

Recommendation System Optimization based on Spark

Insight Data Engineering Fellow Project – Week 4

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Motivation



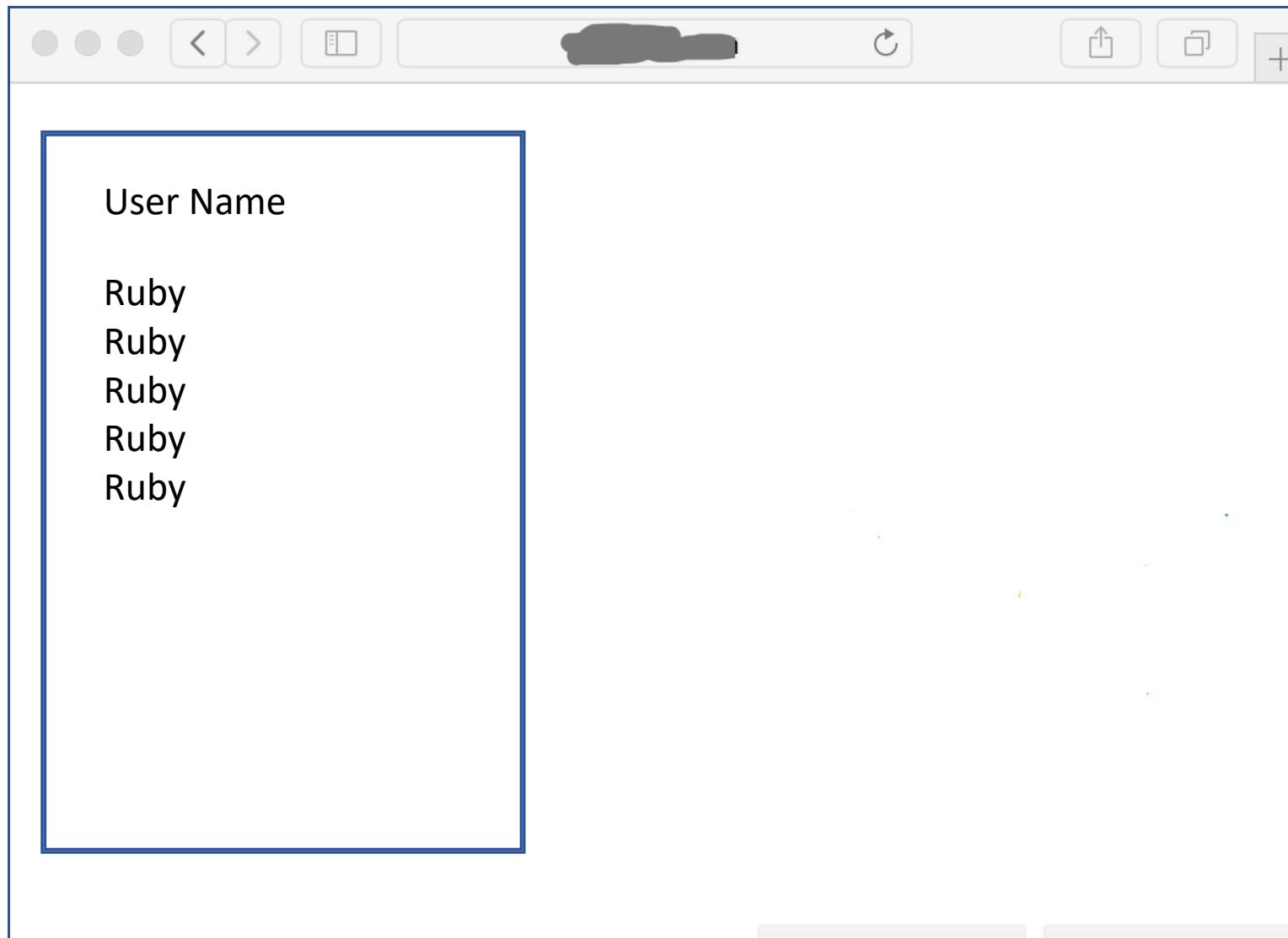
Recommendation System

- Yelp dataset
 - Reviews: 5.2 millions
 - Users: 1.3 millions
 - Business: 174 thousand
- Item-based Collaborative Filtering
- Similarity Matrix Calculation

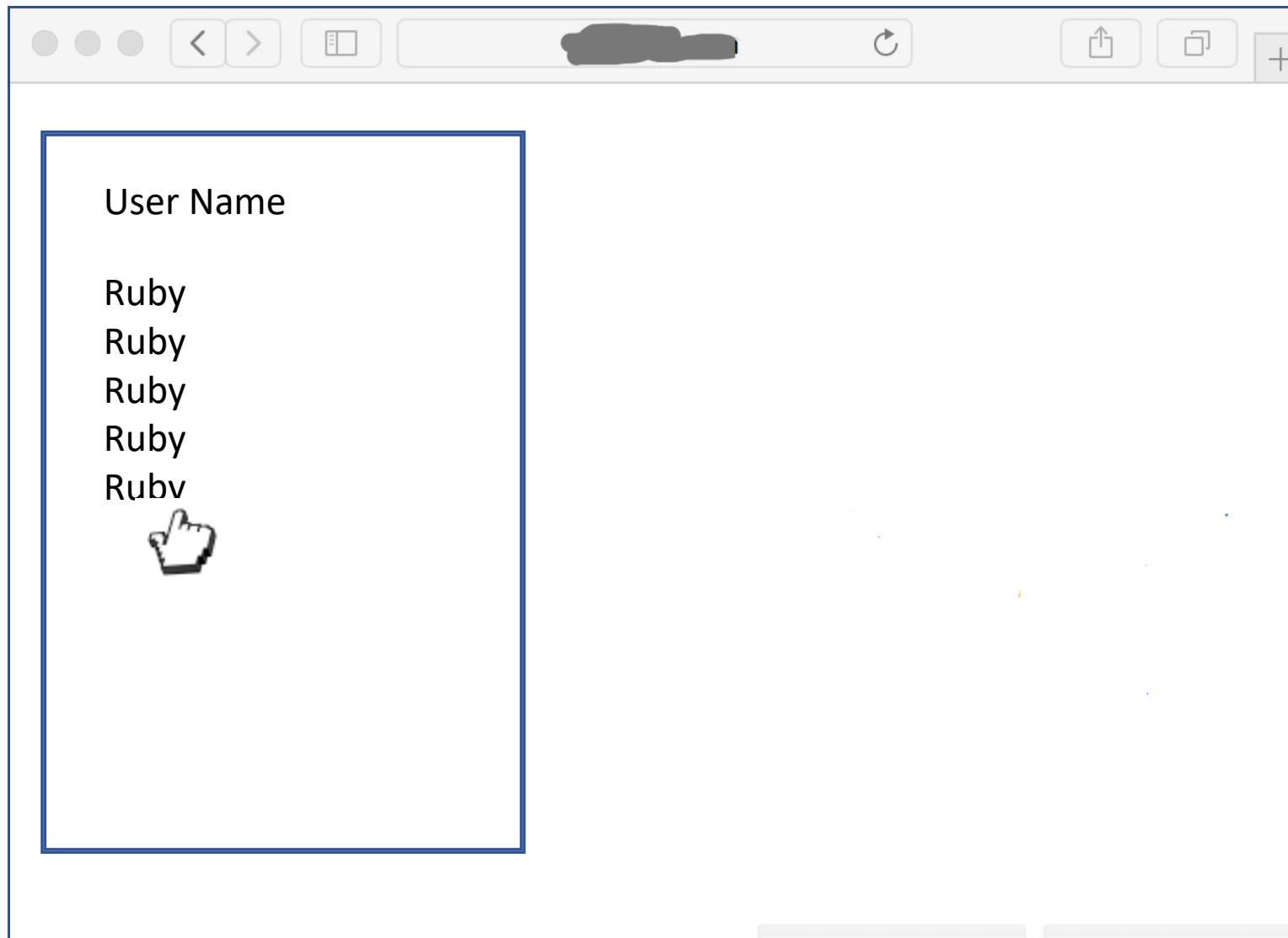
$$Sim(i, j) = \frac{\sum_{u \in U} (R_{u,i} - \bar{r}_i)(R_{u,j} - \bar{r}_j)}{\sqrt{\sum_{u \in U} (R_{u,i} - \bar{r}_i)^2} \sqrt{\sum_{u \in U} (R_{u,j} - \bar{r}_j)^2}}$$

$R_{u,i}$: review from user u to item i

Demo



Demo



Demo

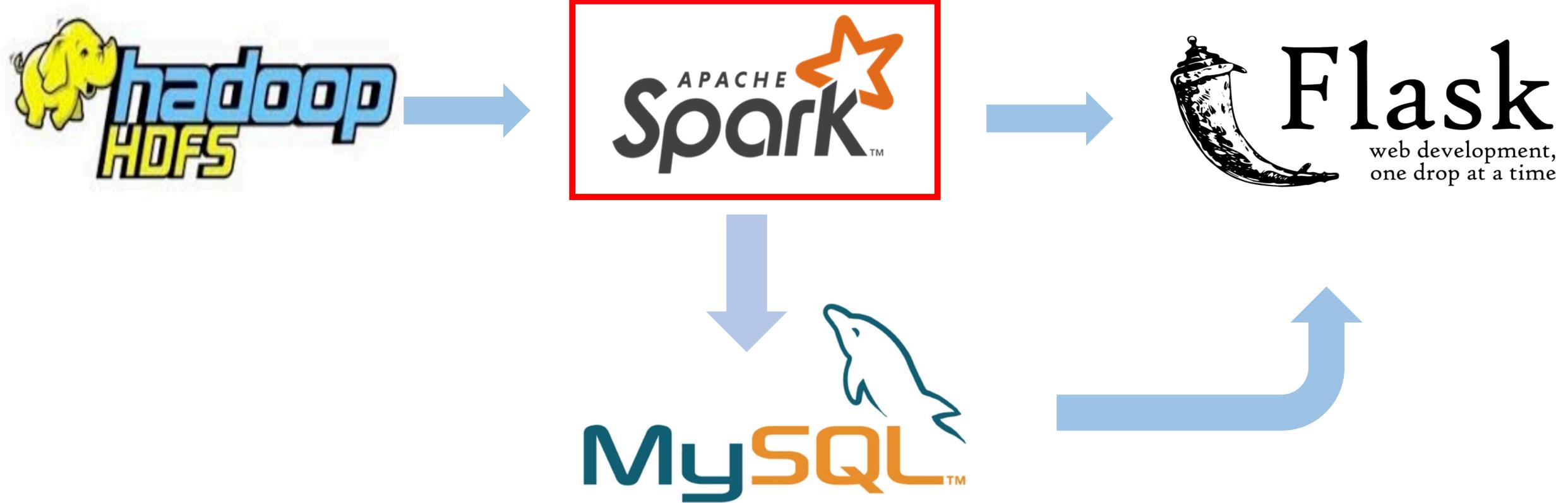
The screenshot shows a web interface with a toolbar at the top containing standard browser controls like back, forward, and refresh, along with a user profile icon and a plus sign for new tabs.

The main content area displays two separate search results:

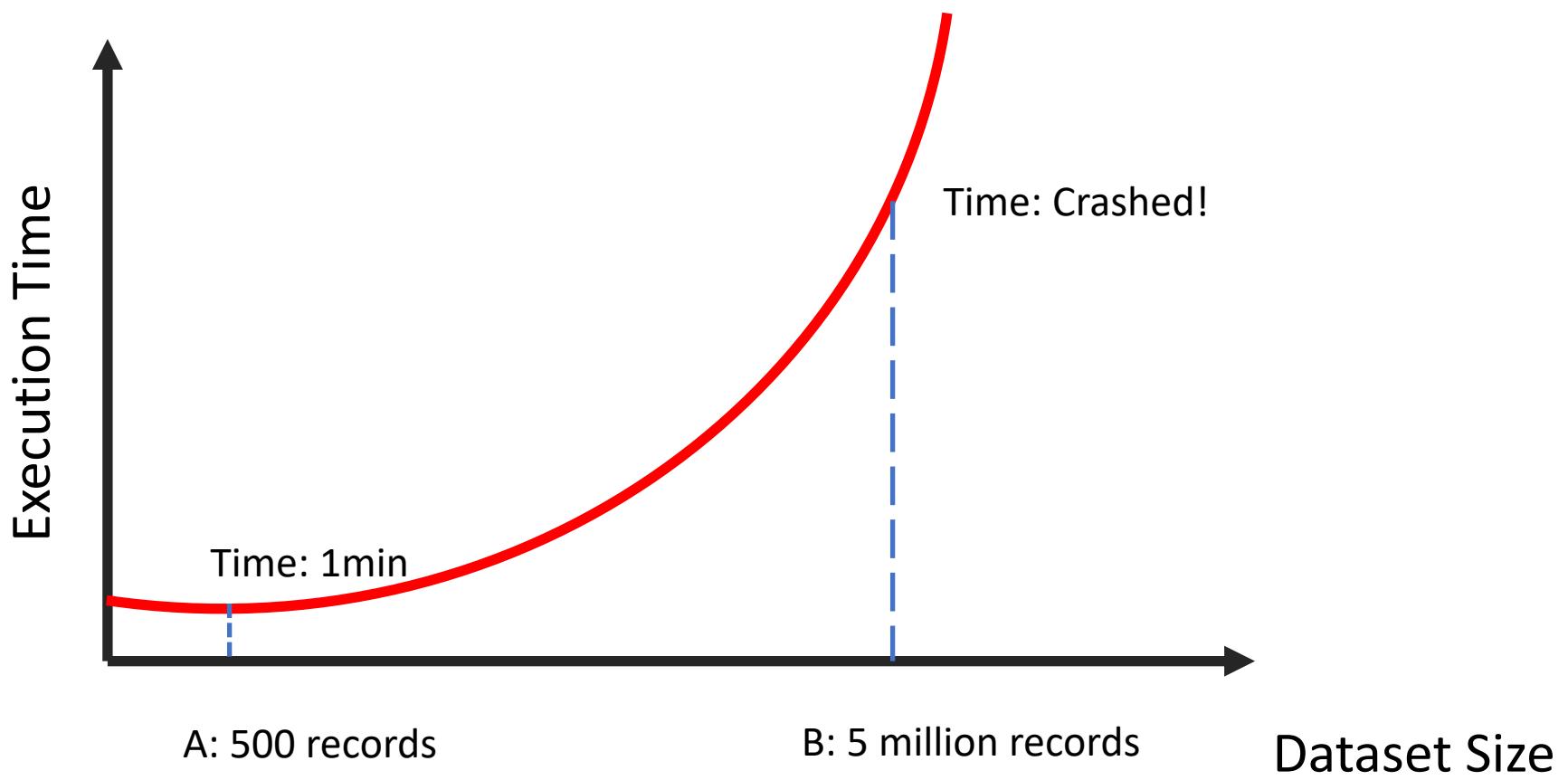
- User Name**: This section contains five entries, all of which are "Ruby".
- Business Name**: This section contains five entries, all of which are "Hotpot Restaurant" followed by a number from 1 to 5.

User Name	Business Name
Ruby	Hotpot Restaurant 1
Ruby	Hotpot Restaurant 2
Ruby	Hotpot Restaurant 3
Ruby	Hotpot Restaurant 4
Ruby	Hotpot Restaurant 5

Pipeline



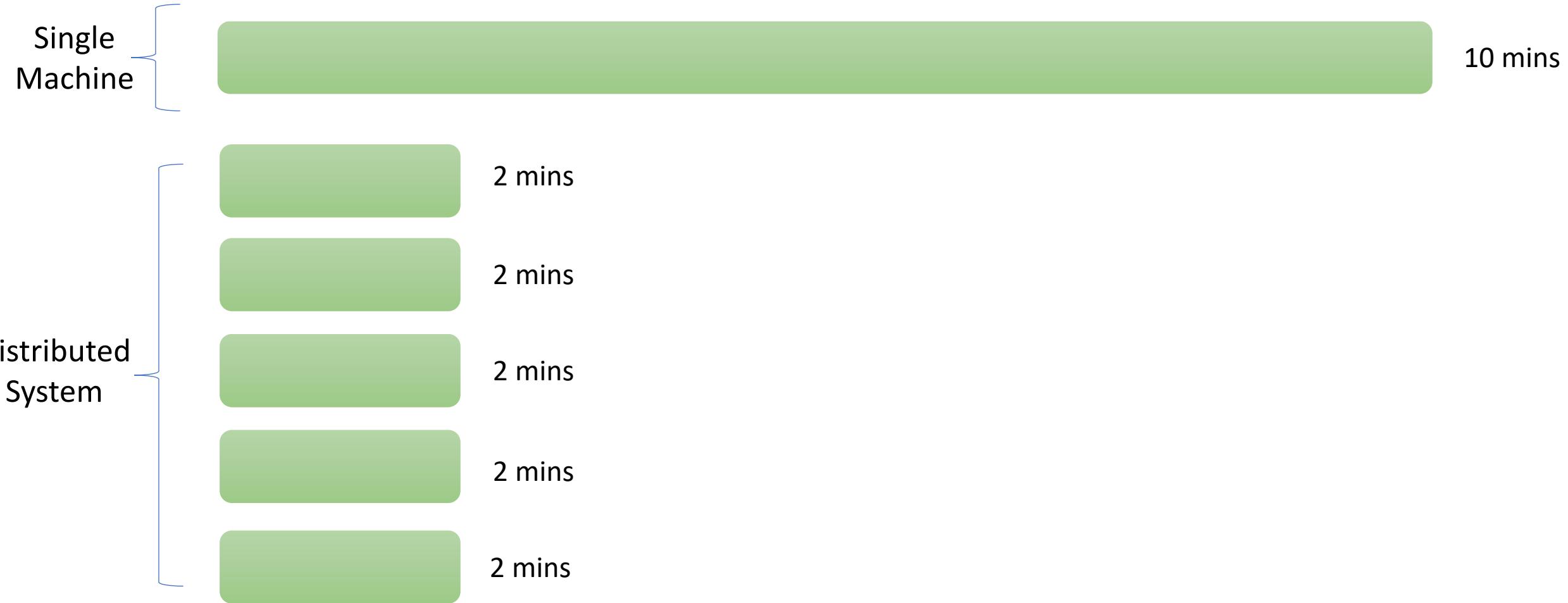
Data Engineering Challenge



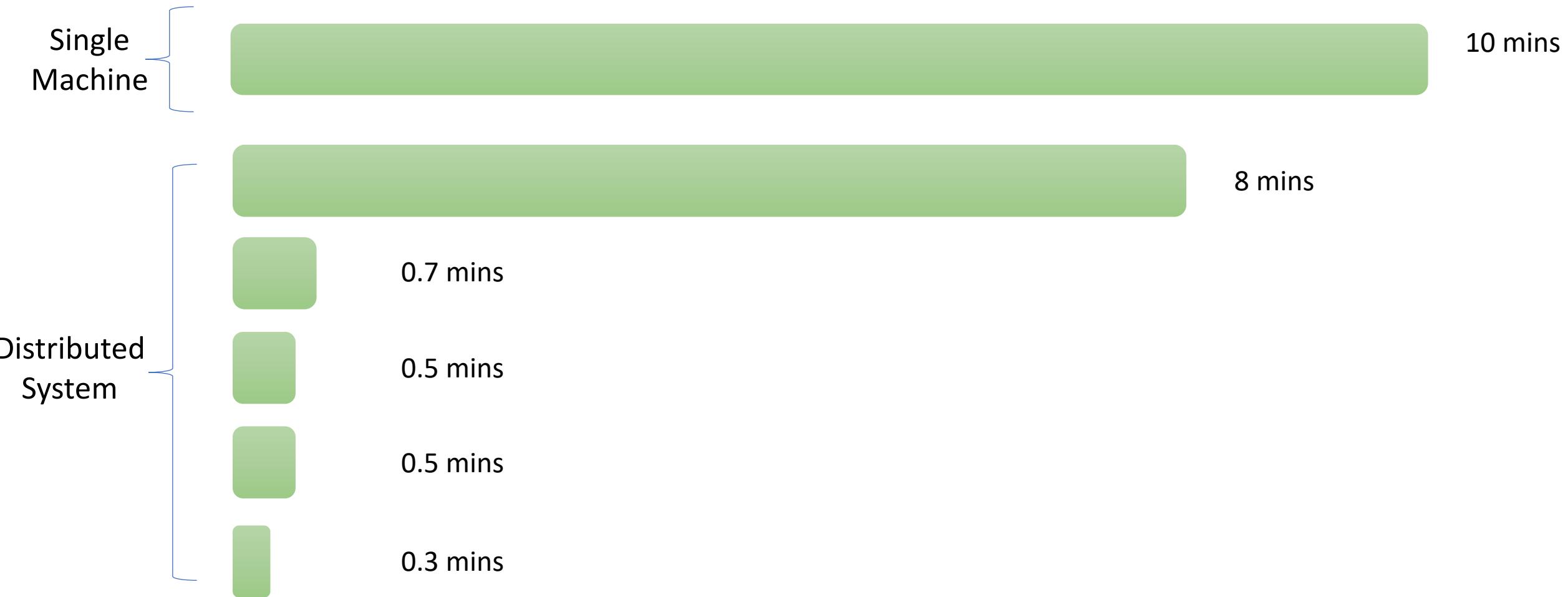
Data Engineer Challenge

- Model crashed at “Table Join”
- Reason: Data skew and Shuffle
- Solution: Use “broadcast” operation to replace table join.

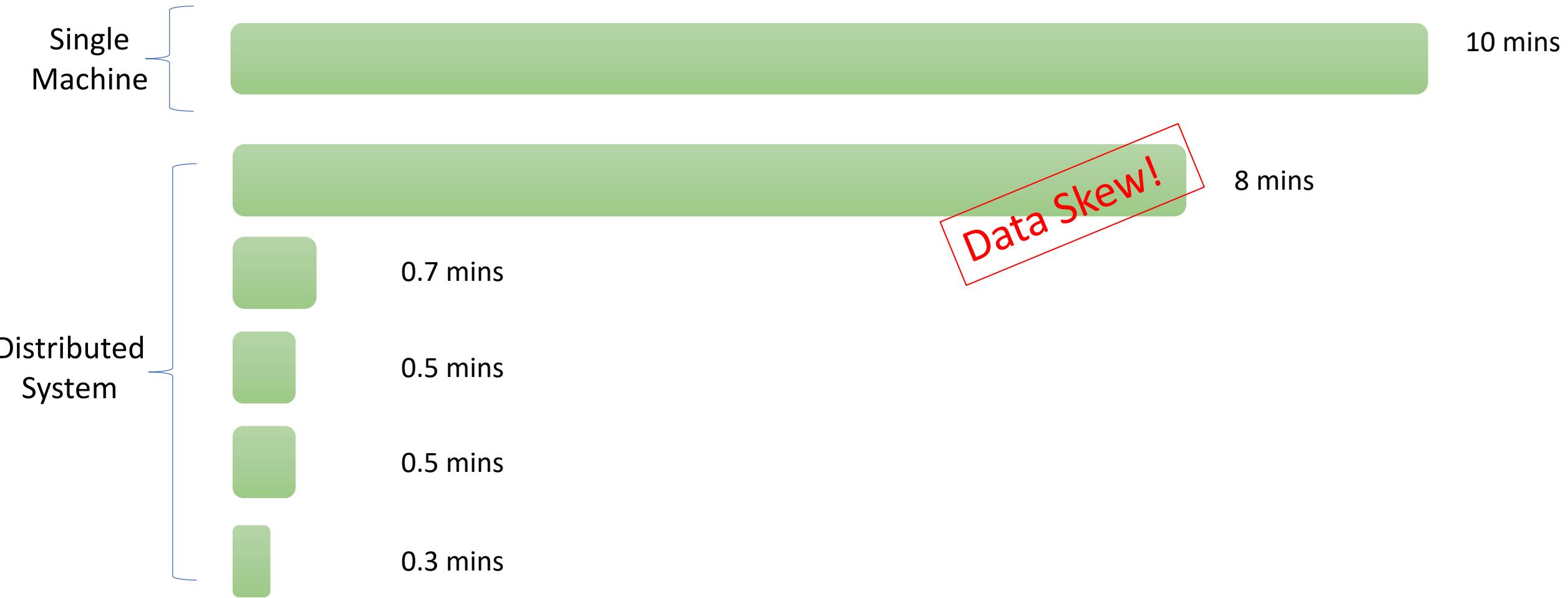
Ideal execution time of distributed system



Real execution time of distributed system



Real execution time of distributed system



Why Data Skew?

-- 20% business provide 80% reviews

Key	Value	
Business	User	Star
Starbucks	Tom	5
Five Guys	Tom	4
Starbucks	Jim	3
Qdoba	John	2
Five Guys	Alice	5
Starbucks	Romia	2
Starbucks	Juliet	5
Qdoba	Sam	3
Starbucks	Carl	5
Starbucks	Wendy	3
Starbucks	Kate	4
Starbucks	Vivian	5

Table Join



Key	Value
Business	Avg_Star
Starbucks	4.5
Five Guys	3.8
Qdoba	3.5

Why Data Skew?

-- 20% business provide 80% reviews

Key	Value	
Business	User	Star
Starbucks	Tom	5
Five Guys	Tom	4
Starbucks	Jim	3
Qdoba	John	2
Five Guys	Alice	5
Starbucks	Romia	2
Starbucks	Juliet	5
Qdoba	Sam	3
Starbucks	Carl	5
Starbucks	Wendy	3
Starbucks	Kate	4
Starbucks	Vivian	5

Table Join

Key	Value
Business	Avg_Star
Starbucks	4.5
Five Guys	3.8
Qdoba	3.5

Send the data to different partitions by hash code of the key

Executor I

Key	Value A	
Starbucks	4.5	
Key	Value B	
Starbucks	Tom	5
Starbucks	Jim	3
Starbucks	Romia	2
Starbucks	Juliet	5
Starbucks	Carl	5
Starbucks	Wendy	3
Starbucks	Kate	4
Starbucks	Vivian	5

Executor II

Key	Value A	
Five Guys	3.8	
Key	Value B	
Five Guys	Tom	4
Five Guys	Alice	5

Executor III

Key	Value A	
Qdoba	3.5	
Key	Value B	
Qdoba	John	2
Qdoba	Sam	3

Executor I

Key	Value A	
Starbucks	4.5	
Key	Value B	
Starbucks	Tom	5
Starbucks	Jim	3
Starbucks	Romia	2
Starbucks	Juliet	5
Starbucks	Carl	5
Starbucks	Wendy	3
Starbucks	Kate	4
Starbucks	Vivian	5

Executor II

Key	Value A	
Five Guys	3.8	
Key	Value B	
Five Guys	Tom	4
Five Guys	Alice	5

Executor III

Key	Value A	
Qdoba	3.5	
Key	Value B	
Qdoba	John	2
Qdoba	Sam	3

Execute “join” on different partitions parallelly

Executor I

Key	Value A
Starbucks	4.5
Key	Value B
Starbucks	Tom
Starbuck	5
Starbuck	3
Starbuck	2
Starbuck	5
Starbuck	5
Starbuck	3
Starbuck	4
Starbucks	Rate
Starbucks	Vivian



Running!!

Executor II

Key	Value B	Value A
Five Guys	Tom	4
Five Guys	Alice	5

Finished!

Executor III

Key	Value B	Value A
Qdoba	John	2
Qdoba	Sam	3

Finished!

Executor I

Key	Value B	Value A
Starbucks	Tom	5 4.5
Starbucks	Jim	3 4.5
Starbucks	Romia	2 4.5
Starbucks	Juliet	5 4.5
Starbucks	Carl	5 4.5
Starbucks	Wendy	3 4.5
Starbucks	Kate	4 4.5
Starbucks	Vivian	5 4.5

Finished!

Executor II

Key	Value B	Value A
Five Guys	Tom	4 3.8
Five Guys	Alice	5 3.8

Finished!

Executor III

Key	Value B	Value A
Qdoba	John	2 3.5
Qdoba	Sam	3 3.5

Finished!

Data Skew Solution – Broadcast Small Table

Key	Value	
Business	User	Star
Starbucks	Tom	5
Five Guys	Tom	4
Starbucks	Jim	3
Qdoba	John	2
Five Guys	Alice	5
Starbucks	Romia	2
Starbucks	Juliet	5
Qdoba	Sam	3
Starbucks	Carl	5
Starbucks	Wendy	3
Starbucks	Kate	4
Starbucks	Vivian	5

Table Join



Key	Value
Business	Avg_Star
Starbucks	4.5
Five Guys	3.8
Qdoba	3.5

Broadcast to
each partition

Data Skew Solution – Broadcast Small Table

Key	Value	
Business	User	Star
Starbucks	Tom	5
Five Guys	Tom	4
Starbucks	Jim	3
Qdoba	John	2
Five Guys	Alice	5
Starbucks	Romia	2
Starbucks	Juliet	5
Qdoba	Sam	3
Starbucks	Carl	5
Starbucks	Wendy	3
Starbucks	Kate	4
Starbucks	Vivian	5

Table Join



Key	Value
Business	Avg_Star
Starbucks	4.5
Five Guys	3.8
Qdoba	3.5

Divide in 3 parts evenly

Broadcast to each partition

Data Skew Solution – Broadcast Small Table

Executor I

Key	Value
Business	Avg_Star
Starbucks	4.5
Five Guys	3.8
Qdoba	3.5

Executor II

Key	Value
Business	Avg_Star
Starbucks	4.5
Five Guys	3.8
Qdoba	3.5

Executor III

Key	Value
Business	Avg_Star
Starbucks	4.5
Five Guys	3.8
Qdoba	3.5

Key Value

Business	User	Star
Starbucks	Tom	5
Five Guys	Tom	4
Starbucks	Jim	3
Qdoba	John	2

Key Value

Business	User	Star
Five Guys	Alice	5
Starbucks	Romia	2
Starbucks	Juliet	5
Qdoba	Sam	3

Key Value

Business	User	Star
Starbucks	Carl	5
Starbucks	Wendy	3
Starbucks	Kate	4
Starbucks	Vivian	5

Data Skew Solution – Broadcast Small Table

Executor I

Key	Value
Business	Avg_Star
Starbucks	4.5
Five Guys	3.8
Qdoba	3.5

Running!!

Executor II

Key	Value
Business	Avg_Star
Starbucks	4.5
Five Guys	3.8
Qdoba	3.5

Running!!

Executor III

Key	Value
Business	Avg_Star
Starbucks	4.5
Five Guys	3.8
Qdoba	3.5

Running!!

Key		
Business	User	Star
Starbucks	Tom	5
Five Guys	Tom	4
Starbucks	Jim	3
Qdoba	John	2

Key		
Business	User	Star
Starbucks	Carl	5
Starbucks	Wendy	3
Starbucks	Kate	4
Starbucks	Vivian	5

Data Skew Solution – Broadcast Small Table

Executor I

Key	Value B	Value A	
Business	User	Star	Avg_Star
Starbucks	Tom	5	4.5
Five Guys	Tom	4	3.8
Starbucks	Jim	3	4.5
Qdoba	John	2	3.5

Finished!

Executor II

Key	Value B	Value A	
Business	User	Star	Avg_Star
Five Guys	Alice	5	3.8
Starbucks	Romia	2	4.5
Starbucks	Juliet	5	4.5
Qdoba	Sam	3	3.5

Finished!

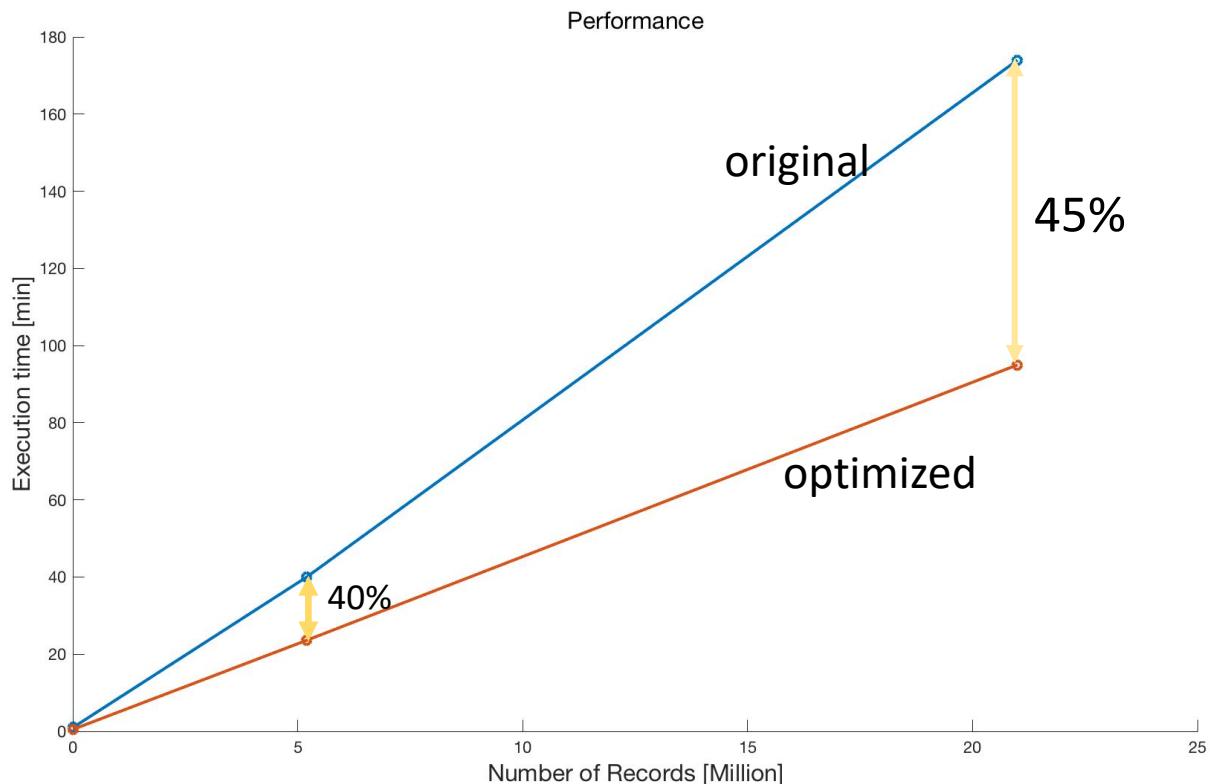
Executor III

Key	Value	Value A	
Business	User	Star	Avg_Star
Starbucks	Carl	5	4.5
Starbucks	Wendy	3	4.5
Starbucks	Kate	4	4.5
Starbucks	Vivian	5	4.5

Finished!

Performance

- System: 1 master node, 3 worker nodes.
- Memory: 6GB each node.



Ruby Liu



Master in Computer Engineering,
@ Northeastern University



Bachelor in Software Engineering,
Double degree in Mathematics,
@ Nankai University

- *Ballet*
- Swimming
- Hiking
- Travelling
- Hotpot!!
- Debug 😬

BLACKMAN AUDITORIUM



Q&A

Thank you!

Further work

- Joined two big tables in Spark
 - Add a column “index” to the balanced table
 - Iteratively broadcast part of the balanced table according to the index value.