HINT on Steroids: Batch Query Processing for Interval Data

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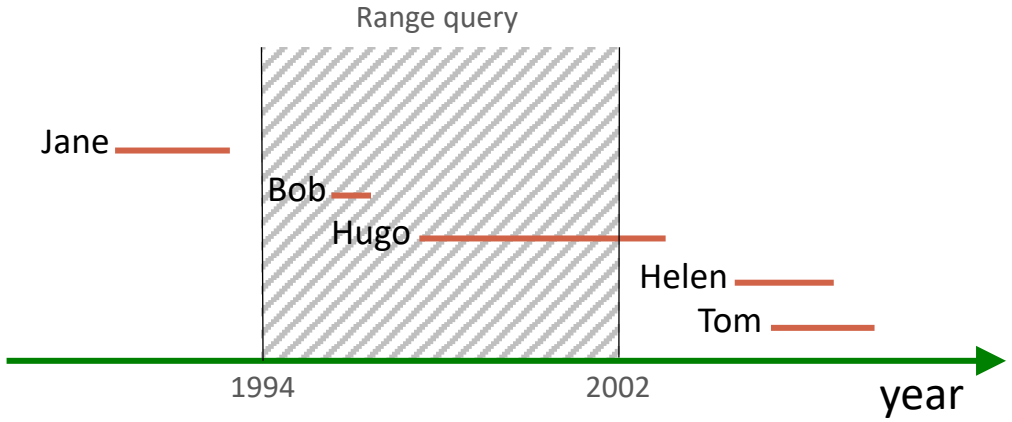
Interval data

employee	start	end
Jane	1990	1993
Bob	1995	1996
Hugo	1997	2003
Helen	2005	2008
Tom	2006	2009



Range query

- Find all employees working at the company from 1994 to 2002

Interval data

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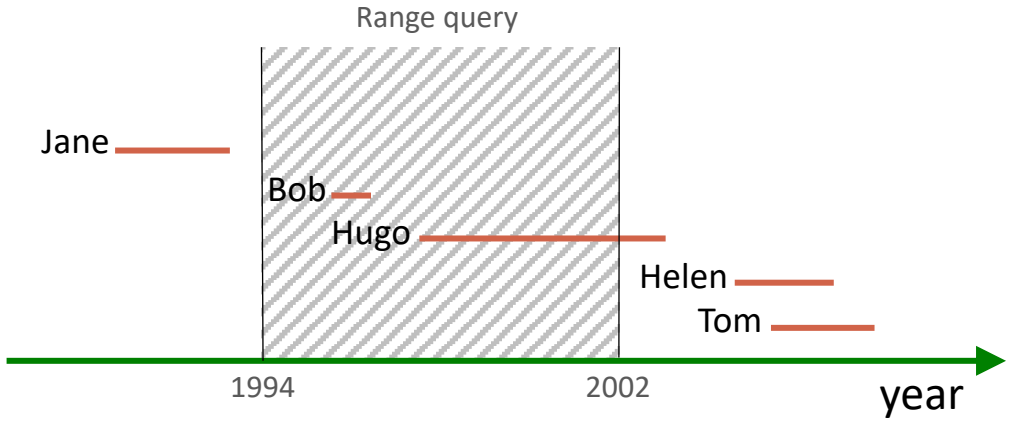

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Need for batch processing

Setting

- Query-heavy workflows
- Thousands or millions of incoming queries per second
- Modern OLTP systems and cloud services
  - Big IT companies, Amazon, Google etc
  - Amazon S3 receives 1M requests per second

Solution

- Process the queries in batches
  - Share and save resources
  - Reduce the overall time

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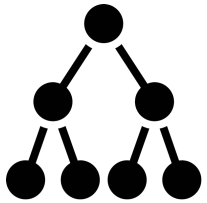
Background

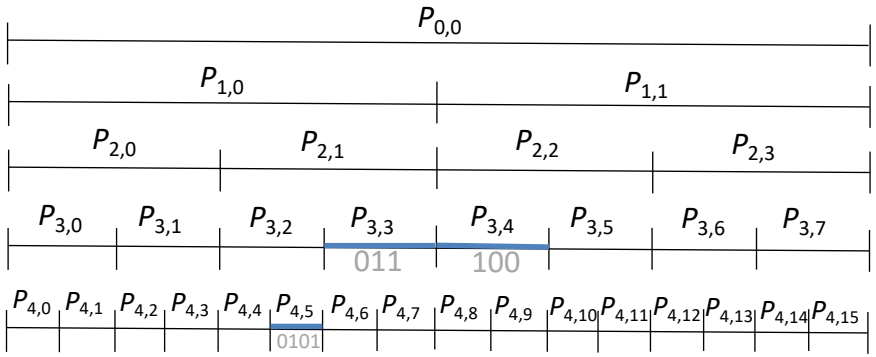


Indexing intervals

[G. Christodoulou, P. Bouros, N. Mamoulis, *HINT: A Hierarchical Index for Intervals in Main Memory*, ACM SIGMOD Conference 2022]
[G. Christodoulou, P. Bouros, N. Mamoulis, *HINT: a hierarchical interval index for Allen relationships*, VLDB Journal 33(1), 2024]

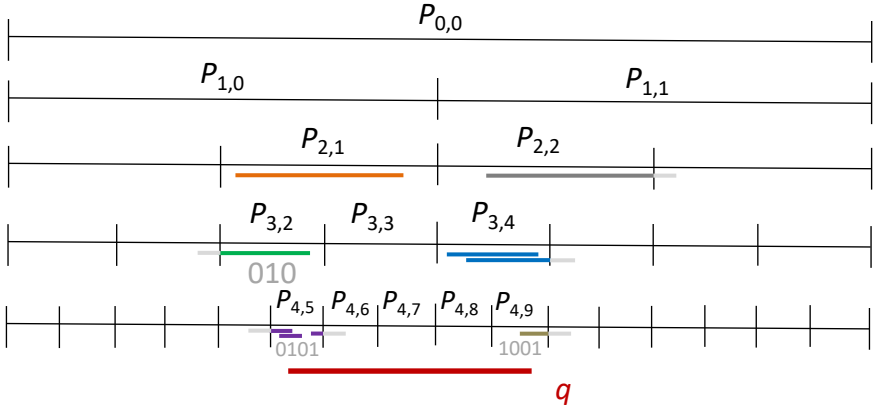
HINT: a hierarchical index for intervals

- Hierarchy of 1D grids
- Long intervals on high levels
- Intervals in at most 2 partitions per level



Query processing

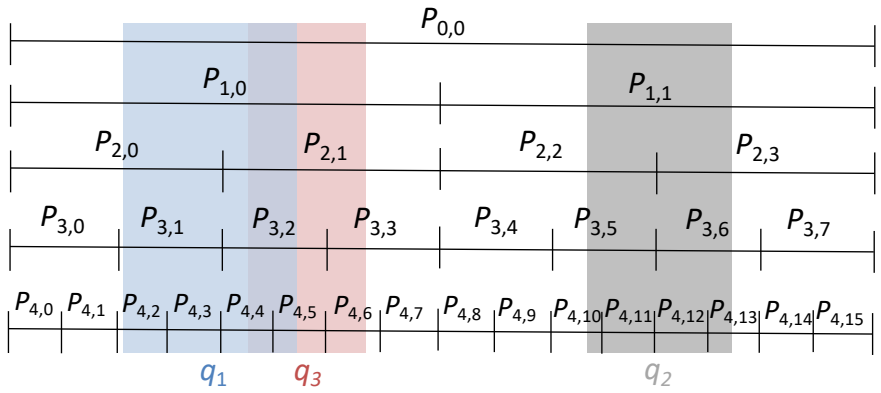
- Duplicate avoidance
- Bottom-up query processing
- Optimizations
  - Subdivisions P^{Oin}, P^{Oaft}, P^{Rin}, P^{Raft}
  - Space decomposition
  - Reduce cache misses
  - Deal with skewness & sparsity
- Allen algebra relationships



Batch processing challenges

Locality

- Avoid jumps in memory to access relevant partitions
- Horizontal jumps
  - Queries cover different parts of the index
  - Example, q_1, q_3 versus q_2
- Vertical jumps
  - Bottom-up traversal
  - Climb hierarchy for q_1, then for q_2, and lastly for q_3



Save resources

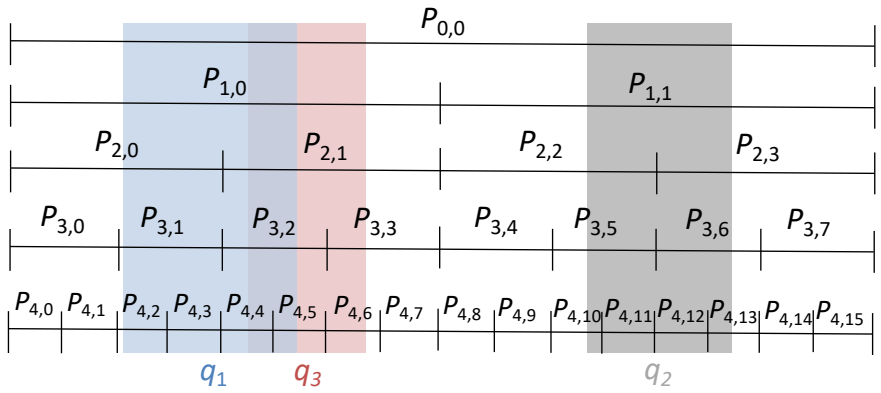
- Share computations among queries

Strategies

Query-based

Idea

- Evaluate queries in serial fashion
- Every query independently probs HINT, bottom-up



Pros

✓ Simple and straightforward

Cons

✗ Cache agnostic

✗ Horizontal and vertical jumps

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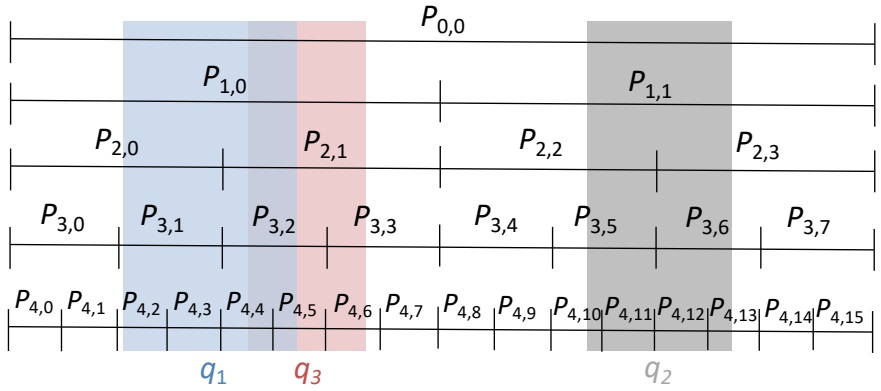

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Improvement

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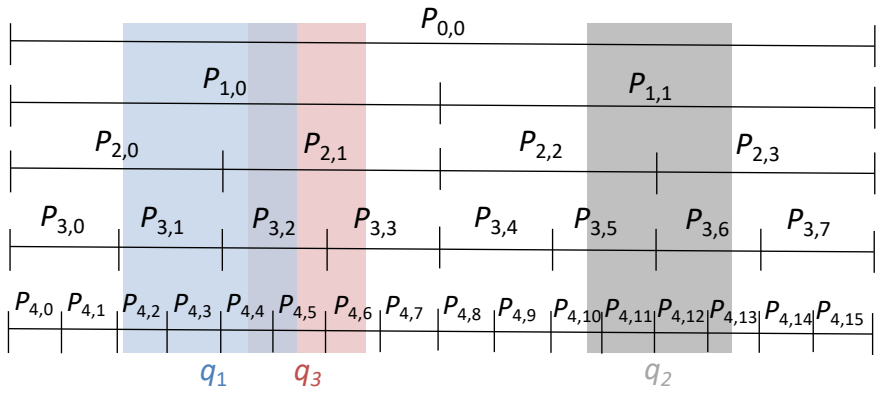

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Level-based

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- Operate in a per-level fashion
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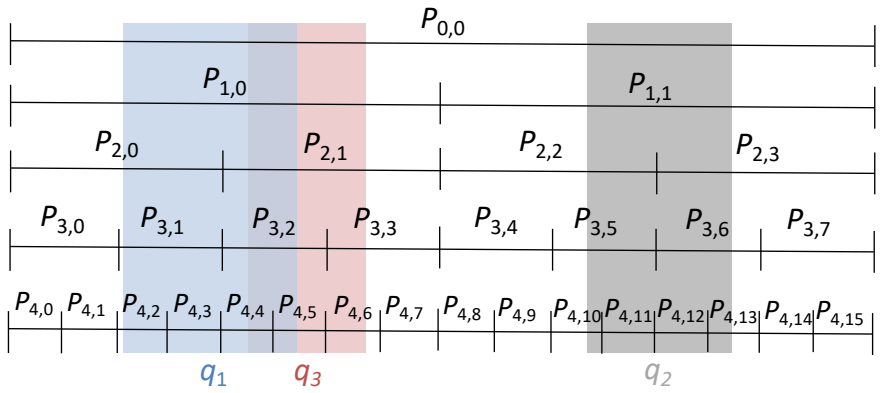

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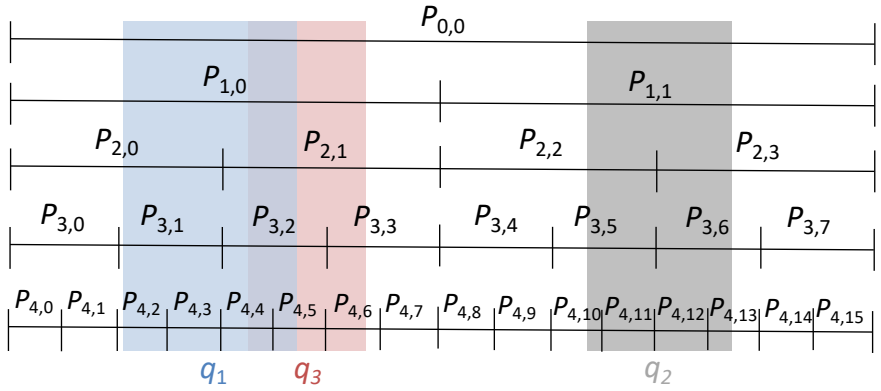

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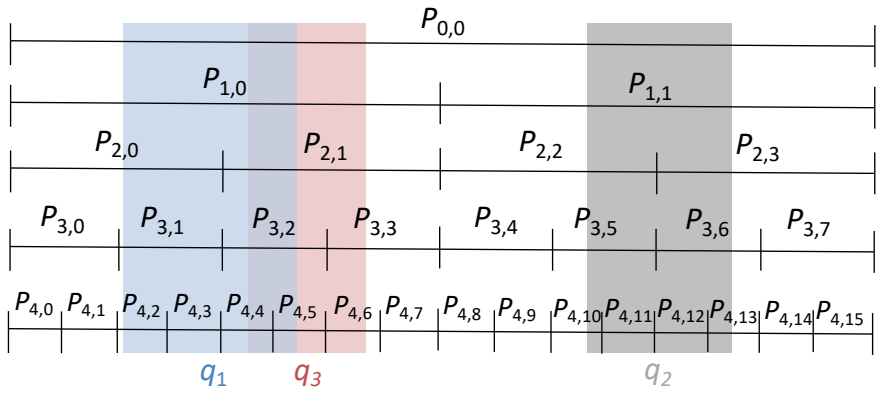

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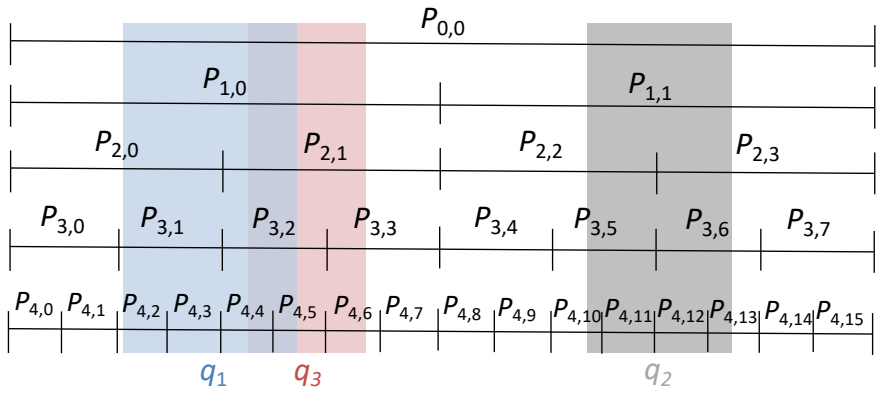

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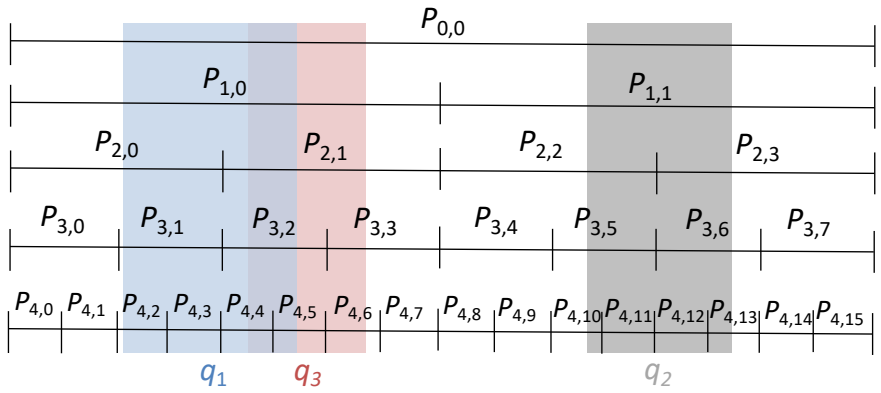

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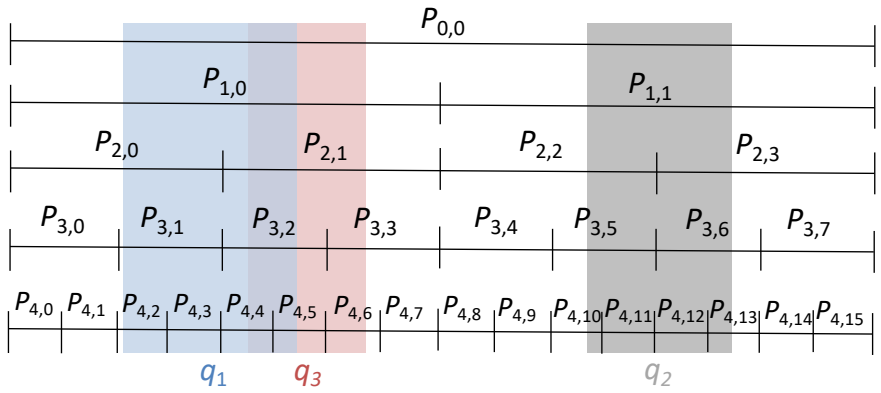

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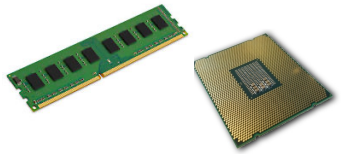
Experiments

Setup



Hardware

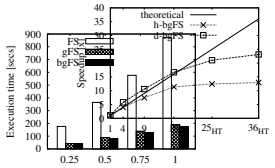
- Intel(R) Xeon(R) CPU E5-2630 v4 @ 2.20 GHz with 384 GBs of RAM running CentOS Linux

Software

- All strategies implemented in C++, compiled with -O3, -mavx and -march=native flags
- HINT variant with subdivisions, sorting, skewness & sparsity and cache misses optimizations

Datasets

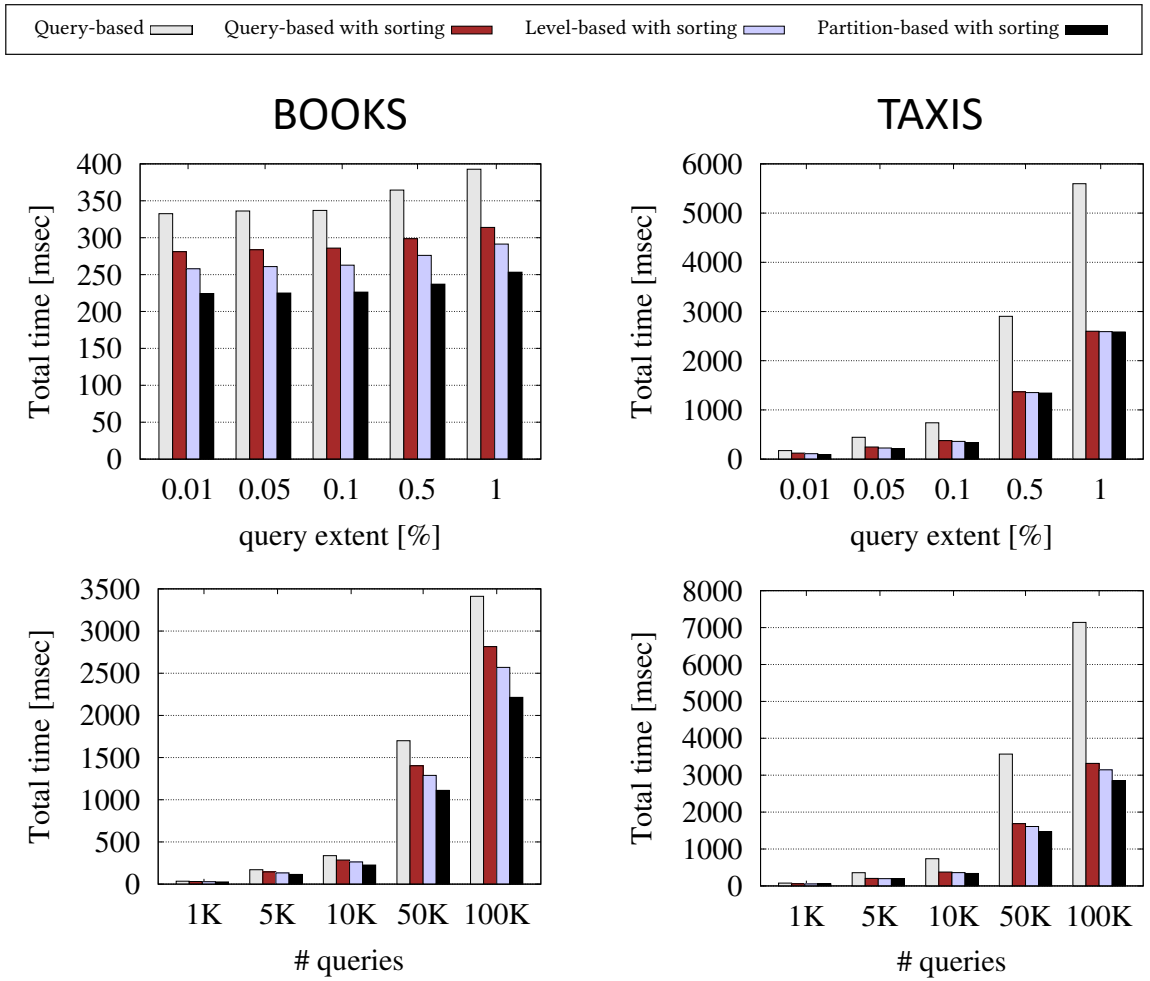
- BOOKS: periods of time book lent in Aarhus city libraries in 2013
- WEBKIT: periods of time file unchanged in git repository from 2001 to 2016
- TAXIS: period of taxi trips in New York City in 2013
- GREEND: power usage from households in Austria and Italy from 2010 to 2014
- Synthetic: interval duration follows exponential distribution, uniformly distributed *starts*



Experiments

- Total execution time of query batch
- Vary batch size (# queries) and query extent

Real datasets



1) Sorting queries reduces horizontal jumps
   - Query-based Vs Query-based with sorting

2) Level-based strategies outperform query-based
   - More pronounced in BOOKS, WEBKIT
   - Longer intervals

3) Partition-based the champion

To sum up…

Conclusions

- Studied batch processing for selection queries on intervals
- Proposed two processing strategies on top of state-of-the-art HINT
  - Operate on a per-level basis
  - Improve locality by eliminating jumps on HINT

Future work

- Investigate how to share and save computations
- Parellel batch processing

Thank you!

Questions ?

To download the source code and the datasets used, visit
https://github.com/pbour/batch_hint