Yabusame update:
Postcopy Live migration for QEmu/KVM

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Agenda

- Precopy vs Postcopy
- Update
- Evaluation
- Future work

From wikipedia

Yabusame is a joint project with Takahiro Hirofuchi, AIST and Satoshi Itoh, AIST.
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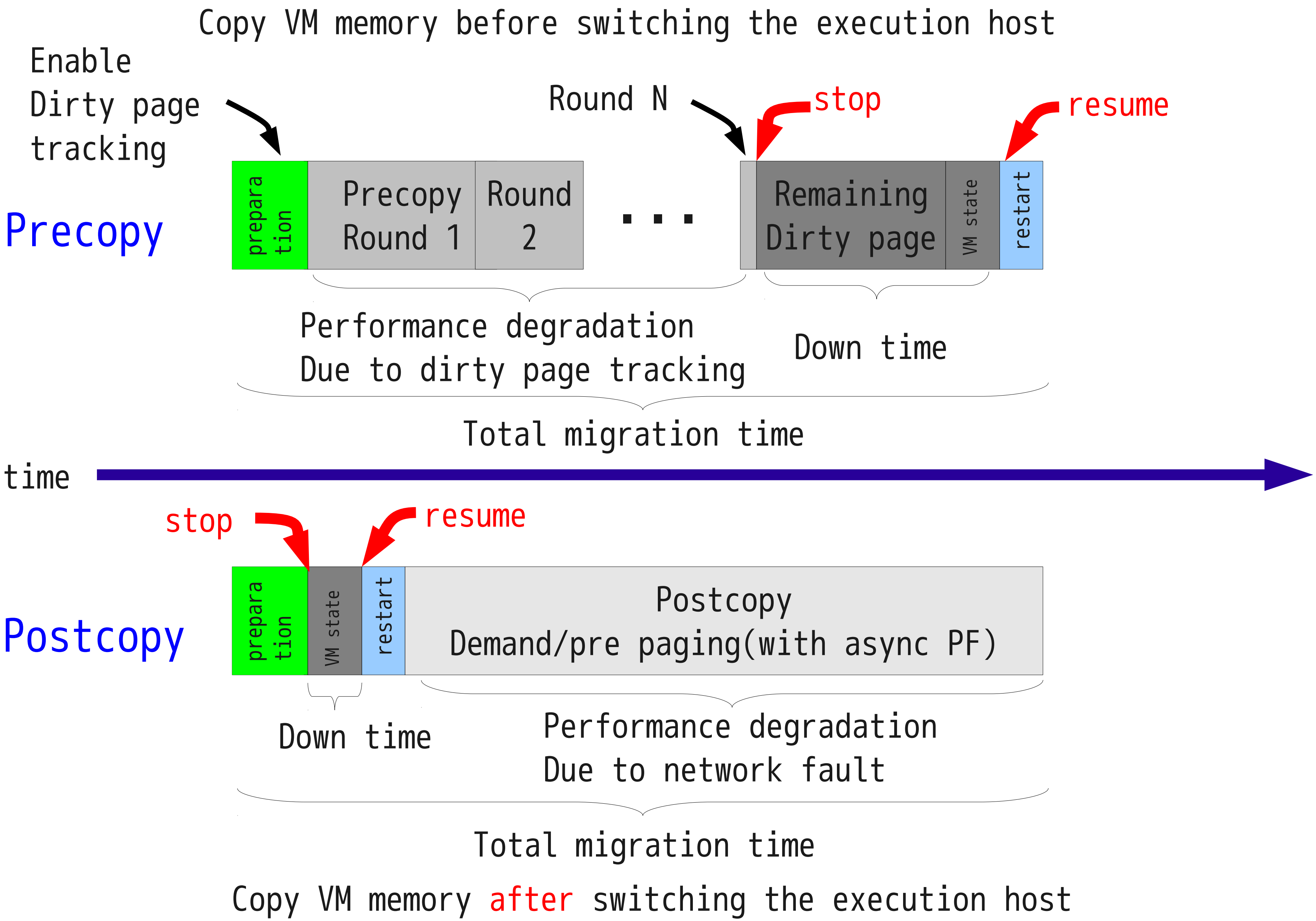
Precopy vs Postcopy

Precopy vs Postcopy



Copy VM memory before switching the execution host

Enable
Dirty page
tracking

Round N

stop

resume

Precopy

prepara
tion

Precopy
Round 1

Round
2

...

Remaining
Dirty page

VM state

restart

Performance degradation
Due to dirty page tracking

Down time

Total migration time

time

stop

resume

Postcopy

prepara
tion

VM state

restart

Postcopy
Demand/pre paging(with async PF)

Down time

Performance degradation
Due to network fault

Total migration time

Copy VM memory after switching the execution host

Characteristic comparison

- Precopy
  - Reliablility
    - Migration process can be aborted safely.
  - Total migration time and downtime depend on memory dirtying speed
    - Especially the number of dirty pages doesn't converge when dirtying speed > link speed
- Postcopy
  - network bandwidth friendly
    - Postcopy transfer a page only once
  - reliability
    - VM can be lost if network failure occurs during migration

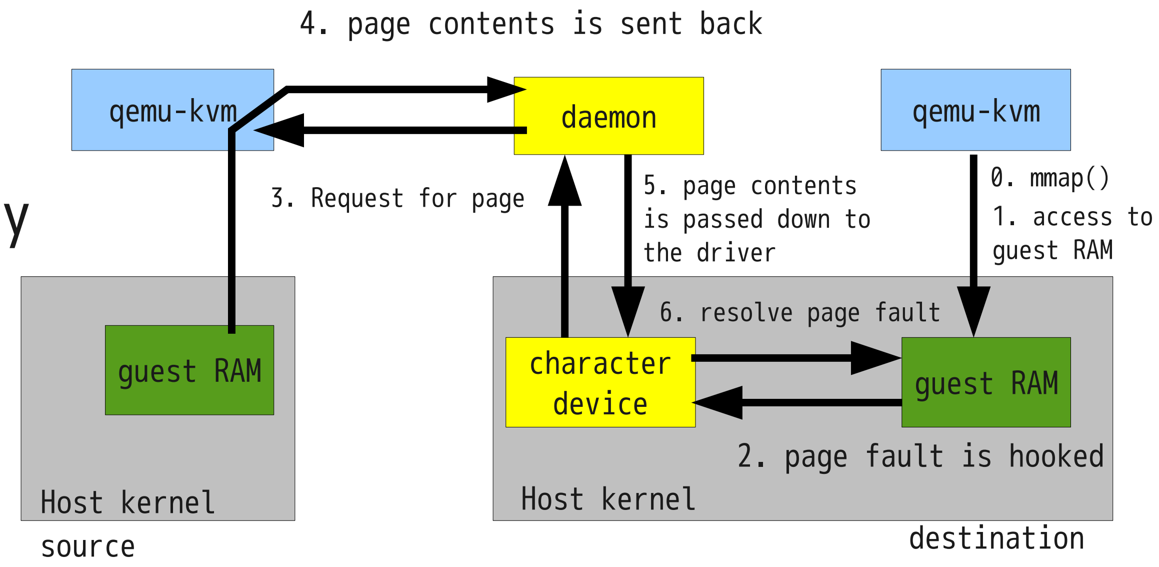
Postcopy is applicable for

- Planned maintenance
  - Predictable total migration time is important
- Dynamic consolidation
  - In cloud use case, usually resources are over-committed
  - If machine load becomes high, evacuate the VM to other machine promptly
    - Precopy optimization (= CPU cycle) may make things worse
- Wide area migration
  - Inter-Datacenter live-migration
    - L2 connectivity among datacenters with L2 over L3 has becoming common
    - VM migration over DCs as Disaster Recovery
- LAN case
  - Not all network bandwidth can be used for migration
  - network bandwidth might be reserved by QoS

Updates on Yabusame implementation

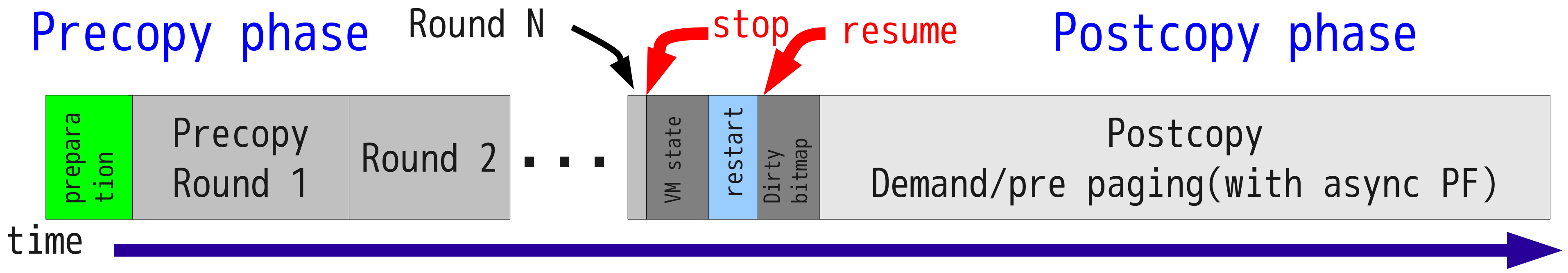
Updates

- Basic design is unchanged
  - Using a character device
- Precopy + postcopy optimization
- Auto detection of postcopy session
- Incoming side threading
- Reduced memory overhead



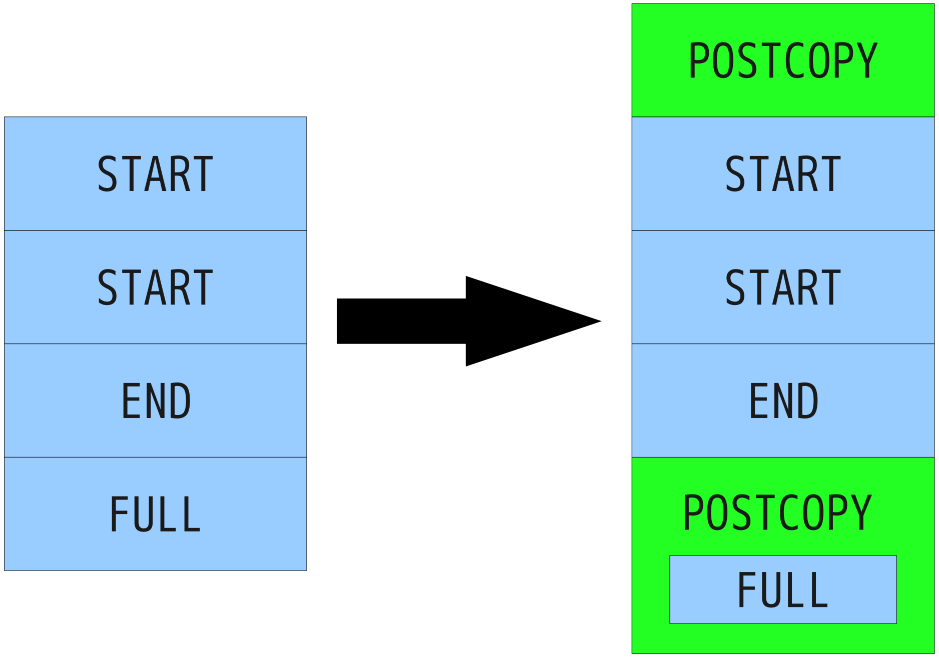
Precopy + postcopy

- migrate -p URI [<precopy count>]
  - Precopy count = 0 => disabling precopy
- Precopy the designated times (or meets downtime), then switches to postcopy mode
- Send dirty bitmaps after precopy
- Sending bitmap is tricky
  - qemu bitmap representation is unsigned long[] which is architecture dependent



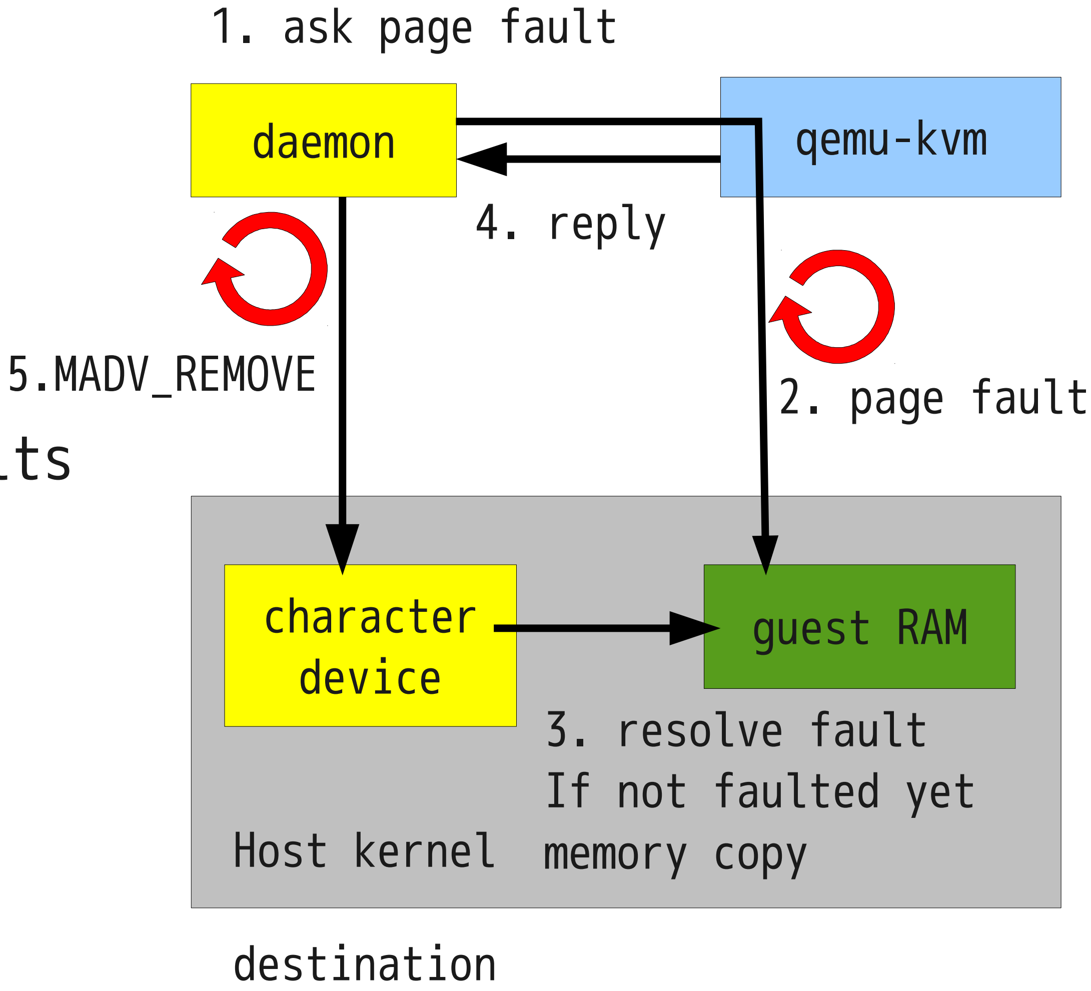
postcopy auto detection

- Incoming side auto-detects postcopy session
- New QEMU_VM_POSTCOPY section
- If incoming side doesn't know postcopy, it notices the new section as unknown and results in error.
- FULL section in POSTCOPY
  - Some device touches guest RAM at post_lost



Threading in incoming side

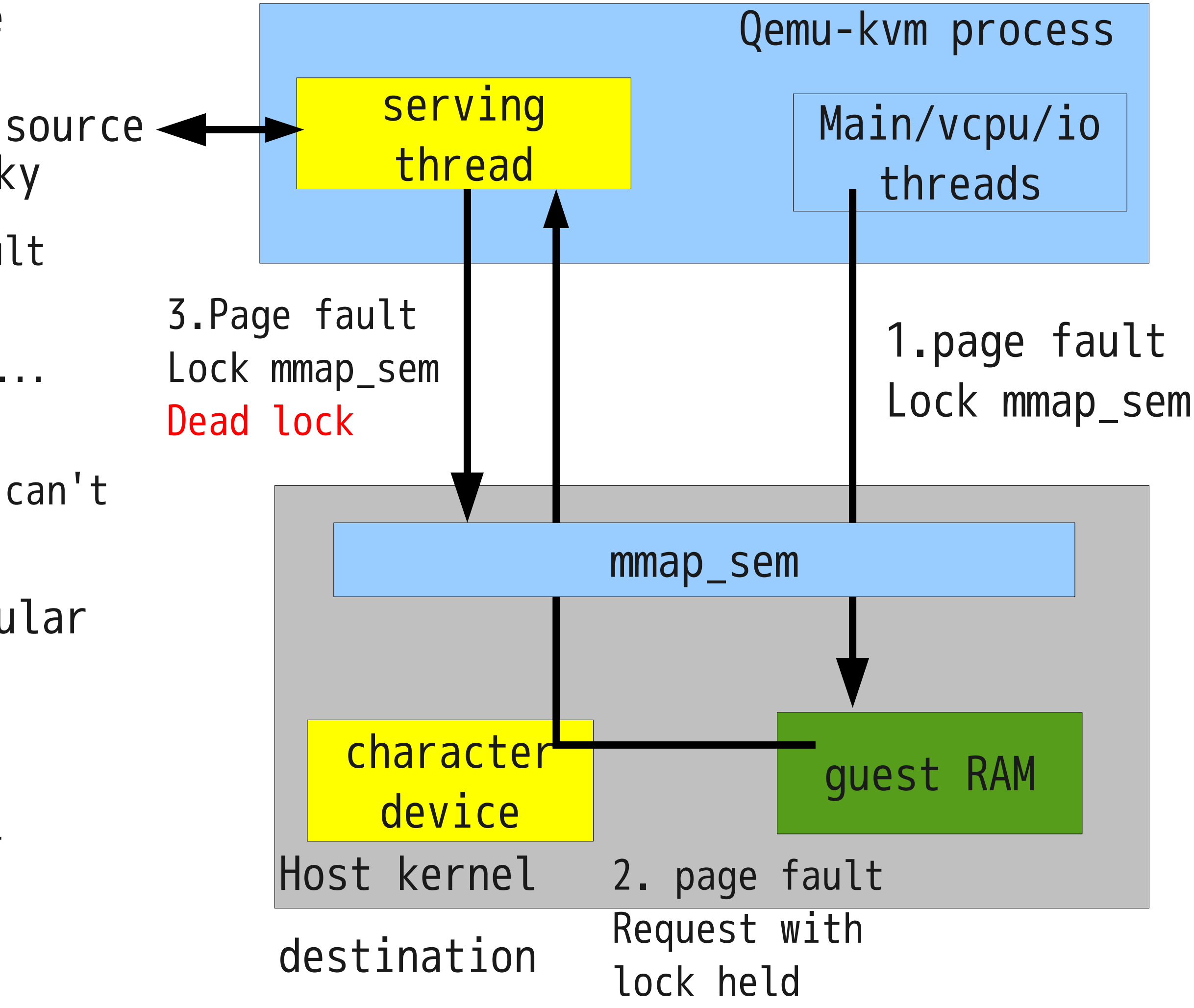
- Code simplification
  - thread vs select multiplex
- Reduce memory overhead
  - Dedicated threads
  - Make sure qemu-kvm faults on the page
  - frees already copy of served pages with dedicated thread



Findings

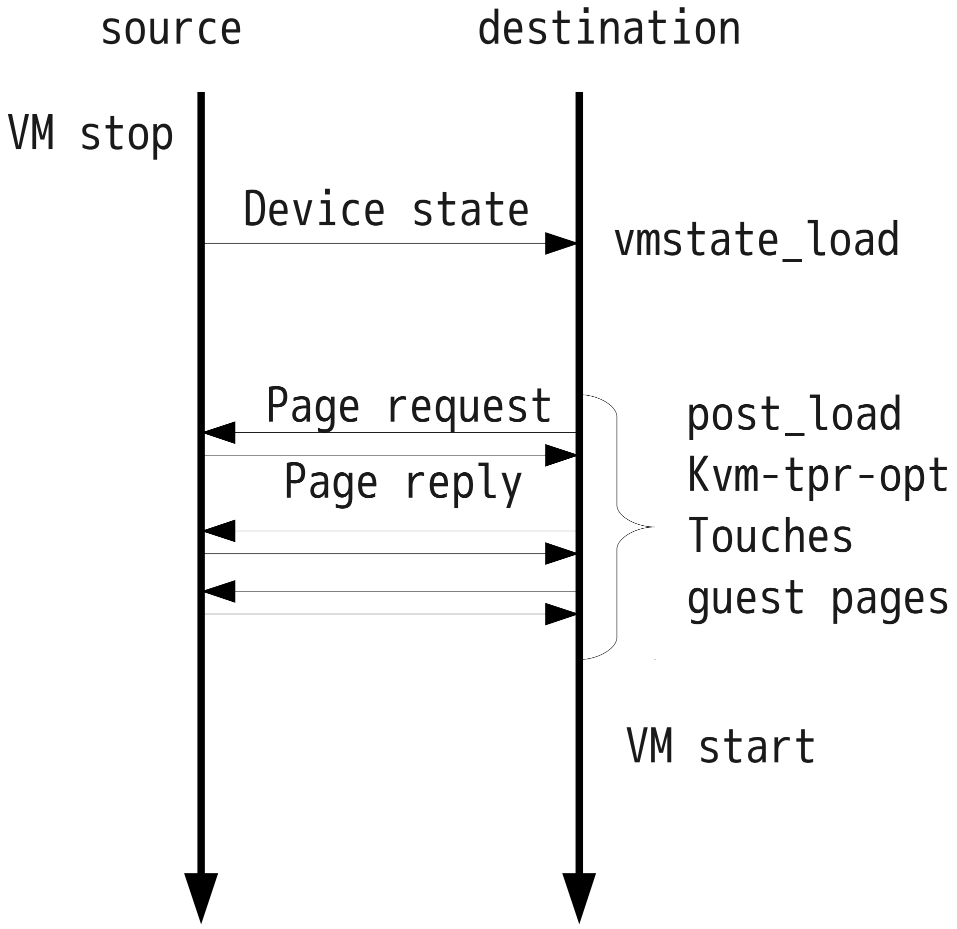
Serving page fault in qemu process is difficult

- Serving thread in qemu process
  - Finer control would be possible
- Abandaned to reverted to fork
- Playing with mmap_sem is tricky
  - Some threads are already in fault handler with mmap_sem held.
    - Sometimes write lock is held: AIO...
    - Qemu does use AIO
  - Threads that serves page fault can't page-fault
- Even with multi process, circular dependency is possible
  - Same with FUSE
  - Essential solution is in-kernel



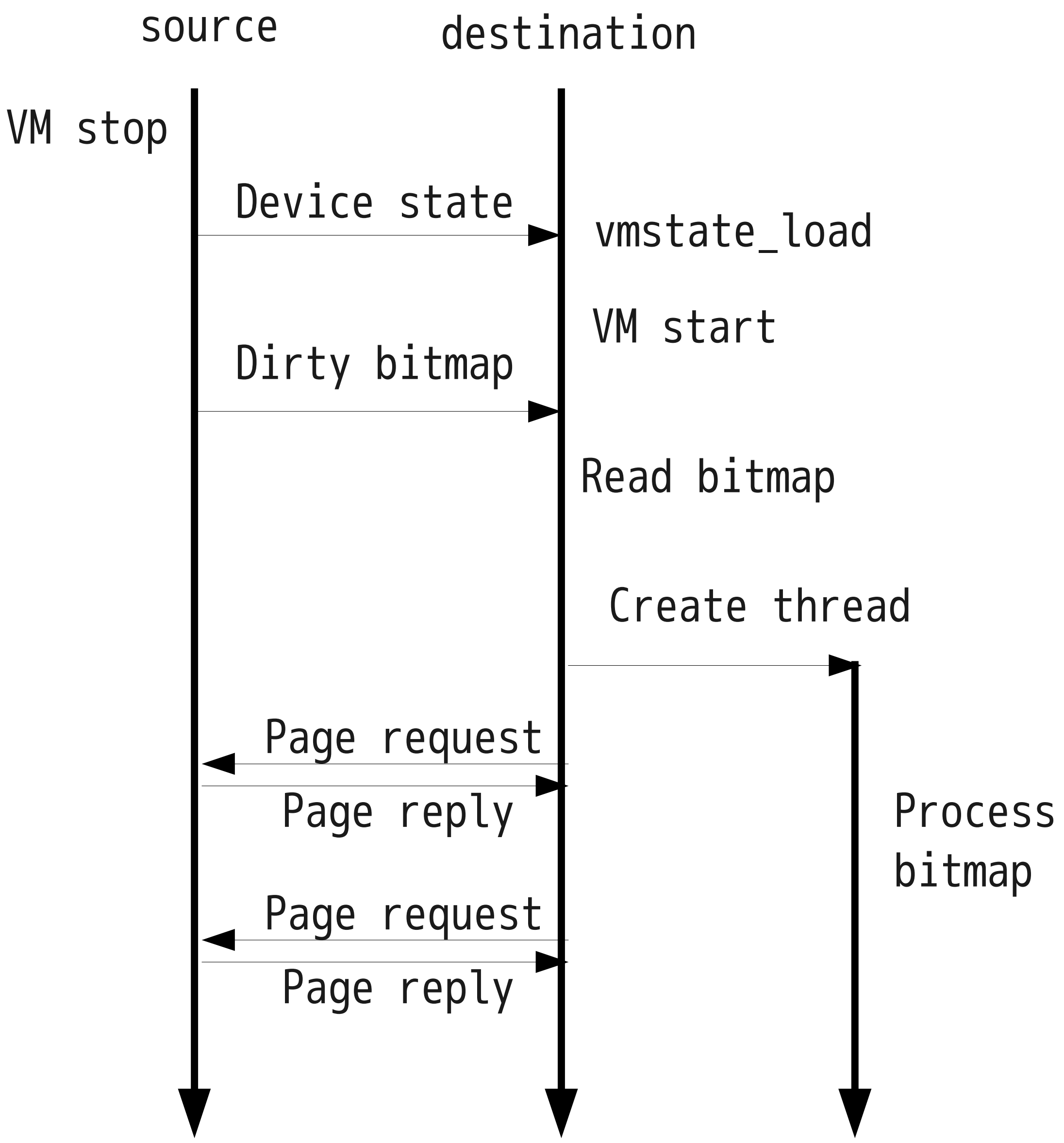
post_load

- Network fault right while device state load
  - Some post_load() touches guest RAM
    - Kvm-tpr-opt: patches guest RAM
    - Some devices start DMA emulation in qemu
  - Qemu main thread blocks before running vcpu thread
- pre+post optimization helps



pre+post dirty bitmap

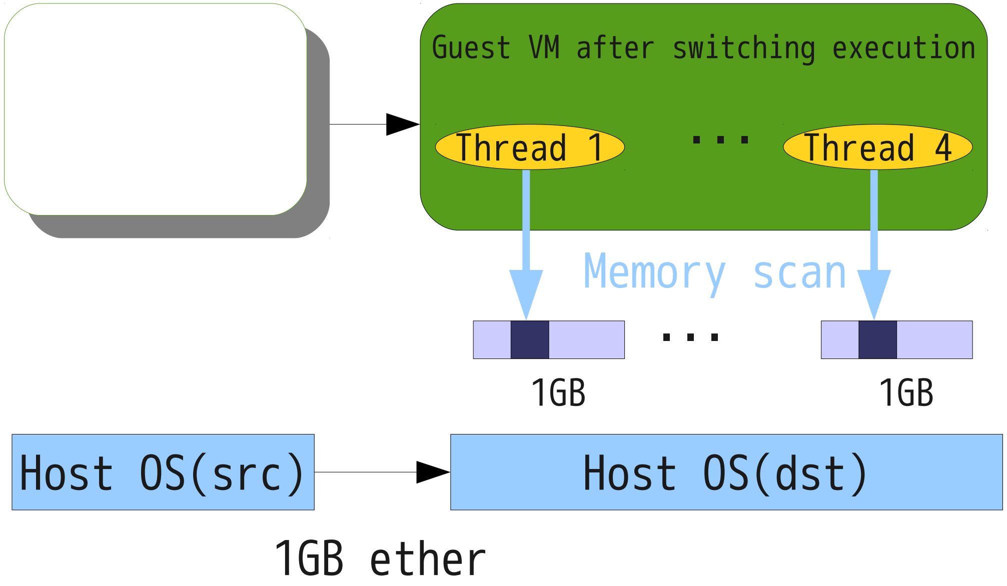
- Processing dirty bitmap causes long time
- Move it into another thread



Evaluation

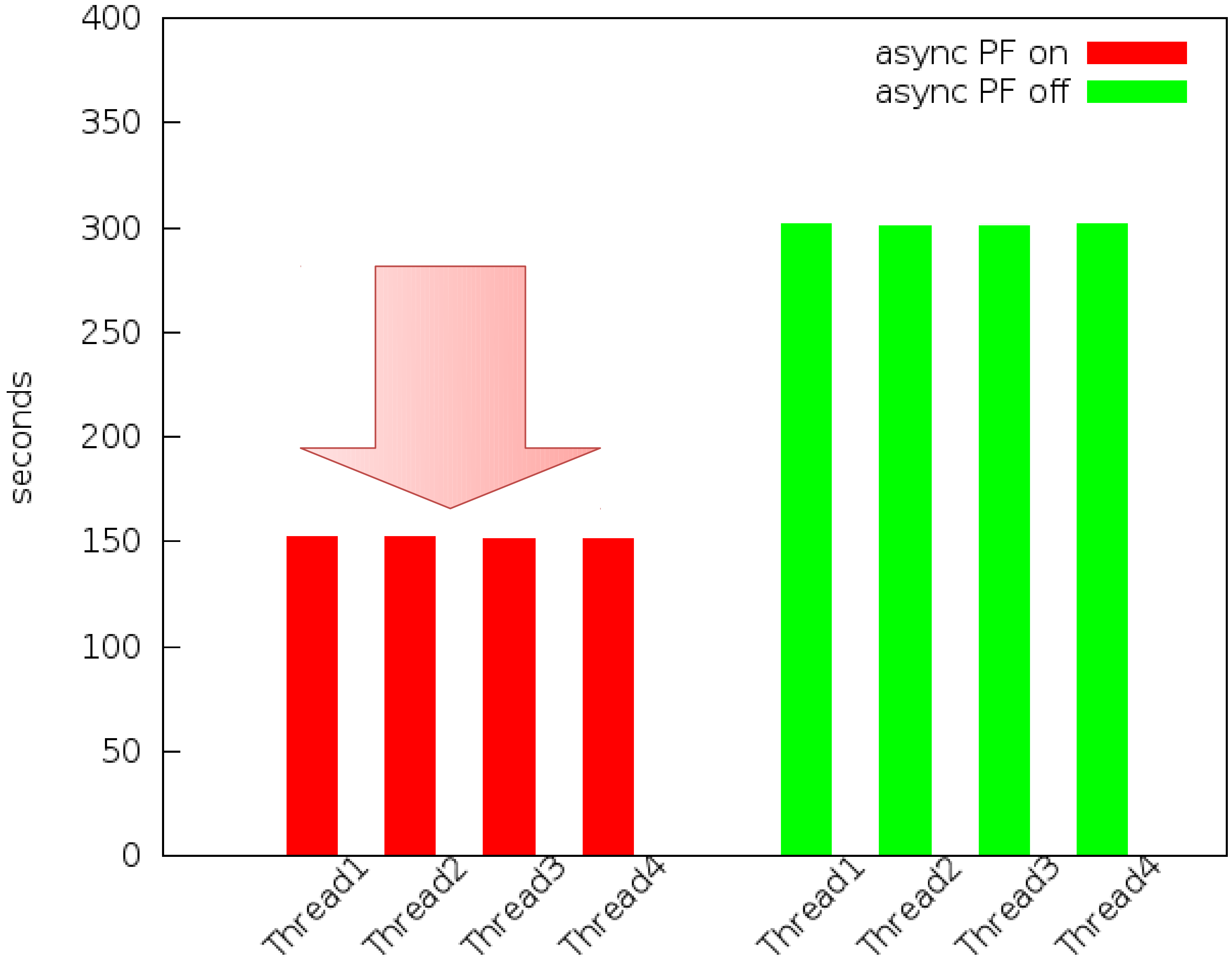
Memory scanning with postcopy

- 6GB memory Guest RAM
- 4thread
- Per-thread
  - 1GB
  - Each thread accessing all pages
  - Time from the first page access to the last page access
- Start each thread right after starting post-copy migration
- Background transfer is disabled

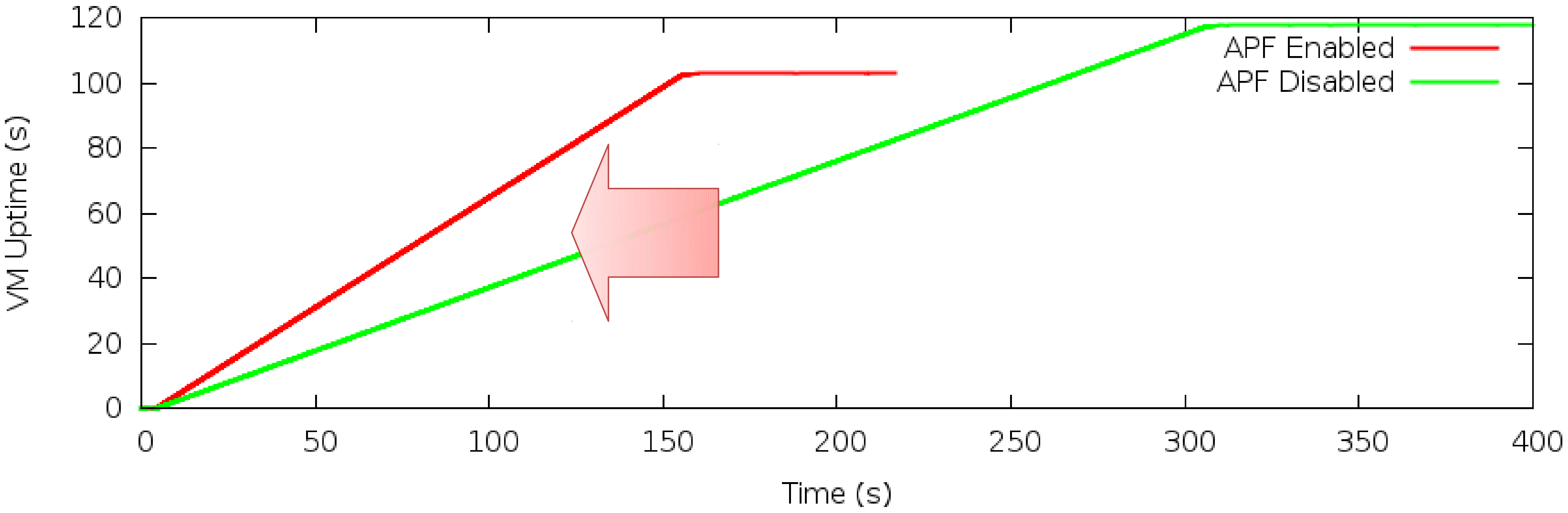


This evaliation is done with old implementation

Memory scan time(real)



Total CPU time allocated to guest VM



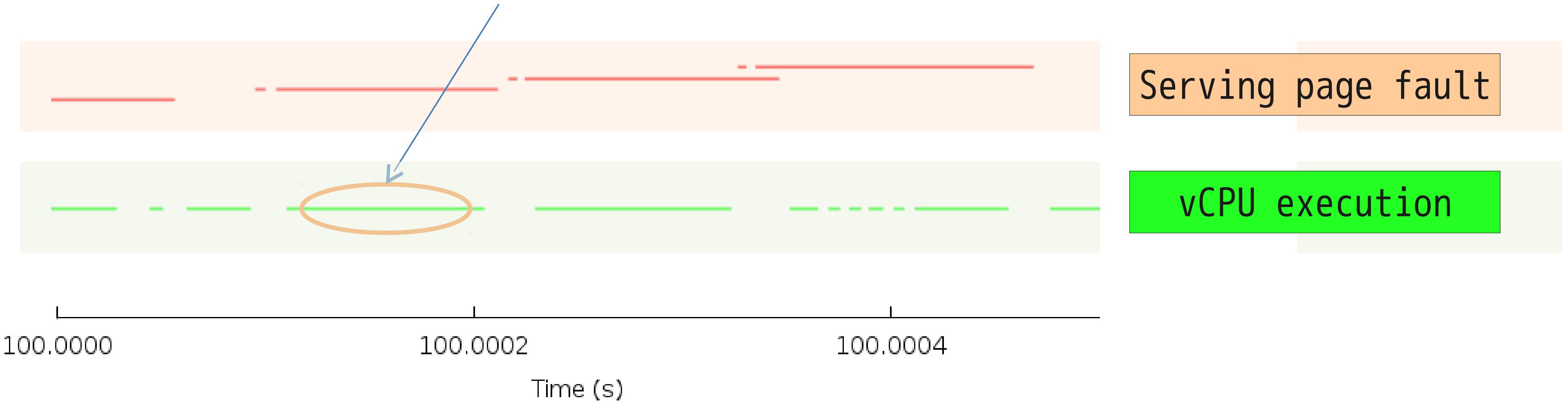
VCPU execution efficiency is improved cpu-time/real-time

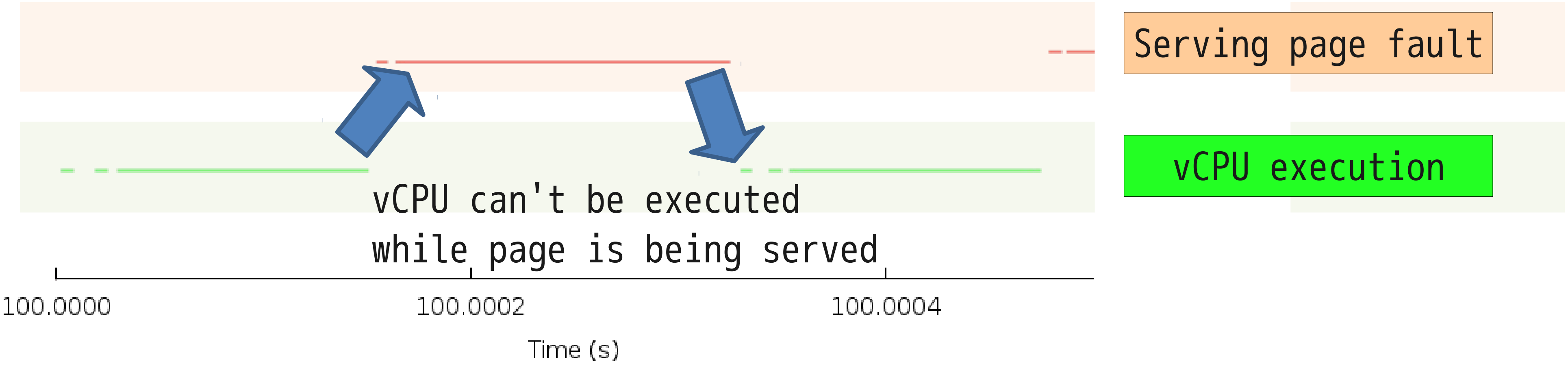
APF enabled: 0.7

APF disabled: 0.39

Analyze with SystemTap

vCPU is executing during page is being served

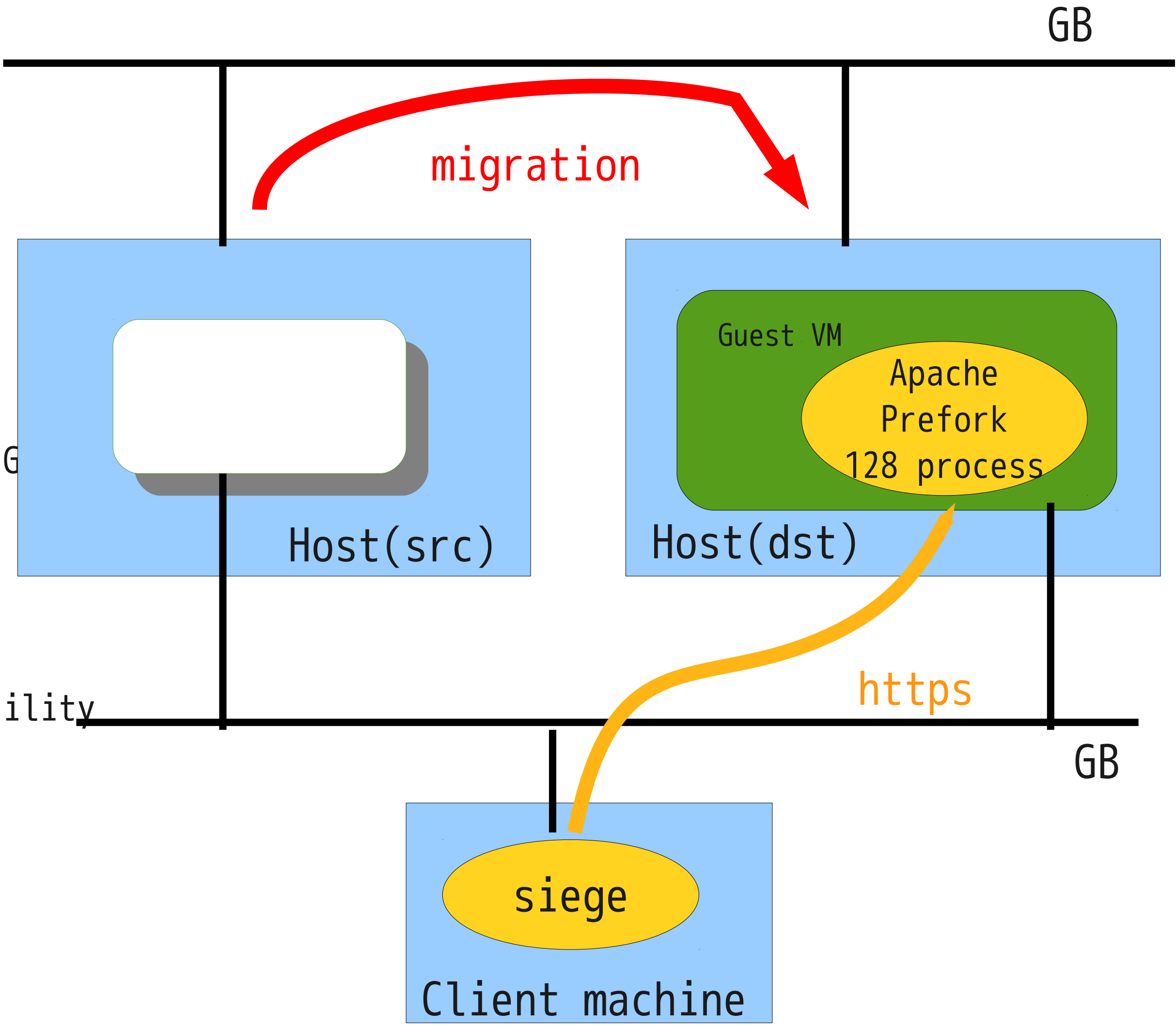




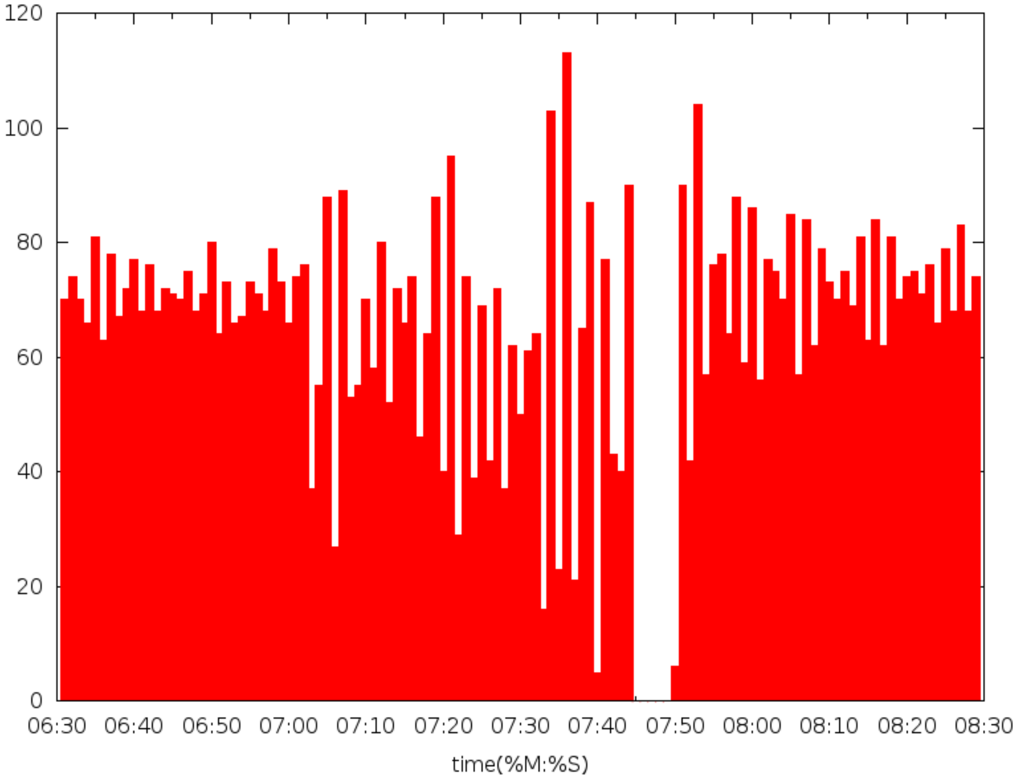
vCPU can't be executed
while page is being served

Siege benchmark with Apache 1GB case

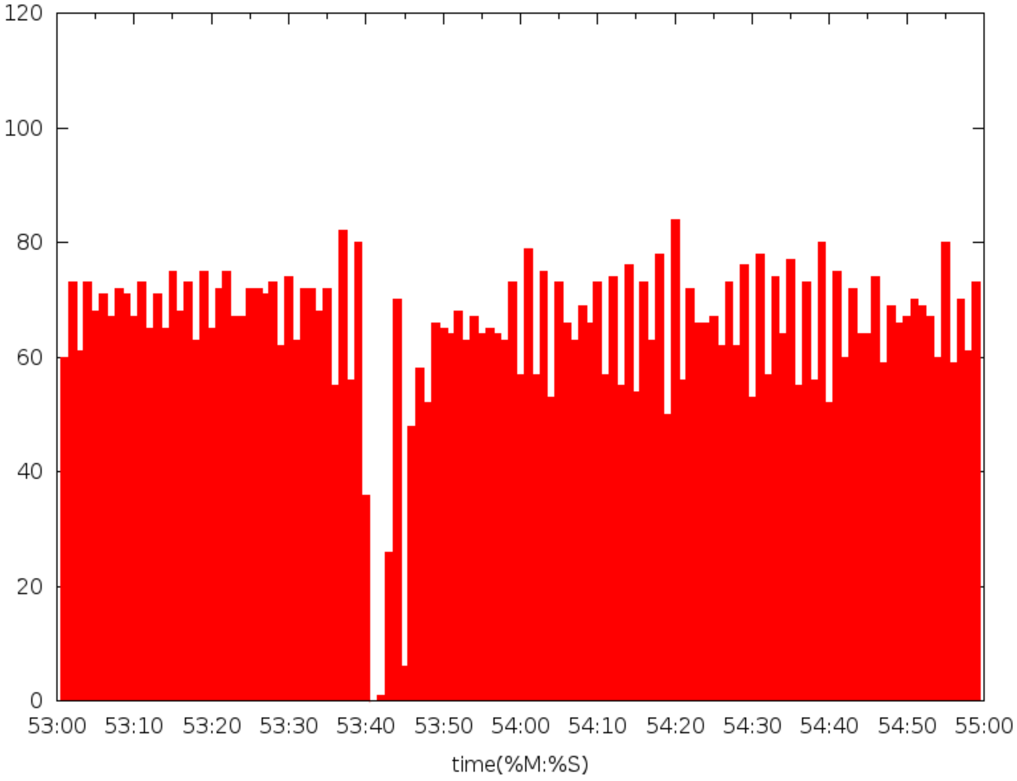
- Host
  - Core2 quad CPU Q9400 4core 2.66GHz
  - Memory 16GB
- Qemu/kvm
  - Memory about 6G(-m 6000)
  - Virtio, kernel_irqchip
- Apache
  - Prefork 128 process fixed
  - Data: 200K * 100000000files = about 2G
  - Warm up by siege before migration
    - So all data are cached on memory
- Siege
  - http load testing and benchmarking utility
  - http://www.joedog.org/siege-home/
  - 128 parallel (-c 128)
  - Random URL to 10000 URLs



Precopy



Postcopy



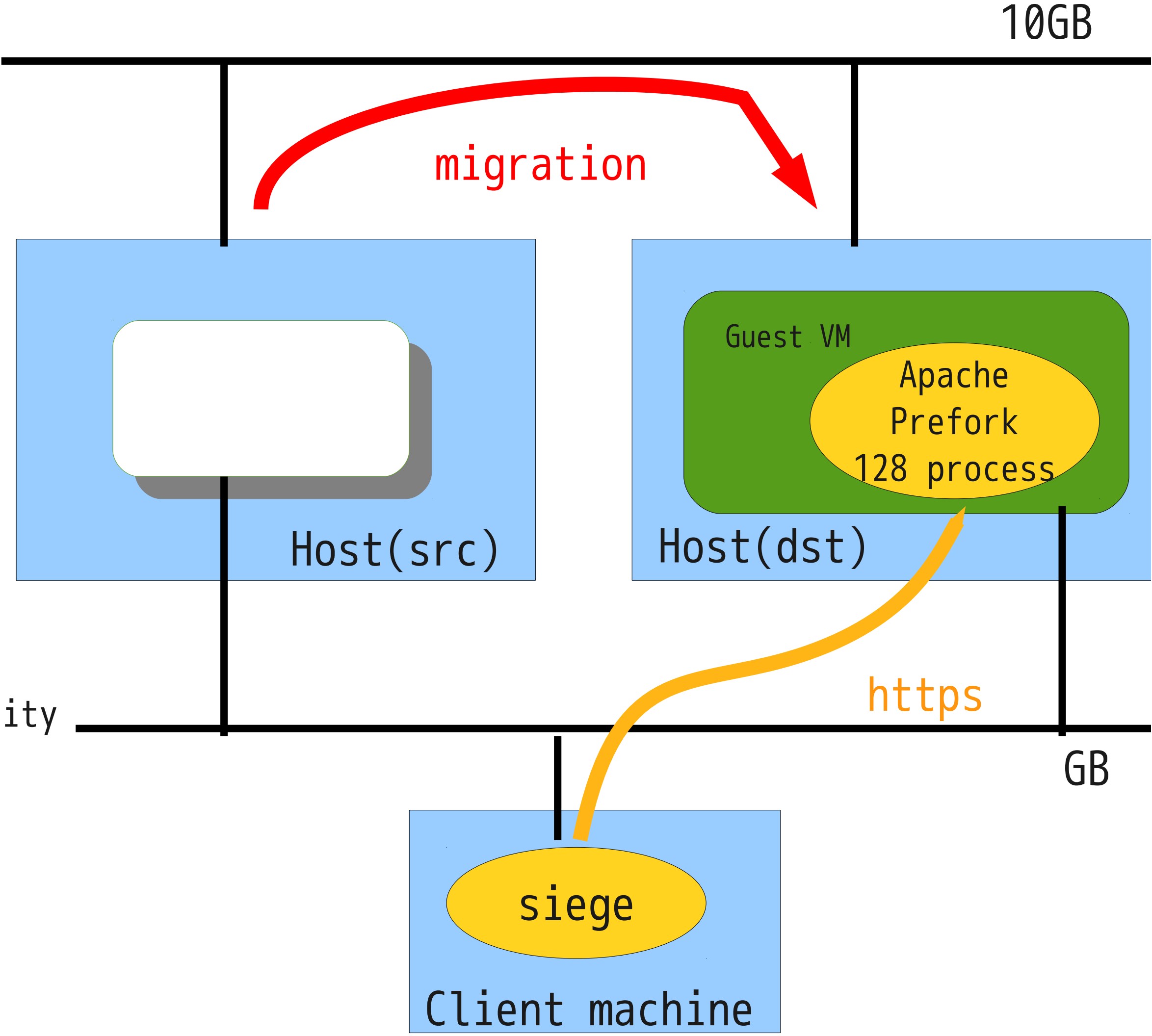
Precopy
Migrate set_speed=125M
(without XBZRLE)

Postcopy w/o background transfer
Prefault forward=100

```
migrate -p -n tcp:<IP address>:4444 0 100 0
```

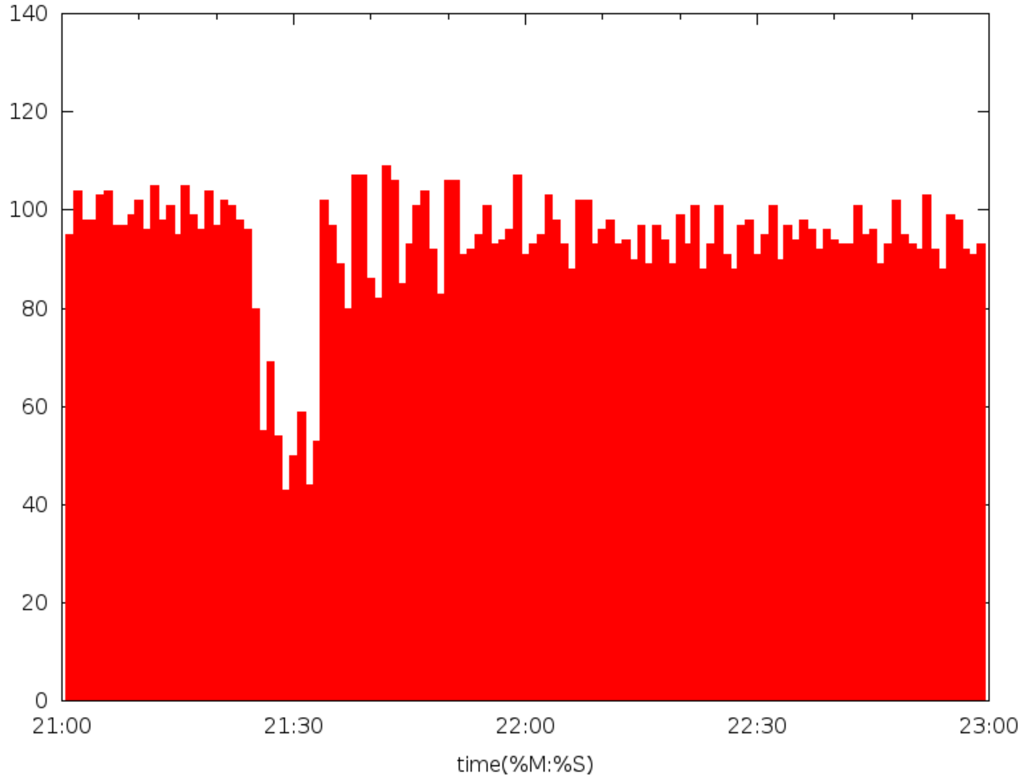
Siege benchmark with Apache 10GB case

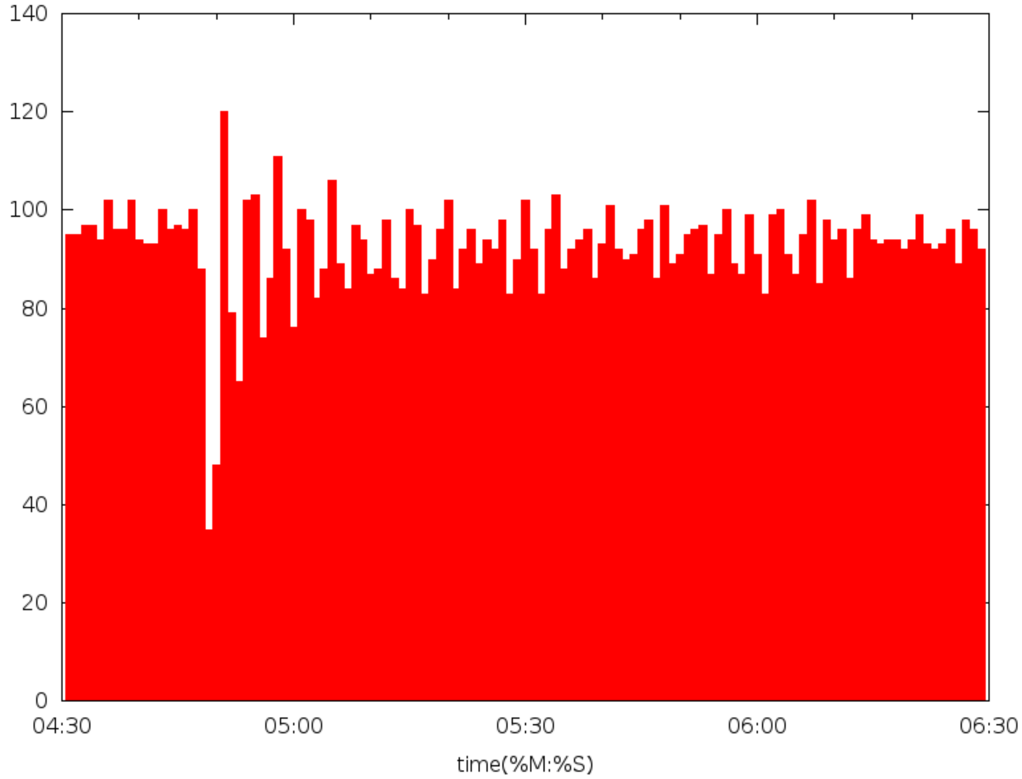
- Host
  - Xeon quad CPU E5620 2.40GHz * 2
  - Memory 24GB
- Qemu/kvm
  - Memory about 6G(-m 6000)
  - Virtio
- Apache
  - Prefork 128 process fixed
  - Data: 200K * 100000000files = about 2GB
  - Warm up by siege before migration
    - So all data are cached on memory
- Siege
  - http load testing and benchmarking utility
  - http://www.joedog.org/siege-home/
  - 128 parallel (-c 128)
  - Random URL to 10000 URLs



Precopy

Postcopy





```
Precopy
Migrate set_speed=1250M
(without XBZRLE)
```

```
Postcopy w/o background transfer
Prefault forward=400
migrate -p -n tcp:<IP address>:4444 0 400 0
```

Future work

- Upstream merge
  - Benchmark: Others are already working on it.(Benoit Hudzia and Vinod, Chegu)
  - Integration with RDMA approach. Find clean design
  - Investigate for fuse version of umem device and evaluation
    - See if it's possible and its performance is acceptable
- downtime work
  - Fetch latency sensitive page first
    - post_load page
    - Pv device page

Thank you

- Questions?
- Resources
  - Project page
    - http://grivon.apgrid.org/quick-kvm-migration
    - http://sites.google.com/site/grivonhome/quick-kvm-migration
  - Enabling Instantaneous Relocation of Virtual Machines with a Lightweight VMM Extension: proof-of-concept, ad-hoc prototype. not a new design
    - http://grivon.googlecode.com/svn/pub/docs/ccgrid2010-hirofuchi-paper.pdf
    - http://grivon.googlecode.com/svn/pub/docs/ccgrid2010-hirofuchi-talk.pdf
  - Reactive consolidation of virtual machines enabled by postcopy live migration: advantage for VM consolidation
    - http://portal.acm.org/citation.cfm?id=1996125
    - http://www.emn.fr/x-info/ascola/lib/exe/fetch.php?media=internet:vtdc-postcopy.pdf
  - Qemu Wiki
    - http://wiki.qemu.org/Features/PostCopyLiveMigration
  - Demo video
    - http://www.youtube.com/watch?v=lo2JJ2KWrlA
  - Github repo
    - git://github.com/yamahata/qemu.git qemu-postcopy-nov-03-2012
    - git://github.com/yamahata/linux-umem.git linux-umem-oct-29-2012