



Scaling up ATLAS Event Service to production levels on opportunistic computing platforms

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Continued growth in public cloud and HPC resources is on track to exceed the dedicated resources available for ATLAS on the WLCG. Examples of such platforms are Amazon AWS EC2 Spot Instances, Edison Cray XC30 supercomputer, backfill at Tier 2 and Tier 3 sites, opportunistic resources at the Open Science Grid (OSG), and ATLAS High Level Trigger farm between the data taking periods.

Because of specific aspects of opportunistic resources such as preemptive job scheduling and data I/O, their efficient usage requires workflow innovations provided by the ATLAS Event Service. Thanks to the finer granularity of the Event Service data processing workflow, the opportunistic resources are used more efficiently. We report on our progress in scaling opportunistic resource usage to double-digit levels in ATLAS production.

Motivations: Using opportunistic resources efficiently and fully for ATLAS processing is an important means for maximizing ATLAS computing throughput within budget constraints. Examples of such opportunistic resources are

- High Level Trigger (HLT) farm, available opportunistically during LHC Run 2
- High Performance Computing (HPC), aka supercomputers
- Opportunistic grid resources, e.g. non-ATLAS OSG sites
- Cloud resources, e.g. the Amazon EC2 spot market
- Volunteer computing, aka ATLAS@Home via BOINC

Requirements: We have to be agile in how we use these opportunistic resources:

- Quick start (rapid setup of software, data and workloads) when they become available
- Quick exit when they are about to disappear
- Robust against their disappearing with no notice: minimal losses
- Use them until they disappear – harvest unused cycles, filling them with fine-grained workloads

Benefits: Fine-grained event-based processing enables agile, efficient utilization of opportunistic resources that appear and disappear with unpredictable timing and quantity. Event consumers can be injected into such a resource when it becomes available, and participate in ongoing task processing, concurrently delivering outputs to an aggregation point until the resource disappears, with negligible losses if the resource disappears too suddenly.

Implementation: The Event Service (ES) [4] leverages excellent networks for efficient remote data access, distributed federated data access (using xrootd), and highly scalable object store technologies for data storage that architecturally match the fine-grained data flows, to support dynamic, flexible, distributed workflows that adapt in real time to resource availability and leverage remote data repositories with no data locality or pre-staging requirements (Fig. 1).

Capabilities: The new ATLAS production system prodsys2 [1] includes a PanDA extension JEDI [2] that adds to the PanDA server the capability to intelligently and dynamically break down tasks (as defined by the prodsys2 task definition component DEFT [3]) based on optimal use of the processing resources currently available. JEDI can break down tasks not only at the job level but also at the event level. The initial application of this capability is for event-level job splitting: jobs are defined in terms of the event ranges within files that they should process, and their dispatch and execution otherwise proceeds as normal. However this capability also presents the opportunity to manage processing and dispatch work at the event or event cluster level.

Figure 1: Event Service architecture including the Event Streaming Service (work-in-progress).

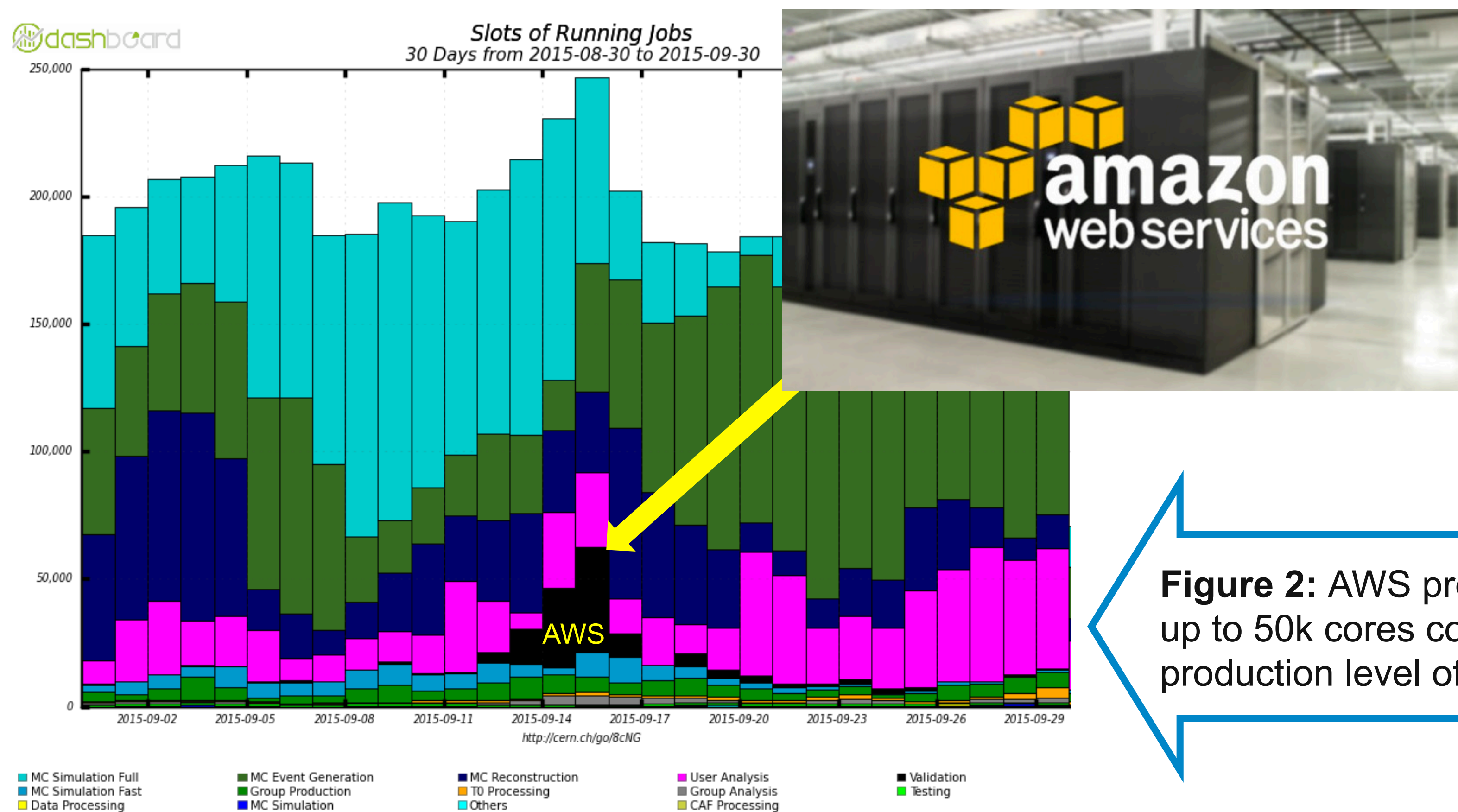
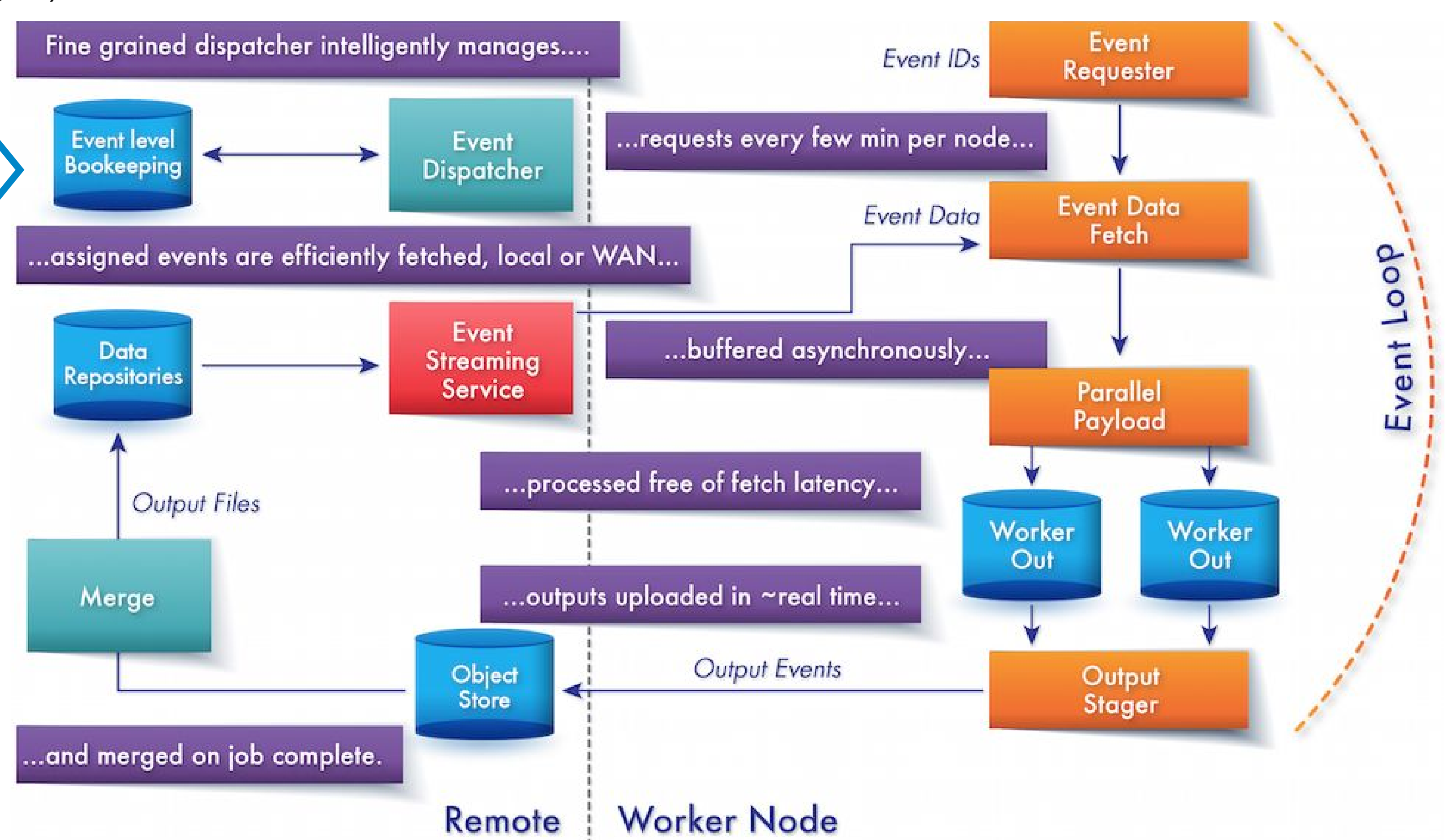
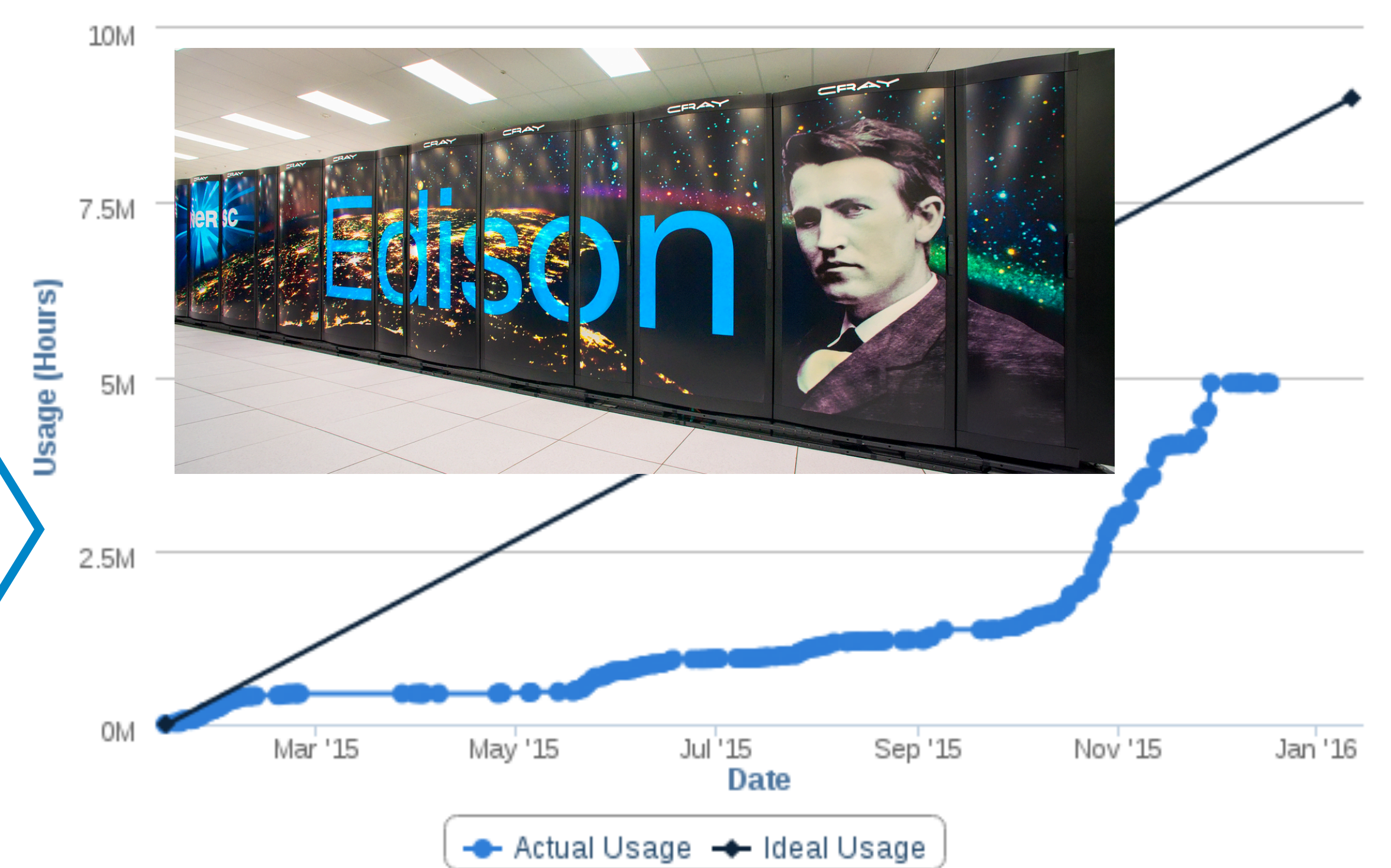


Figure 2: AWS production level of up to 50k cores contributed to ATLAS production level of about 200k cores.

Figure 3: CPU usage of Advanced Scientific Computing Research Leadership Computing Challenge allocation on Edison.



Results: Event Service production commissioning and operation scales up steadily:

- AWS: up to 50k concurrent cores was achieved in production (Fig. 2)
 - costs were lower than those associated with certain ATLAS dedicated resources
 - now preparing for the 100k core production run
- NERSC HPC: successful scaling tests of up to 50k concurrent cores
 - production level achieving up to 25k concurrent cores
 - in the last month before the Edison Cray XC30 supercomputer shutdown for relocation, the slope of simulation production CPU consumption sharply increased with two equal contributions: Yoda [5] and Generator [6] (Fig. 3)
- HLT: working with simulation production and scaling up in tests now ongoing towards 35k core scale
- (Off) Grid platforms at various stages of commissioning and operation
 - backfill on conventional grid sites, US Tier 3, BNL shared Tier 3, campus resources and non-ATLAS Open Science Grid sites
- ARC/Event Service/Yoda integration working, ARC Control Tower integration is underway
- ATLAS@Home implementation underway

Conclusions and next steps: The ATLAS Event Service enables cost-effective exploitation of opportunistic computing on heterogeneous, high capacity and high value platforms such as HPCs ('hole filling'), commercial clouds (dynamic market based spot pricing) and volunteer computing (no resource availability guarantees). In the next months we will continue efficient utilization of preemptible resources, particularly opportunistic such as HPC and AWS spot instances as well as backfilling dedicated ATLAS resources to keep them truly full. In general, the Event Service will serve as the basis for a uniform resource pool consuming in an automated and flexible way a predefined task pool.

References:

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