Query Driven Operator Placement for Complex Event Detection over Data Streams

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Abstract. We consider the problem of efficiently processing subscription queries over data streams in large-scale interconnected sensor networks. We propose a scalable algorithm for distributed data stream processing, applicable on top of any platform granting access to interconnected sensor networks. We make use of a probabilistic algorithm to check whether subscriptions are subsumed by other subscriptions and thus can be pruned for more efficient processing. Our proposed methods are query driven, hence do not replicate data streams, but intelligently place join operators inside the global network of sources. We show by a performance evaluation using real world sensor data the suitability of our approach.

1 Introduction

The emergence of new sensing devices capable of monitoring the environment with high detail, opened the opportunity to react in real time to fine grained events such as weather changes in the Alps or increases of pollution in urban environments. We envision users register their own queries to get updates in real time. Since users are usually interested in data from different sensors and locations, the corresponding data must be joined. Users are expected to have common interests, hence data has to be efficiently related inside the network to avoid increased traffic. As an application scenario we consider interconnected weather stations where data is monitored by sensors in different locations and relayed by wireless antenna from station to station, back to several locations that store and analyze it.

Related Work: The works in the fields of operator placement and publish/subscribe for large-scale streaming systems usually require some form of global knowledge or a centralized setting. In [2], the authors improve general operator placement techniques to allow for dynamic load balancing while minimizing communication costs; identical operators or groups of operators are shared between queries, but no complex sharing can be achieved, thus duplicating result sets. In [1], the authors achieve less duplication, through a publish/subscribe dissemination of results, but assume a centralized processing location and their subscription processing scheme introduces false positives.

2 Our Approach

We consider a system where sensor networks publish advertisements describing the characteristics of their provided data streams and users (consumers) register queries (subscriptions) inside the network to be informed about events of interest. These subscriptions usually consider multiple data streams originating from different places in the network. As subscriptions from users tend to overlap it is important to filter out that redundancy. We have to enhance the basic

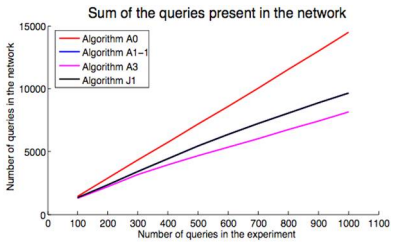

Fig. 1. Queries in the network

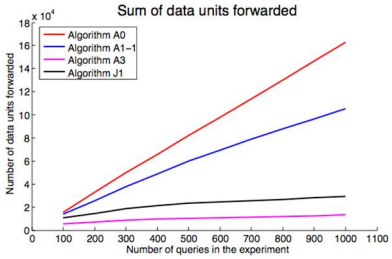

Fig. 2. Data units forwarded

Ouksel filters [3] that can detect whether a set of subscriptions jointly covers another subscription: they cannot be directly applied to data streams, because subscriptions over data streams have varying number of attributes and specific meta-attributes. Each new subscription entering the system passes through "filter, split and forward phases", until it reaches the targeted data stream sources. On the reverse subscription dissemination path, data from the streams of interest is joined and forwarded to the user.

Ouksel filters are applied only between subscriptions over the same attributes. The location meta-attribute is treated like a normal attribute in the filter phase, while the time meta-attribute is ignored, as it is used only for data correlation. If there is no subsumption, a subscription is split into several fragments, based on the sensor networks advertisements. Each fragment groups together attributes corresponding to sources having the same path prefix and locations covered by the location meta-attribute. Only if all attributes are part of some fragment they are forwarded to the neighboring nodes, otherwise the subscription is dropped because it cannot be answered. Then, each forwarded fragment is treated as a new subscription at the receiving node, until it contains just one attribute and has arrived at its data source. Each forwarded fragment is a join operator over the component attributes on the reverse subscription dissemination path. It correlates values from the data streams if they are concurrent and match the corresponding filters and locations, in an efficient way: a value is forwarded only if the operator, as a whole, is matched. The result sets are themselves efficiently forwarded, as each value is sent to the same neighboring node only once, in a publish/subscribe fashion.

Preliminary Experiments: We have analyzed the performance of our algorithm over a simulated network with 100 nodes and 50 sensors replaying real data, coming from a real world deployment (http://sensorscope.epfl.ch), with increasing numbers of generated overlapping queries. We have compared our approach (Algorithm A3), against a naive approach, without any optimization (Algorithm A0), and approximations of $[2, 1]$, (Algorithms A1-1 and J1, respectively). We achieve traffic reductions for both the forwarding of queries (Figure 1) and of result sets (Figure 2).

References

1. B. Chandramouli and J. Yang. End-to-End Support for Joins in Large-Scale Publish/Subscribe Systems. In VLDB 2008.
2. Y. Zhou, K. L. Tan, and F. Yu, Efficient Dynamic Operator Placement in a Locally Distributed Continuous Query System. CoopIS 2006.
3. A. M. Ouksel, O. Jurca, I. Podnar, and K. Aberer. Efficient Probabilistic Subsumption Checking for Content-Based Publish/Subscribe Systems. Middleware 2006.