Freshness-Aware Scheduling of Continuous Queries in the Dynamic Web

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Motivation
Motivation

Wish List 1
Title = Star Wars I
Price = $5
Price < $5

Wish List 2
Price = $2
Price = $5
Price < $7

Web Server

Continuous Queries

- A continuous query is a long-running standing query whose execution is triggered with the arrival of new data

- The output of a continuous query is a continuous data stream (e.g., e-mails or update personalized Web page)

- A Web server should propagate updates to users as soon as they become available, however delays occur due to:
  1) Time spent by a query processing updates
  2) Time spent by a query waiting to be executed
Scheduling Multiple Continuous Queries

- The execution order of continuous queries determines the overall behavior of the system. For example:
  - In Aurora: the Minimum Latency scheduler reduces response time [Carney et. al., VLDB’03]
  - In STREAM: the Chain scheduler minimizes memory usage [Babcock et. al., SIGMOD’03]

- Problem Statement:
  - Devise a policy for scheduling the execution of multiple continuous queries (MCQ) with the objective of maximizing the overall quality of data (QoD) of output data streams

Outline

- Motivation
- Quality of Data (QoD)
- Freshness-Aware Scheduling of MCQ (FAS-MCQ)
- Experimental Evaluation
- Conclusions and Future Work
Quality of Data

- QoD based on freshness (deviation from the ideal)
- At any time instance, the output data stream is fresh when it matches the ideal one, otherwise it is stale

\[ Delay(t_i) = \text{wait time} + \text{processing time} \]

\[ Freshness = 1 - \frac{t_1 + t_2 + t_3}{T_y - T_x} \]

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How updates are processed

Cost of executing operator Q1

Selectivity of operator Q1

Number of pending updates

Wait time of top update in input queue for operator Q1

Incoming updates

Freshness-Aware Scheduling of MCQ (FAS-MCQ)

- Compute loss in freshness (L) under two policies:
  - Policy X: first Q₁, then Q₂
  - Policy Y: first Q₂, then Q₁

- \[ L_X = (W_1 + N_1^\#C_1) + (W_2 + N_2^\#C_2 + N_1^\#C_1) \]

- Loss due to waiting for Q₁ to finish execution

- Loss until processing pending tuples

- Current loss in freshness
Freshness-Aware Scheduling of MCQs

- Under policy X: first Q₁ then Q₂
  \[ L_X = (W_1 + N_1*C_1) + (W_2 + N_1*C_1 + N_2*C_2) \]

- Under policy Y: first Q₂ then Q₁
  \[ L_Y = (W_2 + N_2*C_2) + (W_1 + N_2*C_2 + N_1*C_1) \]

For \( L_X < L_Y \) \( \Rightarrow \) \( N_1*C_1 < N_2*C_2 \)

Priority of \( Q_i = \frac{1}{N_i*C_i} \)

Impact of Selectivity

- A query is a tree of operators
- Each query operator is associated with:
  - Cost (c): processing time
  - Selectivity (s): probability of producing an output after processing an input update

- Maximum cost:
  \[ C = c_1 + c_2 + c_3 \]

- Total selectivity:
  \[ S = s_1 * s_2 * s_3 \]

- Average/Expected Cost:
  \[ C_{avg} = c_1 + (c_2 * s_1) + (c_3 * s_1 * s_2) \]
Selectivity-Aware FAS-MCQ

- Priority of $Q_i = 1/(N_i * C_i^{avg})$
- But we need to consider selectivity:
  - If $S_i = 0$, no appending and the output data stream is fresh
  - If $S_i = 1$, appending and the output data stream is stale
- Compute the staleness probability ($P_i$) = $1 - (1-S_i)^{N_i}$

$$Priority \ of \ Q_i = P_i / (N_i \ * \ C_i^{avg})$$

Summary

- FAS-MCQ behaves as follows:
  - If all queries have the same $P$ (staleness probability) and $N$ (number of pending updates), FAS-MCQ selects the query with the lowest cost
  - If all queries have the same $P$ and $C$ (expected cost), FAS-MCQ selects the query with the lowest number of pending updates
  - If all queries have the same $N$ and $C$, FAS-MCQ selects the query with the highest staleness probability
Intuitions underlying FAS-MCQ

Priority of $Q_i = P_i / (N_i * C_j^{avg})$

- The priority of a query increases if it has:
  - Small processing cost ($C_i$),
  - Small number of pending updates ($N_i$),
  - High staleness probability ($P_i$)

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Simulation Testbed

- Simulated the execution of 250 continuous queries with variable costs and selectivities
- 10 input data streams following Poisson distribution
- Half of the input streams are bursty
- Experiments to show:
  - Impact of utilization,
  - Impact of Selectivity,
  - (Impact of burstiness),
  - Fairness

Scheduling Algorithms

- **FAS-MCQ:**
  Freshness-Aware Scheduling of Multiple Continuous Queries

- **RR:**
  Round-Robin (Aurora)

- **SRPT:**
  Shortest Remaining Processing Time

- **FCFS:**
  First-Come First-Served
Impact of Utilization (Selectivity = 1)

Impact of Selectivity
Conclusions

- We proposed a policy for **freshness-aware scheduling** of multiple continuous queries.
- Our policy exploits the properties of continuous queries (i.e., **cost and selectivity**) as well as the properties of input data streams (**variability of updates**)
- We showed experimentally that our proposed policy outperforms the traditional scheduling policies

**Future:** study multi-stream queries and different definitions for QoD
Ευχαριστώ

Ερωτησεις;

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