Simplifications of network dynamics in large systems

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Abstract

In the first part of the talk, we will show how that significant simplicity can be achieved for pricing-based control of large networks. We consider a general loss network with Poisson arrivals and arbitrary holding time distributions. In dynamic pricing schemes, the network provider can charge different prices to the user according to the current utilization level of the network and also other factors. We show that, when the system becomes large, the performance (in terms of expected revenue) of an appropriately chosen static pricing scheme, whose price is independent of the current network utilization, will approach that of the optimal dynamic pricing scheme. Further, we show that under certain conditions, this static price is independent of the route that the flows take. We then extend the result to the case of dynamic routing, and show that the performance of an appropriately chosen static pricing scheme with bifurcation probability determined by average parameters can also approach that of the optimal dynamic routing scheme when the system is large. These results deepen our understanding of pricing-based network control. In particular, they provide us with the insight that an appropriate pricing strategy based on the average network conditions (hence, slowly changing) could approach optimality when the system is large.

In the second part of the talk, we will also describe how discuss how similar large-system results can be exploited to develop a purely

distributed optimization approach for Quality of Service routing in high-bandwidth networks. We develop a distributed and adaptive algorithm that can efficiently solve the optimization online. Compared with existing `QoS` routing schemes, the proposed optimization based approach has the following advantages:

1. The computation and communication overhead can be greatly reduced without sacrificing performance;
2. The operating characteristics of the network can be analytically studied; and
3. The desired operating point can be tuned by choosing appropriate utility functions.