# ATLAS WORLD-cloud and networking in PanDA

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CHEP 2016 San Francisco

# Rationale

- Original ATLAS Computing Model was designed as static clouds (=mostly national or geographical groupings of sites), setting data transfer perimeters
- Hierarchic model with clear distinctions in Tier 1-2-3 level
- Particular policies enforced in the workload management system:
  - Output of **tasks (=set of jobs**) had to be aggregated in the Tier 1s (O(10))
  - Tasks have to be inflexibly executed within a static cloud
- This model works, but is getting outdated and has a series of disadvantages
  - WLCG networks have evolved significantly in the last two decades and bandwidth has increased O(1000): limiting transfers within a cloud is no longer needed
  - Usage of sites is uneven. In particular Tier 2 storage was not optimally exploited
  - High priority tasks occasionally stuck at small clouds
- First try was to allow sites to below to multiple clouds. WORLD cloud is completely breaking the boundaries

# WORLD cloud

- Dynamic model, defining dynamically the grouping of processing sites for each task
- **Task nucleus:**
  - Task brokerage will choose a nucleus for each task based on various criteria
  - The task output will be aggregated in the nucleus
  - The capability of a site to be a nucleus is defined manually in AGIS (ATLAS Grid Information System): Tier 1s and the bigger Tier 2s are defined as nuclei
- **Task satellites:**
  - Run jobs and ship the output to the nucleus
  - Job brokerage selects satellites for each task, based on usual criteria (e.g. number of jobs and data availability)
  - Satellites are selected across the globe: a network weight will bias towards well connected nuclei and satellites

# Configurator
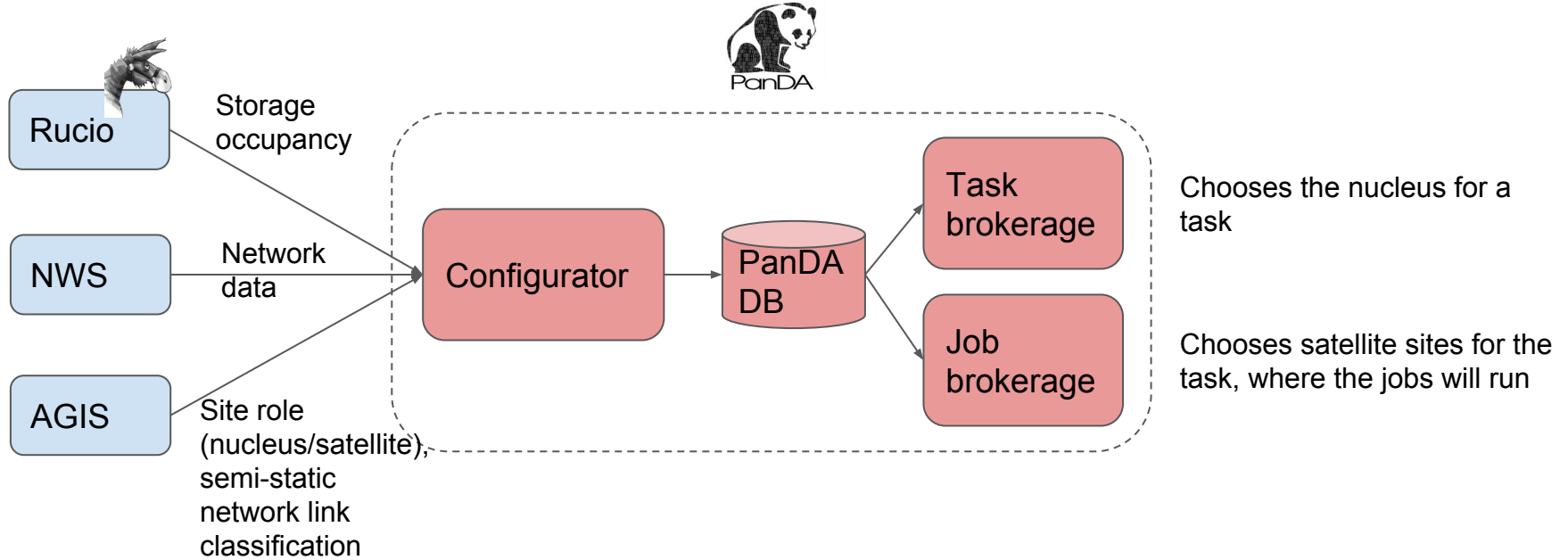
# Network data

- Rucio, FAX, PerfSonar events are collected in the ATLAS analytics platforms [1]
- The Network Weather Service[2] (DDM team) aggregates information from the platform. Per source-destination pair:
  - #files transferred in last hour
  - #files queued
  - Throughput according to FTS (aggregations for last 1h, 1d, 1w)
  - Throughput according to FAX
  - PerfSonar metrics (latency, packet loss, throughput)

  (Used currently in WORLD)

- AGIS also provides semi-static link classification to be used as a backup
- Configurator agent downloads and processes this information every 30 min. Data is cached in a key-value table in PanDA DB
  - Table is extensible for any new metric without modifying the structure

*Presentations in this conference:*

*[1] Ilija Vukotic et al.,"Big Data Analytics Tools as Applied to ATLAS Event Data"*

*[2] Mario Lassnig et al., "Using machine learning algorithms to forecast network and system load metrics for ATLAS Distributed Computing"*

# Task brokerage: nucleus selection

- One nucleus is chosen for each task
- Nuclei must fulfill all hard limits:
  - Be in active state and be able to execute the workload
  - Have over 5TB free space - the free space includes an estimation of the space to be filled by its pending tasks
  - The number of output files transferring to the nucleus must be below 2k
- Eligible nuclei compete through a combined weight, based on data locality, total RW (remaining work) and available storage size in the nucleus.
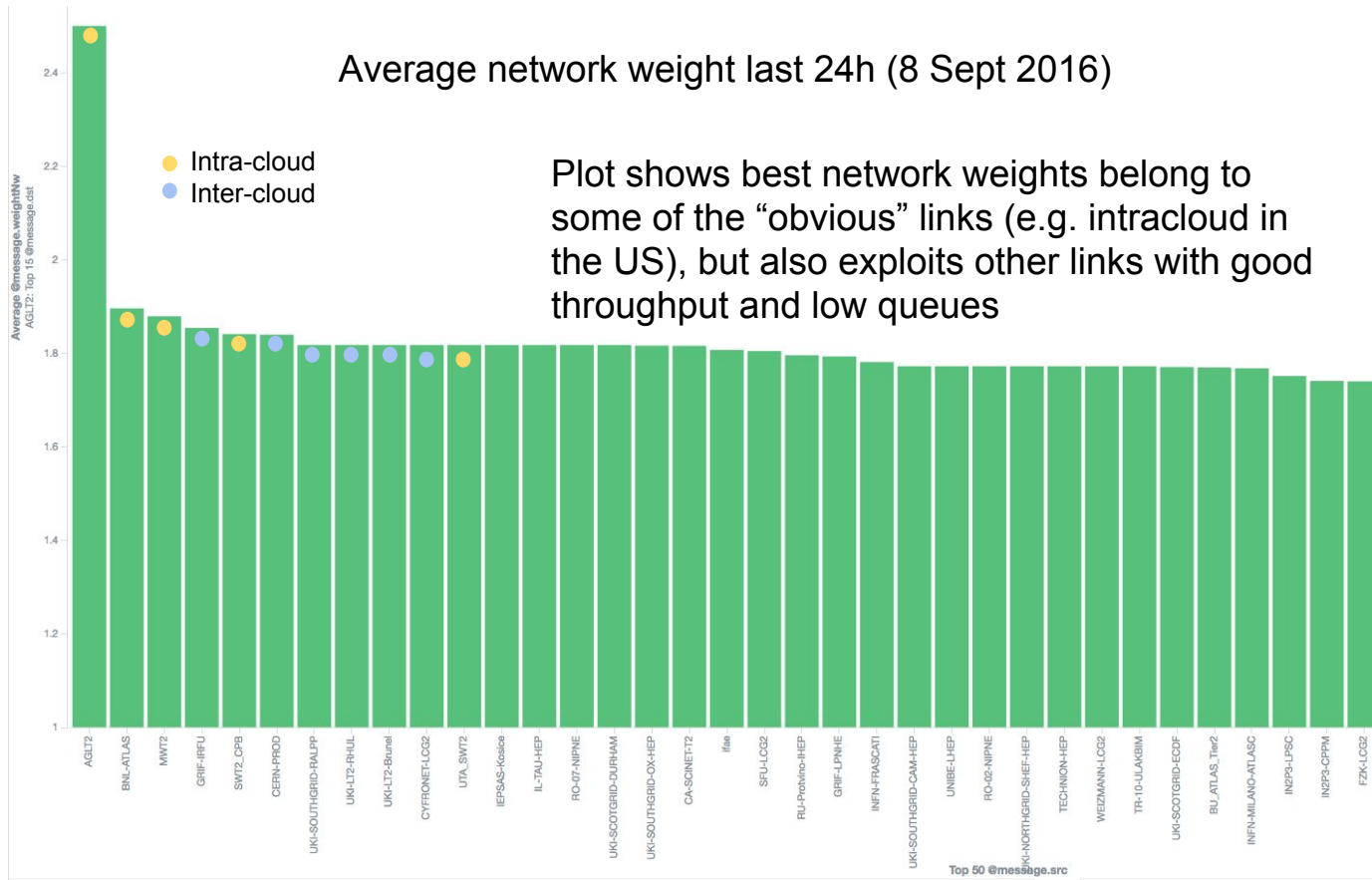
$$RW = (nEvents - nEventsUsed) \times cpuTime$$

$$weight = \frac{1}{totalRW} \times \frac{availableInputSize}{totalInputSize} \times tapeWeight \times \frac{freeSpace}{totalSpace}$$
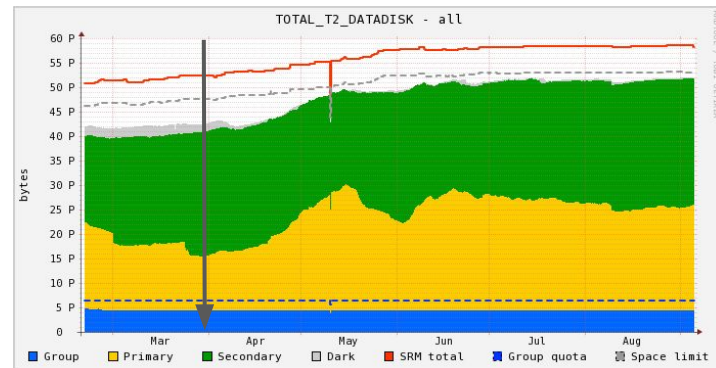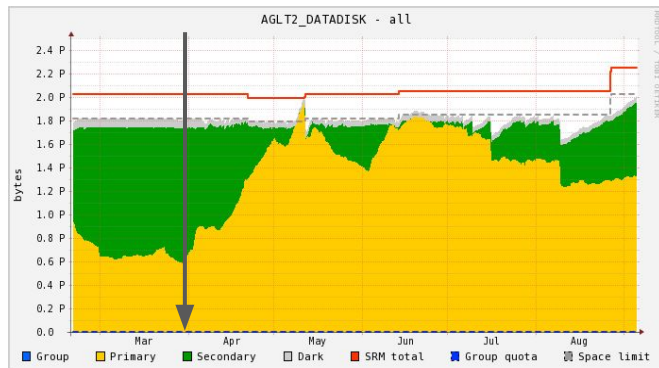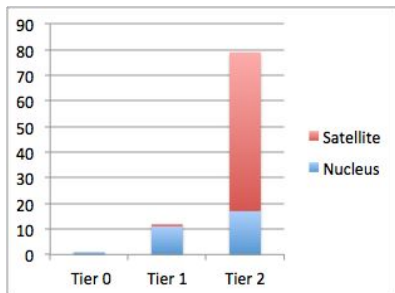
# Job brokerage: satellite selection

- 10 satellites are selected to execute the task
- The satellites must be able to run the jobs (RAM, walltime, core count, queues, SW releases and other settings)
- Sites must have <150 files in the transfer queue to the nucleus
- Eligible sites compete on a weight basis (#jobs, available & missing data)
- We have added the network weight, looking for balance between good throughput and queue length of output files
  - Throughput of FTS transfers satellite→nucleus
  - Queued output files in Rucio/FTS satellite→nucleus

# Example: Top connected sites to Nucleus **AGLT2** (Michigan)

Average network weight last 24h (8 Sept 2016)

Intra-cloud
Inter-cloud

Plot shows best network weights belong to some of the "obvious" links (e.g. intracloud in the US), but also exploits other links with good throughput and low queues
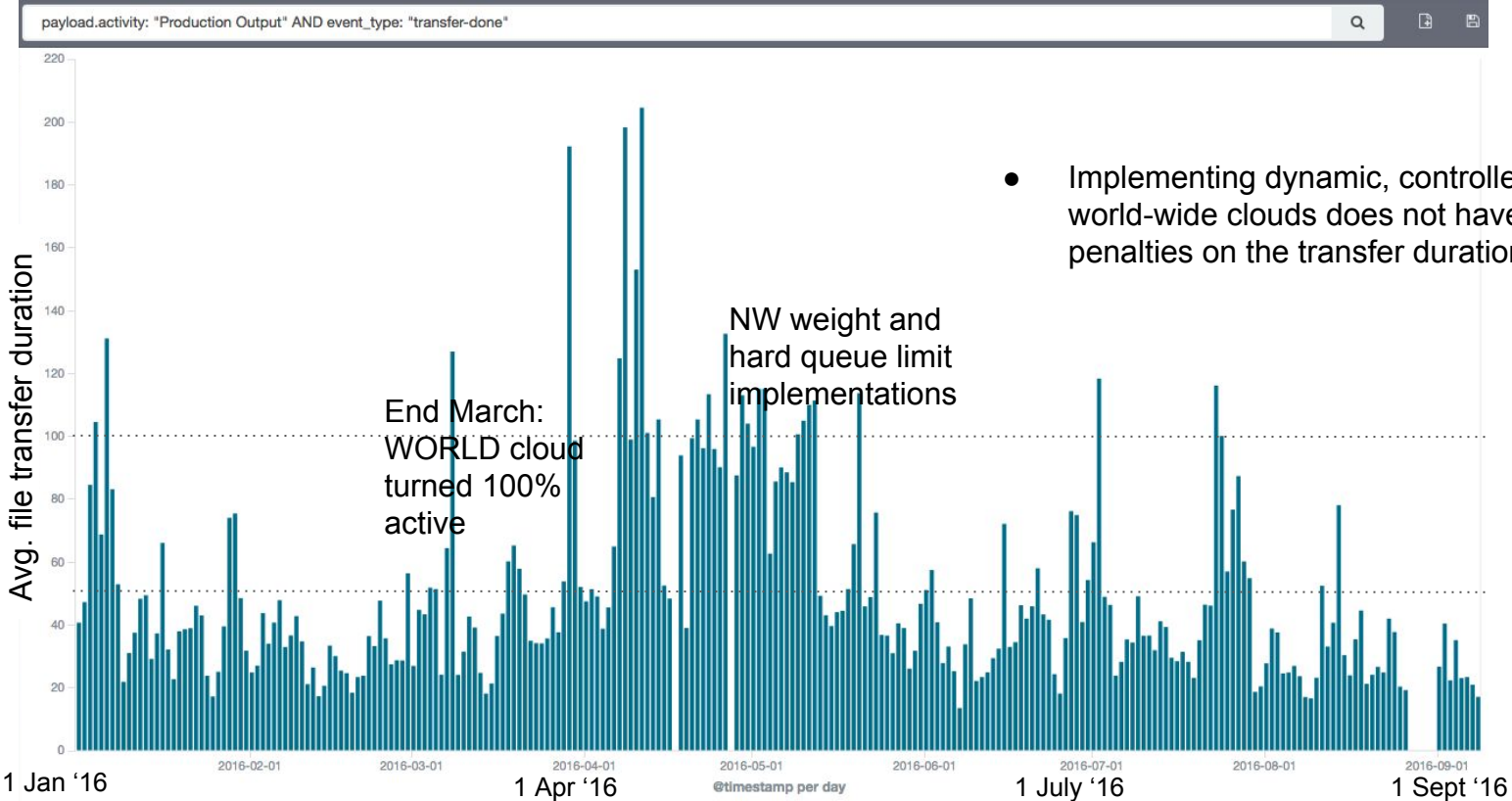
# Status: Impact on T2 disk space usage

- WORLD cloud was fully activated end March 2016
- Nuclei being added progressively
  - Currently T1s and ~20% of T2s (tentatively more T2s will be added)
- Extending task output recipients to T2s is starting to have a positive impact on the overall disk usage (more primary data on T2s)



*Storage plots from David Cameron's space monitoring:*
*http://adc-ddm-mon.cern.ch/ddmusr01/plots/*

# Status: Impact on output file transfer duration



payload.activity: "Production Output" AND event_type: "transfer-done"

End March: WORLD cloud turned 100% active

NW weight and hard queue limit implementations

- Implementing dynamic, controlled world-wide clouds does not have penalties on the transfer durations

Avg. file transfer duration

1 Jan '16    1 Apr '16    1 July '16    1 Sept '16

@timestamp per day

# Observations and future work

- Some sites suffered initially under transfer load during heavy campaigns
  - Not because of inter-cloud transfers, but because their bandwidth was insufficient for the Nucleus role
- Hard limit queue controls worked fine to alleviate issues and deviate the traffic from blocked sites
  - Limits trigger also during unrelated, "accidental" massive transfers
- Further downstream controls could be implemented to e.g. avoid already assigned jobs to run while their nucleus is stuck
  - Pause overloaded nucleus in job brokerage (using a higher queued file threshold to avoid waves)
- We have tried to optimize **output** file transfer, but still need to include some optimization for **input** file transfers
  - This case needs to be solved together with the DDM team, since it involves further uncertainties (multiple copies, tape staging, etc)
- Reduced operational effort/manual interventions to re-broker tasks
- Need to improve analytics data for gridwise analysis