A Methodology for Characterizing the Correspondence Between Real and Proxy Applications

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Proxy Apps are Wonderful!

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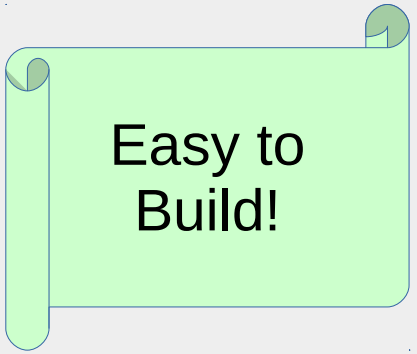

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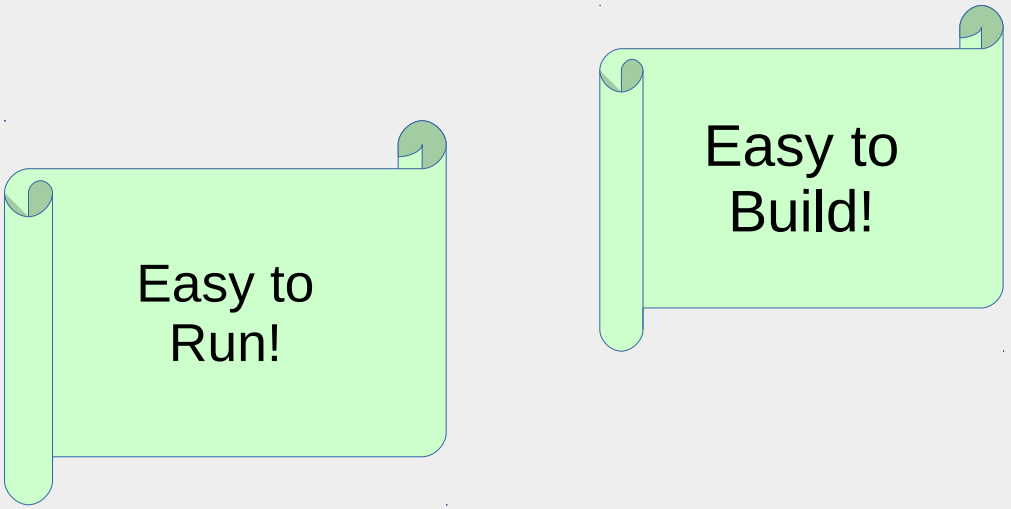

Proxy Apps are Wonderful!

Easy to Build!

Easy to Run!

Self-Monitoring!

Proxy Apps are Wonderful!

Easy to Modify!

Easy to Run!

Easy to Build!

Self-Monitoring!

Explore Ideas!

Proxy Apps are Horrible!

Proxy Apps are just OK

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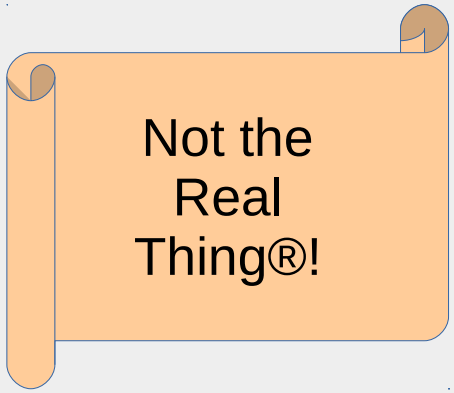

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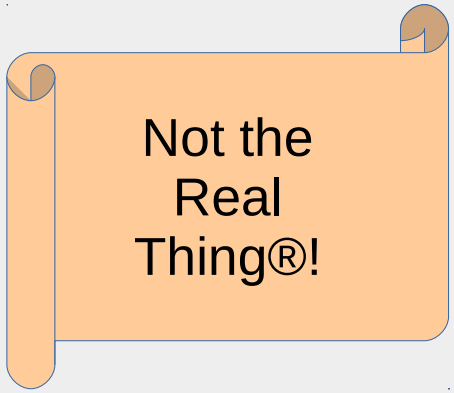

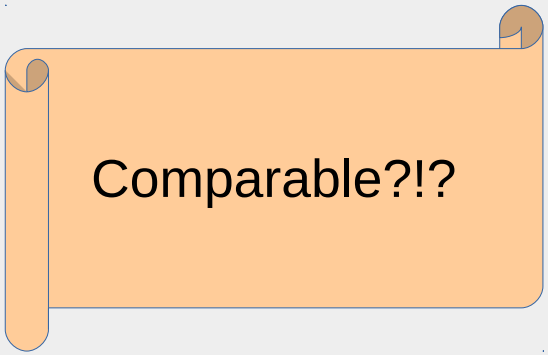

Proxy Apps are just OK

Not the Real Thing®!

Benchmark issues

Comparable?!?

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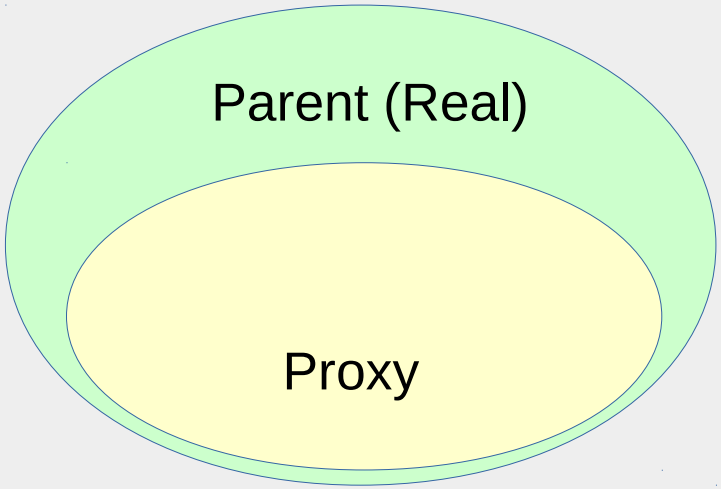
Benchmark issues

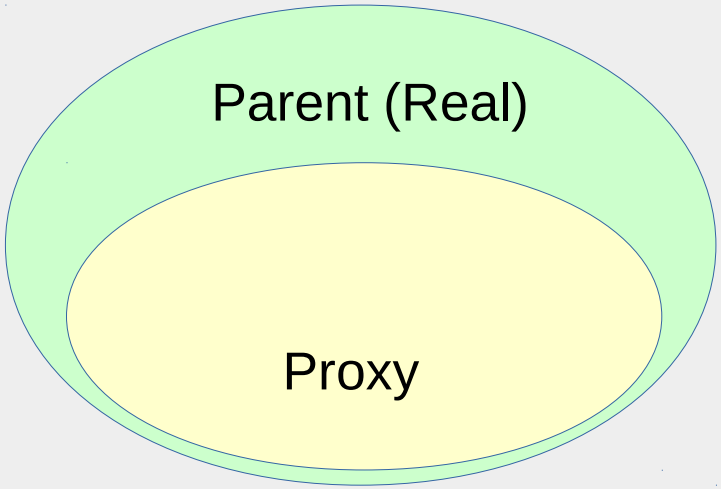
Comparable?!?

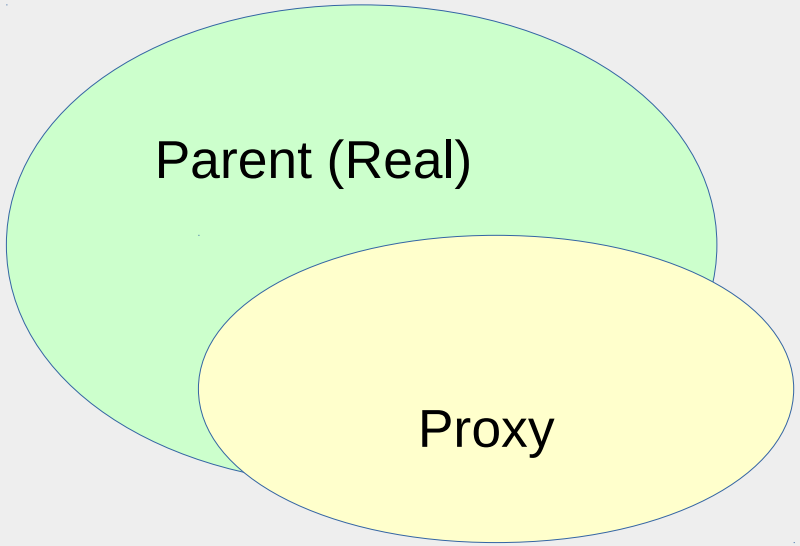
(How) Do they match their parent(s)?

Do Proxies Match the Real Thing?



Do Proxies Match the Real Thing?





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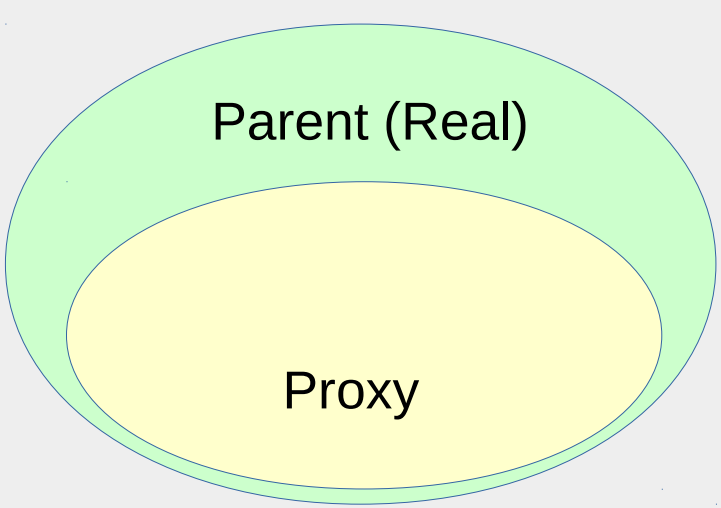

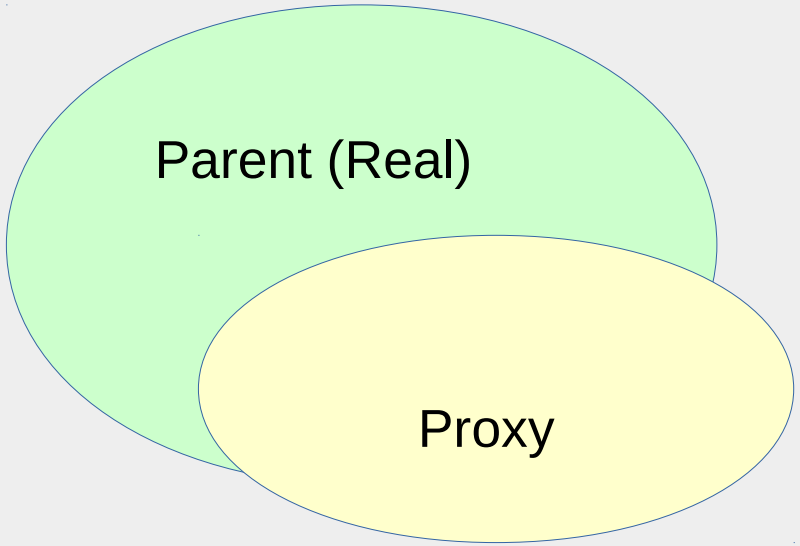

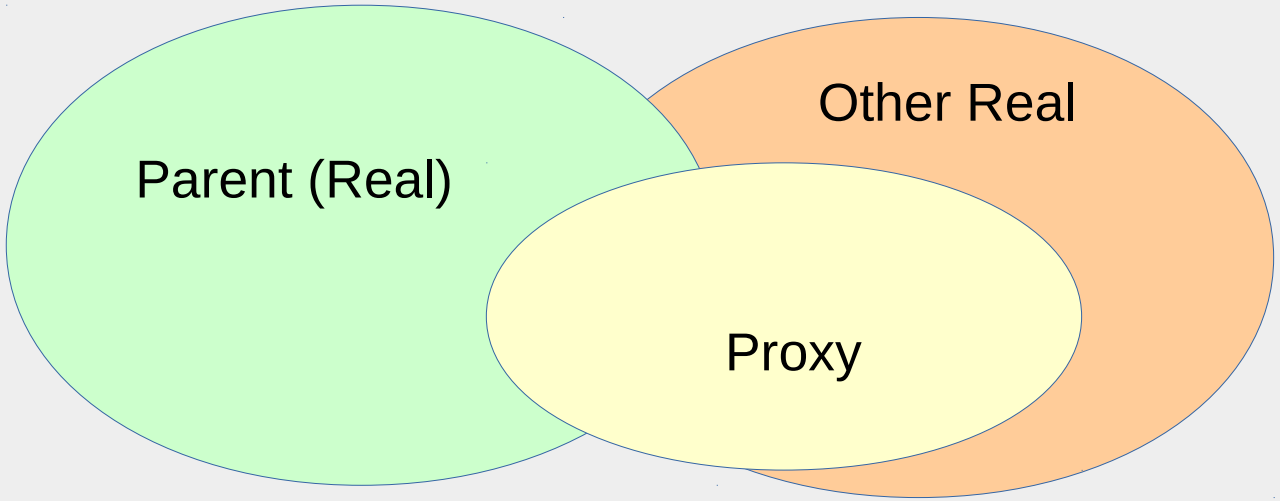

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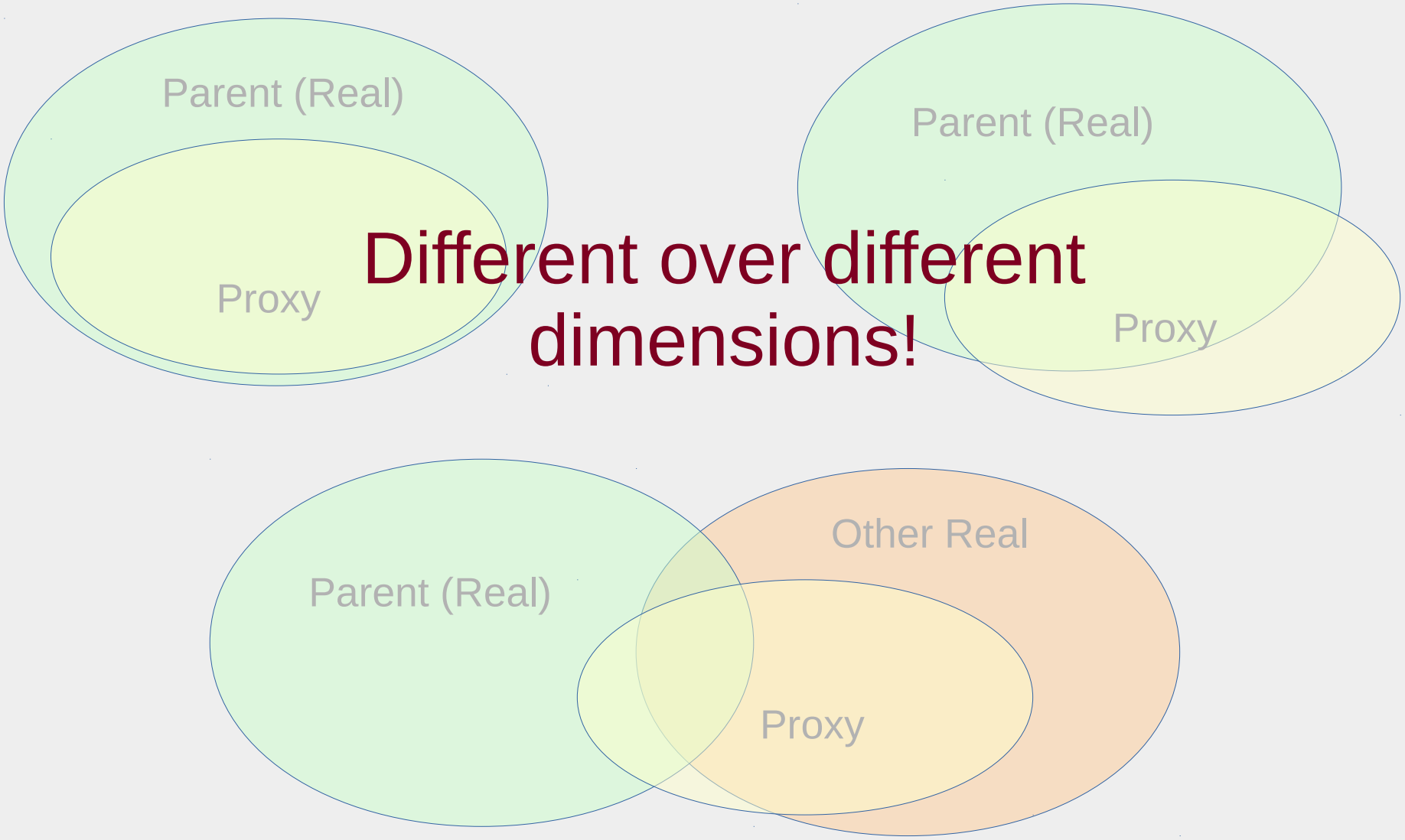


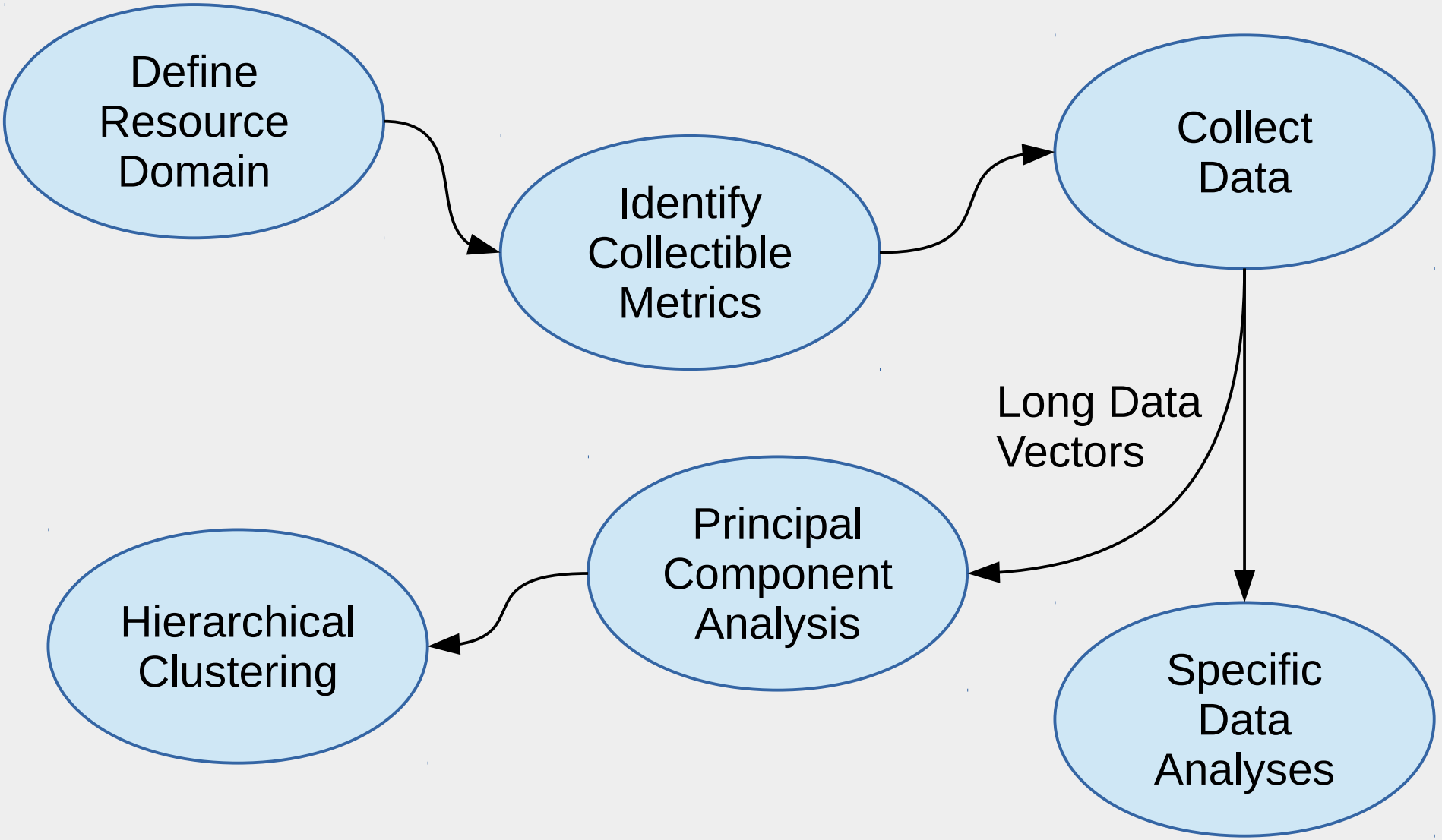
A Methodology

- Define a reusable approach to evaluating parent/proxy correspondences
- Preference towards simplicity
  - But still effective
- Instantiation may be customized
  - For different platforms
  - For different middleware / foundations

Target: Dynamic Behavior

- Goal is to evaluate if proxy exercises the resources similar to the parent
- Measurements should target dynamic behavior
  - Without high perturbation
- Currently: assume that parent and proxy configurations are similar
  - I.e., user knows what they want
  - Build configuration
  - Run configuration

Methodology Flow



FAL, https://commons.wikimedia.org/w/index.php?curid=385145

Dimensions: Resource Domains

- Basic Node
  - Host processors and memory
- Communication
  - Cluster interconnect
- Accelerator
  - GPU, et al.
- Storage I/O
  - Filesystem

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Some success, but needs improvement

- Accelerator
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Dimensions: Resource Domains

- Basic Node
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  - GPU, et al.
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Good results!

Some success, but needs improvement

Not much proxy support, or unavailable resources, so did not do

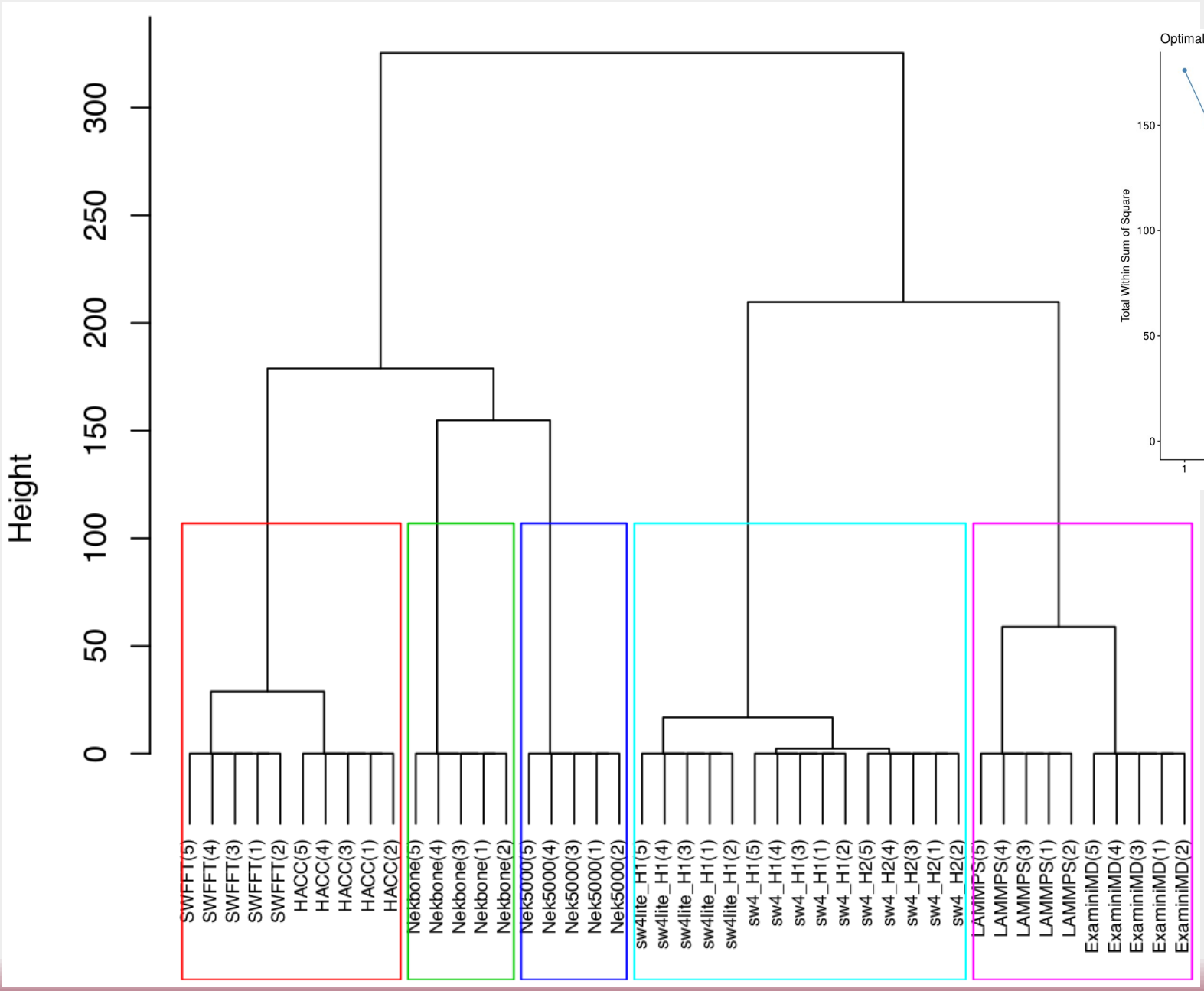
Parents and Proxies

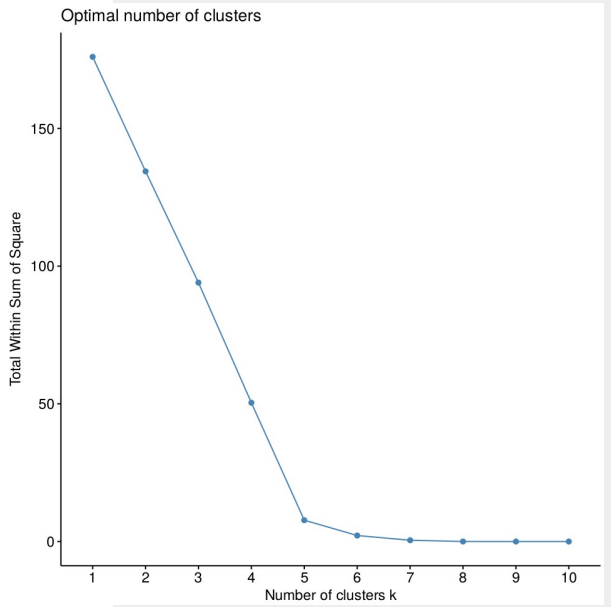
- HACC / SWFFT
- SW4 / SW4lite
- LAMMPS / ExaMiniMD
- Nek5000 / Nekbone

RD: Basic Node

- Used selected metrics over CPU hardware counters
- CPU
  - IPC, UPC, IMIX (5), FLOPS (1-N)
- Memory
  - L1/L2/L3 miss rate, L1/L2/L3 miss ratio, L1-L2-L3 bandwidth
- Vector Size: 22 (*8) on Broadwell, 15 (*8) on Haswell
  - Data collected from rank 0 and 7 random ranks

BW: Basic Node Clustering





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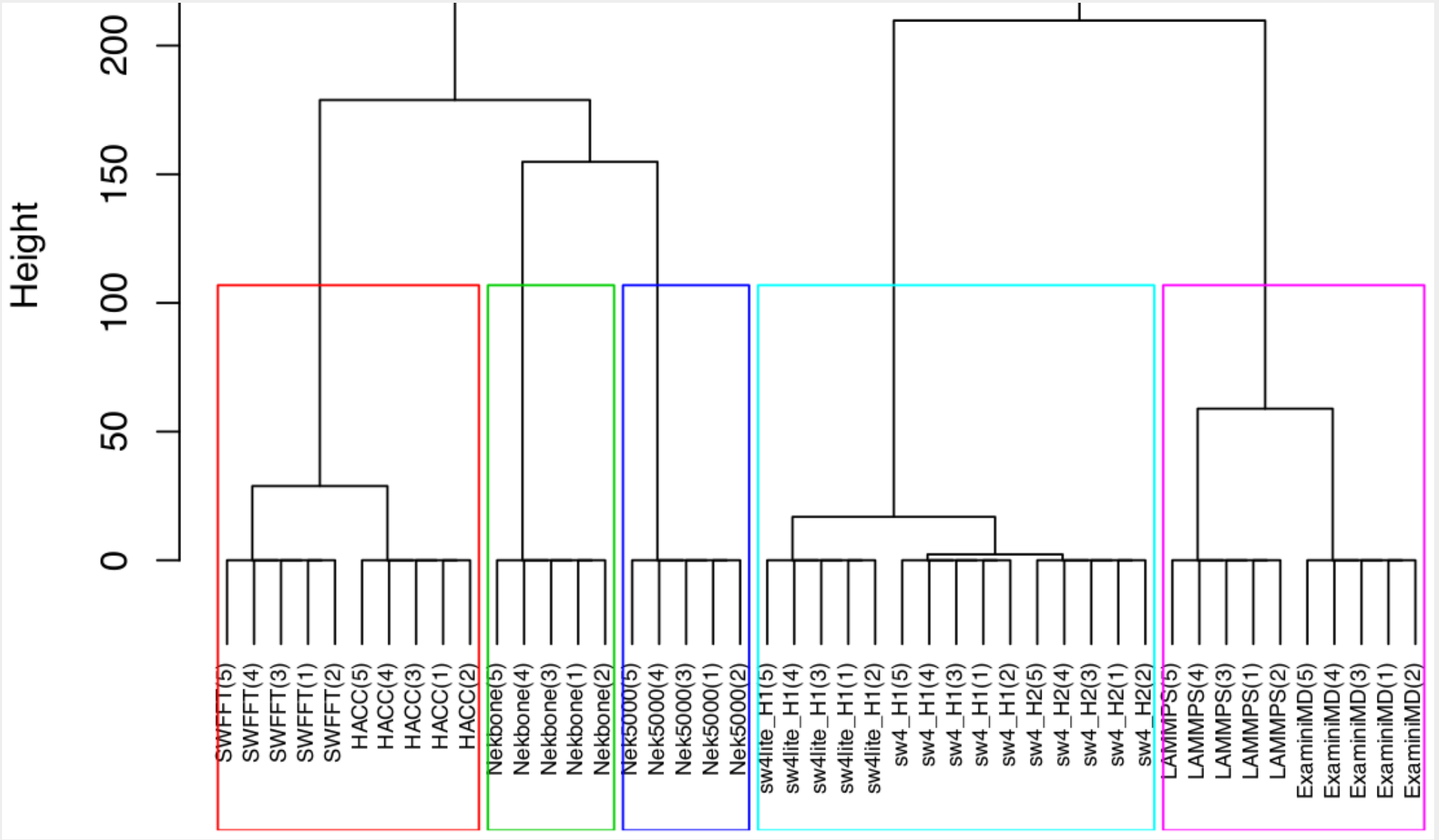

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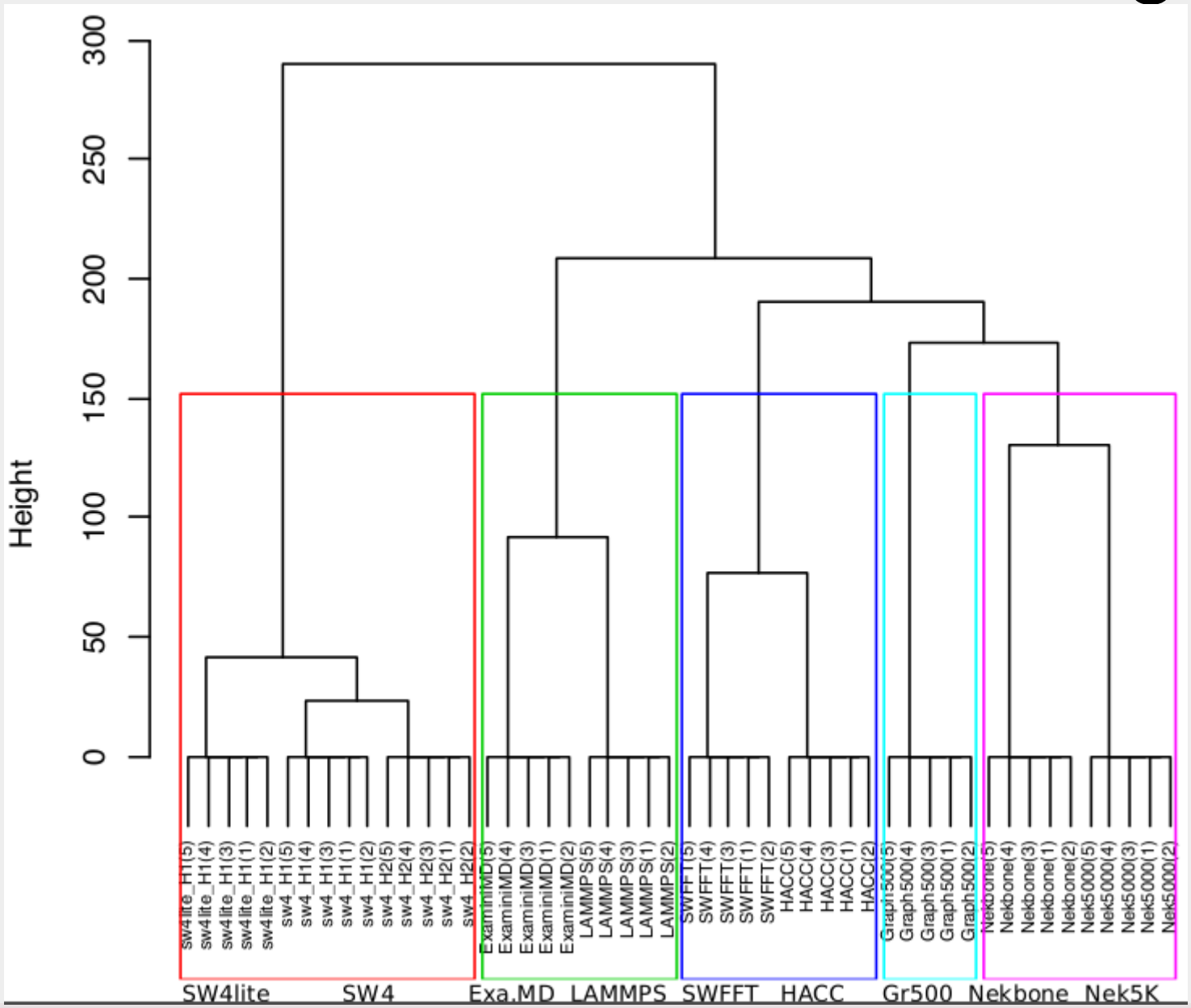

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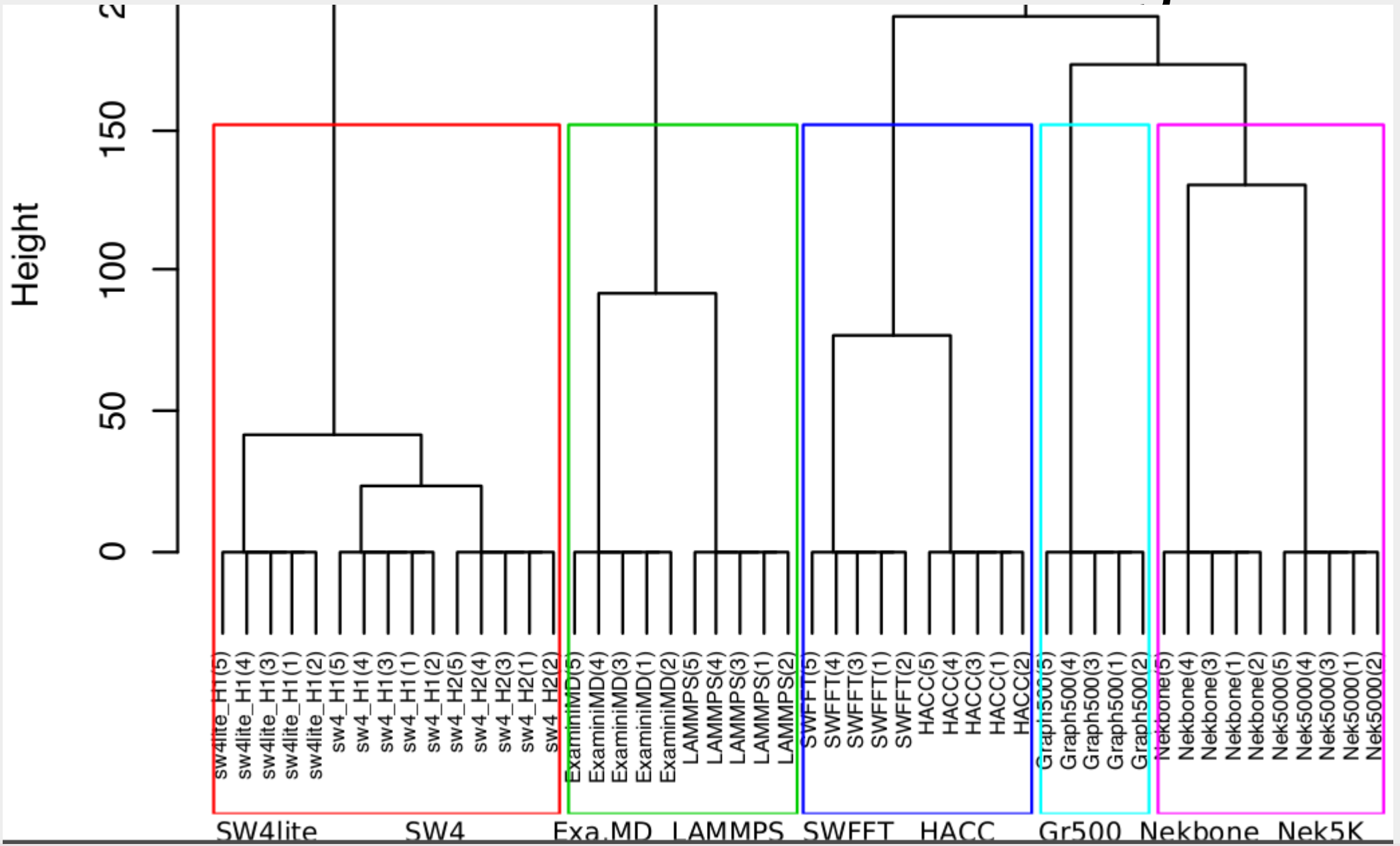
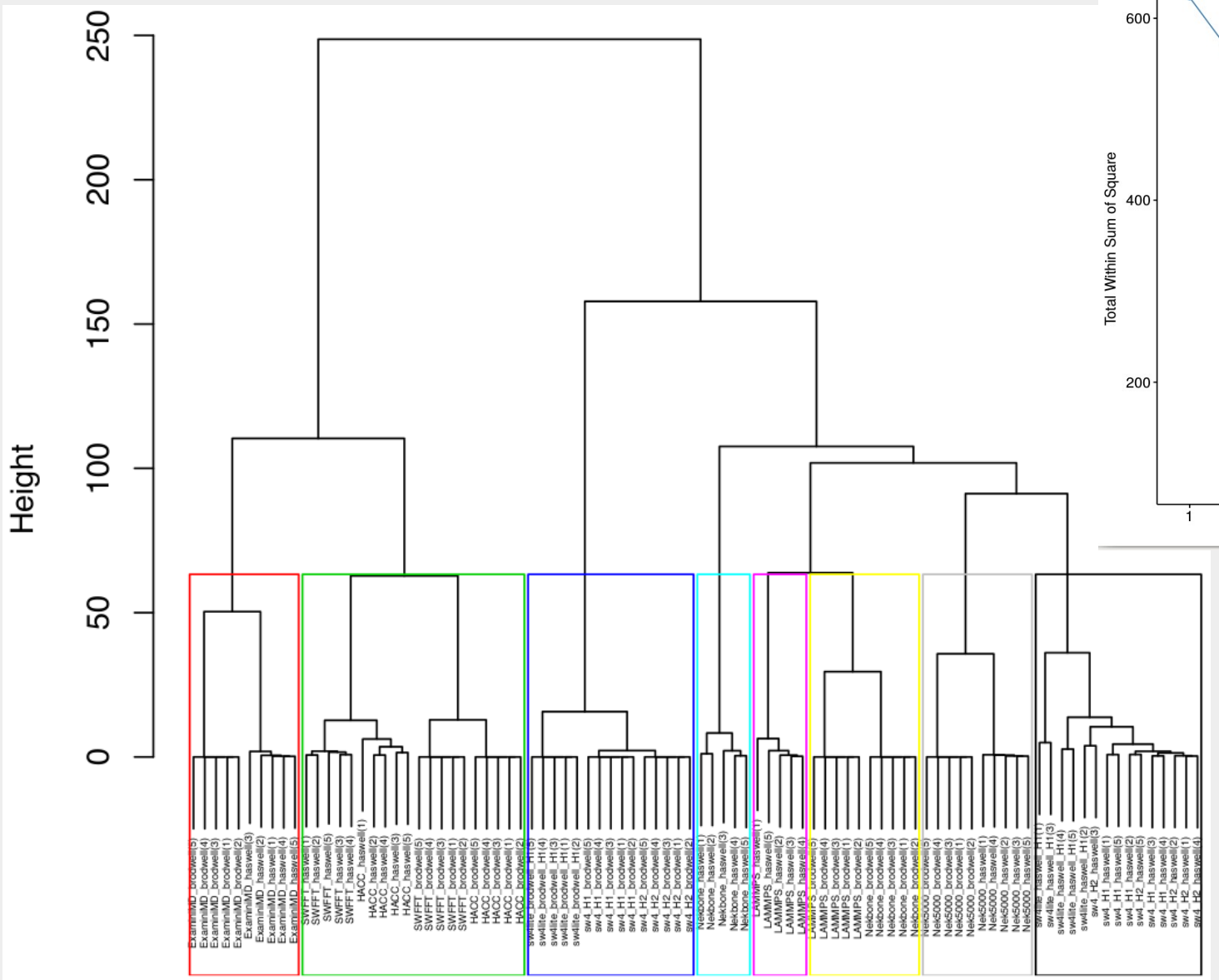
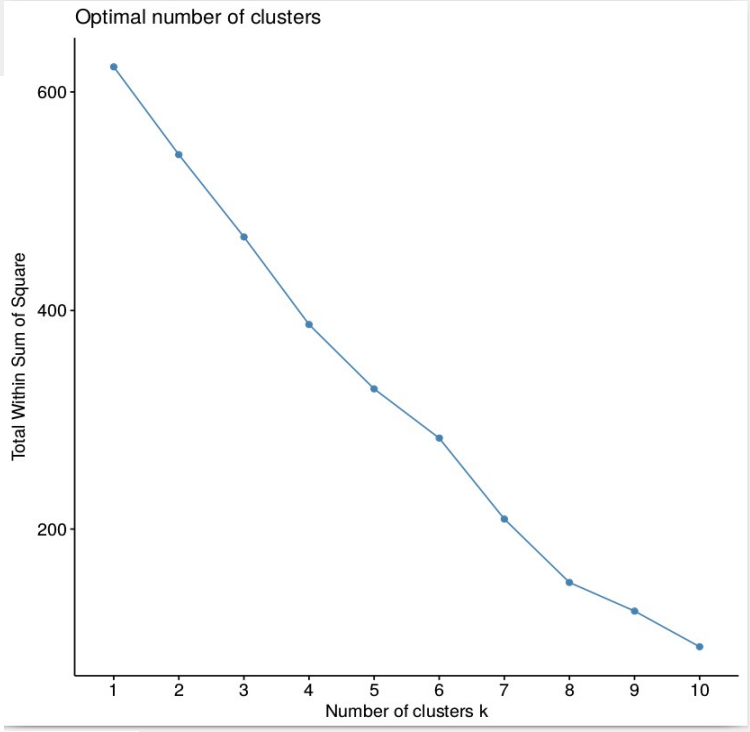
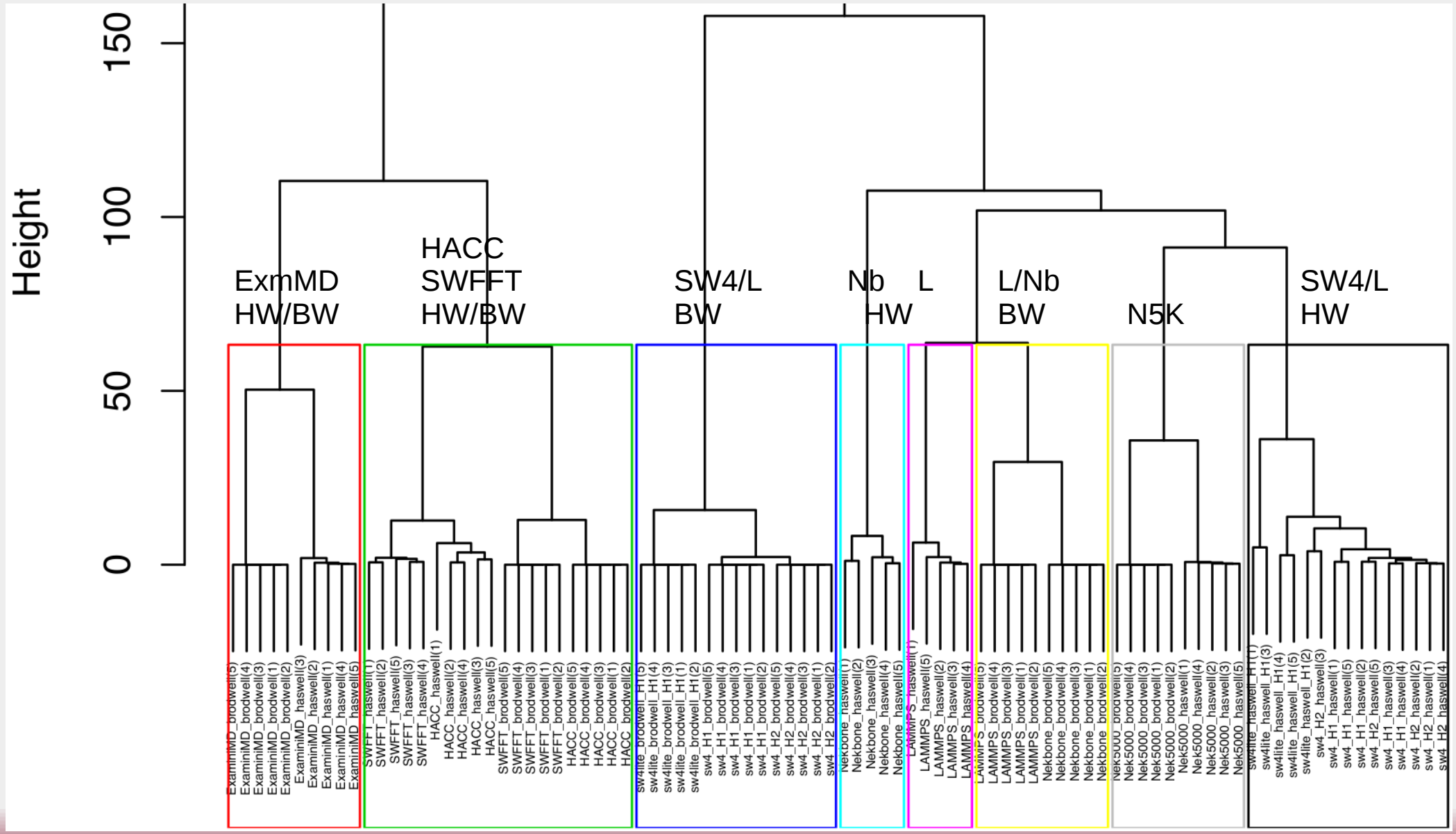


Both: Cluster





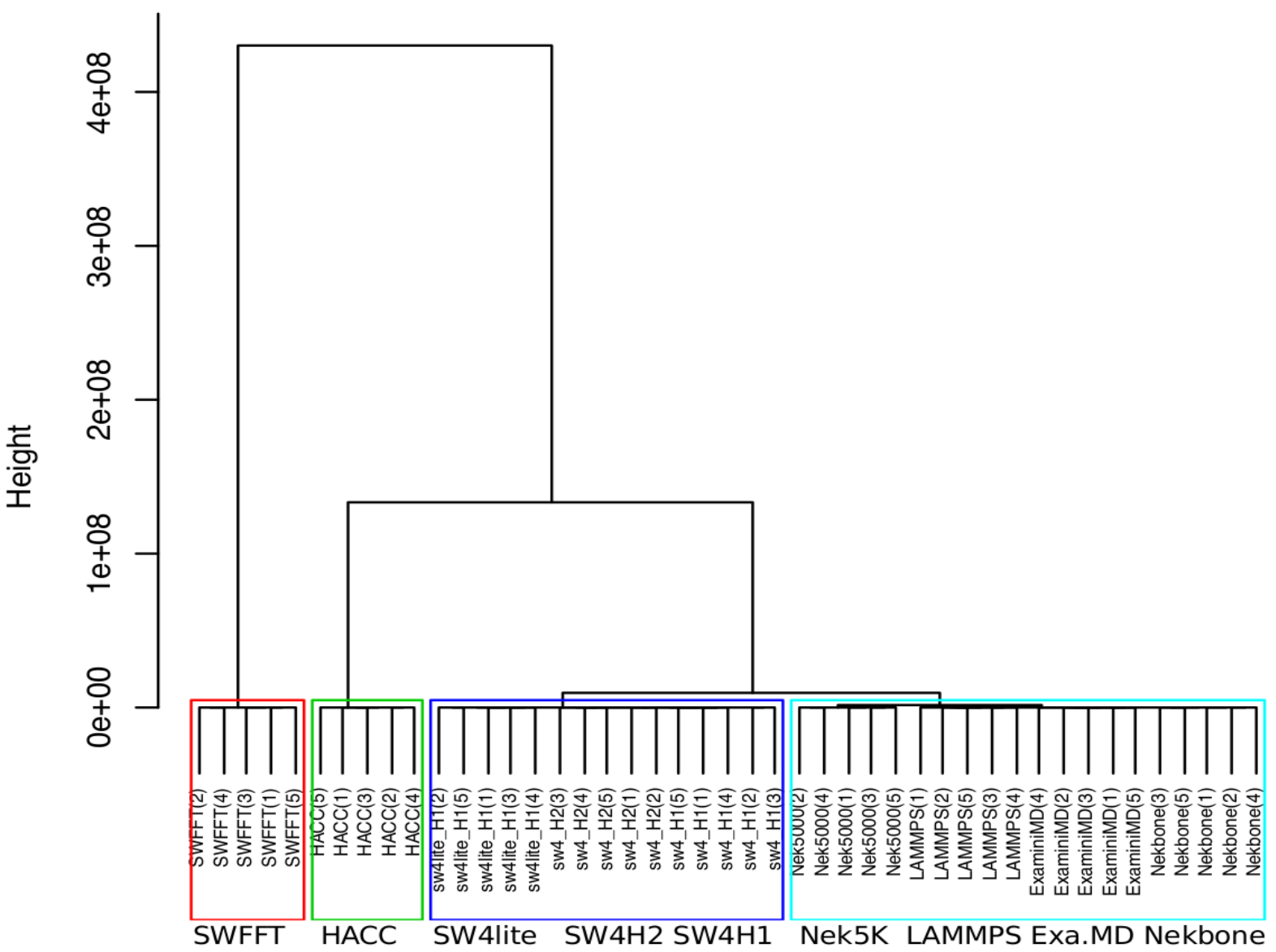
Both: Zoomed Clusters



RD: Communication

- Used mpiP for data collection
  - % of time (app, mpi) for each MPI routine used
  - # of calls, # of bytes sent/received
- Four metrics
  - Apptime%, MPItime%, #calls/apptime, #bytes/apptime
- Four routine groups:
  - all_send, all_recv, all_multi, all_wait
- Data vector size: 14
  - all_wait * 2

BW: Communication Clustering



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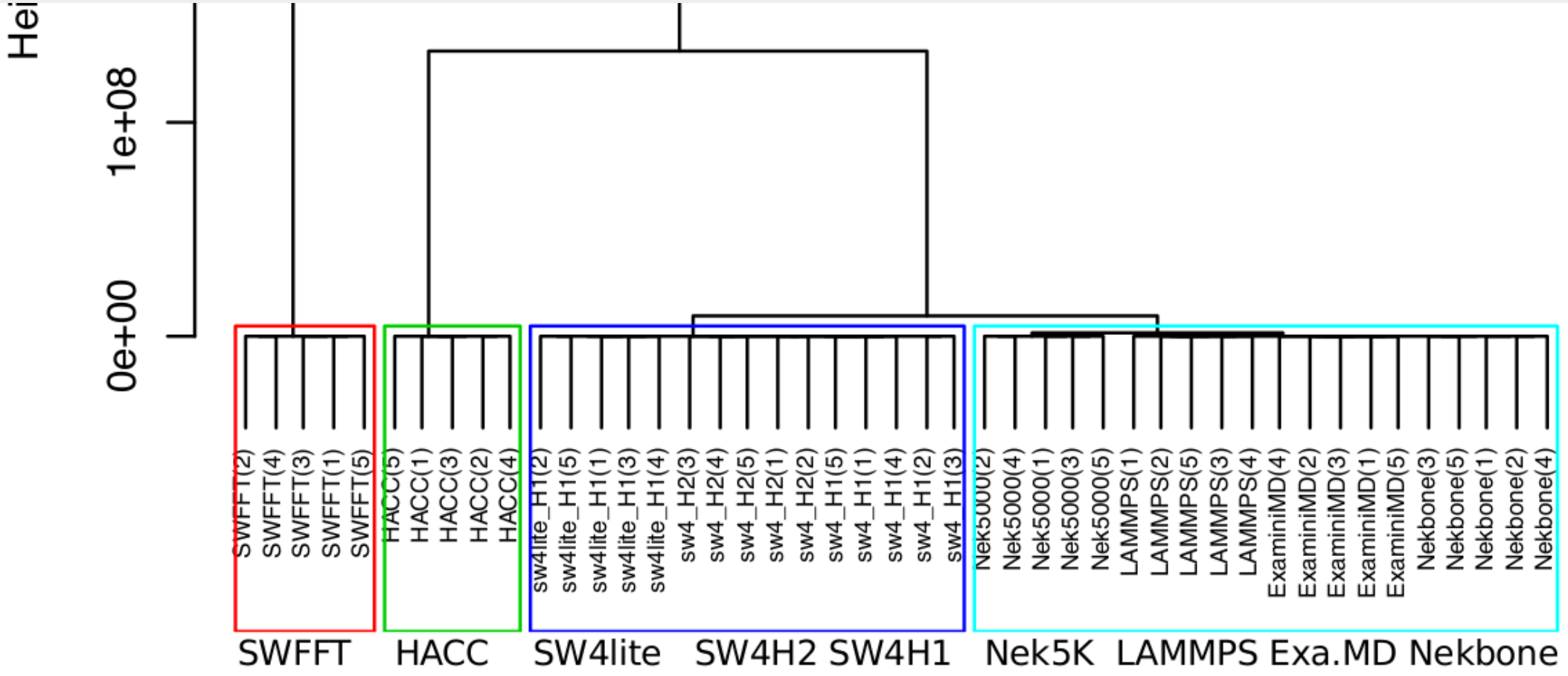

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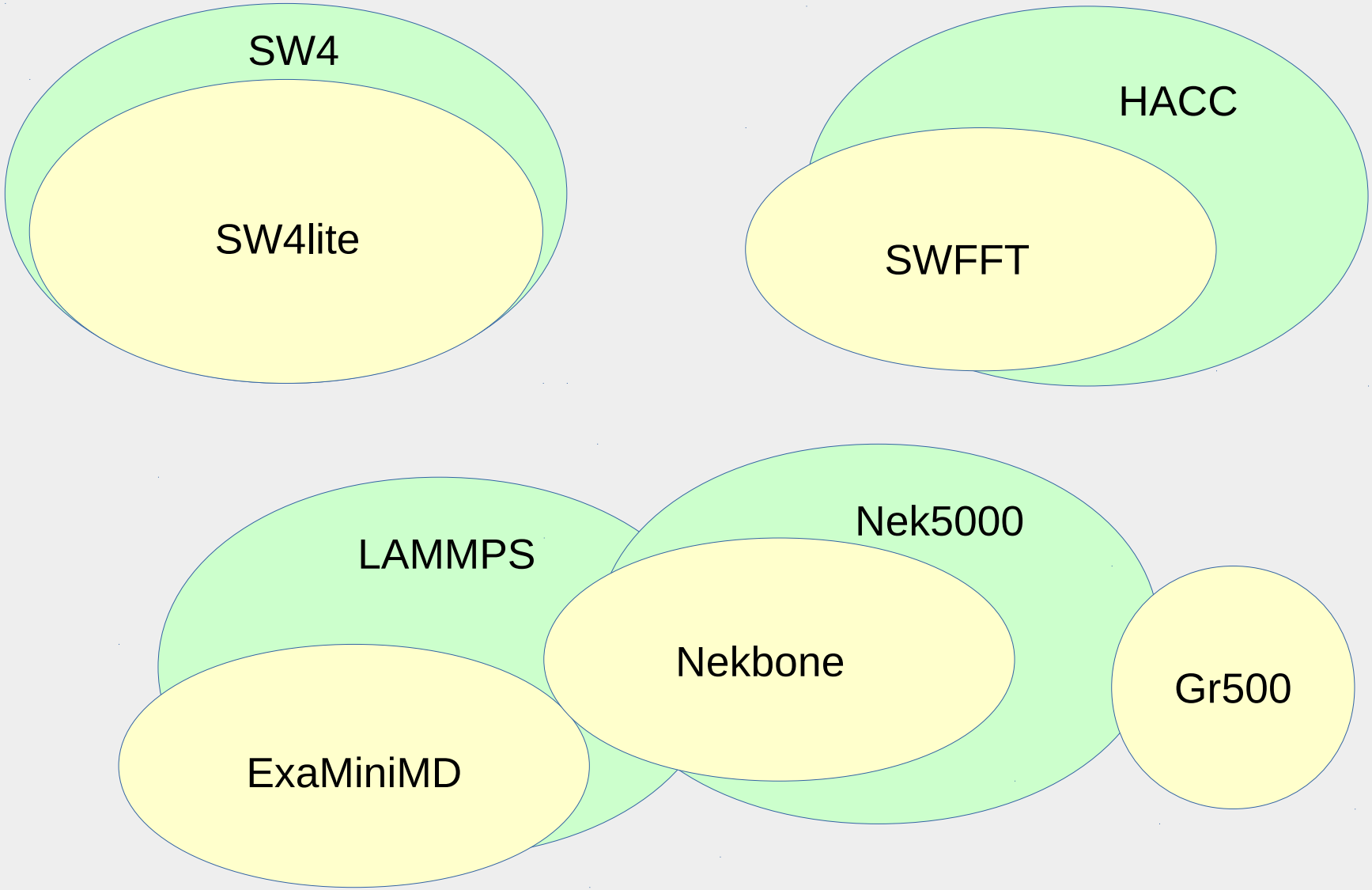
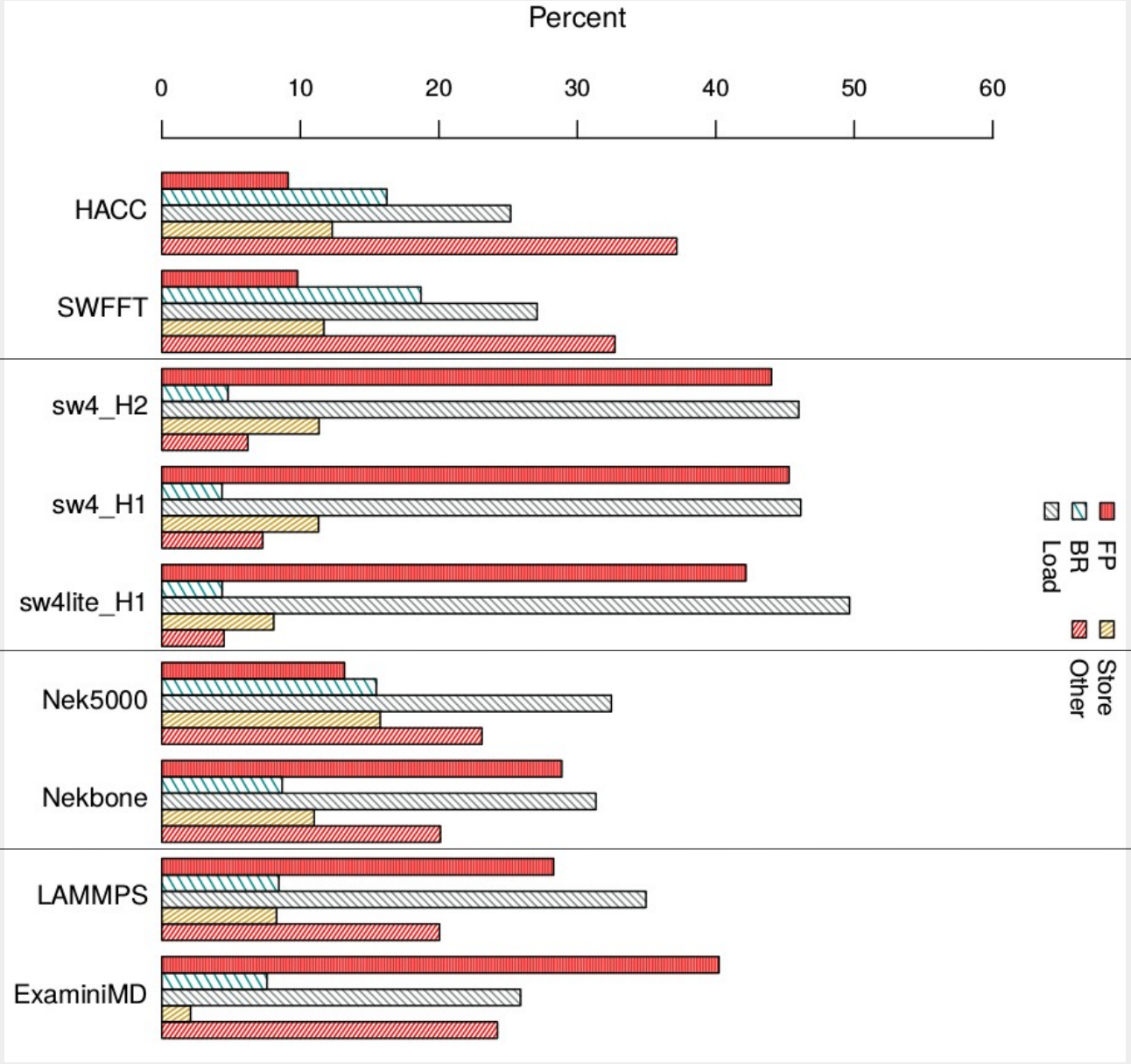


Questions?

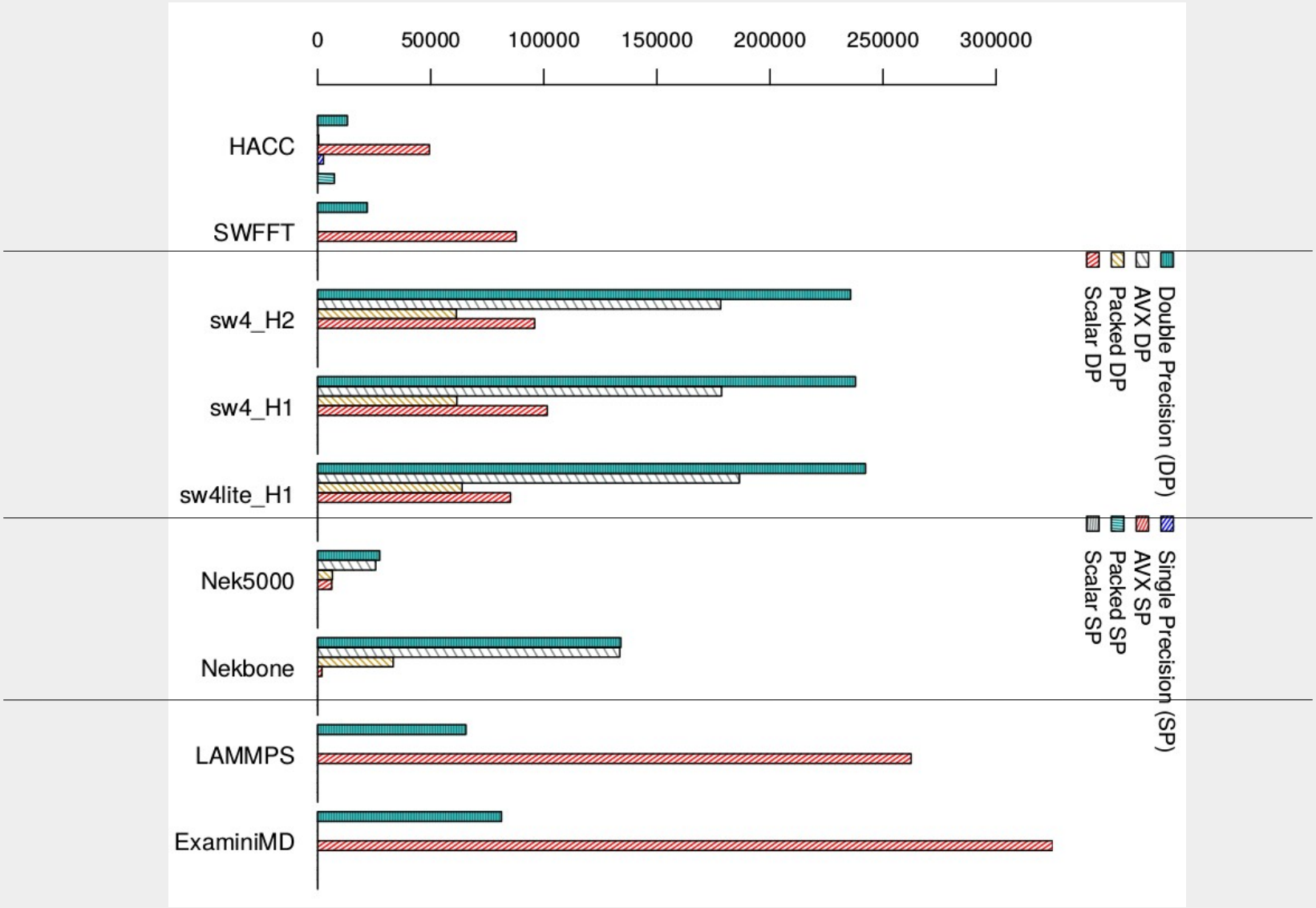
Future Work

- Further data analysis to identify points of difference
- Incorporate performance roofline models to identify where parent/proxy max out resource usage
- Match p/p communications to known patterns (e.g., seven comm. dwarves)
- If proxy is for limited piece of parent, limit parent data to that piece
- Incorporate other data for identifying and characterizing similar run configurations

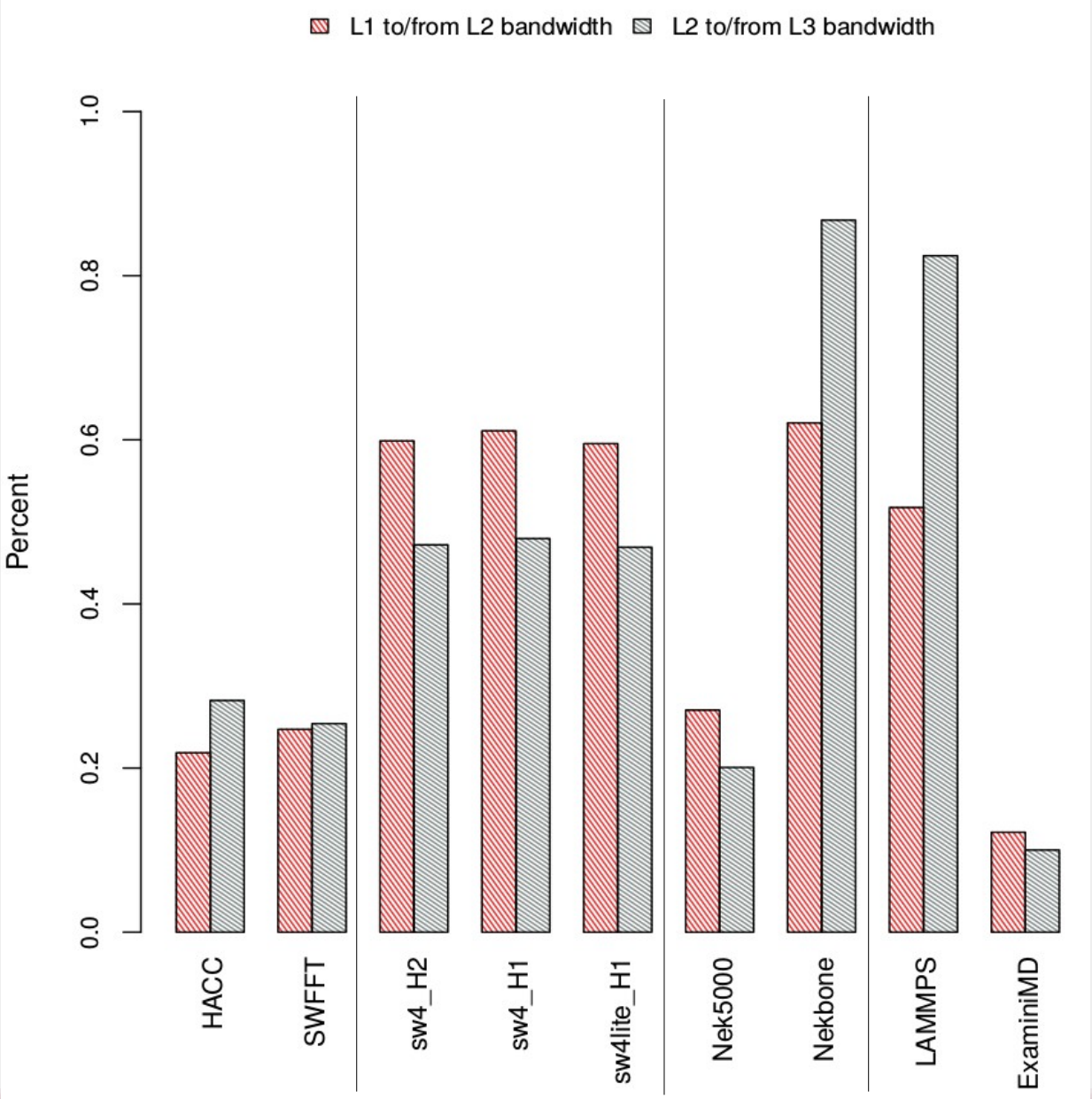
BW: Instruction Mix



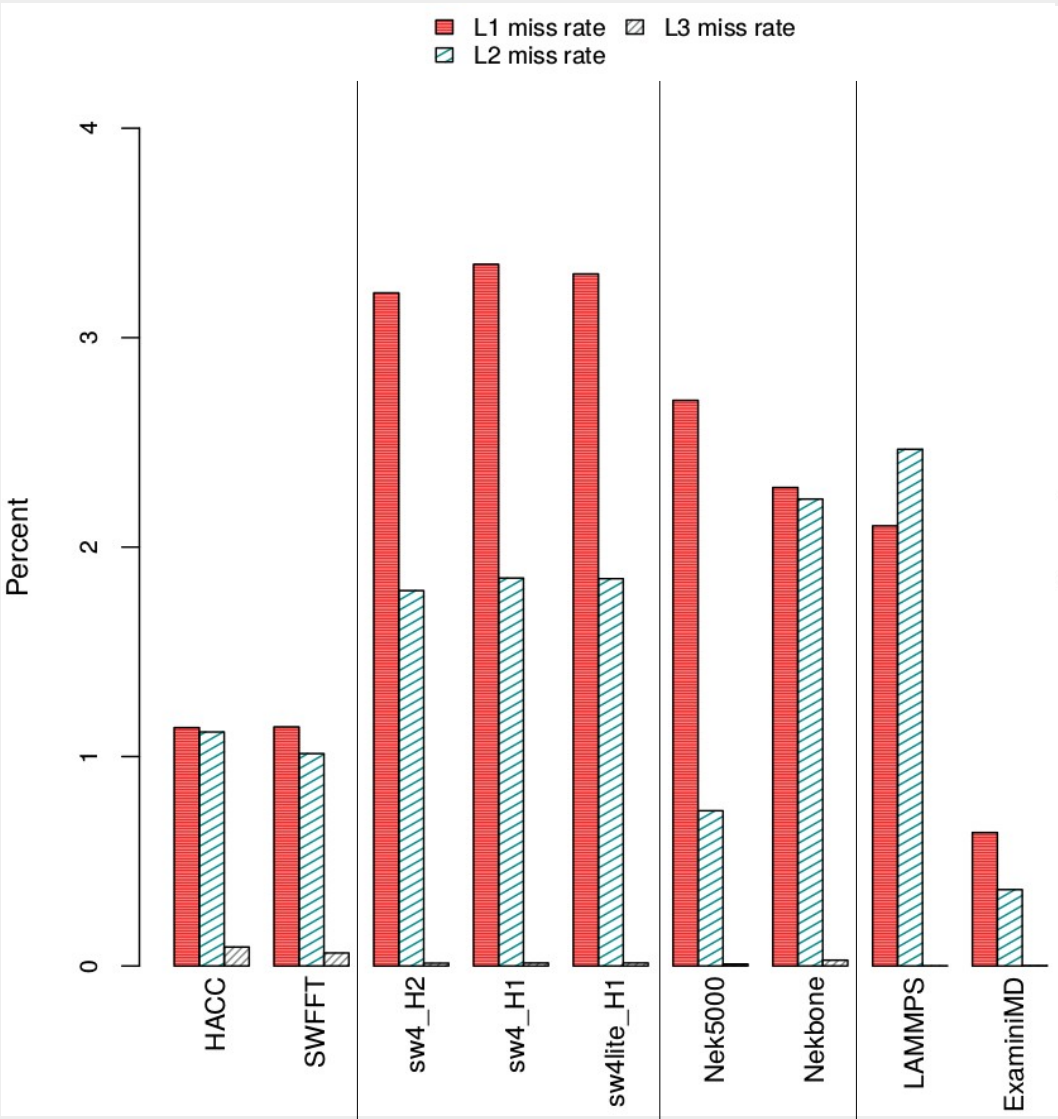
BW: FLOPS Mix

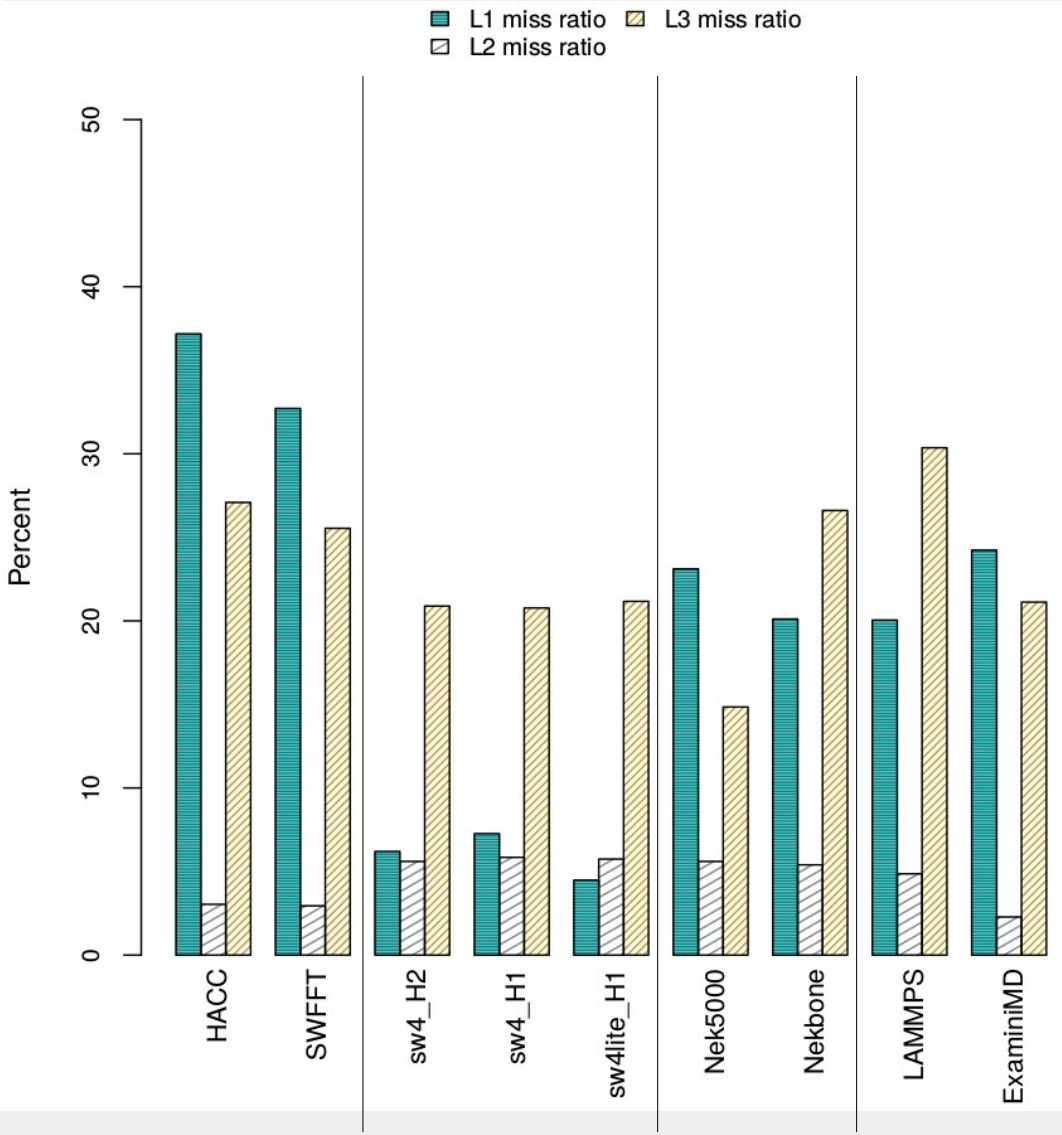

0
50000
100000
150000
200000
250000
300000
HACC
SWFFT
sw4_H2
sw4_H1
sw4lite_H1
Nek5000
Nekbone
LAMMPS
ExaminiMD
Double Precision (DP)
AVX DP
Packed DP
Scalar DP
Single Precision (SP)
AVX SP
Packed SP
Scalar SP

BW: L1-L2-L3 Bandwidth



BW: Miss Rates and Ratios

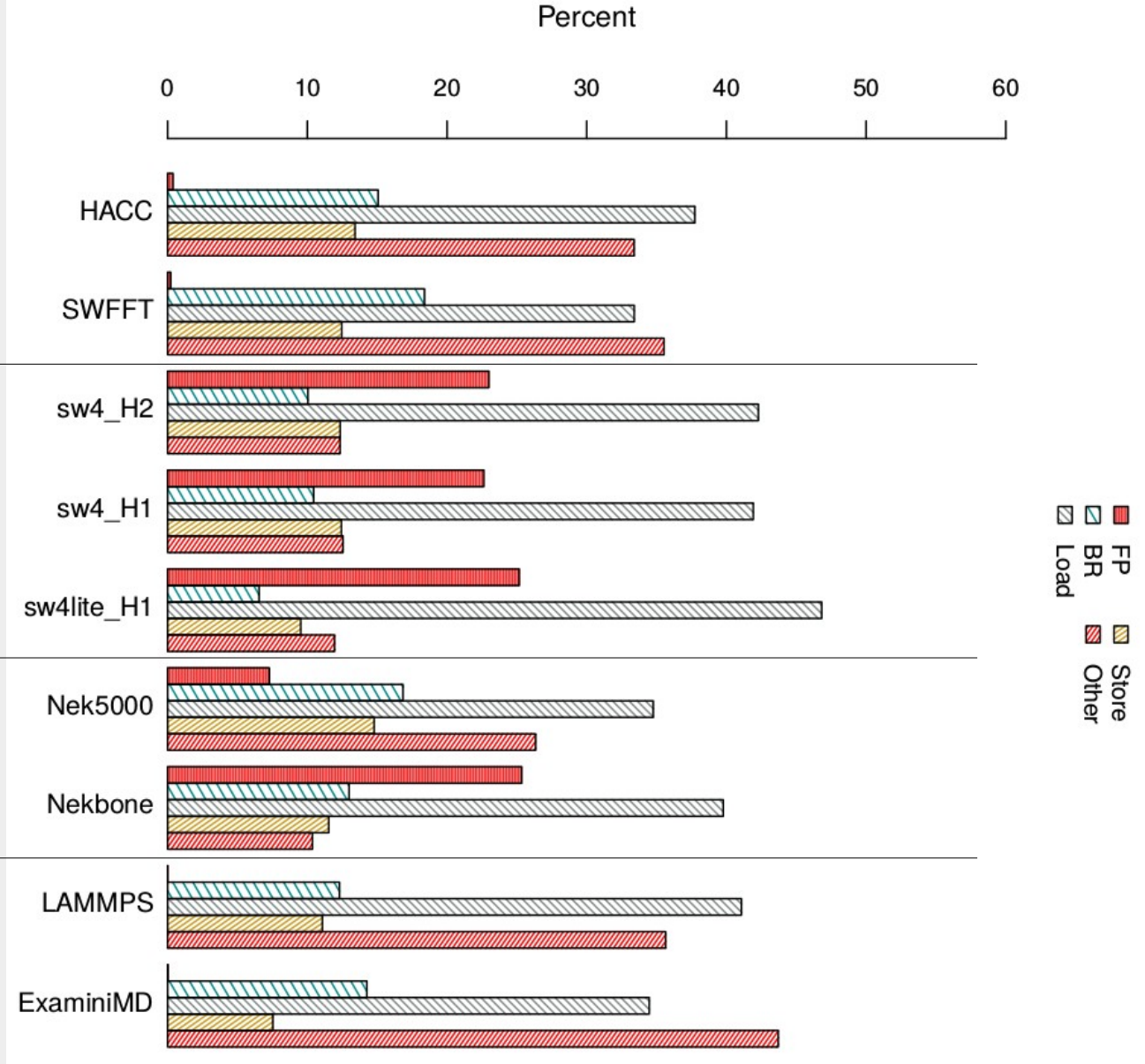




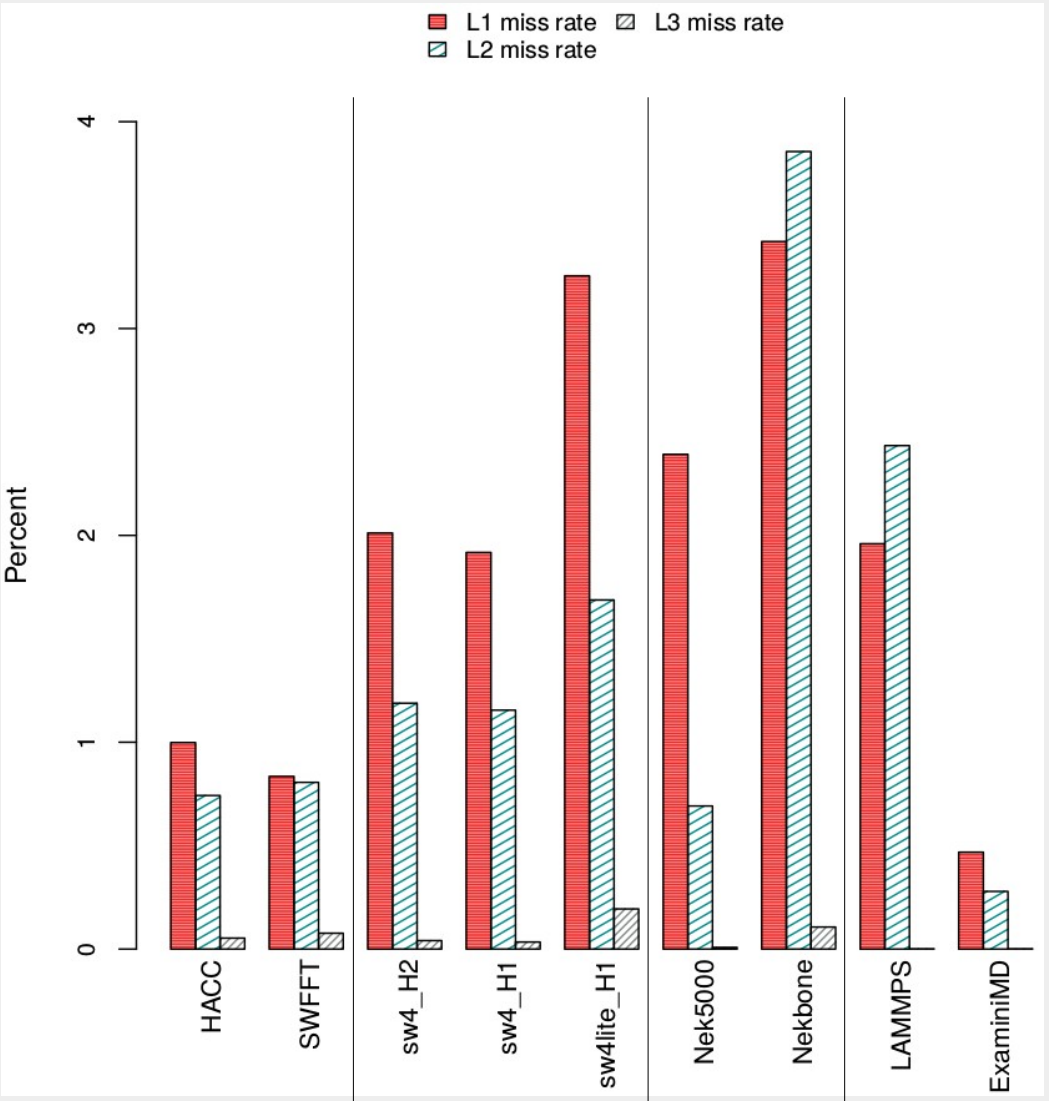
Basic Node Domain on Broadwell

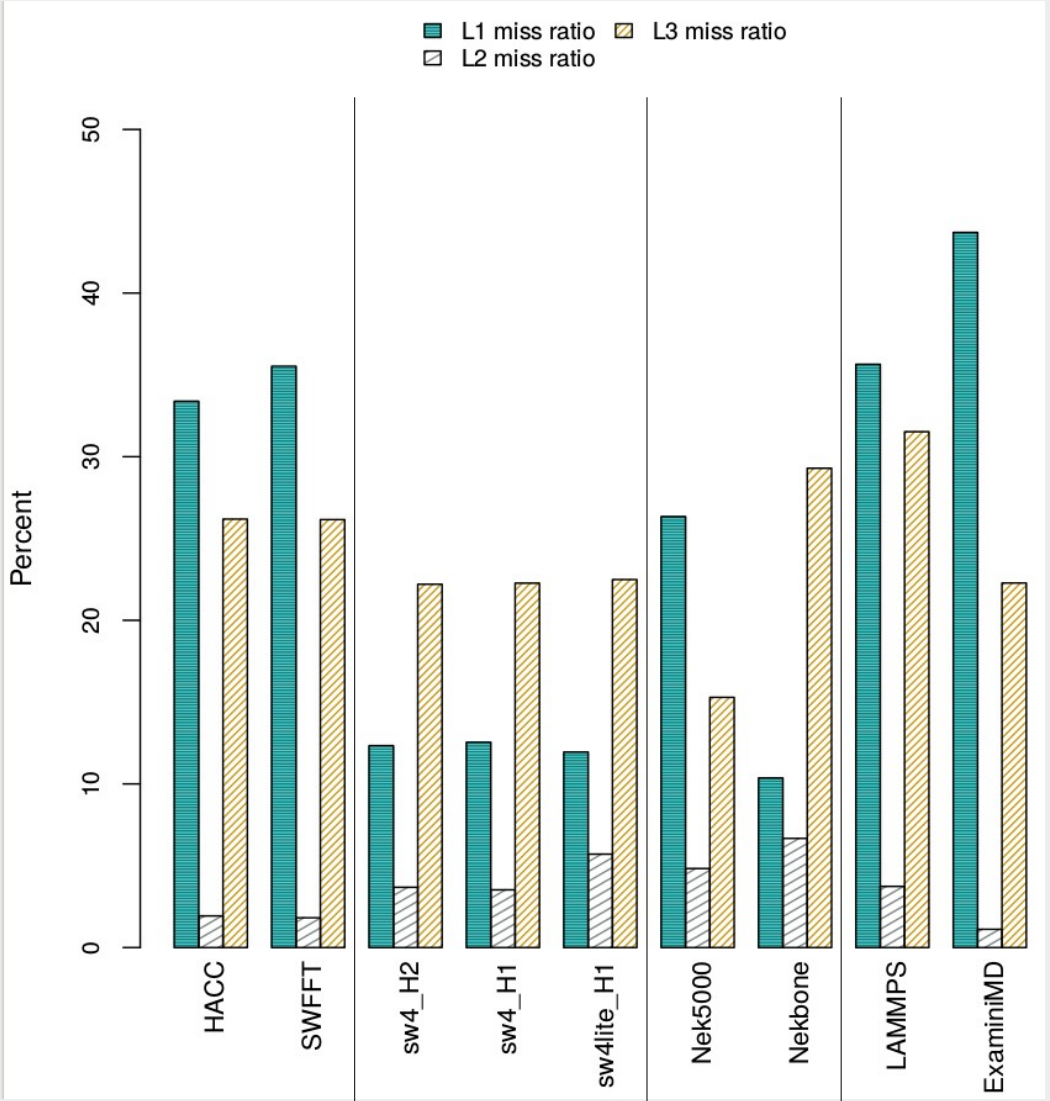
- SW4 and SW4lite are very similar
- HACC and SWFFT are very similar
- LAMMPS and ExaMiniMD are fairly similar
- Nek5000 and Nekbone are somewhat similar
  - cluster slighty after best-cluster fit
- Good: proxy always clusters first with parent
- Memory behavior is what is most divergent for N/N and L/X

HW: Instruction Mix

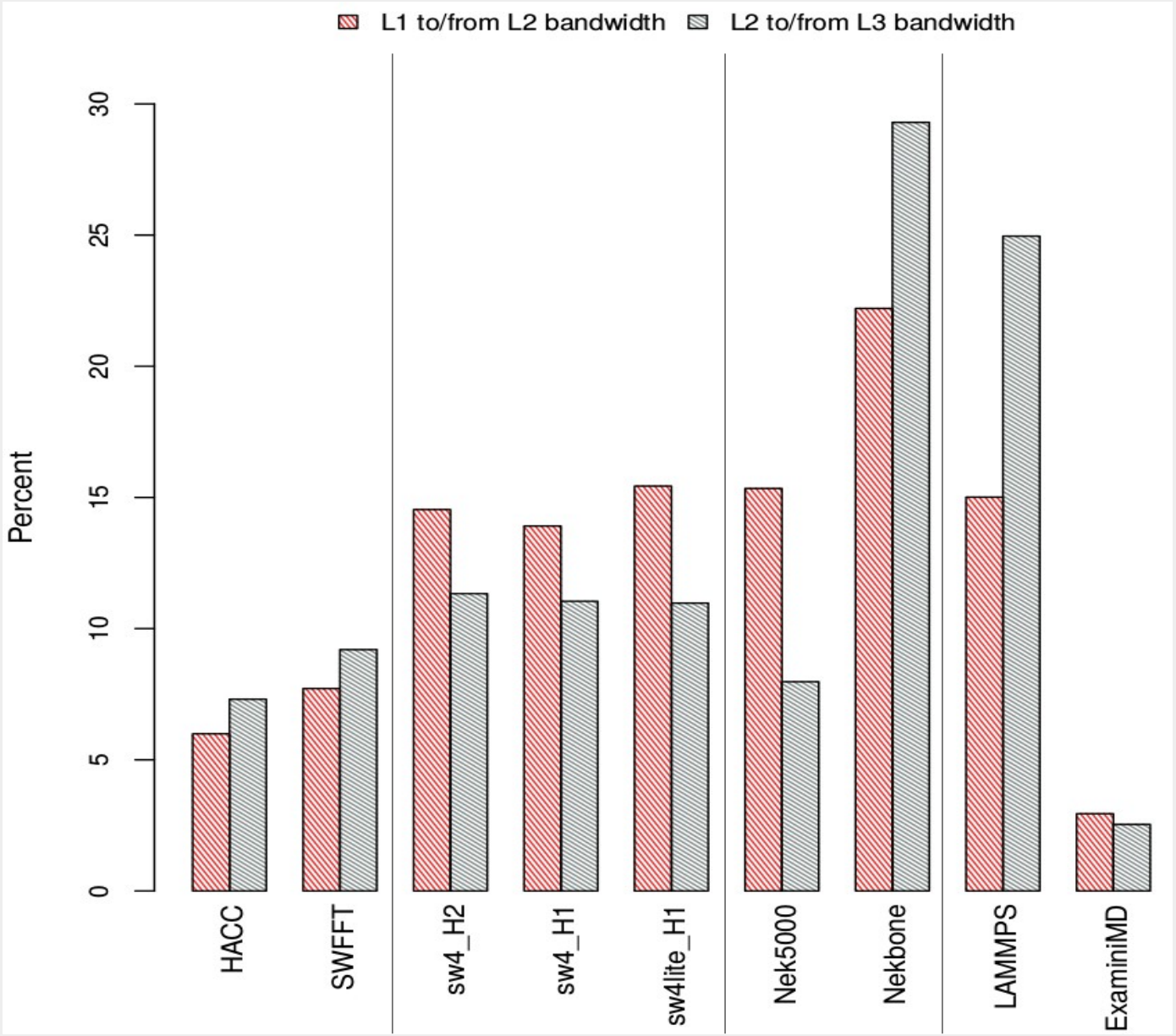


HW: Miss Rates & Ratios





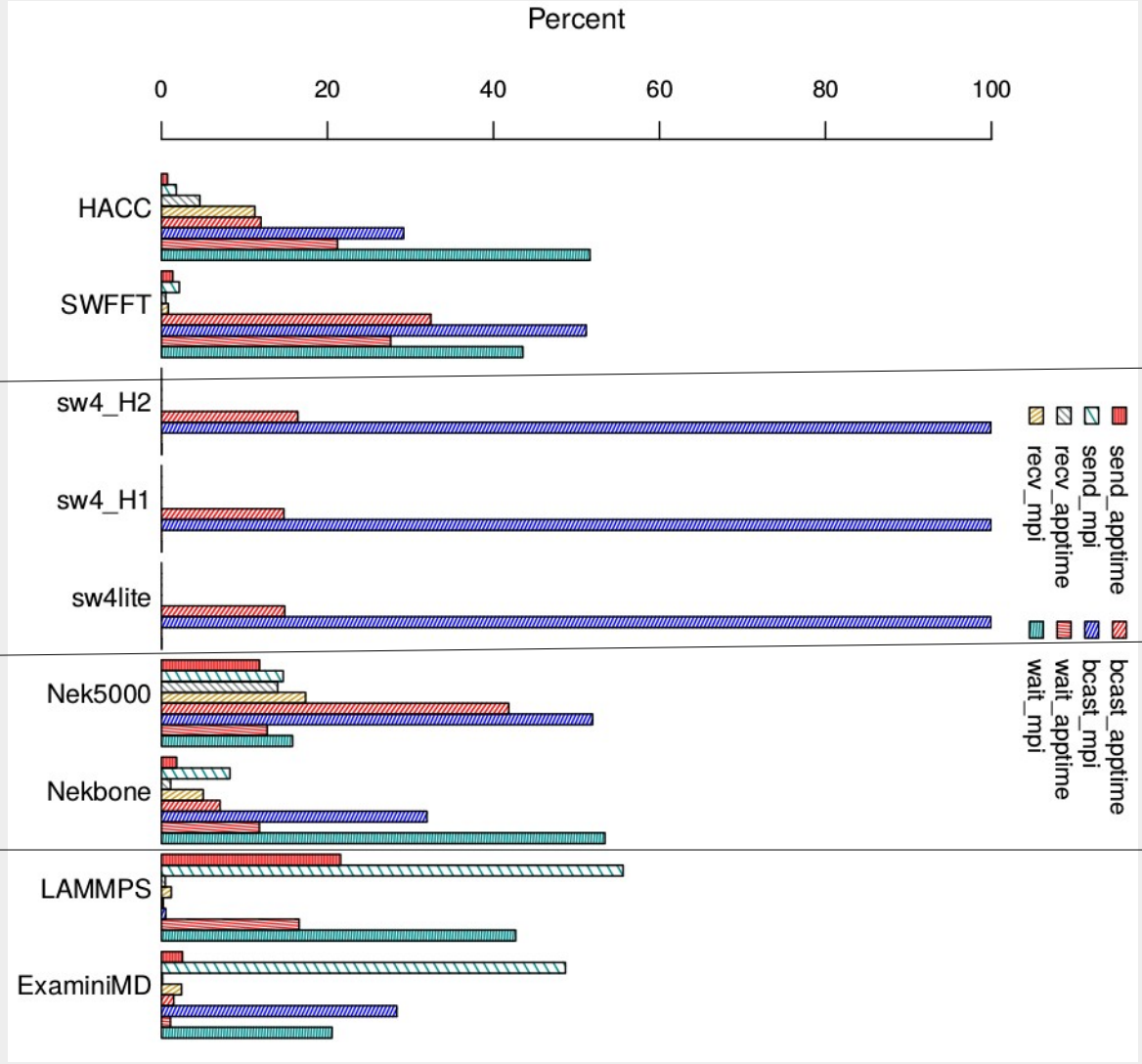
HW: Bandwidths



Basic Node on Haswell

- Good: same clustering order as on Broadwell
- Good: proxy always clusters first with parent
- Good: Graph500 clustered above all proxy/parent pair clusters
  - But not last
- Memory behavior again differentiates N/N and L/X

BW: MPI Times


Percent
0
20
40
60
80
100
HACC
SWFFT
sw4_H2
sw4_H1
sw4lite
Nek5000
Nekbone
LAMMPS
ExaminiMD
send_apptime
send_mpi
recv_apptime
recv_mpi
bcast_apptime
bcast_mpi
wait_apptime
wait_mpi

Communication Domain

- SW4 and SW4lite are very similar
- LAMMPS, ExaMiniMD, Nek500 and Nekbone are quite similar
  - Nekbone clusters with L/E before Nek5000
- HACC and SWFFT are very different from the rest, and from each other
- MpiP data vector not necessarily related to resource usage
  - And does not seem to be a good behavior separator