Hewlett Packard
Enterprise

ORCHESTRATION OF EXASCALE FABRICS USING THE SLINGSHOT FABRIC MANAGER

PRACTICAL EXAMPLES FROM LUMI AND FRONTIER

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May 11, 2023

AGENDA

- Fabric Manager Overview
- Architecture
- Performance and recent optimizations
- Upcoming improvements

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FABRIC MANAGER OVERVIEW: BASIC TECHNOLOGIES

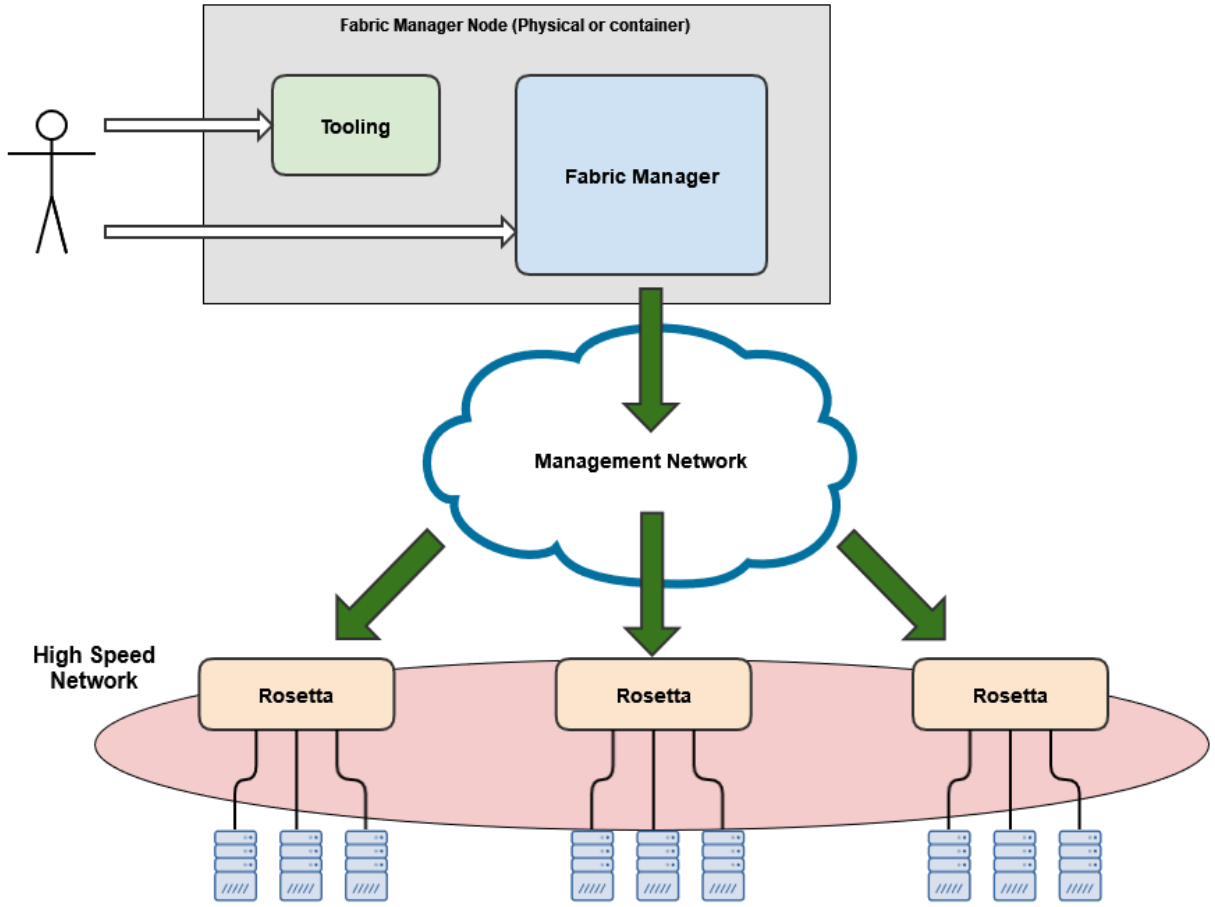
- Written in Java
- Based on existing core technologies
  - DCS Core: open source project from VMware
    - Provides the REST interface and interface to the database
  - Apache Lucene database
    - Provides permanent storage for fabric data
    - Used in many open source projects
      - ElasticSearch is an example

FABRIC MANAGER OVERVIEW

- Responsible for configuring the Slingshot network
- Primary point of contact for the network administrator
- FM vs. FMN:
  - FM: Fabric Manager
  - FMN: Fabric Management Node
- Wide variety of fabric setups
  - From simple clusters with 128 nodes and 3 switches to the largest computers in the world

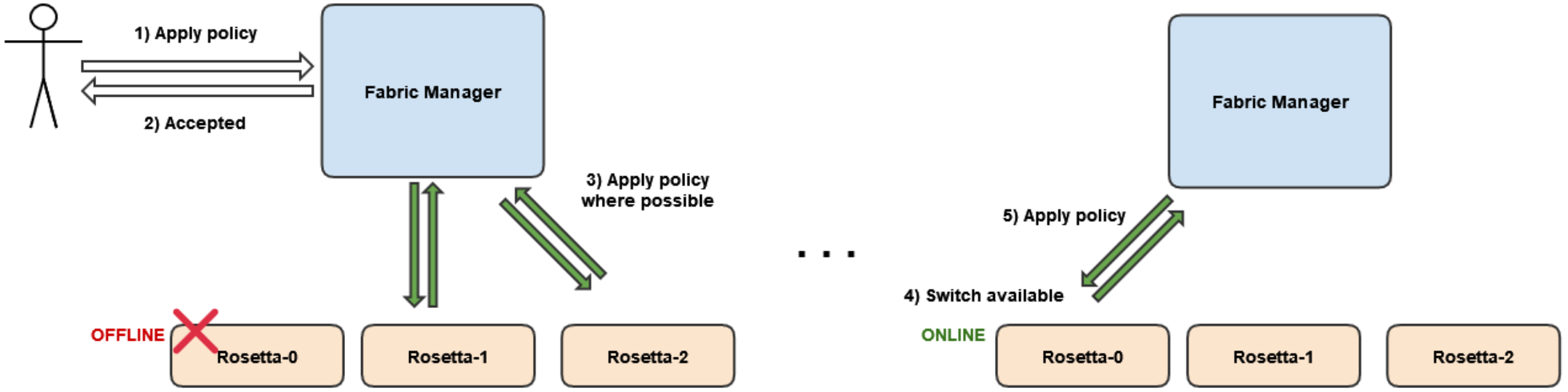
- LUMI
  - 874 switches
  - >4000 nodes , ~12.000 network endpoints

- Frontier
  - 2500 switches
  - ~10.000 nodes, ~40.000 network endpoints



FABRIC MANAGER OVERVIEW: DEPLOYMENT MODEL

- Eventual consistency model
  - Most actions are **not** guaranteed to have been completed when a command finishes
  - Policies will apply when it is possible to do so
  - Covers scenarios where devices are not immediately reachable
  - At large enough scale, equipment failure cannot be ignored
    – "Unlikely" times 40,000 endpoints = Likely
  - Includes redeployment after failures or intentional reboots



FABRIC MANAGER OVERVIEW: FABRIC AGENT

- Won't go into too much detail on the agent
- The Fabric Agent runs on the Rosetta Switch Controllers
- Responsible for the high level interface to lower level switch programming
- The Fabric Agent is built from the same code base as the fabric manager

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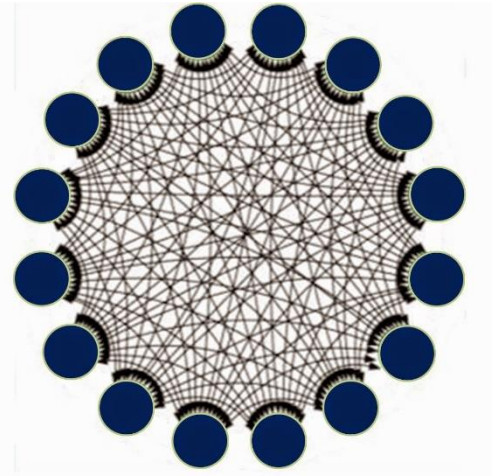
FABRIC MANAGER ARCHITECTURE

- The Fabric Manager is composed of several “services”
- Each service:
  - Is a unit with business logic
  - Exposes a REST interface, ALL services have an associated endpoint
  - Has associated JSON data
  - Interactions done only through REST API calls
    - This includes internal interaction between the services
- Services can be storage-backed or resident in memory

FABRIC MANAGER ARCHITECTURE

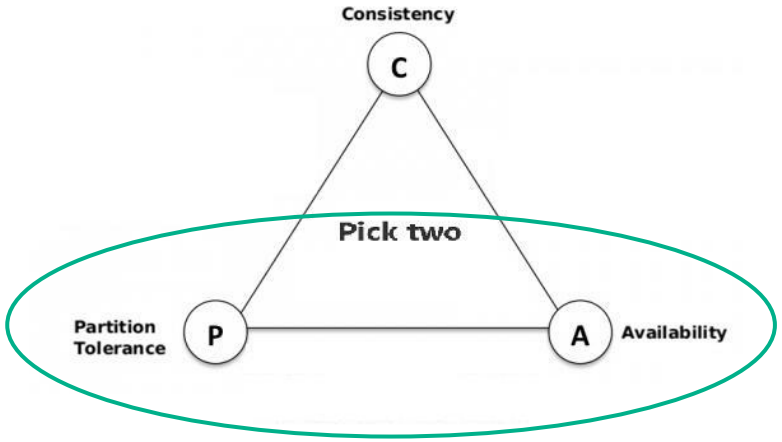
Challenges

- Operate equally well on small and large systems
- Equipment failures can occur
- Ensuring that the entire system is present at any moment is non-practical



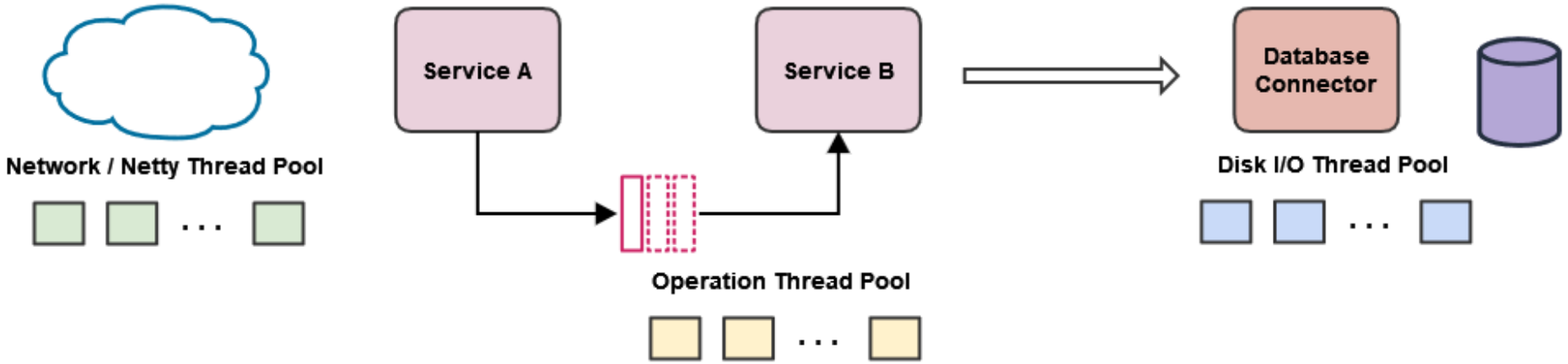
Solutions

- Periodic sweeps / polling of fabric status
  - ALL timers are adjustable at runtime for tuning
- Schedule redeployment of policies when applying a policy fails
- Isolated blocks of business logic and data
- Per-device state machines
  - Ensure actions happen in correct order
  - Allow multiple devices to progress at different rates
    - Eliminate the “no node left behind” issues with xtbounce



FABRIC MANAGER ARCHITECTURE

- Business logic is placed in request handling
  - Fully asynchronous and non-blocking
  - This guarantees that threads are released as soon as possible and can be reused
  - Scheduling is performed by the core framework
- 3 sets of thread pools
  - Operation handling – work-queue processing of operations and services' business logic
  - Network I/O handling
  - Disk I/O and data indexing



FABRIC MANAGER ARCHITECTURE

- Services interact through REST messages or “operations”
  - These are standard HTTP actions: GET, PATCH, PUT, etc
  - Initiated by external requests or by other services
  - Since request handling cannot block, services create chains of asynchronous operations

- That is, services interact through message passing
  - There is a cost incurred in serialization/deserialization of messages
  - Trade-off accepted to achieve a higher degree of parallelism

- With small non-blocking processing request handling blocks, Fabric Manager’s resource consumption largely correlates to:
  1. amount of messages and
  2. size of messages (cost of serialization/deserialization)

FABRIC MANAGER ARCHITECTURE

- Periodic tasks are actions that execute periodically and can trigger requests to services
  - E.g Redeployment of configurations. Periodically checking the state machine for configuration deployment and, if FAILED, start it again to attempt redeployment

- Pros of periodic actions and polling:
  - Provide a more predictable load profile
  - Are easy to tune: timers can be accelerated or slowed down based on a set of conscious trade-offs. E.g. accelerate fabric sweeps for faster re-routing while slowing down redeployment of configurations

- Cons:
  - Delay between an action (e.g applying a policy to a port) and something happening
  - Higher CPU overhead during idle periods

More to be covered in “upcoming improvements”!

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PERFORMANCE AND RECENT OPTIMIZATIONS

- Fabric Manager's resource consumption is tied to the volume and the size of messages
  - The ***format*** of the messages also has an impact
    - Deeply nested data structures incur a much higher serialization and deserialization effort
    - Flat structures offer performance gains

- Slingshot 2.0 introduced over 20 Fabric Manager optimizations

Hash comparisons

- Retrieve and compare hashes of configurations instead of having to retrieve and compare large configurations
  - Slingshot configurations are large and scale linearly with the number of switches
  - Decreases in overall resource usage, one optimization – retrieving only hashes of remote routing configuration – cut CPU and memory usage to half at scale

PERFORMANCE AND RECENT OPTIMIZATIONS

Flatten port and configuration data fields

- At scale there are 10s to 100s of thousands of ports
- There are several per-port configurations
- Automatically makes the process of applying policy to ports more efficient

Restructuring of data used by Forwarding (Routing) Engine

- Routing calculations are expensive and require a full graph containing **all** switches and **all** links
- Simplifying data used by the routing engine provides a large benefit at scale

The above are some of the major optimizations introduced. There were others such as

- Use of caches. Instead of independent services trying to do remote operations, keep a local availability cache that services can consult before attempting to go remote
- Optimize state machine transitions (less operations)
- And many others

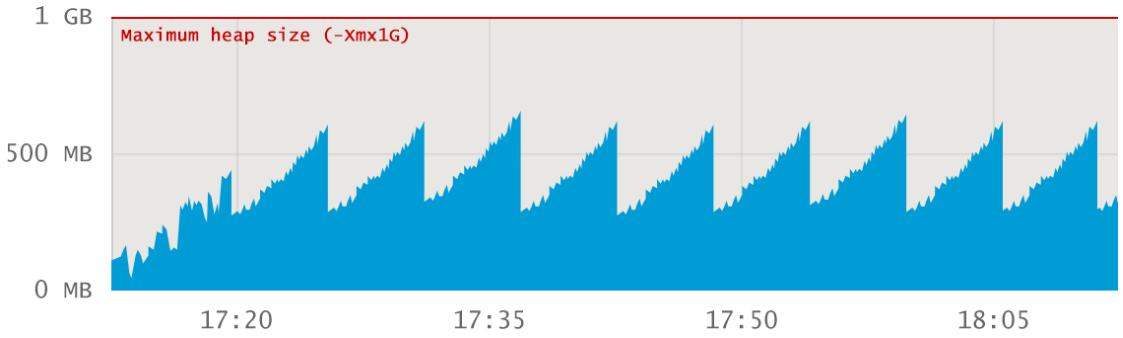
PERFORMANCE AND RECENT OPTIMIZATIONS

- Fabric Manager is written in a Garbage Collected language (Java)
- Memory profiling needs to take into account
- In non-GC languages, memory usage at any point indicates total amount of **actively used memory**
- In GC languages, it represents a cumulative value of **active** and **not yet collected** memory

- Memory profile is different pre and post-GC runs

To eliminate measurement artifacts, GC interference needs to be reduced.

- Run the GC at a deterministic point before measuring
- Not running GC during benchmarking
- Compare apples to apples



PERFORMANCE AND RECENT OPTIMIZATIONS - METHODOLOGY

All numbers obtained on:

- Intel(R) Xeon(R) Gold 6230 CPU @ 2.10GHz with 192GB of RAM
- OpenJDK 11.0.16, launched with **128GB of heap memory** to minimize GC interference

After bringup, using Frontier's template, the GC was manually run before measurement started.

Simulated environment with no real switches, as close to a real load profile as possible.

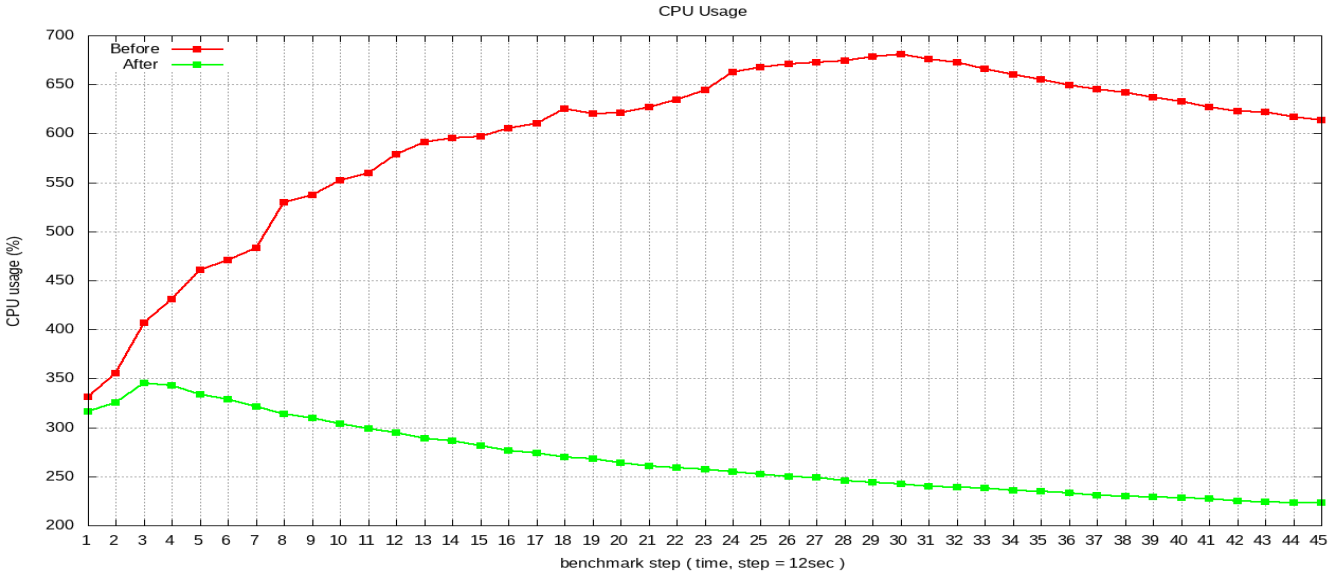
Comparisons between resource usage in 1.7.3 and 2.0.

2 sets of measurements:

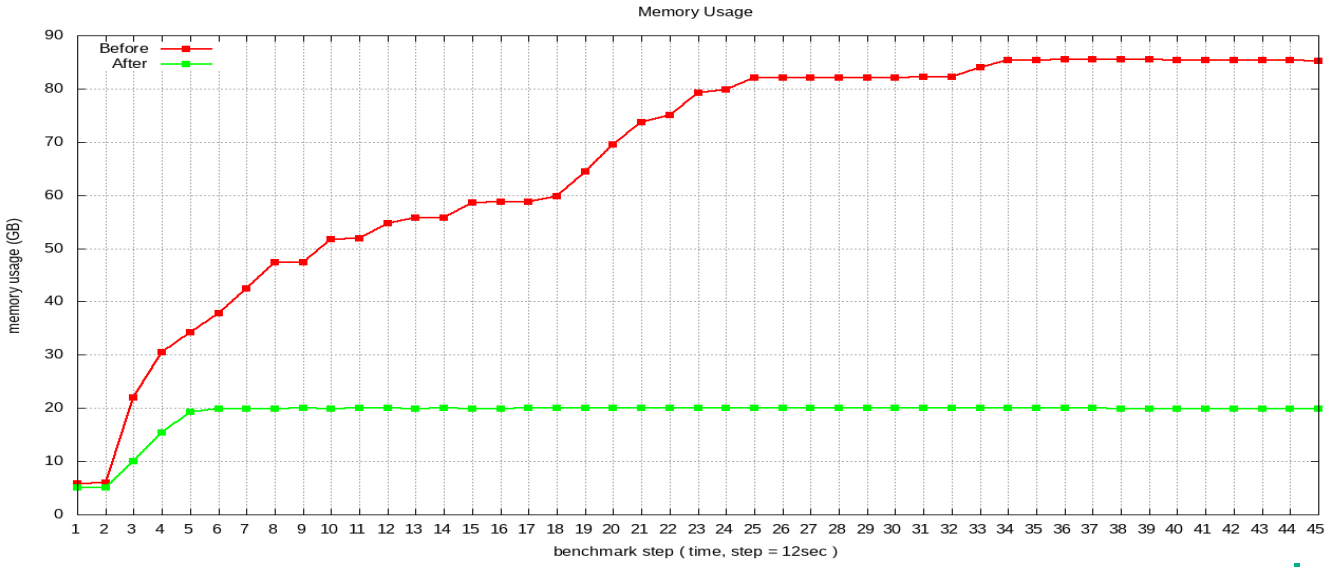
- **Idle state**, following bringup, measurement of resources needed for calculating routing init and apply switch and port configurations
- **Re-routing stress test**, continuously simulate the loss of global connections and cost of recalculating and redeploying routes

PERFORMANCE AND RECENT OPTIMIZATIONS - IDLE

- After optimizations CPU usage in idle reduces a lot (about HALF peak usage)
- Importantly, the peak resource is achieved much earlier
  - Initial configurations pushed much earlier



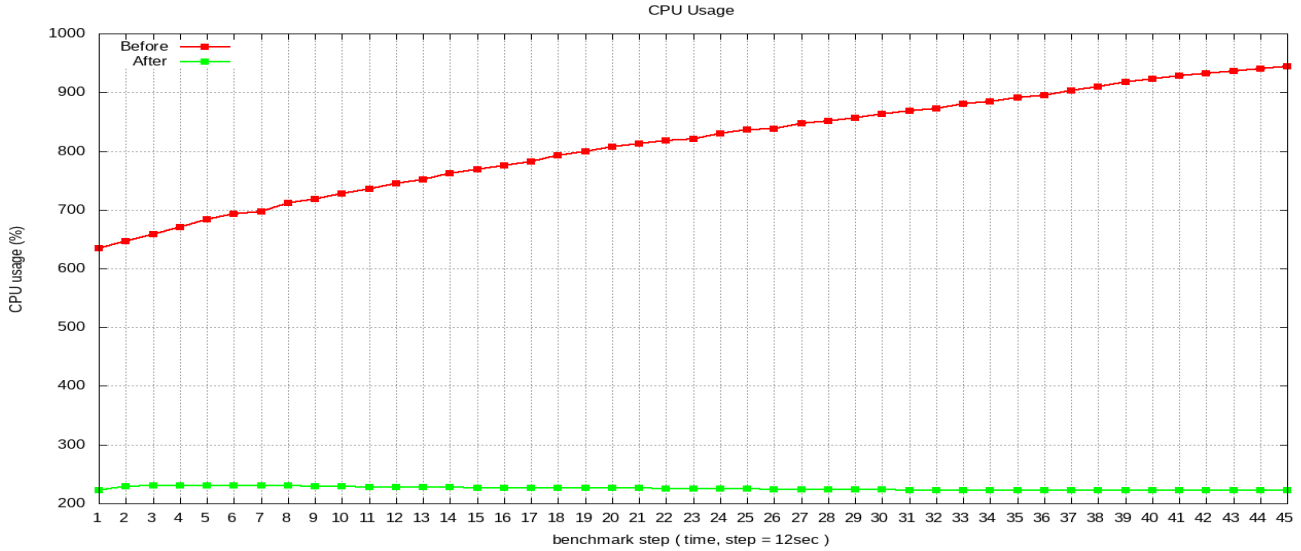
- Cumulative memory usage is reduced by a factor of 4x
- Memory usage directedly correlated to cost of message passing
- Impact of reducing message sizes and frequency of messages is visible
- As for CPU, the stabilization point is reached much earlier

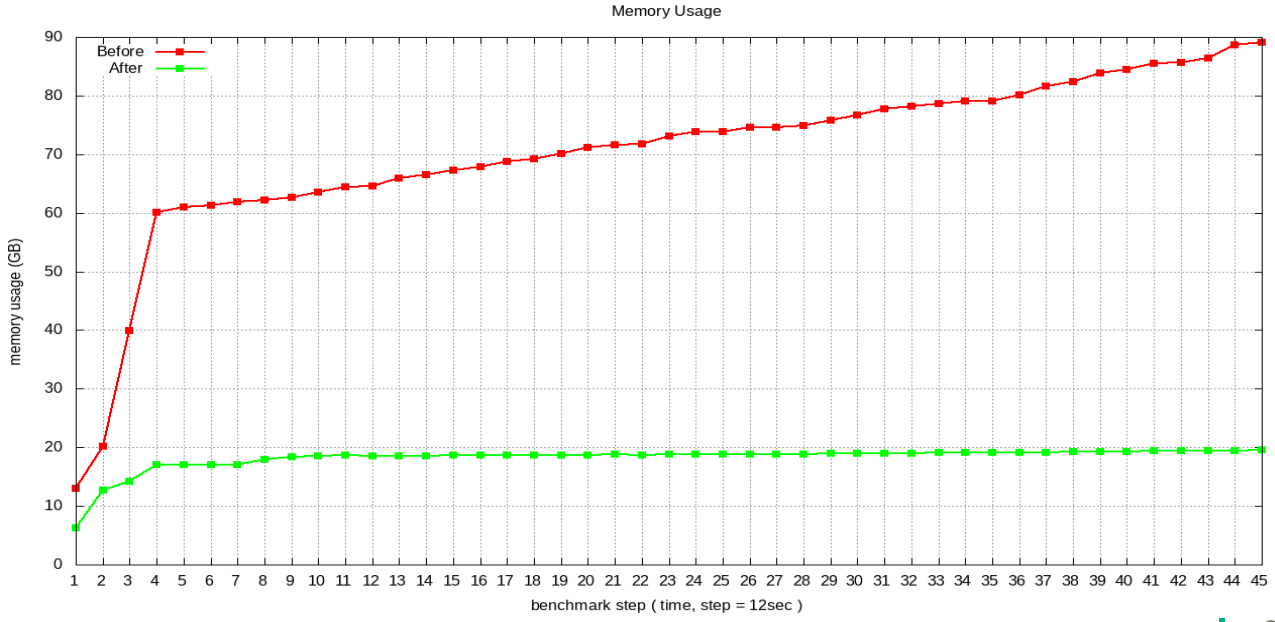


PERFORMANCE AND RECENT OPTIMIZATIONS – REROUTING STRESS TEST

- In 1.7.3 continuous (global) rerouting resulted in rising resource consumption
- CPU and memory could spike out of control (reality check: in this scenario, routing is continuously recalculated. It wouldn't happen in practice due to flap quietening)

- In 2.0, **cumulative** memory usage rises gradually (memory is being consumed for routes)
- CPU usage appear liner due to sampling resolution: when the CPU usage is sampled, routes have been calculated and distributed. It shows that CPU usage does go down.





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UPCOMING IMPROVEMENTS – HYBRID SWEEP AND EVENTING

- Polling and periodic tasks have brought us so far
- Some of you have tuned these timers for production!

- However, “pure” polling presents a number of cons
- An hybrid model is being introduced: events for immediate actions, still maintaining polling cycles
  - Pure event based mechanisms present their own set of pros and cons

- Many Advantages:
  - Faster applications of policies
  - Lower resource usage during idle periods
  - Faster re-routing, leading to less HSN packet loss in case of failure

UPCOMING IMPROVEMENTS (II) – FURTHER OPTIMIZATIONS

- A number of other improvements to come in the future

- We haven't talked about disk usage optimization yet!
- Data restructuring, better decouple data that needs to persist from data that only resides in memory
- Besides better storage usage it also incurs less disk I/O

- Separate sending queues for local and remote operations to avoid Head-of-line blocking

- Obviously, performance optimizations will continue to be guided by profiling
- Prioritization is on changes that have a measurable impact and are noticeable by you: faster rerouting, faster fabric reconfiguration and that will make the Fabric Manager more robust

THANK YOU

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