Data Locality via Coordinated Caching for Distributed Processing

Max Fischer, Eileen Kühn, Manuel Giffels, Christopher Jung

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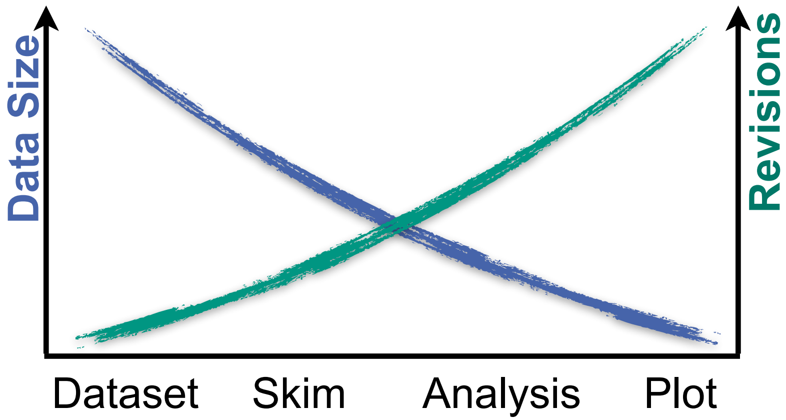
Karlsruhe Institute of Technology

Context: HEP End User Data Analysis

- Hierarchical, iterative workflows
  - Reduction of data size
  - Increase of iterations
  - Dedicated processing environments



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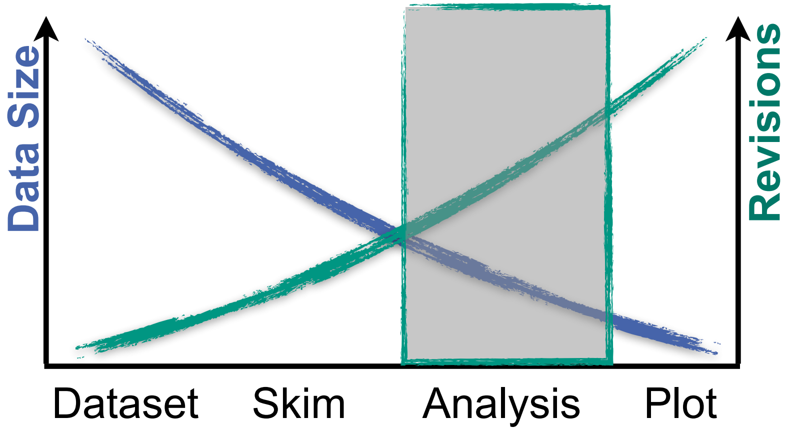

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  - Standard batch systems and fileservers
  - Extraction of observables from optimized data sets/formats

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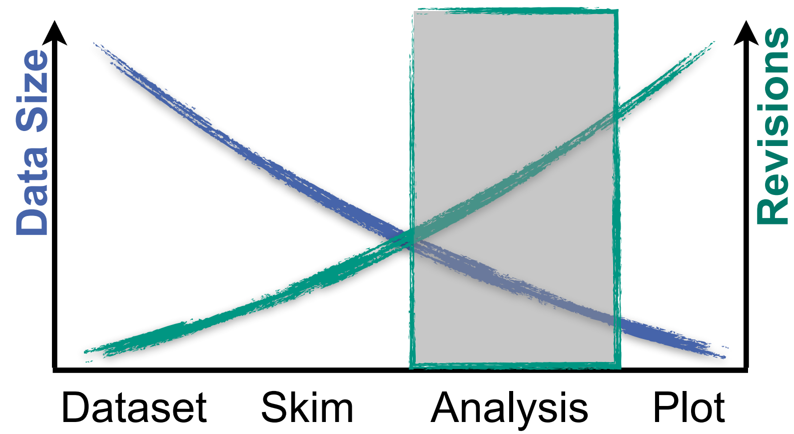
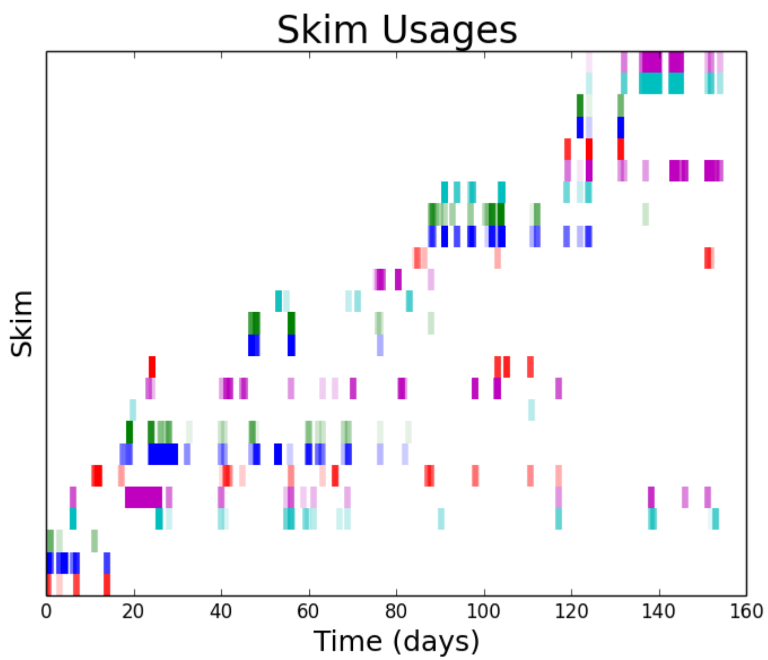
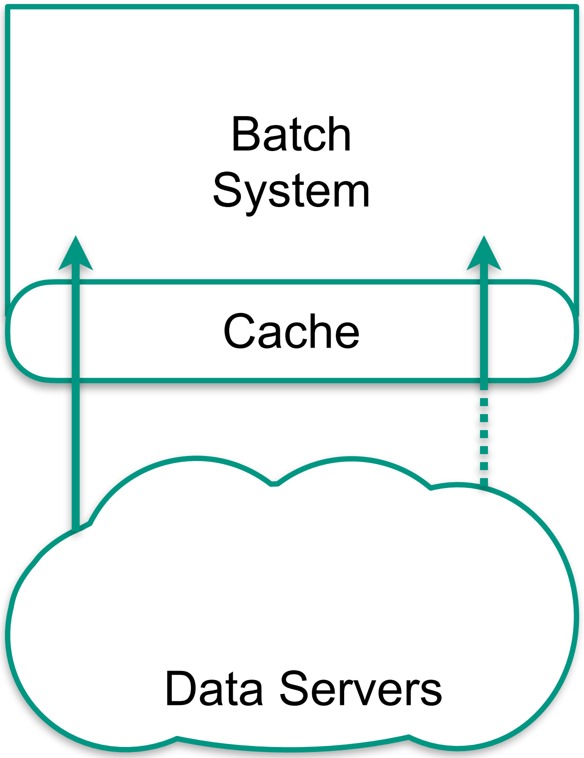
  - Extraction of observables from optimized data sets/formats
- Usage suitable for caching
  - Repeated processing of same input
  - Strongly dependent on input rate





Coordinated Caching: Overview

- Caching between batch system and data sources
  - Consumer focused caching
  - Provides partial data locality



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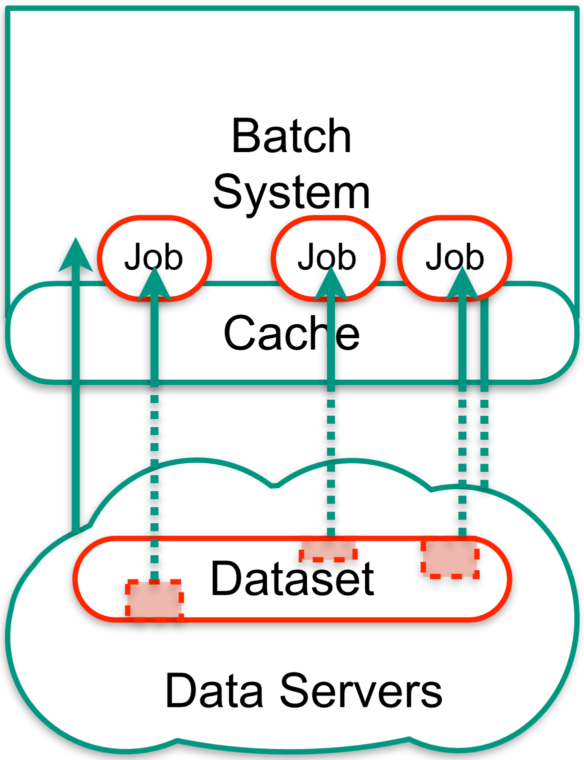

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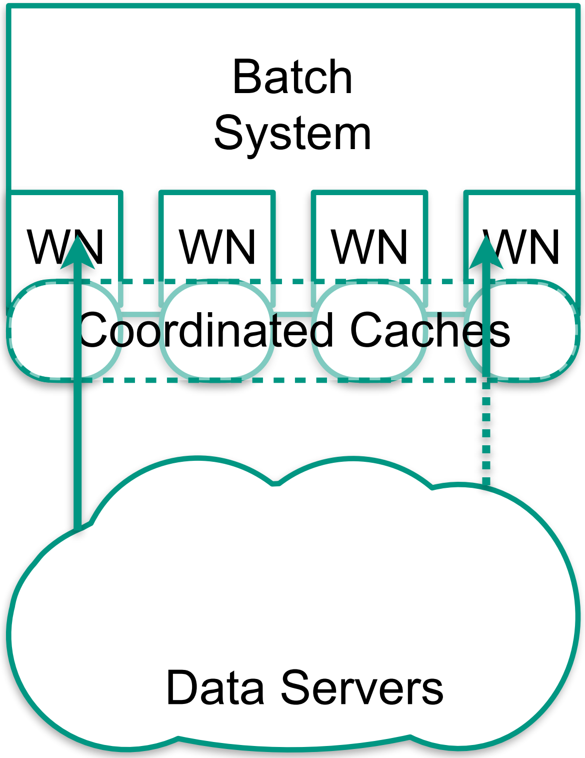
- Implementation at host granularity
  - Array of individual caches on worker nodes
  - Caches coordinated by global service
  - Some glue for data locality…



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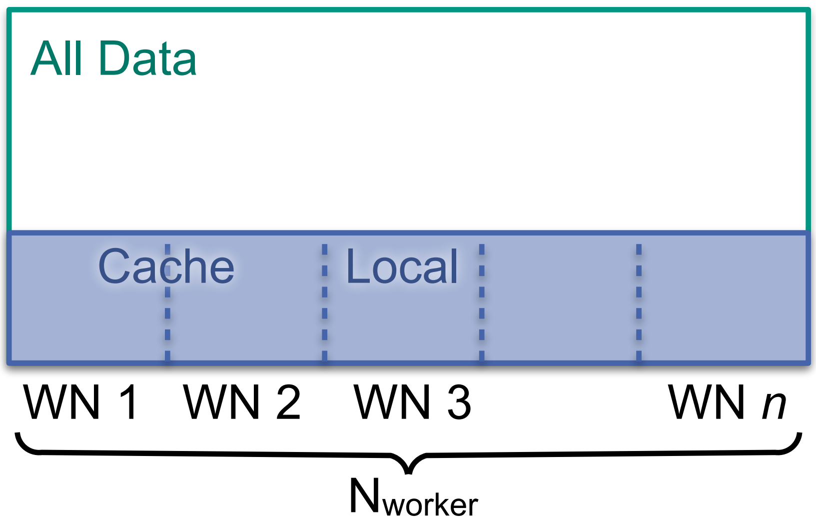

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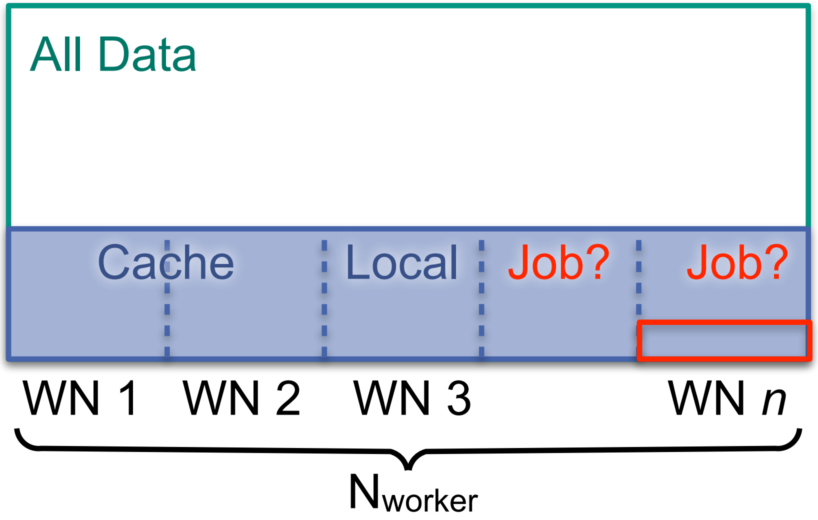
  - Data location published to batch system



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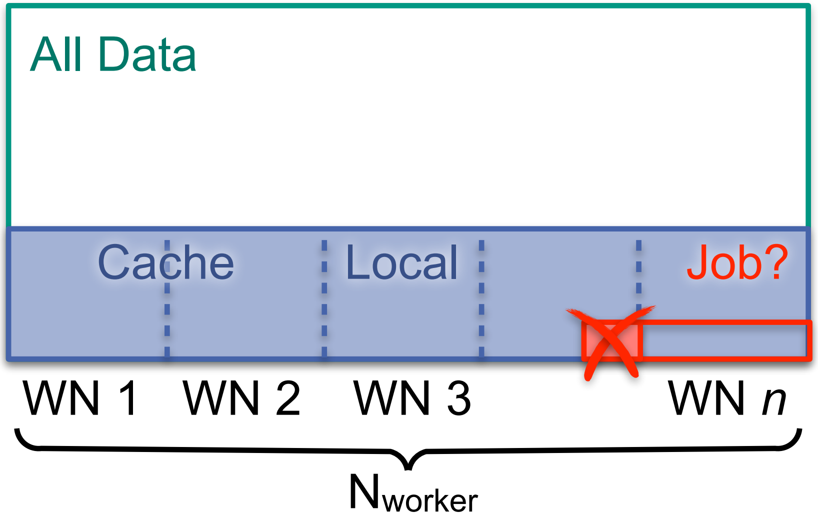
- Place data to match workflows
  - Jobs require groups of files
  - Placement uses observed data splitting



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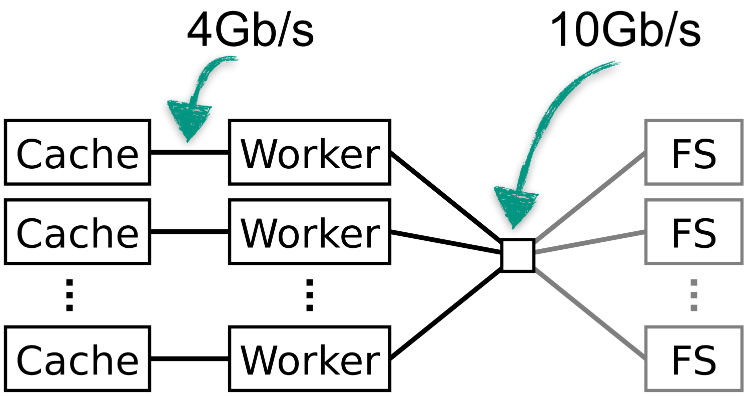

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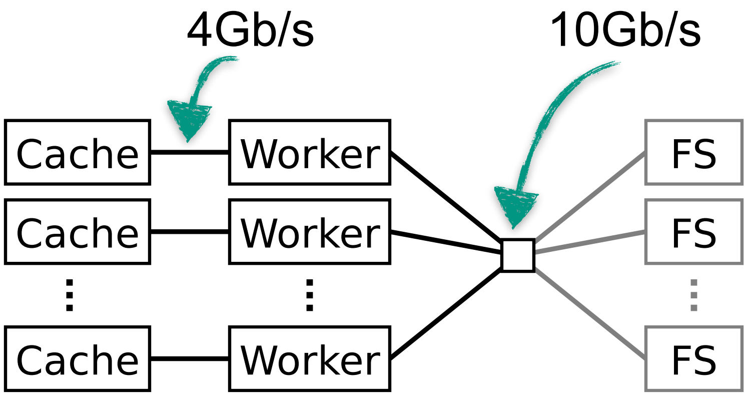

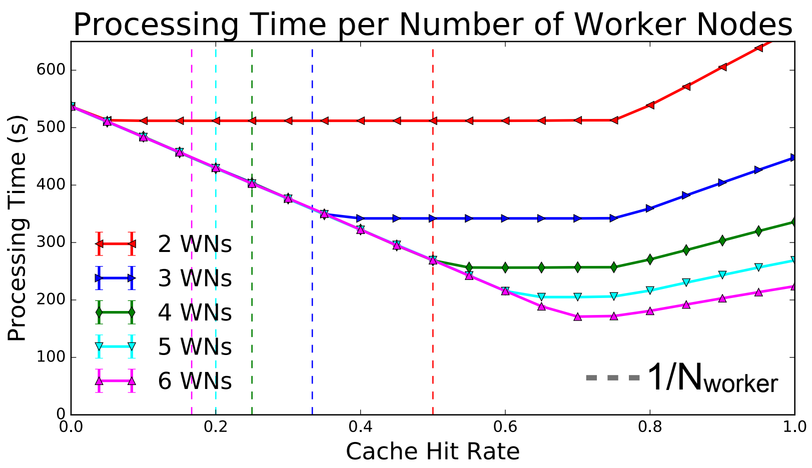

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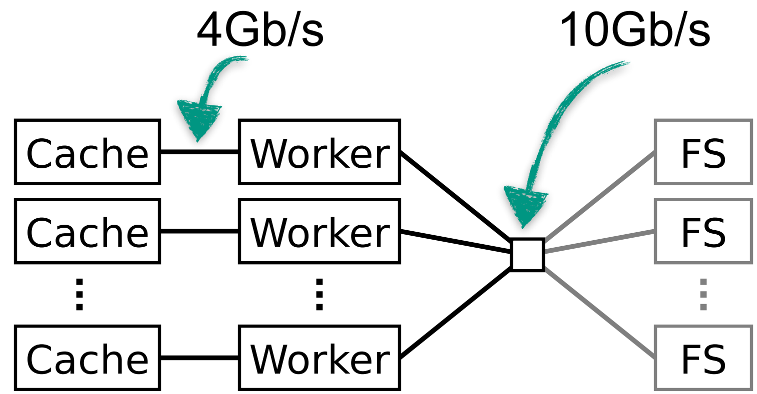
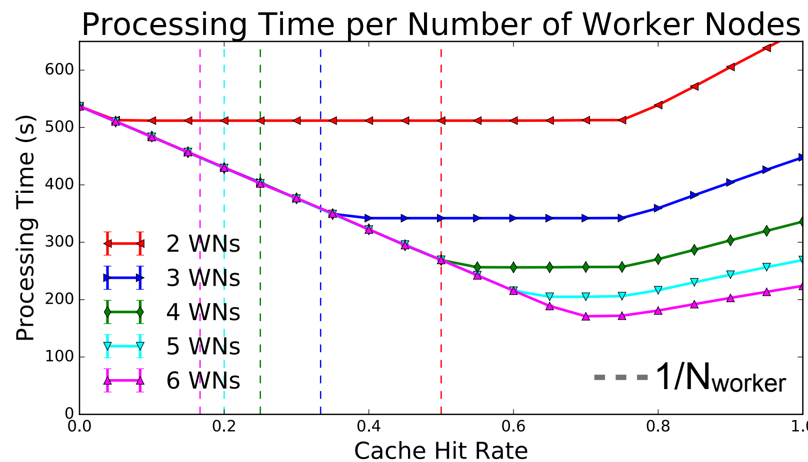
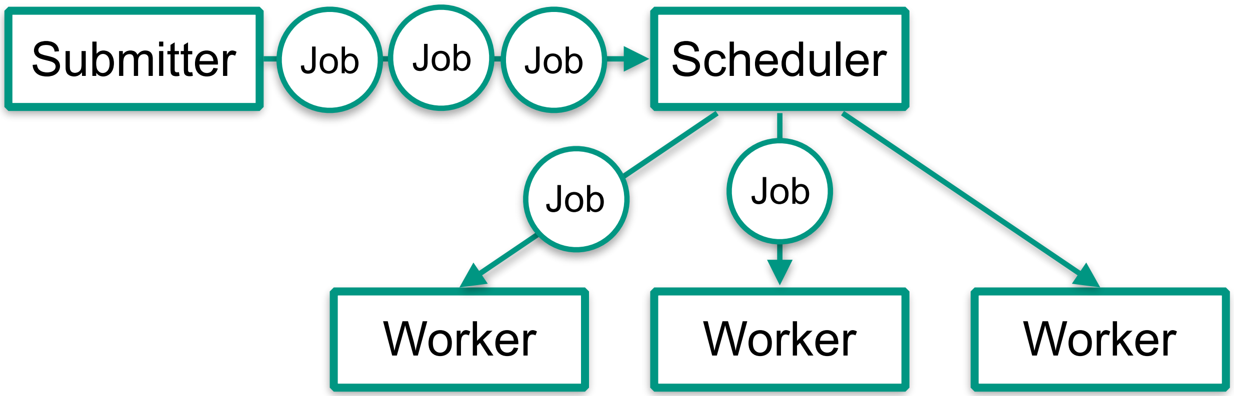
- Perfect hit rate not ideal
  - Leverage remote I/O
  - Potential to…
    - Use simple algorithms
    - Increase effective cache size





HTDA Batch System Extension

High Throughput Data Analysis



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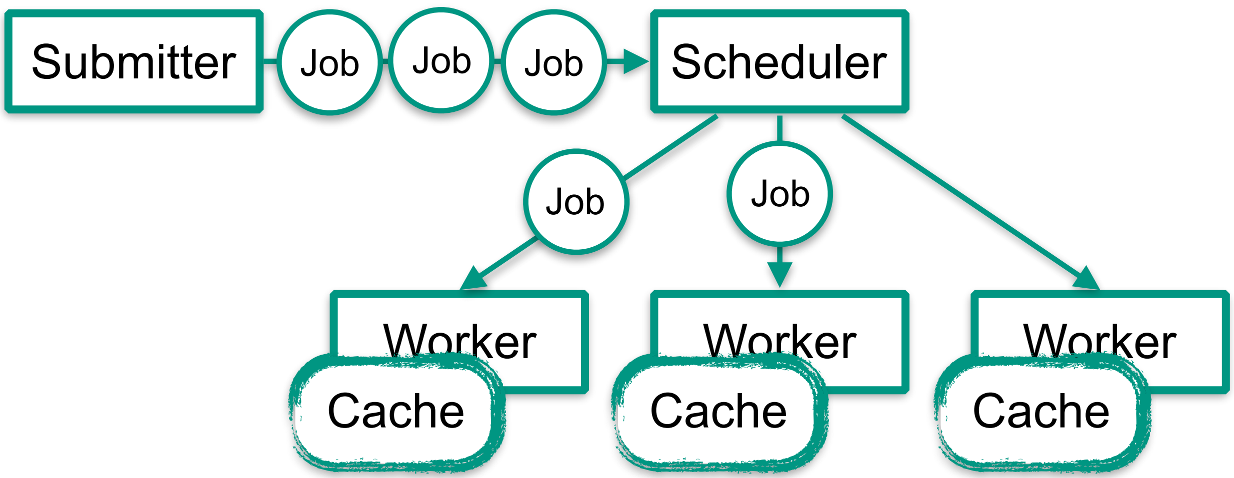

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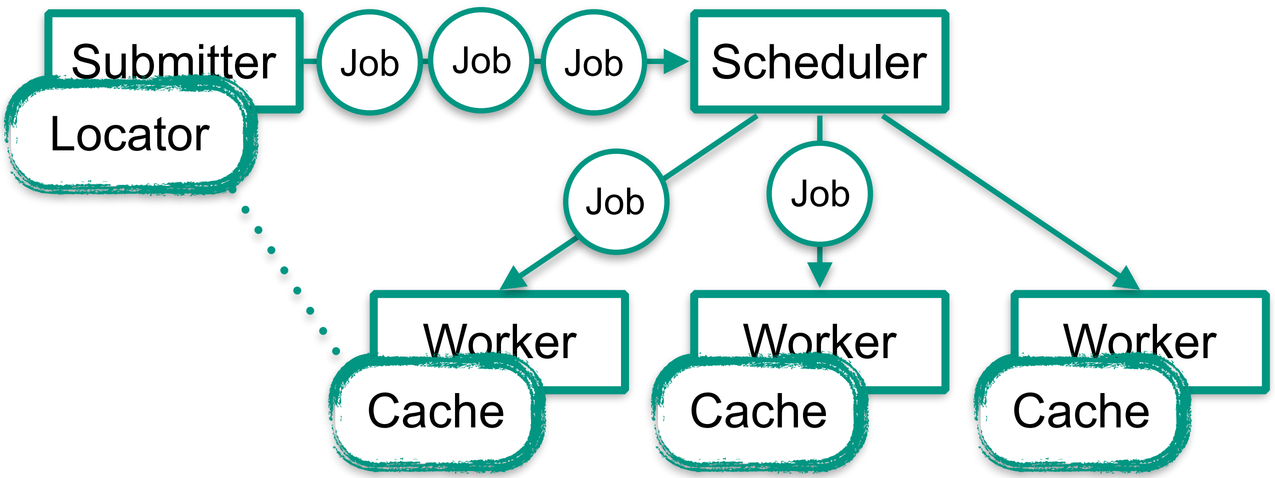

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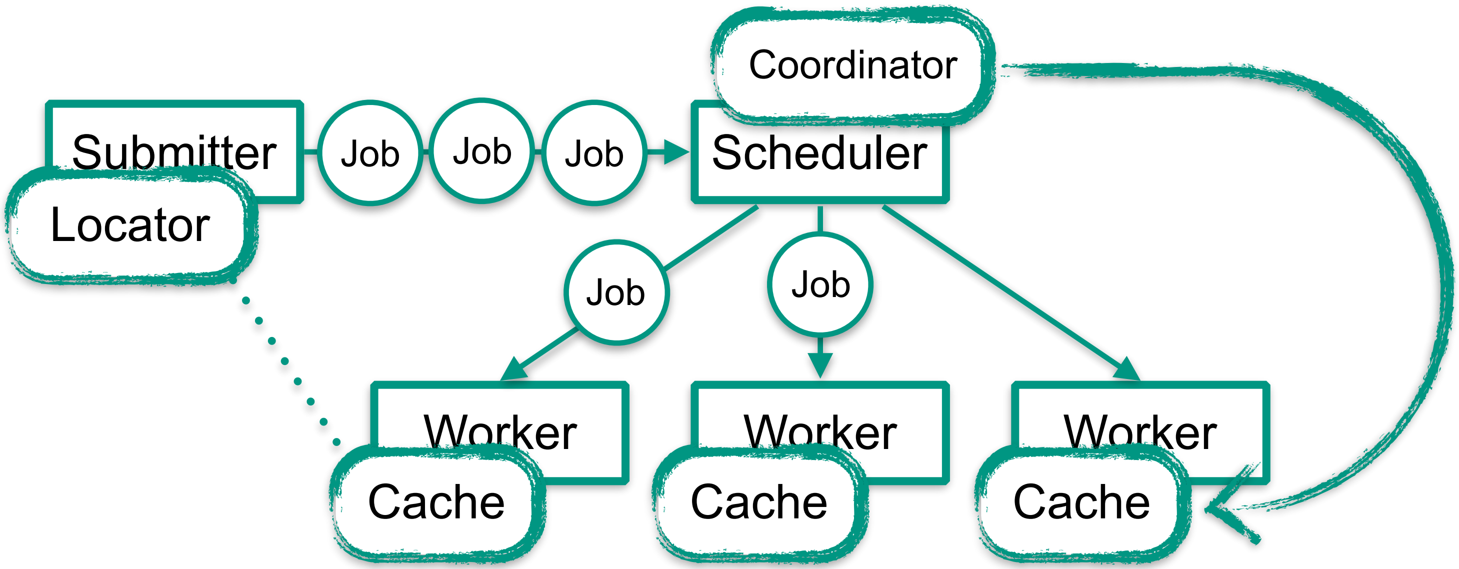

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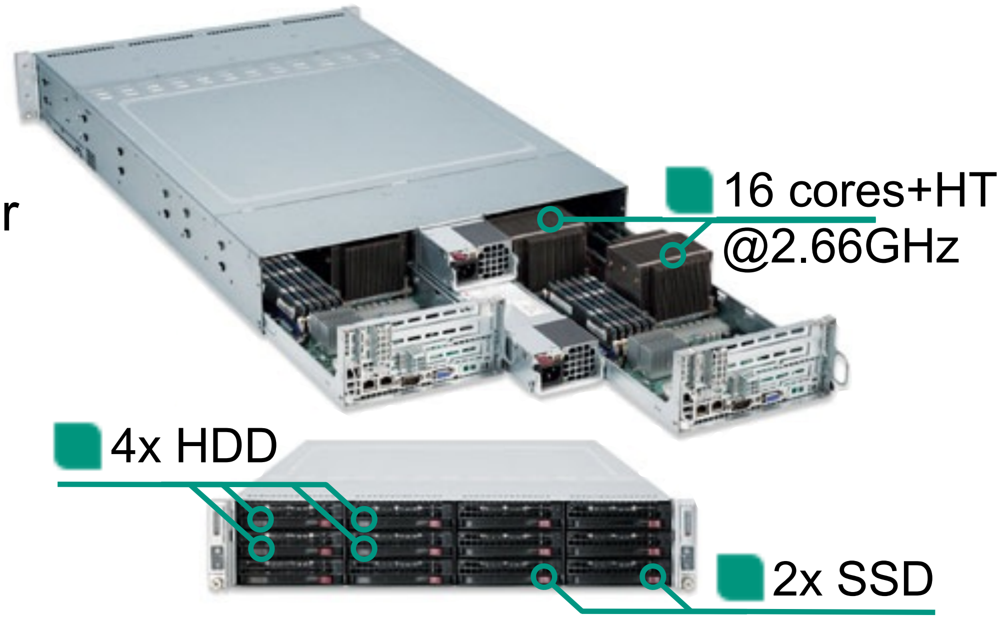
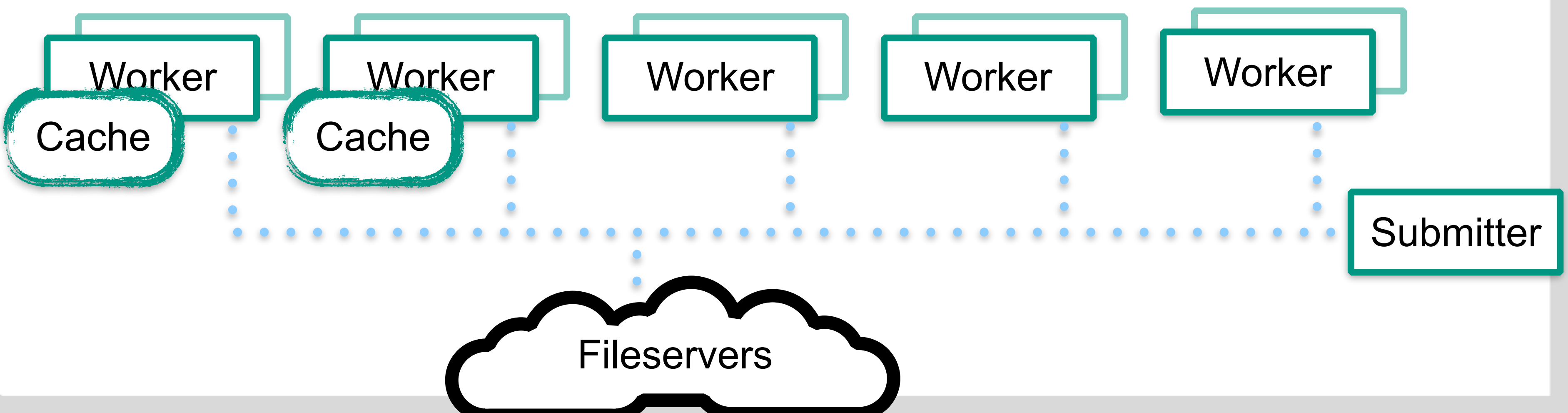
- Locator provides locality information for jobs
- Coordinator schedules files for caching on nodes

Prototype Batch System

- Extends HTCondor setup
  - Static, opportunistic and HTDA nodes in same cluster
  - 5 HTDA worker nodes á 500 GB SSD cache
  - 6 fileservers





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- Hooks on submission hosts via *job_router*
  - Integrates directly into batch system
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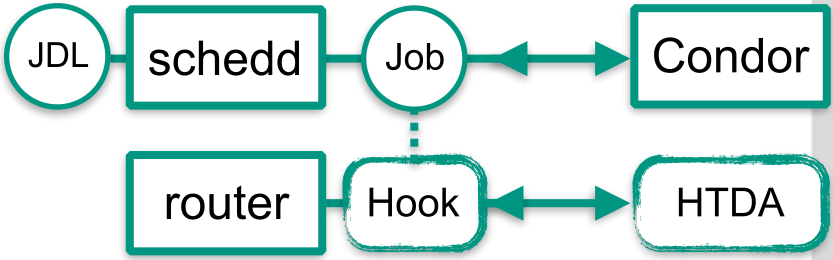

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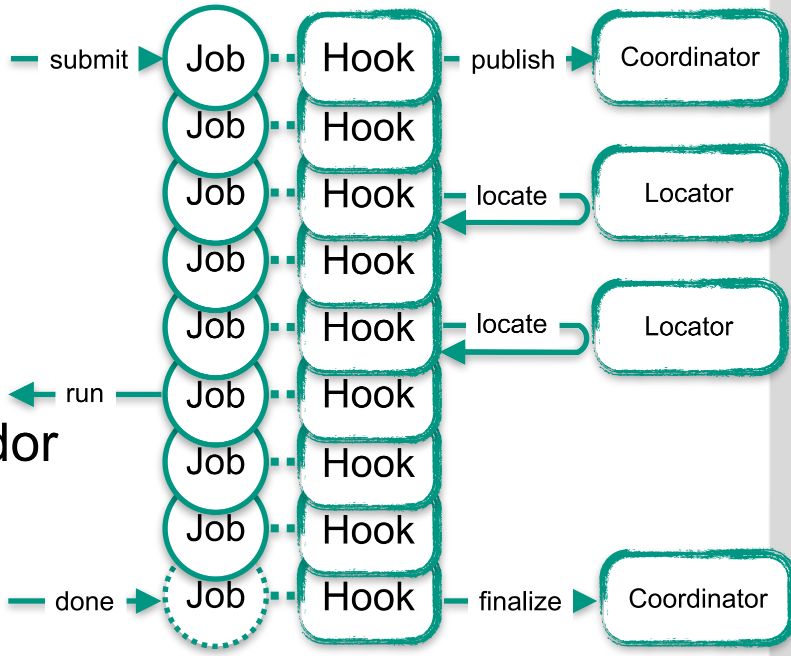
- Efficient interface to HTCondor
  - Selection/tracking handled by HTCondor
  - Hook skips any meaningless updates
  - Arbitrary number of untracked jobs



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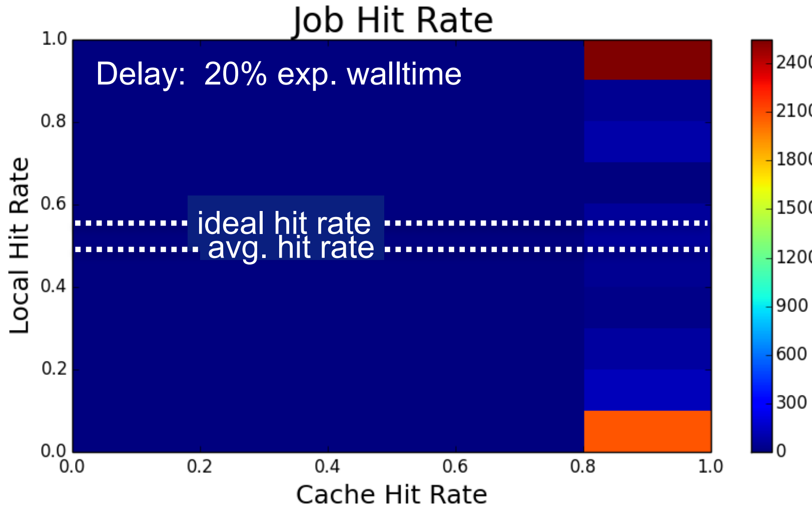

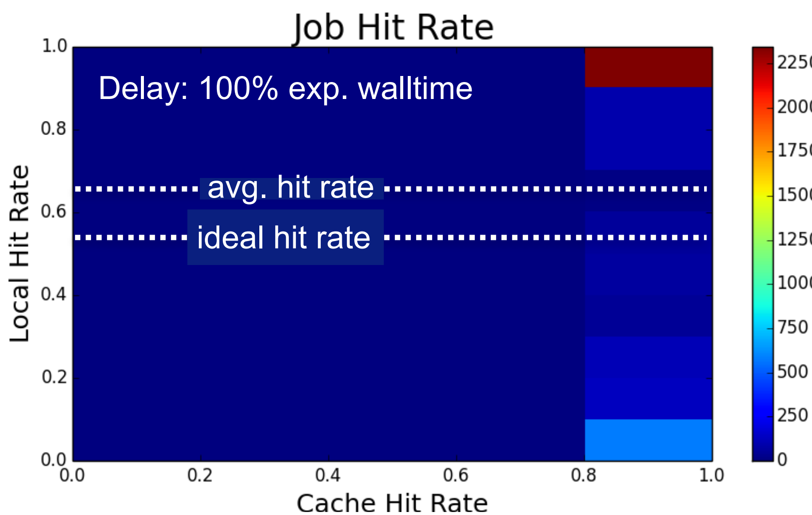

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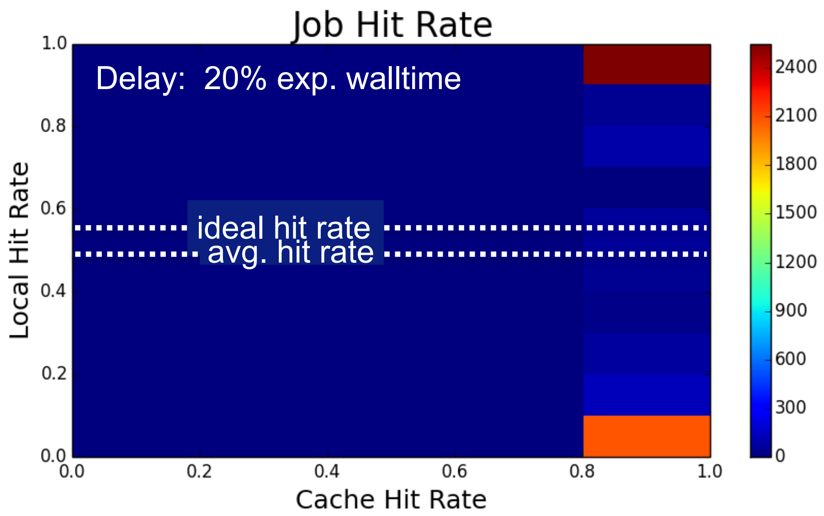
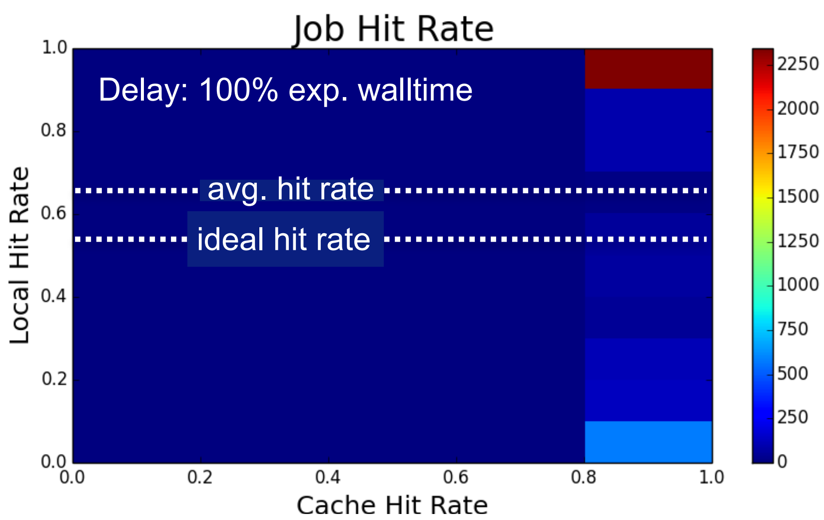
- Simple approach mostly good enough
  - Fixed delay, tuned for user demand
  - Possible „pile-up" of jobs scheduled to inefficient hosts
  - Investigating suspension of inefficient jobs to clear pile-up





Experience: User Workflows

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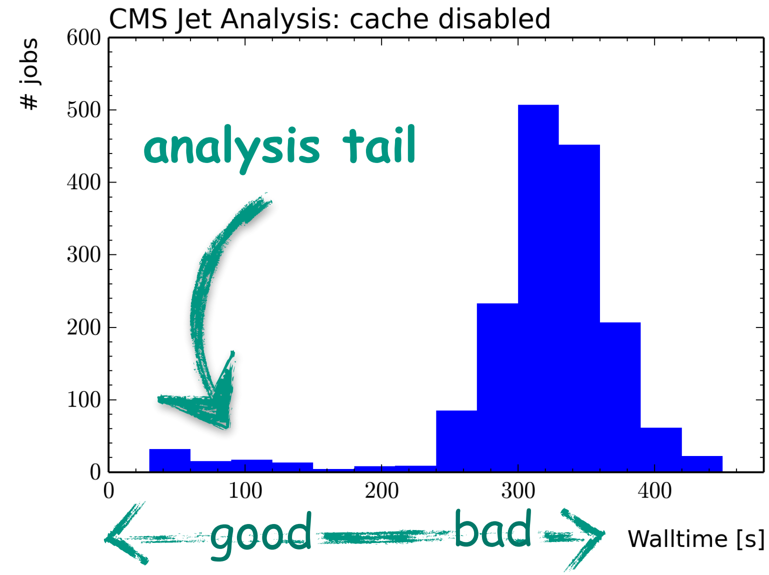
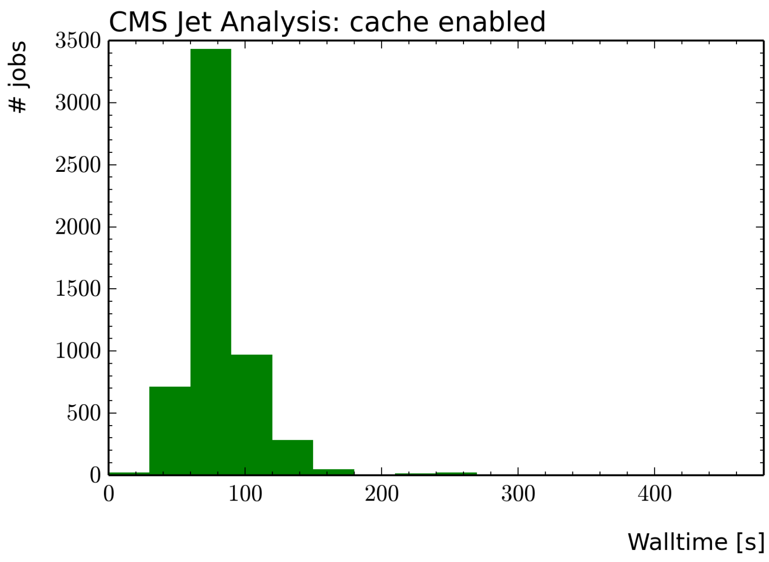
  - ROOT n-tuple analysis
  - 400 GB LHC run1 input data
  - Notable improvement





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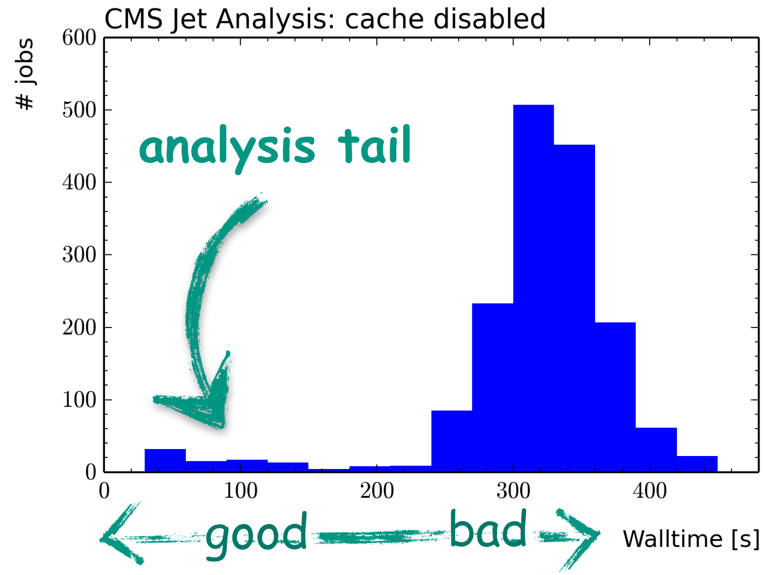
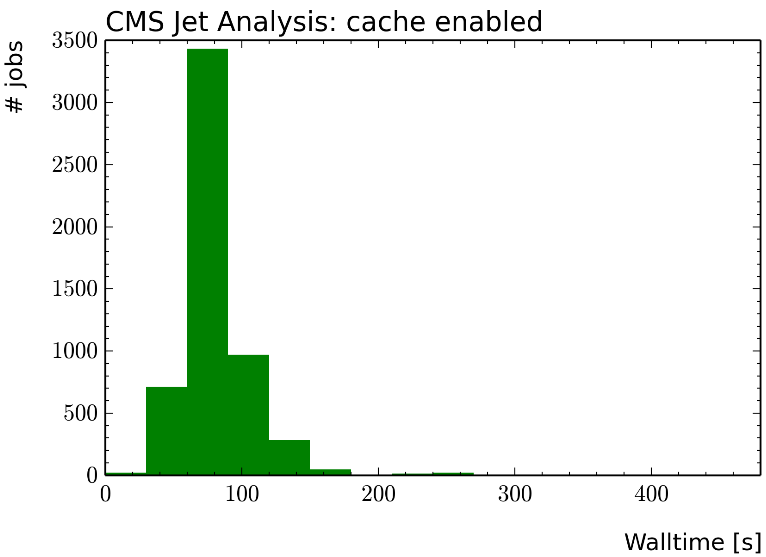
- Used for LHC run2 user analyses
  - Single patch to submission tool
  - Fully transparent in regular cluster
  - Non-intrusive to regular operation





Experience: HTDA Middleware Performance

- Mature prototype implementation
  - Stable operation for 6+ months
  - Worker CPU/RSS overhead negligible

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Cache	3,5 %	120 MB
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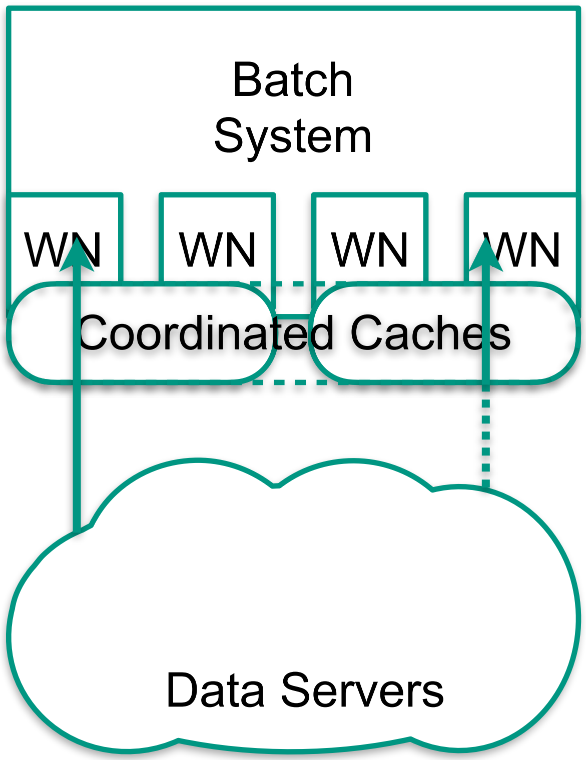
- Open issues: no showstoppers
  - Deliberate cleanup of meta-data and file reallocation
  - Tweaks and optimizations

Outlook: Applicability to other setups

- Shared cache for multiple workers
  - Cache volume shared across hosts
  - Shared filesystem support via POSIX
  - Tweaks to location meta-data format



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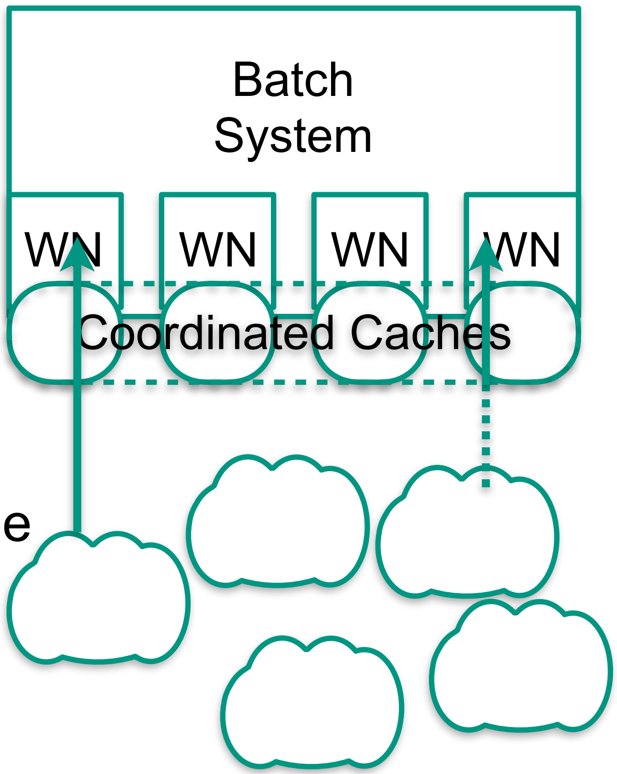

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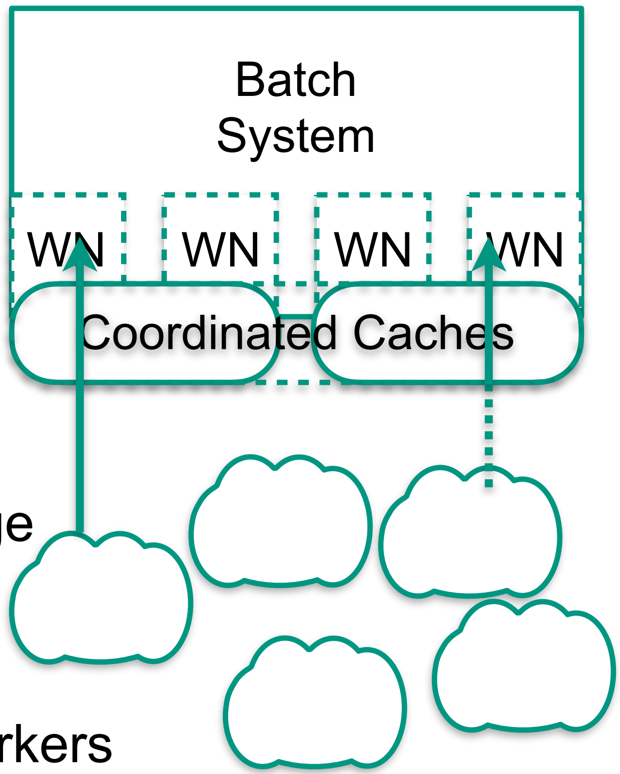
- Opportunistic Data Analysis
  - Semi-persistent cache shared by volatile workers
  - Support for volatile nodes using persistent meta-data
  - Combine shared cache with diskless setup



Summary

- Coordinated Caches for Batch Systems
  - Array of caches on worker nodes
  - Coordination by global service
  - Targets input files of user workflows

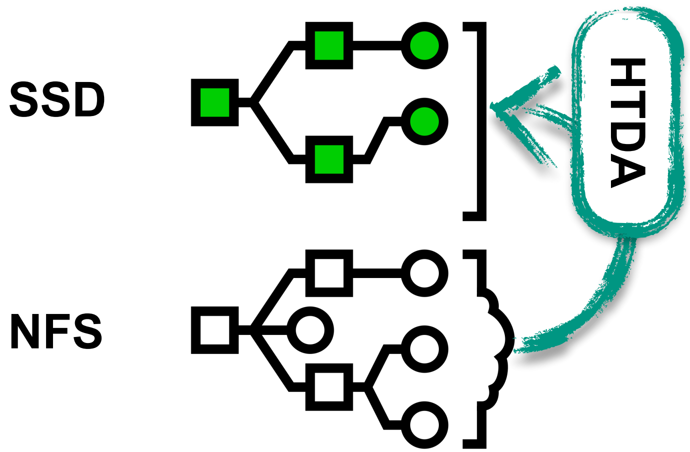
- Prototype Implementation: HTDA
  - Proof of principle, all major features covered
  - Room for improvements and extensions
  - Already considerable performance improvements

- Applicable to other setups
  - Shared caches via parallel filesystems
  - Cache-only Tier3 without dedicated storage
  - Persistent cache for opportunistic resources

BACKUP

Cache Content Access

- Cache node stages/unstages files according to coordinator request



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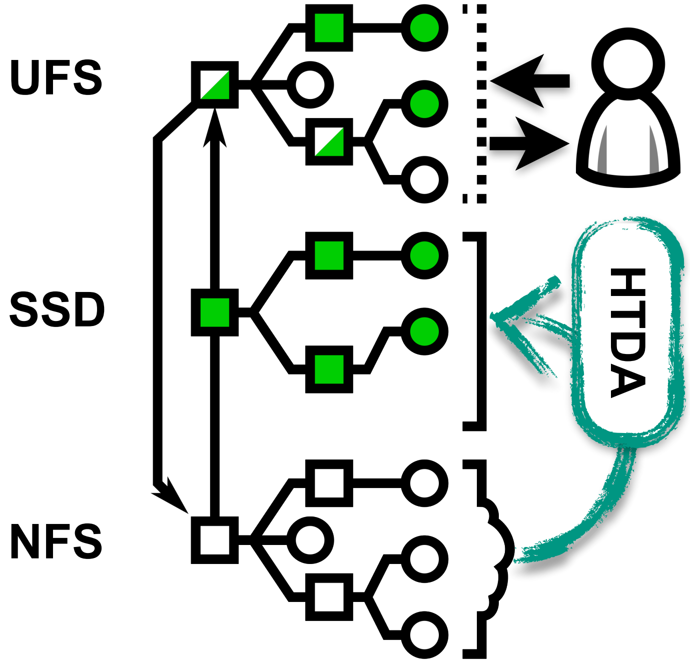

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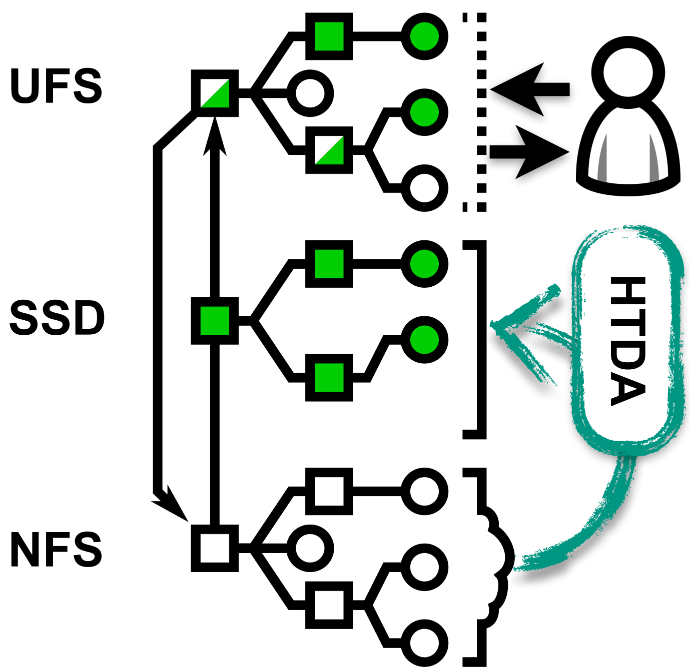
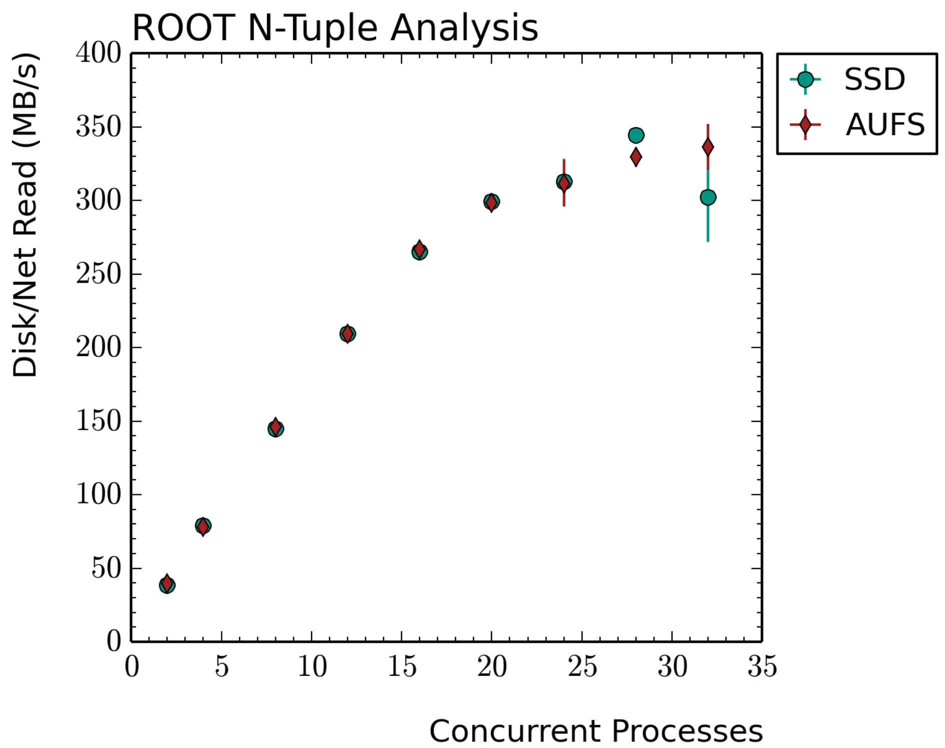
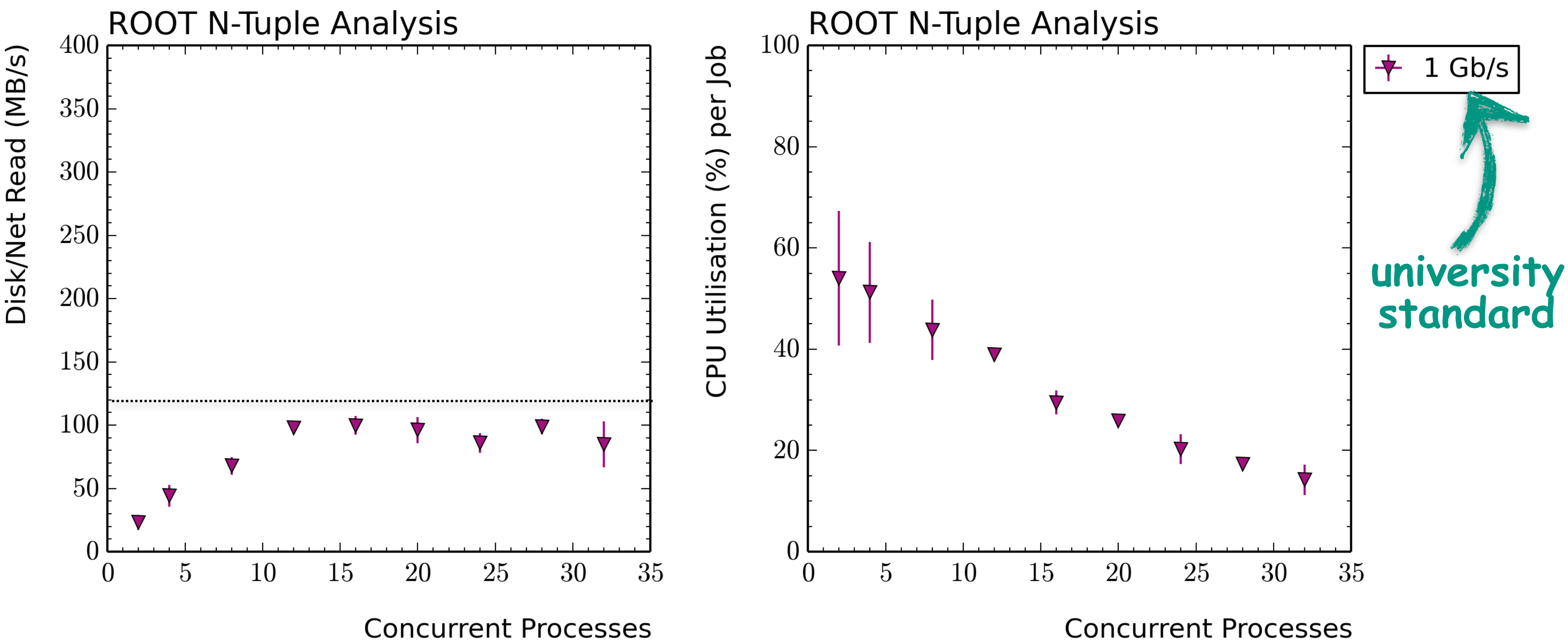




- Lightweight cache access ensures optimal performance

I/O Performance Evaluation

- CMS jet calibration analysis (ROOT n-tuple)



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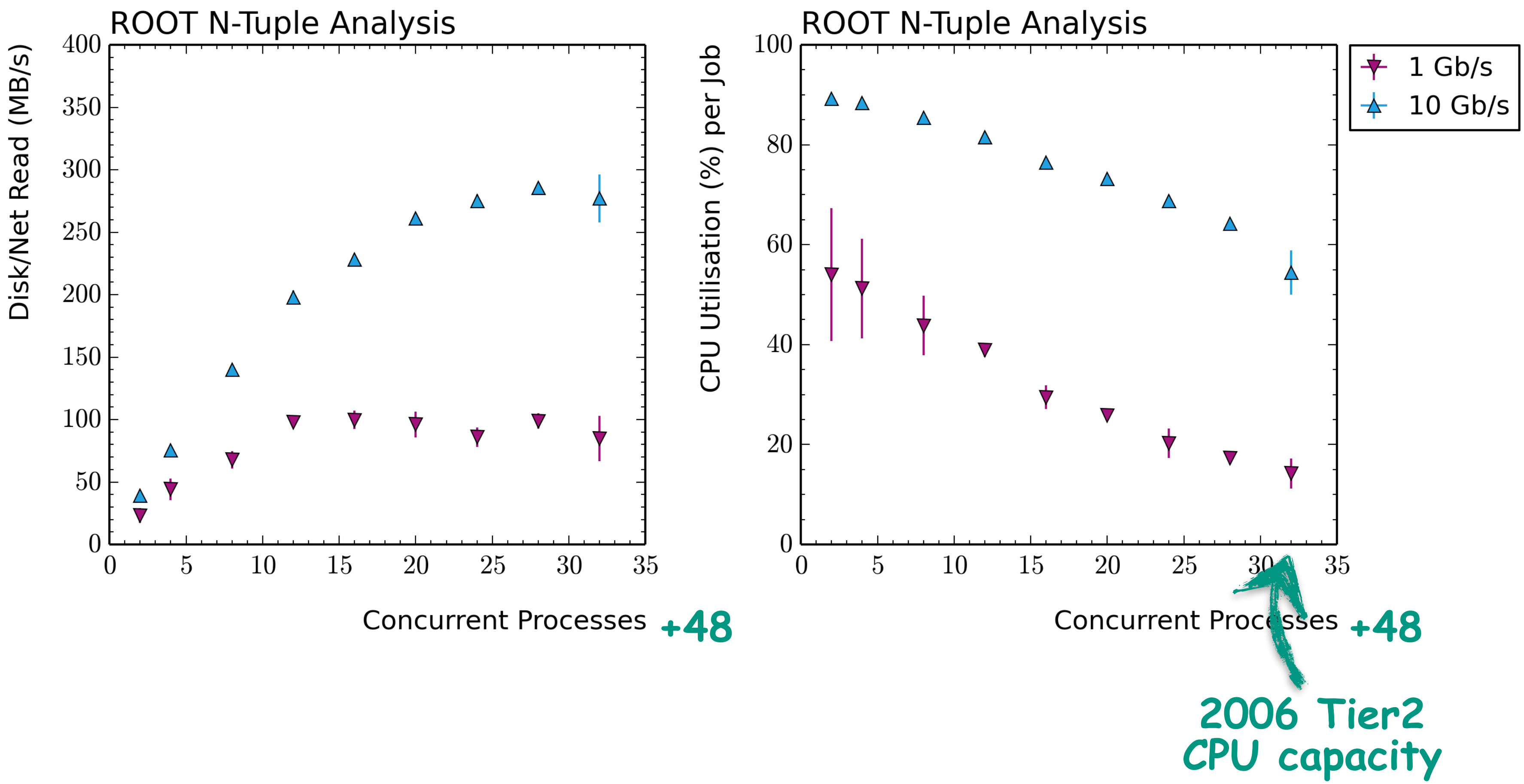

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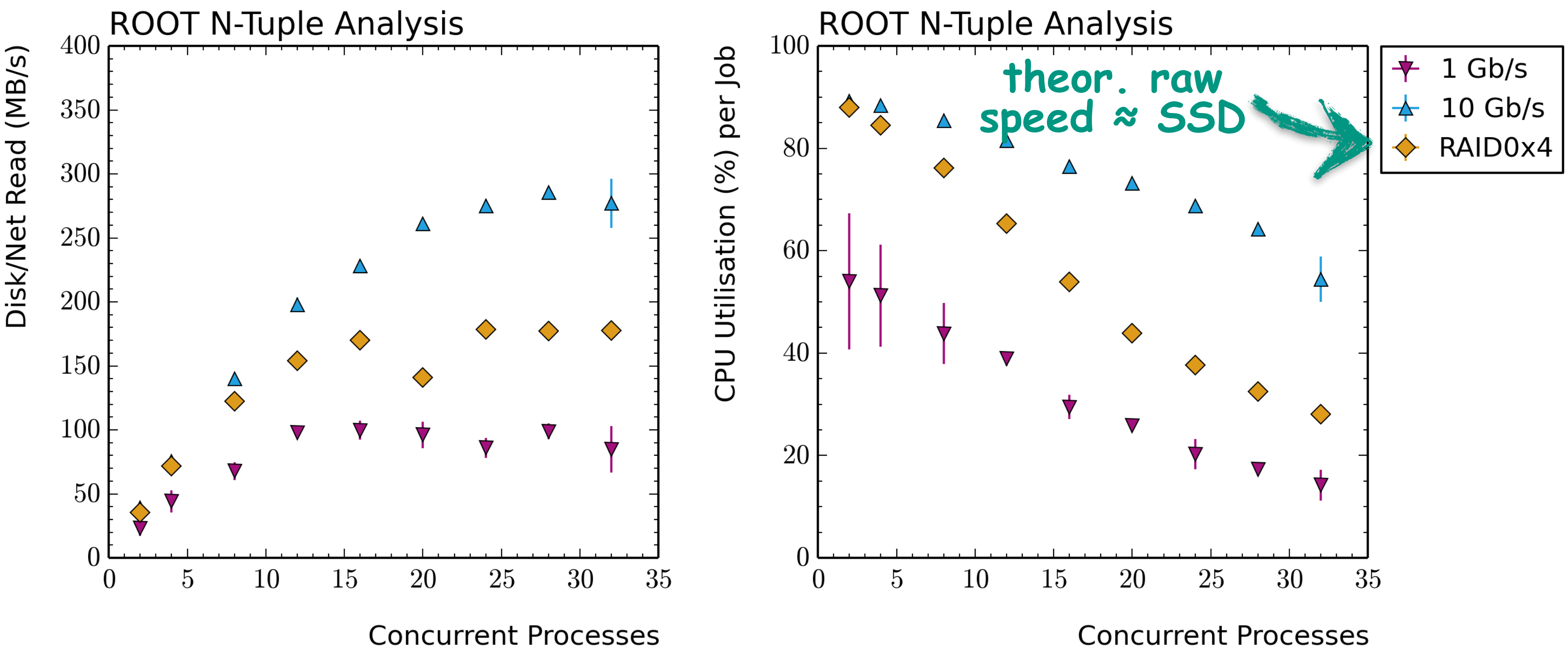

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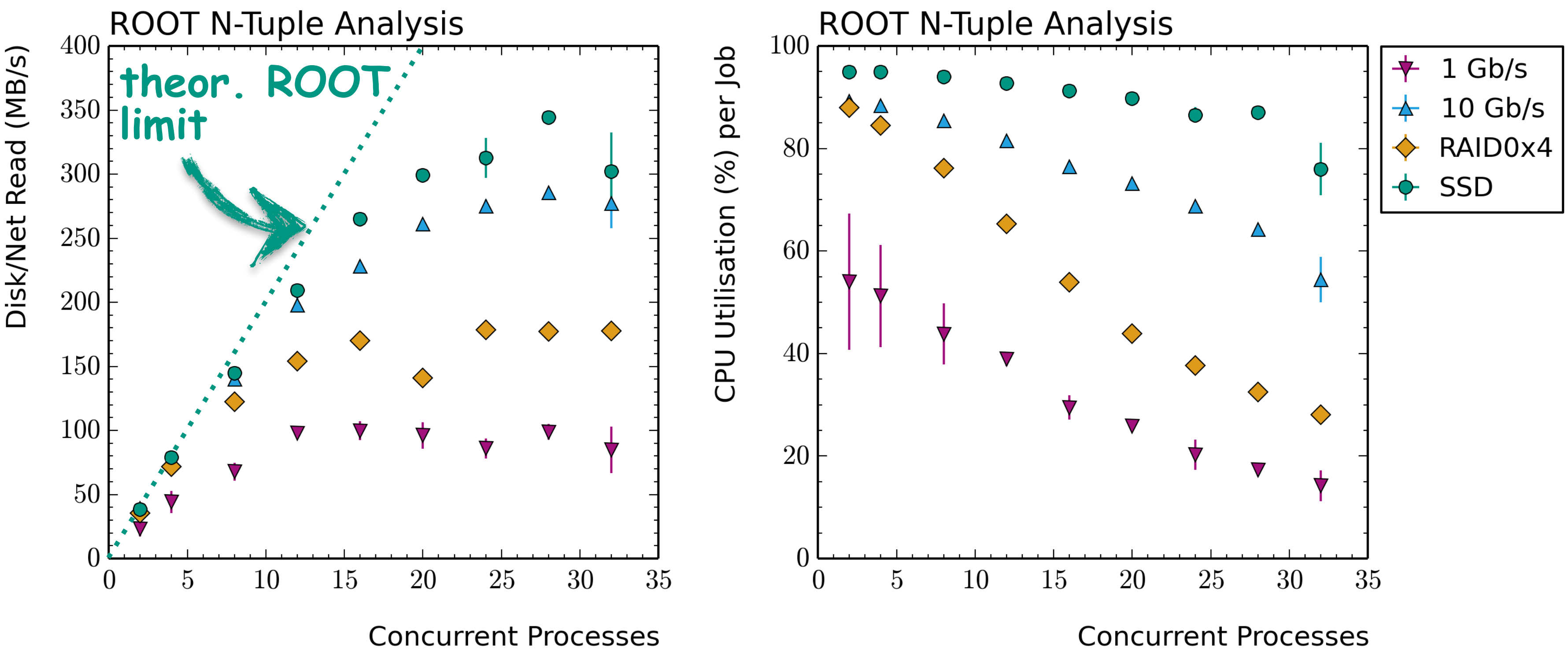

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- SSDs exploit full system capacities