Tachyon: Reliable File Sharing at Memory-Speed Across Cluster Frameworks

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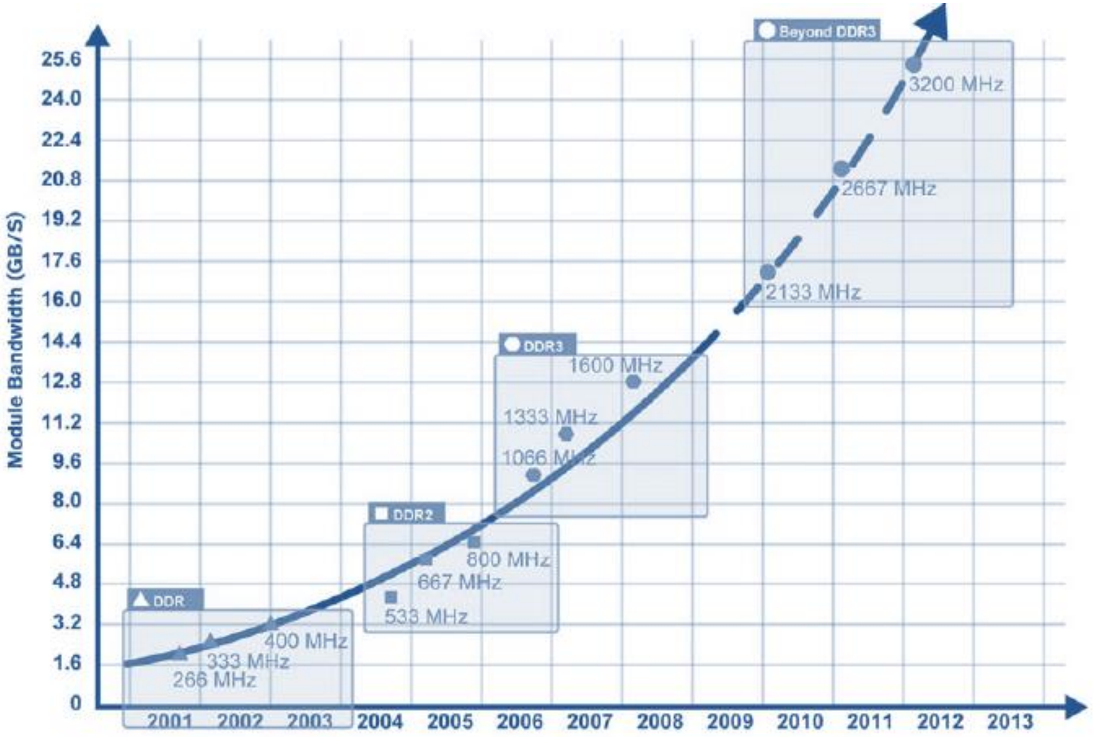
Outline

- Motivation
- System Design
- Evaluation Results
- Release Status
- Future Directions

Memory is King

Memory Trend

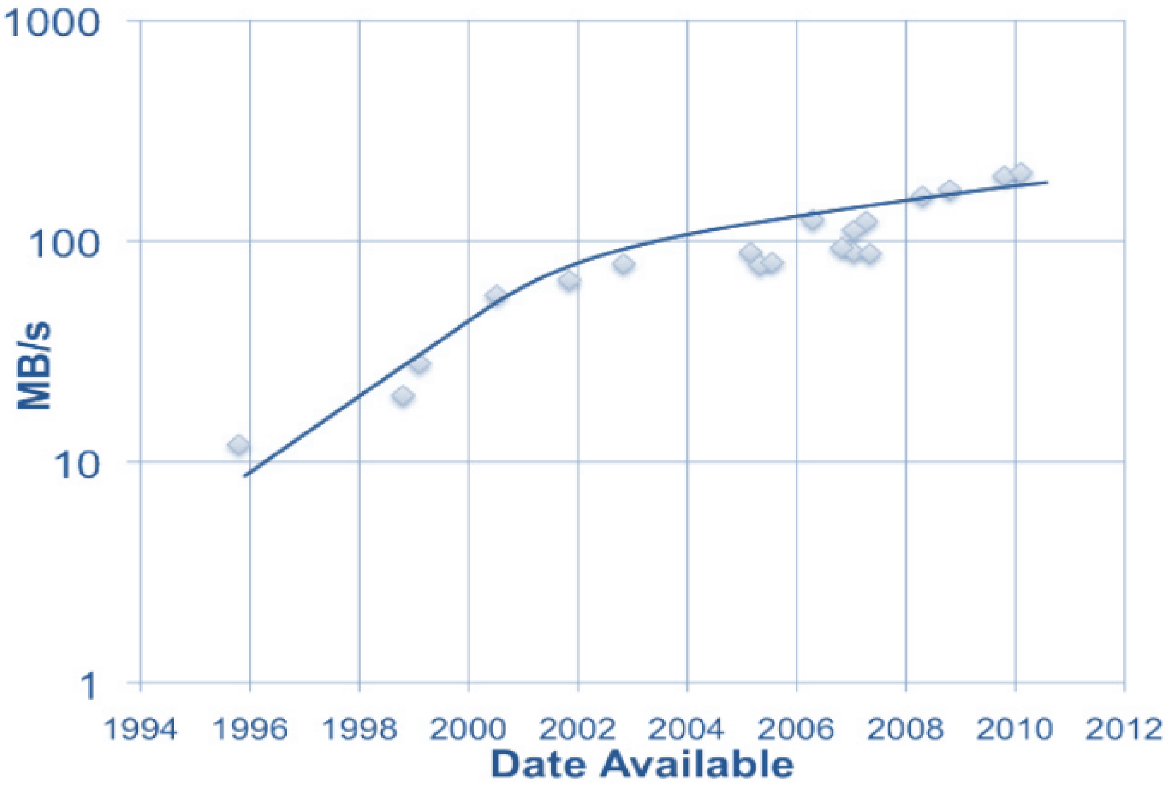
- RAM throughput increasing exponentially



Bandwidths shown for 64-bit memory module. Date indicates approximate industry product introduction.

Disk Trend

- Disk throughput increasing slowly



Consequence

- Memory locality **key** to achieve
  - Interactive queries
  - Fast query response

Current Big Data Eco-system

- Many frameworks already leverage memory
  - e.g. Spark, Shark, and other projects
- File sharing among jobs replicated to disk
  - Replication enables fault-tolerance
- **Problems**
  - Disk scan is slow for read.
  - Synchronous disk replication for write is even slower.

Tachyon Project

- Reliable file sharing at memory-speed across cluster frameworks/jobs

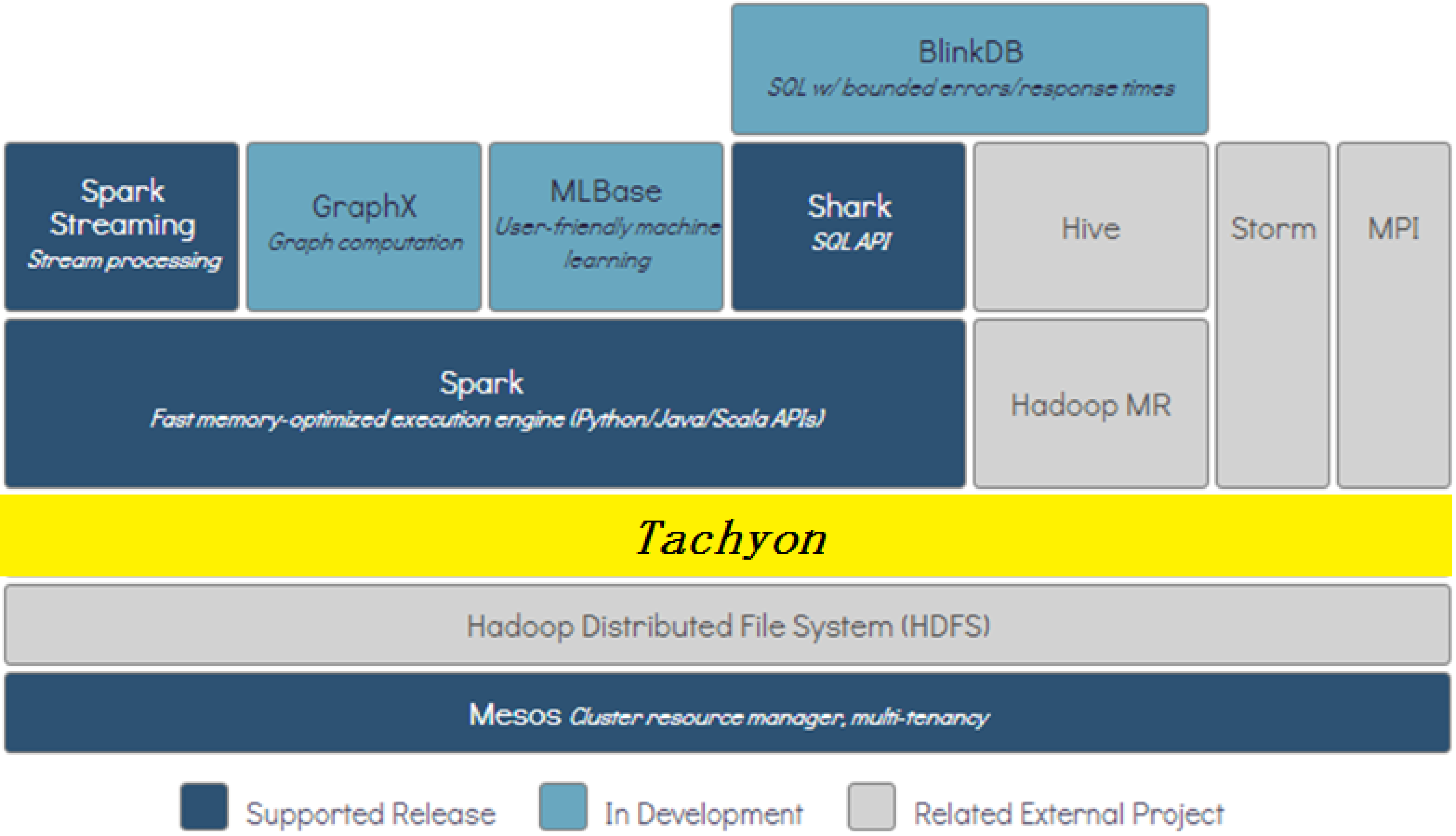
- Challenge
  - How to achieve reliable file sharing without replication?

Idea

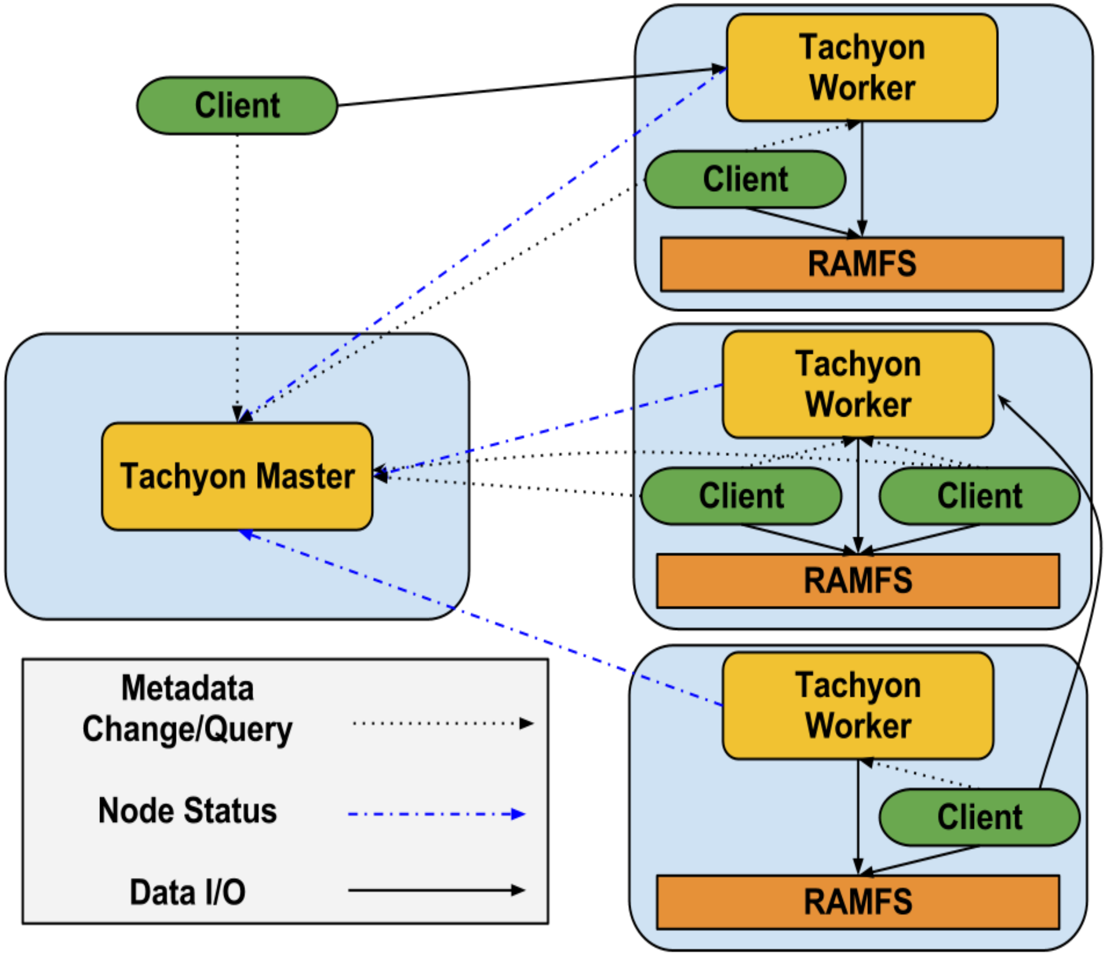
Re-computation (Lineage) based storage using memory aggressively.

1. One copy of data in memory (Fast)
2. Upon failure, re-compute data using ***lineage*** (Fault tolerant)

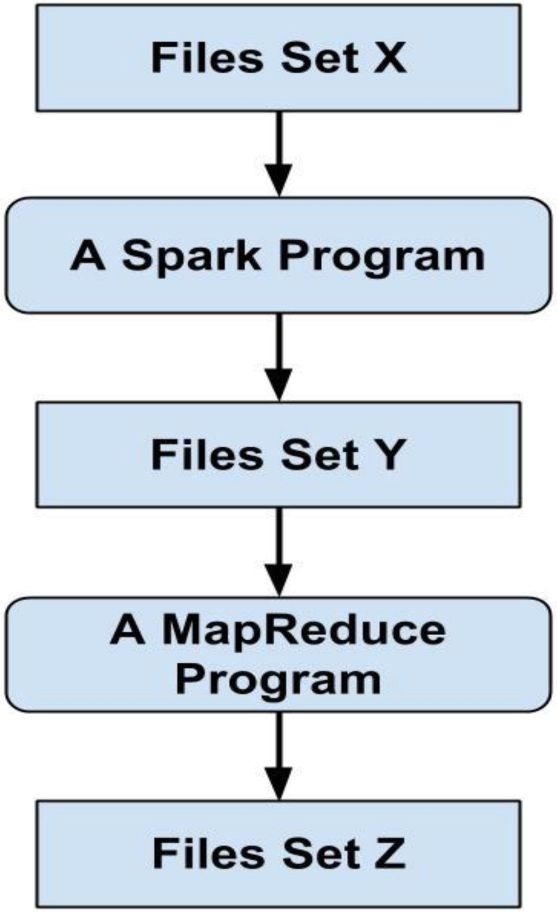
Stack


BlinkDB
SQL w/ bounded errors/response times
Spark Streaming
Stream processing
GraphX
Graph computation
MLBase
User-friendly machine learning
Shark
SQL API
Hive
Storm
MPI
Spark
Fast memory-optimized execution engine (Python/Java/Scala APIs)
Hadoop MR
Tachyon
Hadoop Distributed File System (HDFS)
Mesos Cluster resource manager, multi-tenancy
Supported Release
In Development
Related External Project

System Architecture



Lineage



Files Set X

A Spark Program

Files Set Y

A MapReduce Program

Files Set Z

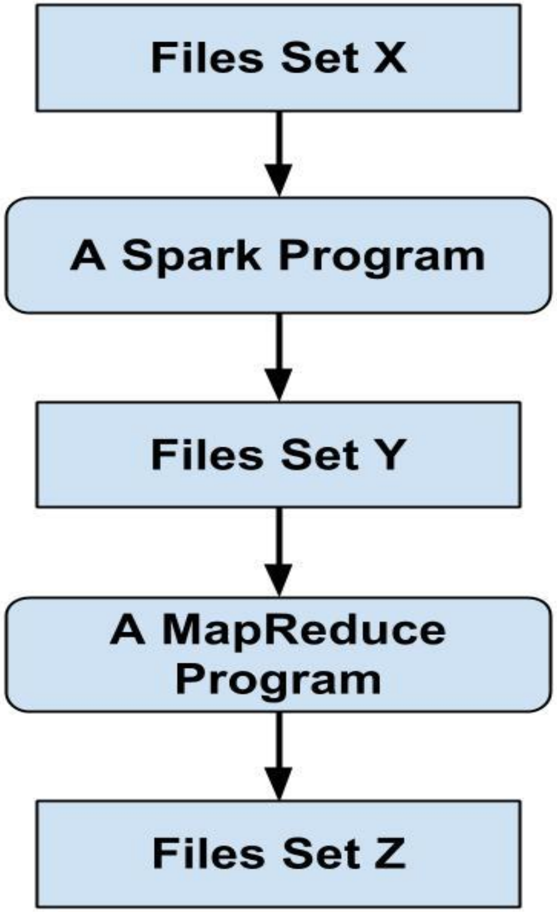
Lineage Information

- Binary program
- Configuration
- Input Files List
- Output Files List
- Dependency Type

Fault Recovery Time

Re-computation Cost?

Example


Files Set X

A Spark Program

Files Set Y

A MapReduce Program

Files Set Z

Asynchronous Checkpoint

1. Better than using existing solutions even under failure.
2. Bounded recovery time (Naïve and Snapshot asynchronous checkpointing).

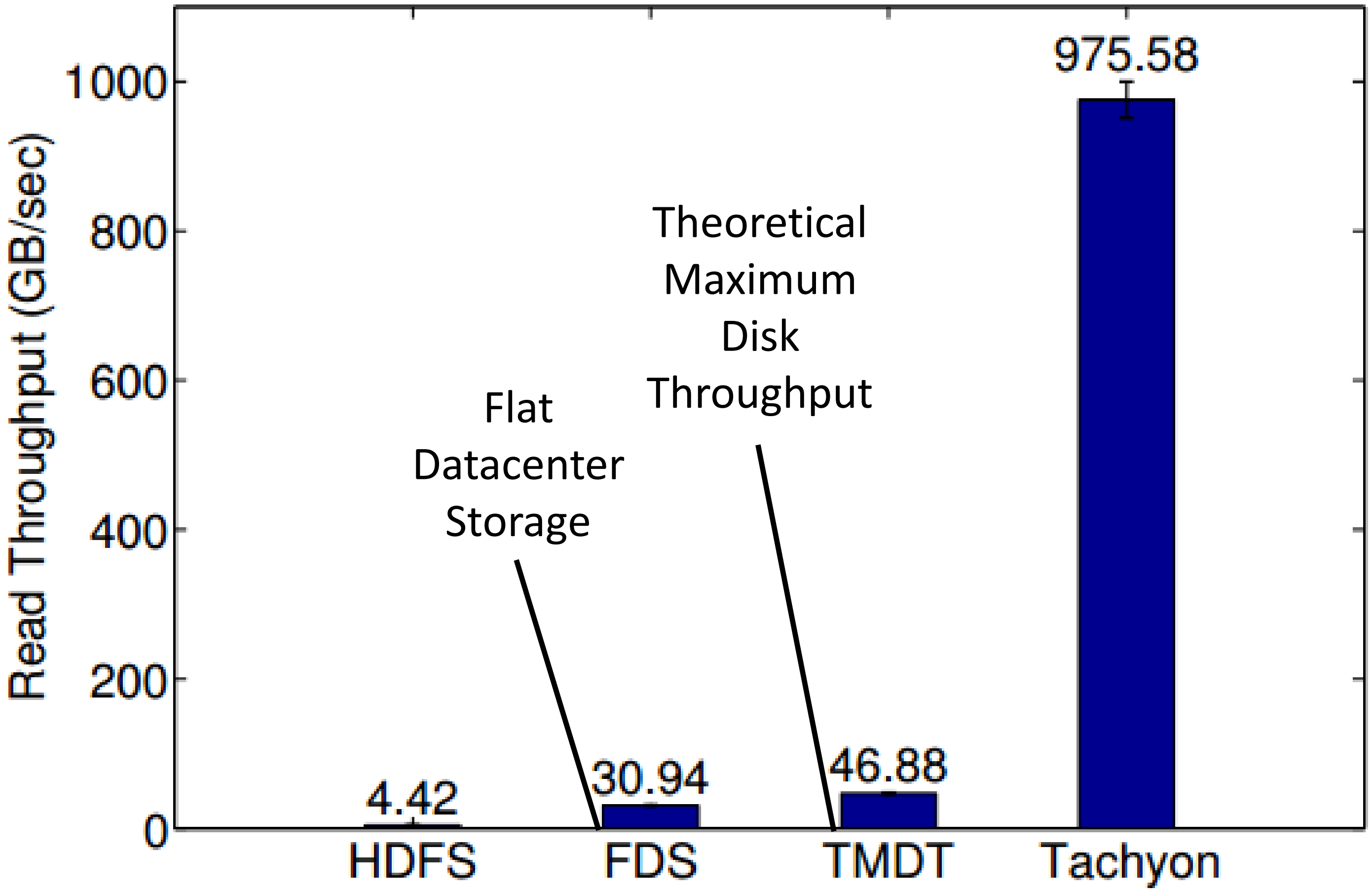
Master Fault Tolerance

- Multiple masters
  - Use ZooKeeper to elect a leader
- After crash workers contact new leader
  - Update the state of leader with contents of caches

Implementation Details

- 15,000+ lines of JAVA
- Thrift for data transport
- Underlayer file system supports HDFS, S3, localFS, GlusterFS
- Maven, Jenkins

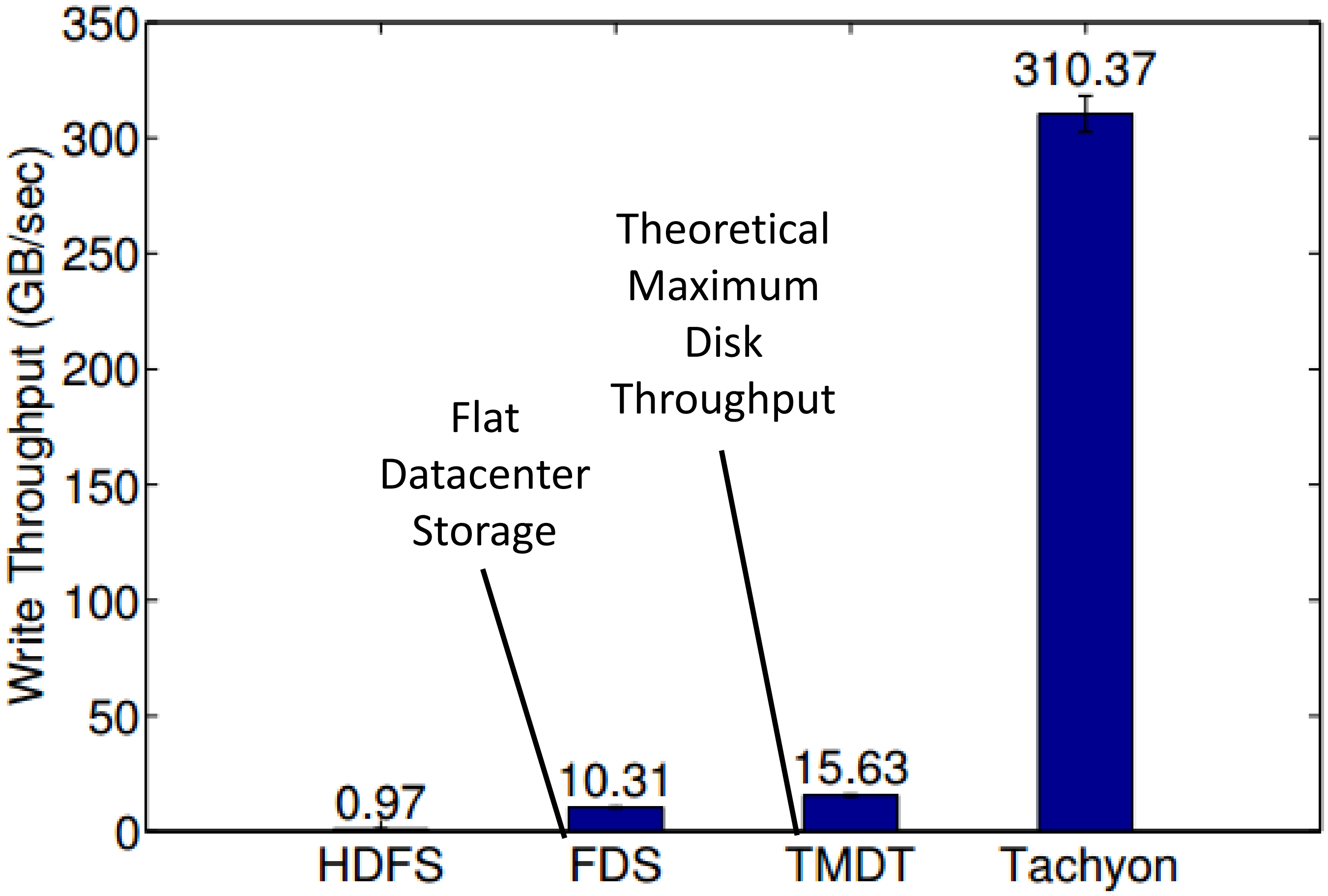
Sequential Read using Spark



Flat Datacenter Storage

Theoretical Maximum Disk Throughput

Sequential Write using Spark



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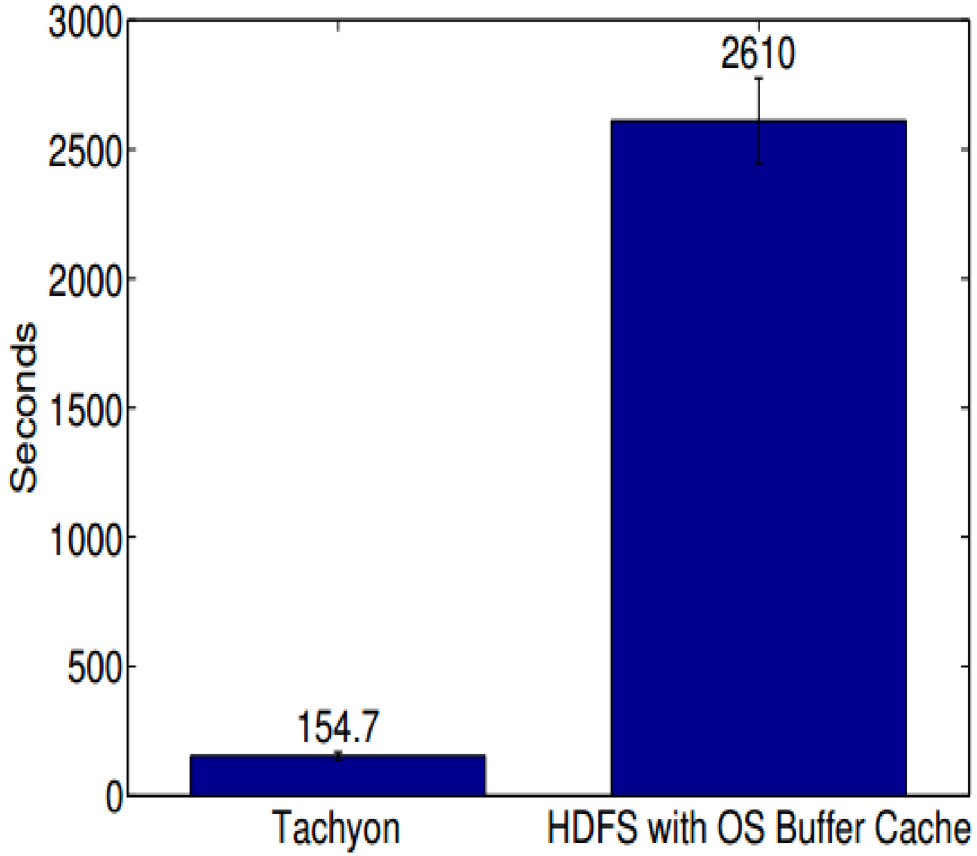
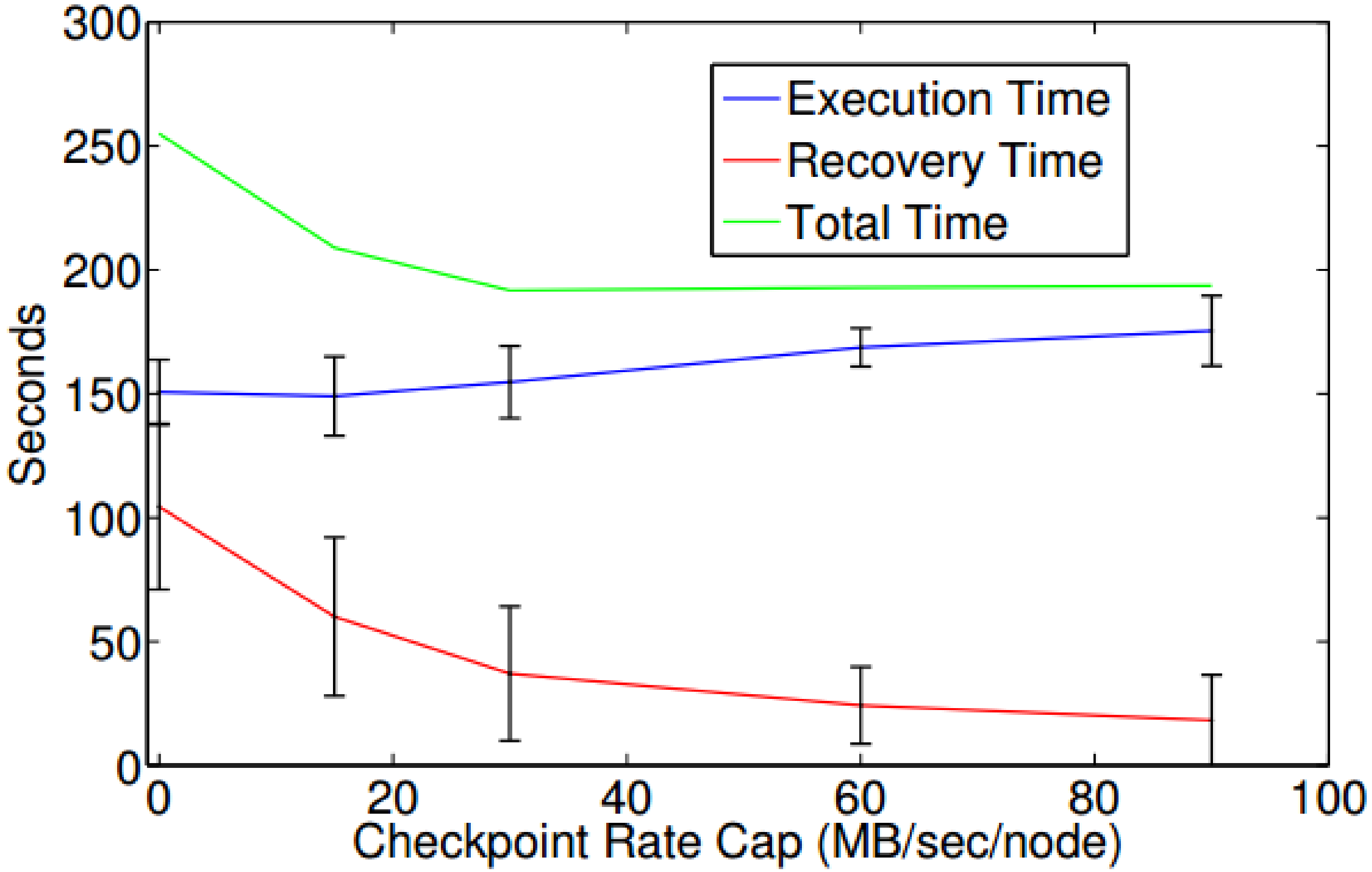
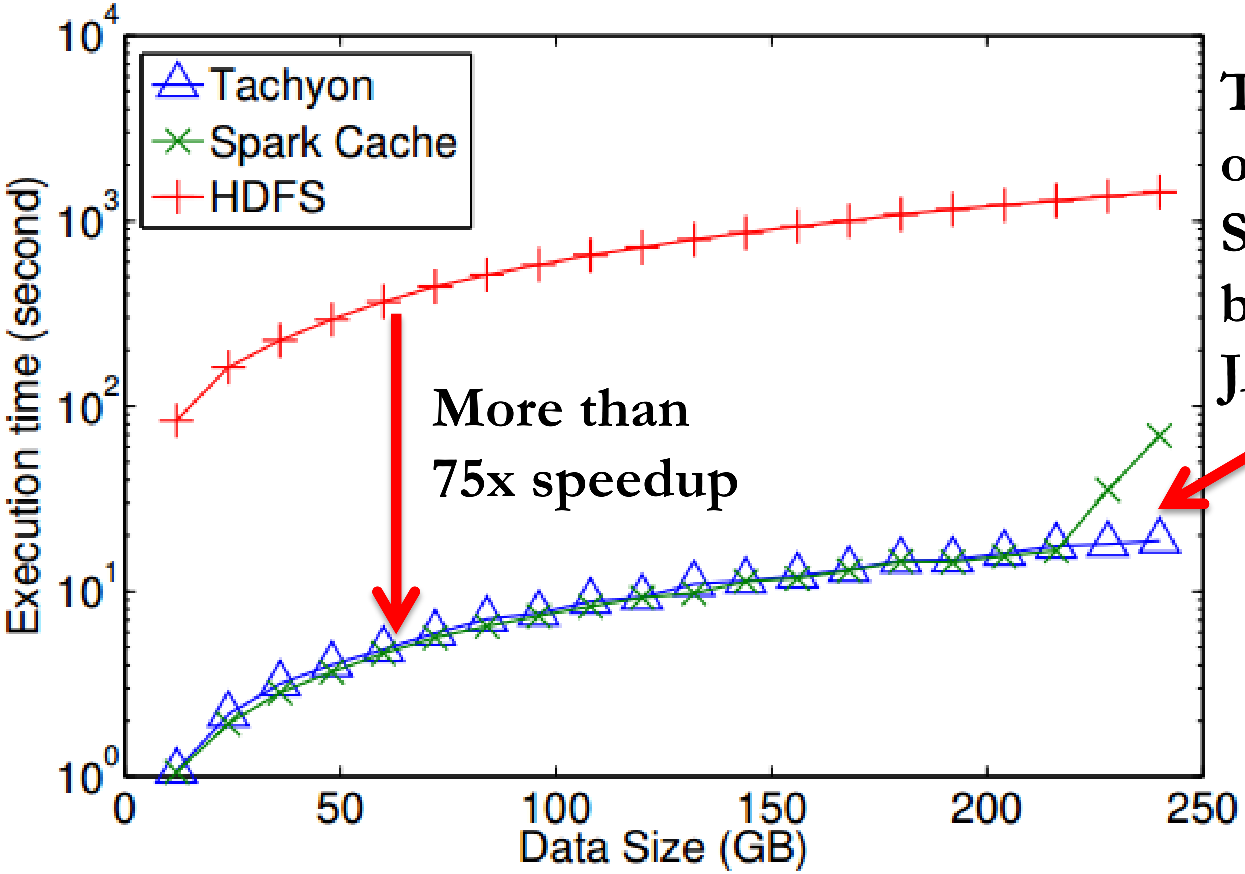
Realistic Workflow using Spark



Realistic Workflow Under Failure



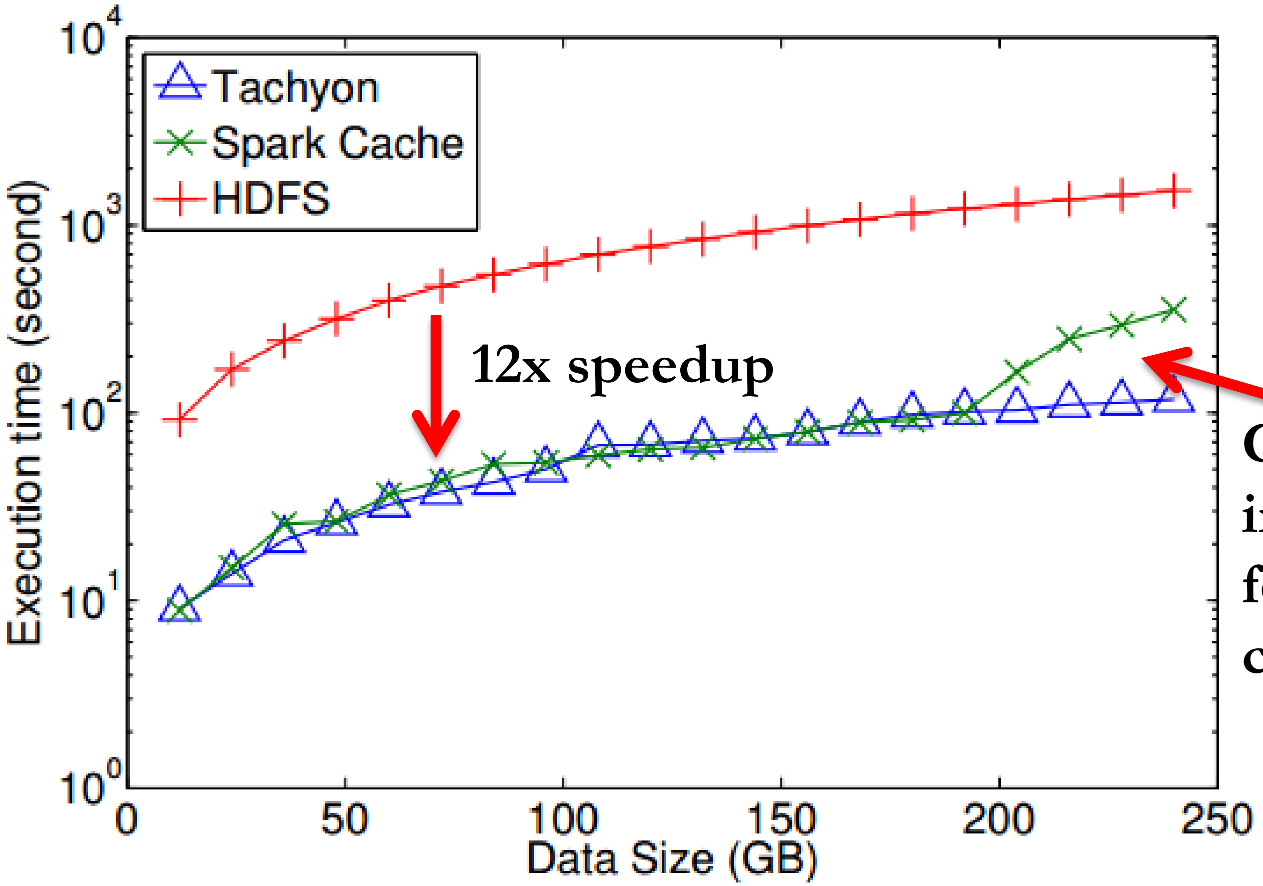
Conviva Spark Query (I/O intensive)



More than 75x speedup

Tachyon outperforms Spark cache because of JAVA GC

Conviva Spark Query (less I/O intensive)



12x speedup

GC kicks in earlier for Spark cache

Alpha Status

- Releases
  - Developer Preview: V0.2.1 (4/25/2013)
  - Contributions from:

YAHOO!

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Alpha Status

- First read of files cached in-memory
- Writes go synchronously to HDFS (No lineage information in Developer Preview release)
- MapReduce and Spark can run without any code change (ser/de becomes the new bottleneck)

Current Features

- Java-like file API
- Compatible with Hadoop
- Master fault tolerance
- Native support for raw tables
- WhiteList, PinList
- Command line interaction
- Web user interface

Spark without Tachyon

```
val file = sc.textFile(“hdfs://ip:port/path”)
```

Spark with Tachyon

```
val file = sc.textFile(“tachyon:// ip:port/path”)
```

Shark without Tachyon

```
CREATE TABLE orders_cached AS SELECT * FROM orders;
```

Shark with Tachyon

```
CREATE TABLE orders_tachyon AS SELECT * FROM orders;
```

Experiments on Shark

- Shark (from 0.7) can store tables in Tachyon with fast columnar Ser/De

20 GB data / 5 machines	Spark Cache	Tachyon
Table Full Scan	1.4 sec	1.5 sec
GroupBys (10 GB Shark Memory)	50 – 90 sec	45 – 50 sec
GroupBys (15 GB Shark Memory)	44 – 48 sec	37 – 45 sec

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4 * 100 GB TPC-H data / 17 machines	Spark Cache	Tachyon
TPC-H Q1	65.68 sec	24.75 sec
TPC-H Q2	438.49 sec	139.25 sec
TPC-H Q3	467.79 sec	55.99 sec
TPC-H Q4	457.50 sec	111.65 sec

Future

- Efficient Ser/De support
- Fair sharing for memory
- Full support for lineage
- Next release is coming soon

Acknowledgment

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Code Contributors: Haoyuan Li, Calvin Jia, Bill Zhao, Mark Hamstra, Rong Gu, Hobin Yoon, Vamsi Chitters, Reynold Xin, Srinivas Parayya, Dilip Joseph

Questions?

http://tachyon-project.org

https://github.com/amplab/tachyon