HPC-Reuse: efficient process creation for running MPI and Hadoop MapReduce on supercomputers

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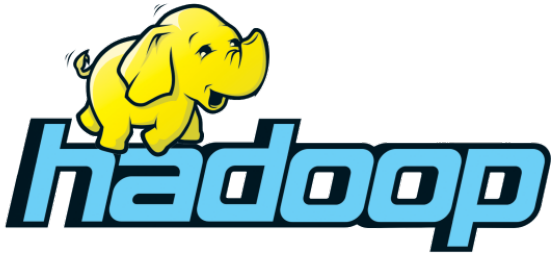
Running Hadoop and Spark on supercomputers

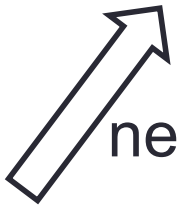
- Good choices to run MapReduce and Machine Learning algorithms



- Mature frameworks and providing standard APIs
- Easy to write applications

Challenge: running Hadoop/Spark on PBS

- PBS: Portable Batch System
  - The de facto resource manager of supercomputers
  - Created to support MPI style-programming and run coarse-grained HPC applications
  - So, dynamic process creation is not the first citizen



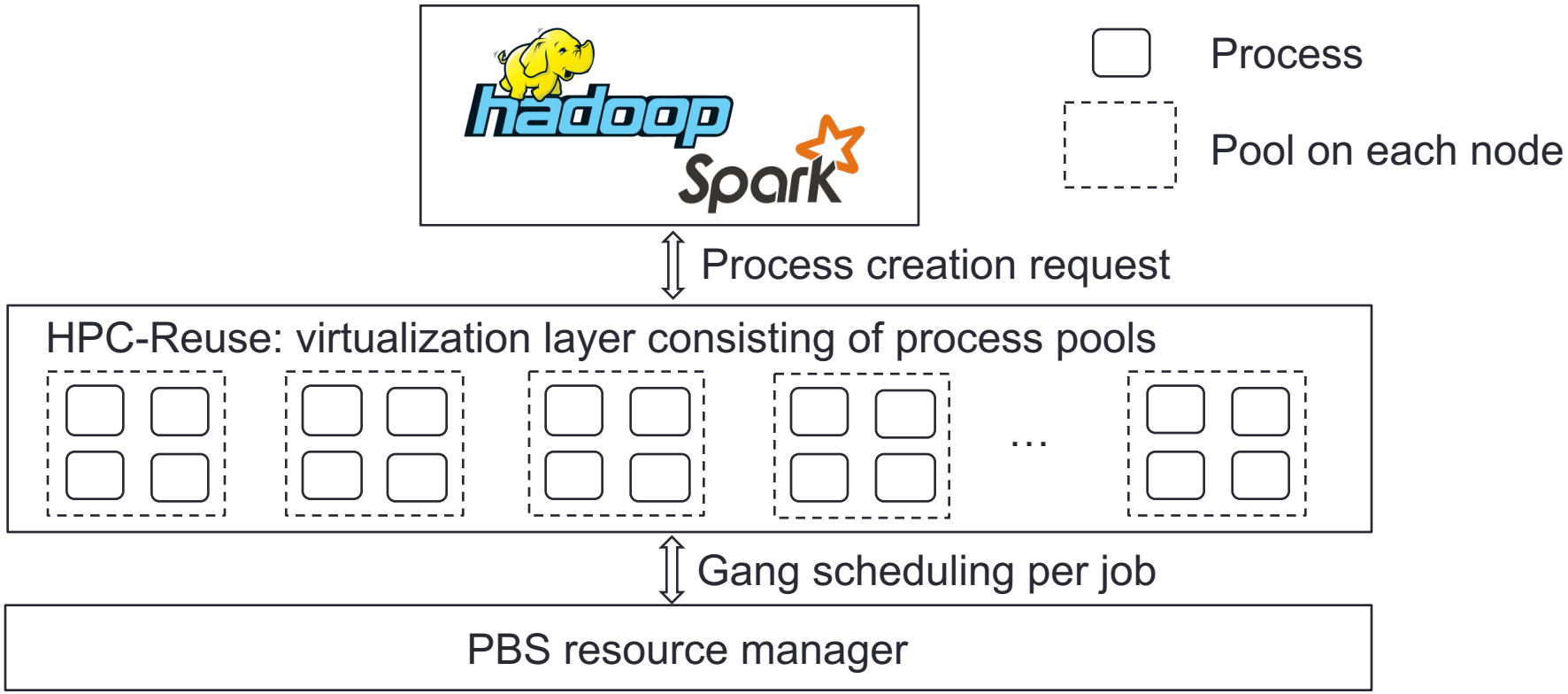
Dynamic process creation: adding a new process to the running job at any time.

Restriction of process creation on PBS

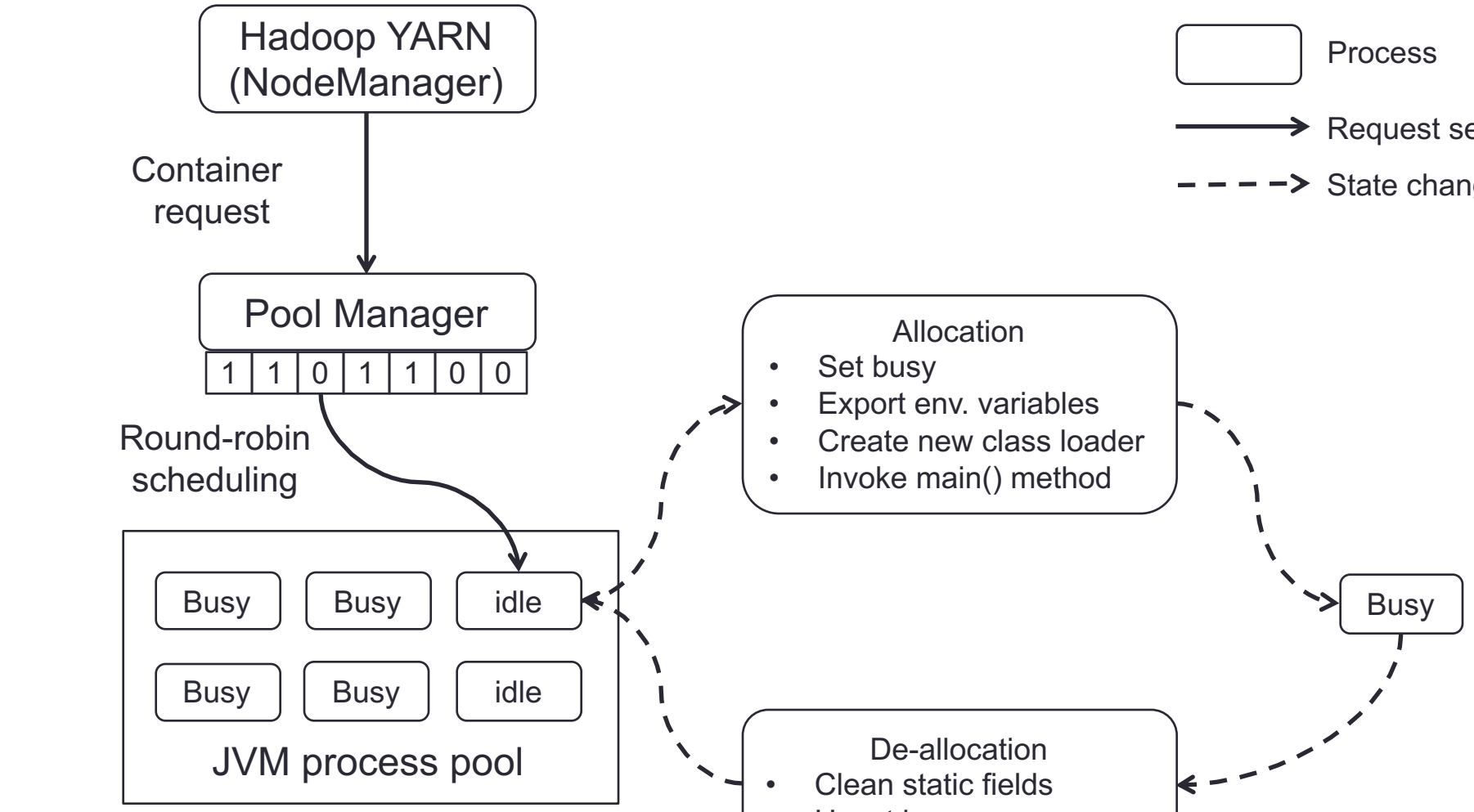
- Hadoop and Spark require dynamic process creation
  - Minimizing the cost of changes in architecture
- Gang scheduling (of processes) more favorable on PBS
  - All-or-nothing scheduling strategy
    - Statically creating all processes at the beginning
    - Since resizing running jobs might affect performance and fairness
  - Dynamically adding a new process is optional, but not recommended
    - MPI-Spawn is slow (not allowed on some supercomputers, e.g. FX10)
    - Process fork causes MPI connection loss

Our proposal: HPC-Reuse

- Virtualize dynamic process creation
  - Create a pool of processes at the beginning of a job (for PBS) and dynamically allocate them to Hadoop/Spark



Implementation: reuse JVM processes



Process Pool on each node
(Create JVM processes and make a pool)

Technical issues

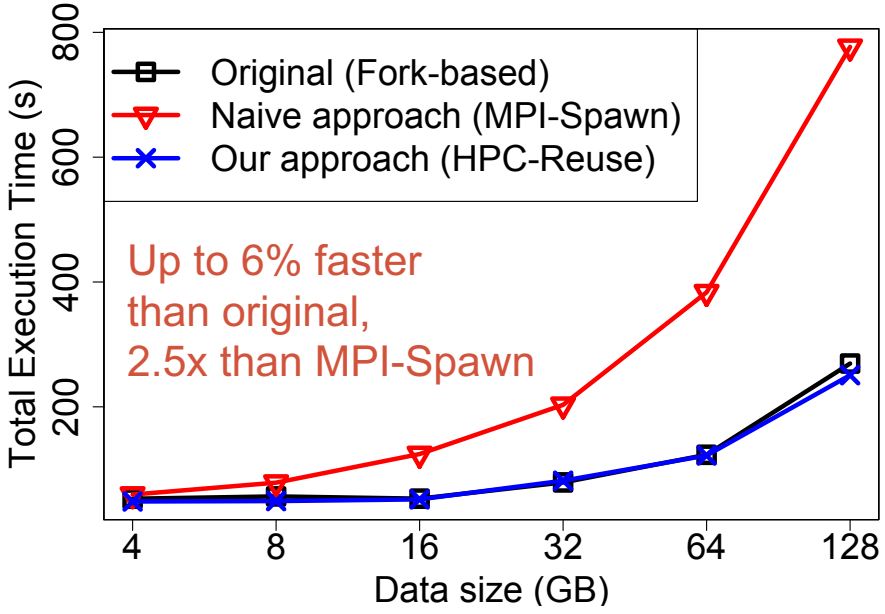
- Class loading
  - How to load user's classes
    - Use new class loader to load them
    - Not reload Hadoop or Spark's classes
    - Reduce class loading time and exploit compilation technology in JVM
- Clean-up
  - Security problem due to reusing static fields
    - E.g. loginUser static field is kept unchanged whenever its value is not null
  - Reset all static fields
    - Current implementation, reset only static fields containing user information and job configuration

Evaluation of HPC-Reuse

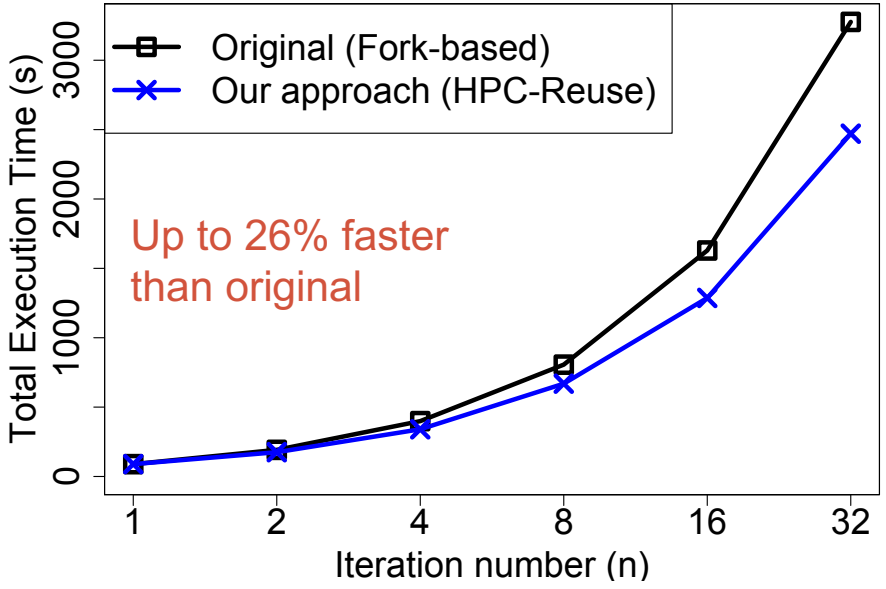
- Test case
  - Fork-based YARN
    - The original
  - MPI-Spawn YARN
    - Process fork mechanism is replaced with MPI-Spawn
  - HPC-Reuse YARN
    - Our proposal
- Cluster
  - 33 TSUBAME nodes
  - 33 FUJITSU FX10 nodes
  - One master and 32 slaves
  - Hadoop v2.2.0
  - OpenJDK 7 and OpenMPI 1.6.5

Evaluation of HPC-Reuse

- Purpose
  - Show HPC-Reuse is as good as fork-based approach in general
  - HPC-Reuse shortens start-up time in iterative workloads



Tera-sort on TSUBAME (33 nodes)



Iterative PageRank on FX10 (33 nodes)

Summary

- Running Hadoop/Spark on PBS of supercomputers
  - Hadoop and Spark require “dynamic process creation”
  - But it is not the first citizen
    - Gang scheduling is more favorable
- Our proposal: HPC-Reuse
  - Virtualization layer
  - Using process pool
  - Up to 26% improvement in iterative PageRank
- Future work
    - MPI-based data shuffle on HPC-Reuse
    - In-memory Hadoop MapReduce

Thank you!

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