Supporting Fault Tolerance in a Data-Intensive Computing Middleware

Tekin Bicer, Wei Jiang and Gagan Agrawal
Department of Computer Science and Engineering
The Ohio State University

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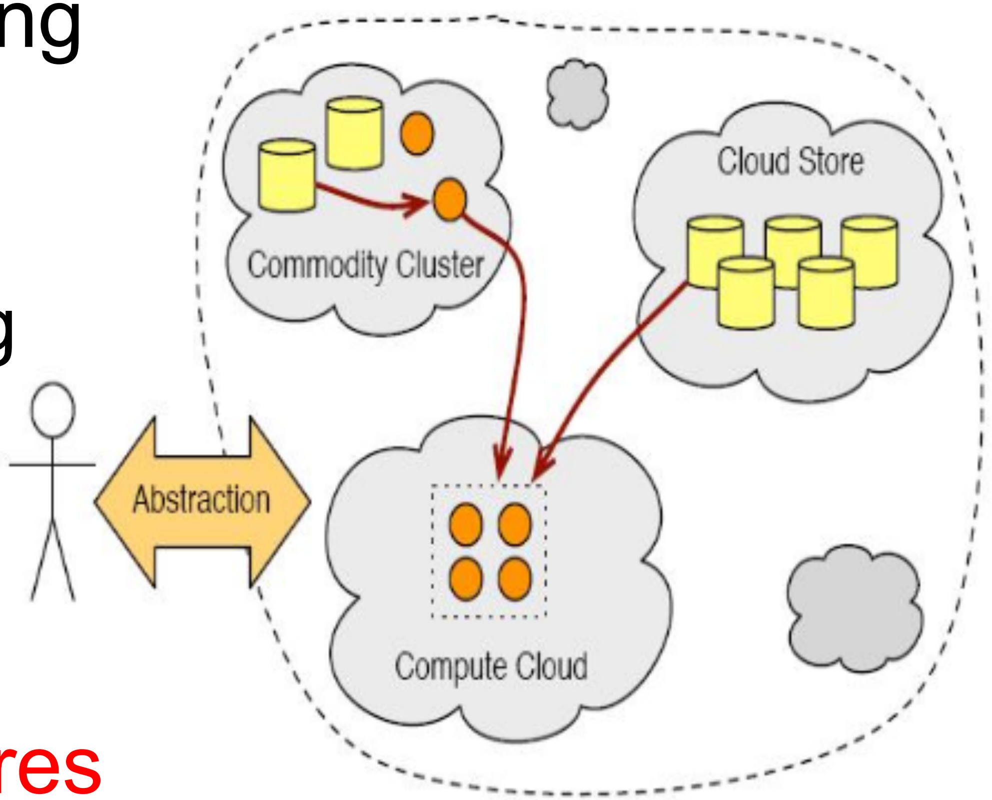
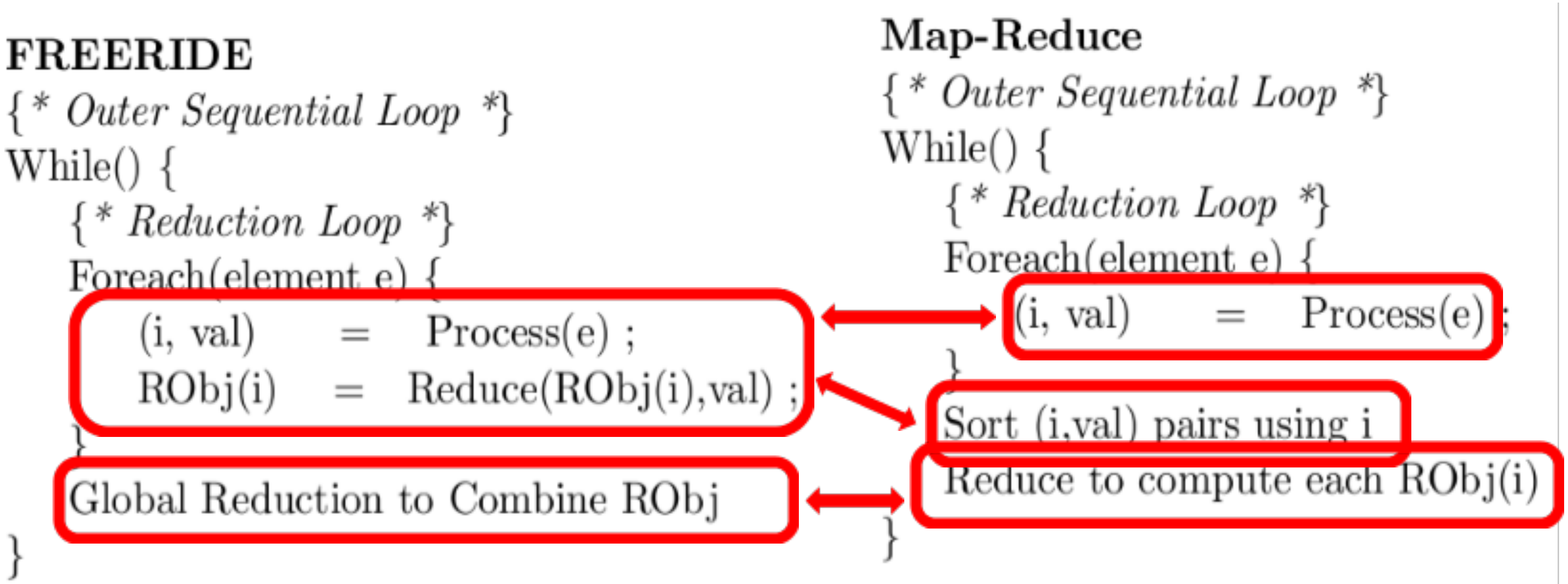
Motivation

- Data Intensive computing
  - Distributed Large Datasets
  - Distributed Computing Resources
  - Cloud Environments
- Long execution time

High Probability of Failures

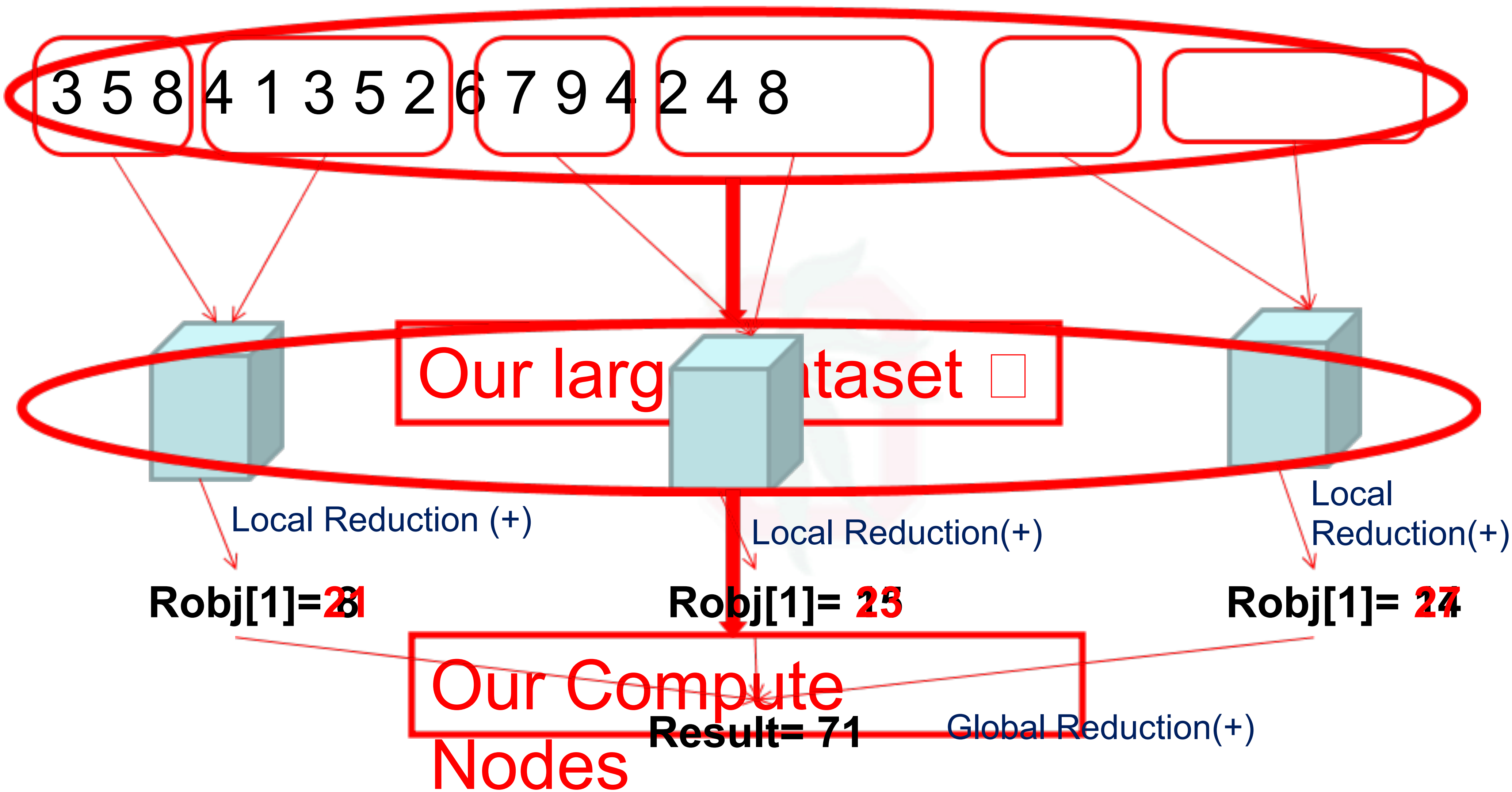


A Data Intensive Computing API FREERIDE



- **Reduction Object** represents the intermediate state of the execution
- Reduce func. is commutative and associative
- Sorting, grouping.. overheads are eliminated with red. func/obj.

Simple Example



Remote Data Analysis

- Co-locating resources gives best performance…
- But may not be always possible
  - Cost, availability etc.
- Data hosts and compute hosts are separated
- Fits grid/cloud computing
- FREERIDE-G is a version of FREERIDE that supports remote data analysis

Fault Tolerance Systems

- Checkpoint based
  - System or Application level snapshot
  - Architecture dependent
  - High overhead
- Replication based
  - Service or Application
  - Resource Allocation
  - Low overhead

Outline

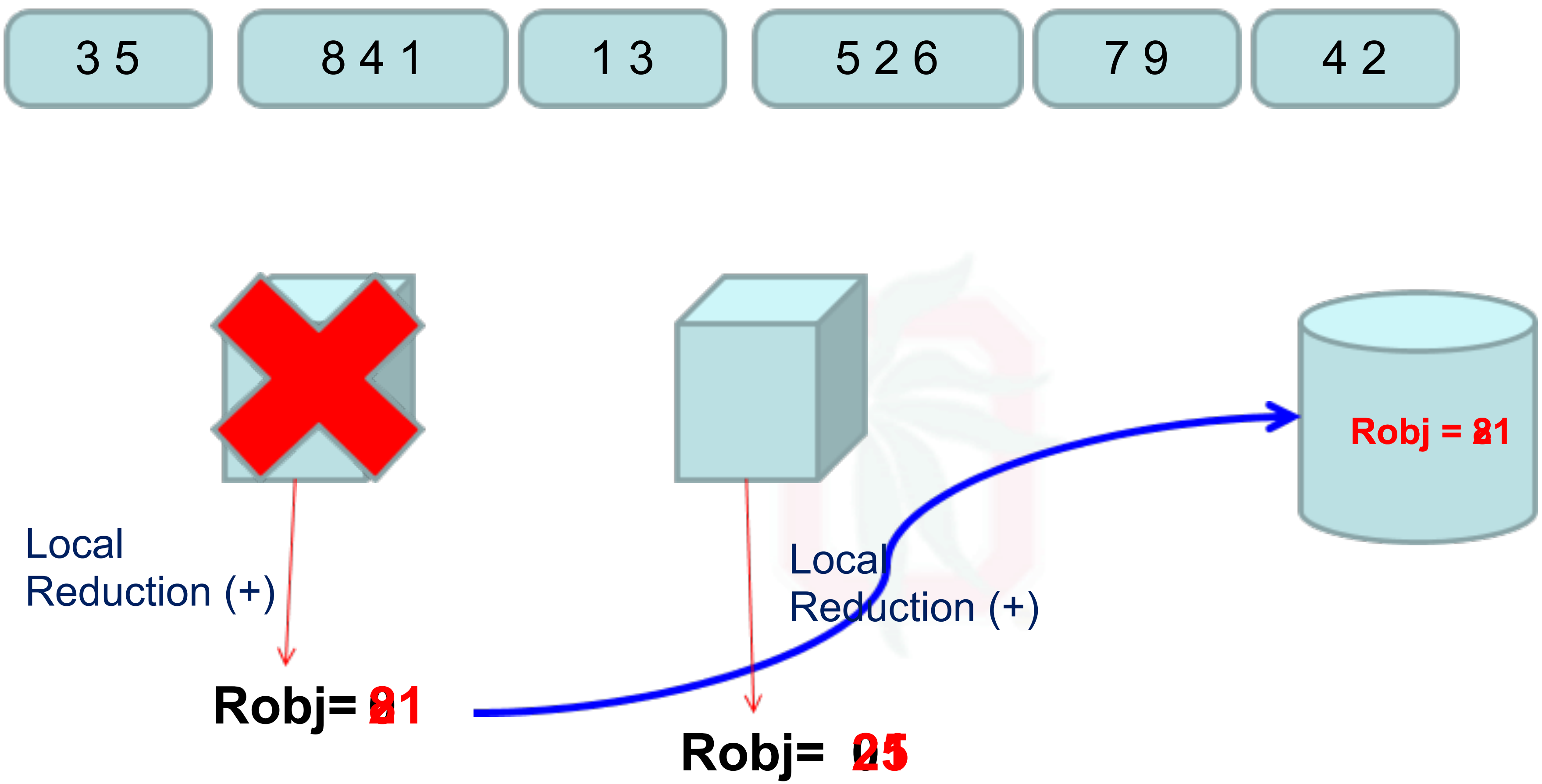
- Motivation and Introduction
- Fault Tolerance System Approach
- Implementation of the System
- Experimental Evaluation
- Related Work
- Conclusion

A Fault Tolerance System based on Reduction Object

- Reduction object…
  - represents intermediate state of the computation
  - is small in size
  - is independent from machine architecture
- Reduction obj/func show associative and commutative properties

Suitable for Checkpoint based Fault Tolerance System

An Illustration



Modified Processing Structure for FTS

```
{ * Initialize FTS * }
While {
Foreach ( element e ) {
(i, val) = Process(e);
RObj(i) = Reduce(RObj(i), val);
{ * Store Red. Obj. * }
}
if ( CheckFailure() )
{ * Redistribute Data * }
{ * Global Reduction * }
}
```

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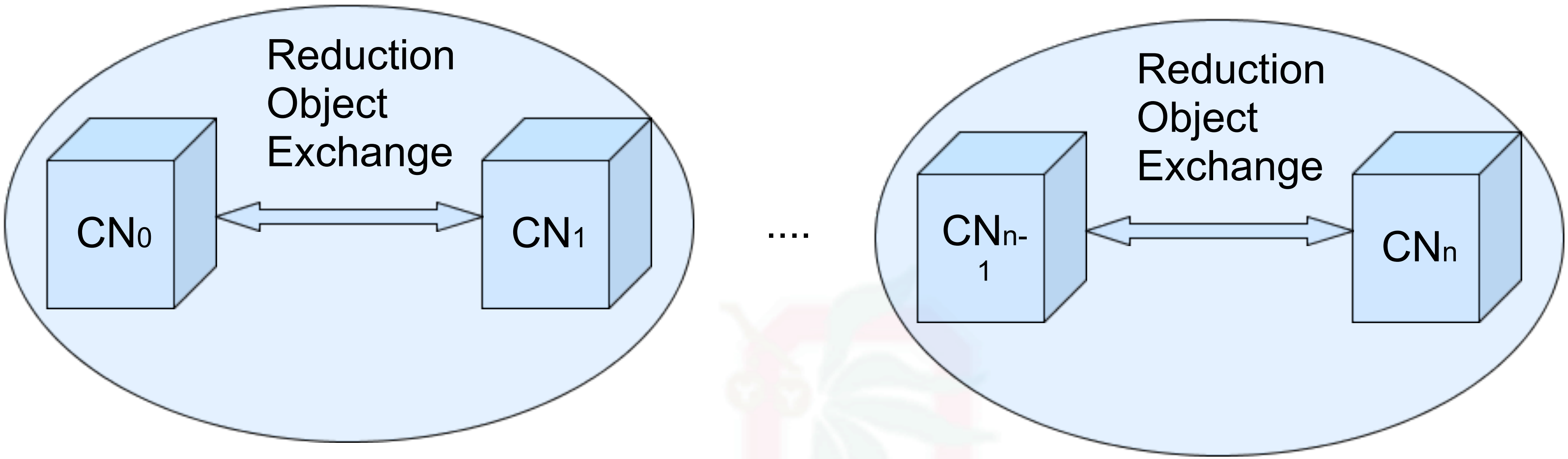
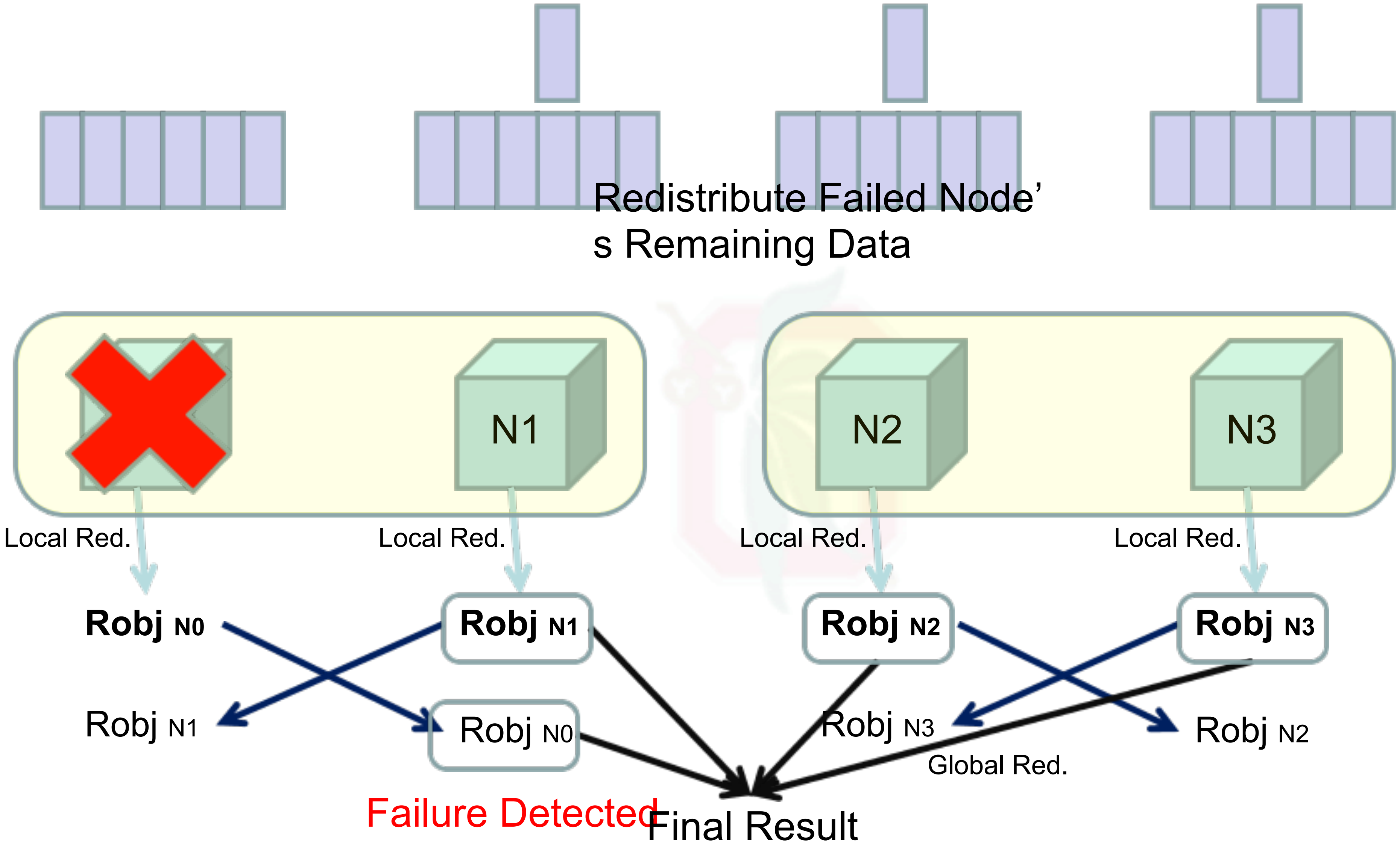
Simple Implementation of the Alg.



- Reduction object is stored another comp. node
  - Pair-wise reduction object exchange
- Failure detection is done by alive peer

Demonstration



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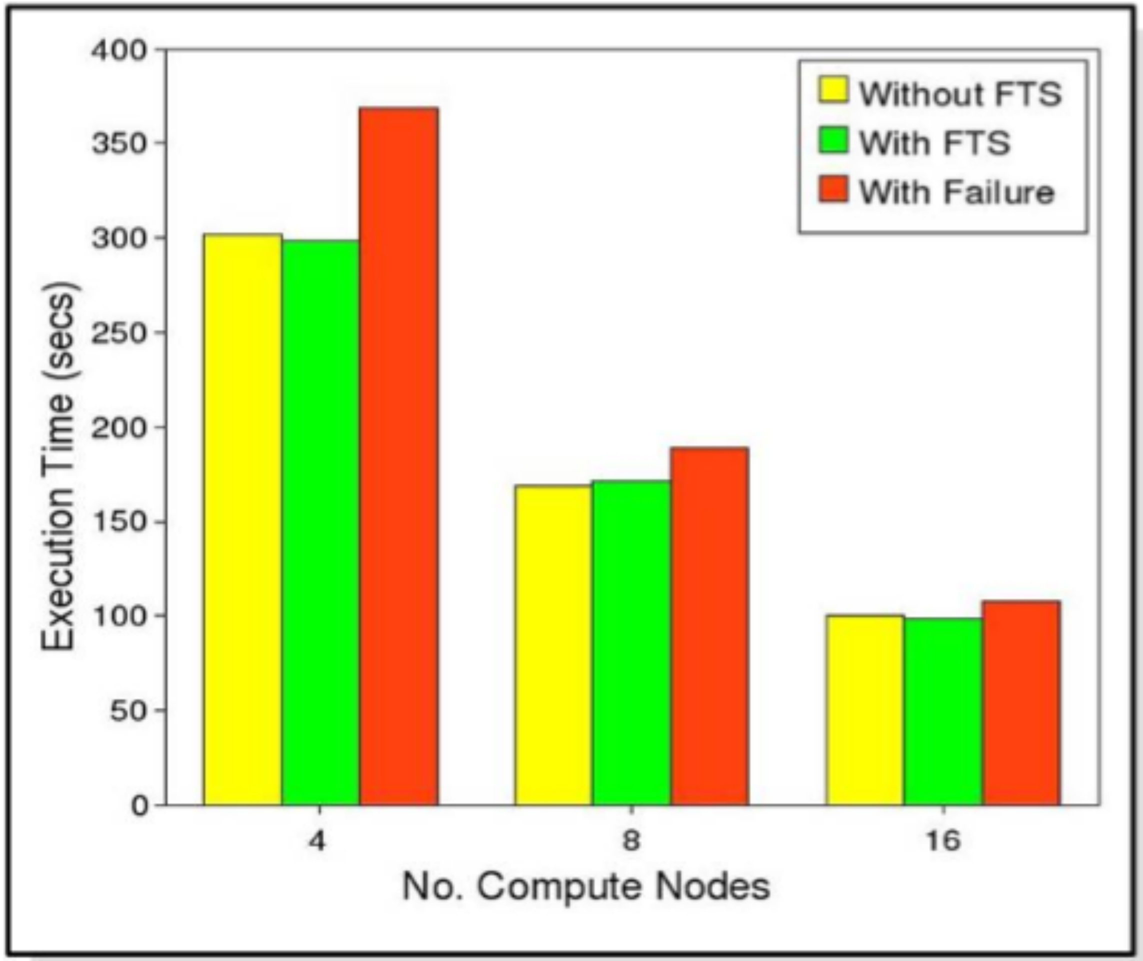
Goals for the Experiments

- Observing reduction object size
- Evaluate the overhead of the FTS
- Studying the slowdown in case of one node's failure
- Comparison with Hadoop (Map-Reduce imp.)

Experimental Setup

- FREERIDE-G
  - Data hosts and compute nodes are separated
- Applications
  - K-means and PCA
- Hadoop (Map-Reduce Imp.)
  - Data is replicated among all nodes

Experiments (K-means)

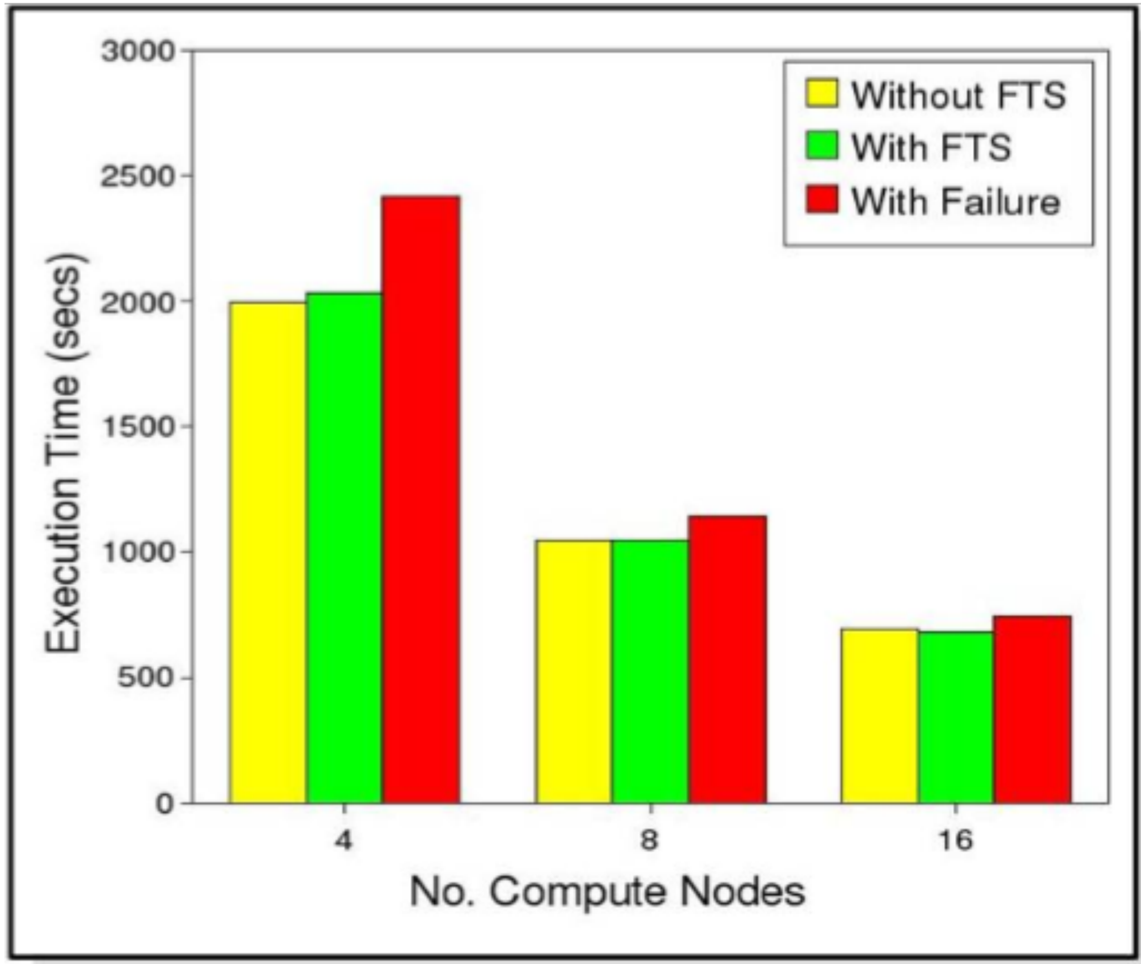


Execution Times with K-means 25.6 GB Dataset

- Without Failure Configurations
  - Without FTS
  - With FTS
- With Failure Configuration
  - Failure after processing %50 of data (on one node)

- Reduction obj. size: 2KB
- With FT overheads: 0 - 1.74%
  - Max: 8 Comp. Nodes, 25.6 GB
- Relative: 5.38 – 21.98%
  - Max: 4 Comp. Nodes, 25.6 GB
- Absolute: 0 – 4.78%
  - Max: 8 Comp. Nodes, 25.6 GB

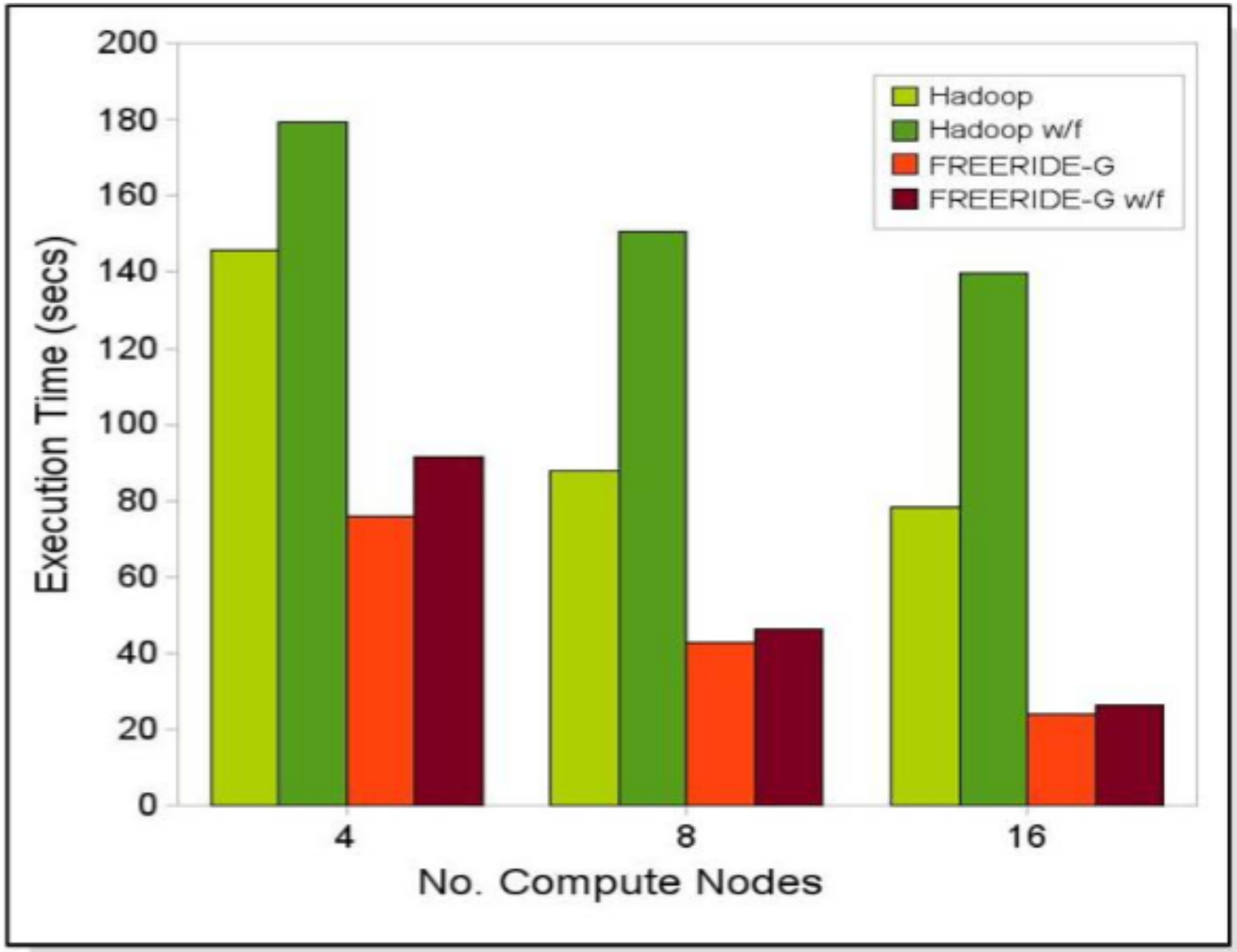
Experiments (PCA)



Execution Times with PCA, 17 GB Dataset

- Reduction obj. size: 128KB
- With FT overheads: 0 – 15.36%
  - Max: 4 Comp. Nodes, 4 GB
- Relative: 7.77 – 32.48%
  - Max: 4 Comp. Nodes, 4 GB
- Absolute: 0.86 – 14.08%
  - Max: 4 Comp. Nodes, 4 GB

Comparison with Hadoop



K-means Clustering, 6.4GB Dataset

- **w/f = with failure**
- Failure happens after processing 50% of the data on one node

Overheads

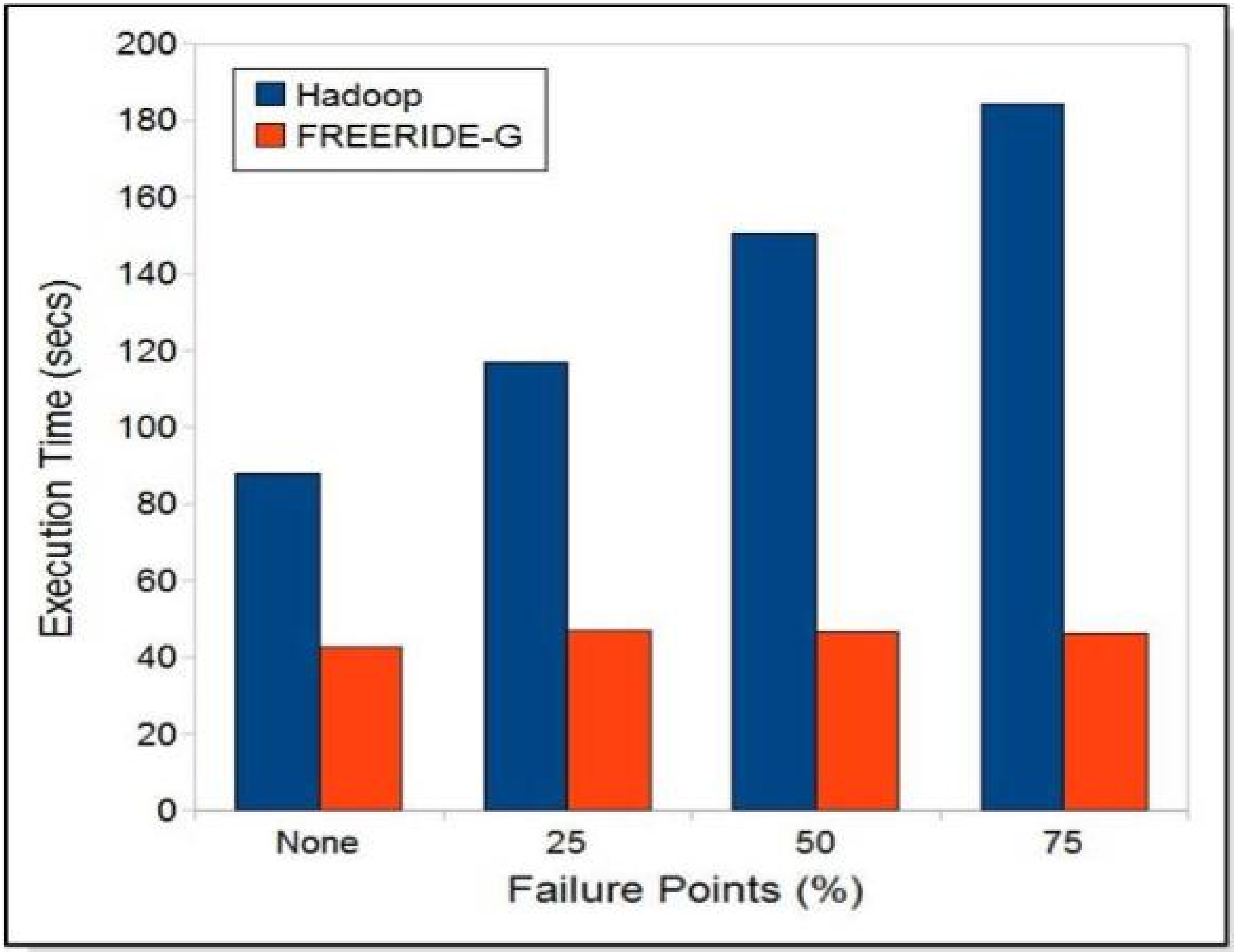
- **Hadoop**

23.06 | 71.78 | 78.11

- **FREERIDE-G**

20.37 | 8.18 | 9.18

Comparison with Hadoop



K-means Clustering, 6.4GB Dataset, 8 Comp. Nodes

- One of the comp. nodes failed after processing 25, 50 and 75% of its data

Overheads

- **Hadoop**

32.85 | 71.21 | 109.45

- **FREERIDE-G**

9.52 | 8.18 | 8.14

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Related Work

- Application level checkpointing
  - Bronevetsky *et. al.:* C^3 (SC06, ASPLOS04, PPoPP03)
  - Zheng *et. al.* : Ftc-charm++ (Cluster04)
- Message logging
  - Agrabia *et. al.* : Starfish (Cluster03)
  - Bouteiller *et. al.* : Mpich-v (Int. Journal of High Perf. Comp. 06)
- Replication-based Fault Tolerance
  - Abawajy *et. al.* (IPDPS04)

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Conclusion

- Reduction object represents the state of the system
- Our FTS has very low overhead and effectively recovers from failures
- Different designs can be implemented using Robj.
- Our system outperforms Hadoop both in absence and presence of failures

Thanks