Investigation of Resource Reallocation Capabilities of KVM and OpenStack

Bachelor Thesis Presentation

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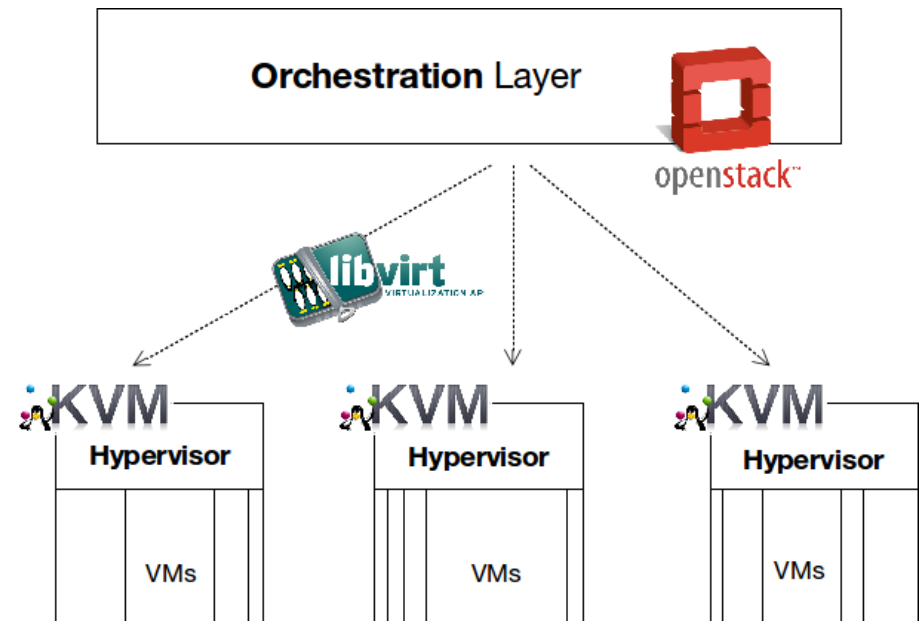
Agenda

Investigation of Resource Reallocation
Capabilities of KVM and OpenStack

1. Research Questions

- How are physical resources (PR) reallocated in cloud computing?

- Which resources can be reallocated in KVM/OpenStack?

- Which methods are used in KVM/OpenStack to reallocate resources?

Investigation of Resource Reallocation
Capabilities of KVM and OpenStack

1. Introduction to Cloud Layers

- **OpenStack:**
  scheduling and deployment of VMs

- **libvirt API:**
  uniform access to resource limits

- Kernel based virtual machine (**KVM**):
  provisions the PRs to the VMs

- Each VM has a hardware template
  referred to as its flavor.

Investigation of Resource Reallocation
Capabilities of KVM and OpenStack

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2. libvirt Hard and Soft Limits

- Hard limit:
  - always active
  - upper boundary of the soft limit
- Soft limit:
  - only enforced if resource is scarce
  - thesis focus
- The libvirt API provides soft limits for
  - CPU
  - RAM
  - and disk IO
- `tc`'s htb qdiscs allow to priorize network bandwidth

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3. VM Resizing and PR Reallocation

- VM **resizing**
  - describes a flavor change
  - **hard** limits change
  - rescheduling needed
  - implemented in OpenStack

- Resource **reallocation**
  - can be flavor independent
  - e.g. a change in VM resource **priorities** (**soft** limits)
  - no rescheduling needed

Agenda

1. Research Questions and Introduction

2. libvirt Hard and Soft Limits

3. VM Resizing and Resource Reallocation

4. **OpenStack Extension Design and Implementation**

5. OpenStack Extension Evaluation

6. Conclusion

7. Future Work and Outlook

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4. OpenStack Extension: Conceptual Formulation

- Design, implementation, evaluation and documentation of an OpenStack extension to control the PR allocation to VMs of individual PMs.

- Extend the OpenStack nova API to allow changes of libvirt's
  - CPU
  - RAM
  - disk IO

  and `tc`'s network bandwidth soft limits at run-time.

- Extend the `nova` python client to make use of the new nova API methods.

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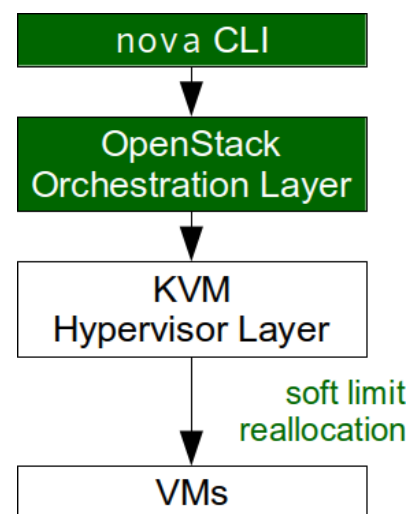
4. OpenStack Extension: High Level Design

Now:

- flavor bound, boot-time resource limits (soft and hard)

- no network bandwidth soft limit
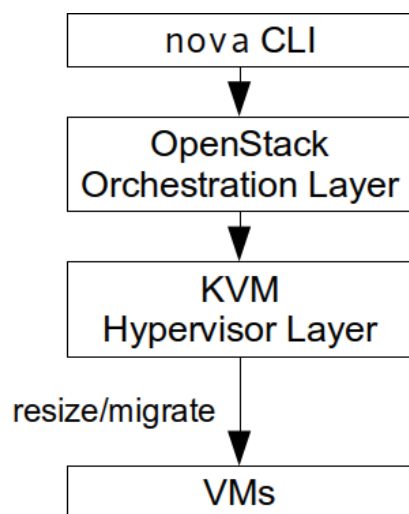
With extension:

- instance bound, run-time soft limit manipulation for all four resources

```
nova CLI
   │
   ▼
OpenStack
Orchestration Layer
   │
   ▼
KVM
Hypervisor Layer
   │
resize/migrate │
   ▼
VMs
```

```
nova CLI
   │
   ▼
OpenStack
Orchestration Layer
   │
   ▼
KVM
Hypervisor Layer
   │
   │  soft limit
   │  reallocation
   ▼
VMs
```

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4. OpenStack Extension: Implementation

- Different extension architectures in OpenStack API version 2 and version 2.1

- Incomplete documentation and fuzzy entry points

- Extension is based on the stable *kilo* OpenStack release and the legacy OpenStack API version 2

- Devstack development environment (1 host)

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5. Evaluation

- The data series in blue, green and red on the following slides represent different VM workloads.

Investigation of Resource Reallocation
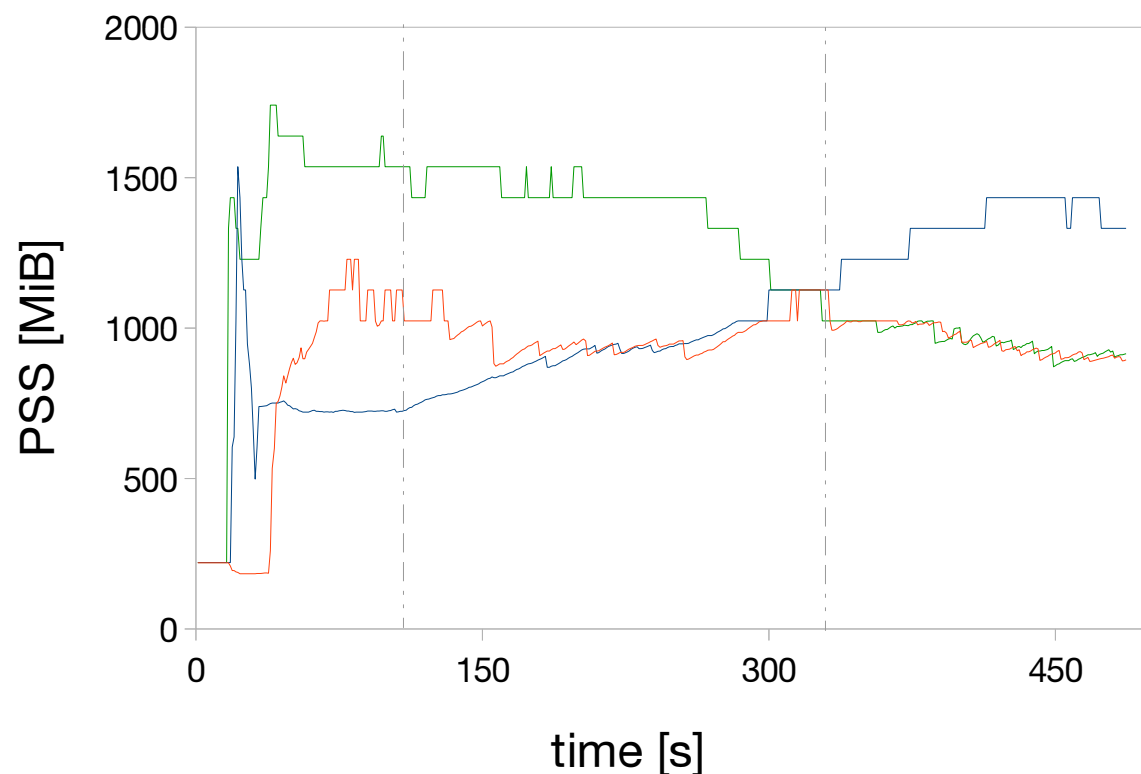Capabilities of KVM and OpenStack

5. Evaluation: CPU Shares
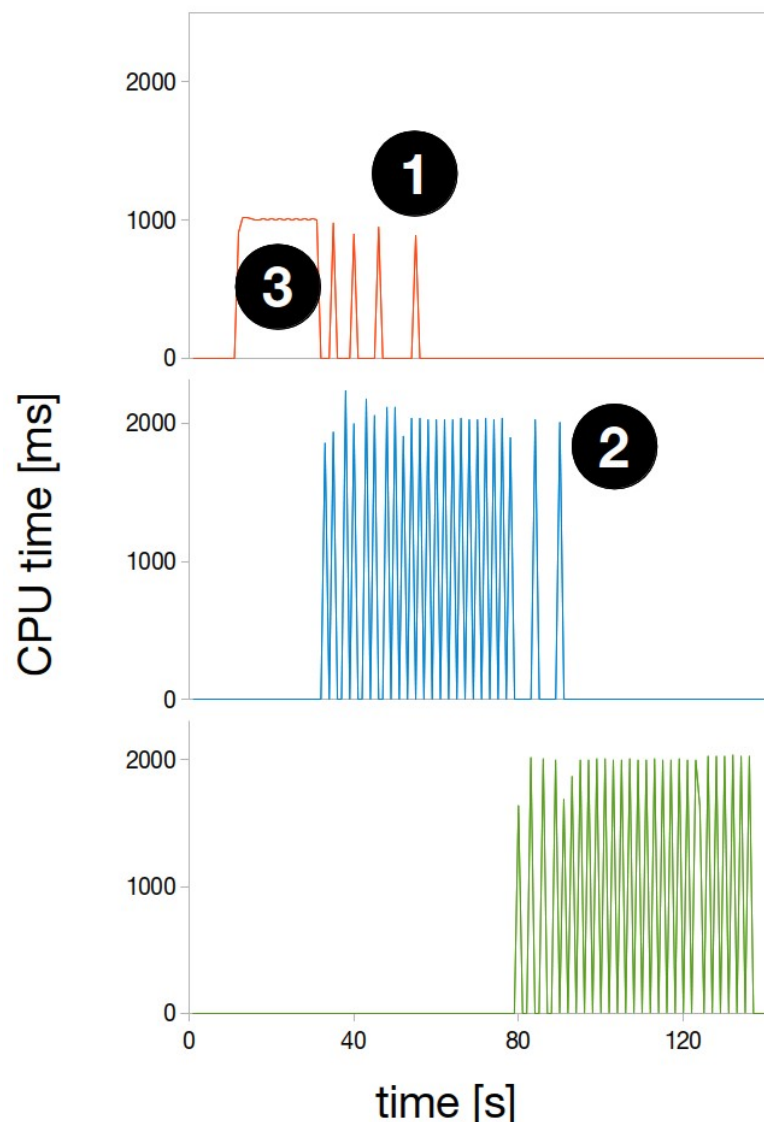
Priorities: 100   500   1'000

1 **2**   priorities are applied

3   constant usage

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Capabilities of KVM and OpenStack
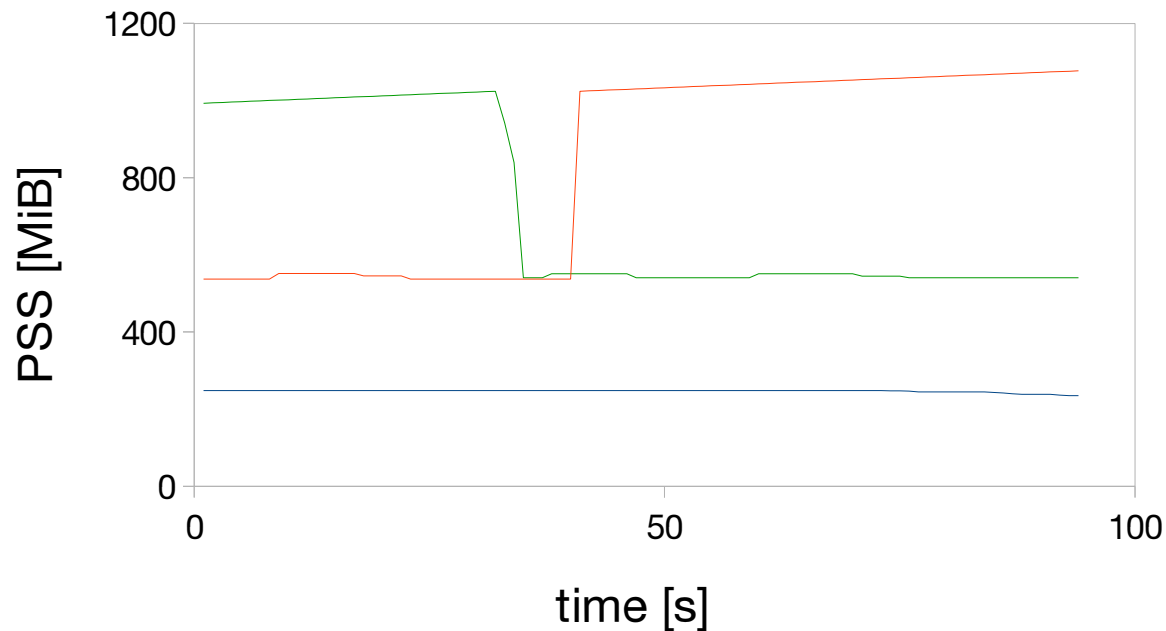
5. Evaluation: Memory Soft Limit

- best-effort feature

- balancing reclaimed memory takes time (slow adaption)

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Capabilities of KVM and OpenStack

5. Evaluation: Memory Hard Limit

- always active

- upper boundary for the soft limit

- fast adaption

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5. Evaluation: Disk IO Soft Limit

Disk IO priorities: 500 900 300
CFQ Scheduler
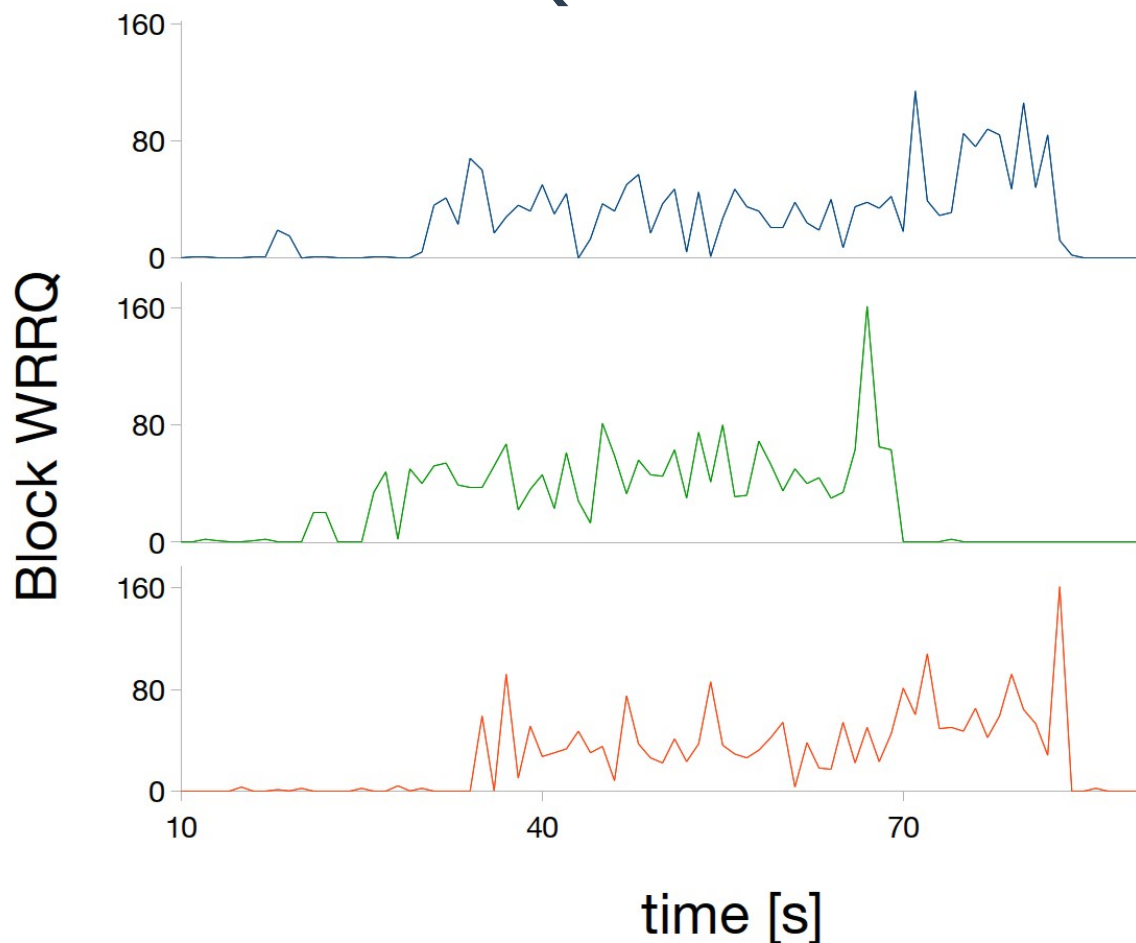
early start,
late finish

early start,
early finish

late start,
late finish

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5. Evaluation: Network Bandwidth Soft Limit
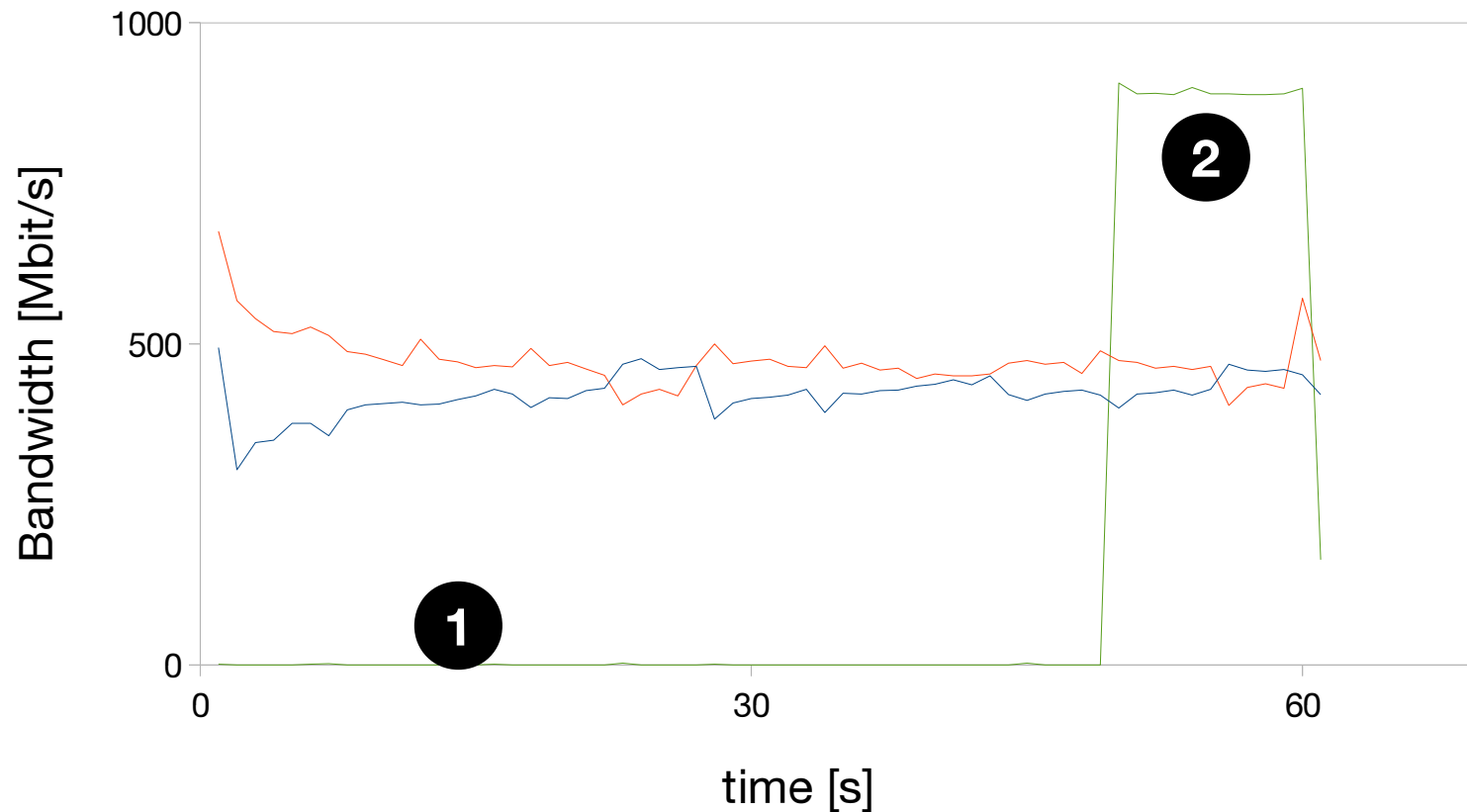
1 starvation of low priorities

2 unreliable, unexpected behaviour

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5. Evaluation: Network Bandwidth Soft Limit
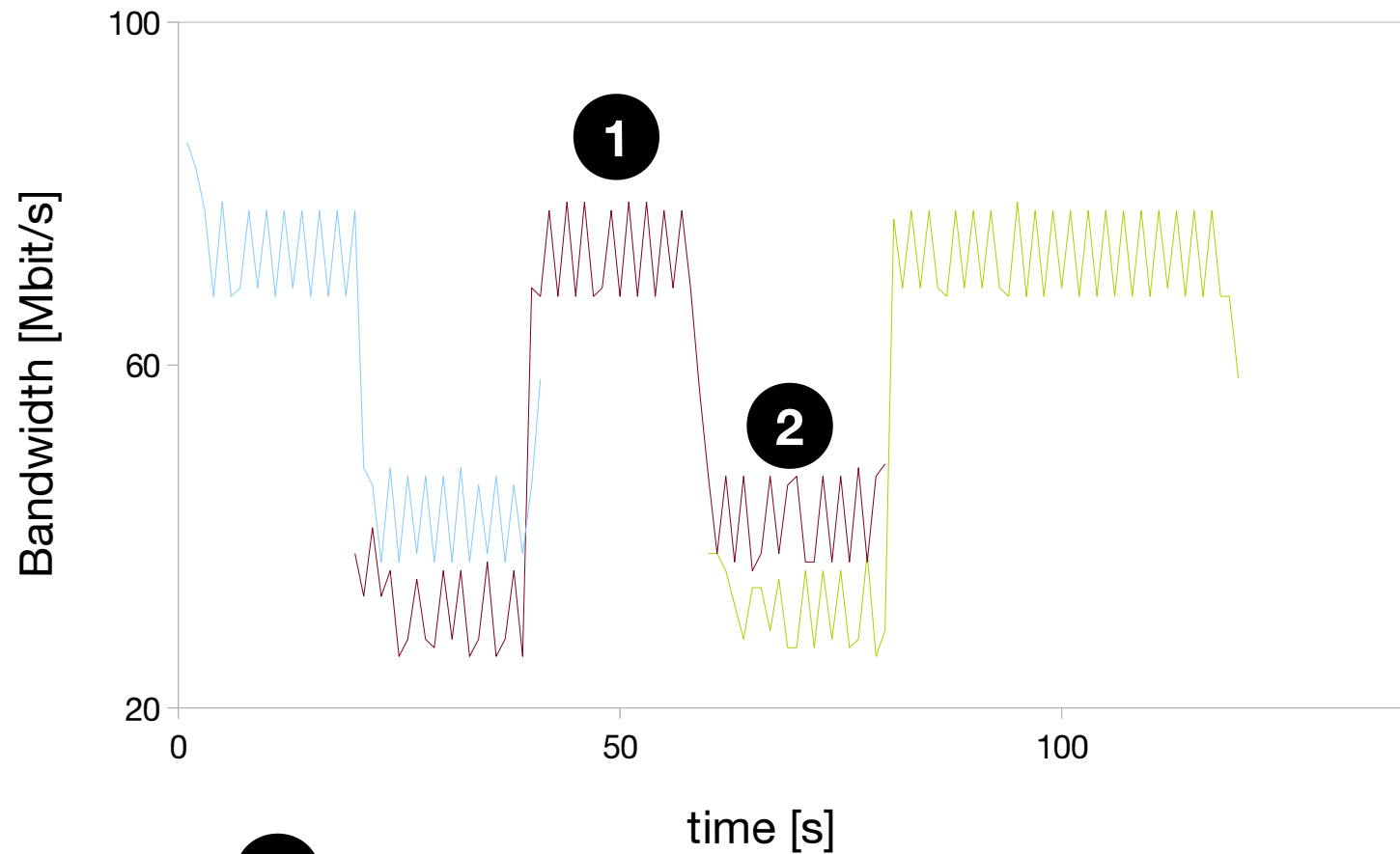
Priorities:

39 26 15

1 borrowing

2 proportional borrowing

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6. **Conclusion**

7. Future Work and Outlook

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6. Conclusion

All four resources,

– CPU,

– disk IO,

– RAM and

– network bandwidth

can be reallocated between VMs competing for scarce resources with the help of libvirt's soft limits and `tc`'s htb qdisc.

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6. Conclusion

- How are PRs reallocated in cloud computing?

  - libvirt virtualization API

  - tc

- Which resources can be reallocated in KVM/OpenStack?

  - All four resources, CPU, disk IO, RAM and network bandwidth

- Which methods are used in KVM/OpenStack to reallocate resources?

  - Resizing (live migration)

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7. Future Work

- Test the new API extension in a "real world" environment with multiple compute nodes

- Reset network priorities (delete `tc qdiscs`)

- Improve `nova` client usability

  – RAM limits: different units (chosen by the user)

  – Uniform priority scale for CPU, disk IO and network bandwidth

  – Priority based RAM reallocation (to be consistent with the other three resources)

- Rewrite extension for the OpenStack API version 2.1 (new microframework plugin architecture)

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7. Outlook

- Flavor change at run-time will not be part of the next stable OpenStack release.

    - Maybe resource priorities soon will?

- Is there interest in resource reallocation with soft limits?

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Thank You for Your Attention!

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