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Performance Evaluation and Robust Optimization of Handoff Algorithms in Heterogeneous Wireless Networks

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Abstract— The convergence of heterogeneous wireless access technologies has been envisaged to exemplify the next generation wireless networks. In such converged systems, the seamless and efficient handoff between different access technologies (vertical handoff) is crucial and vestiges a challenging issue. The heterogeneous co-existence of access technologies with largely different characteristics results in handoff asymmetry that differs from the traditional intra-network handoff (horizontal handoff) predicament. In the case where one network is preferred, the vertical handoff decision should be carefully executed, based on the wireless channel state, network layer characteristics, as well as application requirements. In this paper, we study the performance of vertical handoff using the integration of 4G cellular and wireless local area networks as an illustration. We present an analytical framework to evaluate the converged system performance, which is validated by computer simulation. We show how the proposed network model can be used to provide the optimization of vertical handoff in the future integrated wireless networks.

Index Terms— Robust Optimization, Vertical Handoff, Heterogeneous Wireless Network, 4G, MATLAB .

1 INTRODUCTION

WIRELESS technologies are evolving toward broadband information access across multiple networking platforms, in order to provide ubiquitous availability of multimedia applications. Recent trends indicate that wide-area cellular networks based on the 3G standards and wireless Local Area Networks (WLANs) will coexist to offer multimedia services to end users. These two wireless access technologies have characteristics that perfectly complement each other. By strategically combining these technologies, a converged system can provide both universal coverage and broadband access. Therefore, the integration of heterogeneous networks is expected to become a main focus in the development toward the next generation wireless networks [1–3]. Mobility management is a main challenge in the converged network. It addresses two main problems: location management and handoff management [4,5]. Location management tracks the Mobile Terminals (MT) for successful information delivery. For this purpose, Mobile IP (MIP) enables seamless roaming and is expected to be the main engine for location management in the next generation networks. Handoff management maintains the active connections for roaming mobile terminals as they change their point of attachment to the network. Handoff management is the main concern of this paper.

Intra-technology handoff is the traditional Horizontal Handoff (HHO) process in which the mobile terminal hands-off between two Access Points (AP) and Base Stations (BS) using the same access technology. On the other hand, inter-technology handoff, or Vertical Handoff (VHO), occurs when the MT roams between different accesses technologies. The main distinction between VHO and HHO is symmetry. While HHO is a symmetric process, VHO is an asymmetric process in which the MT moves between two different networks with different characteristics. This introduces the concept of a preferred network, which is usually the underlay WLAN that provides better throughput performance at lower cost, even if both networks are available and in good condition for the user.

There are two main scenarios in VHO: moving out of the preferred network (MO) and moving into the preferred network (MI) [6]. In the converged model, it is highly desirable to associate the MT with the preferred network, as long as the preferred network satisfies the user application. This can improve the resource utilization of both access networks, as well as improving the user perceived QoS. Furthermore, this handoff should be seamless with minimum user intervention, while dynamically adapting to the wireless channel state, network layer characteristics, and application requirements. In this work, we present an adaptive lifetime-based VHO (ALIVE-HO) algorithm which takes into consideration the wireless signal strength and handoff latency. We further propose an analytical model to evaluate the performance of adaptive VHO. This analytical framework is then applied to show how the VHO decision can be optimized based on multiple conflicting criteria including vertical handoff signaling, user available bandwidth, and encountered packet delay. Hence, the optimal ASST value is determined for different QoS requirements.

The rest of this paper is organized as follows. Section 2 provides an overview for the robust optimization method for wireless heterogeneous networks and the related literature work. In Section 3, we present a vertical handoff algorithm that incorporates cross-layer adaptation to terminal mobility, channel state, and application demand. In Section 4, we propose an analytical framework to study the effect of cross-layer adaptation. Numerical and simulation results are provided in Section 5, where we show how to optimize VHO decision. Concluding remarks are presented in Section 6.

2 ROBUST OPTIMIZATION METHOD

Unadventurously, problems have been explained

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pretentious the input data to be invariant. However, in practice, the comprehensions of the input data to the model are, more often than not, different from those unspecified in the mathematical model. This causes the solutions that are attained to be remote from optimal in real life, and in some cases, even infeasible. Models are naturally created by using `best-guess' values or mean-values of input data, or by resolving `worst-case' problems. Such `worst-case' or `best-guess' formulations do not afford acceptable explanations. They are either too expensive (worst-case models) or have vast errors (mean-value models). We pass on to model inputs that are undetermined to be appreciated with certainty, as nominal values; the models devised using nominal inputs as nominal models, and the keys thus attained as nominal solutions. After accomplishing a case-study on the problems in [7] also fulfilled that in the real-world requests of linear programming, one cannot ignore the opportunity that a small uncertainty in the data can create the ordinary optimal solution entirely pointless from a realistic viewpoint"[8].

The widespread linear programming problem with robust optimization using MATLAB is the simulation in feasible solution for constraint problems. As a consequence, the simulation does not crutch up very well common linear programming features such as minimum cost network flow with uncertain demand. However, the widespread linear programming simulation will not be able to be handled by shifting the cost vector to gain vector. The relatively new robust optimization minimum channel gain flow problem is the best simulation which can switch minimum channel gain flow problem for maximizing the minimum throughput in heterogeneous wireless network. In the robust optimization minimum channel gain flow problem, the simulation is done on the equal power distribution and dynamic subcarrier project.

3 Proposed System

Heterogeneous wireless networking is a paradigm that can overcome this limitation by using a combination of existing technologies. It is expected that such networks will be deployed extensively in the near future to redefine our understanding and expectations of wireless communications by simultaneously providing universal coverage and high bandwidth access where available. Heterogeneous Wireless Networks (HWN) consist of several layers of different overlapping access technologies. This multi-layer architecture provides users with the option of choosing between available services based on traffic profiles, mobility patterns, and Quality of Service (QoS) preferences. Currently, the most commonly deployed HWN architecture is the integration of 3G at the overlay with IEEE 802.11 at the underlay. An example is shown in Figure.1. At the top layer the overlay network provides wide-area service, and at the bottom layer, the underlay network provides local-area service. Overlay network availability is, in general, higher as compared to the underlay network, but it provides lower data-rates at a higher cost. It is anticipated that this new service model will become widely popular, and as such, many new mobile hand-sets are equipped with dual-mode interfaces (e.g., 3G/IEEE 802.11).

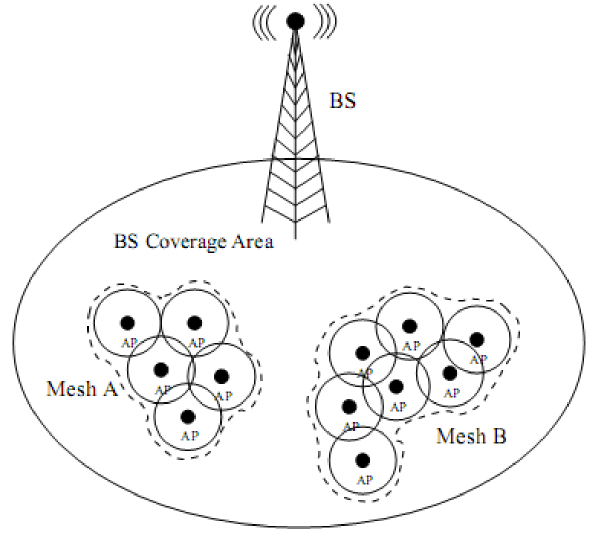

Figure.1 Sample Network Architecture

A major technical requirement for HWNs, before they can be fully incorporated into future wireless infrastructure, is that they support QoS for multimedia services. QoS provisioning in these networks is challenging due to the diversity in existing technologies and the presence of mobile users with different communication preferences. In addition, to achieve an acceptable QoS, performance challenges have to be addressed at two levels. On one level, we are concerned with per packet performance metrics such as packet drop rate and delivery latency and jitter. On another level, we want to guarantee that ongoing calls will not be dropped when a mobile user moves to another coverage area.

When a mobile user crosses the coverage area of a given base station or WLAN AP, it has to disassociate from its current network, and quickly associate with the base station in the target cell. This is referred to as a handoff event. Handoff between two access technologies operating at different layers is called vertical handoff (VHO) [3]. The increasing demand for higher data rates will force network designers to use smaller coverage areas and a larger number of base stations. This will make handoff a more frequent event in future networks.

Vertical handoff from a lower to an upper layer is undesirable because resources at higher layers are more competitive [1]. At higher layers, the transmitting station would interfere with a larger number of stations resulting in less spectrum efficiency. As well, accommodating a VHO requires seamless transition of an ongoing call between two technologies with potentially non-matching QoS specifications. All of this adds up to make proper handling of vertical handovers one of most resource-intensive challenges for a network management module. Here, while the goal is to maximize performance, a fine balance must be maintained between over-reservation of resources and a high handoff drop rate due to under-reservation.

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4 Assumptions and System Model

Generally, in the network planning or upgrade process, the goal is to add N new APs to the underlay architecture which may already have N0 APs. The deployment area is divided into an H-by-W grid space and each block is called a cell. We assume that each cell may contain an AP. The set of adjacent cells with an AP inside them form a cluster. When the planning is done we might have several independent clusters as depicted in Figure.1. Vertical handoff occurs when a mobile user having an active call leaves a cluster and starts to use the overlay networking services. In this chapter our objective is to jointly minimize the total rate of the upward vertical handoff events and to maximize the total supported number of network users. To reduce the optimal planning complexity and to make the problem tractable a discrete search space is assumed in this thesis. Discrete search space for AP placement is used. The error introduced by this approximation is negligible considering the uncertainties in traffic characteristics modeling, i.e., the call arrival rate in each area, the call duration distribution and handoff and coverage-crossing probabilities. This error is also overshadowed by the fact that in practice the placement of an AP is highly dependent on the site-specific constraints.

One key observation here is that the user mobility pattern is independent of the infrastructure presence and its variations. Generally, this is true because users are commonly not concerned with how the networking services are achieved and they make their movements decisions independent of that. This allows us to look at the steady-state occupancy distribution of each cell independently of how the final deployment for the underlay network is done. Furthermore, we assume that all arrival and departure processes are memoryless and as such are Poisson processes. As shown in Figure.2, we denote by λ(i, j) the call arrival rate to cell (i, j), the call termination rate by μ(i, j) and call handoff rates from cell (i, j) to each of its neighboring cells by H(i, j, k).

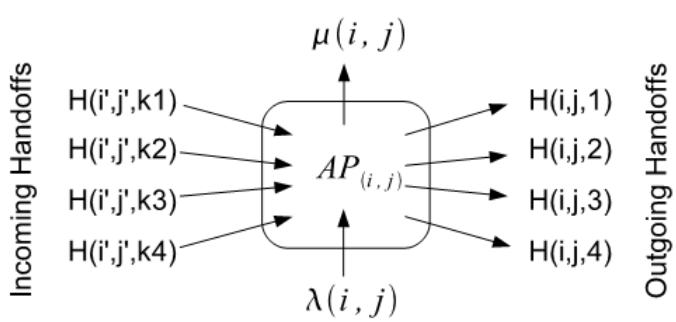
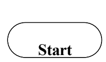


Figure.2 Traffic arrival and departure from AP(i,j)

4 Implementation

The flowchart of Vertical Handoff algorithm is illustrated in figure.3. According to the simulation model, the k-coverage probability for heterogeneous wireless network for wireless network simulator is mentioned in the simulation results.



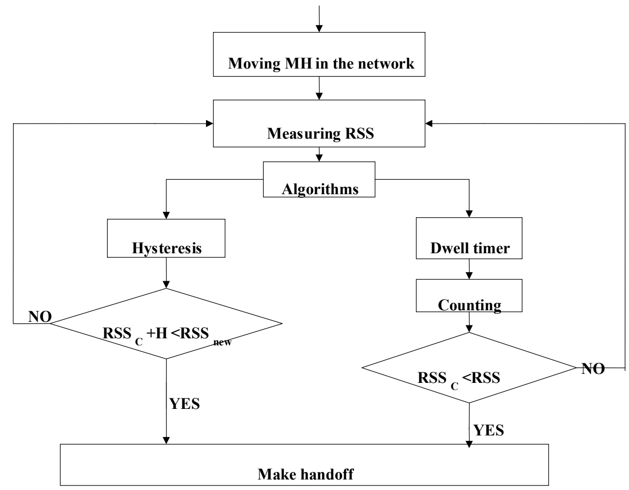


Figure.3 Flowchart for VHO Algorithms

5 Simulation Results

The k-coverage probability for multi nodes network is 0.65 and two nodes network is 0.28. The k-coverage probability for k=1 in HGWN is 1, k=2 is 0.64 and k=3 is 0.25 respectively. Comparison of integration method and simulation method for two base station signal combination and interference cancellation is similar. SINR-based k-coverage probability in heterogeneous wireless network for integration method and simulation method are also similar. The error value may be accepted to complete the optimal network model. Figure.4 to 10 shows the simulation results based on 20 node network model.

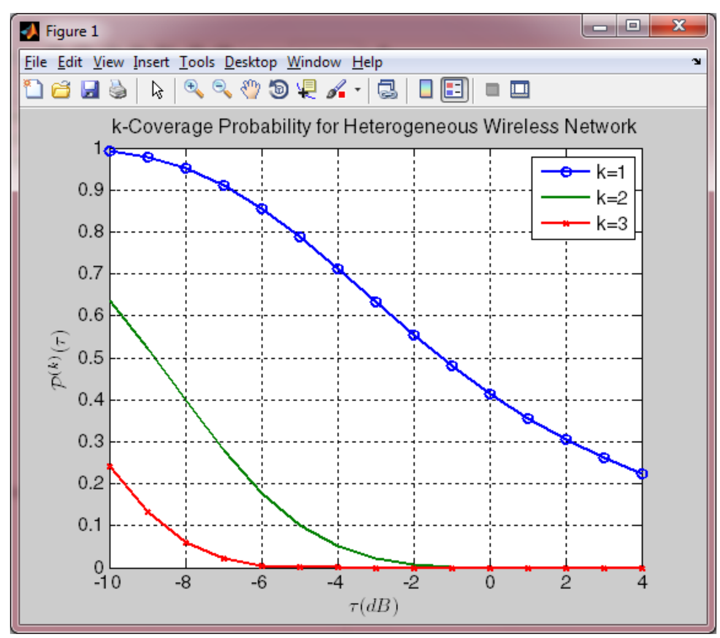


Figure.4 K-Coverage Probability for Heterogeneous Wireless Network

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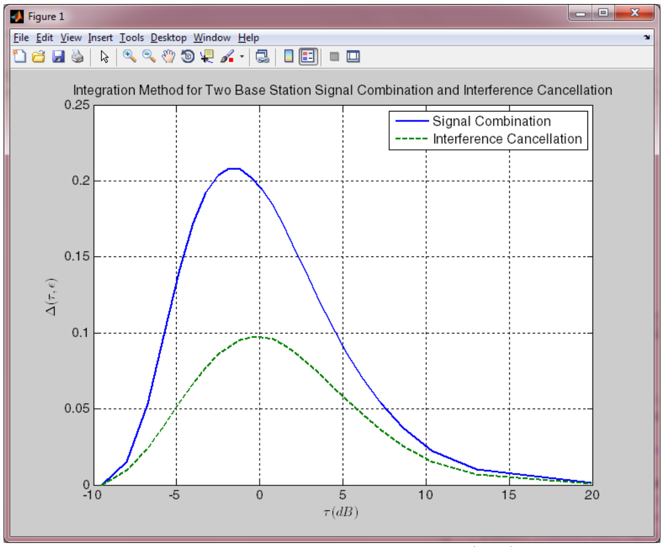

Figure.5 Integration Method

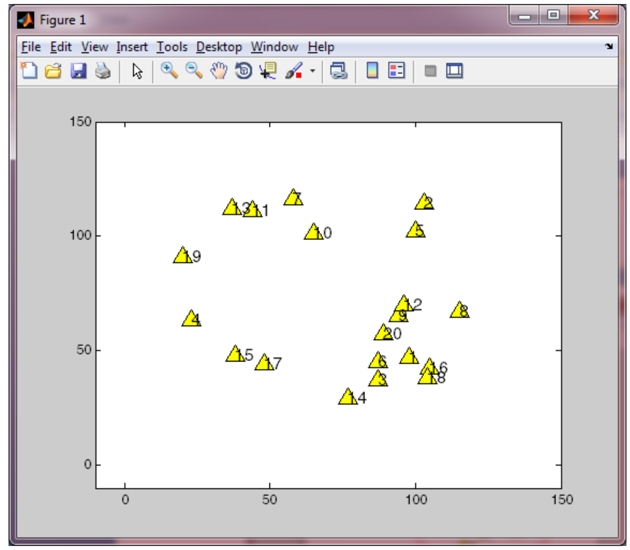

Figure.8 Network Model

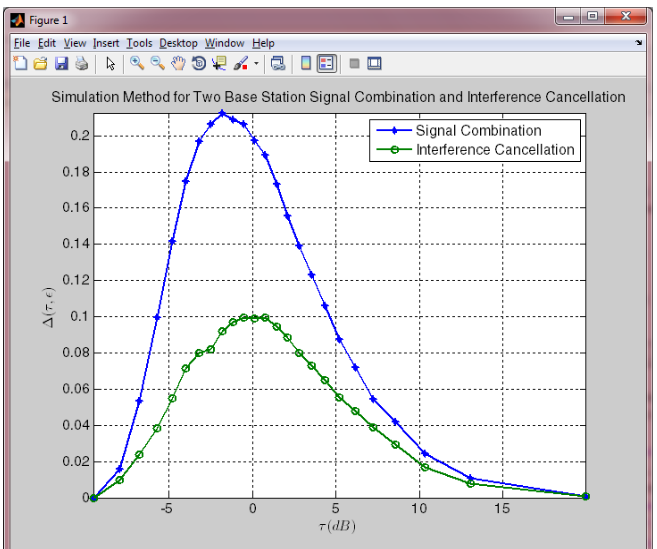

Figure.6 Simulation Method

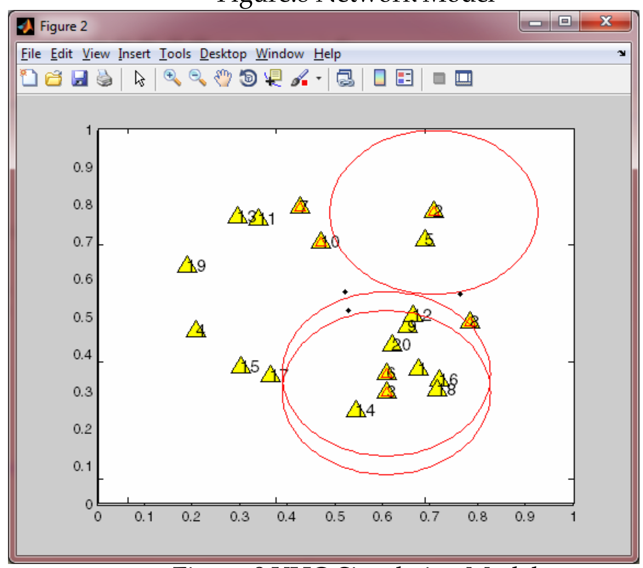

Figure.9 VHO Simulation Model

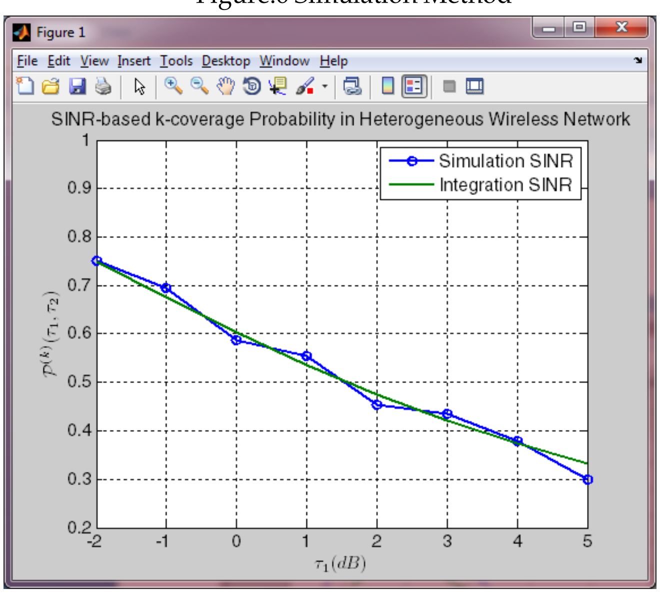

Figure.7 SINR based k-Coverage Probability

4 CONCLUSION

An analytical framework to evaluate VHO algorithms is presented. This work provides guidelines for the robust optimization of handoff in heterogeneous wireless networks. To support both VHO and HHO decisions, this proposed work extends the traditional hysteresis-based and dwelling-timer based algorithms. The heterogeneous wireless network model for 20 nodes has been animated in MATLAB environments. It is anticipated that, in the near future, Heterogeneous Wireless Networks (HWN) will be widely deployed, and mobile handsets will be capable of using a diverse range of communications technologies to remain "always best connected". Due to their inherent heterogeneity, the efficient deployment of these networks and the dynamic management of their communication resources will require a new generation of algorithms and schemes. This work addressed the challenge.

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