

Allocation of Resources for Users by Using Fairness and Stability in Network

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Abstract: *This paper studies about network resource allocation between users that manage multiple connections possibly through different routes where each connection is subject to congestion control I formulate a user –centric Network Utility Maximization problem that takes into account the aggregate rate a user obtains from all connections. In a first proposal a new paradigm for resource allocation in networks which intends to bridge the gap between classical Network Utility Maximization applying to congestion control and the user-centric perspective for fairness. The number of connections can be used to achieve this fairness and I also take one option that is either co-operative control or else through network admission control. By using the term NUM I can able to applied to resources allocation across number of protocol layers. The problem of uncontrolled flow rate is controlled through aggregate rate of connections. By using admission control it ensures both network stability and user centric fairness.*

Keywords: Connection, Network, Resource Allocation, User, Control

1. Introduction

This Project, the object of fair allocation is a set of *users*; by definition, each user owns a set of connections, possibly through different routes. Our goal of network efficiency and fairness is the rate allocation between users, in a manner that optimizes a *user-centric* NUM problem. To achieve this objective, we propose to actively control the number of flows per user, assuming the underlying per-flow allocation is unchanged from the aforementioned standard models of congestion control. We now outline our contributions, other related work is summarized in Section II. Our first result, presented in Section III, is related to the motivation of users to increase the number of active flows. We show, under fairly general assumptions on the network topology, that the aggregate rate a user obtains in a certain route increases with the number of connections in this route, when the competing connections are fixed; thus users' selfish incentives are aligned with increasing connection numbers beyond limit, a mutually destructive outcome. such it appears naturally in telecommunication networks. An important question in the network case is imposed. The main trend in networking research in recent times has been to seek fairness in the transport layer, between the allocated rates of end-to-end flows (or connections) traversing a network. standpoint of network users, however, is the resulting fairness notion adequate? On the contrary, it appears that a *higher* layer aspect interferes: users can open an arbitrary number of connections across the network, skewing the overall rate allocation. In fact, aggressive applications often use this technique to vie for a larger share of the bandwidth "pie", but even non-strategic users who happen to overload a common resource will be rewarded by a higher allocation. We must go beyond flow-rate fairness for a more relevant view of network resource allocation

2. Problem Statement

- A cooperative users control their number of active connections based on congestion prices from the transport

layer to emulate suitable primal-dual dynamics in the aggregate rate

- This control achieves asymptotic convergence to the optimal user-centric allocation.
- The case of non-cooperative users that network stability and user-centric fairness can be enforced by a utility-based admission control implemented at the network edge. This control achieves asymptotic convergence to the optimal user centric allocation.
- This problem can be framed in terms of Network Utility Maximization

Disadvantage as Following

- It cannot be stability and fairness issues
- when routing of incoming connections is enabled at the edge router

3. Proposed System

- This system recommend decentralized means to achieve fairness and stability objective.
- Recommended system develop control laws for the number of connections identified with a certain user, which can include single-path, multipath or more general aggregates of flows, and prove convergence to the optimal resource allocation.
- Recommended system propose to actively control the number of flows per user, assuming the underlying per flow allocation is unchanged from the aforementioned standard models of congestion control.
- In the case where connections are generated exogenously by possibly no cooperative users, this project develop admission control policies that ensure both network stability and user-centric fairness.

Advantage as Following

- Stability results for admission control, and the stability region of the routing policy proposed in future
- To use the analysis as a basis for controlling the number of connections to achieve efficiency and fairness in the

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aggregate rates.

4. System Architecture

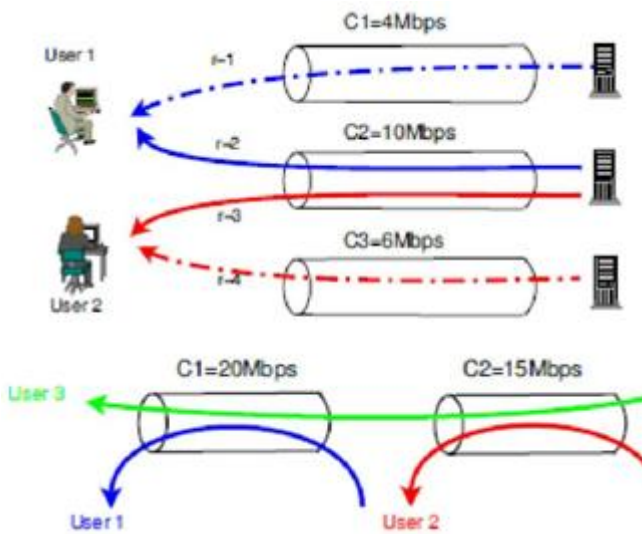


Figure 1: System Architecture

Assume that there is a set of users, indexed by i , which open connections in the network. Each user therefore has a set of routes r and receives an aggregate rate of service $\phi_i = \sum_{r \in \phi_i} \phi_r$. Let U_i be an increasing and concave utility function that models user preferences instead of protocol behavior. Each route is associated with a single user, and if several users open connections along the same path, we duplicate the index r accordingly. Note also that the above framework is very general, with a user defined as a set of routes. This can model users downloading data from several locations, multiple parallel paths, the single-path case, etc. A first step in our analysis will be to assume that users cooperate by controlling the aggregate rate on each route: we will construct a dynamics for the ϕ_r that globally drive the system to the desired optimum, and then analyze how to implement it through connection level control. Note that in this case $\phi_r = n_r \cdot r_x + n_r \cdot r$. The problem under consideration is best explained through on the right, we represent the network by an entity that receives aggregate rates ϕ_r , and returns congestion prices q_r per route. These are used by congestion control to generate the rate x_r per connection; thus the inner loop represents TCP congestion control, for fixed n_r . What we wish to design here is the outer loop (which operates at a slower timescale), controlling the n_r such that the overall dynamics of ϕ_r achieves the desired user-centric fairness. For further clarity, and to facilitate implementation, it is convenient to rewrite the dynamics of n_r in terms of the congestion price, eliminating the variable x_r .

The model in Section IV is applicable to the case where users cooperate by opening or closing connections based on an appropriate feedback from the network. Since selfish incentives of users do not encourage this behavior, we cannot generally count on this cooperation. In such cases, the network must take the role of controlling connection numbers, for which the simplest means is admission control. This approach was advocated in [1], where a stochastic model of connection arrivals and departures is discussed, and

admission control is used to ensure the stochastic stability of the system when the average load is larger than the link capacity; this is done without addressing fairness in the resulting resource allocation. We now would like to derive a decentralized admission control rule, that can be enforced at the network edge, and such that in case of overload resources are allocated according to the User Welfare Problem 2. In the single path case, each user i is associated with a single route r , and thus we can write U_r for the user utility function instead of U_i . In this case, the rule (11) reduces to: if $U_r(\phi_r) > q_r \rightarrow$ admit connection, if $U_r(\phi_r) < q_r \rightarrow$ drop connection. Assume each user on route r opens connections, which arrive as a Poisson process of intensity λ_r , and bring an exponentially distributed workload of mean $1/\mu_r$. Connection arrival and job sizes are independent and also independent between users. Assuming a time scale separation, i.e. that congestion control operates faster than the connection level process, the rate at which a connection is served is $x_r(n) = \phi_r(n)/n_r$, determined by the solution of Problem 1. Also, the aggregate rate on route r is $\phi_r(n)$ and $q_r(n)$ is the route price. This model was introduced by [1], [7]. When the admission control rule (12) is added, the process $n(t)$ is a continuous time Markov chain with the following transition rates: $n \rightarrow n + e_r$ with rate $\lambda_r \mathbb{1}\{U_r(\phi_r) > q_r\}$, $n \rightarrow n - e_r$ with rate $\mu_r \phi_r$, (13) where e_r is the vector with a 1 in coordinate r and 0 elsewhere, and $\mathbb{1}A$ is the indicator function.

Consider now the situation where the user opens connections on several paths, and obtains utility from the aggregate. Assume that connection arrivals on each path are independent, following a Poisson process of intensity λ_r , and with exponentially distributed workloads of mean $1/\mu_r$. For example, this would be the case of users downloading data from different sources at the same time. The lower layers of the network allocate resources as in the single path situation, and each route has an average load $\rho_r = \lambda_r/\mu_r$. Assume that the network implements the admission control rule (11), controlling the aggregate rate each user perceives.

The analysis of the preceding section assumes that each user establishes connections through some set of predefined routes, possibly with multiple destinations. The user manages simultaneously several connections over these routes and derives a utility from the aggregate rate. Moreover, the user has an independent arrival rate λ_r for each route. We now focus on a slightly different situation: here, each user has a set of routes available to communicate with a given destination in the network. These routes are indifferent for the user, all of them serving the same purpose. Each user brings connections into the network, and at each connection arrival, the user or the edge router may decide over which route to send the data. This is a typical instance of the multi-path in the connection level timescale.

5. Experimental Result

Our work touches on several topics that have been studied in other references; these are now overviewed. The impact of parallel TCP connections on aggregate throughput is analyzed in [13], experimentally and invoking the TCP rate formulas of [30]. In these formulas are used for an analysis of strategic user incentives in a single bottleneck network.

Our analysis, based on the NUM framework, enables us to generalize the conclusions to arbitrary network topologies, as well as different notions of flow-rate fairness.

Multi-path congestion control involves endowing each end-to-end connection with multiple paths over which to send traffic, with the capability of controlling each path rate. This has been analyzed from a theoretical perspective in the NUM setting already in [17], for so-called primal algorithms that solve a barrier approximation to NUM; [14], [18] later analyzed the delay stability of this solution. For the exact NUM problem, the difficulty that appears is the lack of strict concavity of the objective function, which leads to oscillations in gradient-type methods. In this respect, the pure dual algorithm considered in [36] yields a discontinuous dynamics that chatters around the equilibrium value, converging only in a mean sense. In [37] this is addressed by replacing the objective function by a strictly concave approximation, thus leading to a stable approximate algorithm. Another strategy to obtain strict concavity is the so-called proximal optimization method, which was applied to multi-path TCP in [25], leading to discrete time algorithms that converge under suitable step size conditions. Non-strict concavity also compromises stability of primal-dual control laws (see [8]); in this regard, our proposal of Section IV provides a new, globally convergent primal-dual law that could be applied to the multi-path TCP problem. From a practical perspective, there is an ongoing discussion in the IETF on multi-path TCP implementations, see [39]. In contrast to these transport layer implementations, our main motivation here is to use the analysis as a basis for controlling the number of (individually single path) connections to achieve efficiency and fairness in the aggregate rates. The use of connection-level control to modify the resource allocation provided by the network was proposed in [4], [5], in the context of wireless networks. Motivated by the high loss rate in these environments, which tampers with adequate congestion feedback, the authors propose an Inverse-Increase.

Multiplicative-Decrease algorithm to adjust the number of connections, an application layer strategy that imposes a certain resource allocation on the problem.

Table 1: Users Details

user1	user 2	user 3	user4
2	10	6	20
3	20	8	30
5	40	9	50

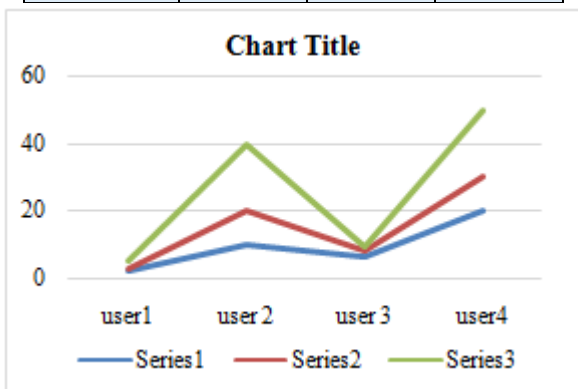


Figure 2: User Details

6. Conclusion

The analysis of the preceding section assumes that each user establishes connections through some set of predefined routes, possibly with multiple destinations. The user manages simultaneously several connections over these routes and derives a utility from the aggregate rate. Moreover, the user has an independent arrival rate λ_r for each route. We now focus on a slightly different situation: here, each user has a set of routes available to communicate with a given destination in the network. These routes are indifferent for the user, all of them serving the same purpose. Each user brings connections into the network, and at each connection arrival, the user or the edge router may decide over which route to send the data. This is a typical instance of the multi-path load balancing problem, but at the connection level timescale. We consider an adaptation of the stochastic.

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