SINA: Scalable Incremental Processing of Continuous Queries in Spatiotemporal Databases

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Presented by: Kristian Torp

Outline

1. Motivation
2. Incremental Evaluation Algorithm
   - Hashing
   - Invalidation
   - Joining
3. Experimental Results
4. Evaluation

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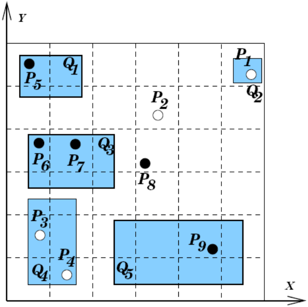
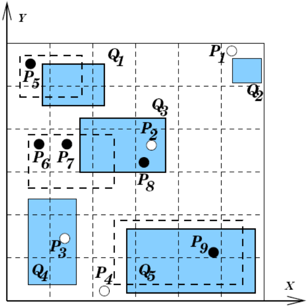
Example



(a) Snapshot at time T_0



(b) Snapshot at time T_1

Positive Update

- $(Q_3, +p_2)$
- $(Q_3, +p_8)$

Negative Update

- $(Q_1, -p_5)$
- $(Q_2, -p_1)$
- $(Q_3, -p_6)$
- $(Q_3, -p_7)$
- $(Q_4, -p_4)$

Spatio-Temporal Applications

Characteristics

- Large number of mobile objects and mobile queries
- Queries are continues by nature
- Delayed results are obsolete

Design Criteria

- Scalable
- Incremental computation

Query Types I

$$\left\{ \begin{array}{c} \text{stationary query} \\ \text{moving query} \end{array} \right\} \times \left\{ \begin{array}{c} \text{stationary object} \\ \text{moving object} \end{array} \right\}$$

Example (Stationary queries on moving objects)

Continuously report the cars that are within 3 miles of my home

Example (Moving queries on stationary objects)

Continuously report all gas stations that are within 3 miles of my location

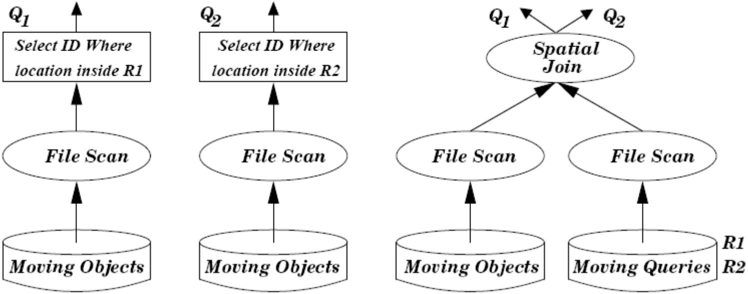
Example (Moving queries on moving objects)

Continuously report all police cars that within 3 miles of my car location

Query Types II

- Range queries (the focus of the paper)
- Nearest neighbor queries
- Aggregation queries
- Predictive queries

Shared Execution



Store spatial extend of

- Moving object
- Moving queries

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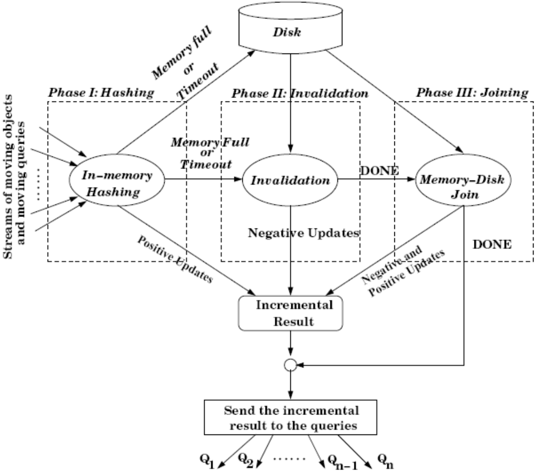
Algorithm Phases

- Hash phase
  - Find positive updates
  - Main memory hash join
- Invalidation Phase
  - Find negative updates
- Joining Phase
  - Find additional positive and negative update
  - Merge positive and negative update
  - Ship changes to clients
  - Clear main-memory data structures

Overview State Diagram



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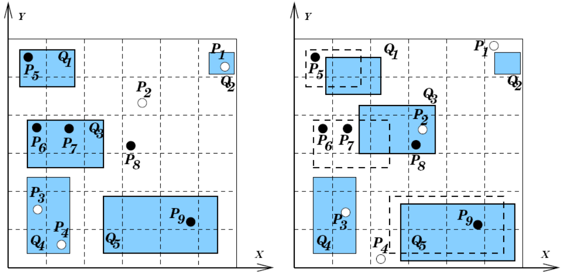


(a) Snapshot at time T_0

(b) Snapshot at time T_1

Updated points

- p_1, p_2, p_3, p_4

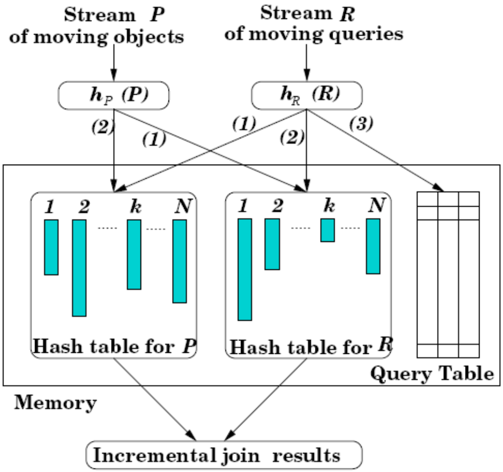
Updated queries

- Q_1, Q_3, Q_5

Positive Updates after join

- $(Q_3, +p_2)$

Data Structures



Algorithm

Procedure HashingPhase(tuple t, source (P/ R))
Begin

1. *If there is not enough memory to accommodate t, start the InvalidationPhase(),* **return**
2. *If (source==P) //Moving object*
   (a) k = *the hash value* $h_P(t)$ *of tuple* t.
   (b) S_q = *Set of queries from joining* t *with queries in* R_k
   (c) *For each* $Q \in S_q$, *add* $(Q, +t)$ *to Updated_Answer*
   (d) *Store* t *in Bucket* P_k
   (e) **return**
3. S_k = *Set of buckets result from hash function* $h_R(t)$
4. *For each bucket* $k \in S_k$
   (a) S_o = *Set of objects from joining* t *with objects in* P_k
   (b) *For each* $O \in S_o$, *add* $(t, +O)$ *to Updated_Answer*
   (c) *Store a clipped part of* t *in Bucket* R_k
5. *Store* t *in the query table*

End.

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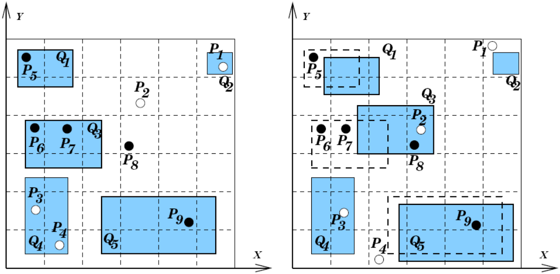


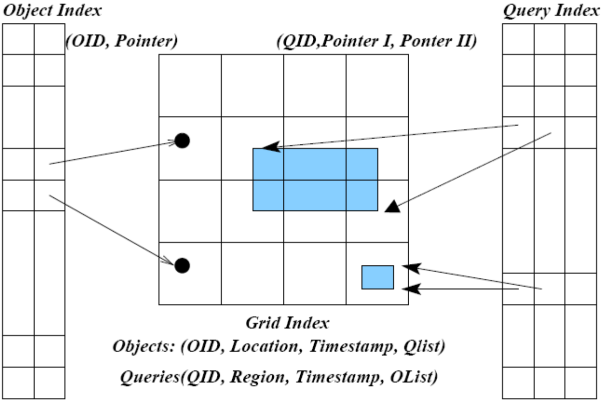
(a) Snapshot at time T_0 (b) Snapshot at time T_1

- p_1 does not cross cell boundary
- p_2 not involved in query at T_0
- p_3 crosses cell boundary
- p_4 is outside Q_4
- Q_1 and Q_5 no result
- Q_2 and Q_4 do not move
- Q_3 leaves cell with p_6 but not cell with p_7

Negative Updates

- $(Q_4, \text{-}p_3)$
- $(Q_4, \text{-}p_4)$
- $(Q_3, \text{-}p_6)$

Data Structures



- Grid can easily be changed to handle skew data

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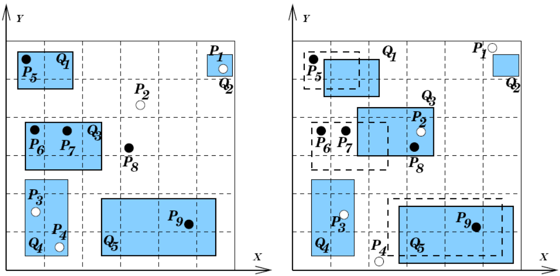
Joining



(a) Snapshot at time T_0 (b) Snapshot at time T_1

Hash join moving objects with stationary queries in grid

- $(Q_2, -p_1)$
- $(Q_4, +p_3)$

Hash join moving queries with stationary objects in grid

- $(Q_1, -p_5)$
- $(Q_3, -p_7)$
- $(Q_3, +p_8)$

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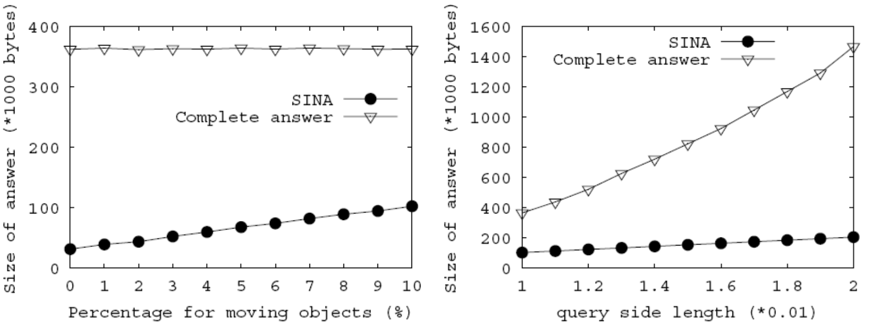
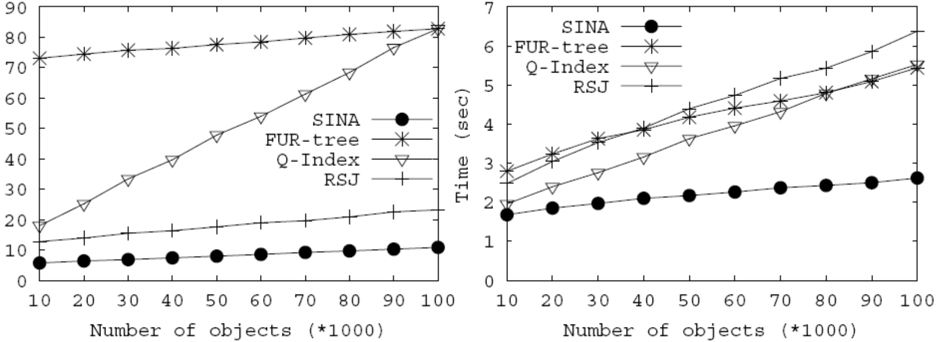
Incremental Computation



(a) Moving objects (%)

(b) Query size

Scalability



(a) I/O (b) CPU Time

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Good Points

- Good description of the characteristics of spatio-temporal apps
- Good overview of related work, like Table 1
- Contributions of the paper are clearly outlined
- Nice that the complicated Section 4 is split into data structures, algorithms, example, and discussion
- Nice running example that is used to explain each step in the core algorithm
- Good experimental validation of incremental and scalability claims
- Complete paper: Clear idea, algorithms, proof, and experiments

Could be Improved

- Section 3 “Shared Execution” is at a very high level of abstraction
- The claim shared execution speeds up query processing could be better supported in the experimentation section
- The refreshment time T is set to 10 seconds. This is a “magic” value
- The discussions in Section 4 could be moved to the end