Chapter 40
Two-Stage Non-Cooperative Game Model for Vertical Handoffs in Heterogeneous Wireless Networks

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ABSTRACT

In a heterogeneous wireless network (HWN) environment, performing an efficient vertical handoff requires the efficient qualitative evaluation of all stakeholders like wireless networks (WN) and mobile users (MU) and mutual selection of best WN-MU. In the literature, most of the work deals with both these requirements jointly in the techniques proposed by them for the vertical handoffs (VHO) in HWNs, leaving very little scope to manipulate the above requirements independently. This may result in inefficient vertical handoffs. Hence, this chapter proposed a generalized two-stage two players, iterative non-cooperative game model. This model presents a modular framework that separates the quantitative evaluation of WNs and MUs (at Stage 1) from the game formulation and solution (at Stage 2) for mutual selection of best WN-MU pair for VHO. The simulation results show a substantial reduction in the number of vertical handoffs with the proposed game theory-based two-stage model as compared to a single-stage non-game theory method like multiple attribute decision making.

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1. INTRODUCTION

Heterogeneous Wireless Networks (HWN)(Pramod Goyal, Lobiyal, & Katti, 2018c) comprises of different types of Wireless Networks (WN) having a hierarchical structure. The difference in the constituent WNs are generally in terms of Network Technologies, Network Architecture & Protocols and Network Operators in the market (Trestian, Ormond, & Muntean, 2012). Fig.1 shows an HWN consisting three wireless networks; Wi-Fi, CDMA and Wi-Max overlapping each other. When a Mobile User (MU) or group of mobile users sitting in a car or a train wish to roam in an HWN environment, they may need to change the current network and connect to another network. This event is termed as Handoff. The handoff is mainly classified between two types as Horizontal Handoff (HHO) and Vertical Handoff (VHO). The HHO occurs between the same type of networks while VHO occurs between two different. In today's fast changing world, the next generation networks like 4G and 5G will all be HWNs. Even the Vehicular Ad-Hoc networks will have to be part of these networks so as to provide cloud based seamless data roaming services to the mobile users.

Like different constituent WNs in a HWN, the participating MUs may also be different. The MUs may be differentiated in terms of the service requests as real-time (e.g. voice/video call) or non- real time service (e.g. emails). Now days, the communicating devices like mobile phone or laptop are equipped with the capability to work as multi-mode or multi-home terminals. A MU with such communicating devices (Wang & Kuo, 2013) can connect with more than one different WNs at any point in time. At the same time, a WN may experience different service requests from multiple MUs. In such situations where multiple mobile nodes are competing with multiple WNs, the selection of mutually best WN – MU pair to perform the seamless and efficient Vertical Handoff (Pramod Goyal, Lobiyal, & Katti, 2017) becomes a challenging task.

Describing a WN as best in HWNs from MU's perspective depends on multiple decision factors which are termed in literature as network selection attributes or Handoff Decision Attributes (HDA) like Received signal strength (RSS), Offered Bandwidth, Delay, Jitter, Bit Error rate (BER), Velocity, Power Consumption, Distance and network usage cost etc. The HDAs may be conflicting in nature to each other like bandwidth and cost. A MU may prefer one HDA over another. Such relative preferences of users are termed in literature as User Preferences. The user preferences may be Static or Dynamic. However, the Dynamic User Preferences (Pramod Goyal, Lobiyal, & Katti, 2018b) are more useful in accommodating the changes in the values of HDAs on real time basis when a MU roam within a HWN which may result in higher user satisfaction.

Similarly, describing a MU as best from the network's perspective is depends on multiple factors like typeof service requested by the MU, requested bandwidth and expected revenue receivable from MU's etc. A WN operator generally charge different network usage cost for different type of service requests from a user. The network usage charges for voice and data services are based on per unit time (e.g. Rs / minute) and per unit data (Rs /Mb) respectively. The differential network usage cost policy force a WN to prefer one type of service request over another and prioritise the competing MU's accordingly in order to maximise its expected revenue.

The Multiple Attribute Decision Methods (MADM) (Pramod Goyal et al., 2017) based on utility theory (Zanakis, Solomon, Wishart, & Dublish, 1998) like "Simple Additive Weighting (SAW), Multiplicative Exponential Weighting (MEW), Analytical Hierarchical Process (AHP), Grey Relational Analysis (GRE) and Technique of Order Preference Similarity to Ideal Solution (TOPSIS)" are commonly used techniques to rank the available WNs. These methods can incorporate multiple & conflicting HDAs along with their

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