



Improving rate allocation for ephemeral traffic using a second-order algorithm

Pejman Goudarzi*

Multimedia Systems Group, IT Faculty, Education and Research institute for Information and Communication Technology (ERICT) Teheran, Iran

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ABSTRACT

Proportional fairness criterion which has been proposed the first time by F.P. Kelly and his colleagues has a number of properties in allocating users' rates. For example, it resembles the AIMD in the TCP-Reno (Jacobson, 1988) in rate allocation to users and there exists a well-established stability analysis in Kelly's work relating to stability of rate allocation algorithm. Another outstanding feature is that Kelly et al. try to solve the optimization problem of maximizing the aggregate utility of users in a distributed manner by decomposing the overall system problem into two sub-problems that can be solved by network and individual users by introducing a pricing scheme (Gibbens and Kelly, 1998). In the current paper, a new high-speed second-order rate allocation algorithm has been proposed which is based on the Jacobi method. The performance of the algorithm, under users' arrival and departure and background variable bit-rate traffic is evaluated in comparison with the conventional Kelly's algorithm. Simulation results show that proposed method outperforms that of Kelly in convergence rate and is particularly suitable for ephemeral (short-lived) users.

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1. Introduction

Rate allocation is becoming more demanding as the network capacity grows. Using conventional TCP rate allocation scheme greatly wastes network resources in high bandwidth-delay product environments. There are proposals like FAST TCP (Jin et al., 2004) and XCP (Katabi et al., 2002) for these environments. XCP achieves its goal by decoupling congestion controller from fairness controller. It assigns AIMD, which is proven to achieve desired fairness properties, to its fairness controller, and MIMD for congestion controller, which is shown to utilize resources more efficiently. FAST TCP is a generalization to TCP Vegas (Brakmo and Peterson, 1995) and uses estimated round trip time (RTT) as indication of congestion instead of loss probability.

Hande et al. (2007) propose a distributed rate allocation strategy which can be used for inelastic (real-time) flows. They consider non-concave utility functions, which turn utility maximization into difficult, non-convex optimization problems. Finally they present conditions under which the standard price-based distributed algorithm can still converge to the globally optimal rate allocation despite non-concavity of utility functions.

Bui et al. (2007) extend recent results on fair and stable resource allocation in wireless networks to include multicast sessions, in particular multi-rate multicast. Their solution for

multi-rate multicast is based on scheduling virtual (shadow) "traffic" that "moves" in reverse direction from destinations to sources. The mentioned shadow scheduling algorithm can also be used to control delays in wireless networks.

Xue et al. (2006) propose a new price-based resource allocation framework in wireless ad hoc networks to achieve optimal resource utilization and fairness among competing end-to-end flows. The authors build their pricing framework on the notion of maximal cliques in wireless ad hoc networks, as compared to individual links in traditional wide-area wireline networks. Based on such a price-based theoretical framework, they present a two-tier iterative algorithm. Distributed across wireless nodes, their proposed algorithm converges to a global network optimum with respect to resource allocations.

Kar et al. (2002) have considered the rate control problem for multi-rate multicast sessions, with the purpose of maximizing the aggregate user utility. This utility maximization problem integrates various fairness criteria in a common framework. The authors presented a simple rate control algorithm that achieves the optimal rates for this problem and can thus be used to achieve various fairness criteria (by choosing the utility functions appropriately).

La and Anantharam (2002) have investigated the fundamental problem of the existence of an algorithm that achieves the system optimum in a distributed network without any explicit feedback from the network elements to the end-hosts. They have described a pricing scheme and two algorithms that solve the system problem at the unique equilibrium point of the algorithms.

* Corresponding author. Tel.: +98 21 84977351.

E-mail addresses: pgoudarzi@erict.ac.ir, pgoudarzi@yahoo.com