UiO : University of Oslo

Exploiting Opportunistic Resources for ATLAS with ARC CE and the Event Service

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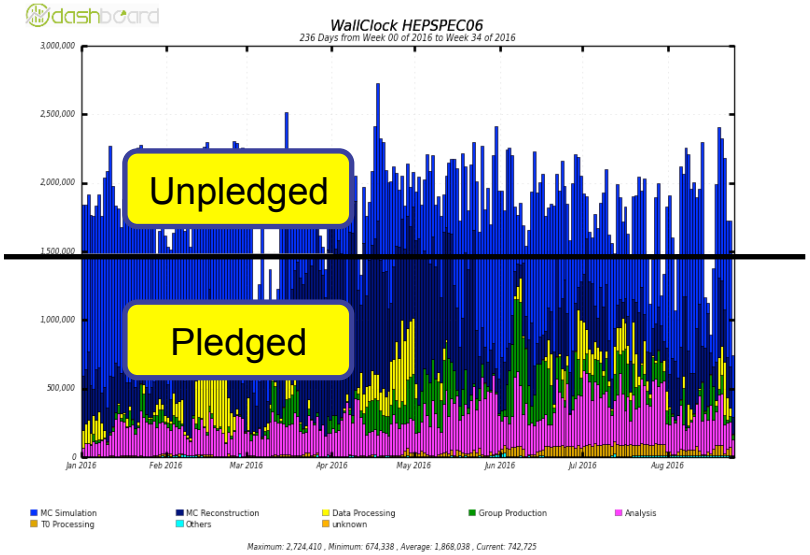
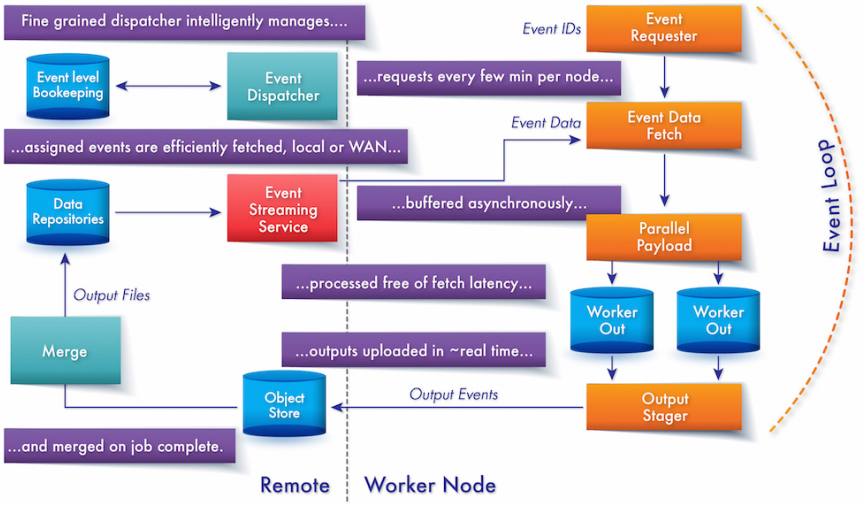
Opportunistic Resources

- A vital contributor to ATLAS computing
  - HPC backfilling, cloud spot market, volunteer computing, HLT farm
- A common factor is that resources can disappear at any time, even in the middle of a job
- Other potential issues:
  - No network connectivity from worker nodes
  - No root-mounted CVMFS for software
  - No persistent edge services on eg login nodes



ATLAS Event Service

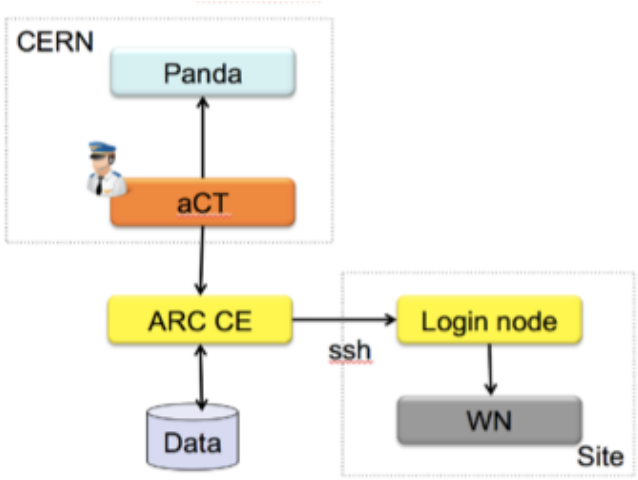
- A regular ATLAS job processes a fixed number of events
- The Event Service goes to event-level granularity
  - As a job runs, it regularly saves events produced to an Object Store
  - If a job is terminated it loses at most the last 10 mins of events
  - Unfinished events are reassigned to another job
  - Events are merged and stored on regular Grid storage

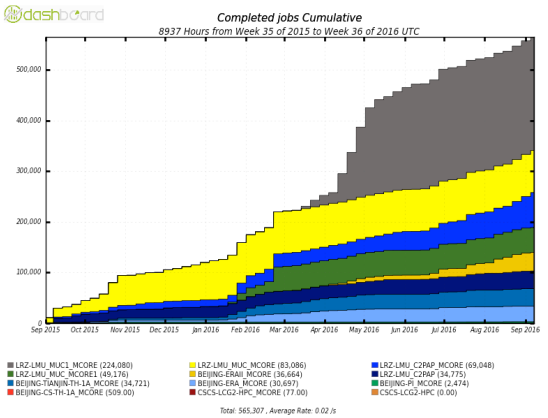


See ES talk for more info

ARC CE and ARC Control Tower

- ARC CE: Designed to be a lightweight non-intrusive resource connector
- Performs staging in and out of data
- ARC Control Tower (aCT) handles communication with Panda (ATLAS workload management system)
- No Grid software or outbound connectivity needed from worker nodes
- ssh mode for the more restrictive HPCs
- Used to integrate HPCs in Europe and China (as well as many “regular” Grid sites)





Integration of ARC CE and Event Service

- How to run jobs on a preemptable resource with no network connectivity?
  - Run Event Service jobs and do asynchronous data staging with ARC CE
  - The job writes each event + metadata to working directory
  - Once finished, the names of events are put in a special file
  - ARC CE detects the job finished in the batch system, and uploads the events listed in the file
  - ARC Control Tower tells Panda which events succeeded
- If preempted, a special ARC CE plugin runs
  - It tells ARC CE that the job succeeded
  - It finds the events that were produced and puts them in the special file

Challenges

- The number of events to upload from one ARC CE quickly became a bottleneck
  - 10k cores, 5 mins per event = 30Hz upload
- Led to zip functionality
  - After job finishes pilot creates a tarball of events
  - Reduces data transfer rate by orders of magnitude
  - Also makes merge job more efficient
- Many extensions of aCT/ARC required
  - Object store support
  - Passing event ranges back and forward
  - Plugin to emulate pilot functionality for preempted jobs

Leibniz Supercomputing Centre
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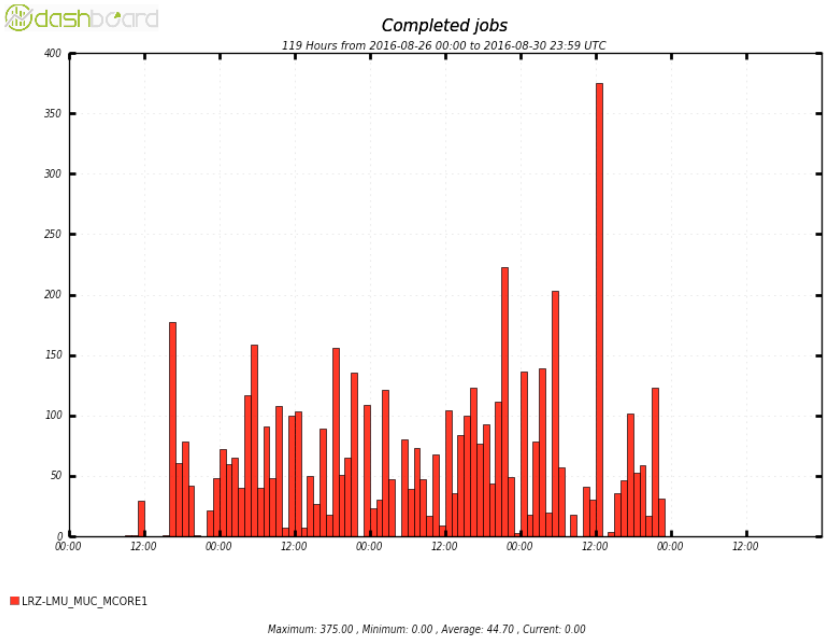
Test setup

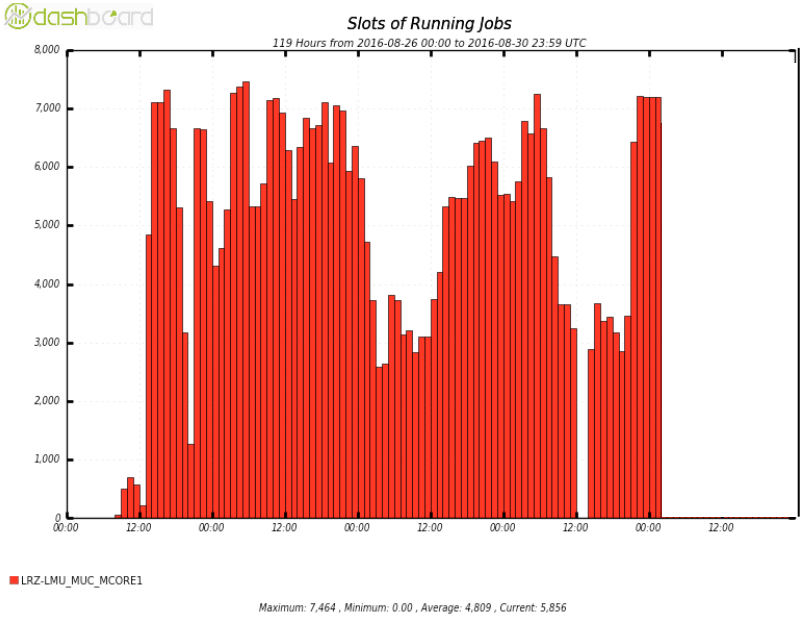
- The SuperMUC HPC in Munich is our test system
  - Phase 1 (2011-13): 155000 cores, 3.2PFlops
  - Phase 2 (2015): 86k cores, 3.6 PFlops
  - #27 on Top500 (June 16)
- Over a period of 3 days ran Event Service jobs on Phase 1
- Each job attempted to run 500 events over 24 cores (~4h walltime)
- All jobs could be preempted at any time

Results

	Finished	Preempted	Total
Jobs	3861	1014	4875
Events (M)	1.93	0.23	2.16
CPU hours (k)	196	24	220

- Jobs used up to 7000 cores (24 each)
- Out of a total of 4875 jobs 21% of jobs were preempted
- 10% of events were saved from preempted jobs





Conclusion

- Integrating ARC and Event Service provides an effective solution for using opportunistic resources in restricted environments
  - Specifically HPC but could be applicable in other areas eg volunteer computing, clouds
- In a 3-day test on SuperMUC we used 1000 CPU days which would have otherwise been lost
- Future directions:
  - Scaling up
  - Using on other HPC sites as Event Service usage grows
  - Adapting to the Event Streaming Service