Handoff Cost Minimization and Planning of Next Generation Heterogeneous Integrated Overlay Networks: Meta Heuristics Based Approach

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ABSTRACT

Next-generation wireless technologies have seen a paradigm shift as multiple standards and protocols emerge almost every day. Each standard has its limitations and merits, which can be either masked or complemented by other standards. For commercialization, various services should be provided in a cost effective manner, compelling a service provider to roll out integrated next generation wireless networks to exploit the virtues of each. This paper discusses the planning problem of overlay network integrating, particularly 3G, WiMAX and WLAN, establishing proper connectivity among the three networks. In the proposed planning approach, the authors focused on the initial phase and have minimized the cost for vertical handoff generated, and the cost for wire line connection amongst the various network gateways of the overlay hierarchy. To validate the planning problem, the simulated annealing (SA), a well-cited meta-heuristic H-II are presented and compared with a variant of distance based planning (DBP).

Keywords: Combinatorial Optimization, Handoff Management, Heterogeneous Network Planning, Meta-Heuristics, Overlay Network, Simulated Annealing

INTRODUCTION

As various multimedia applications with different quality of service (QoS) requirements are becoming popular, provisioning of seamless wireless service to the end customers is becoming a business challenge for a wireless service provider. Due to technological constraints, it is not possible to meet the varied demands of the customers with a single wireless technol-
ogy (Stemm & Katz, 1998). For example, no wireless technology can provide high data rate with high mobility. Thus, we have different wireless technologies with different capabilities that suit different application requirements. For example, Wi-Fi, a wireless local area network (WLAN) caters to high data rate requirements and supports limited mobility. On the other hand, universal mobile telecommunication system (UMTS), a third generation (3G) cellular wireless wide area network (WWAN) offers higher mobility at lower data rate. Again, wireless metro area network (WMAN) such as WiMAX provides higher data rate than 3G and at the same time, higher mobility compared to WLAN. The hardware development with multiple technology interfaces (Simić, 2007) has open up the possibility of using this multiple technology infrastructure in a complementary manner.

The costs of services provided to the end user by employing these technologies are not similar. A case in point, WLAN operates in a license-free frequency band, whereas WMAN or 3G operates on expensive licensed frequency band (Zhuang, Gan, Loh, & Chua, 2003). Consequently, the cost of service delivery using WLAN becomes lower compared to later ones. Similarly, the deployment cost of WMAN varies with that of 3G. So, it also makes business sense to use multiple technologies as a cost effective measure. This gives rise to the architecture of heterogeneous overlay network where, best features of each technology are kept intact and their weaknesses are mediated by the companion technology.

Cost effective service delivery can be achieved through the combination of an integrated network planning and real-time network resource management policy. Nasser, Hasswa and Hassanein (2006) have addressed the latter issue. To the best of our knowledge, substantial works have not been carried out on integrated network planning by researchers. In this paper, we dwell on the aspects of optimal network planning of heterogeneous network.

This planning may be done in the following scenario:

1. Planning to optimize resource utilization of an overlay network with no existing infrastructure i.e. green field approach.
2. Planning to optimize resource utilization of an overlay network with non integrated existing heterogeneous infrastructure i.e. brown field approach.

In reality, the planning is often done to minimize connectivity cost using popular technique such as distance based planning (DBP) where only distance is considered as a criterion for establishing connectivity amongst the different networks. For example, WLAN is always connected to its nearest WiMAX base station (WiMAX BS). But this kind of planning may lead to inefficient use of other network resources like spectra. In wireless network, one of the usages of spectrum is to support mobility management, namely, location management and handoff management. In heterogeneous network environment, two kinds of handoffs occur namely, horizontal handoff and vertical handoff (Nasser et al., 2006). Horizontal handoff occurs when the user moves from one access point to another while both the access points use the same technology. This is the case when the user moves between two WLAN access points (WLAN AP). Vertical handoff refers to the handoff process of a user among access points that employ different network technologies. Handoff process due to movement of user from WLAN to WiMAX is an instance of the vertical handoff.

Traditionally, service providers have experience in managing the horizontal handoff at the individual network level. Management of vertical handoff is a new challenge faced by them in case of heterogeneous network. During the vertical handoff process, various control messages such as authentication, authorization and accounting (AAA) are generated. These control messages may lead to delay, consumption of precious radio resources. As number of users rises, more vertical handoffs increase the load on the radio resources. One of the most important objectives of network planning is
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