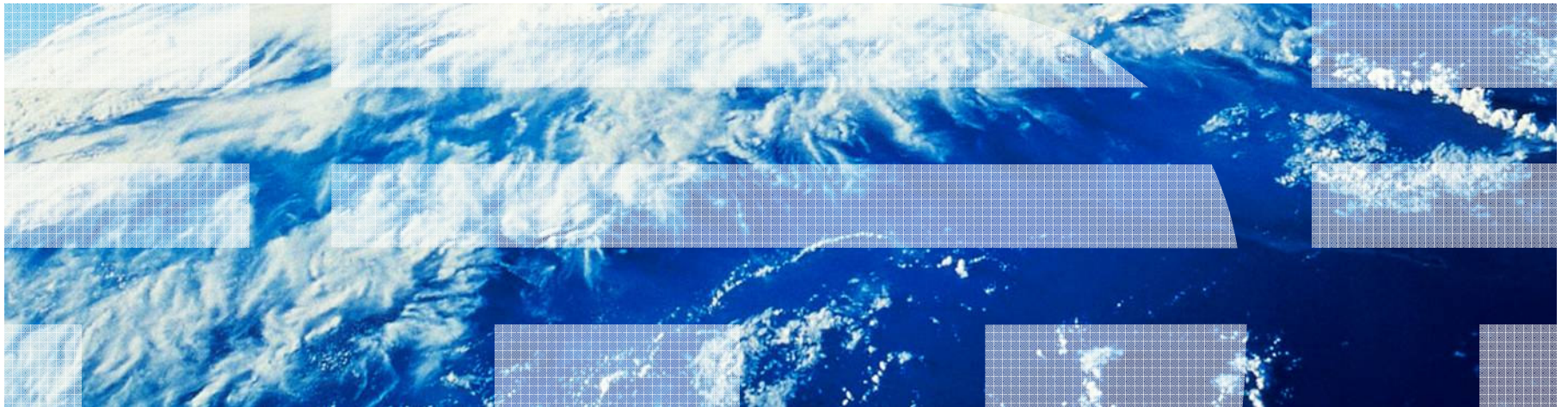


Kenneth Nagin, David Hadas, Zvi Dubitzky, Alex Glikson, Irit Loy, Benny  
Rochwerger, Liran Schour  
IBM Research Lab in Haifa (HRL)

---



# Inter-Cloud Mobility of Virtual Machines

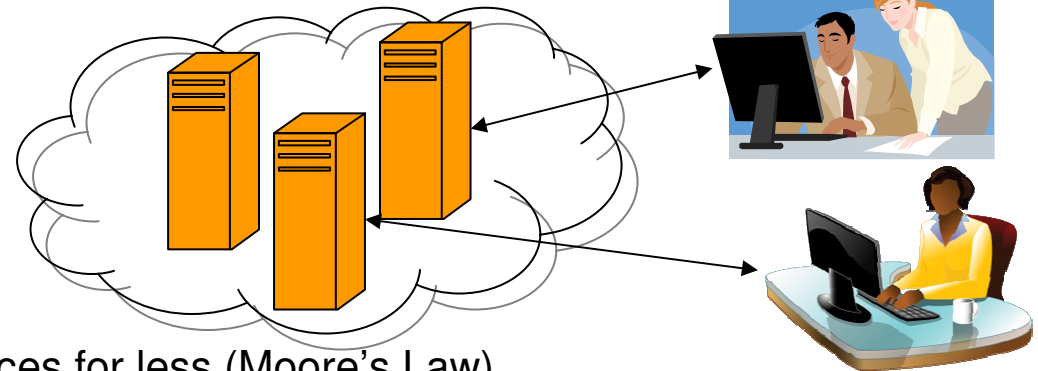


# Cloud Computing 101

- 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:

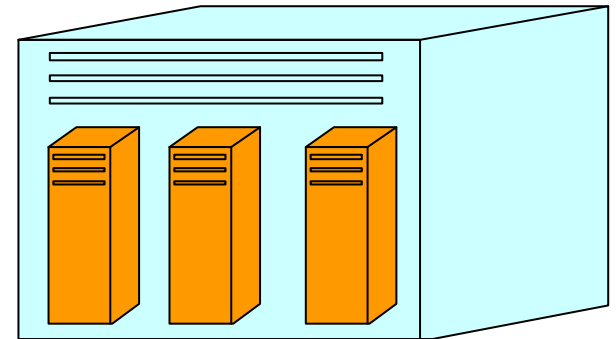
- More powerful hardware resources for less (Moore's Law)
- Virtualization
  - Resource sharing
  - Multi-Tenancy
- Excess Bandwidth (Dotcom Bubble)
  - Remote access
  - Distributed Computing

- Public Clouds:

- Amazon (EC2, S3)
- Rackspace
- Google

- Private Clouds:

- VMWare VCloud
- OpenStack

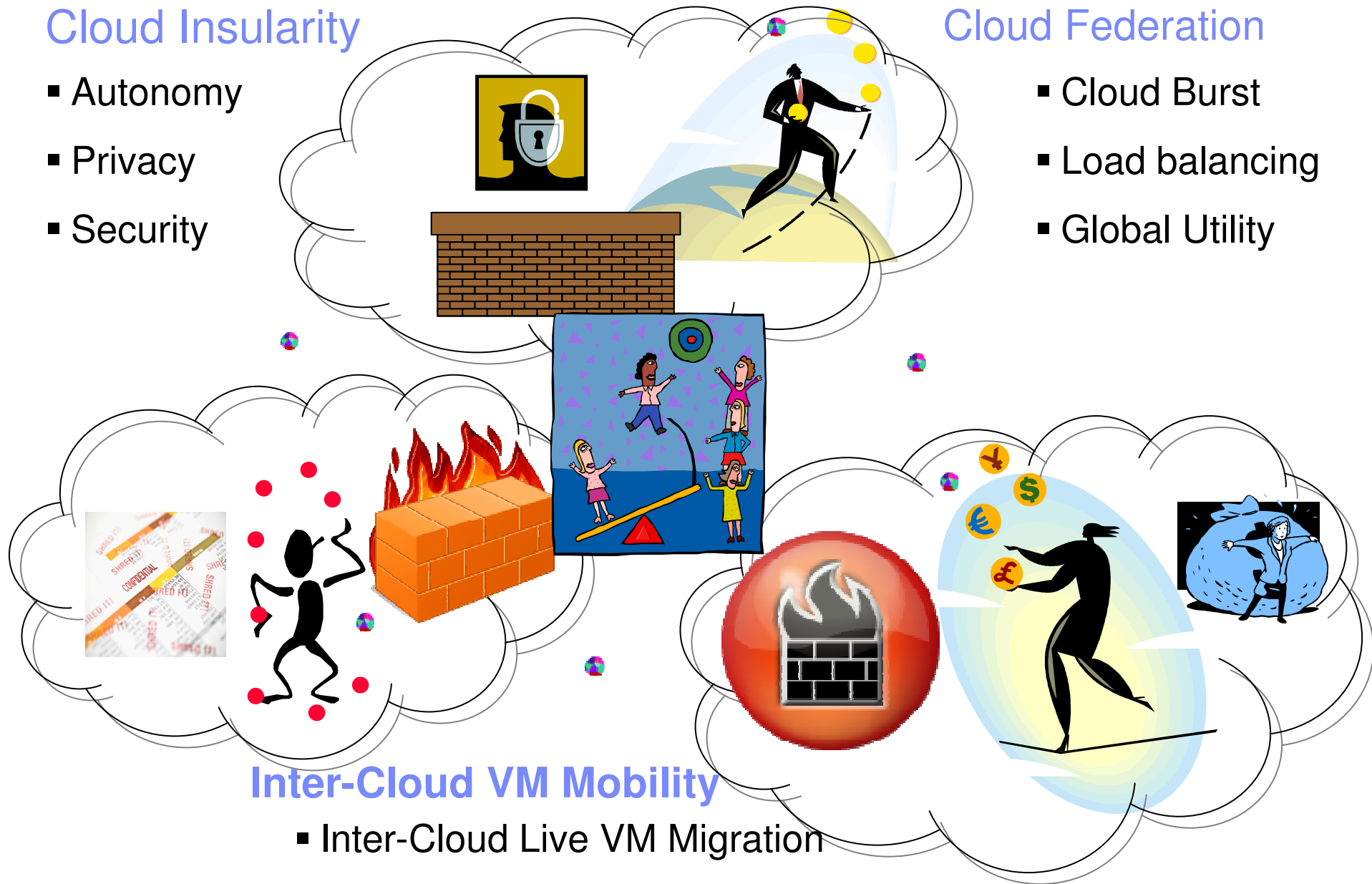


## Cloud Insularity

- 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

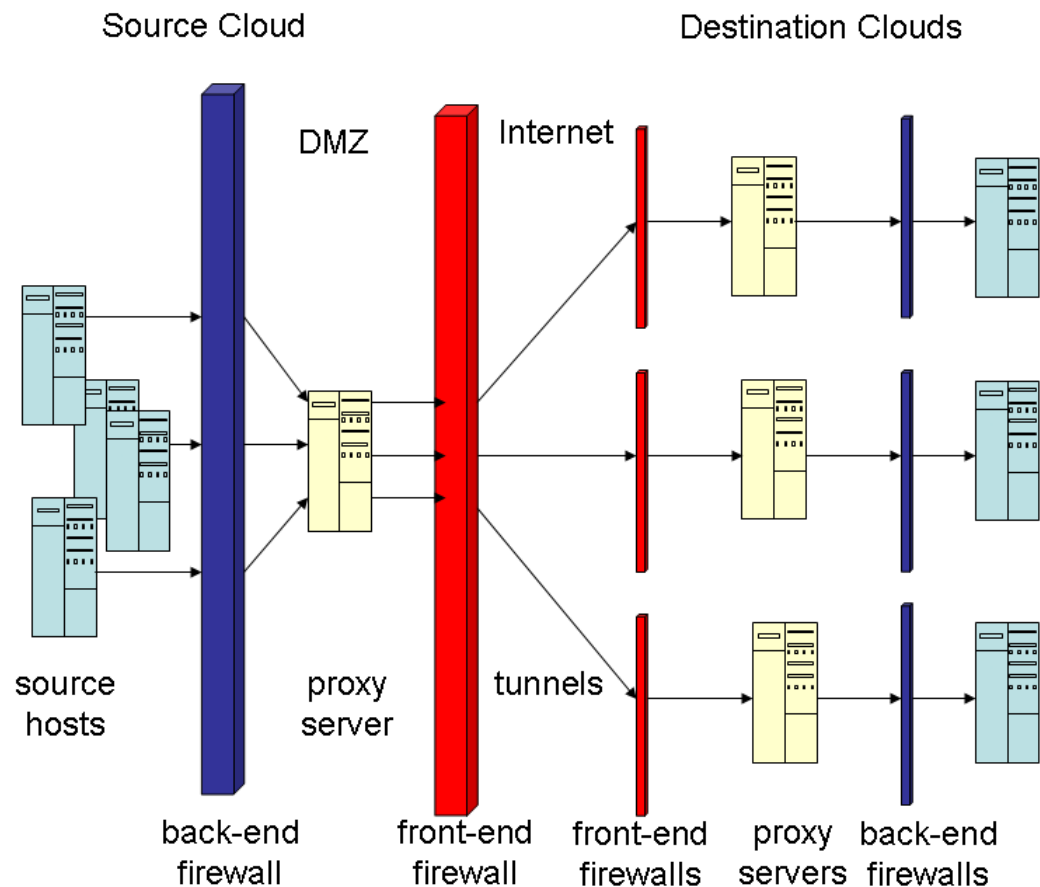
# Live VM migration

## Same Cloud (state of the art)

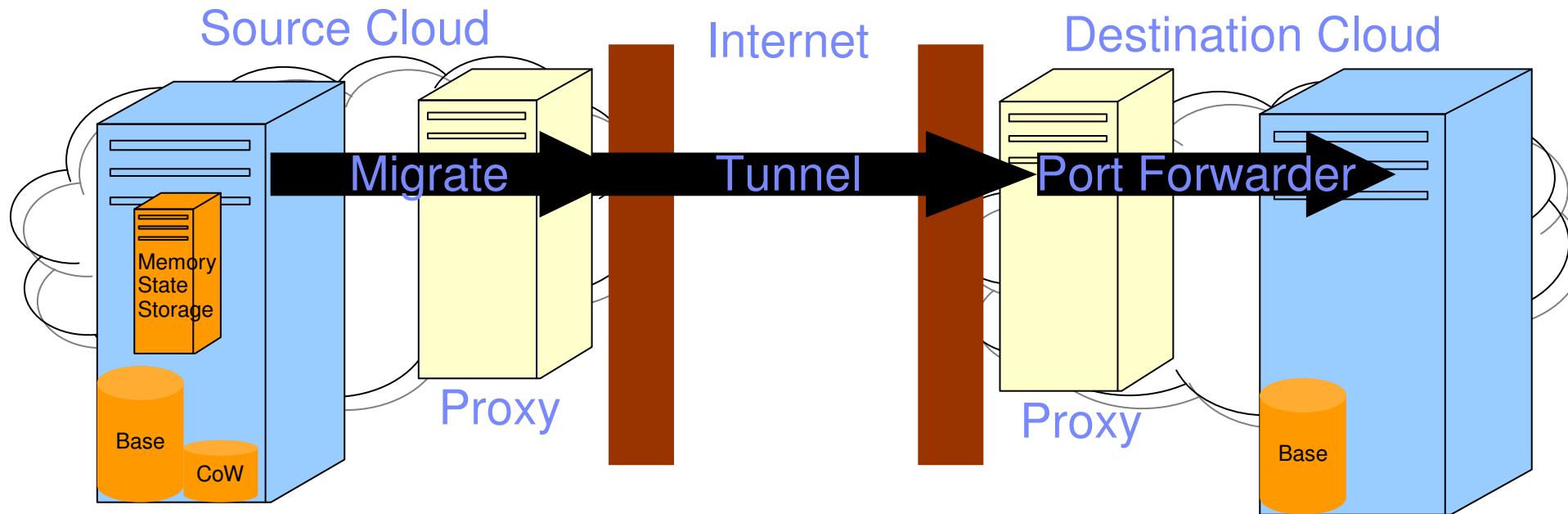
- Between co-located hosts
  - Same subnet
  - Shared storage

## Inter-Cloud (our contribution)

- Spans:
  - subnets
  - WAN
  - administrative boundaries
- Between
  - Anonymous hosts
  - Without shared storage
- Long Distance



# Secure Inter-Cloud Migration Channel

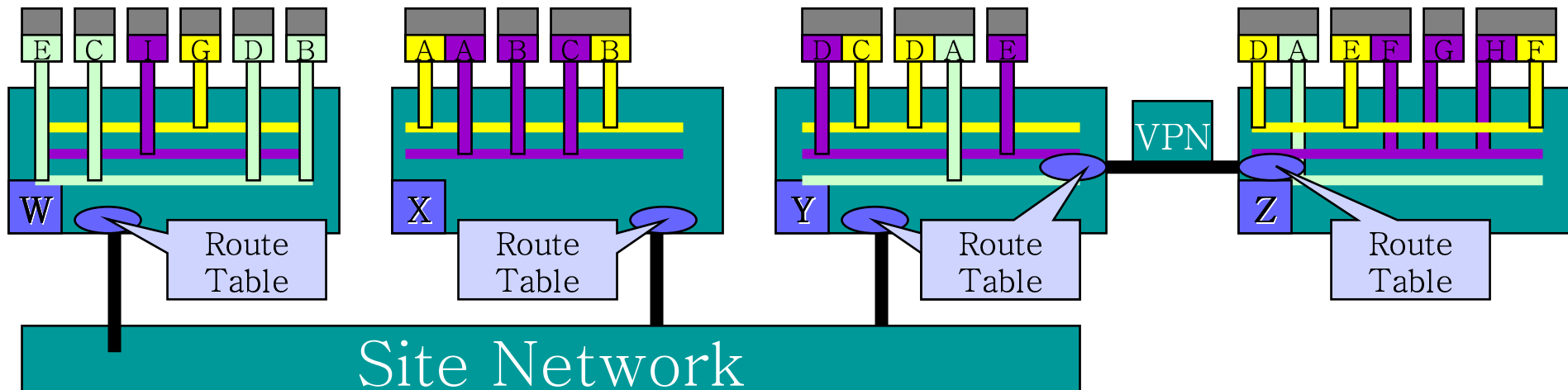


## Migration with Non-Shared Storage

- Copy Modes
  - Whole disk
  - Copy on Write (CoW) – delta copy only
- Open source contributions
  - QEMU-KVM 0.12.1
  - libvirt 0.8.2

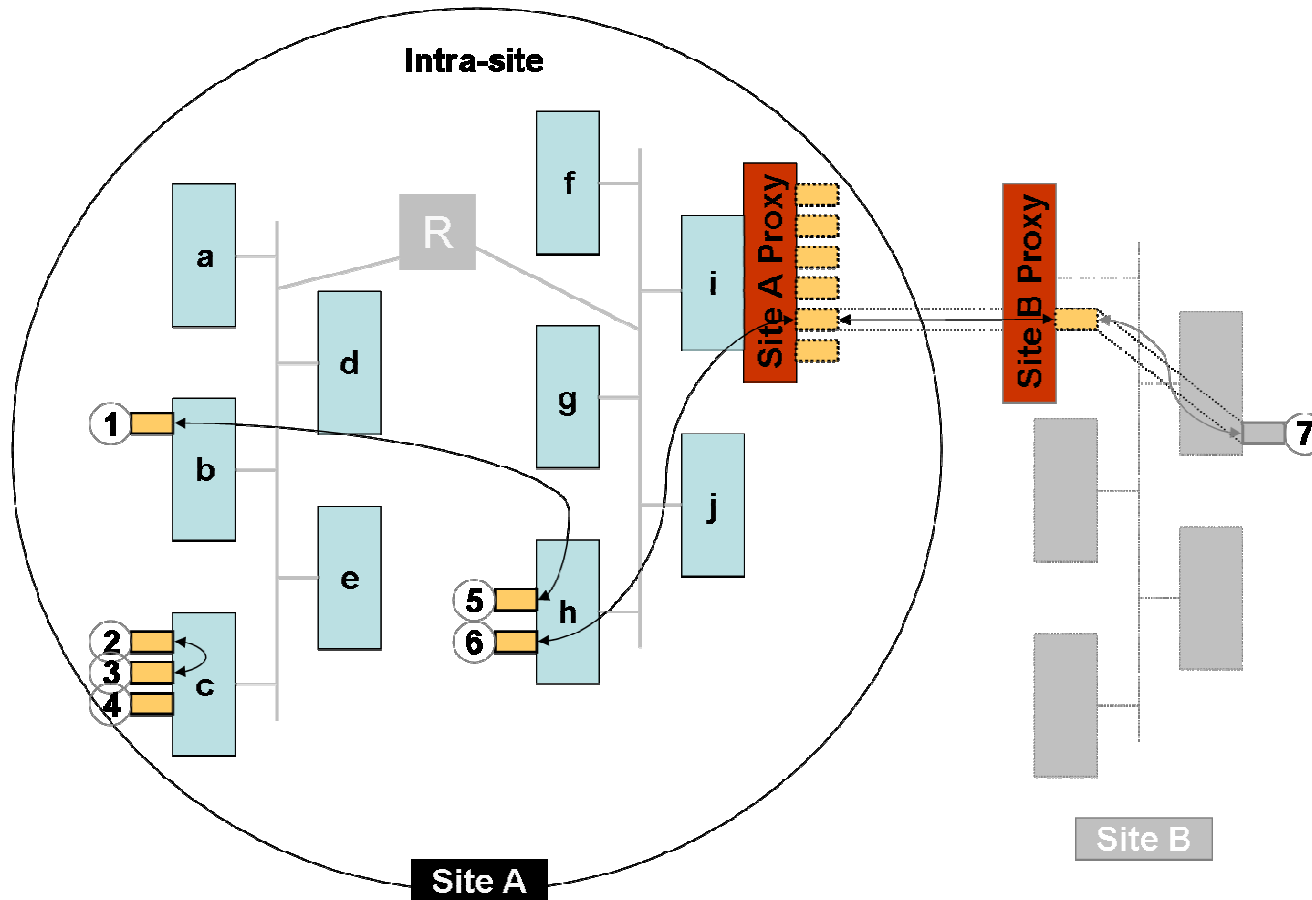
## Virtual Application Networks (VANs)

- 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



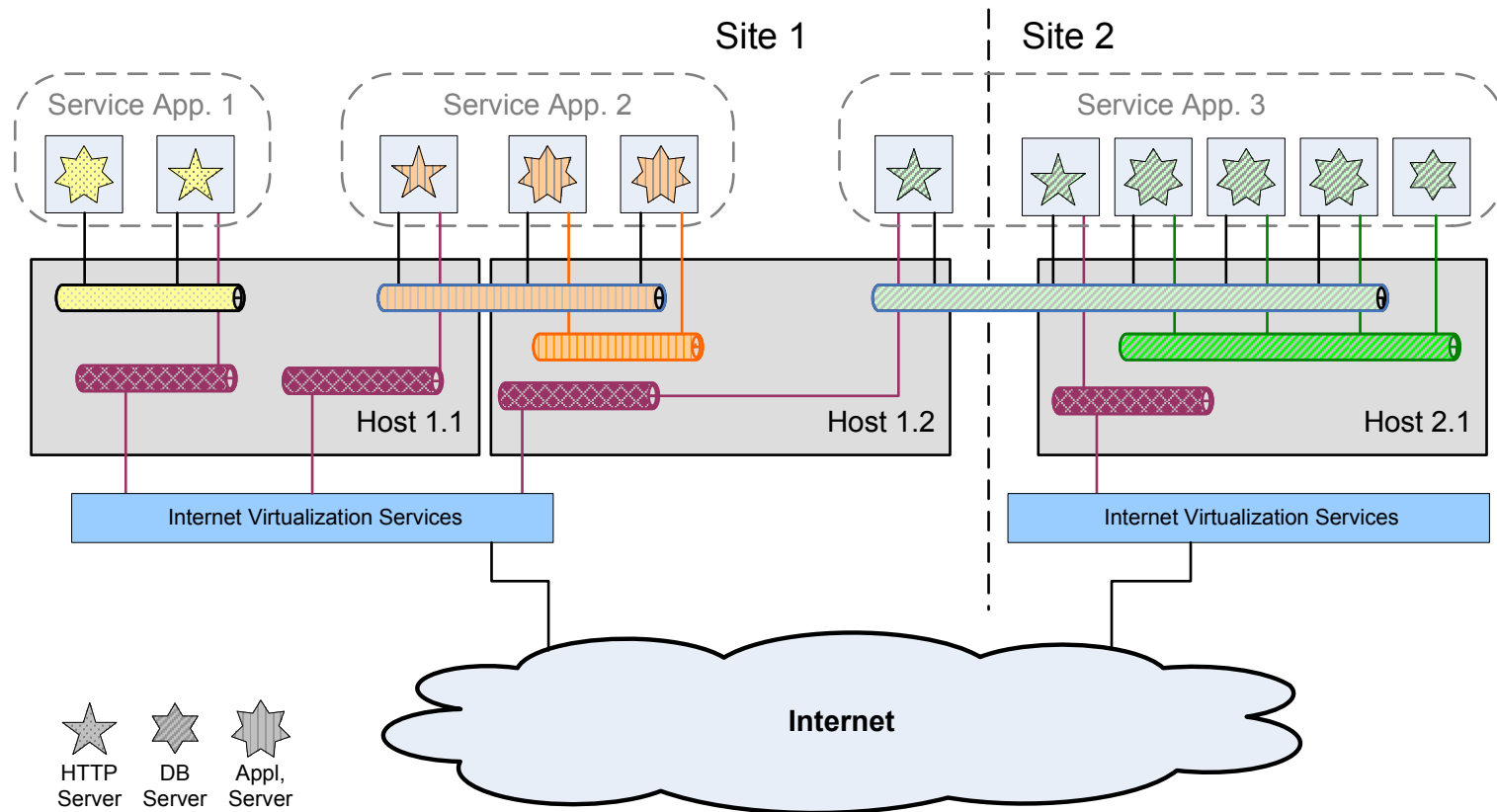
# Location independent virtual networks

- Site Proxies enable cloud insularity



# Internet Scale Network Virtualization

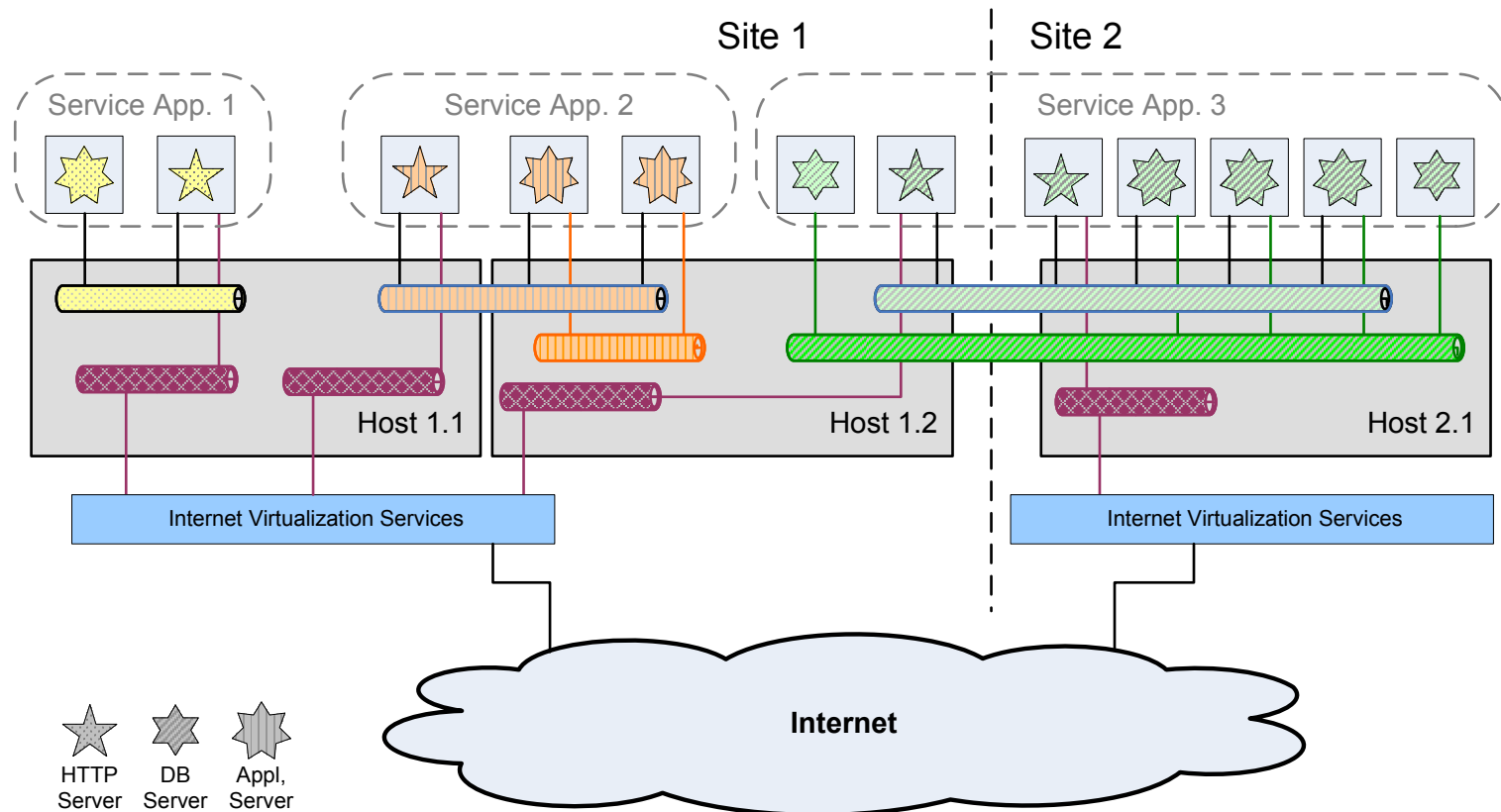
- Zero configuration: created, extended and migrated on-demand





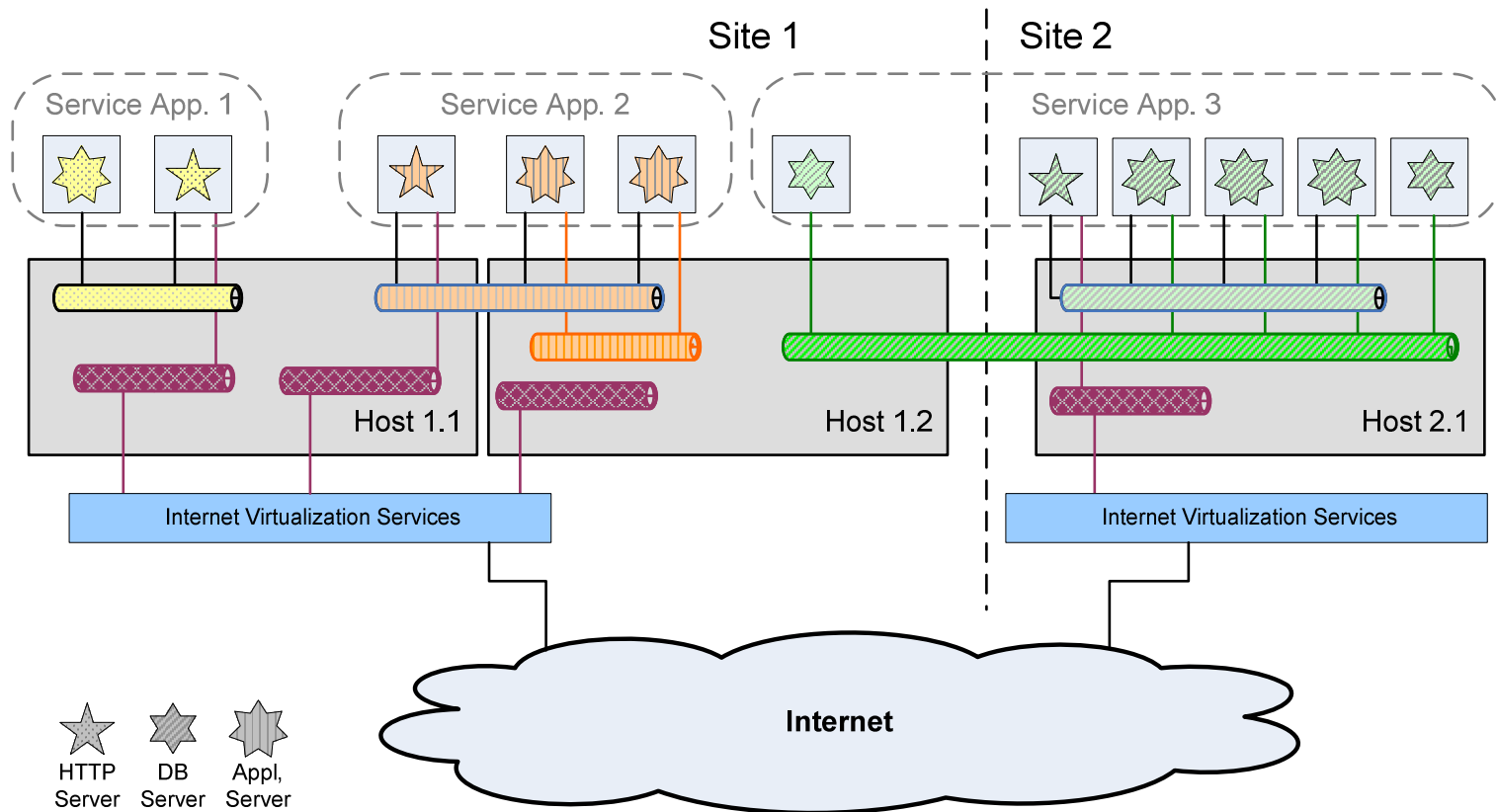
# Internet Scale Network Virtualization

- Zero configuration: created, extended and migrated on-demand



# Internet Scale Network Virtualization

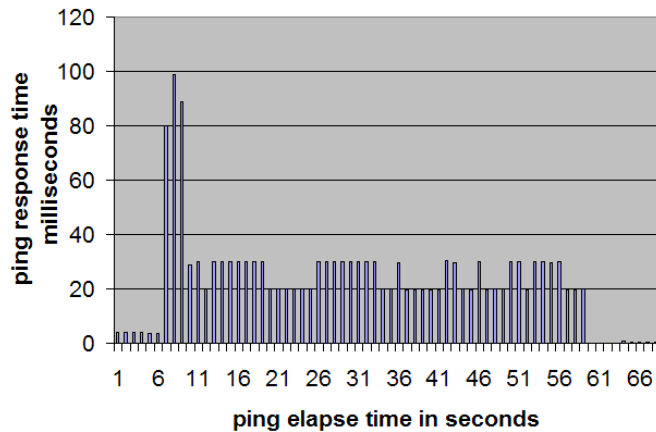
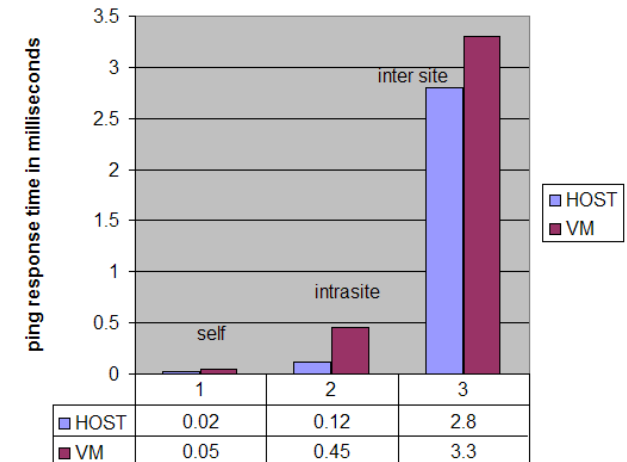
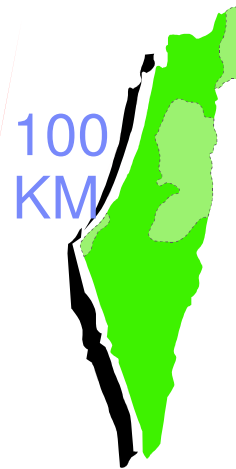
- Zero configuration: created, extended and migrated on-demand



# 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



I/O Access after migrated

Migration Method	10 MB	100 MB	1 GB
Shared Storage	00.06s	15.00s	76.00s
Our Solution	00.03s	05.10s	15.00s

# 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

