller**
  - Serves resource requests from local controllers
  - Allocates resources among virtual containers



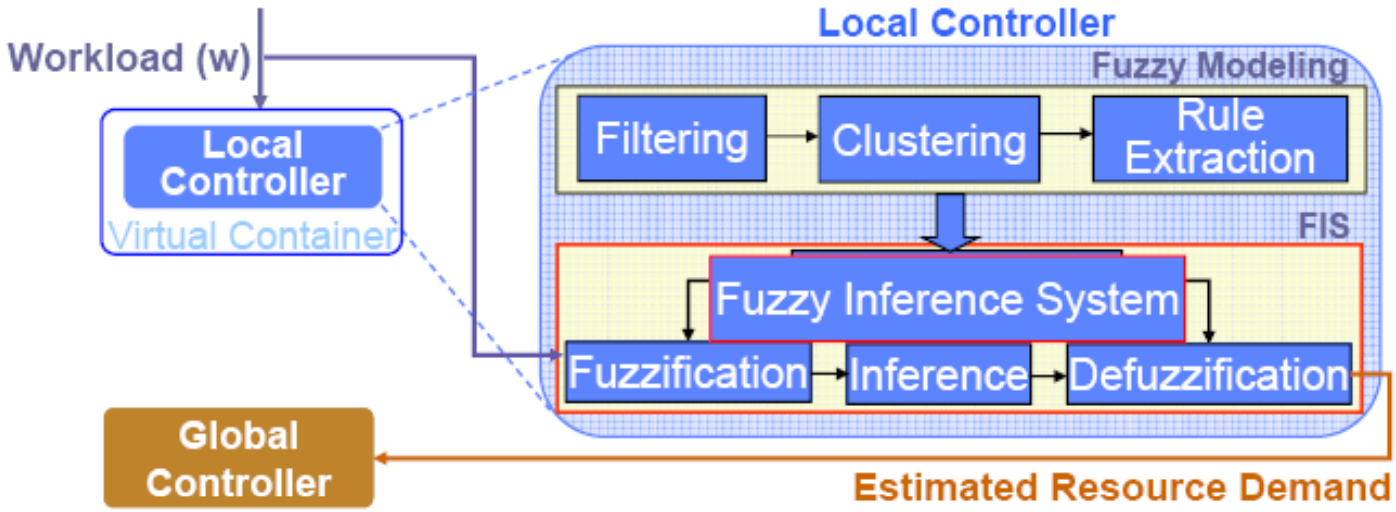
Local Controller

- **Fuzzy Modeling based local controller**
  - Fuzzy Modeling characterize the relation between workload and resource consumption
  - Fuzzy Inference system estimates resource demands using fuzzy models



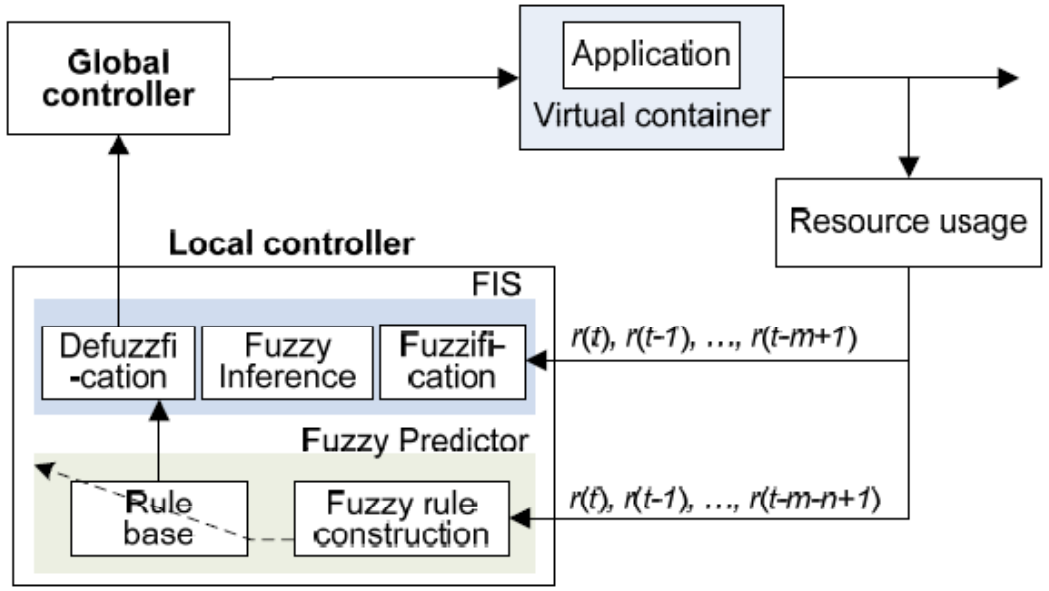
Resource Demand Estimation

- **Fuzzy Inference System (FIS)**
  - Knowledge base stores fuzzy sets and rules
  - Fuzzification compute membership degrees
  - Fuzzy Inference evaluates fuzzy rules
  - Defuzzification calculates weighted average of outputs



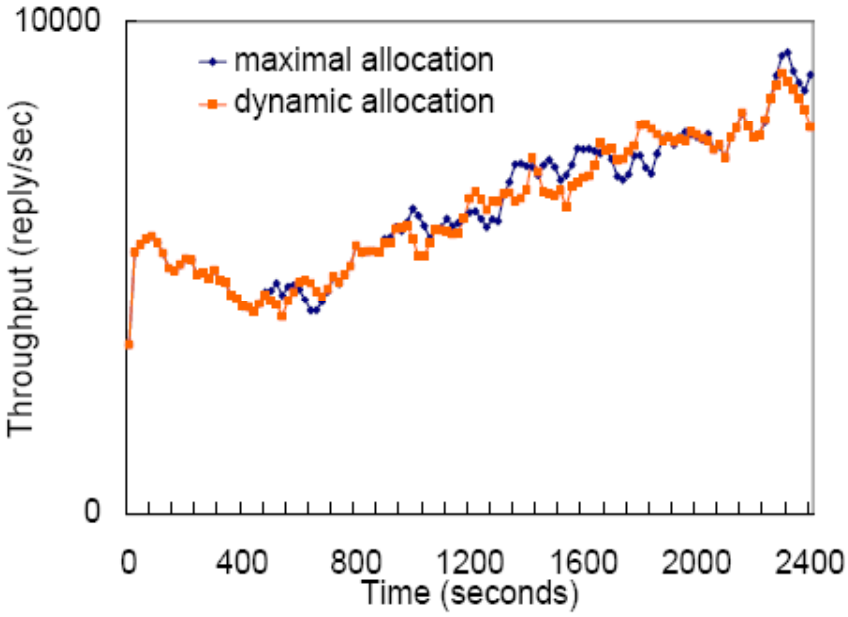
Global Controller

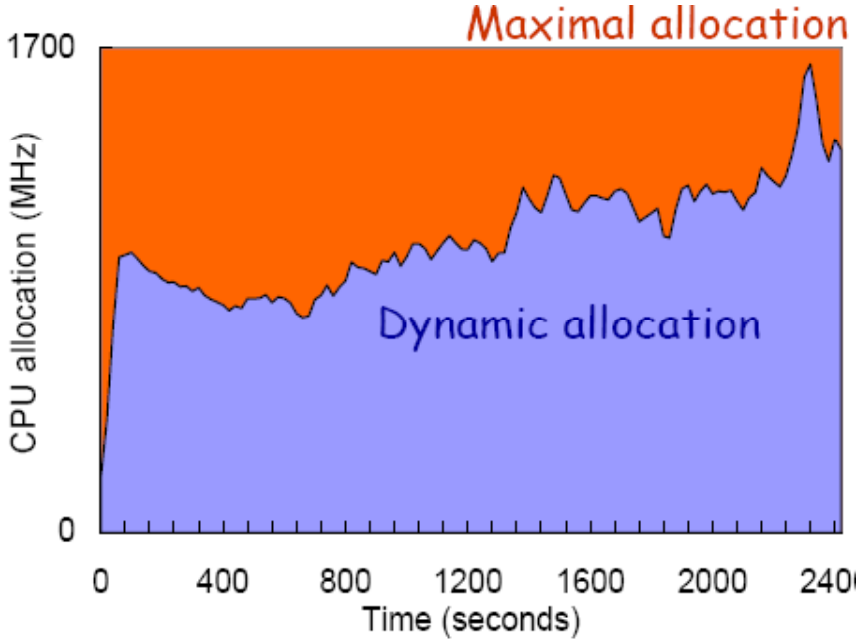
- **Role**
  - Cooperates with the fuzzy-modelling based local controllers
  - Decides resource allocation using a profit-oriented model
- **Profit-oriented global controller**
  - Cooperates with the fuzzy-modeling based local controllers
  - Decides resource allocation using a profit-oriented model
- **Per-container profit**
- **Global profit**



Experiments Result

- **Workload**
  - 8 hours of trace from 98' World Cup web site
  - Replayed at 12x Speedup





Case Study II. Nimbus [7]

- Open Source IaaS Cloud Computing Software

[7] http://workspace.globus.org, Nimbus Open Source IaaS Cloud Computing Software

Nimbus Toolkit

- **Introduction**
  - Initiated by the University of Chicago(UC) and the University of Florida(UFL)
  - Cloud Computing Management Toolkit (using Xen [6])
    - ✓ The Science Clouds provide Amazon EC2[8] -style cycle to scientific projects
    - ✓ A Client request a resource lease for a few hours and, if the request is authorized, a virtual machine(VM) is deployed
  - Open source, extensible architecture, allows us to experiment with different capabilities and SLAs
    - ✓ Amazon EC2 is “a closed platform”
    - ✓ Experiment and use: make your own cloud or configure a private cloud
    - ✓ Customize: try new things, make the IaaS paradigm work for your application domain

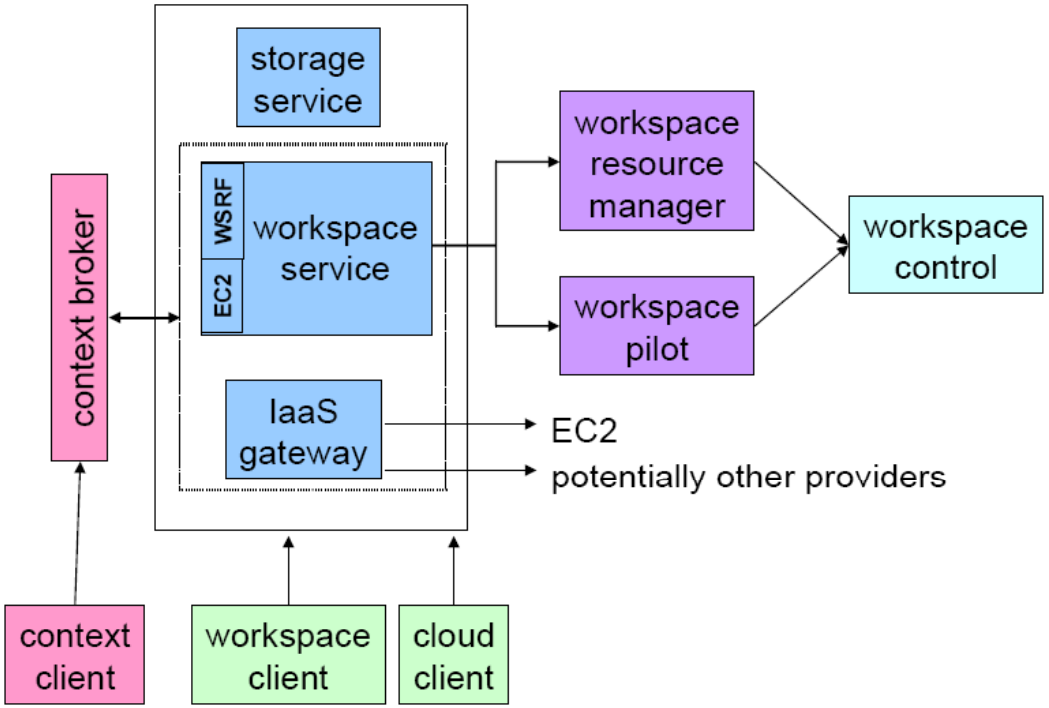
[8] http://aws.amazon.com/ec/, Amazon Elastic Compute Cloud (Amazon EC2)

Nimbus Toolkit Resources

- **University of Chicago (Nimbus):**
  - first cloud, online since March 4th 2008
  - 16 nodes of UC TeraPort cluster, public IPs
- **University of Florida**
  - Online since 05/08
  - 16-32 nodes, access via VPN

Nimbus Toolkit Resources

- **Key Components**
  - Workspace Service
    - ✓ Allow a remote client to deploy and mange flexibly defined groups of VMs
  - Workspace Resource Manager
    - ✓ Implement deployment of VM lease
  - Workspace pilot
    - ✓ Deploy virtual machine
  - Workspace control
    - ✓ Used to start, stop and pause VM
  - IaaS Gateway
    - ✓ Provide connection service to commercial Amazon EC2
  - Workspace Client
    - ✓ Provides full access to function
  - Cloud Client
    - ✓ Provides access to only a select set of functions



[9] VM : Virtual Machine

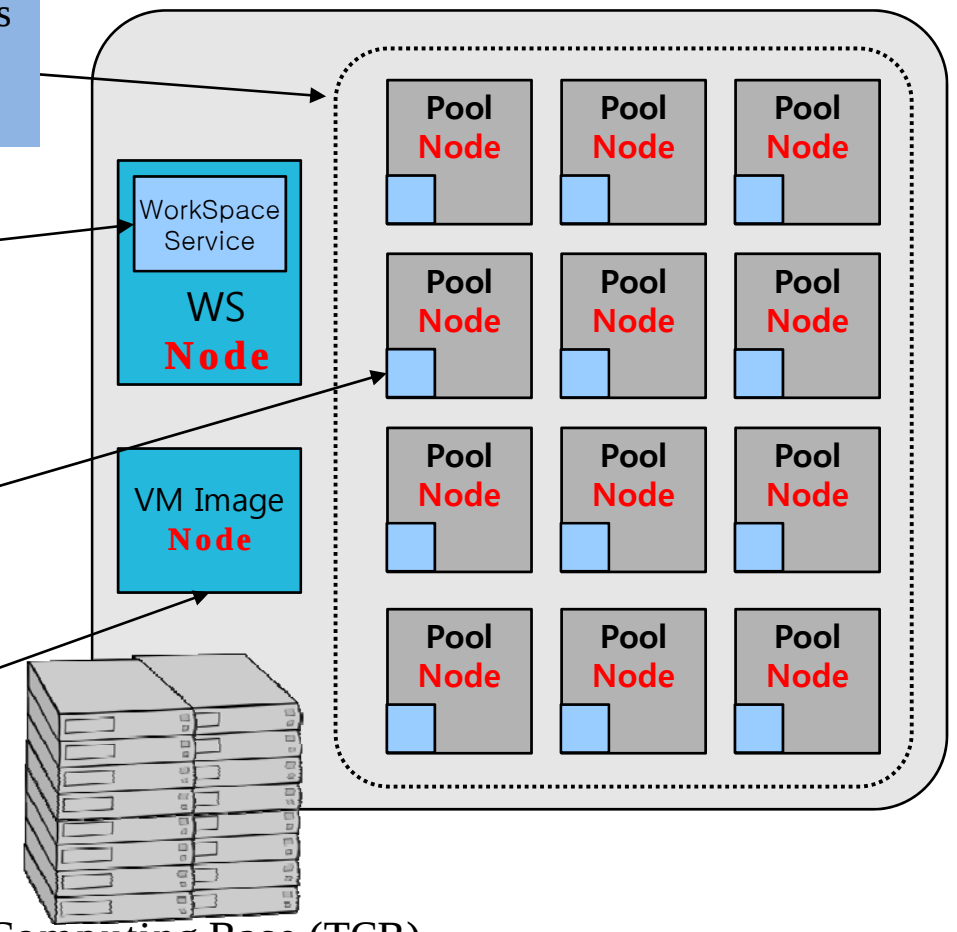
Nimbus Service Usage Scenario

The WS(Workspace) manages a set of nodes inside the TCB (typically a cluster). This is called the *node pool*.

The workspace service has a WSRF[10] frontend that allows users to deploy and manage virtual workspaces

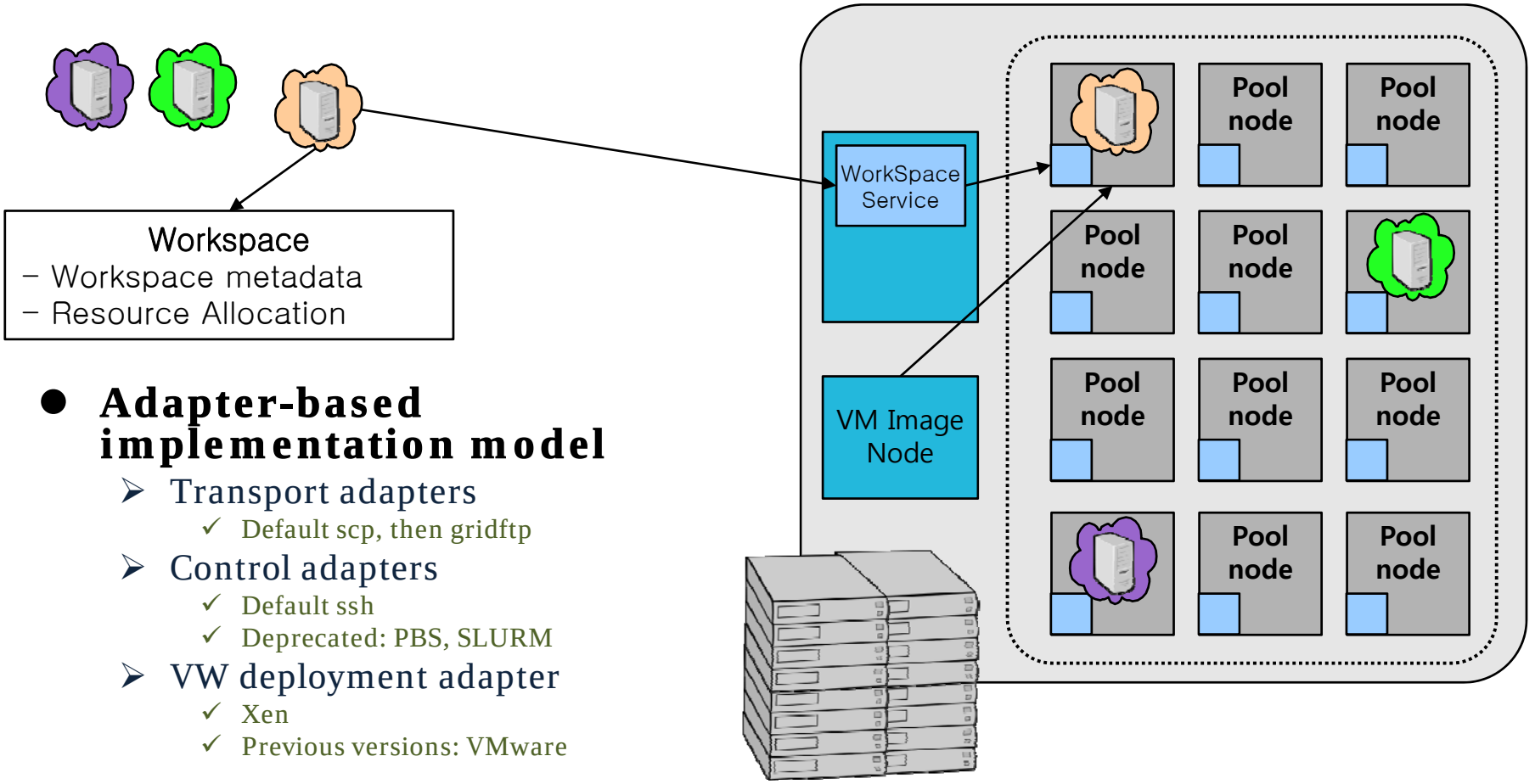
Each node must have a VMM (Xen) installed, along with the *workspace backend* (software that manages individual nodes)

VM images are staged to a designated image node inside the TCB



[10] Web Service Resource Framework

Nimbus Deploying Workspaces



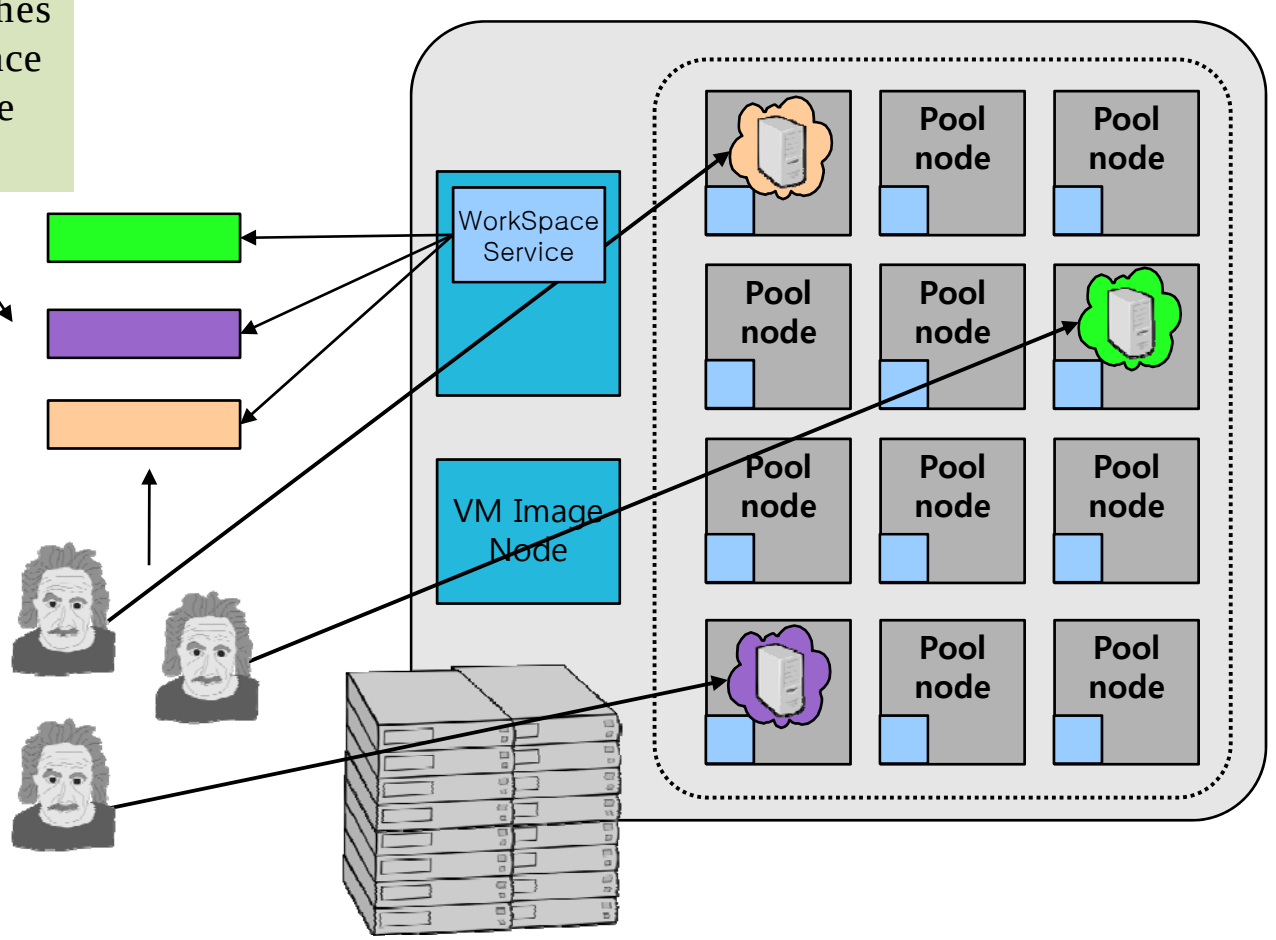
- **Adapter-based implementation model**
  - Transport adapters
    - ✓ Default scp, then gridftp
  - Control adapters
    - ✓ Default ssh
    - ✓ Deprecated: PBS, SLURM
  - VW deployment adapter
    - ✓ Xen
    - ✓ Previous versions: VMware

Nimbus Interacting with Workspaces

The workspace service publishes information on each workspace as standard WSRF Resource Properties.

Users can query those properties to find out information about their workspace (e.g. what IP the workspace was bound to)

Users can interact directly with their workspaces the s ame way the would with a p hysical machine.



Nimbus Toolkit Issue : Virtualizing Network

- **Motivation**
  - Presense of **firewall and NATs** in the current IPv4 Internet limit the connectivity among VM host servers and deployed VMS, especially when crossing LAN boundaries
- **Solution (See the next Page)**
  - Nimbus Toolkit combined with VPN Technology

Nimbus Toolkit Issue : Cloud Interoperability

- **Interoperability between Amazon EC2 Cloud <-> Nimbus Cloud**
  - E.g., STAR app EC2->Science Cloud and vice versa is very easy
  - Rough consensus on the interfaces needed to provision resources in the cloud
- **OGF gridvit-wg**
  - Chairs: Erol Bozak, Wolfgang Reichert
  - Define the requirements for integration of Grid architecture with system virtualization platforms
  - Exploring the impact of virtualization on Grid use cases
  - Exploring the relationship with standards (DMTF, etc.)

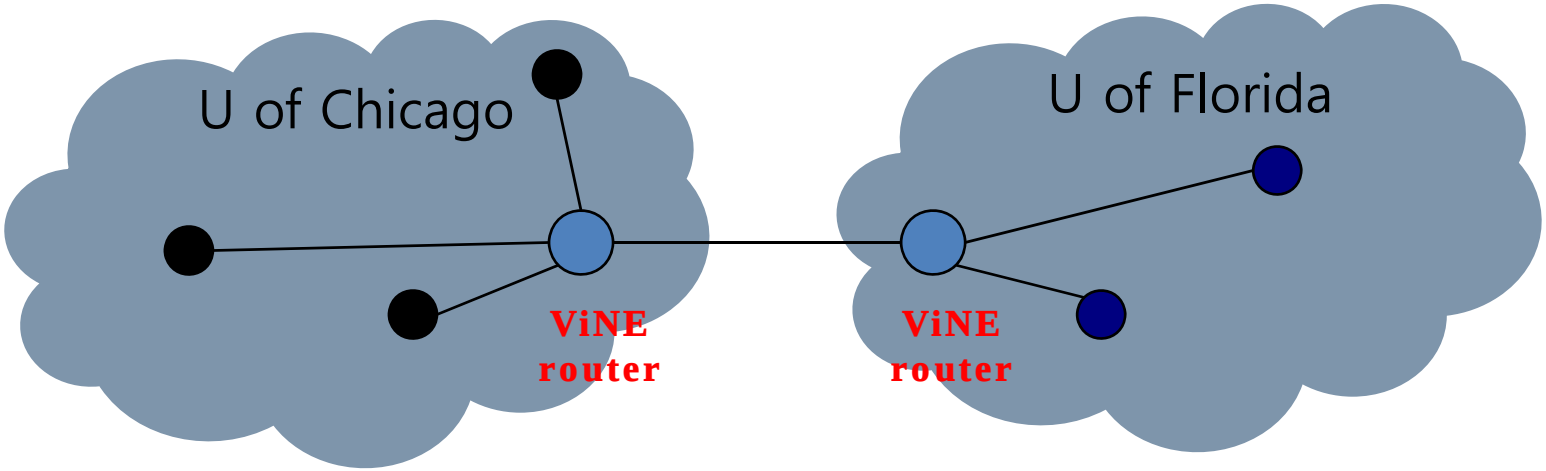
Case Study III.
A Virtual Network Architecture (ViNe)[11]

[11] M.Tsugawa, and J. Fortes, A Virtual Network(ViNe) Architecture for Grid Computing, Parallel and Distributed Processing Symposium, 2006, IPDPS 2006, 20th International

Motivation

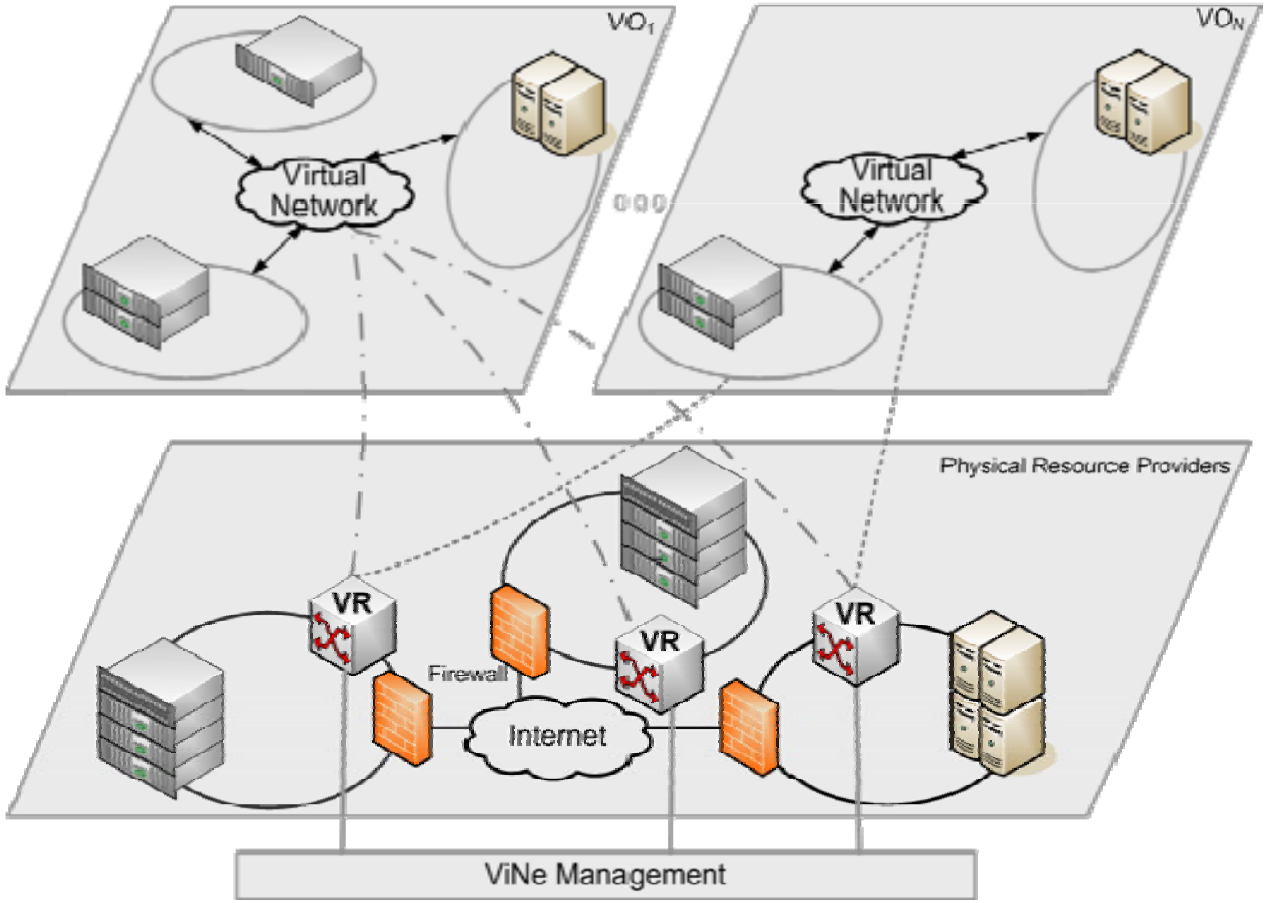
- **Motivation**
  - Internet is highly asymmetric
    - ✓ Private networks
    - ✓ Firewalls.
- **What does ViNe propose?**
  - General solution to the problem of symmetrically connecting resources in different administrative domains.
  - In addition to restoring symmetry, the approach allows, with low administration overhead, the inclusion of machines and networks in distinct computational grids.

Conceptual Diagram



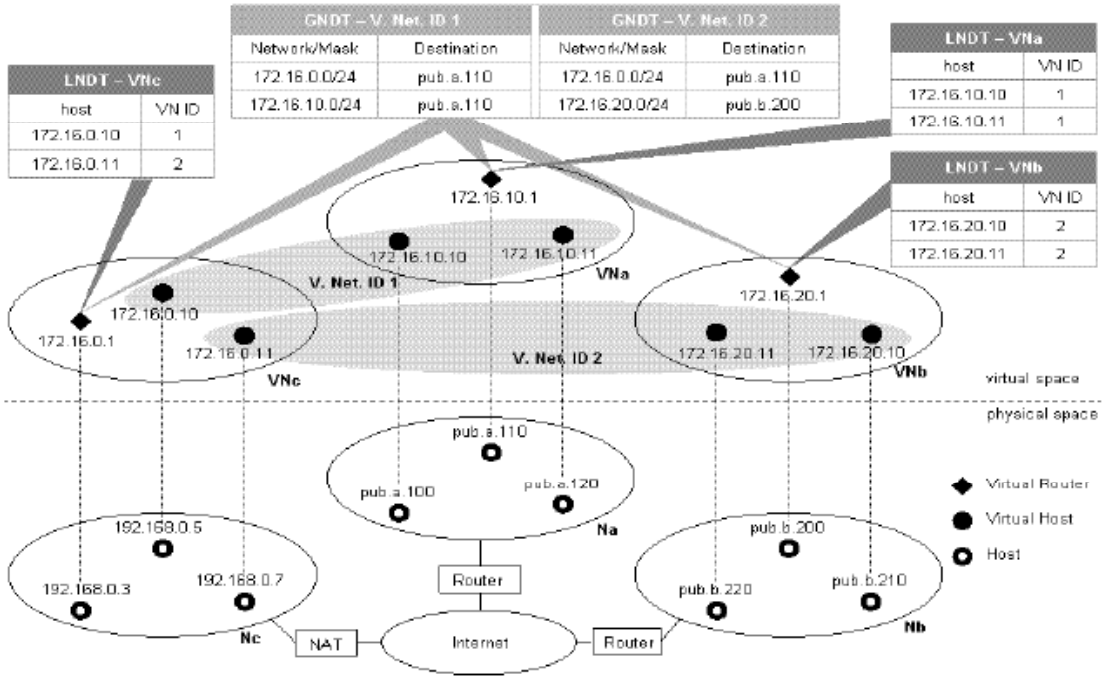
- Install ViNe router at local site (U of Chicago, U of Florida)
- CS research: investigate latency-sensitive apps
- Need access to distributed resources, and high level of privilege to run a ViNE router
- Virtual workspace: ViNE router + application VMs

Conceptual Diagram



Case Study ViNe : Architecture Components

- **Key Components**
  - Hosts : Virtual Network Interface
  - Virtual Address Space
  - Firewall and NAT
  - Virtual Routing Infrastructure
  - Multiple Isolated Virtual Network
  - ViNe Address Allocation



Thank You

Contact Information

Prof. Chan-Hyun Youn
School of Engineering and
Director of Grid Middleware Research Center
Information and Communications University

E-mail : chyoun@icu.ac.kr
Mobile Phone : 010-6219-5674
Homepage : http://lans.icu.ac.kr