PRICE COMPETITION AND USERS' NETWORK SELECTION IN WIRELESS NETWORKS

by

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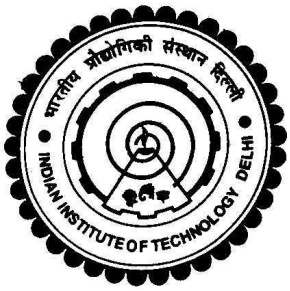

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Certificate

This is to certify that the thesis entitled **" Price Competition and Users' Network Selection in Wireless Networks"** being submitted by Abhinav Kumar to the Department of Electrical Engineering, Indian Institute of Technology, Delhi, for the award of the degree of Doctor of Philosophy is the record of the bona-fide research work carried out by him under my supervision. In my opinion, the thesis has reached the standards fulfilling the requirements of the regulations relating to the degree.

The results contained in this thesis have not been submitted either in part or in full to any other university or institute for the award of any degree or diploma.

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Abstract

The number of users connecting to the Internet has been rapidly increasing. A significant proportion of these users connect to the Internet through various wireless access networks. Each of these wireless networks is controlled by a service provider (SP). These SPs offer diverse quality of service (QoS) to the users for a price. In the presence of overlapping coverage areas, the SPs compete over the common group of users using the price charged by them as a tool to attract users and maximize profits. This results in a scenario of price competition among wireless SPs. The analysis of such price competition is of interest to the users, SPs, regulators, and network designers. The price competition can occur between SPs using the same technology (homogenous SPs) or among SPs with asymmetric access networks (heterogenous SPs). The demand of the users connecting to the SPs can be modeled as homogenous or heterogeneous based on the varying QoS requirements of the users and their ability to pay for the same.

In this thesis, we consider multiple wireless SPs operating in an overlapping coverage area. Initially, we analyze the price competition of wireless local area network (WLAN) SPs in the presence of heterogeneous user demand. Analytical

expressions are derived for the Nash equilibrium (NE) price vectors, social welfare, and price of anarchy (PoA) for the case of duopoly of WLAN SPs. For the case of more than two WLAN SPs (oligopoly), a suitable framework for calculation of the above parameters is presented. It is found that, while in one extreme monopoly leads to very high revenue for WLAN SPs with minimal consumer surplus, in the other extreme unregulated duopoly/oligopoly leads to high consumer surplus at the cost of minimal revenue generation for the competing SPs. Thus, price regulation is proposed in the WLAN market for equitable distribution of the surplus amongst the SPs and users.

Again, we consider multiple heterogeneous SPs (like WLAN and cellular) with overlapping coverage areas. Such SPs do not have dynamic access to complete information about the user demand. We present a novel probabilistic framework for modeling network selection behavior of mobile users in the presence of heterogeneous wireless networks. The proposed framework utilizes the price charged and utility obtained at the SPs for obtaining the network selection probabilities, even in the presence of multi-homing users. Explicit analytical expressions for the transition and steady state network selection probabilities of the users are derived. Further, network level parameters like call blocking probabilities and throughput are obtained in terms of the steady state probabilities. It is shown that the prices and utilities at the heterogeneous SPs have considerable impact on the overall network performance.

Next, we consider WLAN SPs' duopoly price competition with uncertainty

in users' network selection. The uncertainty is modeled by the proposed novel framework. In the presence of such uncertainty, the price competition game of WLAN SPs is analyzed and the existence of Bayesian NE is proved. Using the PoA as a metric of efficiency for social welfare maximization, it is shown that an increase in competition does not result in significant losses in efficiency. Compared to a monopoly, an unregulated duopoly of WLAN SPs is recommended as it results in a more equitable distribution of surplus amongst the SPs and users.

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