Understanding and modelling of the distributed infrastructure & computing models

With H-LHC in mind

Input from Daniele and Eric

- Which I tried to integrate
- Attached to the Indico page

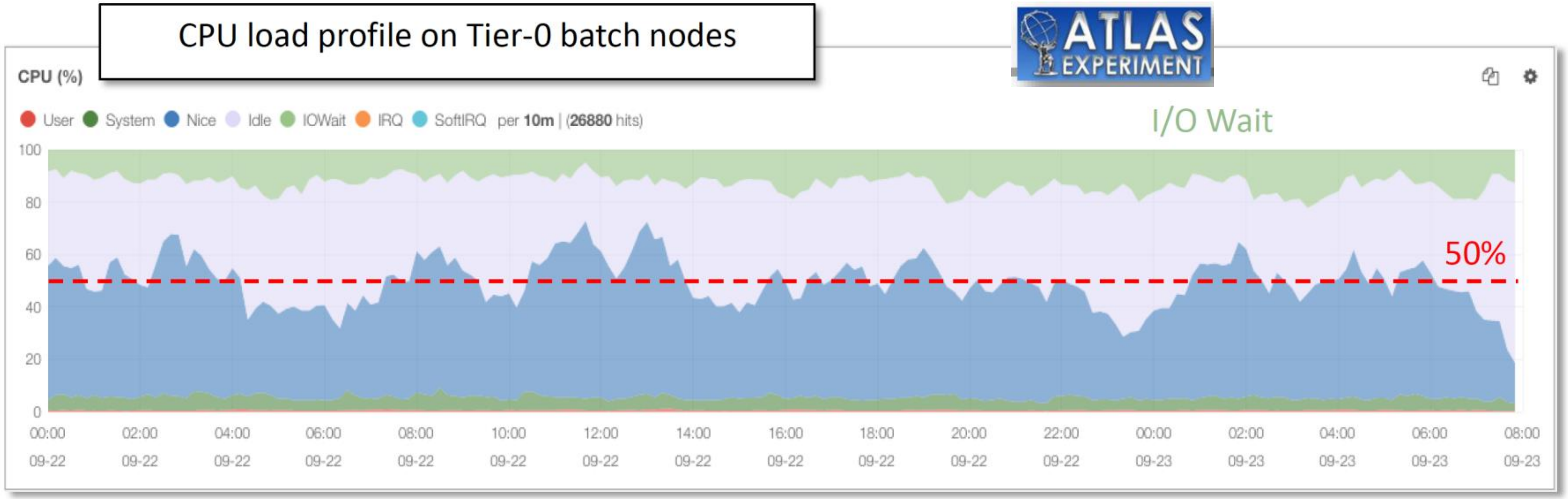
From the Agenda

- *How well do we understand our current workflows, their behavior and resource needs?*
  - *with respect to storage, remote access, networks, CPU, memory*
  - *How well do we understand the behavior of our current infrastructure?*
  - *What can we do to improve this understanding in an experiment independent way?*
  - *how independent can this be?*
- *What has been done already in experiments?*
- *What would be desirable? Ability to model ideas of infrastructure to understand performance, costs, etc.*
- *What is potentially common across experiments? What is specific?*
- ***Can we derive a cost model for the infrastructure to explain the full costs of computing and the relative costs of each component?***

Information gathering (++)

- Monitoring data very fine grained for workflows and infrastructure
    - xrootd monitoring
    - PerfSonar
    - Data management monitoring
    - Fabric monitoring
    - Dashboards ……….
- Performance analysis tools
    - Detailed traces
        - Memory, cpu, storage etc.
- Analytics
    - Significant investment (people and hardware) using advanced tools
        - Machine learning etc.

Examples

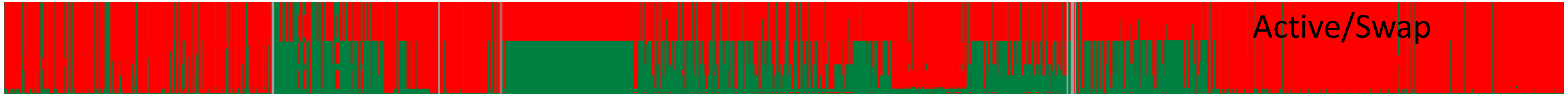


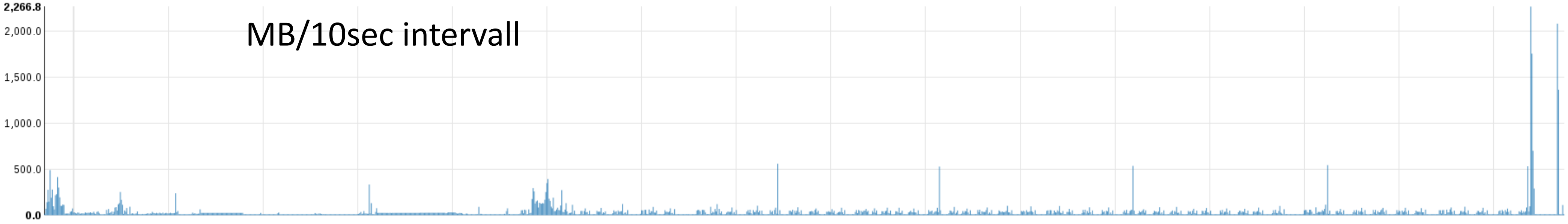
CPU load profile on Tier-0 batch nodes

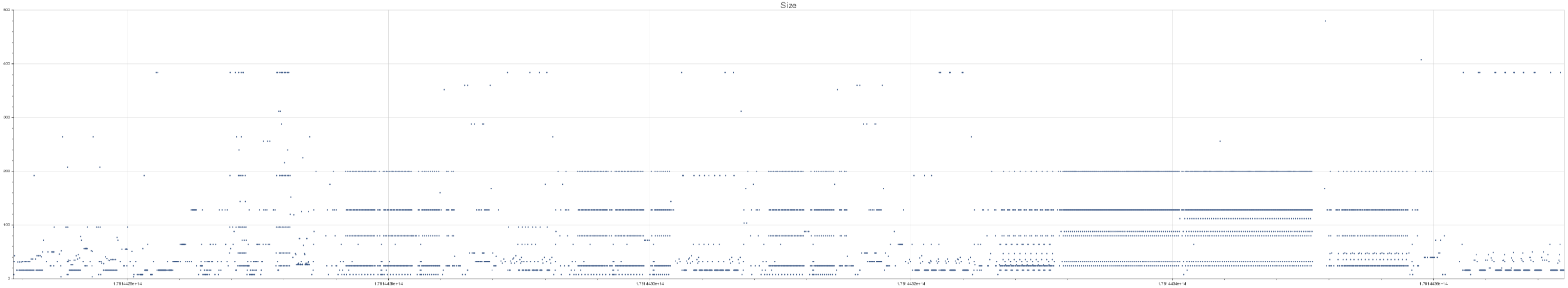
Step	Setup	RAWtoESD*	RAWtoESD validation	ESDtoAOD setup	ESDtoAOD*	ESDtoAOD validation	DQHistogram Merge setup	DQHistogram Merge	DQHistogram Merge valid.	ESDtoDPD setup	ESDtoDPD*	POOLMerge Athena setup	POOLMerge Athena	ESDtoDPD validation	POOLMerge file validation	Finalisation
Wall time (*MP)	6m 26s	2h 47m 26s	6m 29s	7m 56s	1h 0m 54s	4m 13s	19s	2m 37s	1s	3m 6s	16m 22s	1m 2s	32m 58s	5m 7s	33m 15s	8s
CPU time, efficiency	N/A	10h 20m 56s 92.7%	N/A	N/A	2h 34m 16s 63.3%	N/A	N/A	29s 18.5%	N/A	N/A	20m 49s 31.8%	N/A	5m 18s 16.1%	N/A	N/A	N/A

Did we expect this?
Do we know why this workflow behaves this way (quantitatively) ?
What would change if we double/half the network/memory?

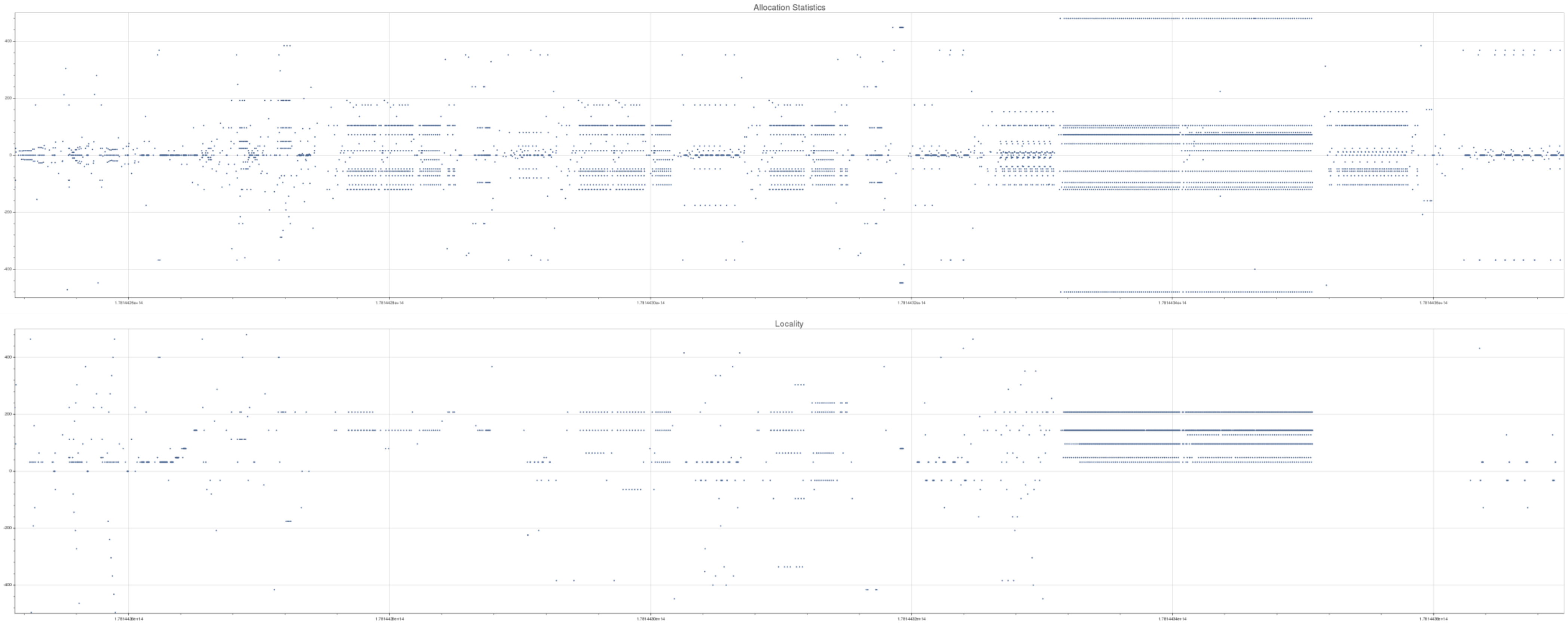
Examples: Tracking Memory at the Nanoscale







Examples: More



Incredible detailed information. Why do we see these patterns. Do we expect them? What is the impact on performance?

However….

- When things change we are often surprised:
    - CERN/Wigner performance differences
    - Virtualization performance differences
    - Move to multi threaded processing
- We are very good at noticing and measuring effects
    - Good monitoring and logging of “all and every thing”
- We are bad (quantitative) at answering: **What if ?**
    - Can’t predict well the effects of changes (workflows, infrastructure…)
    - Can’t easily identify the main reasons and interdependencies
        - If more than one thing changes at the same time (as it always does)
    - CERN-Wigner extension, single core → multi core, Spinning disks/SSDs
- Not surprisingly given the complexity of the environment….
    - Very divers, many factors driving efficiency and performance.
    - Large phase space

Knowledge / Understanding

- Understanding can be seen as a model based form of data compression *
  - *understanding* something means being able to figure out a simple set of rules that explains it.
  - Think about how the model of a rotating earth allows to predict data as brightness, temperature, and atmospheric composition during a day

* Gregory Chaitin

What we could use Models for

- Understanding better the existing system
- Document and represent what we think that we have understood
    - Comparing measurements and model
- Spot gaps in our understanding
    - Guide analysis of infrastructure and workflows
- Exploring alternative approaches
    - Workflows and Infrastructures
    - More quickly and more cheaply
- Guide purchase decisions → meaningful cost model
    - When a cost model is included
    - X1 cores + Y1 disks + Z1 MB/core + R1 MB network will me n events/hour of workflow D per Euro

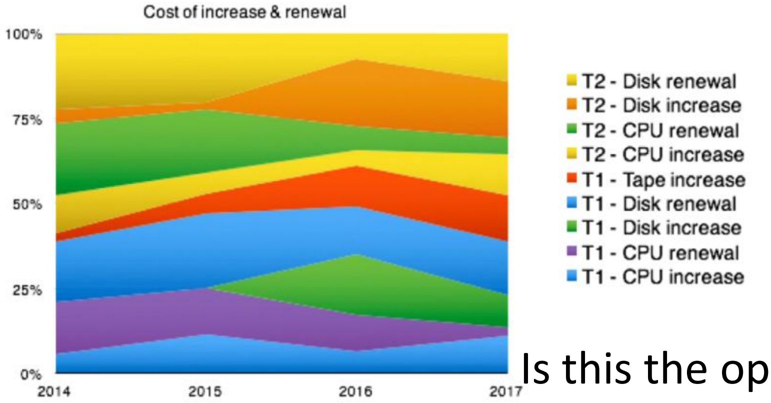
What kind of Model(s) might be useful?

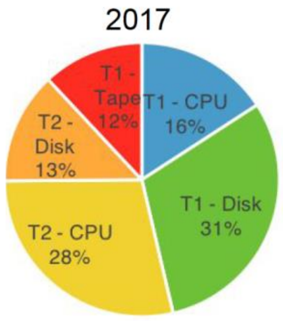
- Model in the sense of ”**simulation**” of the infrastructure elements and their interaction
  - Discrete Event Simulations (used in real time systems and networks)
  - Hybrids
    - Like SimGrid (used for HPC, Grid, Cloud ..)
- Model in the sense of an **analytical model** describing the behavior of infrastructure and applications
  - Could be a set of rules to do back of the envelope calculations
  - In the most basic case an Excel table
  - Probably several already around
- In HPC it is standard practice to use modeling of workloads and machines during the design phase
  - Maybe we can profit from their expertise

Cost model?

- **What is the metric that we want to look at**?
  - HepSpec/Watt?
  - HepSpec/CHF ?
  - **Workflow-A/B/C/D events per week /CHF ?**
    - Best in a mixture representing our needs
  - …….
- Goal: Understand better on what we should spent our budgets on
  - Answer questions like: Is it better to move to from 2 to 3.5 GB memory per core and buy 10% less disk?
  - Needs good model for cost prediction

- **<u>Complications:</u>**
- How do we account for human effort?
  - Cloud, many/few sites, etc.
- Budgets are often not fluid
- Funding agencies are driven by additional/different motivations
  - But they are not brain dead and having quantitative arguments might help





Is this the optimum?

Common/Specific

- Common:
  - Models of the **infrastructure**
    - Global, local, generic storage….
  - ***Framework*** to model experiment workflows
  - Tools and ”survey program” to analyze the workflows and their impact on the infrastructure
    - Like the FOM tool (HSF) and the allocation tracer
  - Metric to express the parameters of models
- Specific:
  - Models for specific storage systems/sites
  - The analysis and modeling of the different workflows
    - Using common tools as far as possible
  - Comparing model and monitoring data for a specific experiment/site
  - Exploration of new concepts

What happened to MONARC ?

- LCG Modeling effort in the late 1990s early 2000
- Guided the design towards the hierarchical T0/T1/T2 mdel
- Then was used very little

- Was done ***before*** we had any infrastructure or established workflows
  - No rapid feedback loop
  - WLCG’s focus quickly shifted to make it work all….

- Why not the obvious it as a starting point?
  - Tech evolved
  - Infrastructure evolved

First Steps?

Mostly speculative …

- Do not start a large (EC funded) project!
- Many different ongoing activities
  - Concurrency Forum
  - HSF
  - Experiments
    - Like RUCIO modeling based on SimGrid
- →**First step**: collect and document ongoing activities
- Modeling needs a home: WLCG / HSF ?
  - WLCG better connection to the infrastructure
  - HSF better linked with the workflows/applications
- Start with a very primitive model!
  - Maybe estimating on paper what the theoretical best efficiency of workflows could be
    - Academic exercise, but will collect input data that can be re-used later.
  - Be aware of the limitation of models! 20% precision == outstanding
  - Don’t get lost in details (packet level modeling of WLCG