Scatter-Gather Live Migration of Virtual Machines

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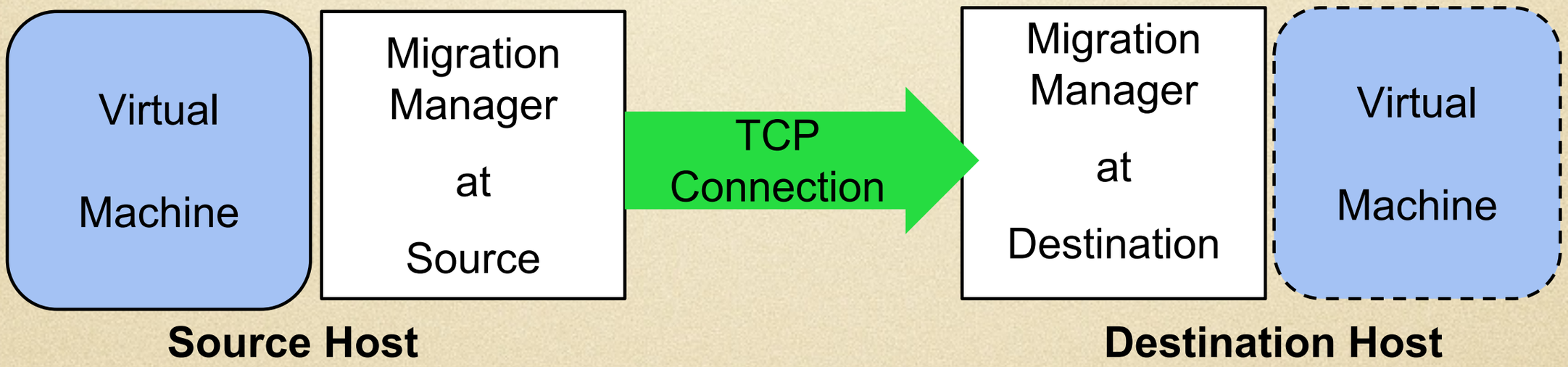
Funded by

Motivation: VM Eviction Time

- Live VM Migration: Transfer of a running VM between hosts
  - VCPU, Memory, (Disk), and (Network state)
- Traditional metrics
  - Downtime, Total Migration Time, Network Overhead, Application performance
- We consider a new metric
  - VM Eviction time: Time to completely evict a VM's state from the source.
- Why is it important?
  - Quickly eliminate hotspots by moving out VMS
  - Opportunistic power saving by turning off servers
  - Quickly de-provision less important VMs to accommodate more important ones
  - Emergency maintenance; handling imminent failures

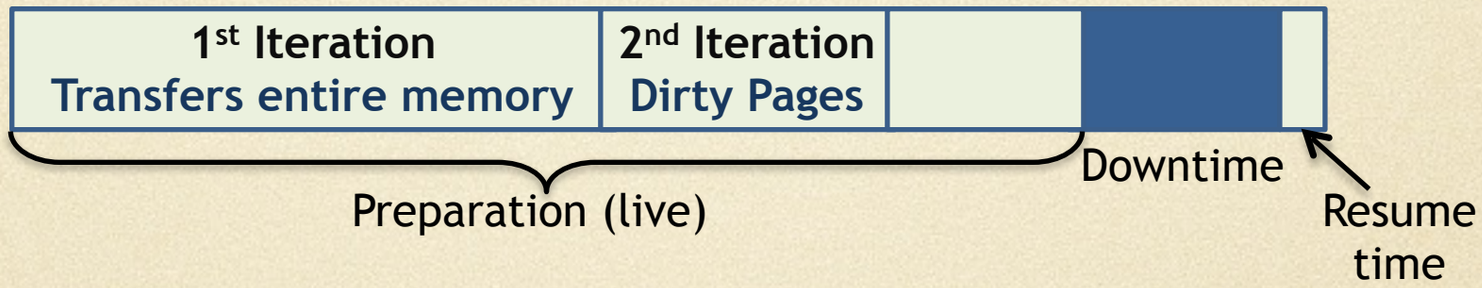
Coupling of Source and Destination

- Traditionally
  - Eviction time = Total Migration Time
- Source cannot eliminate the outgoing VM's state until target receives the entire VM.

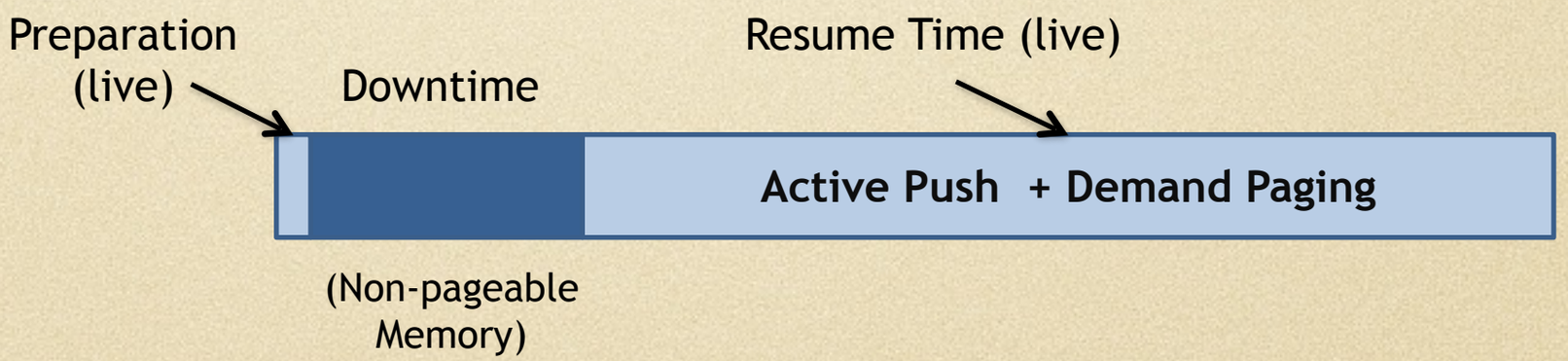


Pre-copy and Post-copy

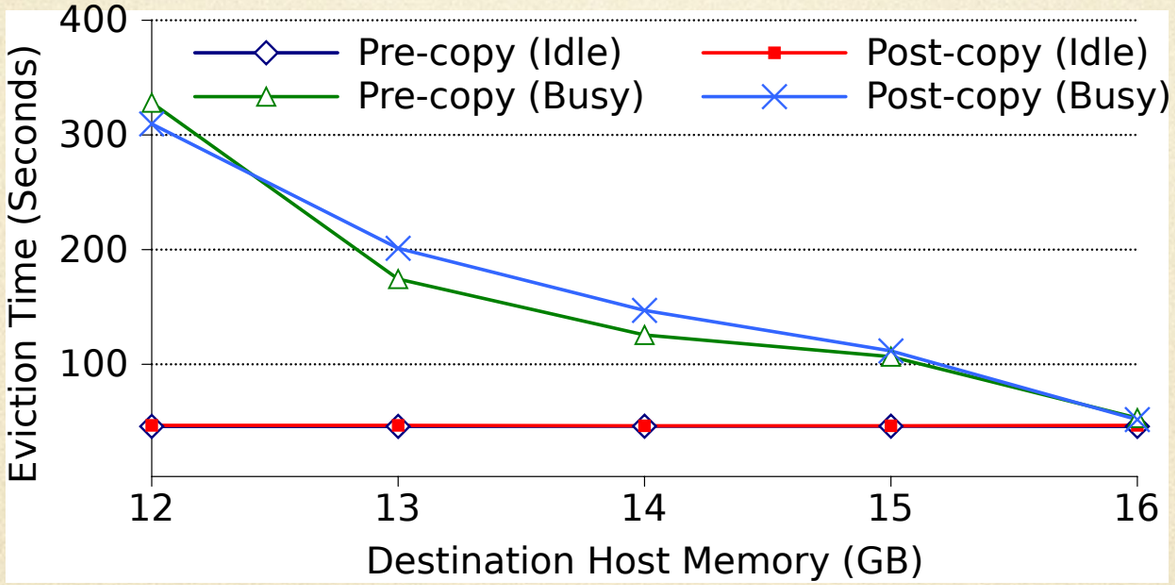
- Pre-Copy



- Post-Copy



Impact of Destination Resource Pressure

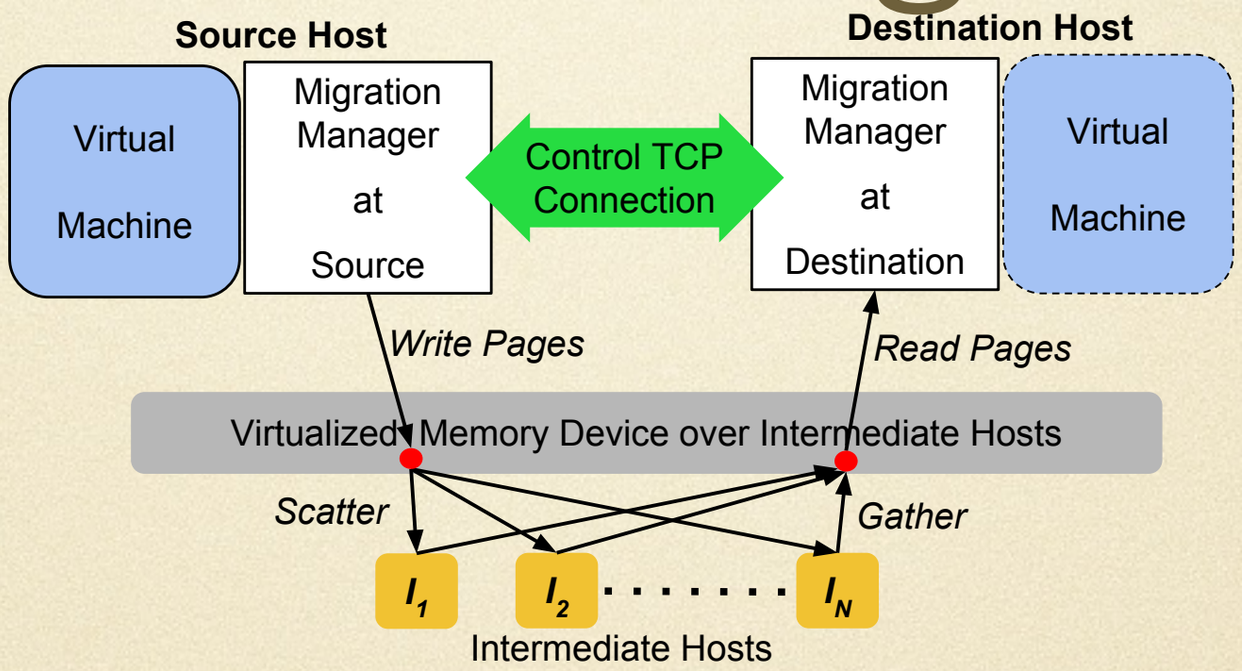


- Source migrating a 5GB idle VM
- Destination running two 5GB VMs running Tunkrank with 4GB memory footprint.
- Eviction time is 6X longer when destination memory = 12GB
- Similar effects when other resources are constrained at the destination
  - CPU cores busy
  - Network interface under contention

State of the Art

- Lowering Total Migration Time
  - Ballooning, compression, dropping the guest cache, deduplication
  - Orthogonal to our approach
- Checkpoint/Restore
  - Typically non-live; restore follows checkpoint; large downtime
  - Remus does high-frequency checkpointing for high availability; quick restoration but large runtime overhead for write-intensive apps; doubles memory usage.
- Post-copy Migration
  - Quickly offloads VM's CPU state to destination.
    - Memory follows from the source
  - Snowflock, Jettison, Reactive consolidation use post-copy

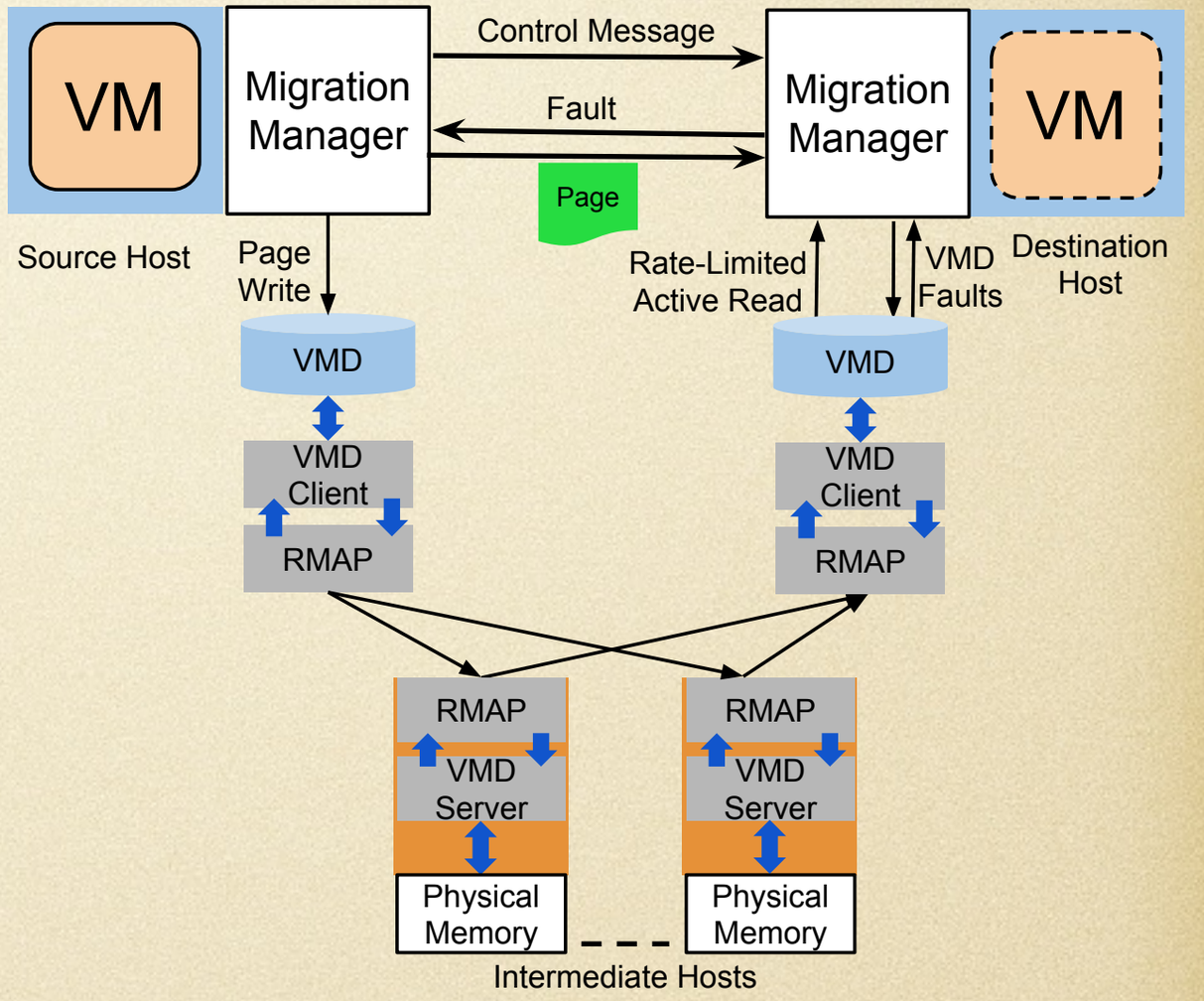
Solution: Scatter-Gather VM Migration



- Scatter VM memory to intermediaries, Gather VM memory from intermediaries
- Intermediaries could be hosts at the destination rack, memory appliances, middleboxes, etc.
- Scatter-Gather = Post-copy variant + live checkpoint/restore via intermediate nodes
  - Concurrent Scatter (checkpoint) and Gather (restore) phases
  - Post-copy variant
    - Pre-paging via intermediaries
    - Page-faults serviced from source/intermediaries.

Implementation

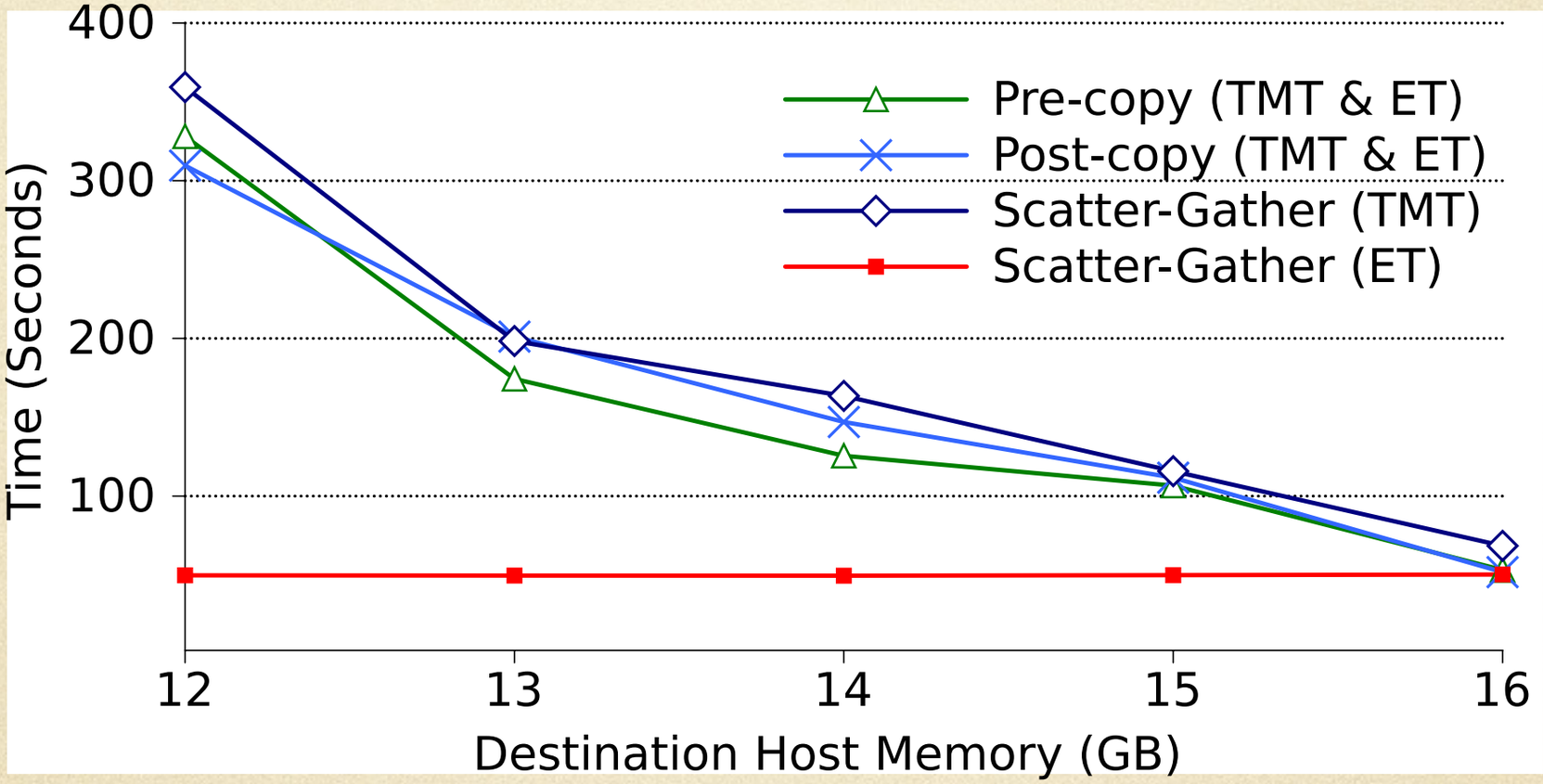
- Source
  - Scatters pages to VMD;
    - Sends IDs of scattered pages to destination
  - Services faults from destination
  - Prioritizes fault servicing over scatter
- Destination
  - Gathers pages from VMD
  - Requests faulted pages
    - from source while source is scattering, from VMD afterwards
- Virtualized Memory Device (VMD) Layer
  - Peer-to-peer memory sharing system over Ethernet
  - Presents the aggregated free memory of intermediaries as a block device to Migration Managers



Preliminary Results

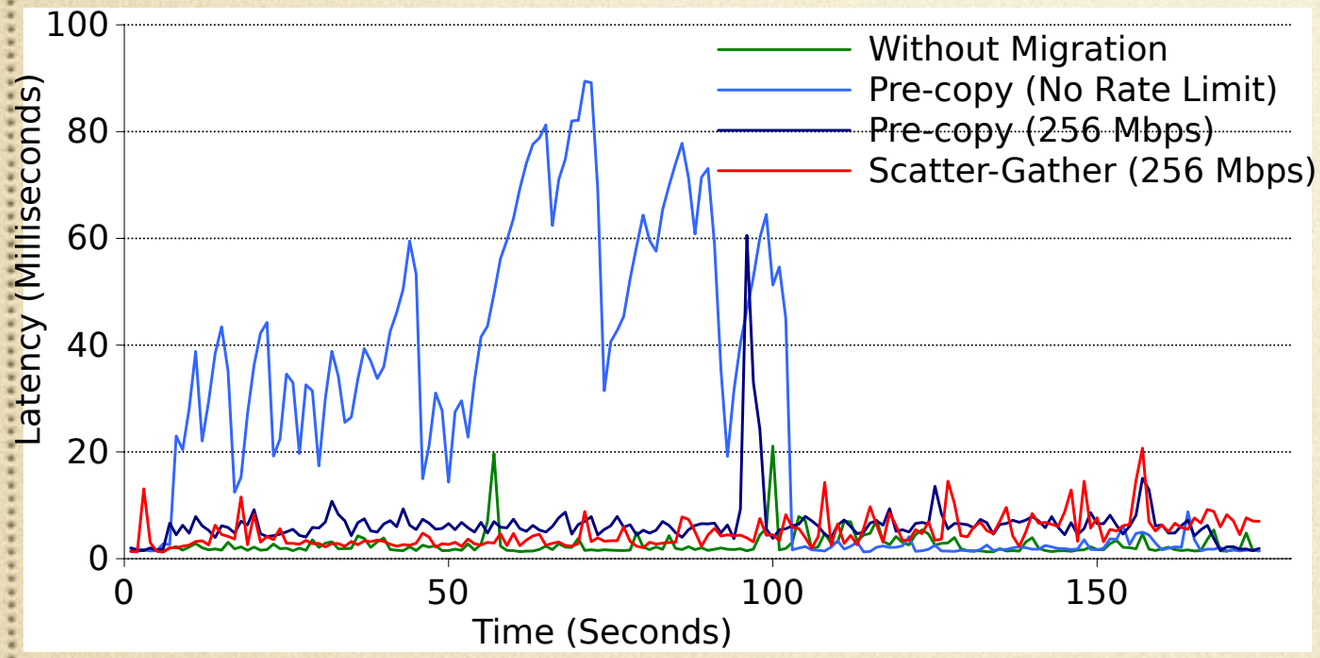
- Goal:
  - When destination is resource constrained, Scatter-Gather Migration can deliver lower eviction time than pre-copy or post-copy
- Setup
  - Dual quad-core servers with 1.7 GHz CPUs and 16GB DRAM
  - 1Gbps links to a Nortel 4526-GTX switch
  - Host runs Linux 2.6.32 KVM/QEMU 1.6.50; VMs run Linux 3.2.
  - Standard pre-copy implementation in QEMU
  - Post-copy implementation from Yabusame project.
    - Modified for Scatter-Gather

Eviction Time: Idle VM to Busy Destination



- Scatter-Gather delivers constant eviction time with increasing memory pressure
- TMT higher by about 10%
  - since VMD transmission protocol delivers lower throughput (750 Mbps) than TCP in our current implementation

Bandwidth Pressure at the Destination: Tradeoff between Eviction Time and Application Performance



Memcached request latency when migrating a 5GB VM

Two 5GB VMs at destination servicing memcached requests from external client

	Eviction Time (Seconds)		
	Pre-copy	Post-copy	Scatter-Gather
Rate Limit (256 Mbps)	160.8	164.3	49.8
No Rate Limit	98.6	106.3	49.5

TABLE I
EVICTION TIME COMPARISON WHEN THE MIGRATING 5GB IDLE VM WITH AND WITHOUT RATE LIMITING.

Conclusions

- Scatter-Gather Live VM migration
  - Reduces eviction time without affecting total migration time
  - Network overhead can be tackled using compression/ deduplication
  - Bigger impact when migrating multiple VMs together
- Leads to the idea of permanently “scattered” VMs
  - Removes memory as a bottleneck for consolidation
  - Provides greater agility in scaling out when demand increases.

Thanks!

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