Puma: pooling unused memory in virtual machines for I/O intensive applications

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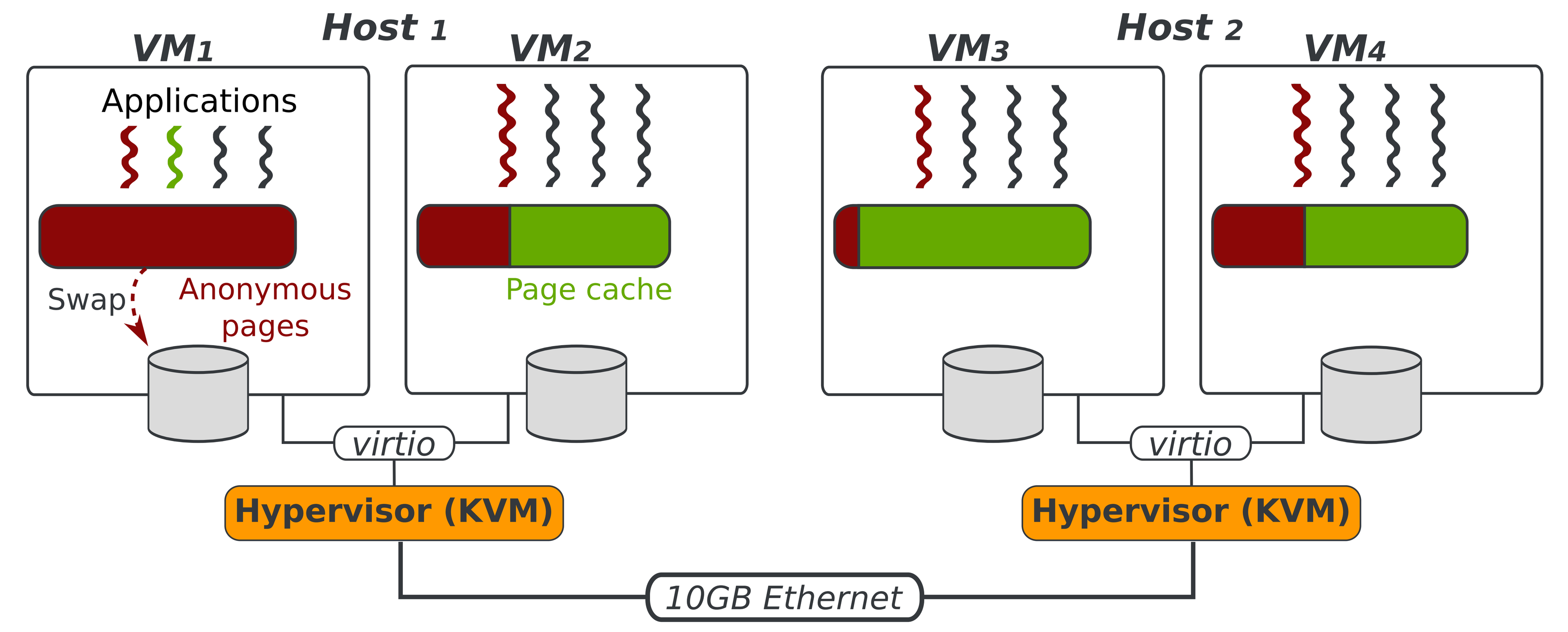
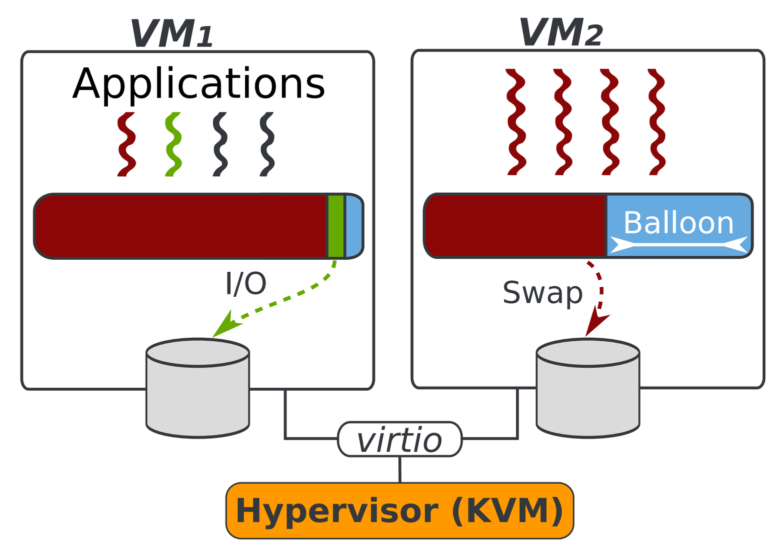
Context: virtualization fragments available memory

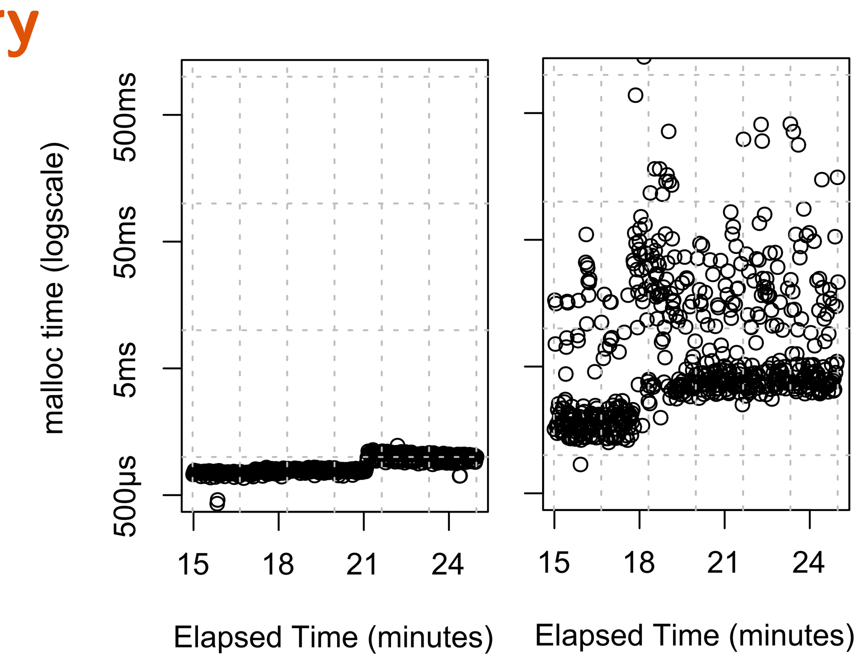


- Virtualization allows more flexibility and isolation
  Problem: it fragments available memory
  - ⇒ Memory cannot be reassigned as efficiently as CPU time
  - ⇒ *Unused* memory (*i.e.* idle caches) is wasted

Existing solution: Memory Ballooning

- ⇒ Allows to dynamically resize VM's memory
- ⇒ Cannot efficiently reclaim *unused* memory
- ⇒ Does not benefit of unused memory on other hosts
- ⇒ **Slow to recover memory**



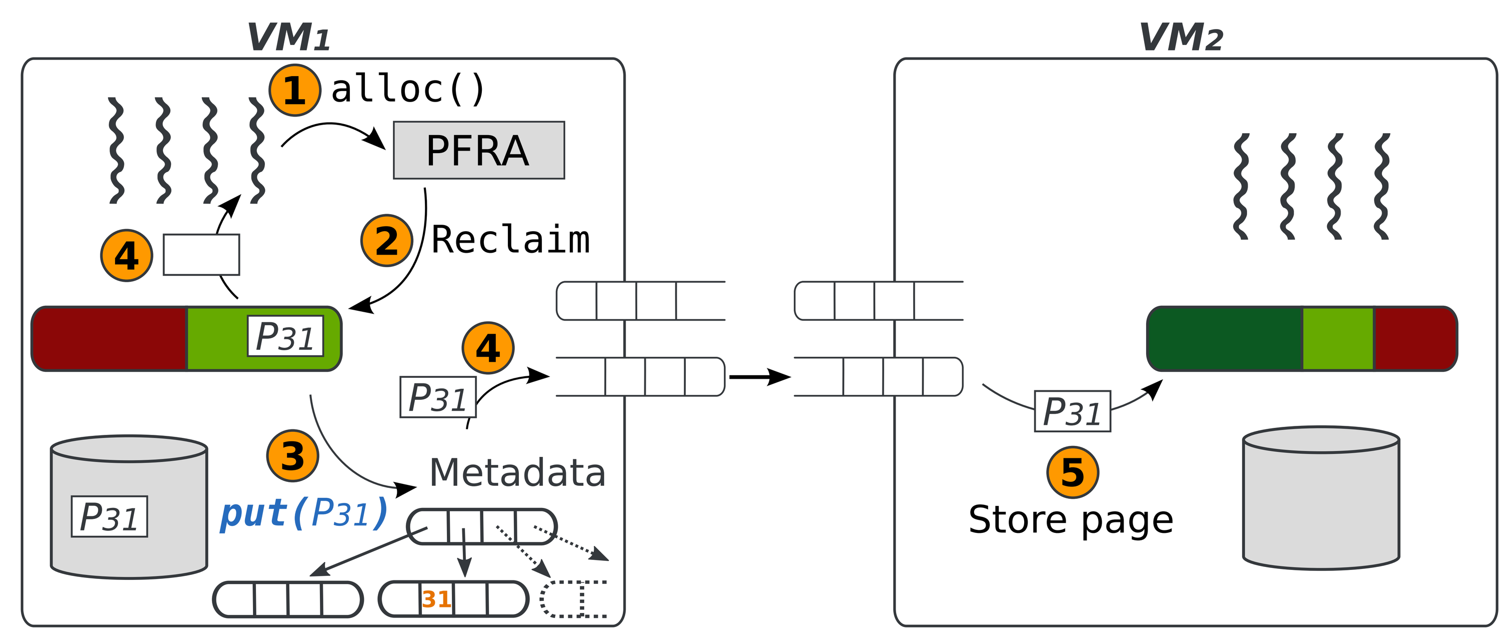


Baseline *Auto-ballooning*

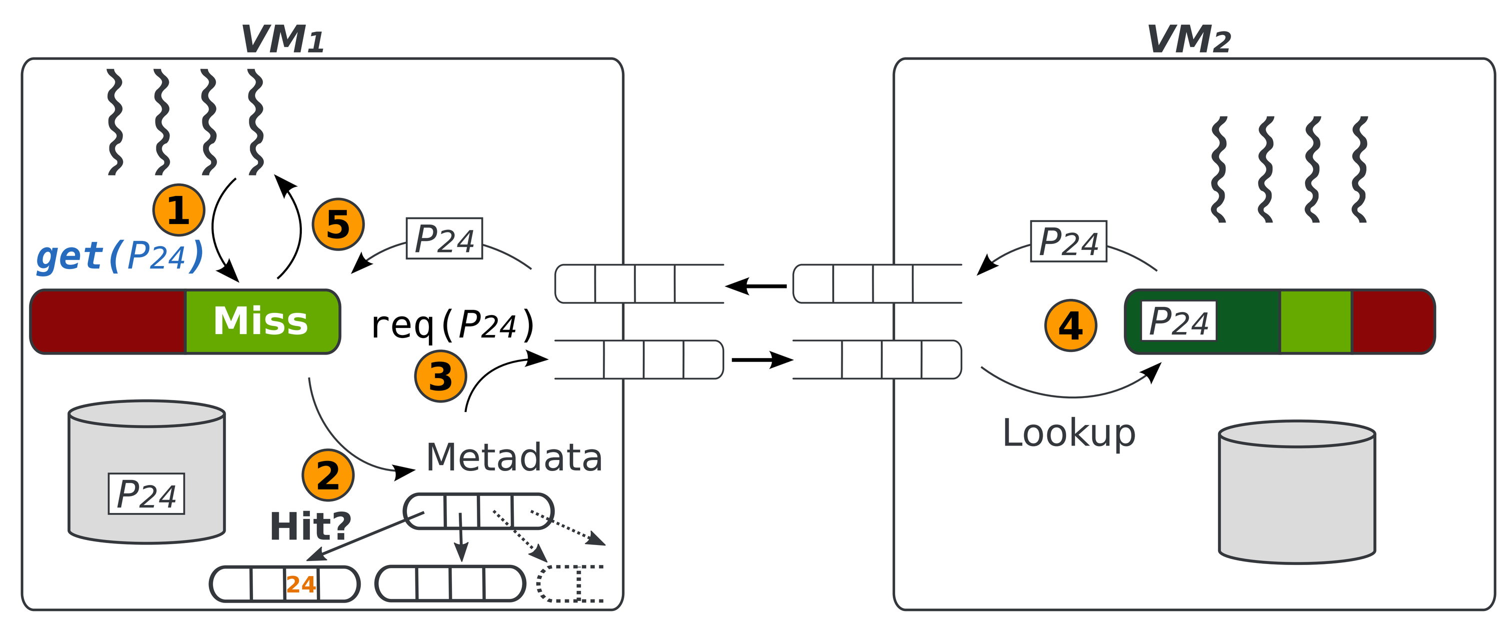
Our approach: PUMA

- Rely on a fast network between VMs and hosts
  - ⇒ PUMA can reuse unused memory of VMs hosted on different hosts
- Handles *clean* cache pages
  - ⇒ Writes are generally non-blocking
  - ⇒ Simple consistency scheme
  - ⇒ **Fast to recover memory!**
- Exclusive and non-inclusive caching strategies

Architecture overview



***put()* operation**



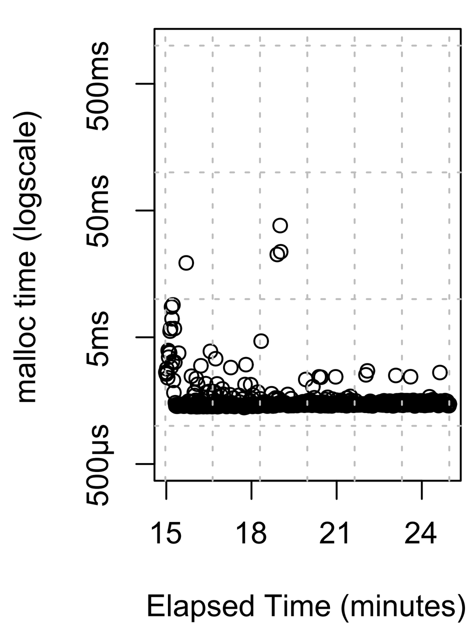
***get()* operation**

PUMA design

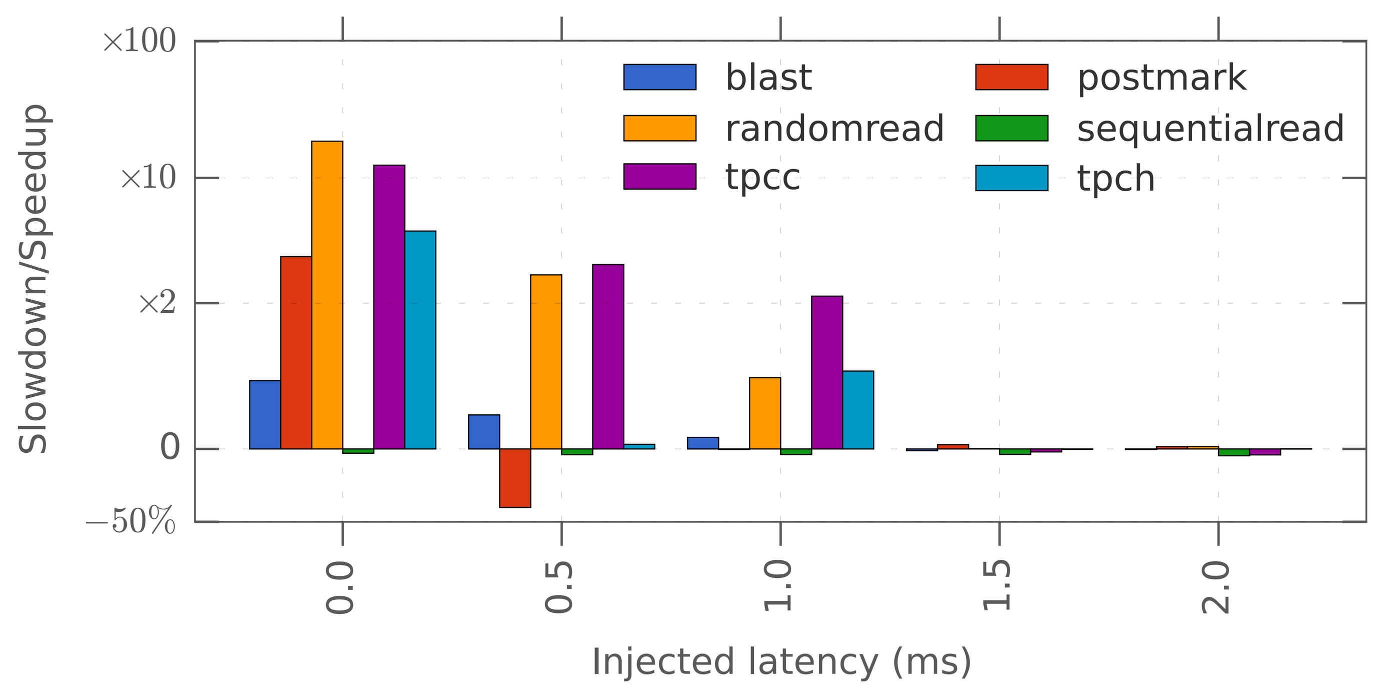
- 2 basics operations
  - ⇒ ***get()***: gets a page from the [remote] page cache
  - ⇒ ***put()***: sends a victim page to the remote page cache
- Local metadata with small memory footprint
  - ⇒ amortized 64 bits/page, 2 MB of metadata per GB of cache
- Pages are directly stored into the existing page cache
  - ⇒ Memory is reclaimed naturally
- Sequential I/O are detected and filtered
  - ⇒ Disk bandwidth > network bandwidth
- Network latency monitoring
  - ⇒ PUMA is throttled when the latency becomes too high

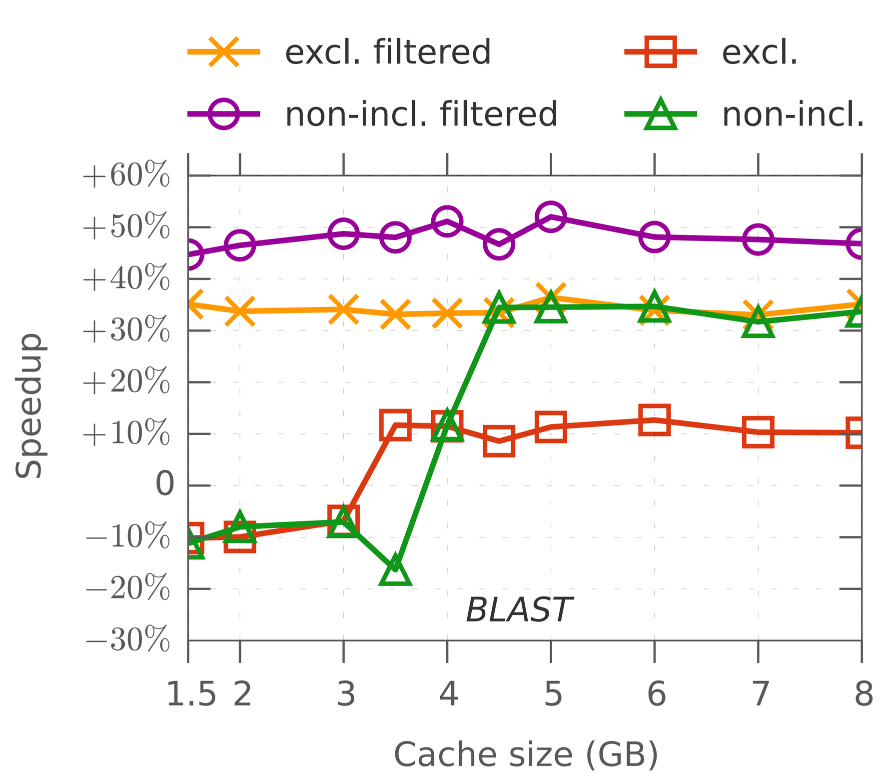
Evaluation

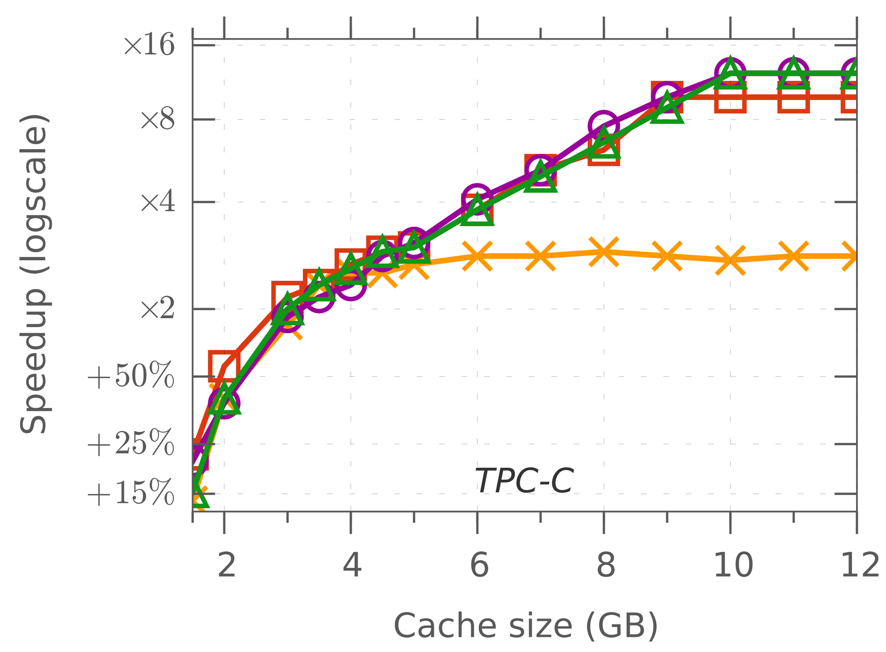
- Experiment setup
  - Active VM: 1 GB memory
  - Inactive VM: 512 MB→12 GB memory
  - Network latency injection with Netem [LCA'05]
  - Benchmarks: Filebench, BLAST, TPC-C, TPC-H, Postmark



Puma







Conclusion and Future Work

- PUMA solves the page cache fragmentation problem
  - ⇒ It is based on an efficient kernel-level remote caching mechanism
  - ⇒ It handles *clean* cache pages to quickly recover the memory
  - ⇒ It works with co-localised VMs and remote VMs
- Ongoing work: detecting when a VM has *unused memory*
  - ⇒ Our idea: toggle PUMA service based on Linux's active/inactive LRUs activity

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