

2025-1209

Fault Tolerant Distributed Sorting System

csed332



Team Orange

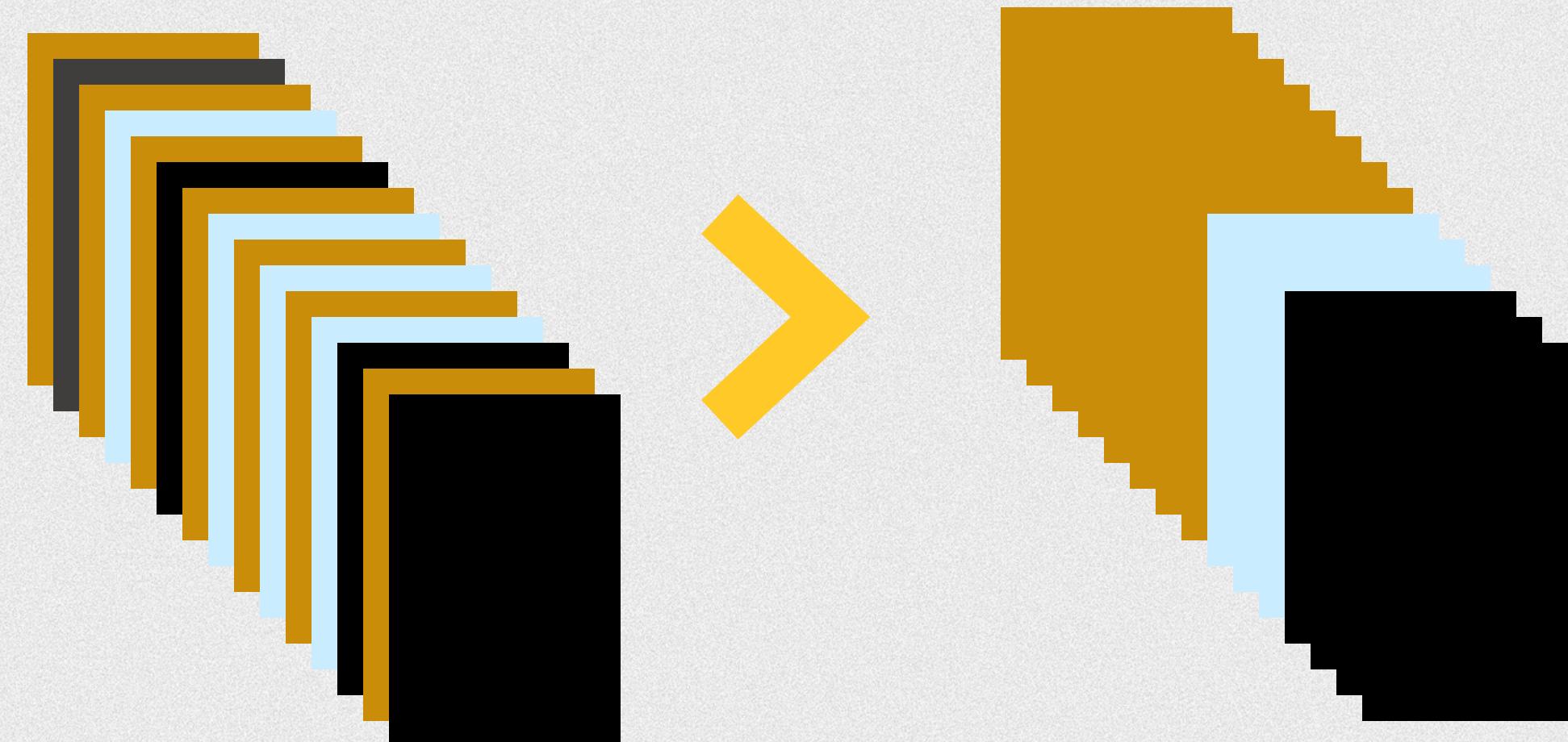
20210212
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이지민
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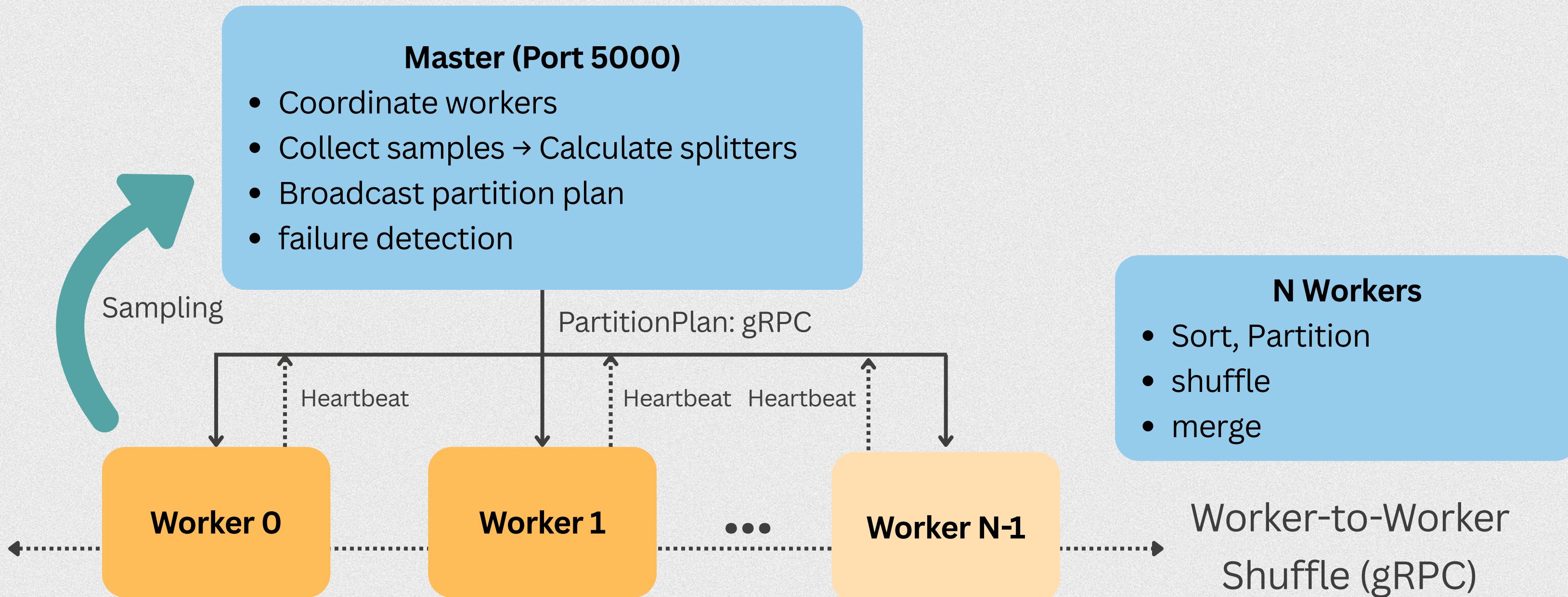
Before → After

Goal: Globally sorted output over all workers, even with worker crashes

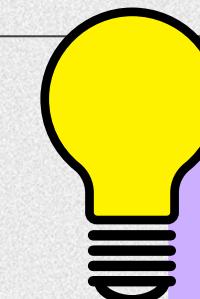
- 100-byte records (10-byte key + 90-byte value)
- worker failures can happen mid-execution



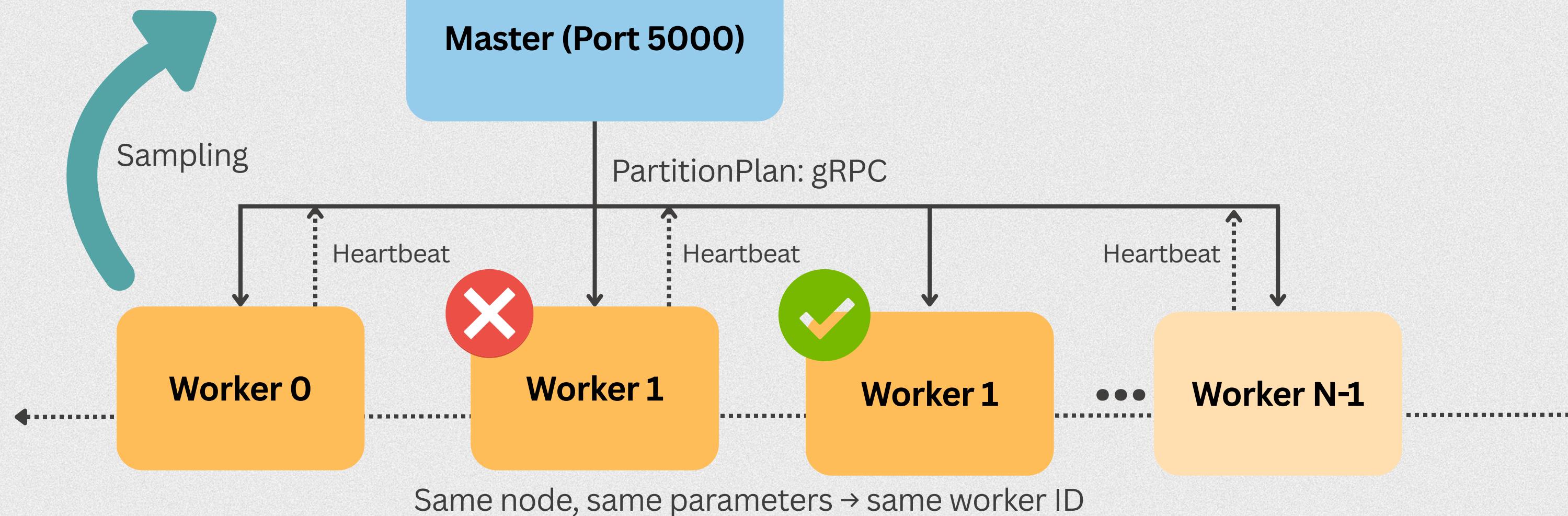
System Architecture



Fault Tolerance



- If a worker crashes mid-execution, a new worker restarts on the same node
- Master reuses the same worker ID
- Final output must be identical to non-failure run



Master: WorkerRegistry & Partitions

WorkerRegistry

◦ ID	◦ IP	◦ Phase	◦ Partitions
0	◦ 2.2.2.117	◦ ALIVE 	◦ {0,1,2,3}
1	◦ 2.2.2.118	◦ DEAD 	◦ {4,5,6,7}
2	◦ 2.2.2.119	◦ ALIVE 	◦ {8,9,10,11}

Partition Ownership

p0 p1 p2 p3
p4 p5 p6 p7 → (p4 p5 p6 p7) Orphaned
p8 p9 p10 p11

Heartbeat → DEAD if no signal for ~5s
Dead Worker's partitions become orphaned
Rejoin worker gets the same ID and partitions back

Failure & Recovery: mid-shuffle crash

step 1

All workers are shuffling, but Worker 1 crash

step 2

Worker 1 rejoin

Worker 1 rejoining with ID 1

step 3

Master assign

Assigning recovery partitions: {4, 5, 6, 7}

step 4

Worker 1 recovery mode (finalize)

Serves its checkpointed partitions to others
Requests missing partitions from peers

step 5

Distributed sorting complete

Each worker merges and writes its final partitions

Worker: Normal Execution

Sampling completed → Worker executes its local pipeline

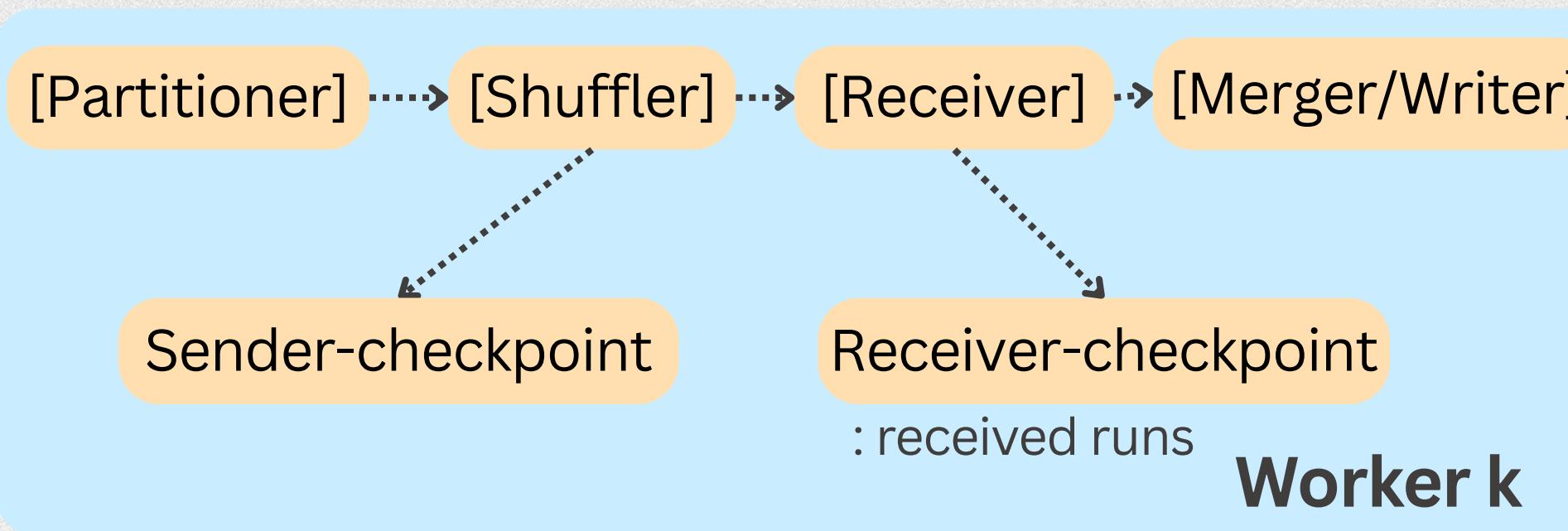


- Loads input from -l directory
- Sorts locally using multiple threads
- Partitions by global splitters and shuffles to target workers

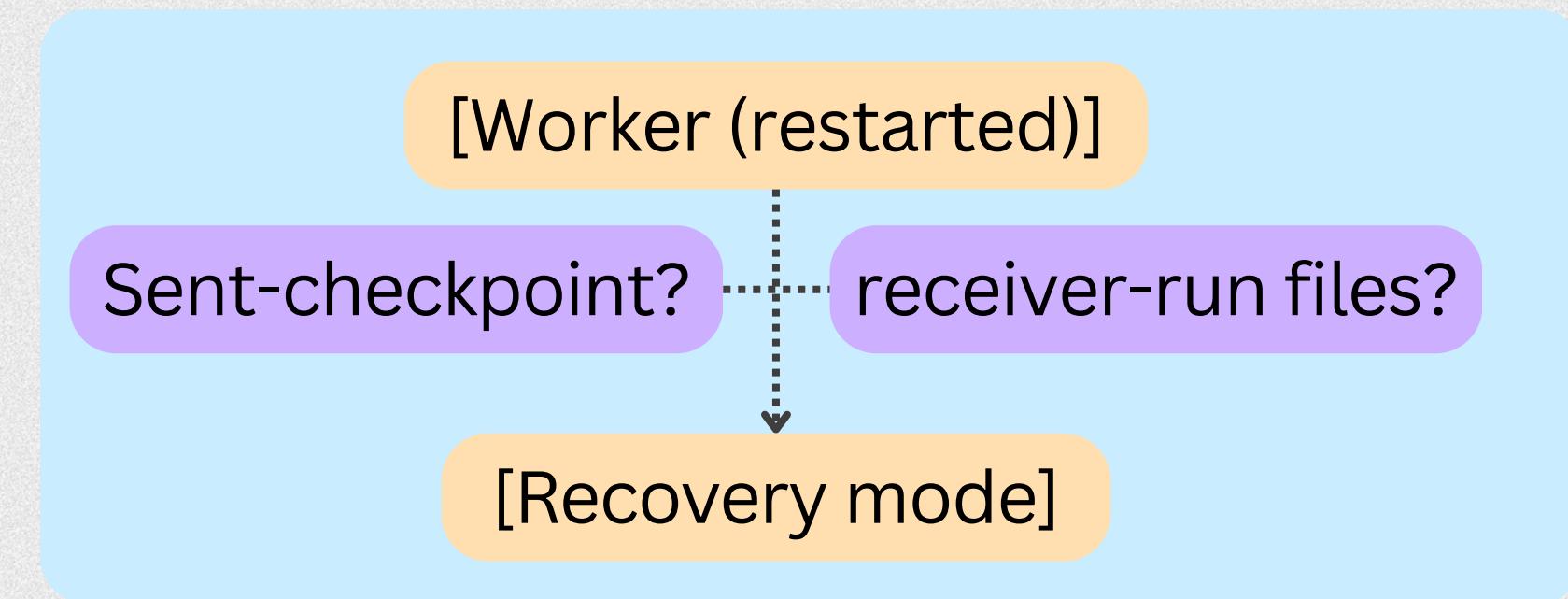
Checkpoint & Recovery Mode

Crash-safe shuffle with sender & receiver checkpoints

Normal execution



After Restart - Recovery Mode



Checkpoint Guarantees

• Sender-checkpoint

Prevents recomputing shuffle output after crash.

• Receiver-checkpoint

Prevents losing received data after crash.

→ **worker restart becomes fully deterministic.**

Recovery actions

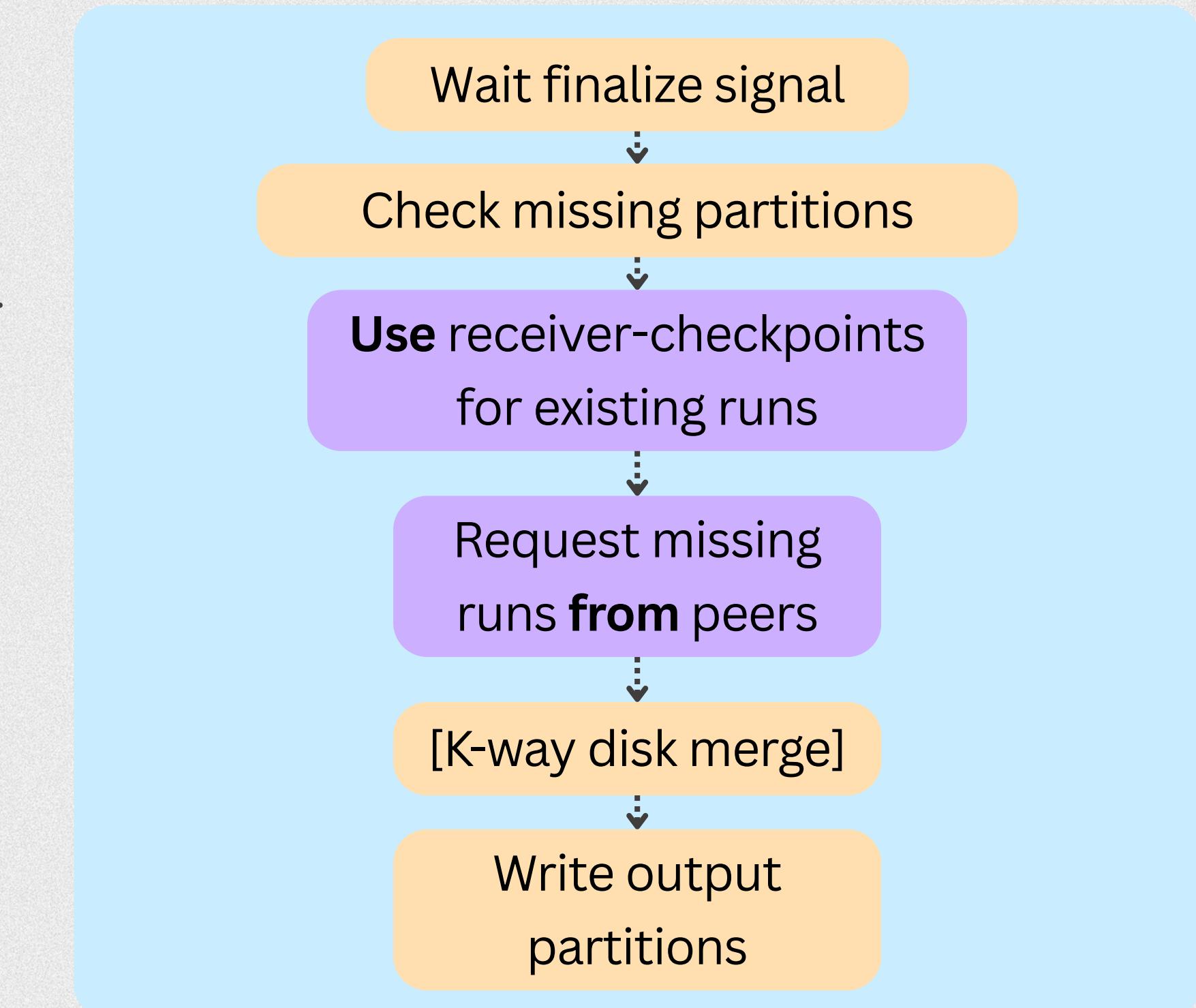
- **Skip:** sampling, local sort, partition, shuffle.
- Report shuffle-complete to Master immediately.
- Wait for re-broadcasted PartitionPlan.

Checkpoint & Recovery Mode

Recovery Finalize Flow

- **During finalize:**

- Serve missing partitions from sender checkpoints.
- Request missing partitions using receiver runs info.
- Merge all available runs and write sorted outputs.



Remaining Tasks



(Completed)

W1

W2

W3

W4

W5

RPC → Reg/HB → Sampling → Splitters/Plan → Shuffle (send/recv)

	W6	W7
Merge I/O (finalize + E2E)	Reliability + Logs (retry, FT, logback)	Integration + Perf (full pipeline)

- ✓ Global sorting
- ✓ Fault tolerance
- ✓ Cluster deployment

Test

```
[orange@vm-1-master 332project]$ java -Xms1G -Xmx2G -XX:MaxDirectMemorySize=4G -jar target/scala-2.13/dist-sort.jar master 10  
2.2.2.254:38562  
2.2.2.103, 2.2.2.112, 2.2.2.115, 2.2.2.111, 2.2.2.120, 2.2.2.119, 2.2.2.116, 2.2.2.101, 2.2.2.105, 2.2.2.110  
  
➤ All workers registered!  
  
➤ Broadcasting PartitionPlan to workers...  
✓ Shuffle phase started  
  
✓ Worker 0 shuffle complete (1/10)  
✓ Worker 5 shuffle complete (2/10)  
✓ Worker 7 shuffle complete (3/10)  
✓ Worker 3 shuffle complete (4/10)  
✓ Worker 4 shuffle complete (5/10)  
✓ Worker 2 shuffle complete (6/10)  
✓ Worker 1 shuffle complete (7/10)  
✓ Worker 6 shuffle complete (8/10)  
✓ Worker 8 shuffle complete (9/10)  
✓ Worker 9 shuffle complete (10/10)  
  
=====  
All workers completed shuffle phase!  
=====  
  
➤ All workers completed shuffle, triggering finalize  
➤ Triggering finalize phase...  
  
✓ Worker 2 merge complete (1/10)  
✓ Worker 6 merge complete (2/10)  
✓ Worker 4 merge complete (3/10)  
✓ Worker 7 merge complete (4/10)  
✓ Worker 0 merge complete (5/10)  
✓ Worker 9 merge complete (6/10)  
✓ Worker 3 merge complete (7/10)  
✓ Worker 8 merge complete (8/10)  
✓ Worker 5 merge complete (9/10)  
✓ Worker 1 merge complete (10/10)  
  
=====  
➤ Distributed sorting complete!  
=====  
  
==== FINAL EXECUTION REPORT =====  
Total workers: 10  
Shuffle completed: 10  
Merge completed: 10  
Execution time: 110.51 s  
=====  
● Broadcasting shutdown to workers...  
  
➤ All work complete! Shutting down in 3 seconds...  
➤ Goodbye!  
Shutting down Master...
```

```
=====  
== Global record counts across workers ==  
Input : 6400000 records (bytes: 640000000)  
Output: 6400000 records (bytes: 640000000)  
✓ Input and output record counts MATCH
```