



Optimizing HPC resource allocation through monitoring

Alexandre Beche <alexandre.beche@epfl.ch>





I. Context

2. Job monitoring

3. Beyond Slurm monitoring





Context





Host Institution

Ecole Polytechnique Fédérale de Lausanne (EPFL)

Director

Henry Markram

Co-Directors

Sean Hill, Felix Schürmann

Team today

~85 scientists, engineers & staff

Timeline

2005 founded at EPFL 2011/2012 ETH Board funding 2013-2016 Swiss National Research Infrastructure

Main International Collaborations

Switzerland (CSCS, CERN) Israel (HUJI) USA (Yale, ANL, Allen Brain) Spain (UPM) Saudi Arabia (KAUST) Europe (HBP)





Data-Driven Modeling & Simulation!



Neuronal anatomy Neuronal anatomy 10. ~ 2 mm thick • 55 morphological types • 13 excitatory & 42 inhibitory m-types

- 31,000 neurons
- 111,700 neurons/mm³
- Excitatory to inhibitory neuron ratio of 86:14 %
- 346 m of axon
- 211 m of dendrites
- Maximum branch order of m-types:



- 0.63 synapses/mm³
- Extrinsic to intrinsic synapse ratio of 75:25 %
- 3025 possible synaptic pathways
- 2258 viable synaptic pathways
- 664 excitatory pathways
- 1594 inhibitory pathways
 - 600 intra-laminar pathways
 - 1658 inter-laminar pathways
 - Mean synapses/connection





- **13** HH type ion channel models
- bAP & EPSP attenuation for 207
 morpho-electrical types
- Ion channel density distribution
 profiles:



- 6 synapse types
- 207 synaptomes
- Space clamp corrected synaptic
- conductances for 607 pathways
- The per synapse conductance of 1.5 nS for connections between L5TTPCs is
- the highest in the microrcircuit
- Mean conductance per synapse:
 0.85 nS for excitatory & 0.66 nS for inhibitory synapses
- Total conductance in a single neuron is **971** nS





Markram et al, Cell 2015

https://bbp.epfl.ch/nmc-portal

- 80 authors
- Joint effort between computer and neuroscientists
- Reproducible work
- Extensible



HPC Today's Infrastructure





IBM BlueGene Active Storage



HPC Resources usage



Facts:

- 70 Users
- 35 Projects
- 3 Clusters

	Daily core hours available	Daily Job submitted	Active user*
BlueGene	1572864	103	20
Lugano cluster	13824	632	53
Geneva cluster	4512	259	20

* User who submitted at least one job over the last month





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Observations:

- Clusters are scheduling 10x more jobs than bluegene
- Cluster nodes are shared (--exclusive is limited), not bluegene

Emphasis of the presentation will be put on HPC clusters





Job monitoring



Problem description







Extracted from *sreport*



Problem description





Interactive HPC Clusters usage over time

Extracted from sreport

Symptoms:

User can't get an allocation

Cause: Cluster is fully allocated

Solution:

- 1) Buy a bigger one 😇
- 2) See if resources are optimally used





Knowledge of all jobs / step executed

- Average waiting time in the queue
- Submission rate by user / project

"sacct" data are indexed into ElasticSearch

- Near real-time (every 10 minutes)
- Analytics, web report generation

Limitations:

• Not natively aware of resources used by the job

Blue Brain Project BBP Monitoring infrastructure





Scalable and extensible framework

- Based on open source technologies
- Enable data collection and analysis

Blue Brain Project BBP Monitoring infrastructure





- 10 seconds resolution
- 250 metrics per node

Scalable and extensible framework

- Based on open source technologies
- Enable data collection and analysis



Limitation: System metrics does not have any knowledge about workload



Dashboard 1/3







Dashboard 2/3



@ -	HPC - Job monitoring Slurm User Group Meeting -				Ċ			< :	Zoom Out	>	O Last 24 hours	C
cluster:	- 2	jobID: 461483 -	hosts: All -	🕈 Job Start 🕑	🕈 Job End 🗹	* Job Events 🕑						

User: Account: proj38 Partition: prod Nodes: 2 CPUs: 32 raw time: 2132992



AGGREGATED METRICS FOR THE JOB



Dashboard 3/3









Allocation details:

 Single nodes, all cores, batch partition

Job details:

CPU bound







Developers

- Analyze code from a system perspective
 - Non-intrusive monitoring / negligible (perf) overhead
- Detect code inefficiency / limiting resource
 - Non optimal parallelization





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System admins

- Analyze system metrics with workload context
- Detect non-optimal allocation
 - Allocation bigger than execution time

Holistic view enabling cross team (competencies) debugging





Ongoing work

- Creating KPI out of the available metrics
 - Efficiency of a job (cpu seconds used /reserved)





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 - Efficiency of a job (cpu seconds used /reserved)

Limitations

- Mainly system metrics so far
 - Only memory are collected at cgroup level
- Missing infiniband metrics
- Job internals are hidden





Beyond Slurm monitoring





Focus has been put on monitoring the job in the infrastructure

No hint is given to the job internals

• Job entering in a given phase





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Providing a library to enhance job context

- Workload manager agnostic
- Not a profiling tool
- Lightweight way of sharing information from the job
- Allows to ship user-defined metadata





def count_element(self): lines = self._data.count()















Detection of non-optimal usage

- Un-used allocation
- Developers now have tools to understand job behaviors

Internal job monitoring

 Allows understanding which resources are consumed by section of job through user-defined metadata

Correlation of scattered information enable powerful analysis







BBP core services & HPC teams