

Traffic-Sensitive Live Migration of Virtual Machines

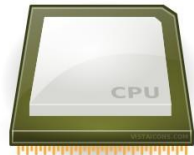
Umesh Deshpande
Computer Science, Binghamton University

Dr. Kate Keahey
Mathematics and Computer Science Division,
Argonne National Lab

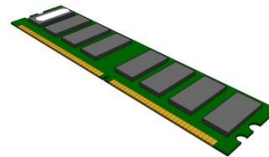
Contact: umesh.deshpande@binghamton.edu

Background: Live VM Migration

- Migration of a running Virtual Machine between hosts
- Transfer



CPU states

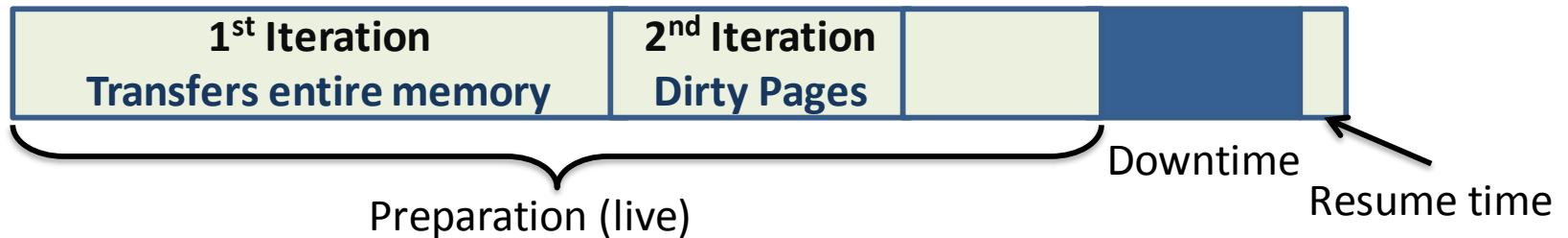


Memory

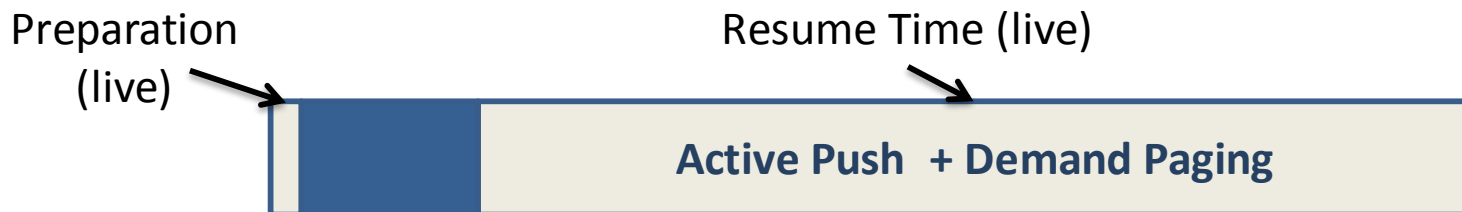


Disk Image

- **Pre-copy** live VM migration

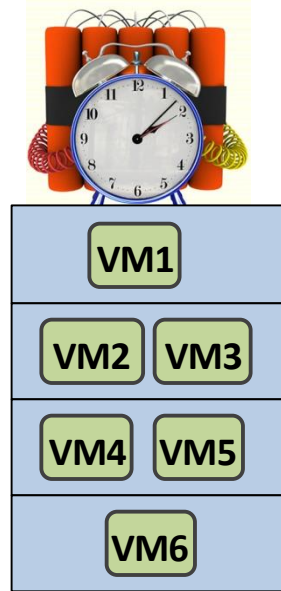


- **Post-copy** live VM Migration



Motivation: Migration of VMs

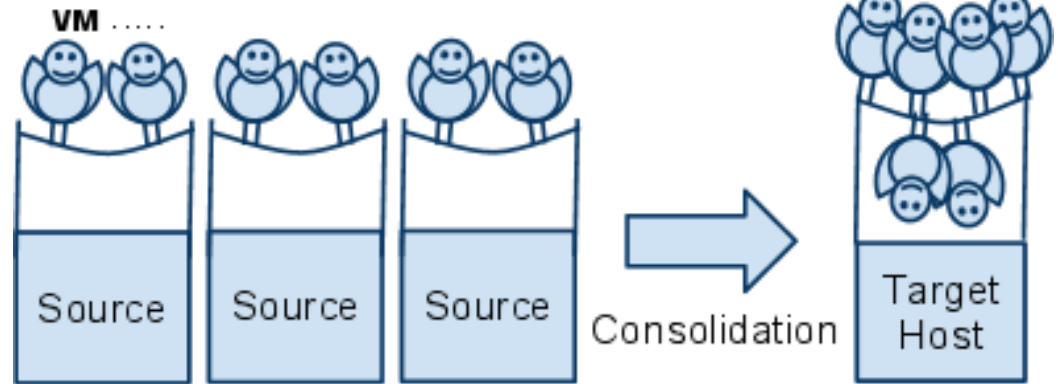
- Shutting down rack for cluster maintenance
- Imminent failures
- Power Saving



Source Rack



Target Rack



 Physical machine  VM Migrating VMs

Problem

- Migration of Network-bound VMs
 - Transfer of Gigabytes of memory
 - **Contention between VM application and migration traffic at the NICs**

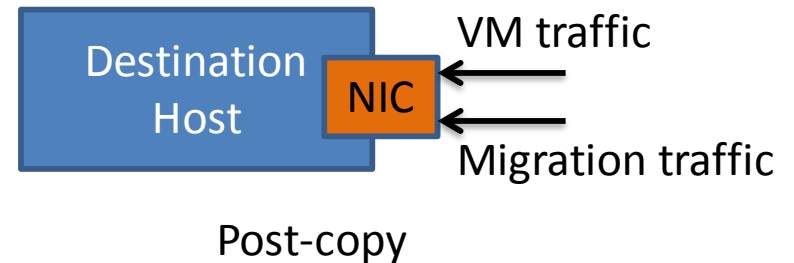
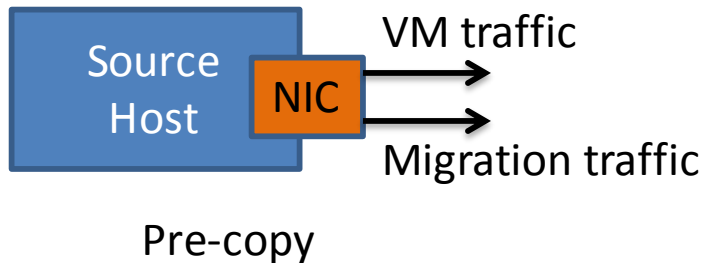


Migration traffic VM traffic

- Contention depends upon direction of traffic
 - Flows in the same direction **compete**
 - Flows in opposite direction **complement**

Problem

- Migration traffic competes with
 - **Pre-copy:** Outbound VM application traffic at source
 - **Post-copy:** Inbound VM application traffic at destination



- Effect of contention
 - **Prolongs Migration**
 - **Degrades VM applications**

Problem

- Contention during migration depends upon
 - VM's predominant traffic direction
 - VM migration technique selected
- Effect of contention
 - **Prolongs Migration**
 - **Degrades VM applications**

Solution: Traffic-sensitive migration

- **Goal:** Reduce contention at migration endpoints for migration of co-located VMs
- Select migration technique for each VM
 - Direction of most VM traffic complements the direction of migration traffic

Existing Solutions

- Post-copy: Transfers each page only once
- Content optimization:
 - **Shrinker, Gang Migration, VMFlock**
 - Compression, Differential compression, Deduplication
- Migration of Virtual Clusters
 - VCT: Non-live migration of VMs and disk images
 - VC Migration: Compares different strategies for migration of multiple VMs

Design

1. Periodically measure TX and RX traffic rate for each VM
2. Calculate severity possible contention with every combination of pre-copy and post-copy
 - E.g. (vm1, vm2, vm3) : (pre, pre, post), (pre, post, pre)...
3. Select the one that yields the least contention

Design: Calculating Contention

For each combination

- Source contention = \sum Rate of outgoing traffic for VMs migrated with **pre-copy** + Outgoing background traffic
- Destination contention = \sum Rate of incoming traffic for VMs migrated with **post-copy** + Incoming background traffic
- Contending Traffic = **Max** (Source contention, Dest. Contention)

Design (Example)

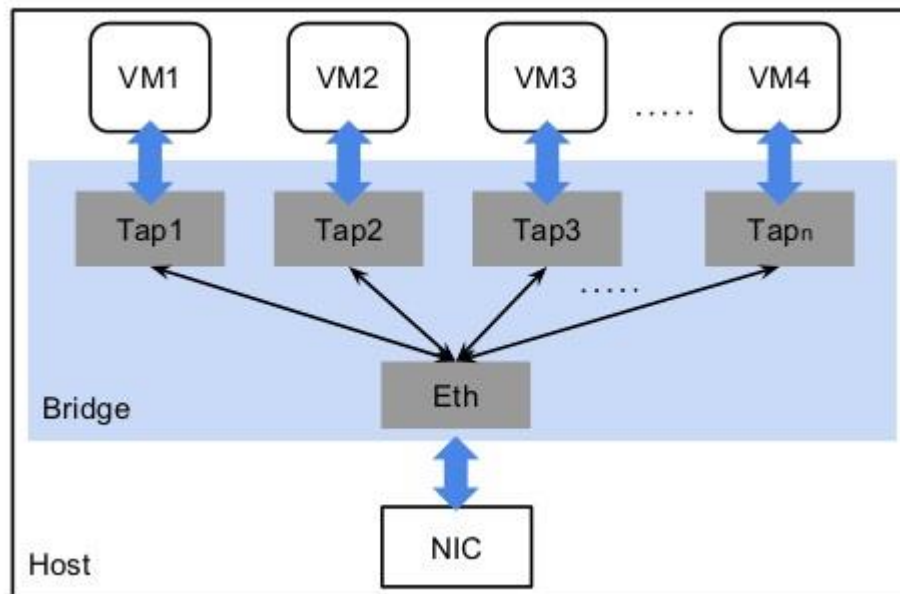
Two co-located VMs	Tx Rate	Rx Rate
VM1	200 Mbps	400 Mbps
VM2	300 Mbps	500 Mbps

1. VM1 pre-copy, VM2 pre-copy
 - Source contention = 500 Mbps
 - Destination contention = 0
 - Contention = $\text{Max}(500, 0) = 500$ Mbps
2. VM1 post-copy, VM2 pre-copy
 - Source contention = 300 Mbps
 - Destination contention = 400 Mbps
 - Contention = $\text{Max}(300, 400) = 400$ Mbps

⋮

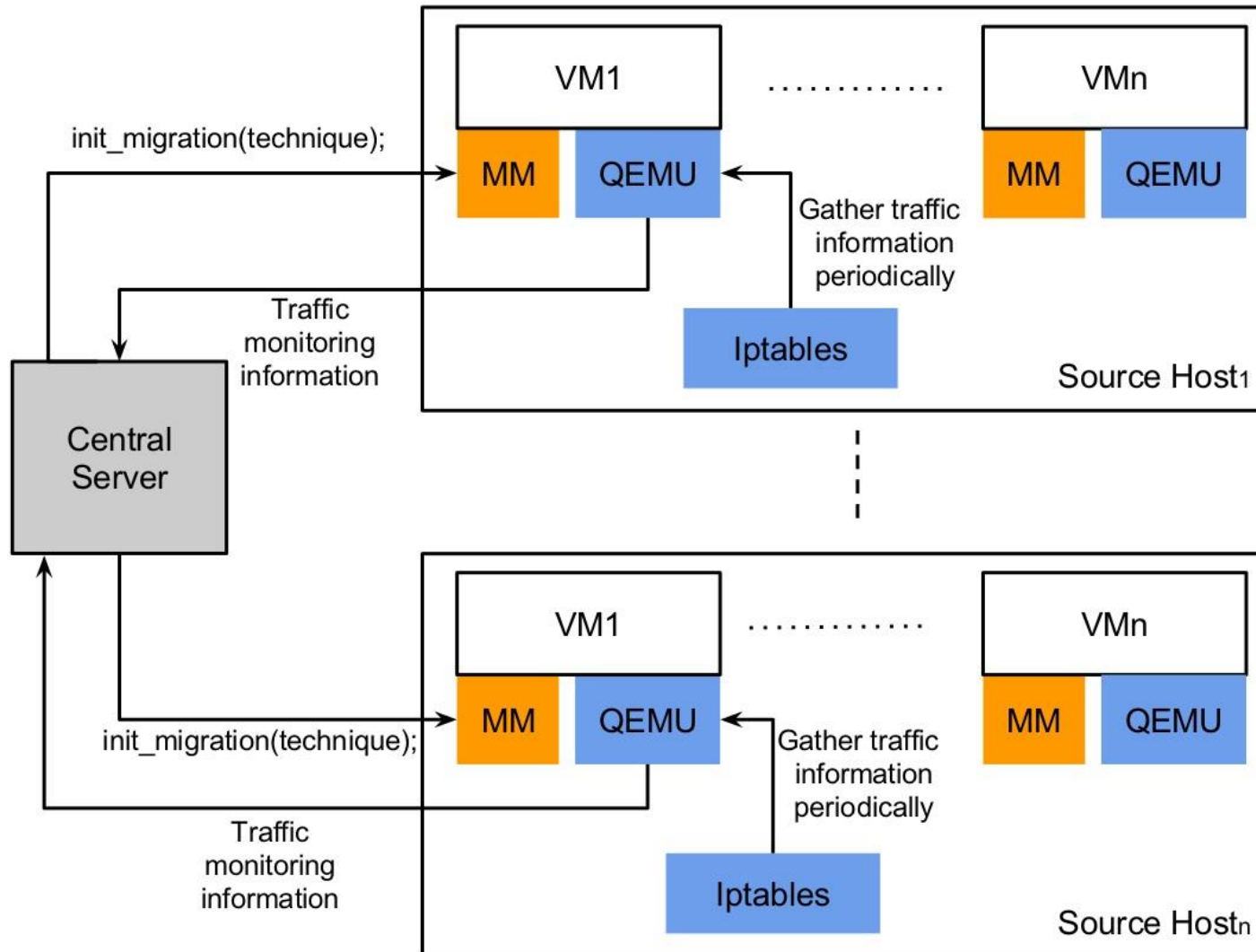
Implementation: Networking

- Implemented on KVM/QEMU platform
- 1Gbps Ethernet interconnect



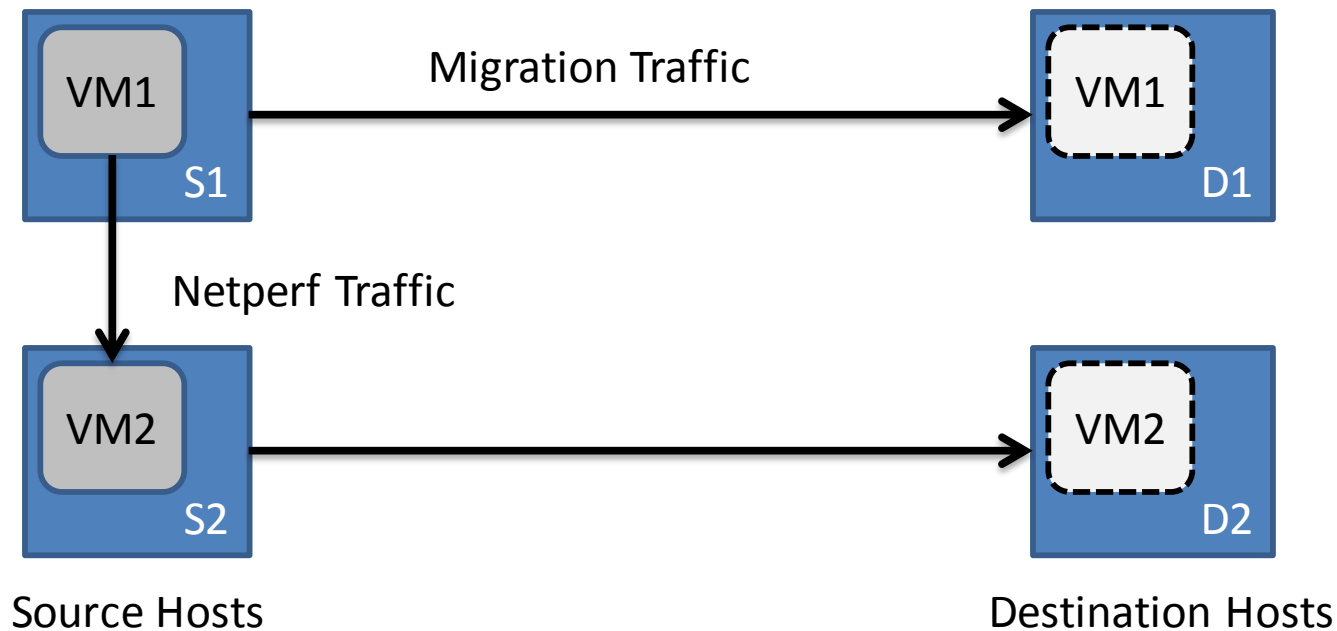
Virtual Networking in KVM/QEMU

Implementation



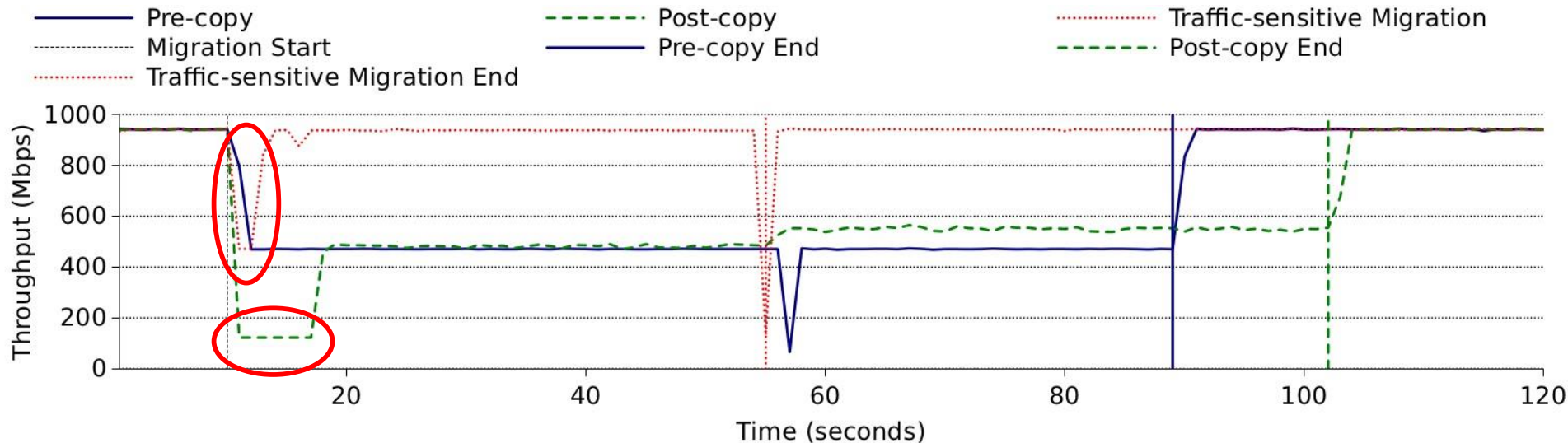
Evaluation

- Compare Against : Pre-copy only, Post-copy only
- Configuration
 - Host : 8 CPUs, 16GB memory, VM: 2 vCPUs, 5GB memory
- VM1: Netperf client, VM2: Netperf server (VM1 → VM2)



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	Pre-copy	Post-copy	Traffic-sensitive Migration
Total Migration Time (seconds)	79.1	92.1	48.2
Amount of Data Transferred (MB)	10280	10277	10278
Netperf Performance (Mbps)	690.47	660.05	894.65

- TMT: 42% and 49% lower than pre-copy and post-copy
- Performance: 29% and 35% higher than pre-copy and post-copy

Evaluation

- 8 Source Hosts, each host runs 2 VM
- 12 VMs run Redis database server
- 4 VMs query with YCSB workload
 - Insert, read, update queries

	Without Migration	Pre-copy	Post-copy	Traffic-sensitive Migration
Average Migration Time (seconds)	-	50.56	60.48	37.79
Total Migration Time (seconds)	-	74.5	139	57.75
Amount of Data Transferred (GB)	-	50.90	30.18	34.07
YCSB Performance (Operations / second)	4802	3875	4161	4126

- TMT reduction: **23%** vs pre-copy, **59%** vs post-copy
- Vs. Pre-copy: **6%** lesser degradation, **68%** lower network traffic overhead

Future Work

- Migration from same source host to different destination hosts
 - Scattering or consolidation of VMs
 - Considering the combinations across the hosts
- Account for the traffic at the destination host to selecting a suitable destination

Conclusions

- Combination of pre-copy and post-copy to reduce network contention
 - Esp. for VMs with unidirectional traffic
- Reduces total migration time
 - Allows faster eviction
- Minimizes application network-bound degradation

Thanks!

Contact:

umesh.deshpande@binghamton.edu

Website:

<http://www.umeshhome.com>

