Concepts and Models of Parallel and Data-centric Programming

Apache Spark – Job Scheduling and Fault Tolerance

Lecture, Summer 2020

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Outline

0. Organization
1. Foundations
2. Shared Memory
3. GPU Programming
4. Bulk-Synchronous Parallelism
5. Message Passing
6. Distributed Shared Memory
7. Parallel Algorithms
8. Parallel I/O
9. MapReduce
10. **Apache Spark**

a. Spark Programming Model
b. Resilient Distributed Datasets (RDDs)
c. **Job Scheduling and Fault Tolerance**
d. Streaming and Applications
e. Concluding Remarks

Job Scheduling (1)

- Job scheduler gets active when driver program runs an RDD action
- Scheduler examines RDD's lineage graph → Build DAG of execution stages
  - Try to pipeline as many transformations as possible (for narrow dependencies)
  - Shuffle operations are boundaries of the stages
  - Again: Try to use already computed partitions to speedup computation
- Scheduler launches tasks to compute missing partitions from each stage
- Respect data locality for task assignment
  - First priority: Node with the required partition stored in memory
  - Second priority: Node with preferred location for a partition in the file system (HDFS)

Job Scheduling – Example

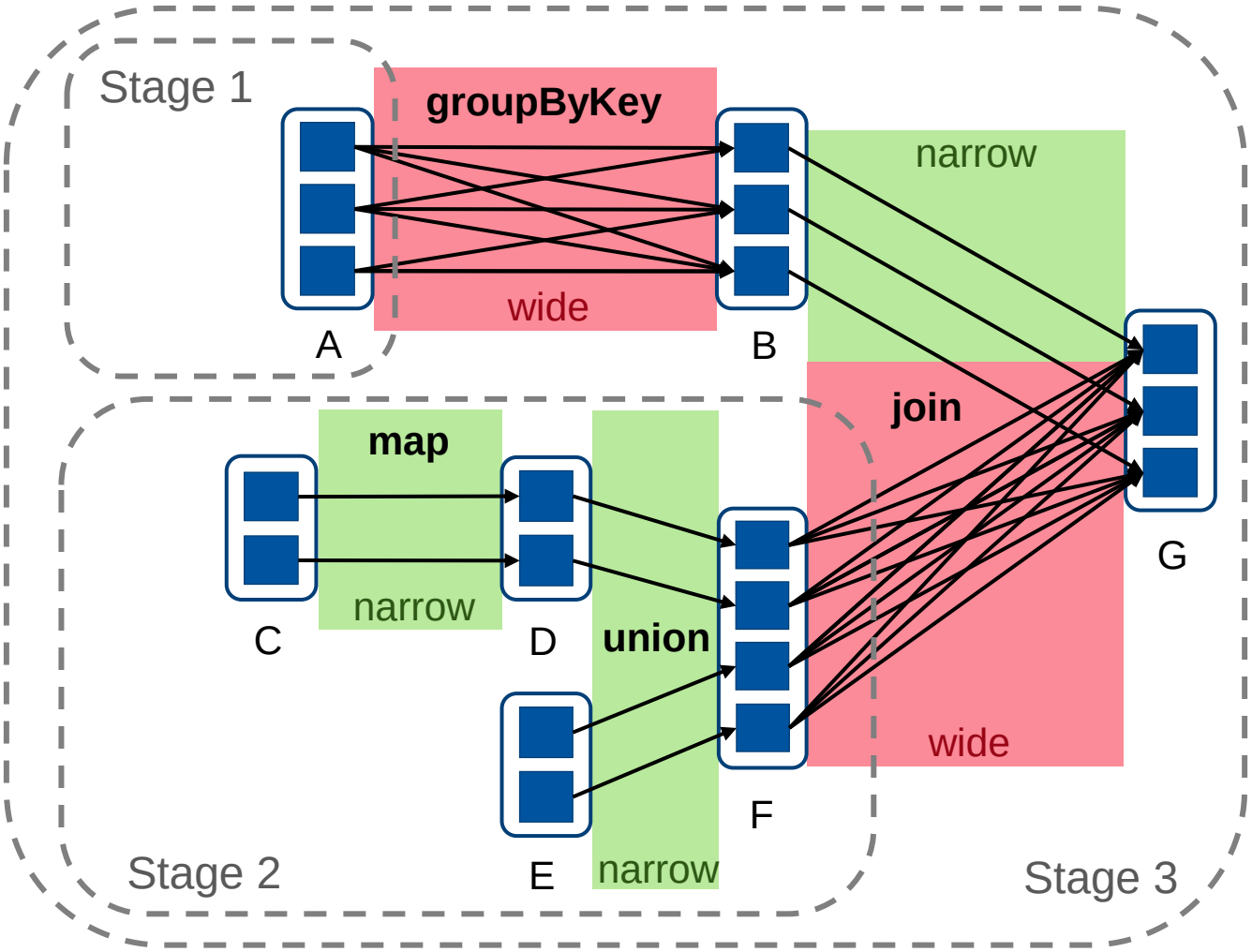


Image Source: Matei Zaharia, Mosharaf Chowdhury, Tathagata Das, Ankur Dave, Justin Ma, Murphy McCauly, Michael J. Franklin, Scott Shenker, Ion Stoica. "Resilient Distributed Datasets: A Fault-Tolerant Abstraction for In-Memory Cluster Computing." NSDI2012: 15-28

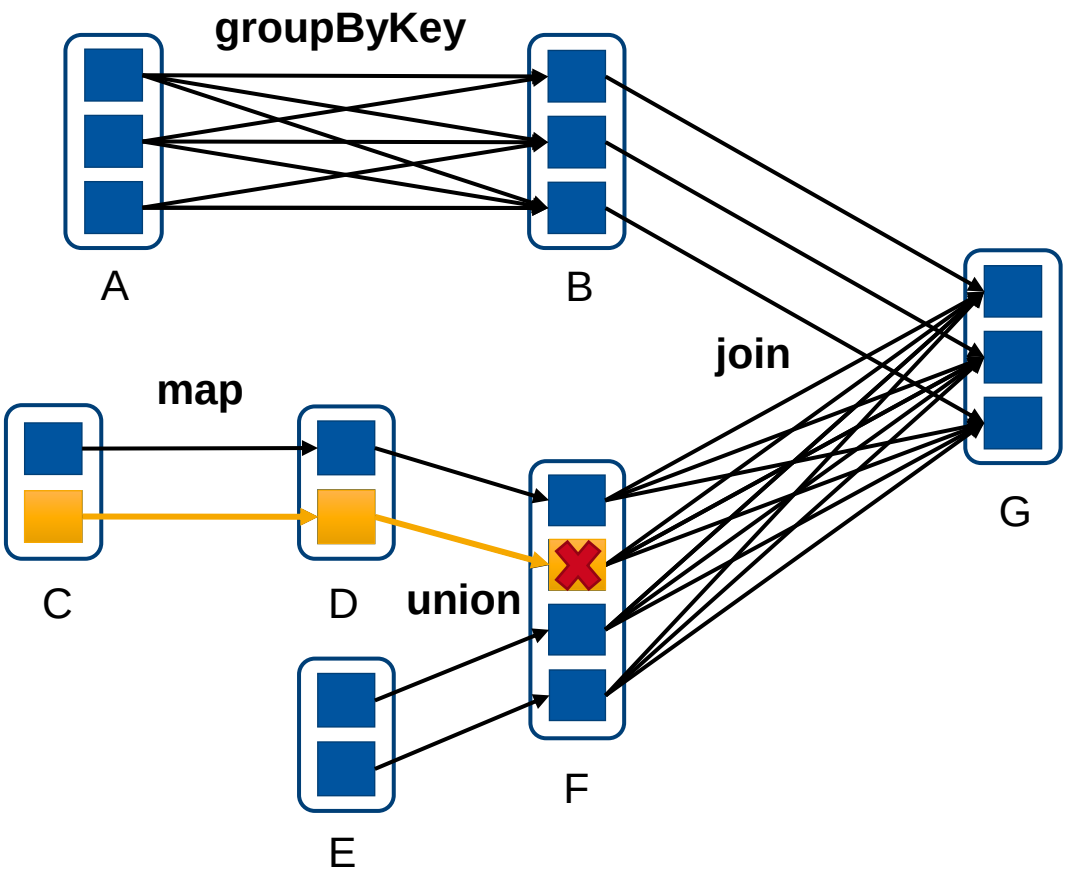
Job Scheduling (2)

- On task failure
  - Re-run task on another node if stage's parents still available
  - If some stages got unavailable, resubmit tasks to compute missing partitions in parallel
- Scheduler is single point of failure
- However: Replication of the RDD lineage graph straightforward

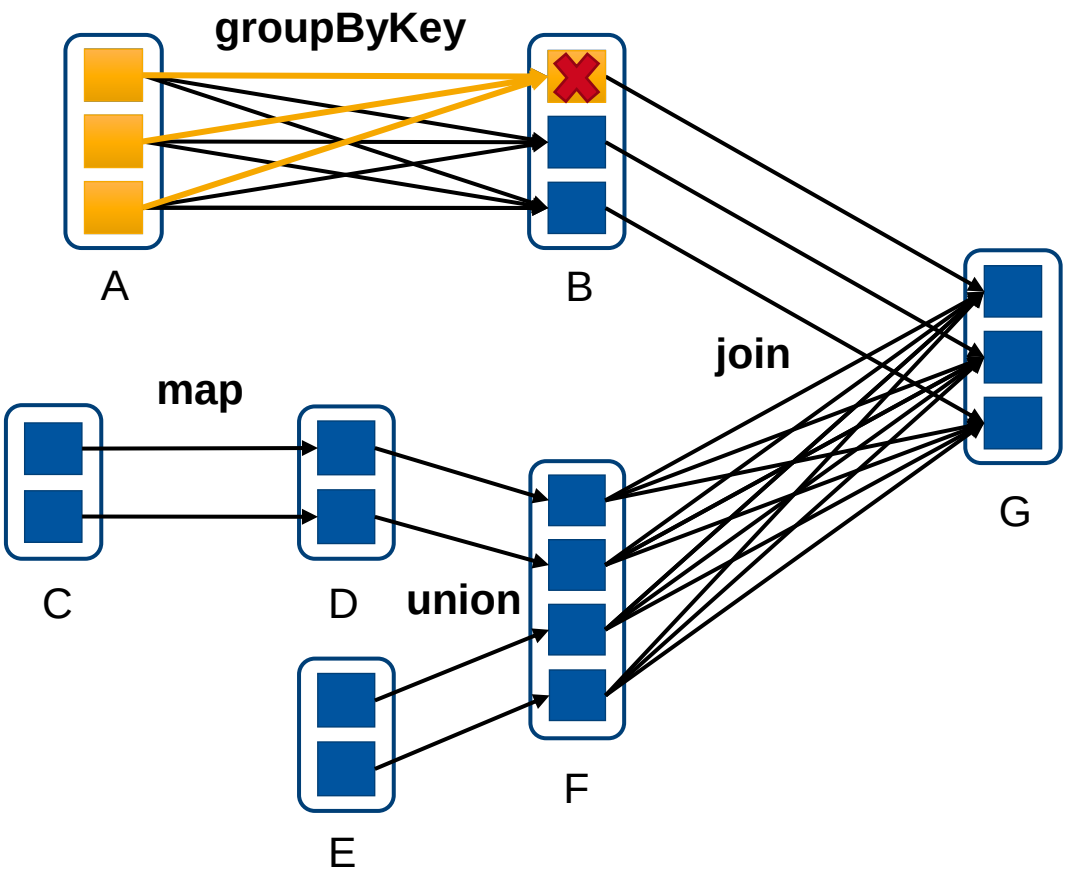
Fault Tolerance with Lineage Graphs

- RDDs can be rebuilt on node failure using the lineage graph
- If some partition of an RDD is lost (e.g., due to node failure)
  - Check the dependencies of this partition in the lineage graph
  - Recompute the lost partition by reapplying the RDD transformations
  - Try to use already computed or cached parent RDD partitions for reconstruction
- Partitions with only narrow dependencies fast to recover
- Partitions with wide dependencies slow to recover
- Fault tolerance without writing every transformed RDD to disk

Fault Tolerance with Lineage Graphs – Example (1)



Fault Tolerance with Lineage Graphs – Example (2)



Fault Tolerance with Lineage Graphs – Example (3)