Automatic Run-time Adaptation in Virtual Execution Environments

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Virtual Machine Grid Computing

Aim
Deliver arbitrary amounts of computational power to perform distributed and parallel computations

Traditional Paradigm

Grid Computing

Resource multiplexing using OS level mechanism

Problem 1:
Complexity from resource user’s perspective

Problem 2:
Complexity from resource owner’s perspective

Solution

New Paradigm

Grid Computing using virtual machines

Virtual Machines

What are they?

How to leverage them?
Virtual Machines

Virtual machine monitors (VMMs)

- Raw machine is the abstraction
- VM represented by a single image
- VMware GSX Server
The Simplified Virtuoso Model

User's LAN

Virtual networking ties the machine back to user's home network

Orders a raw machine

VM

Specific hardware and performance

Basic software installation available

Virtuoso continuously monitors and adapts
Virtual Networks

A machine is suddenly plugged into a foreign network. What happens?

- Does it get an IP address?
- Is it a routeable address?
- Does firewall let its traffic through? To any port?

VNET: A bridge with long wires
Measurement and Inference

Underlying network
- Topology
- Bandwidth
- Latency

Host and VM
- Size and compute capacities
- Size and compute demands

Application (VTTIF)
- Topology
- Traffic load

[Gupta et al. In submission]

[Gupta et al. LNCS 05]
Adaptation Mechanisms

VM Migration
- Third party migration schemes

Topology changes
- Overlay links
- Overlay forwarding rules
  [Sundararaj et al. LCR 04, HPDC 05]

Resource reservation
- Network
- CPU
  [Lange et al. HPDC 05]
  [Lin et al. GRID 2004]

VM Migration
- VM layer

Topology changes
- VNET daemons

Resource reservation
- Physical hosts
Generic Adaptation Problem In Virtual Execution Environments

• Goal:
  – VMs to Hosts mapping
  – Path to each 4-tuple
  – Meeting all demands within constraints
  – Such that
    • Sum of residual bottleneck bandwidth over each mapped path is maximized
Optimizing Objective functions

- Many possibilities

- Maximizing sum of residual bottleneck bandwidths over each mapped path
  - Intuition:
    - Leave the most room for application to increase performance

- Minimizing the residual bottleneck capacity
  - Intuition:
    - Increase room for other applications to enter system
Claim

• Wide spectrum of possibilities
  – Adaptation transparent to application
  – Application directed adaptation

• Claim
  – Adaptation using a single metric for a wide range of applications is possible and feasible
• For More Information
  – Prescience Lab (Northwestern University)
    • http://plab.cs.northwestern.edu
    • http://virtuoso.cs.northwestern.edu
• VNET is publicly available from
  • http://virtuoso.cs.northwestern.edu