Optimal Allocation of Electronic Content in Networks

BRIEF ANNOUNCEMENT

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The delivery of multimedia information over networks presents providers with a trade-off between the cost of expensive high bandwidth capacity, and the cost of replicating the fast and high storage servers, to save on bandwidth. In this paper we propose an algorithm for finding the optimal allocation of electronic content in a tree oriented distributed network (e.g., a cable TV tree). The algorithm optimizes the cost of storage (storing electronic content in servers) plus the communication cost (transferring electronic content over the network to the end-users). The algorithm is distributed, and requires a small memory capacity and computational power at each node.

Our algorithm has also a sequential version, with time complexity that is $O(N^2)$. Let d be the maximum number of hopes between the root and a node of the tree. When the algorithm execute as a distribution algorithm the message complexity is $O(N)$, the bit complexity is $O(d \cdot N)$, and the time complexity is $O(d)$.

Another practical problem solved is the allocation of servers. That is, assume that the content may be allocated only to a node that contains a server, and there is a cost associated with the server (in addition to the cost associated with the content). The problem is to decide how many servers to allocate and where in the distribution network. We present an algorithms that solves the servers allocation problem, and the electronic content allocation simultaneously. The time complexity of the sequential version of the algorithm is $O(N^{k+1})$, where k is the number of different programs contained in the distribution network. The distributed version of the algorithm sends $O(N)$ messages where the total number of bits is $O(N \cdot d^k)$ and the time complexity of the distributed algorithms is $O(d)$.

We also show how to map this contemporary problems to an area of classical plant location problems in operational research. For example, the "multi copy file allocation" [1] (NP-complete on a general graph) was explored in the context of theoretical computer science. Another example is the "uncapacitated plant location" [2] [3] in the context of operational research. There are several additional problems from the operational research field that can be mapped into networking, such as, the p-median problem and the Medi-Centers problem [5] [3].

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