Remembrance of Streams Past: Overload-Sensitive Management of Archived Streams

Authors: S. Chandrasekaran, M. Franklin

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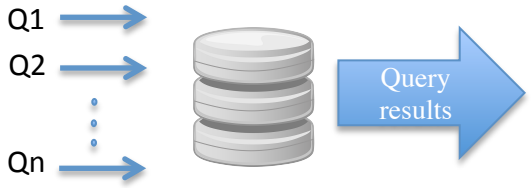
(Traditional) View on DBMS

OLTP/OLAP



- Finite relations
- Data is stored
- Queries keep coming in

Q: Add an item to your amazon shopping cart

DSMS

- Finite + infinite relations
- Data keeps coming in
- Triggers(queries) are stored

Q: identify rush hour by counting # cars passing between A and B

System Under Study

Disk-based DSMS that
combines real-time data streams
with historical data
simultaneously

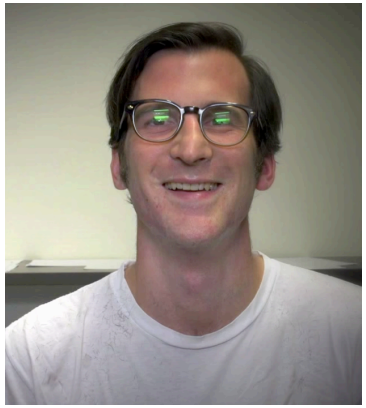
e.g.: Since the last accident, report an hourly # cars pass through gate A

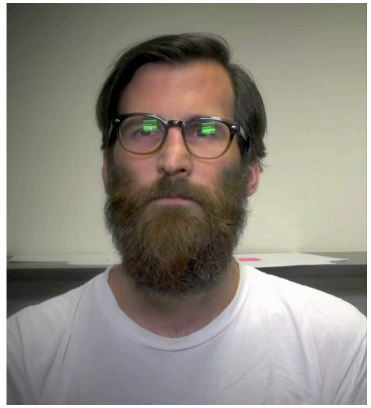
Where is the bottleneck?

- An analogy:
  - CPU clock: **1 second**
    - Look down at your desk
  - L1 cache: **3 seconds**
    - Grabbing a piece of paper from your desk
  - L2 cache: **14 seconds**
    - Picking up a book for a nearby shelf
  - Main memory: **4 minutes**
    - Walking down the hall to buy a Twix bar
  - Disk: ?

Disks

1 year and 3 months



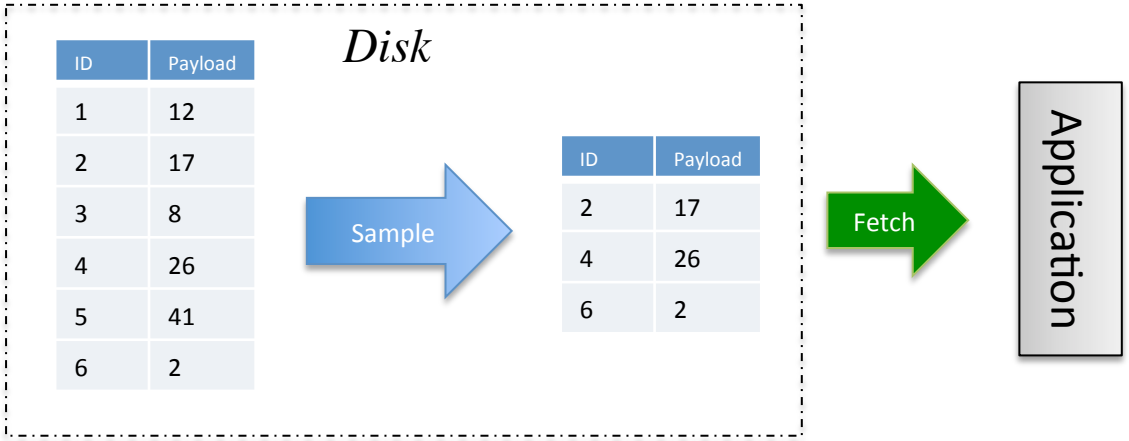
(Traditional) Remedies for Overload

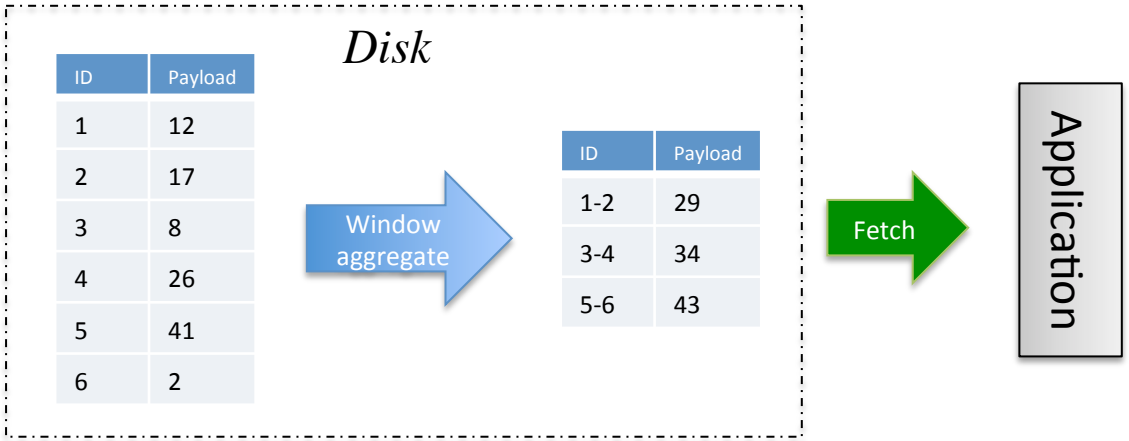
- Indexes and optimizations (OLTP)
  - Not quite as possible as in OLTP
- Postponing computation (Data warehousing)
  - Falls even further behind the live data
- Load shedding (DSMS)
  - Does not confront the root of the problem
  - Dropped data might be important in future

Proposed Idea

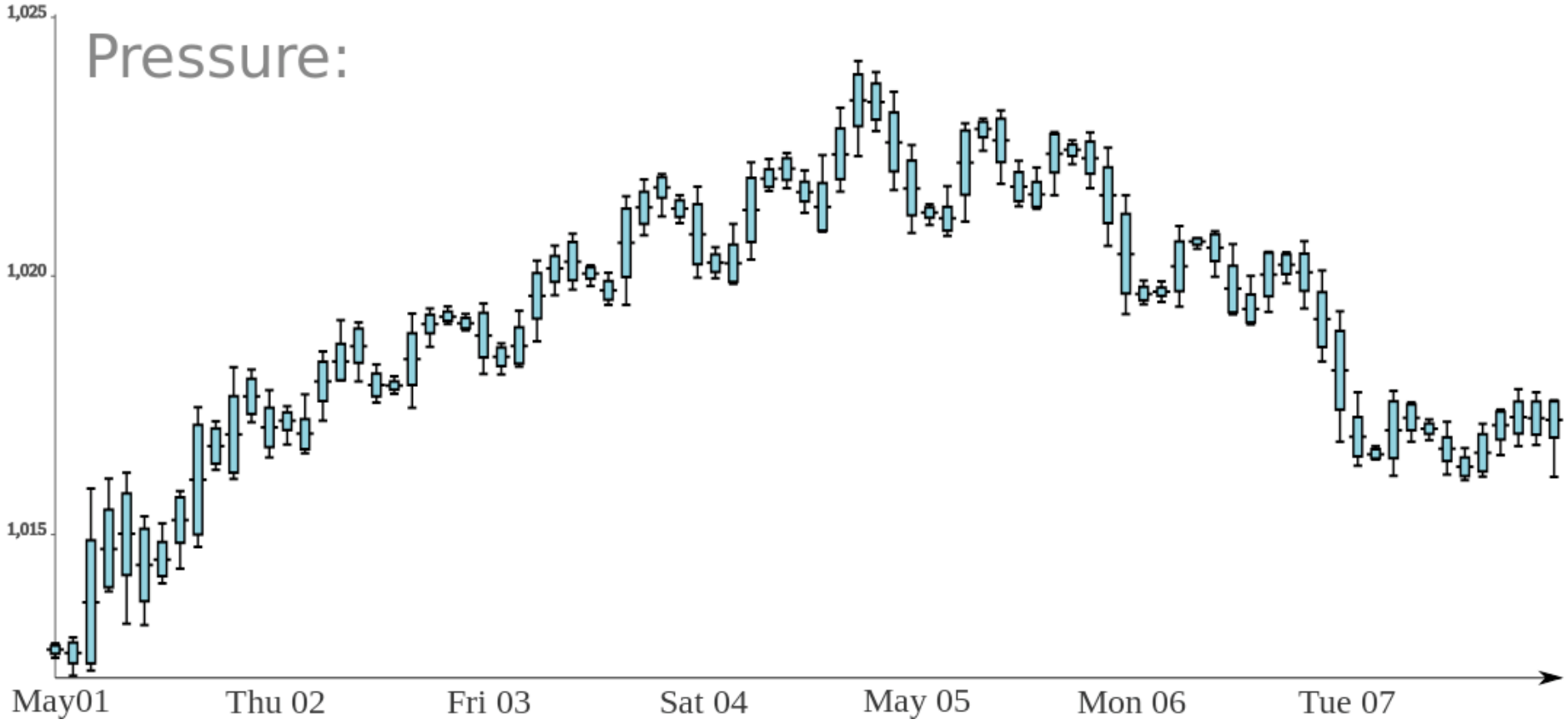
- Reduce I/O cost
  - Retrieve a reduced version of the historical data
  - In the form of:
    - Sampled (e.g. random sampling)
    - Summarized (e.g. window aggregation)
- Trade-off I/O for data quality
- Focuses on the architectural issues, rather than DR techniques

Sampling/Summarization





A Famous Windowed Aggregation: Candlestick Chart



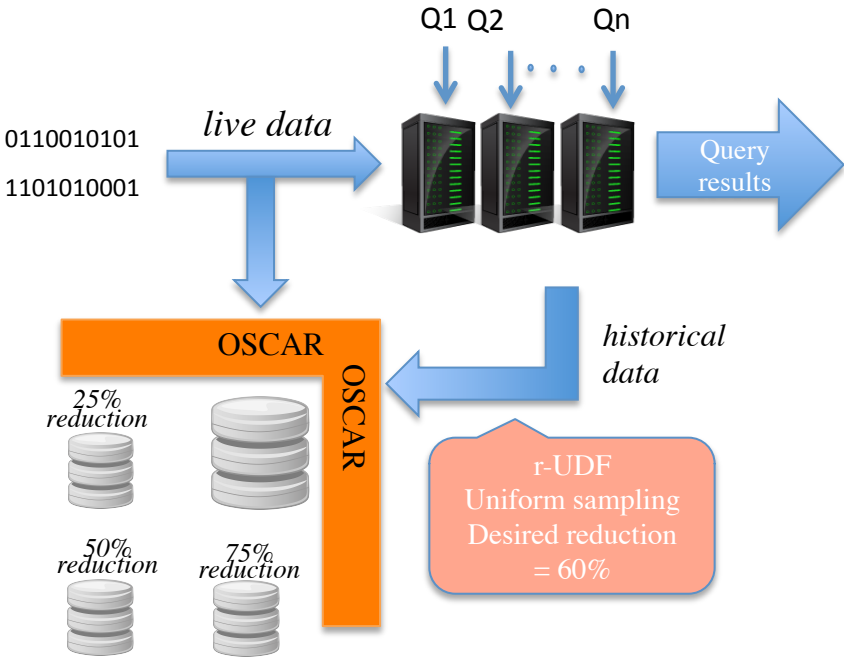
Problem's Settings

- No a-priori knowledge of queries
  - Multiple resolutions of reduced data
- Varying load/resources in the system
  - The reduction level must be decided based on the system load
- No fixed sampling/summarization techniques
  - The DSMS must have flexibility to choose their desired technique

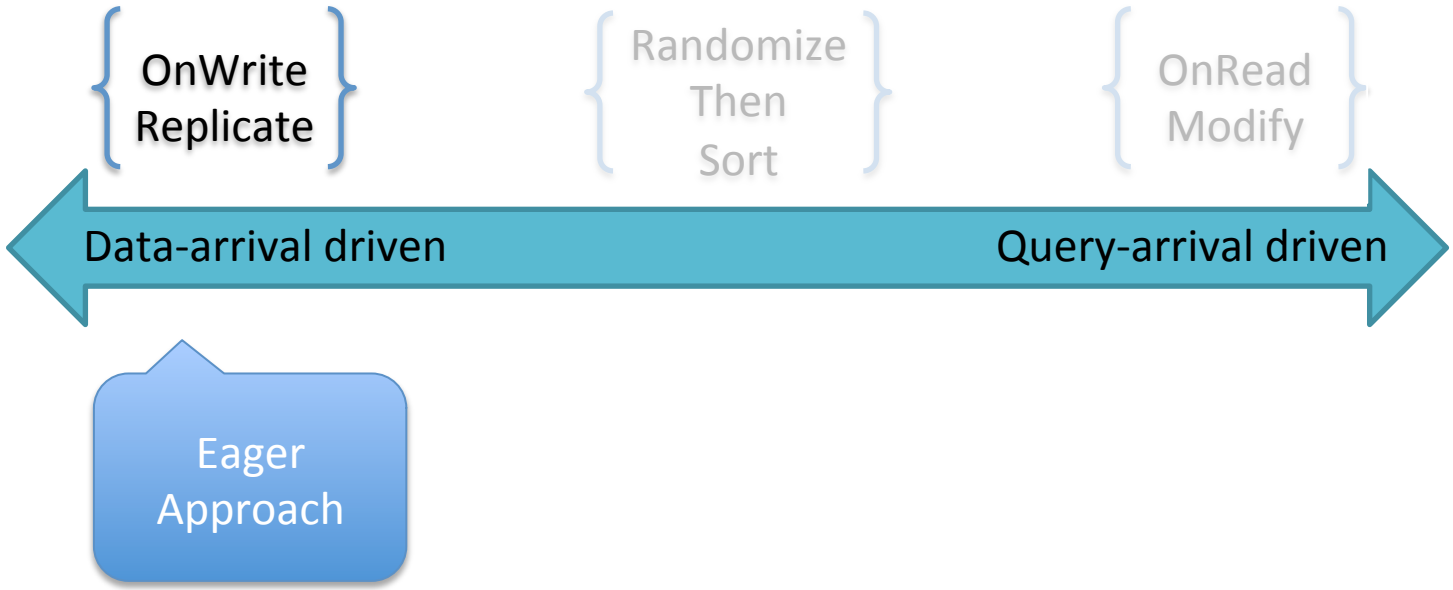
Add an Overload-sensitive Stream Capture and Archive Reduction component

Proposed Architecture

- Sits between disk and executor
  - The disk's content is invisible to executor
  - Only change to executor: r-UDF
- Sits between NI and disk
  - No change to NI is needed
- Maintains multiple resolutions of data
  - Finds the best matching version
- Each physical scan is associated with an R-UDF
  - notifies OSCAR as to the reduction degree
  - Depends on the system load



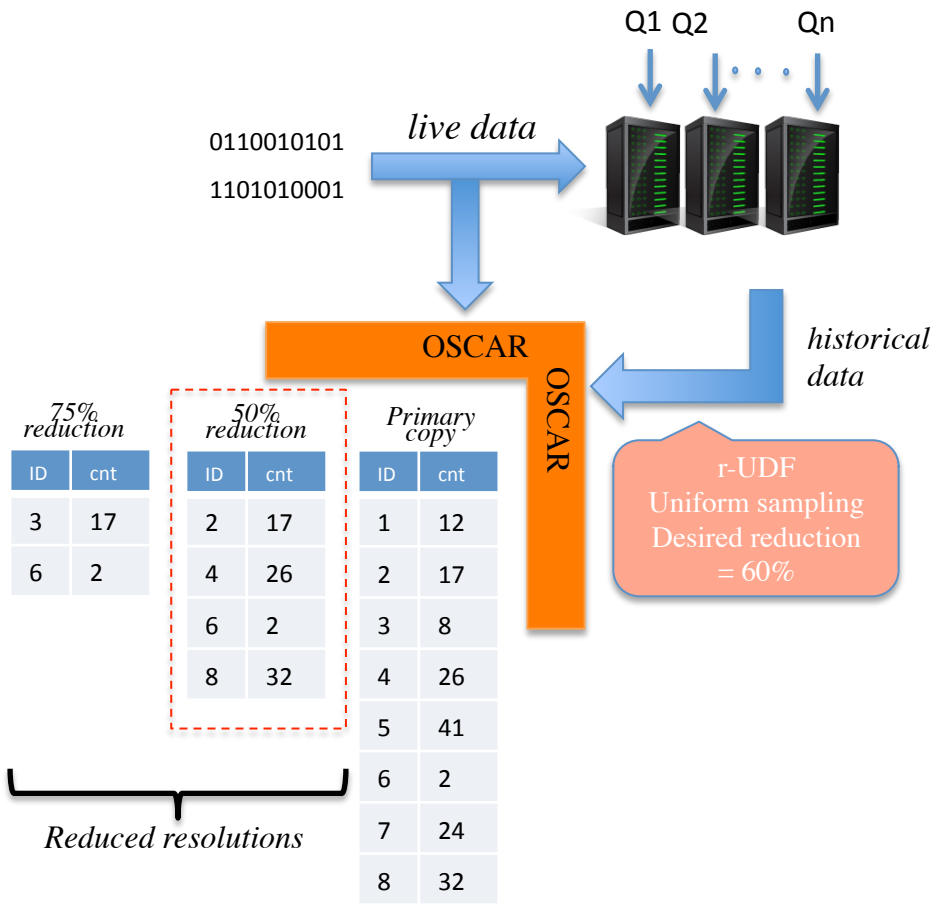
Different Designs:
Different Points of (uniform) Sampling



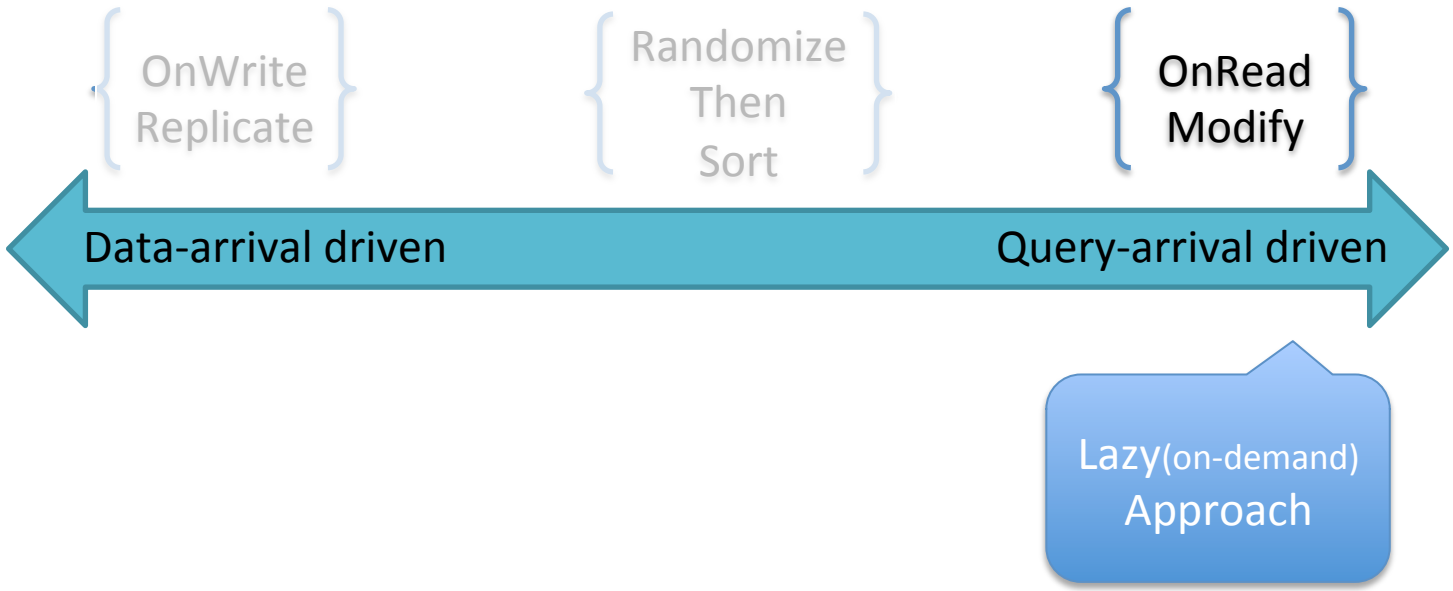
OSCAR v1: OnWriteReplicate

At data arrival

At query arrival



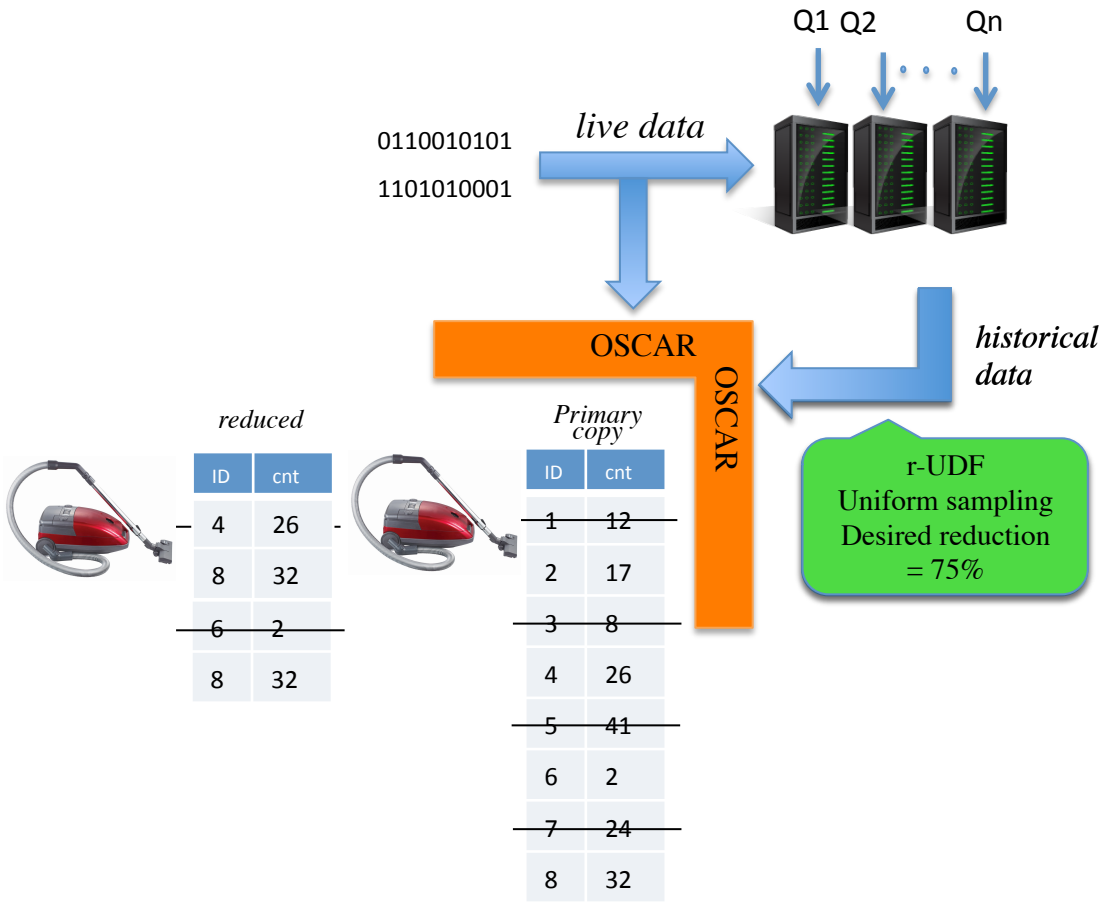
Different Designs: Different Points of (uniform) Sampling



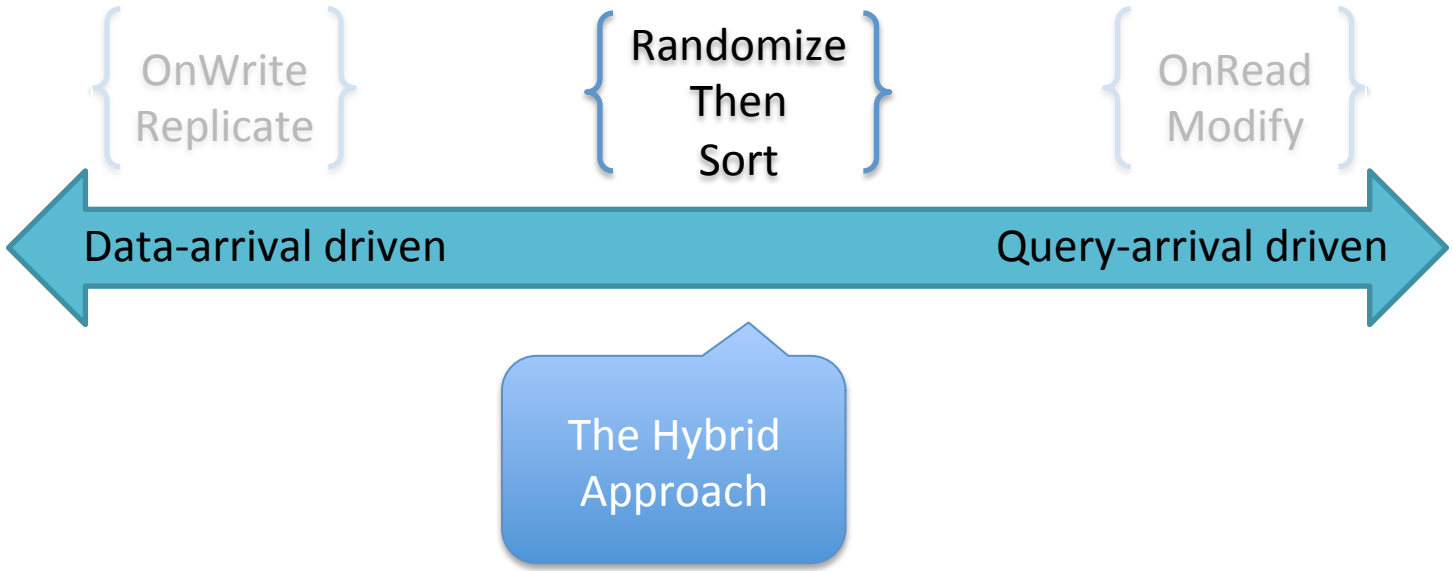
OSCAR v2: OnReadModify

At data arrival

At query arrival x2



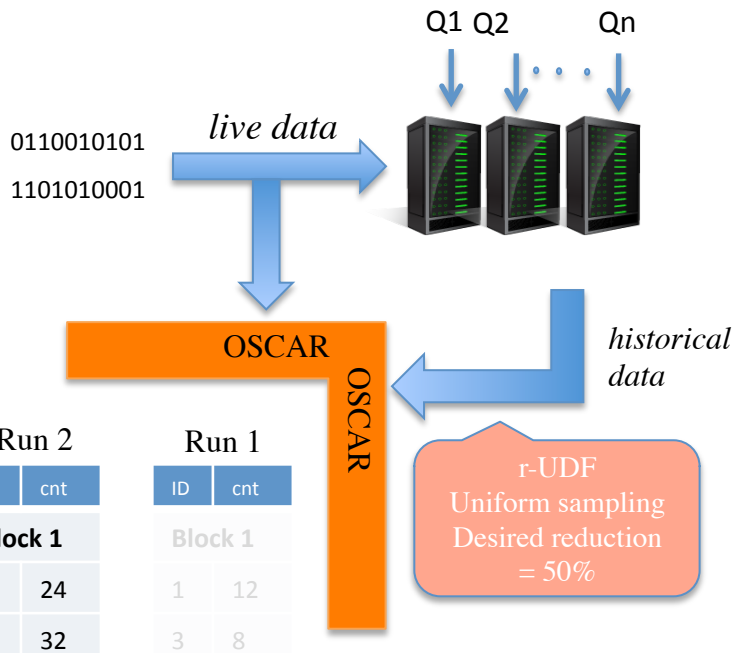
Different Designs: Different Points of (uniform) Sampling



OSCAR v3: RandomizeThenSort

At data arrival

At query arrival



Run 2

ID	cnt
Block 1	
7	24
8	32
Block 2	
5	41
6	2

Run 1

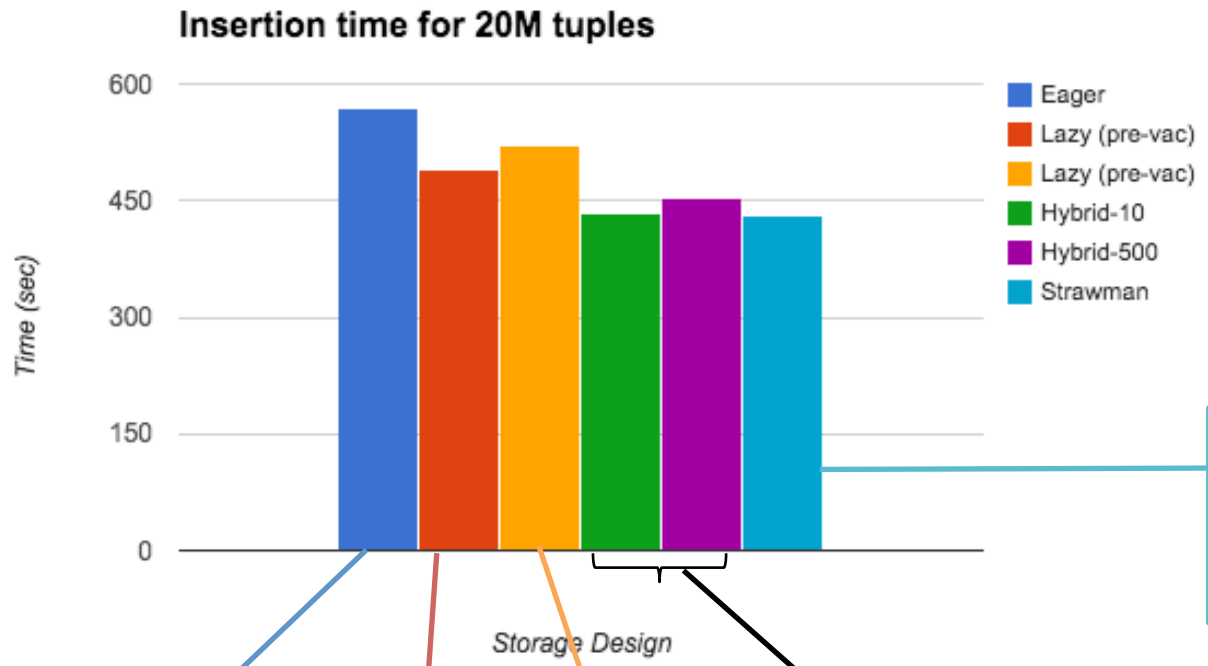
ID	cnt
Block 1	
1	12
3	8
Block 2	
2	17
4	26

Run length = 2 Blks
#Tuples/Blk = 2

Original Data (not materialized)

ID	cnt
1	12
2	17
3	8
4	26
5	41
6	2
7	24
8	32

Experiments: Inserting Without Querying



- This is the baseline
- One copy at the arrival
- Read the original copy at query time

- 4 reduced resolutions: 20%, 40%, 60%, 80%
- Is sublinear in the size of the original stream and copies
- Due to the cost amortization in the NI

- slower than strawman due to the extra samplerate attribute

- due to additional copy overhead for both tables

The slight difference is because of different wasted space in runs

Experiments: Querying While Inserting

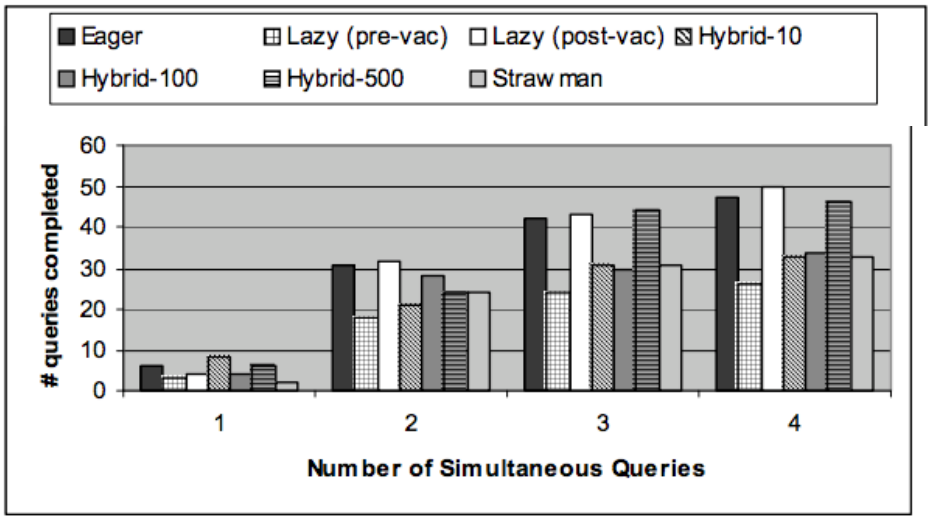


Figure 15: #queries completed within 20M tuples insertion, 25% reduction

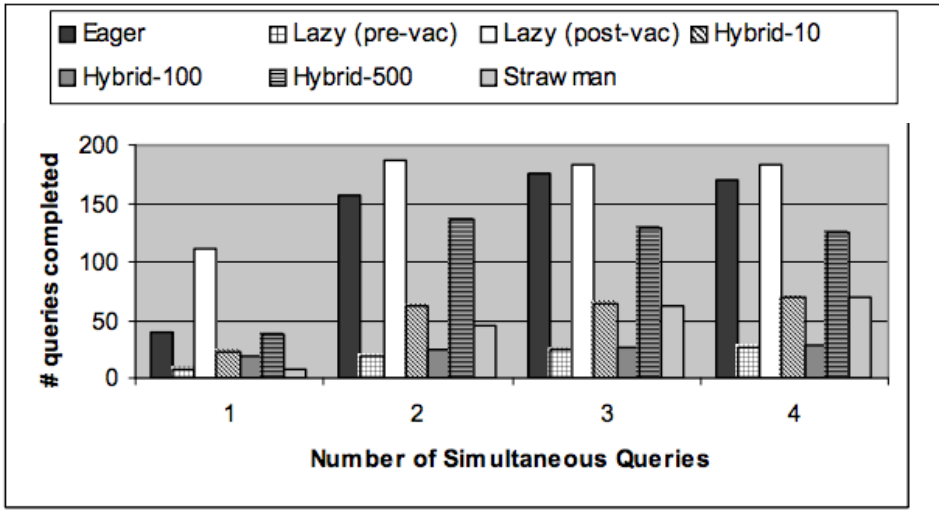


Figure 16: #queries completed within 20M tuples insertion, 75% reduction

- All methods stabilize eventually simultaneous queries
- Eager approach pays little cost at query time
- Post-vac Lazy approach has the best performance
- Hybrid solutions with larger runs have better performance
  - For RTSs with smaller runs
    - The blocks are close on disk
    - Due to pre-fetching and buffering, disk ends up doing a sequential scan

Summary

- OSCAR is a framework disk-based DSMS
- The goal is to alleviate the bottleneck (disk) by reading only a reduced historical data
- OSCAR organizes data on disk into multiple resolutions of reduced summaries
  - such as samples of different sizes.
- Depending on stream speed, the system picks the right resolution level for QP