Performance study of Spindle, a web analytics query engine implemented in Spark

CloudCom 2014

Brandon Amos[*] and David Tompkins, **Adobe Research**

[*] Adobe summer intern, Ph.D. Student at Carnegie Mellon University.

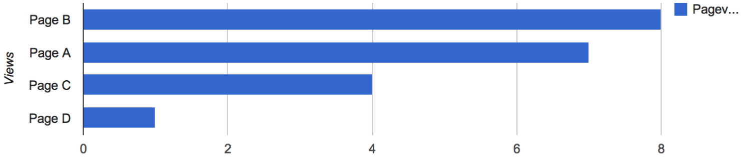
December 19, 2014

Motivation

- Adobe Marketing Cloud offers web analytics.

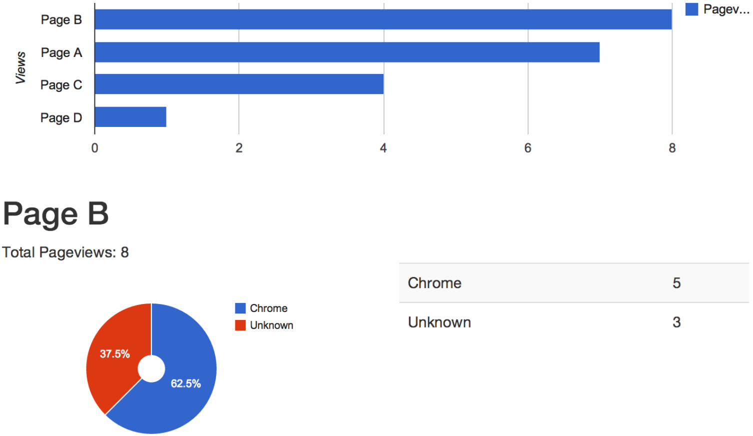
Motivation

- Adobe Marketing Cloud offers web analytics.



Motivation

- Adobe Marketing Cloud offers web analytics.



Page B

Total Pageviews: 8

Chrome	5
Unknown	3

Motivation

- Adobe Marketing Cloud offers web analytics.
- Terabytes of data, thousands of servers.

Motivation

- Adobe Marketing Cloud offers web analytics.
- Terabytes of data, thousands of servers.
- Trending general-purpose distributed data processing engines.

Motivation

- Adobe Marketing Cloud offers web analytics.
- Terabytes of data, thousands of servers.
- Trending general-purpose distributed data processing engines.
  - Apache Spark

Motivation

- Adobe Marketing Cloud offers web analytics.
- Terabytes of data, thousands of servers.
- Trending general-purpose distributed data processing engines.
  - Apache Spark
  - Cloudera Impala

Motivation

- Adobe Marketing Cloud offers web analytics.
- Terabytes of data, thousands of servers.
- Trending general-purpose distributed data processing engines.
    - Apache Spark
    - Cloudera Impala
    - Google Dremel

Motivation

- Adobe Marketing Cloud offers web analytics.
- Terabytes of data, thousands of servers.
- Trending general-purpose distributed data processing engines.
  - Apache Spark
  - Cloudera Impala
  - Google Dremel
- **Spindle** is an early investigation of the feasibility of Apache Spark for web analytics

Motivation

- Ideal Spark features

Motivation

- Ideal Spark features
  - In-memory caching

Motivation

- Ideal Spark features
  - In-memory caching
  - Lineage

Motivation

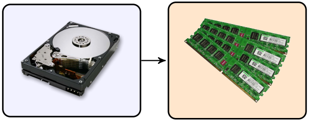
- Ideal Spark features
  - In-memory caching
  - Lineage

Motivation

- Ideal Spark features
  - In-memory caching
  - Lineage

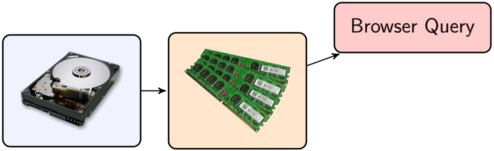
Motivation

- Ideal Spark features
  - In-memory caching
  - Lineage



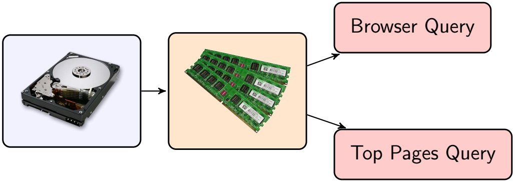
Motivation

- Ideal Spark features
  - In-memory caching
  - Lineage



Motivation

- Ideal Spark features
  - In-memory caching
  - Lineage



- **Problem:** Current performance studies do not show Spark's performance for interactive web analytics application.

Spindle Architecture

Overview.

What is Spindle?

Spindle Architecture

Overview.

What is Spindle?

```
http://server/query
```

Spindle Architecture

Overview.

What is Spindle?

Parameters:
Date Range
Spark Tuning Options

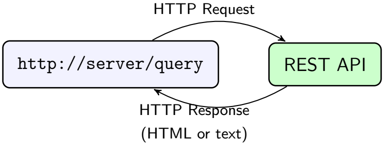
`http://server/query`

Spindle Architecture

Overview.

What is Spindle?

Parameters:
Date Range
Spark Tuning Options



HTTP Request

`http://server/query`

REST API

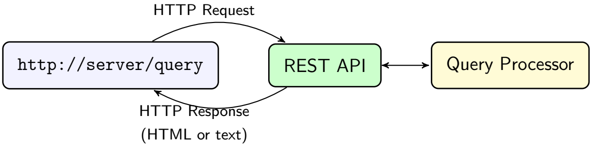
HTTP Response
(HTML or text)

Spindle Architecture

Overview.

What is Spindle?

Parameters:
Date Range
Spark Tuning Options

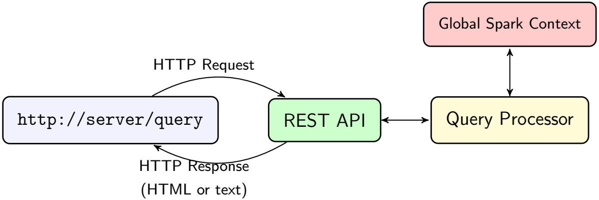


Spindle Architecture

Overview.

What is Spindle?

Parameters:
Date Range
Spark Tuning Options

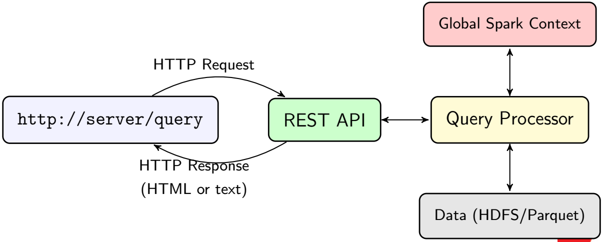


Spindle Architecture

Overview.

What is Spindle?

Parameters:
Date Range
Spark Tuning Options



HTTP Request

http://server/query

REST API

Query Processor

Global Spark Context

Data (HDFS/Parquet)

HTTP Response
(HTML or text)

Shorthand	Name
Q0	Pageviews

Shorthand	Name
Q0	Pageviews
Q1	Revenue

Shorthand	Name
Q0	Pageviews
Q1	Revenue
Q2	RevenueFromTopReferringDomains

Shorthand	Name
Q0	Pageviews
Q1	Revenue
Q2	RevenueFromTopReferringDomains
Q3	RevenueFromTopReferringDomainsFirstVisitGoogle

Shorthand	Name
Q0	Pageviews
Q1	Revenue
Q2	RevenueFromTopReferringDomains
Q3	RevenueFromTopReferringDomainsFirstVisitGoogle
Q4	TopPages

Shorthand	Name
Q0	Pageviews
Q1	Revenue
Q2	RevenueFromTopReferringDomains
Q3	RevenueFromTopReferringDomainsFirstVisitGoogle
Q4	TopPages
Q5	TopPagesByBrowser

Shorthand	Name
Q0	Pageviews
Q1	Revenue
Q2	RevenueFromTopReferringDomains
Q3	RevenueFromTopReferringDomainsFirstVisitGoogle
Q4	TopPages
Q5	TopPagesByBrowser
Q6	TopPagesByPreviousTopPages

Shorthand	Name
Q0	Pageviews
Q1	Revenue
Q2	RevenueFromTopReferringDomains
Q3	RevenueFromTopReferringDomainsFirstVisitGoogle
Q4	TopPages
Q5	TopPagesByBrowser
Q6	TopPagesByPreviousTopPages
Q7	TopReferringDomains

Shorthand	Name
Q0	Pageviews
Q1	Revenue
Q2	RevenueFromTopReferringDomains
Q3	RevenueFromTopReferringDomainsFirstVisitGoogle
Q4	TopPages
Q5	TopPagesByBrowser
Q6	TopPagesByPreviousTopPages
Q7	TopReferringDomains

	Q0	Q1	Q2	Q3	Q4	Q5	Q6	Q7

Shorthand	Name
Q0	Pageviews
Q1	Revenue
Q2	RevenueFromTopReferringDomains
Q3	RevenueFromTopReferringDomainsFirstVisitGoogle
Q4	TopPages
Q5	TopPagesByBrowser
Q6	TopPagesByPreviousTopPages
Q7	TopReferringDomains

	Q0	Q1	Q2	Q3	Q4	Q5	Q6	Q7
post_pagename	×				×	×	×	

Shorthand	Name
Q0	Pageviews
Q1	Revenue
Q2	RevenueFromTopReferringDomains
Q3	RevenueFromTopReferringDomainsFirstVisitGoogle
Q4	TopPages
Q5	TopPagesByBrowser
Q6	TopPagesByPreviousTopPages
Q7	TopReferringDomains

	Q0	Q1	Q2	Q3	Q4	Q5	Q6	Q7
post_pagename	×				×	×	×	
user_agent						×		

Shorthand	Name
Q0	Pageviews
Q1	Revenue
Q2	RevenueFromTopReferringDomains
Q3	RevenueFromTopReferringDomainsFirstVisitGoogle
Q4	TopPages
Q5	TopPagesByBrowser
Q6	TopPagesByPreviousTopPages
Q7	TopReferringDomains

	Q0	Q1	Q2	Q3	Q4	Q5	Q6	Q7
post_pagename	×				×	×	×	
user_agent						×		
visit_referrer			×	×				

Shorthand	Name
Q0	Pageviews
Q1	Revenue
Q2	RevenueFromTopReferringDomains
Q3	RevenueFromTopReferringDomainsFirstVisitGoogle
Q4	TopPages
Q5	TopPagesByBrowser
Q6	TopPagesByPreviousTopPages
Q7	TopReferringDomains

	Q0	Q1	Q2	Q3	Q4	Q5	Q6	Q7
post_pagename	×				×	×	×	
user_agent						×		
visit_referrer			×	×				
post_visid_high			×	×			×	×

Shorthand	Name
Q0	Pageviews
Q1	Revenue
Q2	RevenueFromTopReferringDomains
Q3	RevenueFromTopReferringDomainsFirstVisitGoogle
Q4	TopPages
Q5	TopPagesByBrowser
Q6	TopPagesByPreviousTopPages
Q7	TopReferringDomains

	Q0	Q1	Q2	Q3	Q4	Q5	Q6	Q7
post_pagename	×				×	×	×	
user_agent						×		
visit_referrer			×	×				
post_visid_high			×	×			×	×
post_visid_low			×	×			×	×

Shorthand	Name
Q0	Pageviews
Q1	Revenue
Q2	RevenueFromTopReferringDomains
Q3	RevenueFromTopReferringDomainsFirstVisitGoogle
Q4	TopPages
Q5	TopPagesByBrowser
Q6	TopPagesByPreviousTopPages
Q7	TopReferringDomains

	Q0	Q1	Q2	Q3	Q4	Q5	Q6	Q7
post_pagename	×				×	×	×	
user_agent						×		
visit_referrer			×	×				
post_visid_high			×	×			×	×
post_visid_low			×	×			×	×
visit_num			×	×			×	×

Shorthand	Name
Q0	Pageviews
Q1	Revenue
Q2	RevenueFromTopReferringDomains
Q3	RevenueFromTopReferringDomainsFirstVisitGoogle
Q4	TopPages
Q5	TopPagesByBrowser
Q6	TopPagesByPreviousTopPages
Q7	TopReferringDomains

	Q0	Q1	Q2	Q3	Q4	Q5	Q6	Q7
post_pagename	×				×	×	×	
user_agent						×		
visit_referrer			×	×				
post_visid_high			×	×			×	×
post_visid_low			×	×			×	×
visit_num			×	×			×	×
visit_referrer								×

Shorthand	Name
Q0	Pageviews
Q1	Revenue
Q2	RevenueFromTopReferringDomains
Q3	RevenueFromTopReferringDomainsFirstVisitGoogle
Q4	TopPages
Q5	TopPagesByBrowser
Q6	TopPagesByPreviousTopPages
Q7	TopReferringDomains

	Q0	Q1	Q2	Q3	Q4	Q5	Q6	Q7
post_pagename	×				×	×	×	
user_agent						×		
visit_referrer			×	×				
post_visid_high			×	×			×	×
post_visid_low			×	×			×	×
visit_num			×	×			×	×
visit_referrer								×
hit_time_gmt							×	

Shorthand	Name
Q0	Pageviews
Q1	Revenue
Q2	RevenueFromTopReferringDomains
Q3	RevenueFromTopReferringDomainsFirstVisitGoogle
Q4	TopPages
Q5	TopPagesByBrowser
Q6	TopPagesByPreviousTopPages
Q7	TopReferringDomains

	Q0	Q1	Q2	Q3	Q4	Q5	Q6	Q7
post_pagename	×				×	×	×	
user_agent						×		
visit_referrer			×	×				
post_visid_high			×	×			×	×
post_visid_low			×	×			×	×
visit_num			×	×			×	×
visit_referrer								×
hit_time_gmt							×	
post_purchaseid		×	×	×				

Shorthand	Name
Q0	Pageviews
Q1	Revenue
Q2	RevenueFromTopReferringDomains
Q3	RevenueFromTopReferringDomainsFirstVisitGoogle
Q4	TopPages
Q5	TopPagesByBrowser
Q6	TopPagesByPreviousTopPages
Q7	TopReferringDomains

	Q0	Q1	Q2	Q3	Q4	Q5	Q6	Q7
post_pagename	×				×	×	×	
user_agent						×		
visit_referrer			×	×				
post_visid_high			×	×			×	×
post_visid_low			×	×			×	×
visit_num			×	×			×	×
visit_referrer								×
hit_time_gmt							×	
post_purchaseid		×	×	×				
post_product_list		×	×	×				

Shorthand	Name
Q0	Pageviews
Q1	Revenue
Q2	RevenueFromTopReferringDomains
Q3	RevenueFromTopReferringDomainsFirstVisitGoogle
Q4	TopPages
Q5	TopPagesByBrowser
Q6	TopPagesByPreviousTopPages
Q7	TopReferringDomains

	Q0	Q1	Q2	Q3	Q4	Q5	Q6	Q7
post_pagename	×				×	×	×	
user_agent						×		
visit_referrer			×	×				
post_visid_high			×	×			×	×
post_visid_low			×	×			×	×
visit_num			×	×			×	×
visit_referrer								×
hit_time_gmt							×	
post_purchaseid		×	×	×				
post_product_list		×	×	×				
first_hit_referrer				×				

Spindle Architecture

Queries.

- Demo: `http://adobe-research.github.io/spindle/`

Spindle Architecture

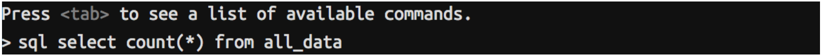
Ad hoc queries.

- Spark SQL processes relational queries.

Spindle Architecture

Ad hoc queries.

- Spark SQL processes relational queries.

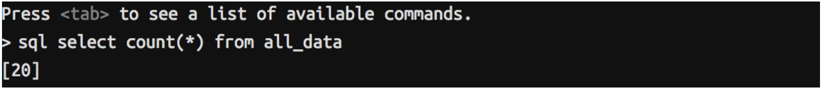


```
Press <tab> to see a list of available commands.
> sql select count(*) from all_data
```

Spindle Architecture

Ad hoc queries.

- Spark SQL processes relational queries.

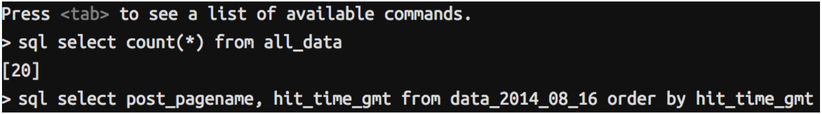


```
Press <tab> to see a list of available commands.
> sql select count(*) from all_data
[20]
```

Spindle Architecture

Ad hoc queries.

- Spark SQL processes relational queries.

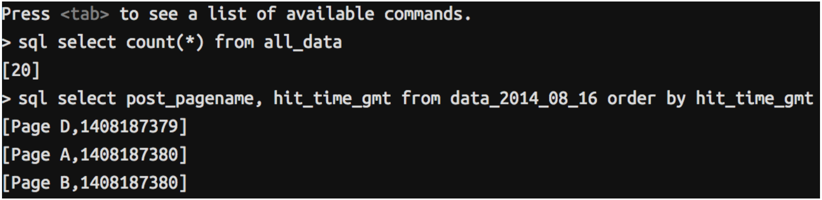


```
Press <tab> to see a list of available commands.
> sql select count(*) from all_data
[20]
> sql select post_pagename, hit_time_gmt from data_2014_08_16 order by hit_time_gmt
```

Spindle Architecture

Ad hoc queries.

- Spark SQL processes relational queries.



```
Press <tab> to see a list of available commands.
> sql select count(*) from all_data
[20]
> sql select post_pagename, hit_time_gmt from data_2014_08_16 order by hit_time_gmt
[Page D,1408187379]
[Page A,1408187380]
[Page B,1408187380]
```

Empirical Results

Caching.

- Six cluster nodes, Spark and HDFS on each.

Empirical Results

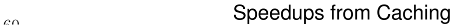
Caching.

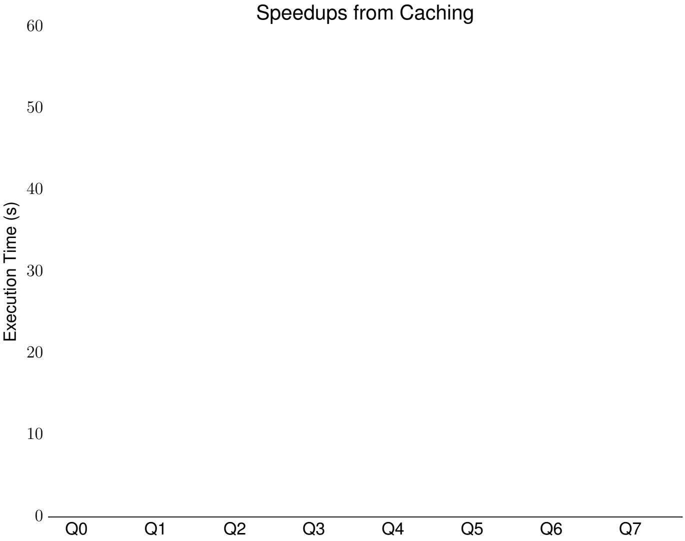
- Six cluster nodes, Spark and HDFS on each.
- 13.1GB of data.

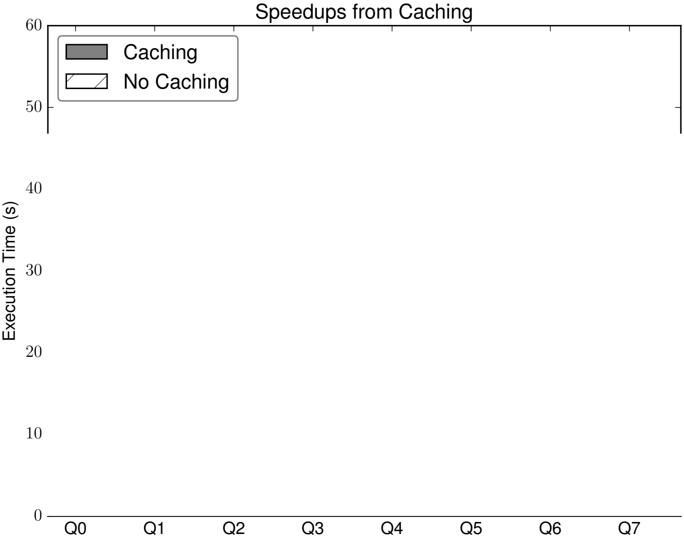
Empirical Results

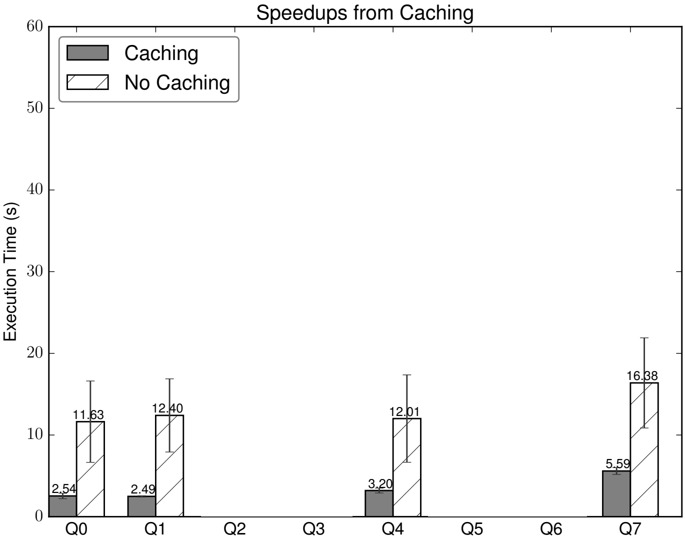
Caching.

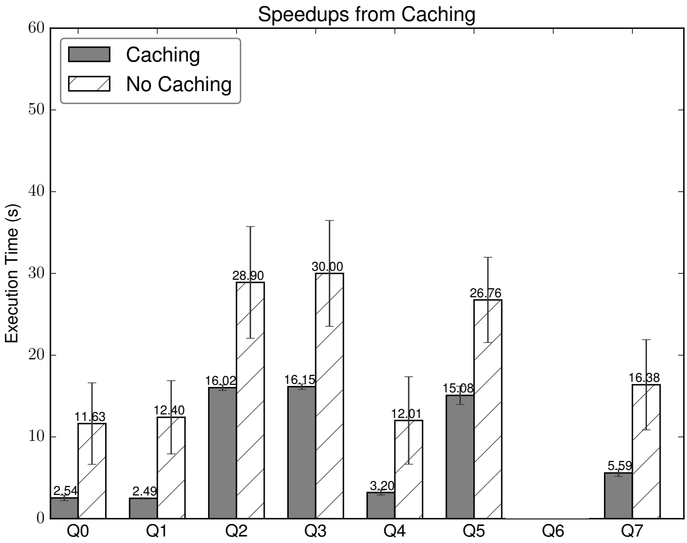
- Six cluster nodes, Spark and HDFS on each.
- 13.1GB of data.
- **Question:** How does caching in-memory improve performance?

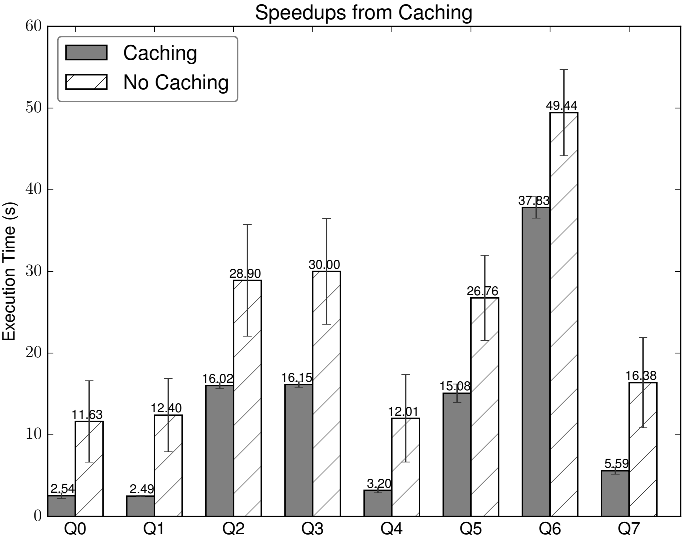

Speedups from Caching


Speedups from Caching
Execution Time (s)
60
50
40
30
20
10
0
Q0
Q1
Q2
Q3
Q4
Q5
Q6
Q7


Speedups from Caching
Caching
No Caching
Execution Time (s)
60
50
40
30
20
10
0
Q0
Q1
Q2
Q3
Q4
Q5
Q6
Q7


Speedups from Caching
Caching
No Caching
Execution Time (s)
60
50
40
30
20
10
0
Q0
Q1
Q2
Q3
Q4
Q5
Q6
Q7
2.54
11.63
2.49
12.40
3.20
12.01
5.59
16.38


Speedups from Caching
Caching
No Caching
Execution Time (s)
0
10
20
30
40
50
60
Q0
Q1
Q2
Q3
Q4
Q5
Q6
Q7
2.54
11.63
2.49
12.40
16.02
28.90
16.15
30.00
3.20
12.01
15.08
26.76
5.59
16.38


Speedups from Caching
Caching
No Caching
Execution Time (s)
0
10
20
30
40
50
60
Q0
Q1
Q2
Q3
Q4
Q5
Q6
Q7
2.54
11.63
2.49
12.40
16.02
28.90
16.15
30.00
3.20
12.01
15.08
26.76
37.83
49.44
5.59
16.38

Empirical Results

Benchmarking concurrent queries.

- How much will Spindle's performance degrade if multiple users are utilizing it at the same time?

Empirical Results

Benchmarking concurrent queries.

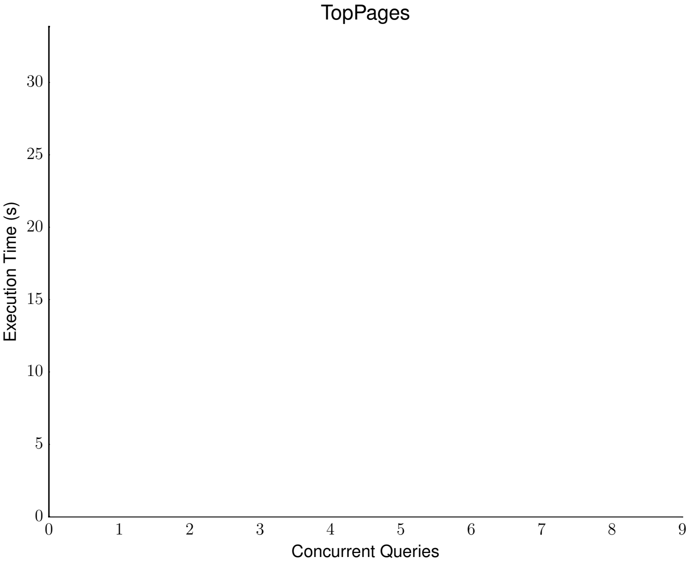
- How much will Spindle's performance degrade if multiple users are utilizing it at the same time?
- Concurrently call a single query on the same data.

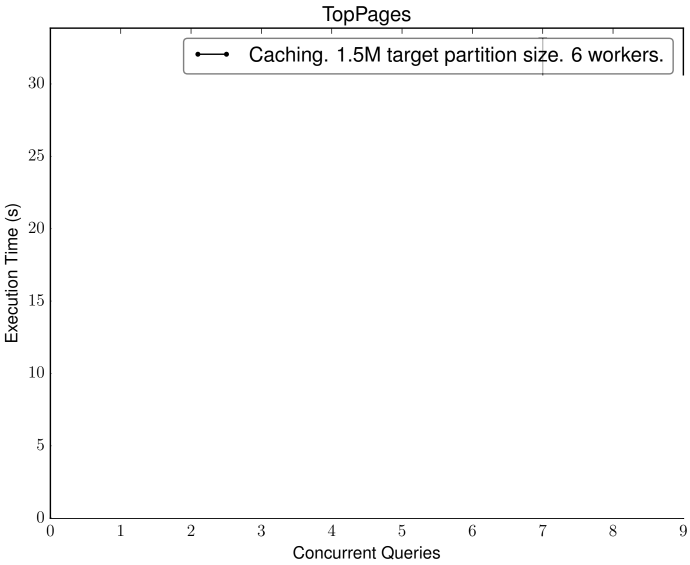
Empirical Results

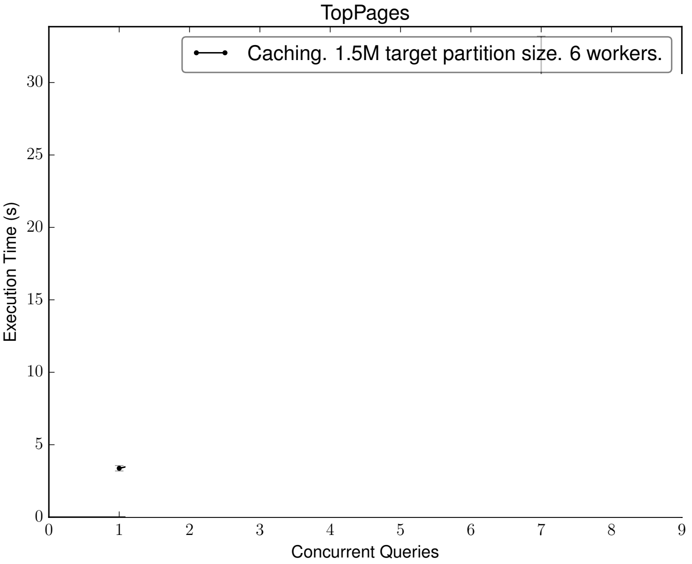
Benchmarking concurrent queries.

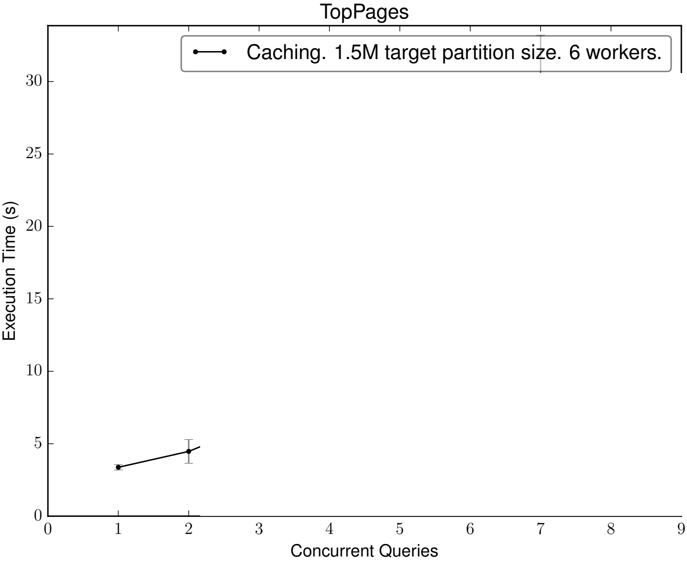
- How much will Spindle's performance degrade if multiple users are utilizing it at the same time?
- Concurrently call a single query on the same data.
- Average the execution time.

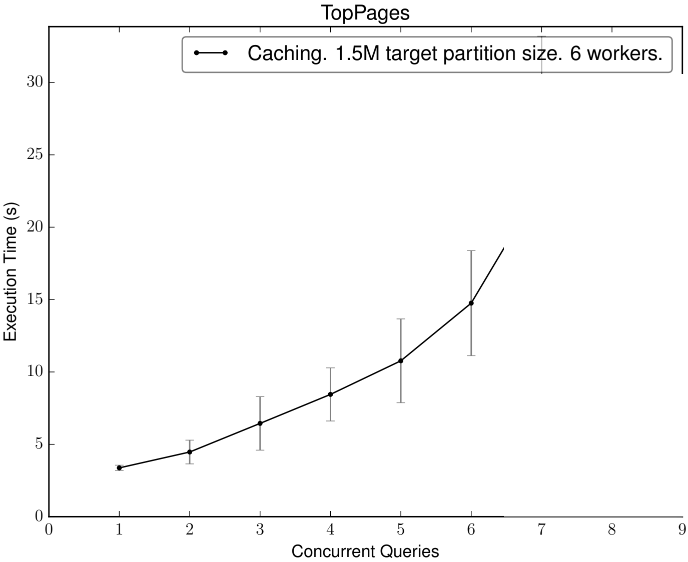
TopPages

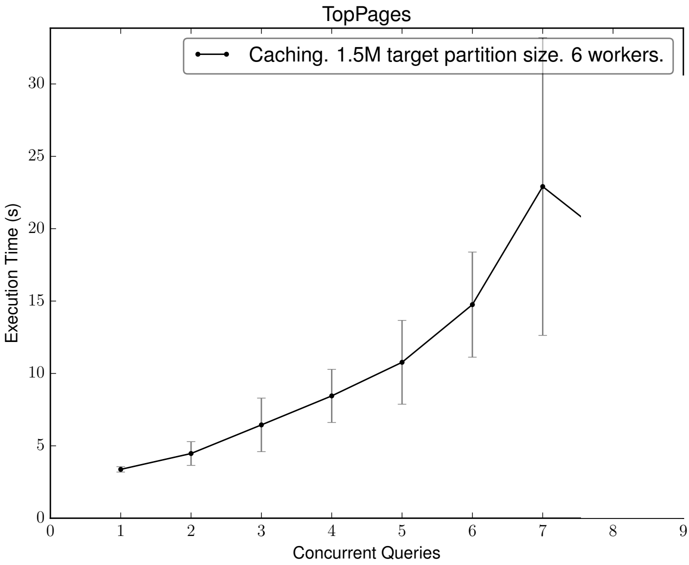

TopPages
Execution Time (s)
0
5
10
15
20
25
30
0
1
2
3
4
5
6
7
8
9
Concurrent Queries

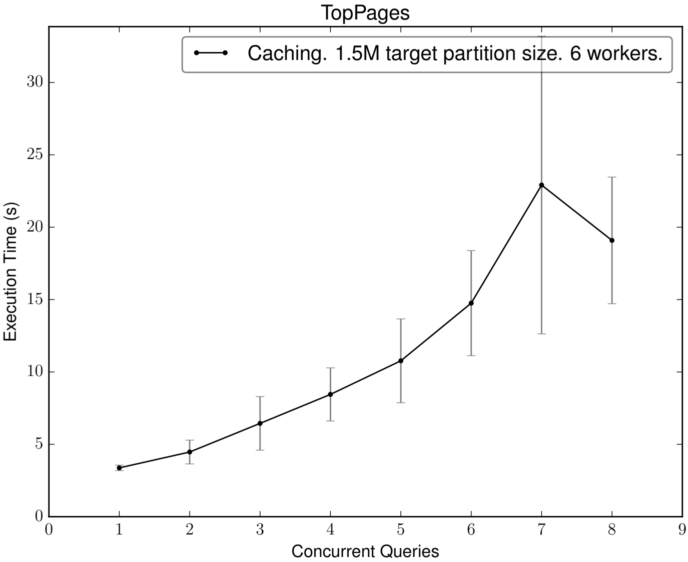

TopPages
●—● Caching. 1.5M target partition size. 6 workers.
Execution Time (s)
0
5
10
15
20
25
30
Concurrent Queries
0
1
2
3
4
5
6
7
8
9


TopPages
Caching. 1.5M target partition size. 6 workers.
Execution Time (s)
0
5
10
15
20
25
30
Concurrent Queries
0
1
2
3
4
5
6
7
8
9

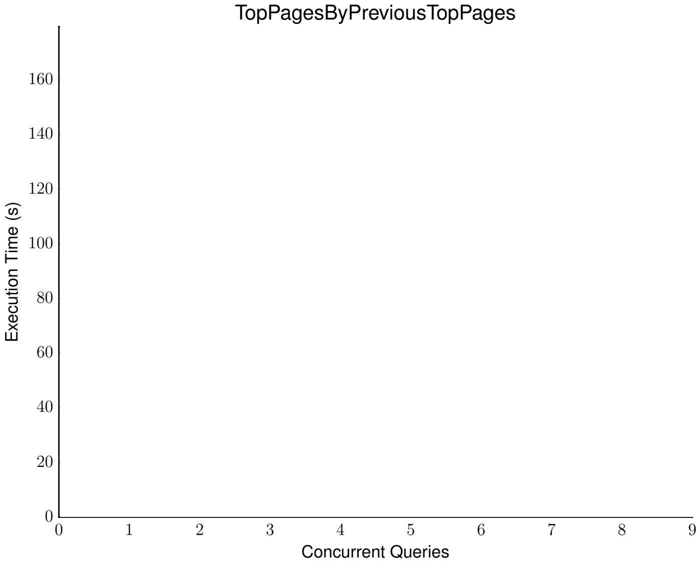

TopPages
Caching. 1.5M target partition size. 6 workers.
Execution Time (s)
0
5
10
15
20
25
30
Concurrent Queries
0
1
2
3
4
5
6
7
8
9

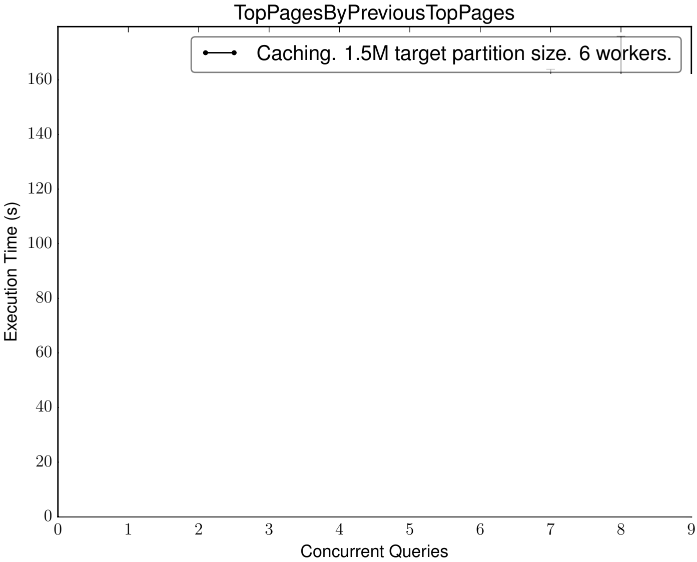

TopPages
Caching. 1.5M target partition size. 6 workers.
Execution Time (s)
0
5
10
15
20
25
30
Concurrent Queries
0
1
2
3
4
5
6
7
8
9

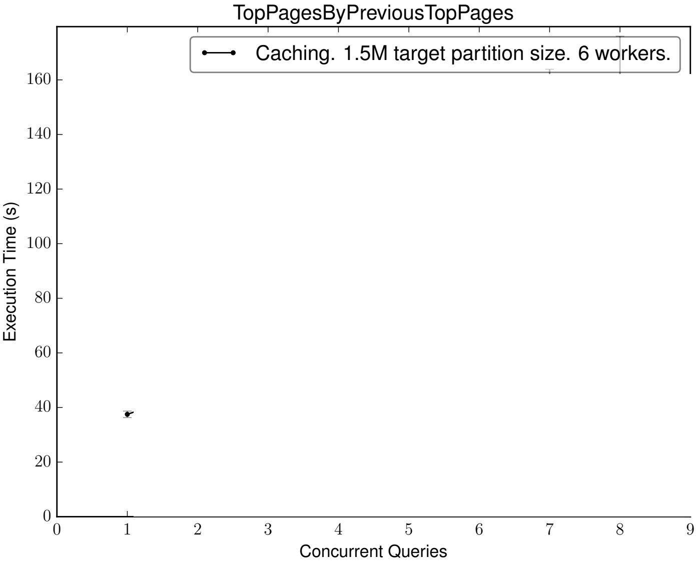

TopPages
Caching. 1.5M target partition size. 6 workers.
Execution Time (s)
0
5
10
15
20
25
30
Concurrent Queries
0
1
2
3
4
5
6
7
8
9

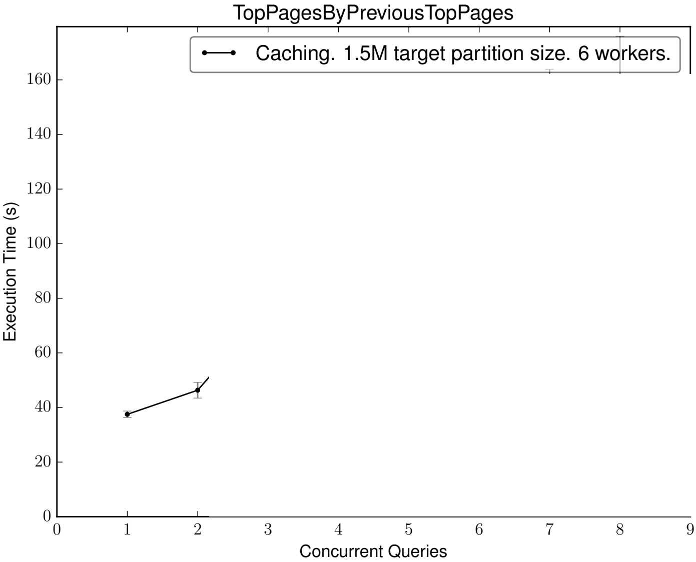

TopPages
Caching. 1.5M target partition size. 6 workers.
Execution Time (s)
0
5
10
15
20
25
30
Concurrent Queries
0
1
2
3
4
5
6
7
8
9

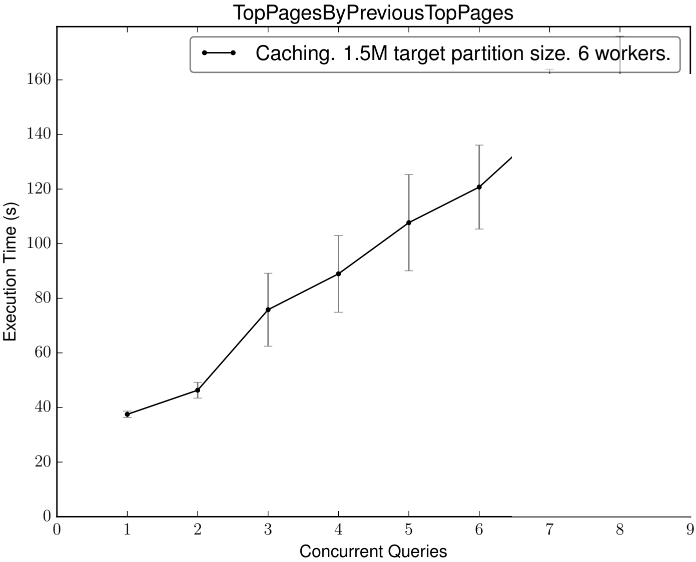
TopPagesByPreviousTopPages

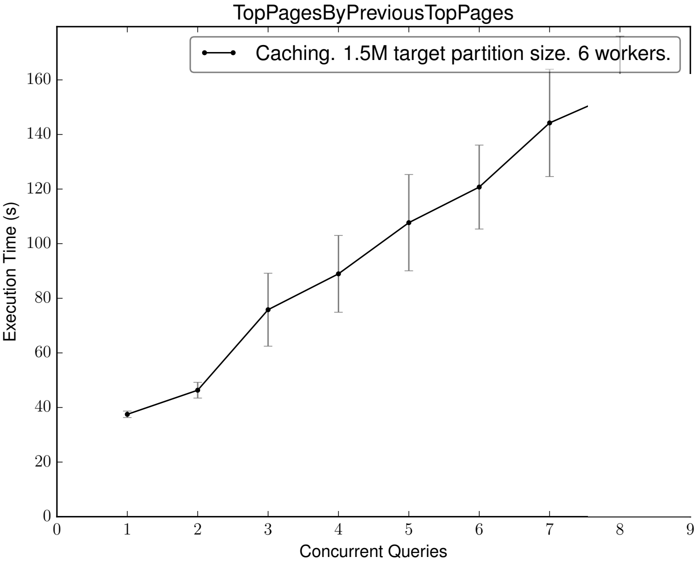

TopPagesByPreviousTopPages
Execution Time (s)
0
20
40
60
80
100
120
140
160
Concurrent Queries
0
1
2
3
4
5
6
7
8
9

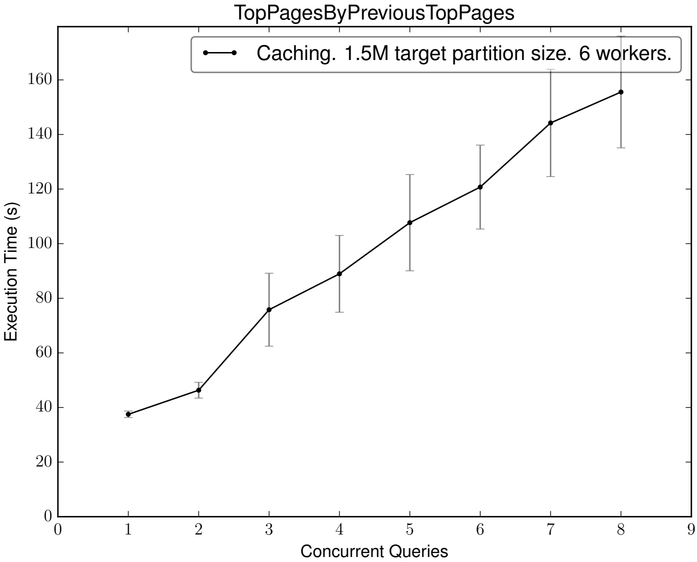

TopPagesByPreviousTopPages
Caching. 1.5M target partition size. 6 workers.
Execution Time (s)
0
20
40
60
80
100
120
140
160
Concurrent Queries
0
1
2
3
4
5
6
7
8
9


TopPagesByPreviousTopPages
Caching. 1.5M target partition size. 6 workers.
Execution Time (s)
0
20
40
60
80
100
120
140
160
Concurrent Queries
0
1
2
3
4
5
6
7
8
9


TopPagesByPreviousTopPages
Caching. 1.5M target partition size. 6 workers.
Execution Time (s)
0
20
40
60
80
100
120
140
160
Concurrent Queries
0
1
2
3
4
5
6
7
8
9


TopPagesByPreviousTopPages
Caching. 1.5M target partition size. 6 workers.
Execution Time (s)
Concurrent Queries
0
20
40
60
80
100
120
140
160
0
1
2
3
4
5
6
7
8
9


TopPagesByPreviousTopPages
Caching. 1.5M target partition size. 6 workers.
Execution Time (s)
0
20
40
60
80
100
120
140
160
Concurrent Queries
0
1
2
3
4
5
6
7
8
9


TopPagesByPreviousTopPages
Caching. 1.5M target partition size. 6 workers.
Execution Time (s)
0
20
40
60
80
100
120
140
160
Concurrent Queries
0
1
2
3
4
5
6
7
8
9

Empirical Results

Remaining.

- Scaling Spark and HDFS workers.

Empirical Results

Remaining.

- Scaling Spark and HDFS workers.
- Intermediate data partitioning.

Conclusions

- Spark is a good candidate for real-time analytics processing.

Conclusions

- Spark is a good candidate for real-time analytics processing.
- **Spindle** is an open-source prototype analytics processing engine.

Conclusions

- Spark is a good candidate for real-time analytics processing.
- **Spindle** is an open-source prototype analytics processing engine.
    - Sample set of web analytics queries.

Conclusions

- Spark is a good candidate for real-time analytics processing.
- **Spindle** is an open-source prototype analytics processing engine.
    - Sample set of web analytics queries.
    - REST-based interface to tune parameters.

Conclusions

- Spark is a good candidate for real-time analytics processing.
- **Spindle** is an open-source prototype analytics processing engine.
  - Sample set of web analytics queries.
  - REST-based interface to tune parameters.
- Spindle's future work is on preprocessing.

Conclusions

- Spark is a good candidate for real-time analytics processing.
- **Spindle** is an open-source prototype analytics processing engine.
  - Sample set of web analytics queries.
  - REST-based interface to tune parameters.
- Spindle's future work is on preprocessing.

Conclusions

- Spark is a good candidate for real-time analytics processing.
- **Spindle** is an open-source prototype analytics processing engine.
  - Sample set of web analytics queries.
  - REST-based interface to tune parameters.
- Spindle's future work is on preprocessing.

Spindle Project	`http://github.com/adobe-research/spindle`
Brandon Amos	`http://github.com/bamos`
David Tompkins	`http://github.com/DavidTompkins`