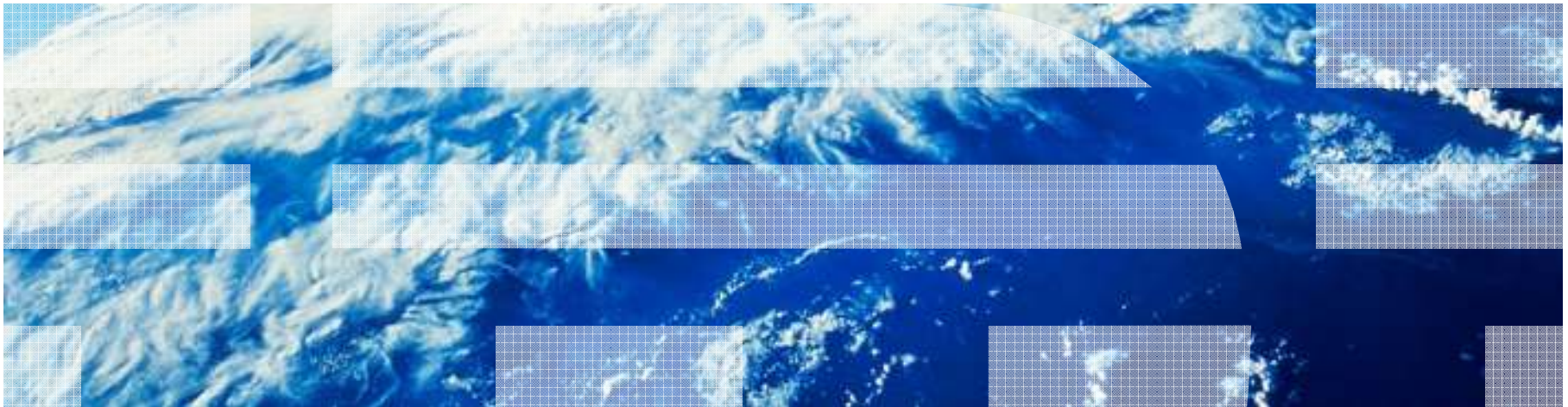




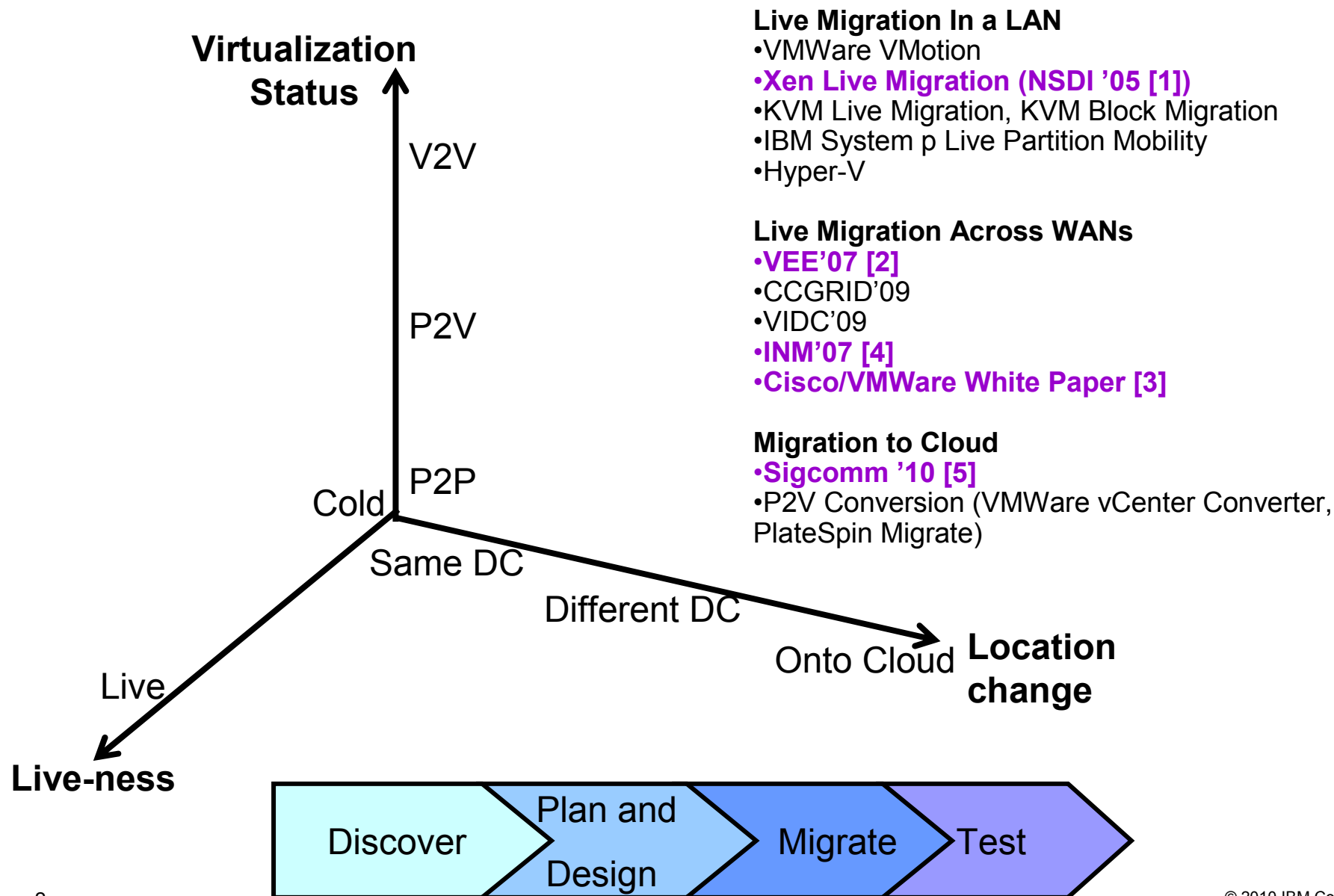
RESEARCH

# Columbia University COMS W6998-6 Virtual Machine Migration

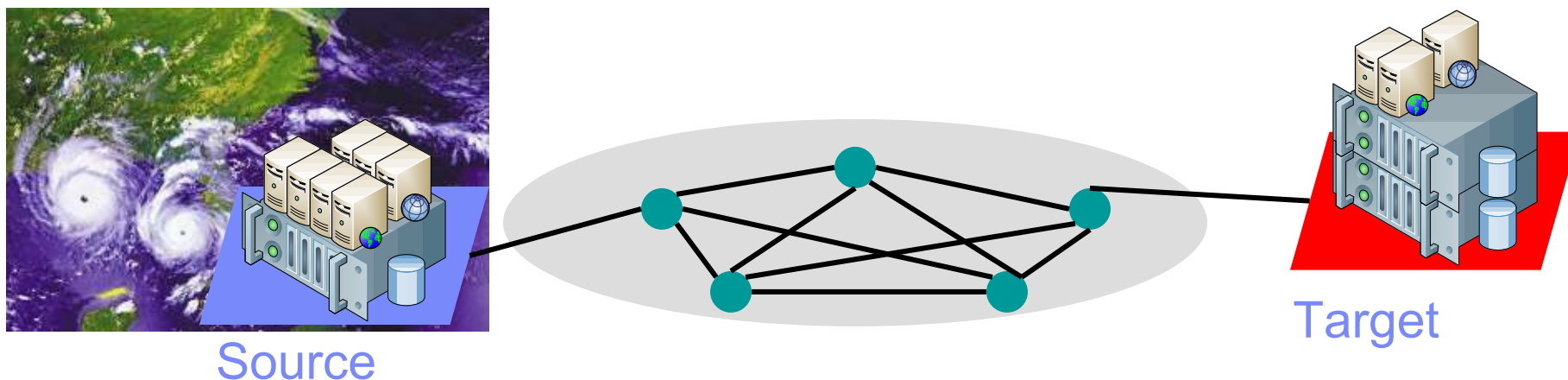
Kay Sripanidkulchai, IBM T.J. Watson Research Center  
October 13, 2010



## Migration Technologies and Process Steps



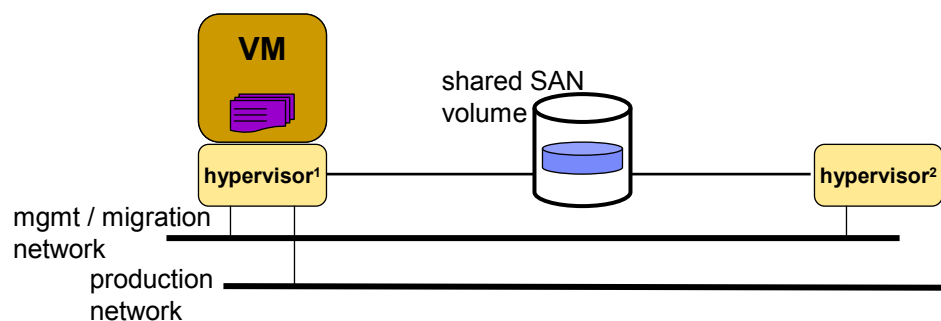
## Virtual Machine Migration Use Cases



- Disaster avoidance: migrate virtual machines out of hurricane-prone data center to a more stable data center during hurricane season
- Dynamic resource management, on-the-fly infrastructure maintenance with low customer impact
- Spill-over from private to public cloud, load-sharing/off-loading between clouds
- Migrate between test and production environments
- Data Center consolidation and relocation

## Live memory migration capabilities in the LAN

Migrate memory, register, and configuration files of a VM from one hypervisor to another hypervisor while the VM is running.



Live Migration Requirements		
	LAN (mature)	
Network	Migrated VM uses same IP address	
	High bandwidth, short delay, stable	
Storage	Shared storage	

# Xen Live Memory Migration

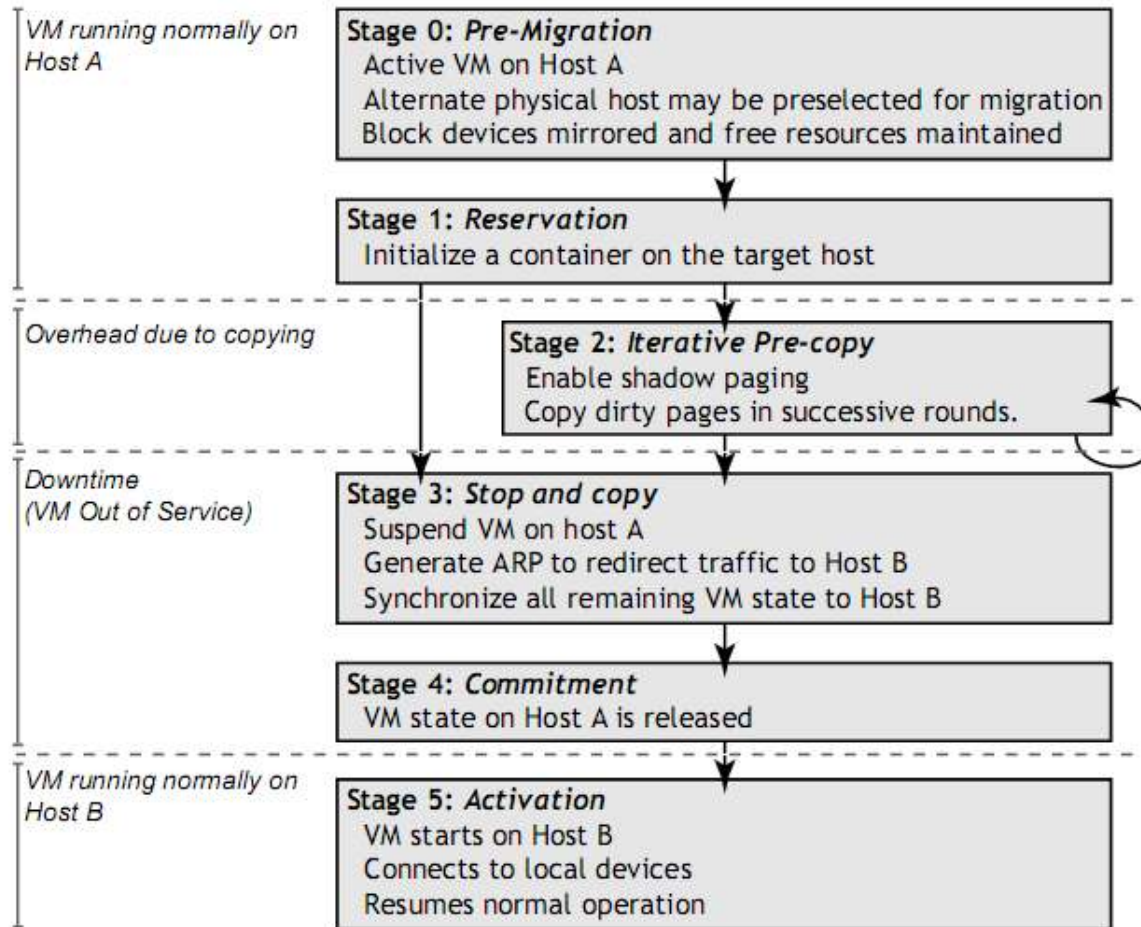


Figure 1: Migration timeline

From [ NSDI '05]

# How long does it take to migrate a running VM? What is the impact on running applications?

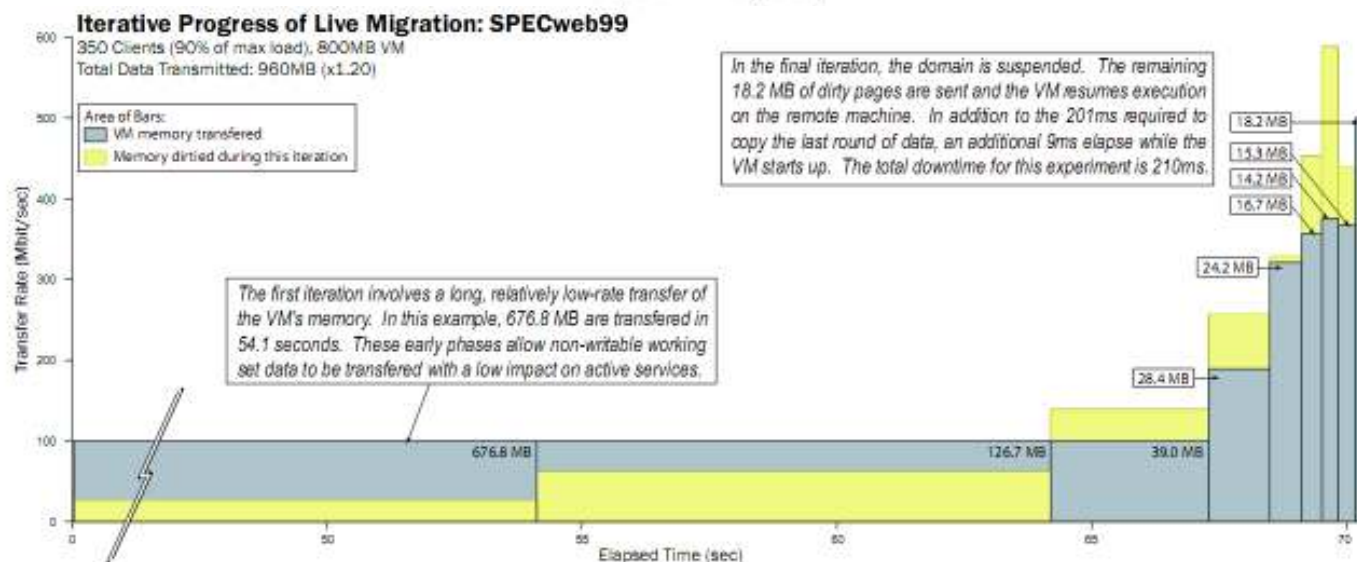
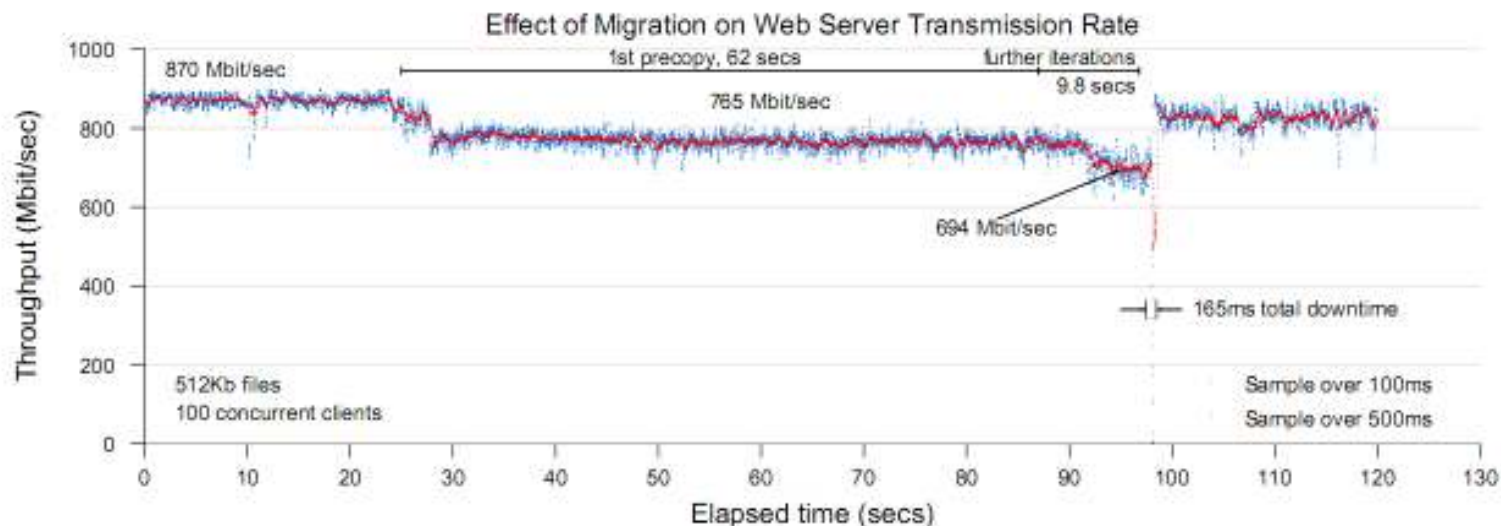
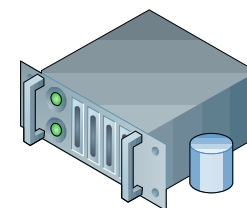
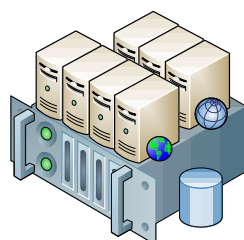
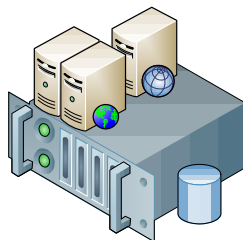
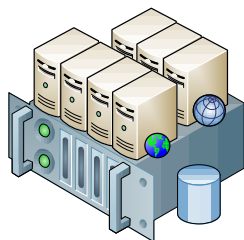


Figure 9: Results of migrating a running SPECweb VM.

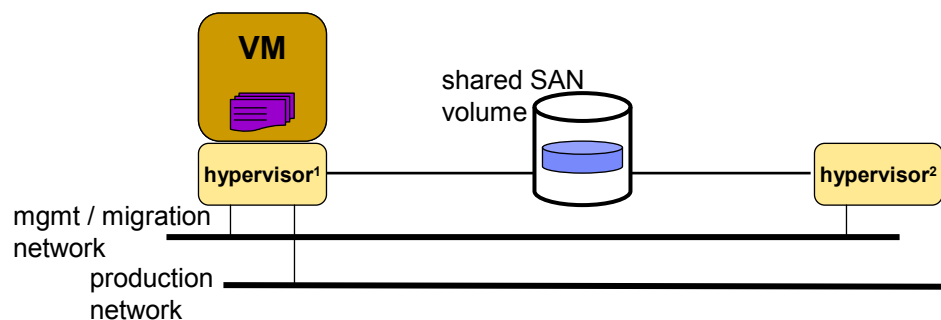
# Planning when to migrate, what to migrate, where to migrate to?



## Technical challenges for live migration across the wide area

### LAN Live Memory Migration

Migrate memory, register, and configuration files of a VM from one hypervisor to another hypervisor while the VM is running.

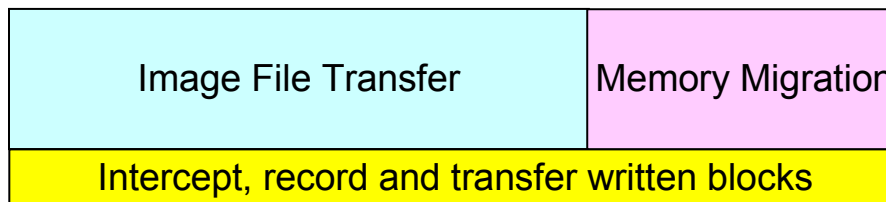


Live Migration Requirements		
	LAN (mature)	WAN (not commercially available)
Network	Migrated VM uses same IP address	May require change of IP address
	High bandwidth, short delay, stable	Lower bandwidth, longer delays, shared network
Storage	Shared storage	No shared storage

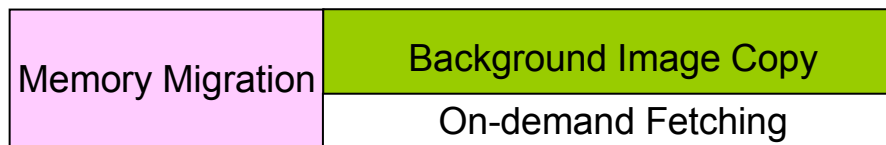


## Pre-copy vs. post-copy

Pre-copy  
 “pre-copy the image,  
 then transfer the  
 memory” VEE '07 [2]



Post-copy  
 [6,7]



Pre+Post-copy [8]

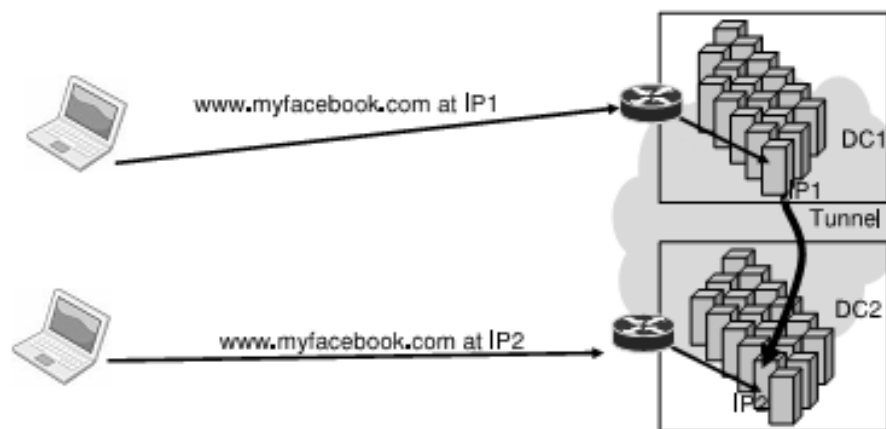


Pros and Cons?

## Networking issues: How can client connections continue to function after wide area migration?

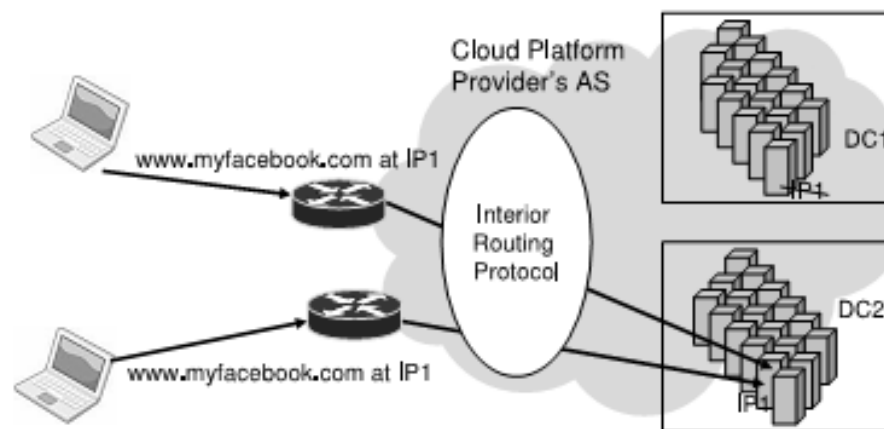
### Scenario 1: Assuming VM undergoes IP address changes

- Dynamic DNS
- Tunneling



### Make VM keep its old IP address

- LAN extensions over the wide area (VPN, VLAN, VPLS/MPLS)
- Mobile IP



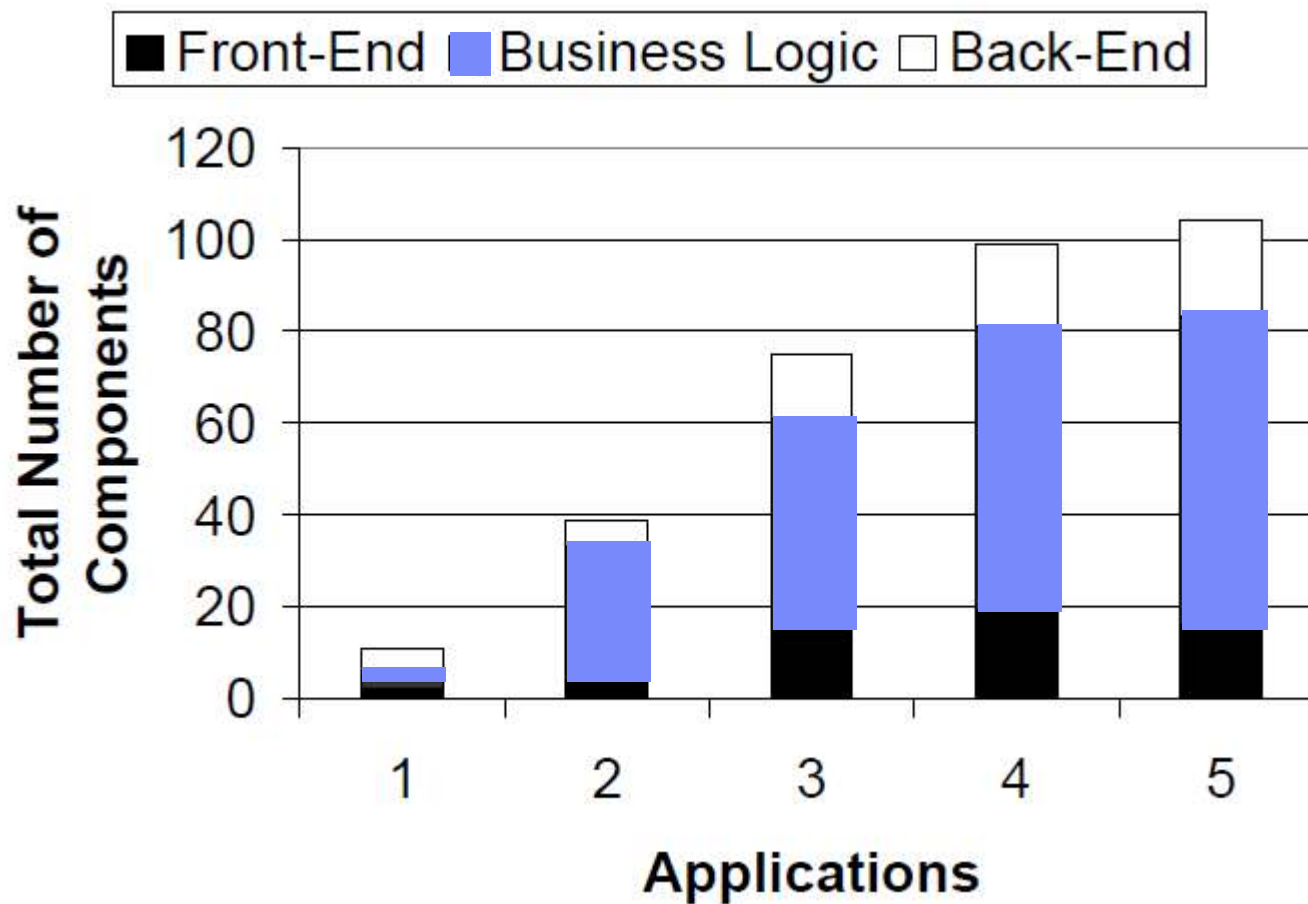
## Live migration performance over the wide area [VEE '07]

		scp	rsync	Our system
LAN	Migration time (s)	148.32	228	206.79
	Disruption time (s)	148.32	72	3.12
WAN	Migration time (s)	4585	2160	3777
	Disruption time (s)	4585	279	67.96

**Table 2.** Comparison with freeze-and-copy approaches, with HTTP traffic carried over the secondary network.

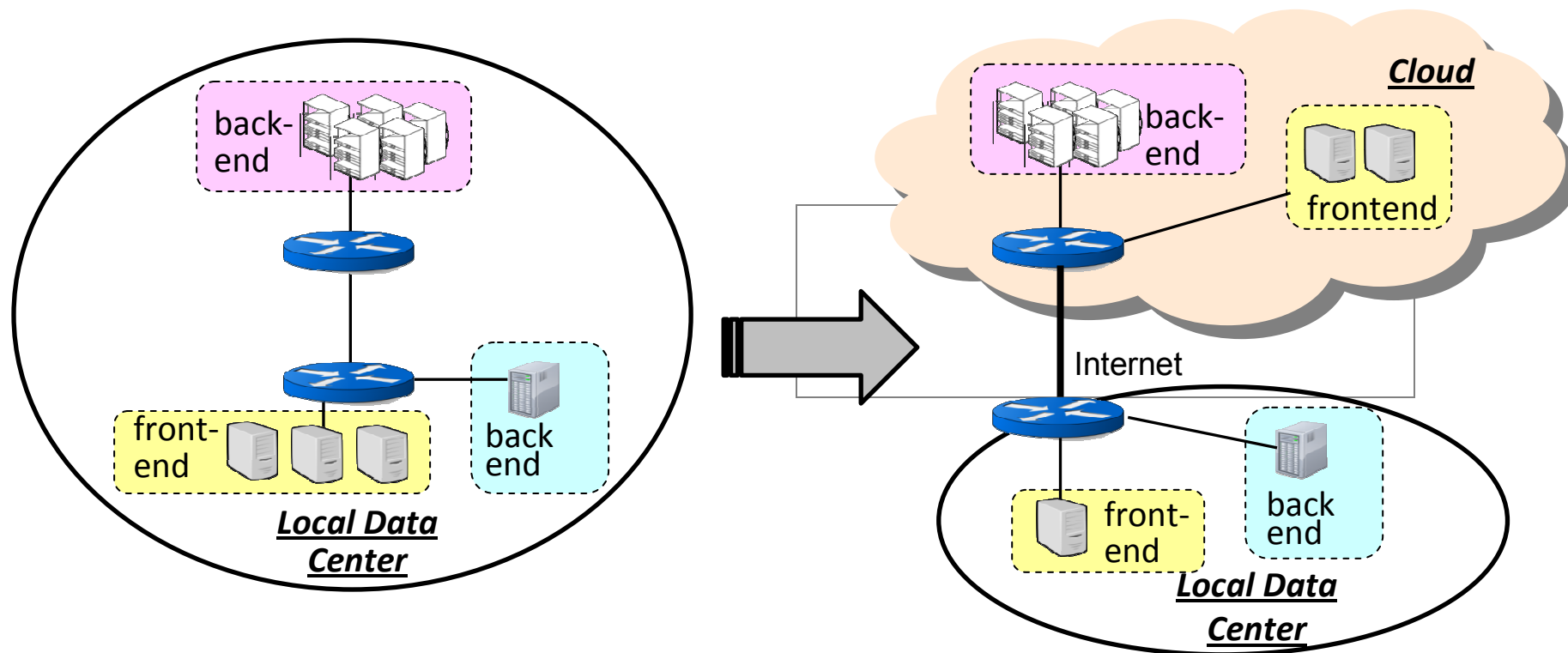
What can we do to improve this?

## Planning migrations to the cloud [Sigcomm'10]



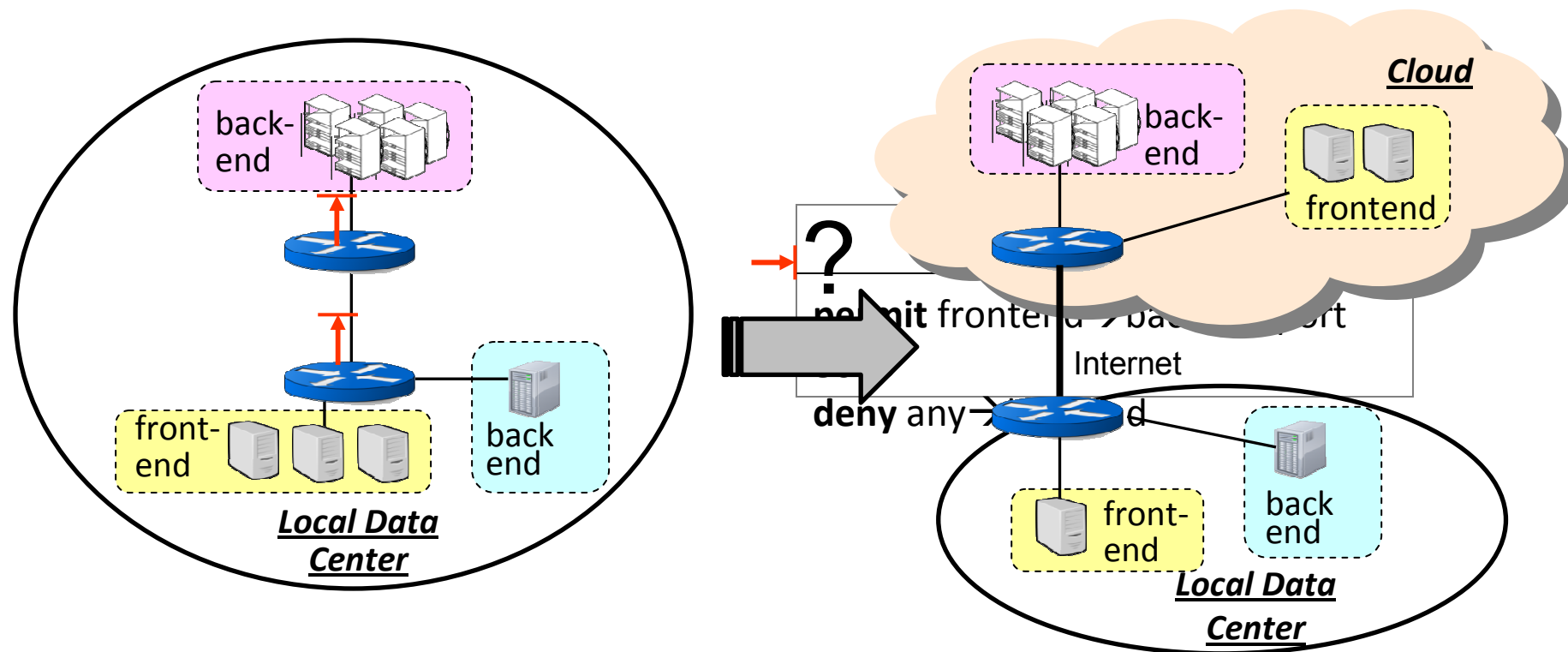
## Planning hybrid cloud layouts

- Cost savings, Application response times, Bandwidth costs
- Scale and complexity of enterprises applications



## Other migration considerations such as migrating security policies

- Security most important initiative for 83% of surveyed operators
- Security policies often realized using Access Control Lists (ACLs)
- Typical to see hundreds of firewall contexts, ACLs with hundreds of rules



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## Reference Material

- Reading Materials:

1. C. Clark, K. Fraser, S. Hand, J. G. Hansen, E. Jul, C. Limpach, I. Pratt, and A. Warfield. Live Migration of Virtual Machines, NSDI 2005.

2. Robert Bradford, Evangelos Kotsovinos, Anja Feldmann, Harald Schiöberg. Live Wide-Area Migration of Virtual Machines Including Local Persistent State, VEE 07.

3. Virtual Machine Mobility with VMware VMotion and Cisco Data Center Interconnect Technologies, Cisco White Paper, 2009.

- Presentation Papers:

4. K. Ramakrishnan; Prashant Shenoy; Kobus van der Merwe, Live Data Center Migration across WANs: A Robust Cooperative Context Aware Approach, INM 2007

5. Mohammad Hajjat, Xin Sun, Yu-Wei Sung, Dave Maltz, Sanjay Rao, Kunwadee Sripanidkulchai and Mohit Tawarmalani. Cloudward Bound: Planning for Beneficial Migration of Enterprise Applications to the Cloud, Sigcomm 2010.

## Other papers

- 6. Takahiro Hirofuchi, Hidemoto Nakada, Hirotaka Ogawa, Satoshi Itoh, and Satoshi Sekiguchi. A live storage migration mechanism over wan and its performance evaluation. In VIDC'09: Proceedings of the 3rd International Workshop on Virtualization Technologies in Distributed Computing, Barcelona, Spain, 2009.
- 7. Takahiro Hirofuchi, Hirotaka Ogawa, Hidemoto Nakada, Satoshi Itoh, and Satoshi Sekiguchi. A live storage migration mechanism over wan for relocatable virtual machine services on clouds. In CCGRID'09: Proceedings of the 2009 9<sup>th</sup> IEEE/ACM International Symposium on Cluster Computing and the Grid, Shanghai, China, 2009.
- 8. Yingwei Luo, Binbin Zhang, Xiaolin Wang, Zhenlin Wang, Yifeng Sun, and Haogang Chen. Live and Incremental Whole-System Migration of Virtual Machines Using Block-Bitmap. In IEEE International Conference on Cluster Computing, 2008.