Pricing and Flow Control in Communications Networks

by

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Abstract

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In the first part of this dissertation, we study the economic interests of a wireless access point owner and his paying client, and model their interaction as a dynamic game. The key feature of this game is that the players have asymmetric information – the client knows more than the access provider. We find that if a client has a "web browser" utility function (a temporal utility function that grows linearly), it is a Nash equilibrium for the provider to charge the client a constant price per unit time. On the other hand, if the client has a "file transferor" utility function (a utility function that is a step function), the client would be unwilling to pay until the final time slot of the file transfer. We also study an expanded game where an access point sells to a reseller, which in turn sells to a mobile client and show that if the client has a web browser utility function, that constant price is a Nash equilibrium of the three player game. Finally, we study a two player game in which the access point does not know whether he faces a web browser or

file transferor type client, and show conditions for which it is not a Nash equilibrium for the access point to maintain a constant price.

In the second part of this dissertation we study a simple ingress policing scheme for a stochastic queuing network that uses a round-robin service discipline, and derive conditions under which the flow rates approach a max-min fair share allocation. The scheme works as follows: Whenever any of a flow's queues exceeds a policing threshold, the network discards that flow's arriving packets at the network ingress, and does so until all of that flow's queues fall below their thresholds. To prove our results, we consider the fluid limit of a sequence of queuing networks with increasing thresholds. Using a Lyapunov function derived from the fluid limits, we find that as the policing thresholds are increased, the state of the stochastic system is attracted to a smaller and smaller neighborhood surrounding the equilibrium of the fluid model. We then show how this property implies that the achieved flow rates approach the max-min rates predicted by the fluid model.

Professor Jean Walrand
Dissertation Committee Chair

To my mother and father.

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Preface

This dissertation addresses two important problems in communications networks. Part I addresses the problem of WiFi access point pricing by modelling the interaction of an access point owner and paying client as a dynamic game. Part II addresses the problem of flow control in a queueing network. In particular, we show that a simple ingress policing scheme is capable of achieving long-term average flow rates that are arbitrarily close to being max-min fair. To prove our result, we show that the flow rates of the stochastic network approach the flow rates of a fluid model.