Inter-Cloud Mobility of Virtual Machines
Cloud Computing 101

- Subscribe to virtual computing resources hosted on the network

- User Benefits:
  - Pay as you go
  - No upfront capital outlay
  - No hardware maintenance
  - Illusion of infinite computing resources available on demand

- Enablers:
  - More powerful hardware resources for less (Moore’s Law)
  - Virtualization
    - Resource sharing
    - Multi-Tenancy
  - Excess Bandwidth (Dotcom Bubble)
    - Remote access
    - Distributed Computing

- Public Clouds:
  - Amazon (EC2, S3)
  - Rackspace
  - Google

- Private Clouds:
  - VMWare VCloud
  - OpenStack
Cloud Insularity
- Autonomy
- Privacy
- Security

Cloud Federation
- Cloud Burst
- Load balancing
- Global Utility

Inter-Cloud VM Mobility
- Inter-Cloud Live VM Migration
- Internet Scale Virtual Application Network
Live VM migration

Same Cloud (state of the art)

- Between co-located hosts
  - Same subnet
  - Shared storage

Inter-Cloud (our contribution)

- Spans:
  - subnets
  - WAN
  - administrative boundaries

- Between
  - Anonymous hosts
  - Without shared storage

- Long Distance
Secure Inter-Cloud Migration Channel

Migration with Non-Shared Storage

- **Copy Modes**
  - Whole disk
  - Copy on Write (CoW) – delta copy only

- **Open source contributions**
  - QEMU-KVM 0.12.1
  - libvirt 0.8.2
Virtual Application Networks (VANs)

- Fully isolated virtual application networks
  - Complex Application with multiple components, e.g. 3 tier
  - Supports multi-tenancy
- Host Based Solution with Dynamic Routing
- A Distributed Virtual Network
- Offers L2-like network services
Location independent virtual networks

- Site Proxies enable cloud insularity
Internet Scale Network Virtualization

- Zero configuration: created, extended and migrated on-demand
Internet Scale Network Virtualization

- Zero configuration: created, extended and migrated on-demand
Internet Scale Network Virtualization

- Zero configuration: created, extended and migrated on-demand
Inter-Cloud Mobility Empirical Study

**IBM Israeli Evaluation**
- Haifa
- Tel Aviv
- Conclusions
  - Time to migrate is function of rate or change and CoW size (not VM size)
  - Co-located VM network performance not adversely affected by migration

<table>
<thead>
<tr>
<th>Migration Method</th>
<th>10 MB</th>
<th>100 MB</th>
<th>1 GB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shared Storage</td>
<td>0.06s</td>
<td>15.00s</td>
<td>76.00s</td>
</tr>
<tr>
<td>Our Solution</td>
<td>0.03s</td>
<td>05.10s</td>
<td>15.00s</td>
</tr>
</tbody>
</table>
Cloud Federation Load Balancing

- Reservoir EU Project Federation
  - Thales, France
  - Umea University, Sweden
  - UNIME University, Italy

- Use case
  - Thales cloud deploys SAP but lacks resources
  - Migrates Sun Grid Engine VMs to UMEA

- Measurements
  - 30-60 second migration time
  - Inter-cloud network latency 55 milliseconds
  - 0.5 millisecond network latency co-located VMs