Feather: Hierarchical Querying for the Edge

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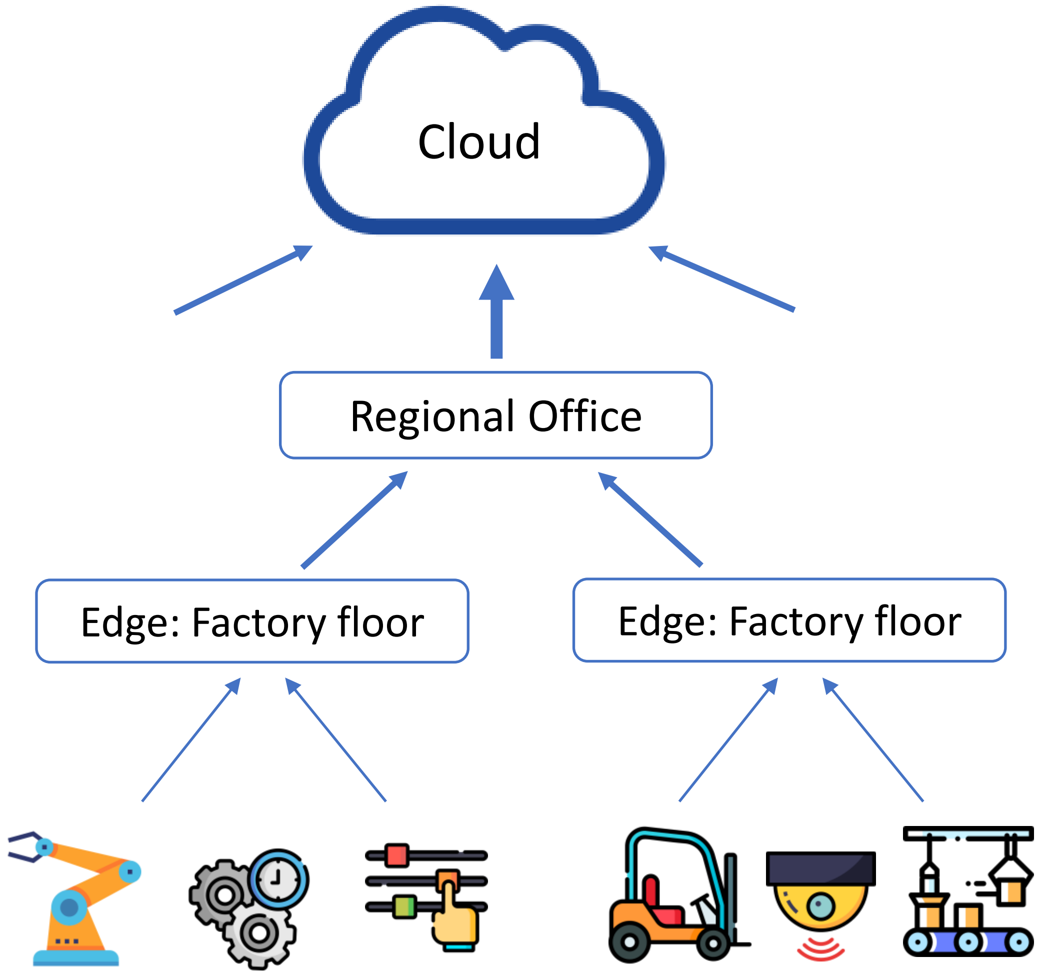
Data on the Edge

- Data is generated over a wide geographic area
  - Is stored near the edges
  - Pushed periodically upstream to a hierarchy of data centers

- Network properties:
  - Limited bandwidth
  - High latency
  - Failures



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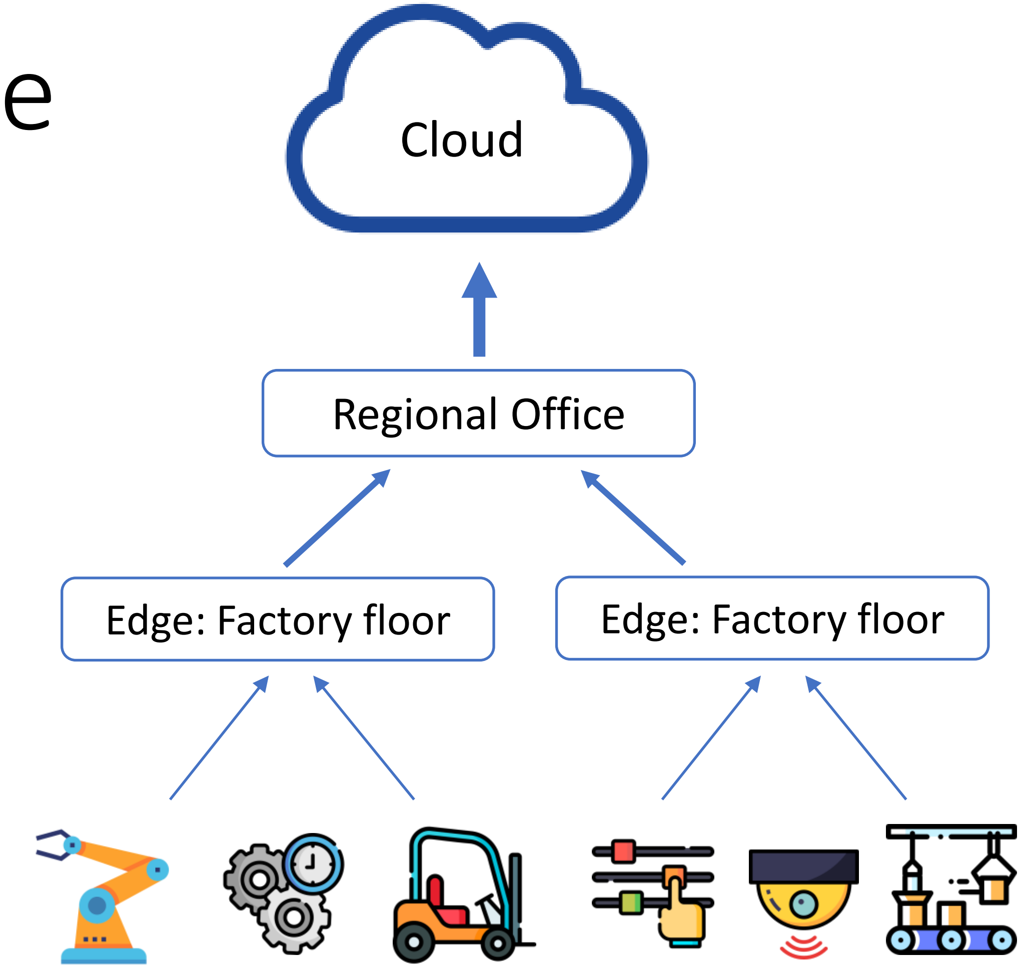
Querying data on the Edge

```
SELECT monitor_id,
MAX(temperature)
FROM Sensors
GROUP BY monitor_id
WHERE now() – timestamp < 600s
```



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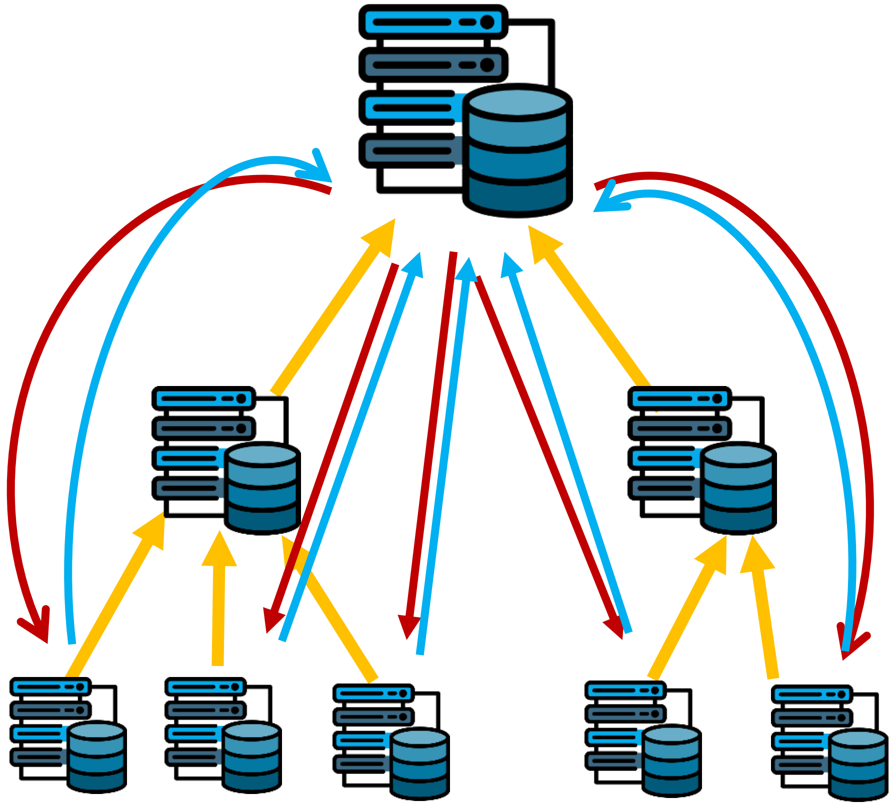
Querying Over a Distributed Hierarchical Database

Common approaches:

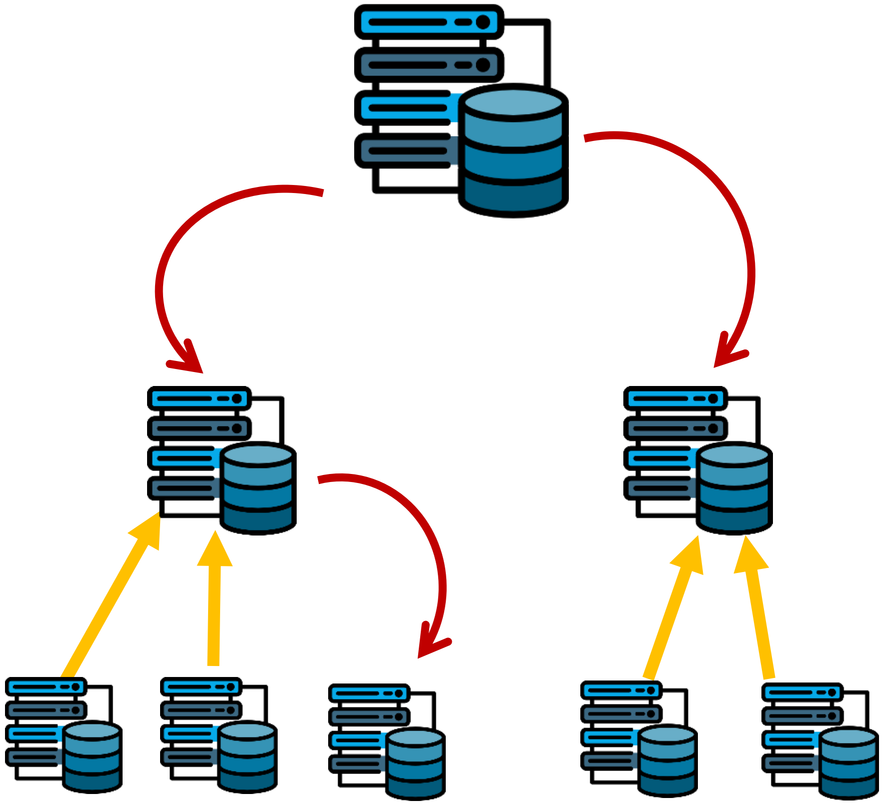
- Process on query on the Cloud
- Stream Processing (continuous query)
- Query edge data centers



Feather

➢ **Hybrid Approach**
  - Take benefit of data that exists on intermediate nodes

- User specifies data freshness
  - System guarantees data freshness criteria
  - Improved query response time and total bandwidth



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Querying

- Get max temperature for each sensor in the last 10 minutes

```
SELECT monitor_id,
MAX(temperature)
FROM Sensors
GROUP BY monitor_id
WHERE now() – timestamp < 600s
LAXITY = 60s
```

Contributions

- Global queries with control over staleness and query latency
- Fault tolerance with estimates about result completeness, coverage

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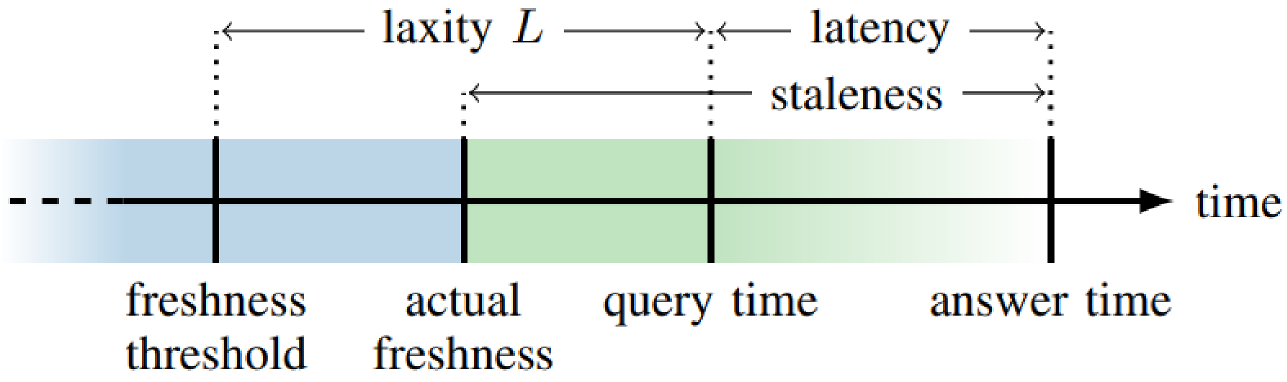
Idea: Relax Freshness Requirement



- User provides minimum freshness requirement (“**Laxity**”)
- System guarantees answer is at least as fresh (“**Staleness”**)

Freshness guarantee is similar to formal treatments such as Δ-atomicity (Golab et a) [27] and t-freshness (Rahman et al.)

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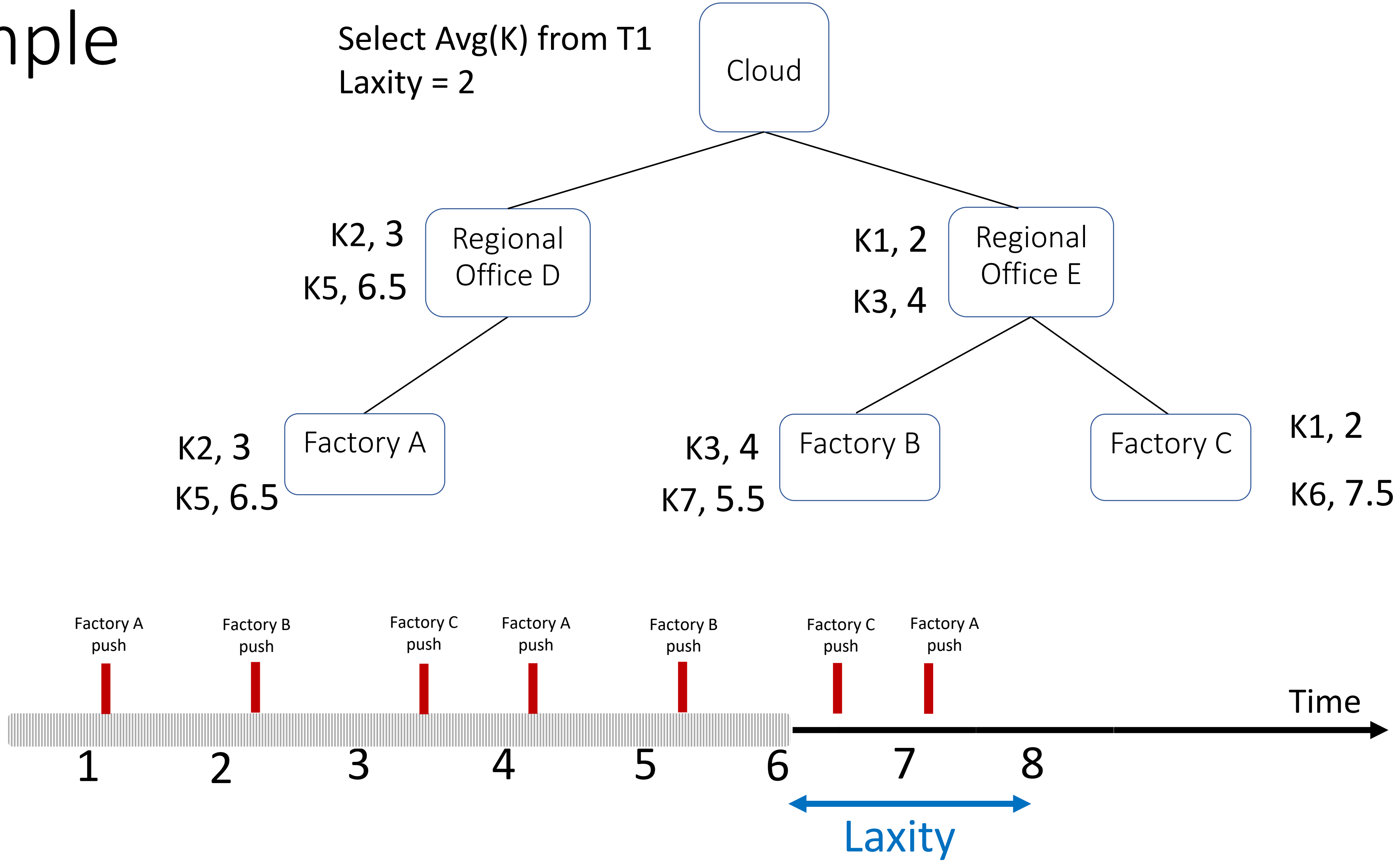
Example

Select Avg(K) from T1
Laxity = 2



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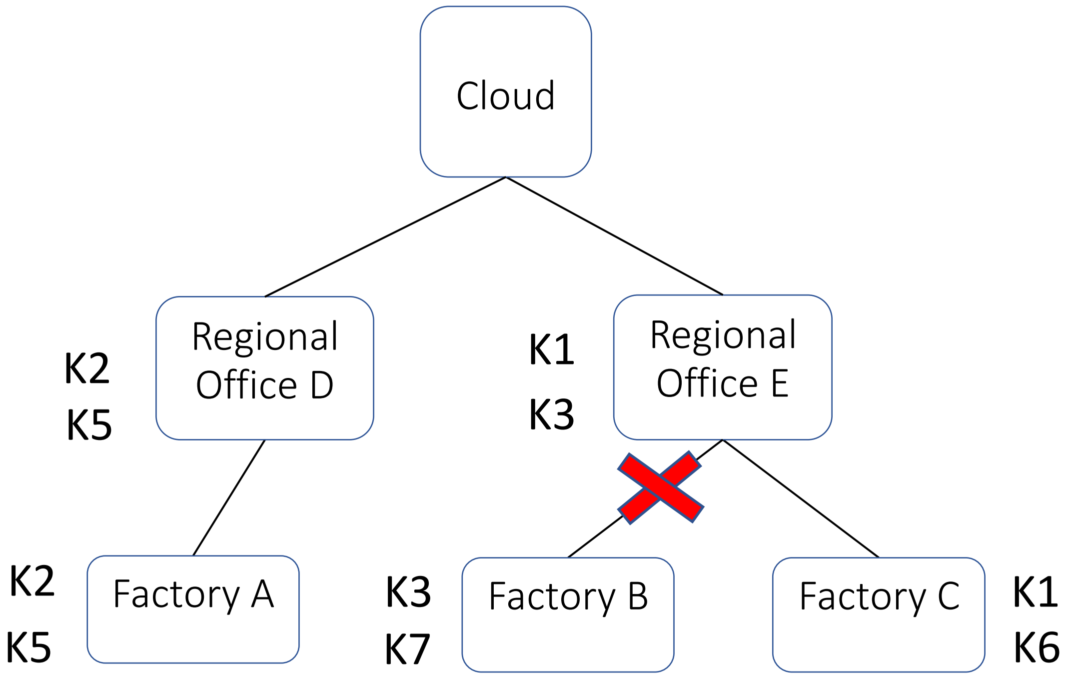
Feather Features

- Supports: Filtering, aggregation, grouping, ordering, and limiting of the result set.
- Coverage estimation:
  - For each query return network and row coverage estimation
- Failures:
  - Best effort: Relax freshness guarantee and provide best results
    - (K1, K2, K3, K5)
  - Return partial results but up-to-date results
    - (K1, K2, K5)



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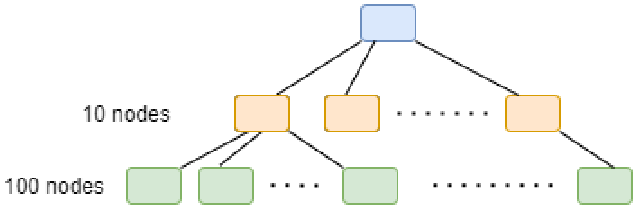
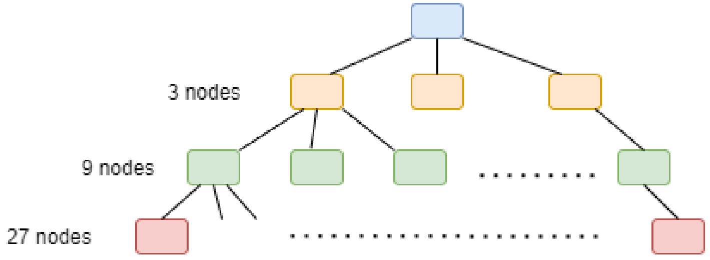
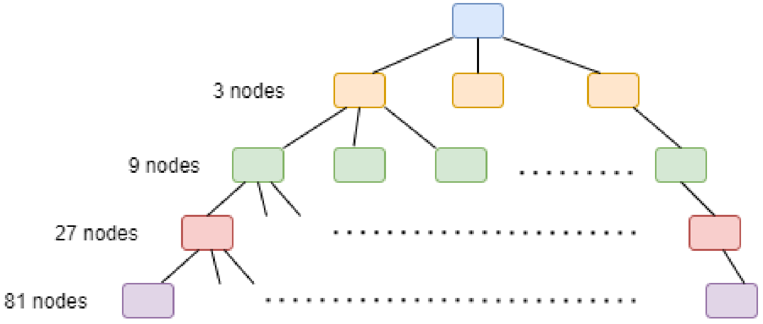
Experimental Setup for Controlled Experiments



Wide topology



Medium topology



Deep topology

- NYC Taxi Dataset
  - 7 million taxi rides of December 2019
    - (sped up x30 times for more dense data)
- Geo-distributed labelled data
  - SELECT, GROUPBY, MIN queries

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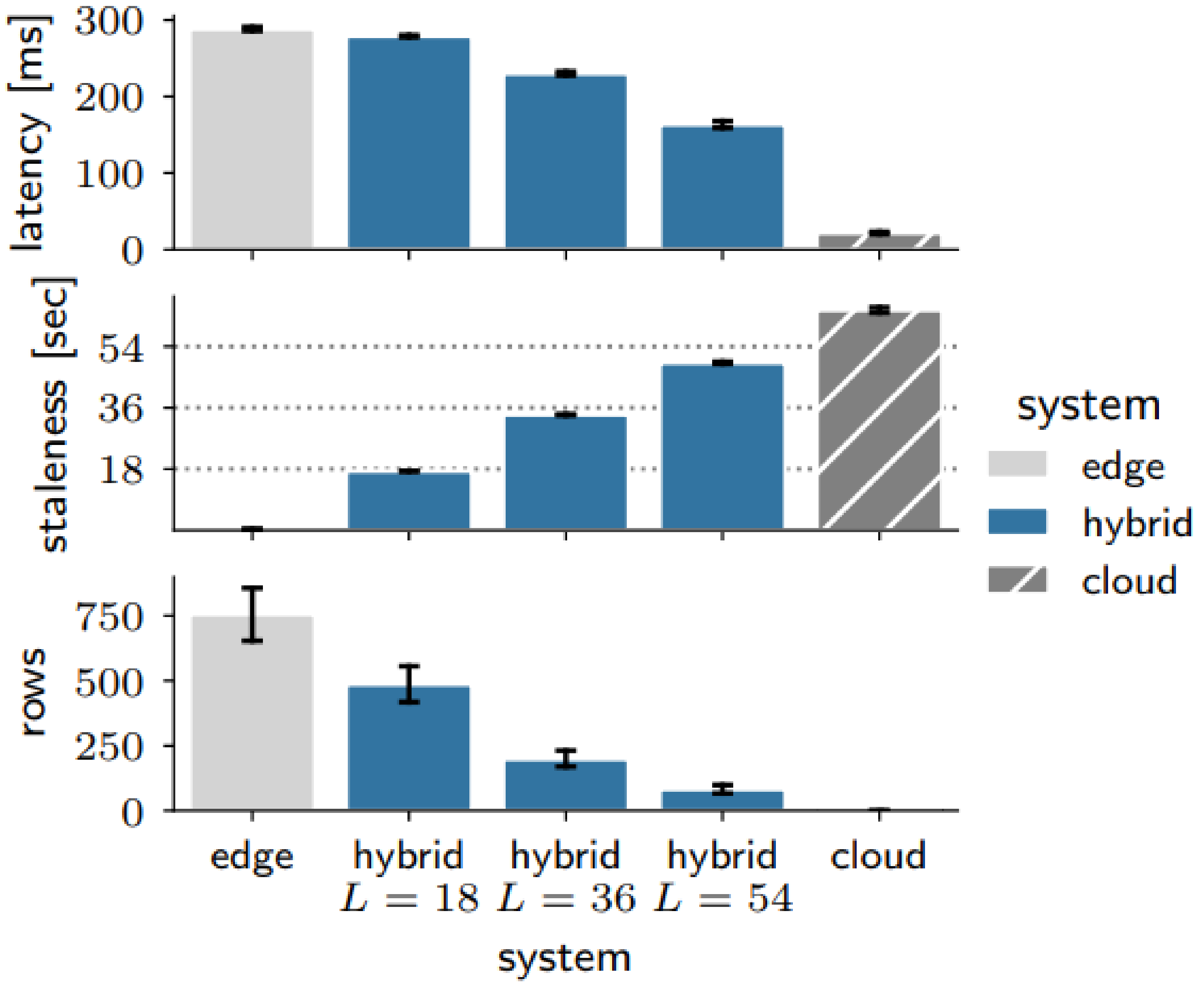
Feather Tradeoffs

- Flexible trade-off between latency, staleness while guaranteeing the freshness threshold



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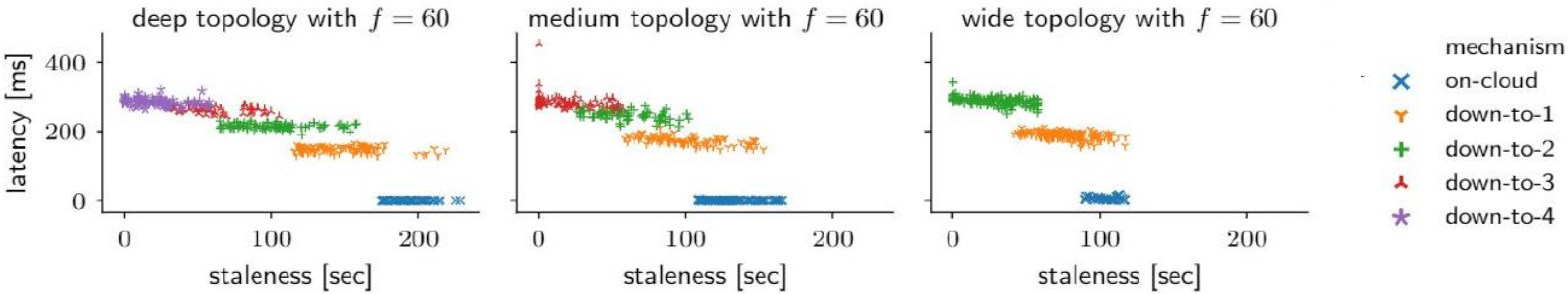
Staleness vs latency



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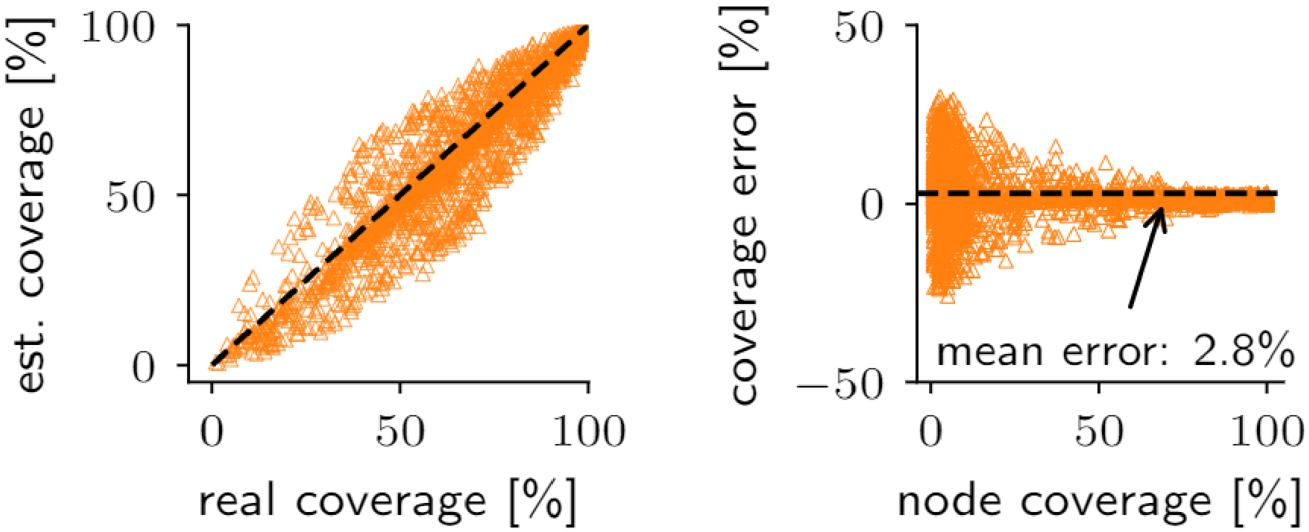
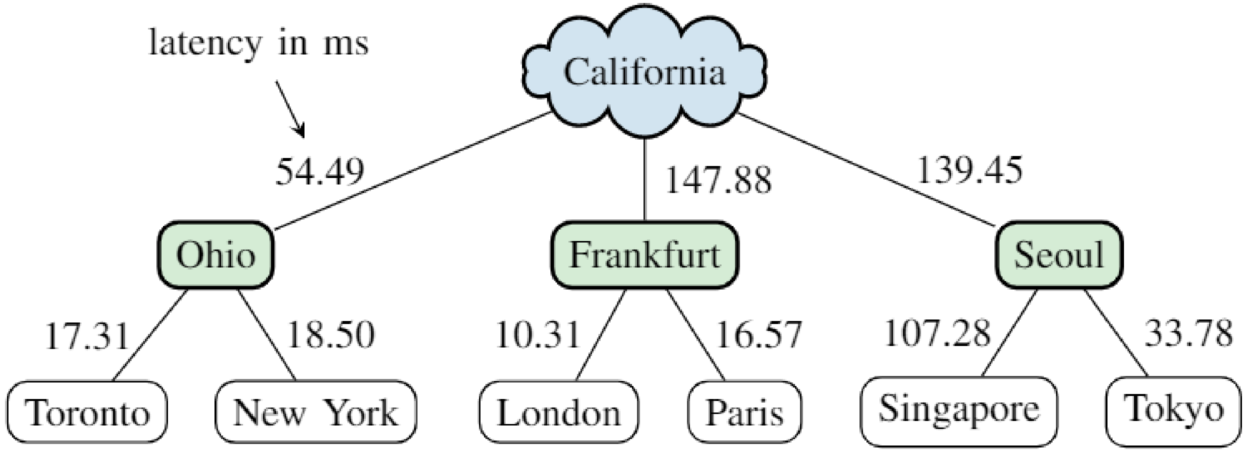
Coverage



Strong agreement between the real and the estimated row coverage

Real world Experiment



- Geo-tagged public tweets as the dataset
- 10 datacenters from three different cloud operators spread over three continents
- Scraped a total of 1 million tweets from 6 edge cities over a one-week period from December 2019.
- Real world latencies are not uniform!

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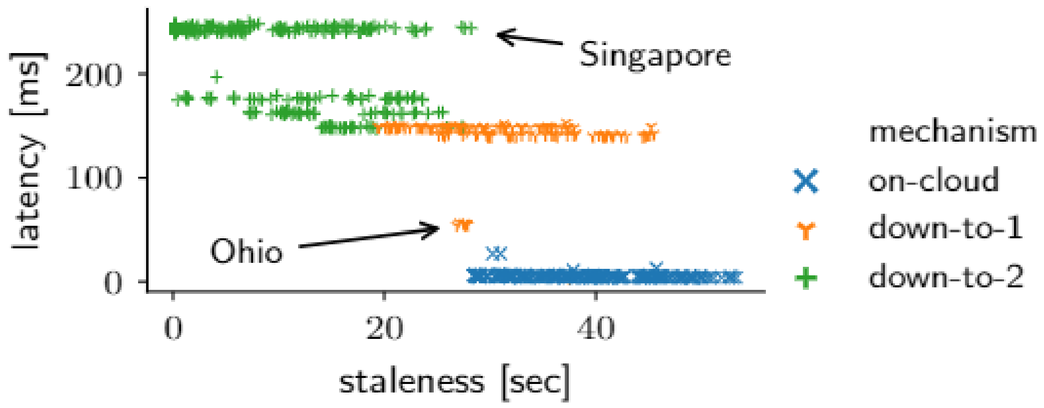
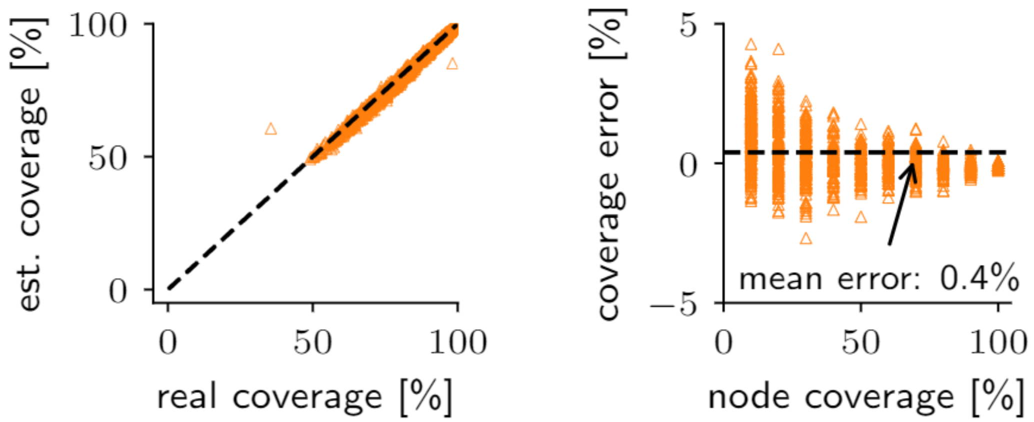
Real world Experiment



Latency/staleness tradeoff for queries in the twitter experiment shows more clusters



Coverage estimation remains very accurate

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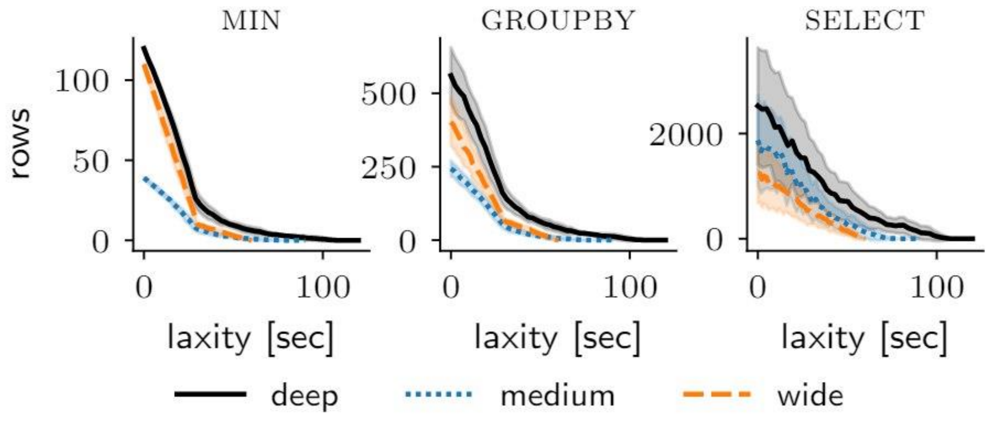
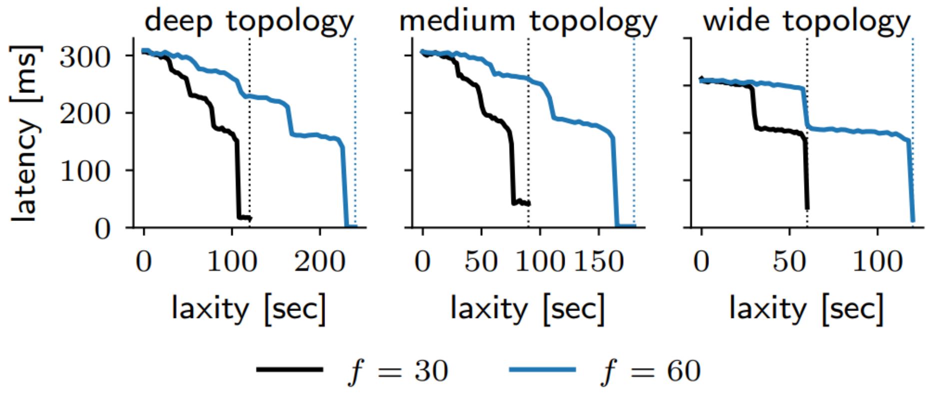
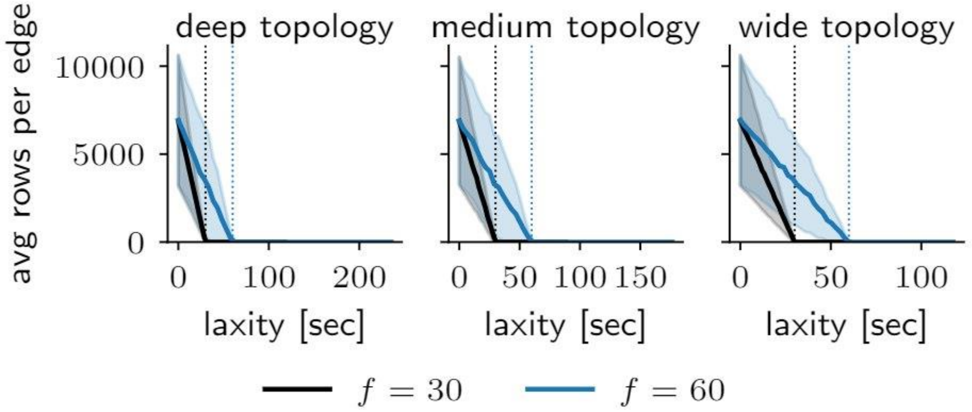
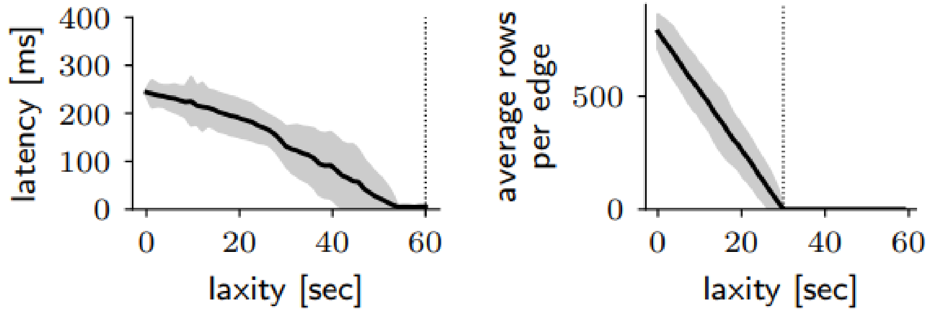
More results









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Summary

- Feather: a geo-distributed, hierarchical, eventually-consistent tabular data store that supports efficient global queries
- Feather provides a user-controlled tradeoff between latency, staleness, bandwidth, and load on edge nodes
- Feather provides completeness (coverage) estimate.

- Future work:
  - Improve the implementation for non-disjoint keys.
  - To investigate dynamic control policies for the latency/staleness tradeoff

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Questions

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