BlinkDB: Queries with Bounded Error and Bounded Response Times on Very Large Data

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Presented by Liqi Xu

Problem: very large data

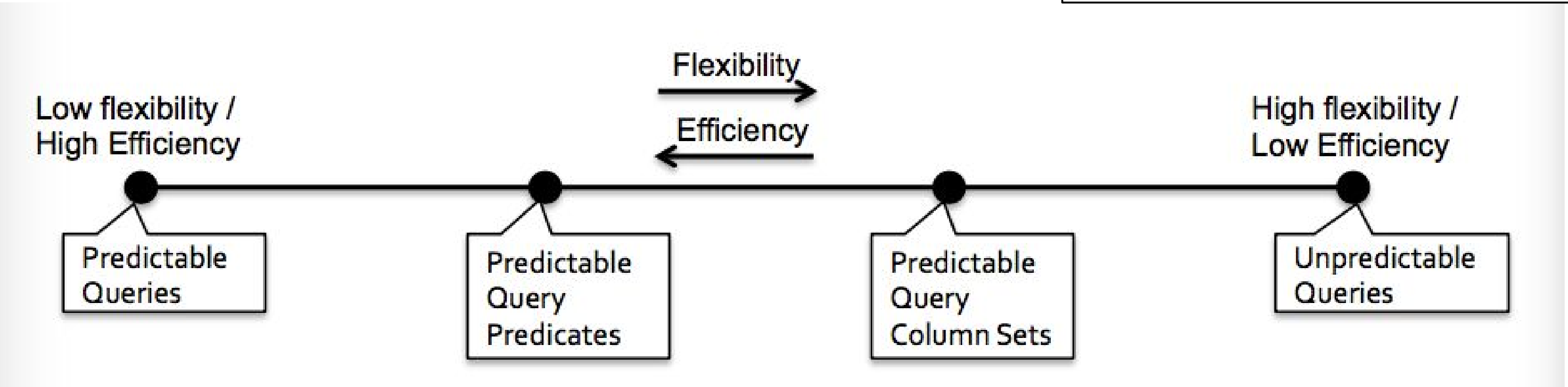
```
SELECT AVG(SessionTime)

FROM Sessions

WHERE City  = ‘New York’
```

- 100 million tuples for ‘New York’
- Problem:
    - High cost in execution *time* and *space*
- Idea: trade *result accuracy* for *response time and space*
- Sampling:
    - 10,000 tuples for ‘New York ’
    - return an approximate result (with error bound)
        - E.g. appox. avg 234.23 ± 5.32

Problems: approx. techniques

```
SELECT AVG(SessionTime)
FROM Sessions
WHERE City  = 'New York'
```

efficiency v.s. *flexibility* of the queries



All future queries are known in advance

Frequencies of group and filter predicates do not change over time

Frequencies of **set of columns used for** group and filter predicates do not change over time

No future queries are known in advance

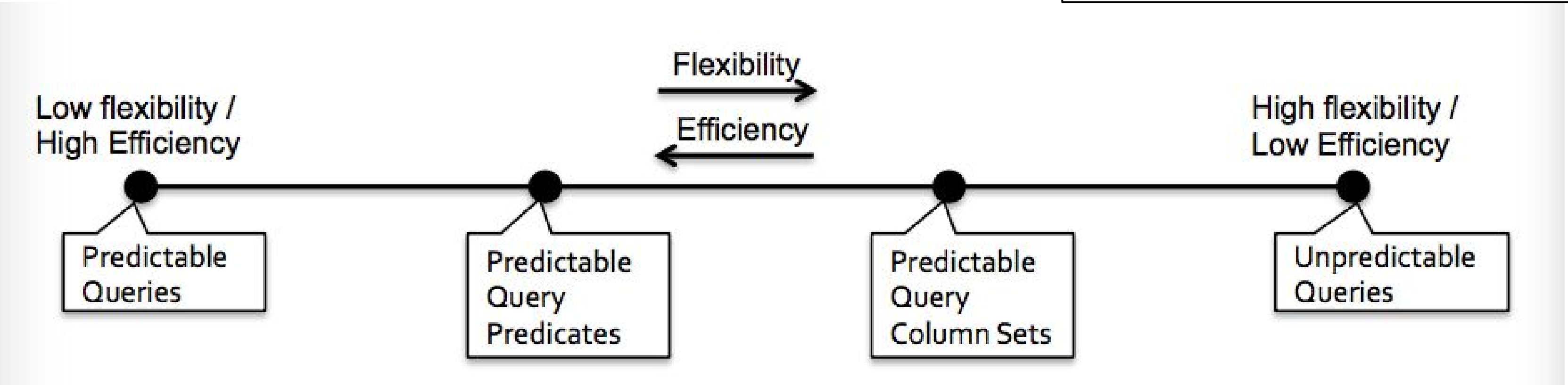
Problems: approx. techniques

SELECT AVG(SessionTime)

FROM Sessions

WHERE City = 'Urbana'

efficiency v.s. *flexibility* of the queries



All future queries are known in advance

Frequencies of group and filter predicates do not change over time

Frequencies of **set of columns used for** group and filter predicates do not change over time

No future queries are known in advance

'current' sampling

Online Aggregation

BlinkDB

- “a distributed sampling-based approximate query processing system”
- Efficient
  - ~TBs data in seconds
  - with meaningful error bounds

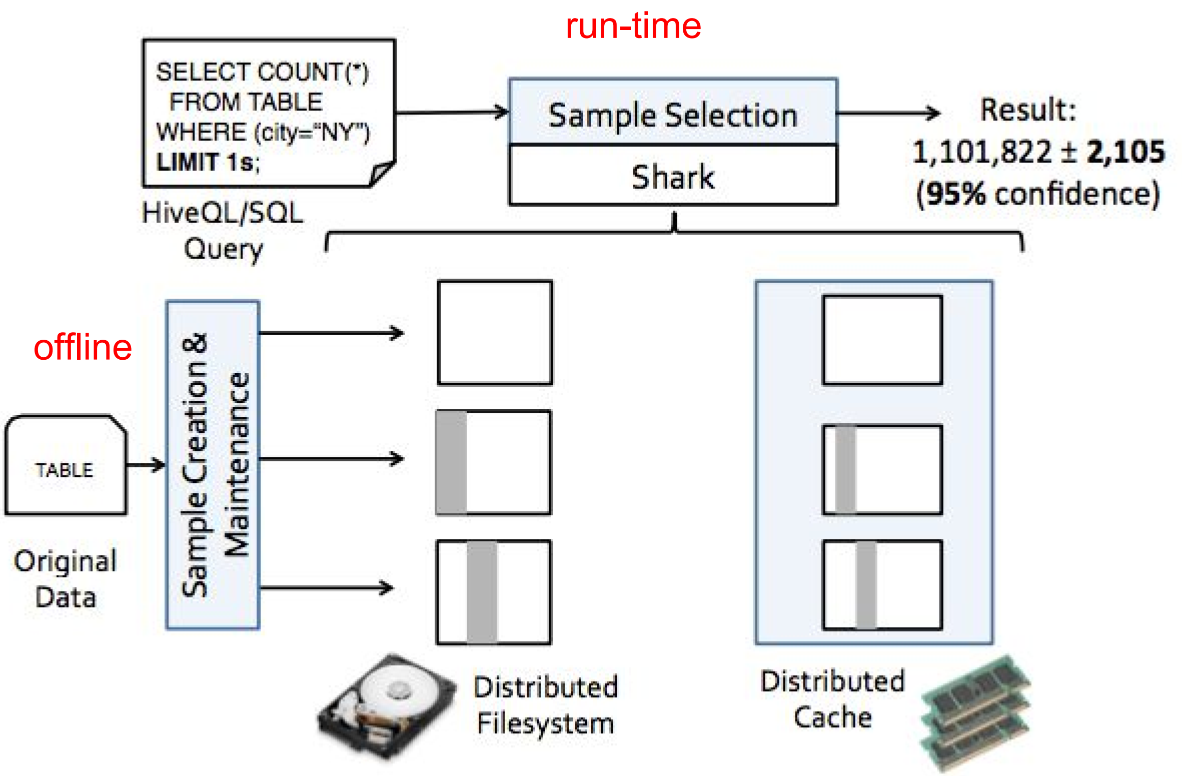
```
SELECT COUNT(*)
FROM Sessions
WHERE Genre = ‘western’
GROUP BY OS
ERROR WITHIN 10% AT CONFIDENCE 95%
```

```
SELECT COUNT(*)
FROM Sessions
WHERE Genere = ‘western’
GROUP BY OS
WITHIN 5 SECONDS
```

BlinkDB

- "a distributed sampling-based approximate query processing system"
- Efficient
  - ~TBs data in seconds
  - with meaningful error bounds
- More general queries
  - Only assumption:
    - *"query column sets"* (QCSs) are *stable*
    - QCSs: columns used for grouping and filtering (ie. in WHERE, GROUP BY, and HAVING)

BlinkDB Architecture



Sample creation

- Construct stratified samples

Problem with Uniform Samples

1. higher possibility of missing under-representing groups

```
SELECT AVG(SessionTime)
FROM Sessions
WHERE City = ‘Urbana’’
```

ID	City	Age	Session_Time
1	NYC	20	212
2	Urbana	40	532
3	NYC	30	243
4	Urbana	40	291
5	NYC	20	453
6	NYC	30	293

Sampling_rate = ⅓

ID	City	Age	Session_Time
3	NYC	30	243
5	NYC	20	453

Problem with Uniform Samples

1. higher possibility of missing under-representing groups
2. Error of each aggregate is NOT equal

ID	City	Age	Session_Time
1	NYC	20	212
2	Urbana	40	532
3	NYC	30	243
4	Urbana	40	291
5	NYC	20	453
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Sampling_rate = ⅔

ID	City	Age	Session_Time
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Stratified Samples (on *City*)

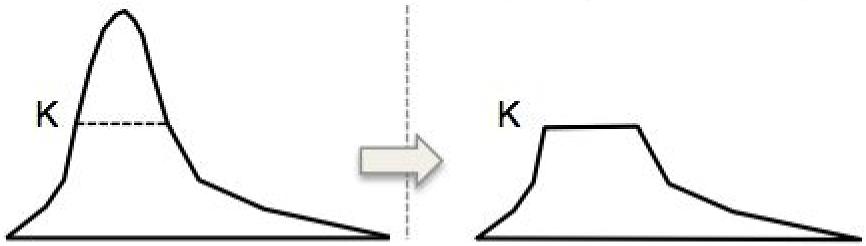
ID	City	Age	Session_Time
1	NYC	20	212
2	Urbana	40	532
3	NYC	30	243
4	Urbana	40	291
5	NYC	20	453
6	NYC	30	293

Sampling_rate(NYC) = 1/4
Sampling_rate(Urbana) = 1/2

ID	City	Age	Session_Time
3	NYC	30	243
4	Urbana	40	291

Assign equal sample size to each groups

Stratified Samples (on *City*)



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Sampling_rate(NYC) = 3/4
Sampling_rate(Urbana) = 2/2

ID	City	Age	Session_Time
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Storage cost of stratified samples

- Build several multi-dimensional stratified samples
  - increase query accuracy and latency
- n columns ⟶ 2^n possible stratified samples

ID	City	Age	Session_Time
1	NYC	20	212
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[City]
[Age]
[Session_Time]
[City, Age]
[City, Session_Time]
[Age, Session_Time]
[City, Age, Session_Time]

Storage cost of stratified samples

- Build several multi-dimensional stratified samples
  - increase query accuracy and latency
- n columns ⟶ 2^n possible stratified samples
- Solution:
  - Find subsets of column sets that maximize the weighted sum of coverage of the QCSs of the queries q_j

Optimization formulation

probability of a query type in workload

Coverage probability of each query type

Maximize $G = \sum_j p_j \cdot y_j \cdot \Delta(q_j, M)$

Sparsity of the data

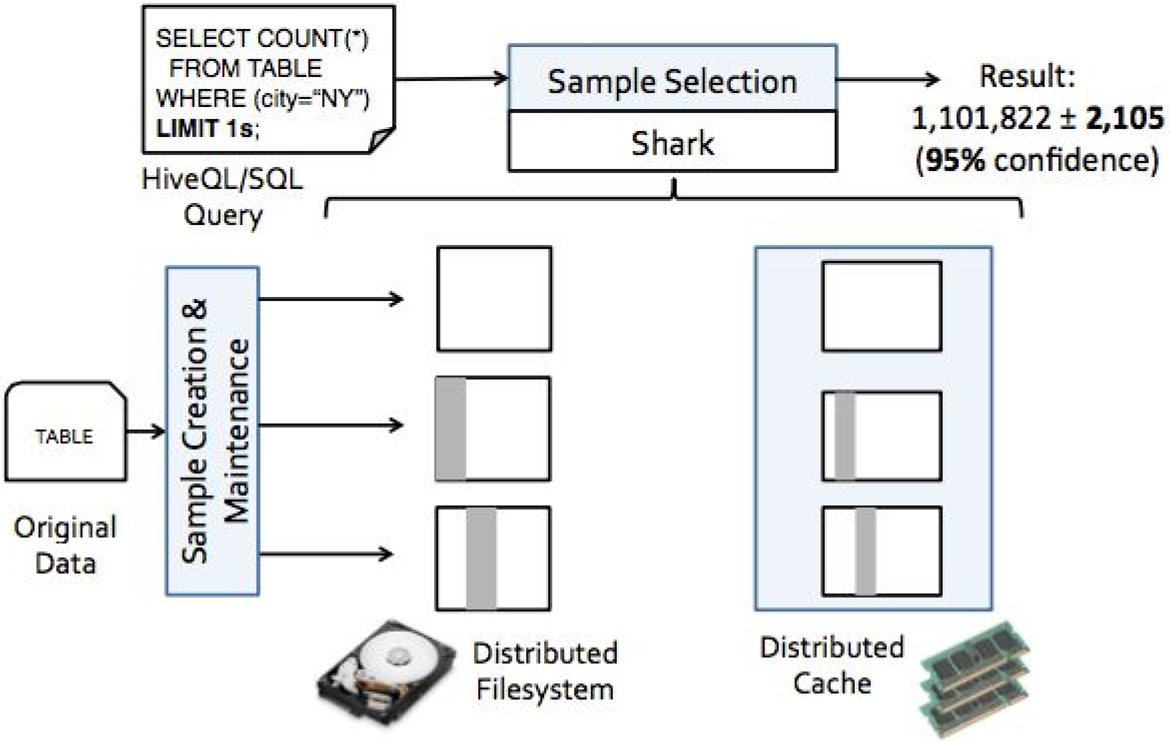
subject to

$$\sum_{i=1}^{m} |S(\phi_i, K)| \cdot z_i \leq \mathbb{C}$$

Overall storage capacity budget

storage cost of all samples

System Overview

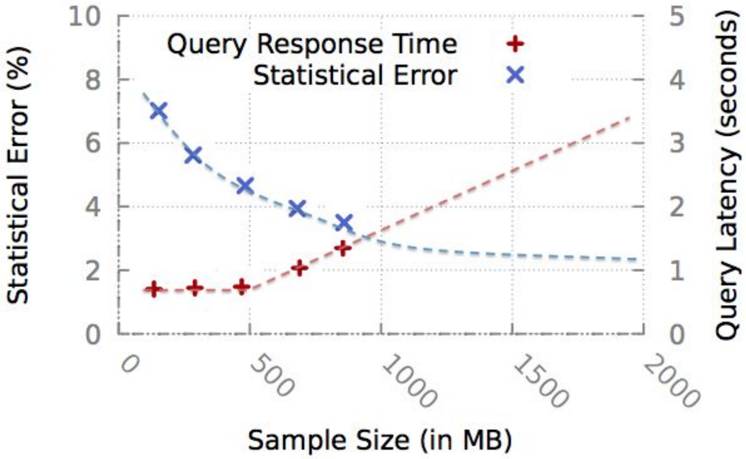


Online sample selection

- Given a Query Q with specified time/error constraints
    - BlinkDB generate different query plans for the same query Q
- How to pick the plan that best satisfies the time/error constraints?

Strategy

- Select appropriate sample(s)
- execute the query Q on small samples of those appropriate samples(s), in order to gather statistics about
  - query’s selectivity
  - complexity
  - underlying distribution of its query
- For each candidate sample
  - construct an *Error Latency Profile* (ELP)
  - statistically predict for larger samples



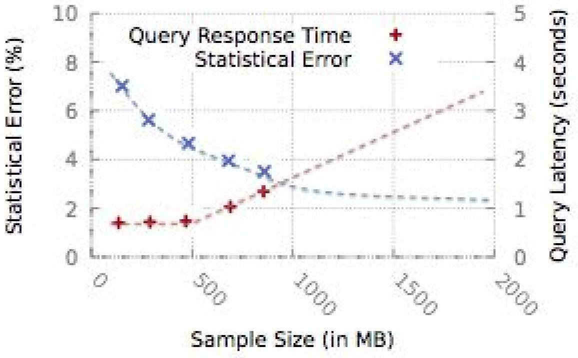
Example

SELECT AVG(SessionTime)

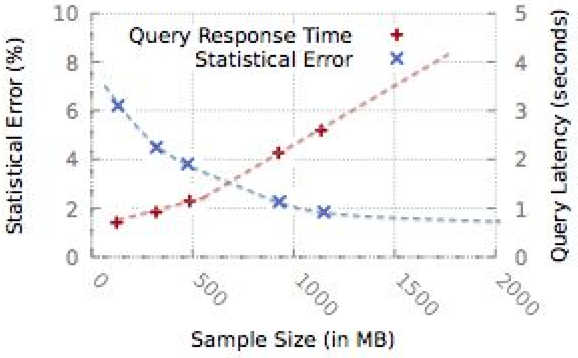
FROM Sessions

WHERE City = Galena'

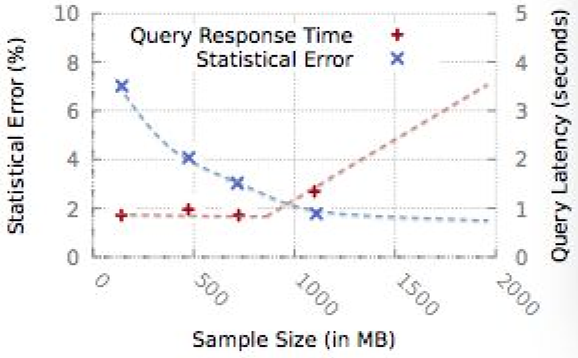
- System has 3 stratified samples
  - [date, country]
  - [date designated media area for a video
  - [date, ended_flag]
- Construct an ELP for each of the samples



(a) dt, country



(b) dt, dma



(c) dt, ended_flag

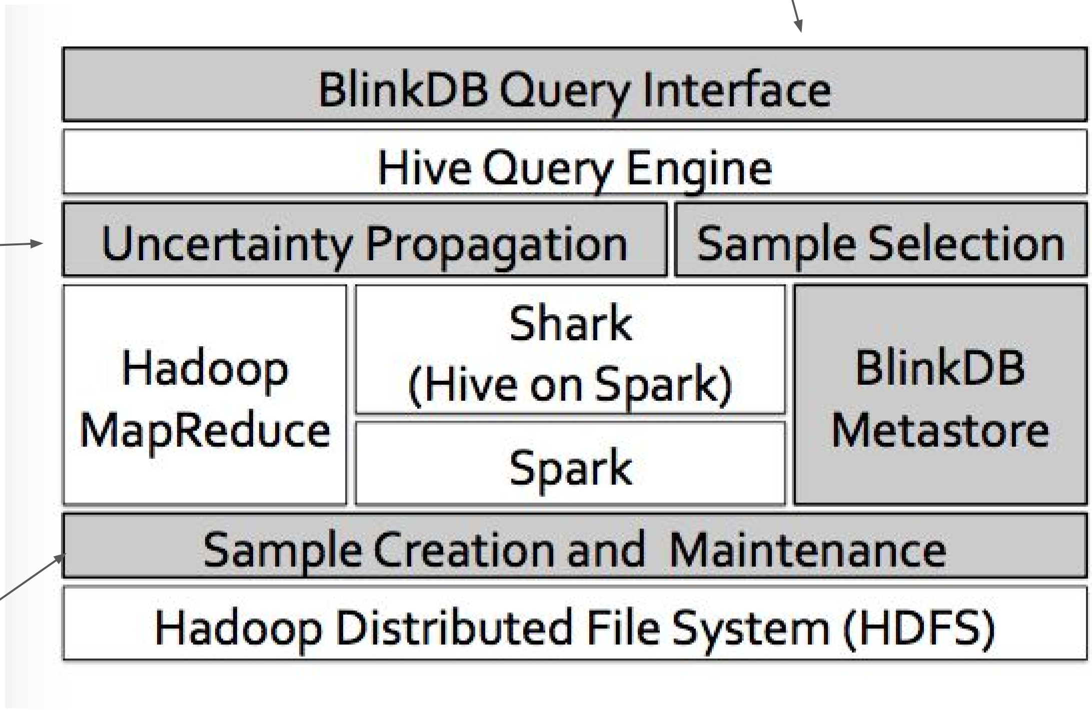
Implementation

enable queries with response time and error bounds

return error bars and confidence interval

assign query sized samples iteratively

create/update the set of random and multi-dimensional samples

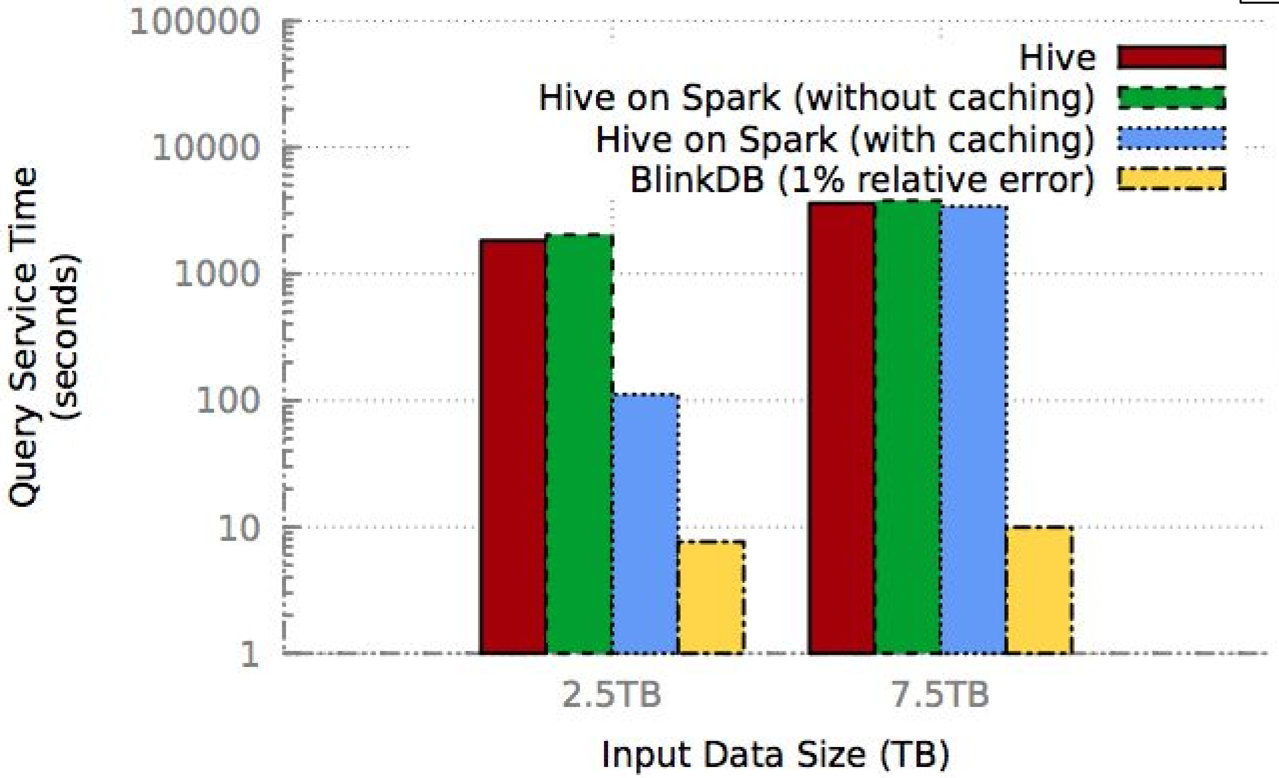


Evaluation Setting

- Conviva Workload
  - 17 TB in size
  - log of media accessed by Conviva users across 30 days
  - A sige big fact table with ~ 5.5 billion rows & 104 columns
  - raw query log constitutes 19,296 queries
- TPC-H workload
  - 1 TB of data
  - 22 benchmark queries
- For both of the workloads
  - partitioned data across 100 nodes
  - 50% storage budget

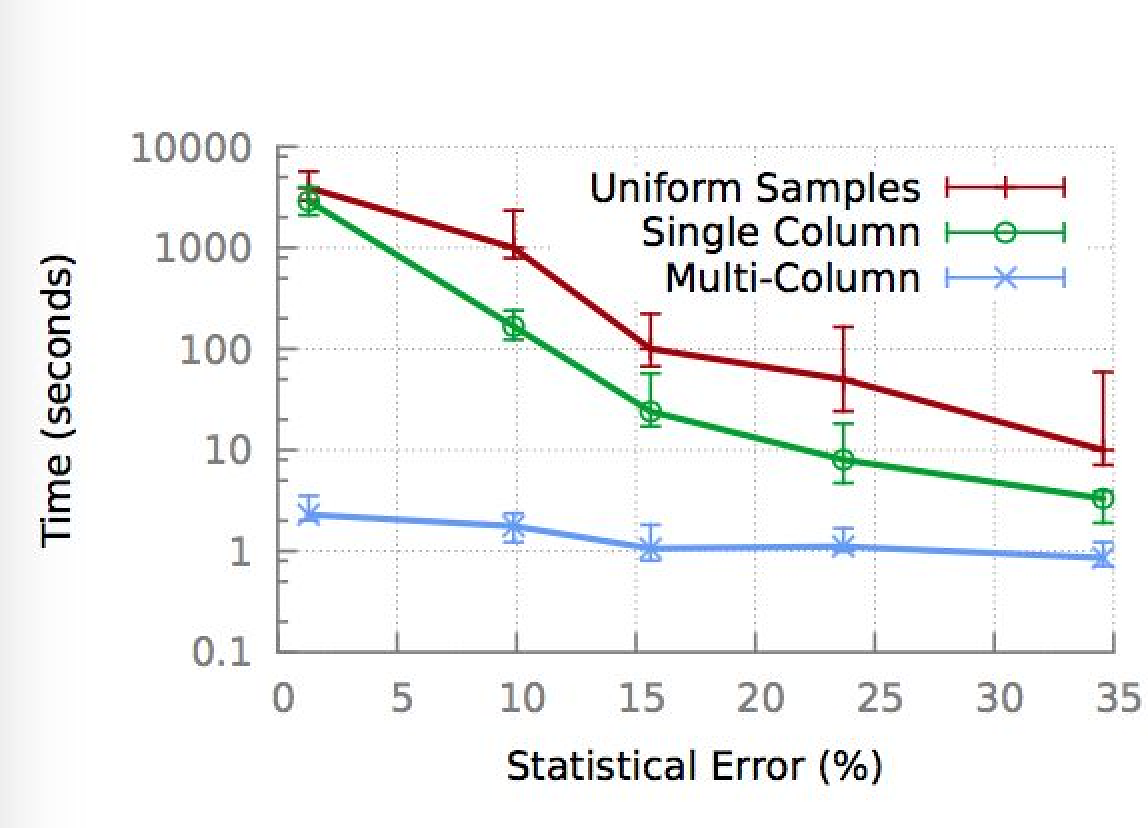
BlinkDB v.s. No Sampling

```
SELECT AVG(Session_Time)
FROM Sessions
WHERE date = …
GROUP BY City
```



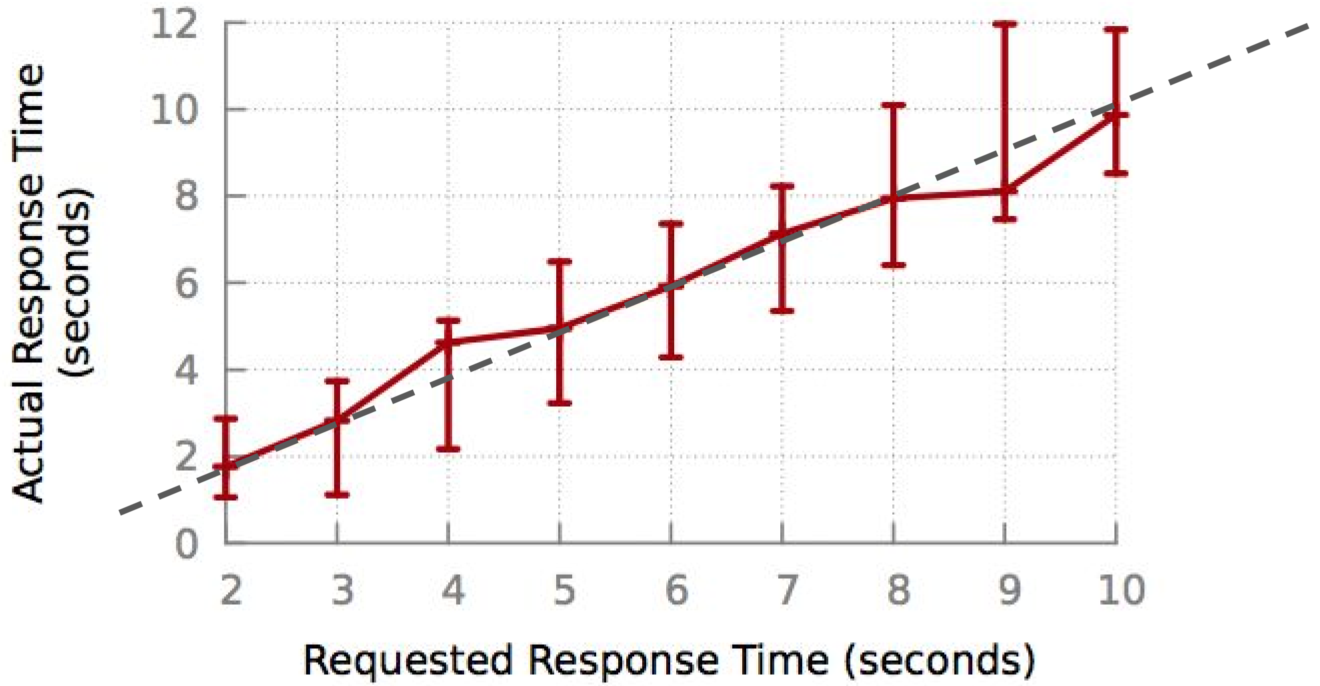
Response time v.s. Error

- Uniform samples: 50% of entire data
- Single Column: stratified on 1 column
- Multi-Column: stratifies on <= 3 columns



Time Guarantees

sample of 20 Conviva queries
ran each of them 10 times
on 17 TB data set



Error Guarantees

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