Online and Offline Algorithmic Techniques for Communication Performance Optimization in Distributed Systems

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Abstract

The focus of the research work presented in this paper is on theoretical and practical aspects of communication optimization in distributed systems. Communication is a key issue in every distributed system and, since good communication performance is often difficult to achieve, optimization techniques are welcome, if not even strictly required. We present both the achieved results and future research plans.

1. Theoretical Problems and Results

From a theoretical perspective, we considered the following problems and developed efficient polynomial algorithms for them: (1) centralized online and batch data transfer scheduling using mutual exclusion graphs with particular structures (e.g. trees, chordal graphs) [1]; (2) non-preemptive scheduling of two communication flows on multiple disjoint packet-type aware paths (we determined a set of non-trivial structures of the optimal schedules); (3) optimal broadcast strategies in tree networks with sending and receiving constraints (we developed new models and extensions for the single-port broadcast problem in trees); (4) maximum reliability k-hop multicast strategy in trees [2].

2. Centralized Data Transfer Scheduling

Data transfer scheduling techniques were developed in the context of a centralized communication optimization framework. Centralized systems are still of interest, because they are the building blocks of larger, decentralized architectures. We considered both the time-slot based and event-based models, together with preemptive and non-preemptive data transfer requests. For the time-slot model, we developed new data structures (e.g. [3]), based on which a bandwidth reservation mechanism was built. The data structures are non-trivial extensions of the well-known segment tree and block partitioning method.

3. Collaborative Peer-to-Peer Architectures

We investigated the use and development of collaborative peer-to-peer architectures in 4 directions. The first direction considers using peer-to-peer architectures for increasing the overall throughput of the communication flows within the system, by routing messages over multiple paths, in a load-balanced manner [4]. The 2nd direction considers offering bandwidth and/or latency guarantees, by using a distributed mechanism for path reservations. The 3rd direction considers the maintenance of a peer-to-peer small-diameter, bounded degree, spanning (multicast) tree of the nodes, under dynamic node arrivals and departures. The 4th direction is focused on the development of a peer-to-peer system with load-aware topology for the retrieval (especially range queries) and replication of data items. Each data item has a bounded number of properties, forming the property space; each peer's id is mapped into the property space of the data items. Each data item *D* is stored at the peer *P* whose id is closest to the tuple of property values of *D* and is also replicated at all the peers within a certain distance from *P*. In all the 4 types of systems, the peers make decisions based only on their local view of the system.

4. References

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