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Road Based Mobility with Network Information Services

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Abstract

Increasing traffic demand and mobility pose many challenges for wireless networks. Lack of sufficient wireless resources and attempts to fix the problem by equipping networks with more small cell base stations challenge mobility managers. Network information services have been widely cited to help mobile users and networks cope with increasingly dense heterogeneous network environment. In this paper, an information service enhanced with information about base station coverage areas and expected driving routes of end systems are used as basis to improve mobility. Especially, emergency and other high-priority vehicles with pre-known driving routes could benefit from the proactive selection of base stations and their configuration to guarantee quality of service throughout the traversed path. The results indicate that the demanded quality is likely not met when networks suffer from congestion. Moreover, cell selection based on the known route can decrease the number of handovers even almost by half compared to the traditional algorithm using signal strength measurements as basis for the handover target selection.

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1. Introduction

Substantially growing data traffic over cellular networks can cause big variations in the Quality of Service (QoS) when handing over base stations (BSs) in a heterogeneous network environment. Traffic loads in networks and individual BSs vary, which can cause increased transmission delays and packet losses. Moreover, the average cell size is anticipated to decrease in the future in order to better cope with the increasing capacity demand. This poses challenges especially for high-speed vehicular mobility as the number of handovers can potentially increase significantly when the traditional cell selection scheme, based on the strongest signal criterion, is used.

More and more, emergency vehicles are capitalizing on wireless networks to get remote assistance or to inform other parties of emergency situations in real-time. For example, wireless telemedicine will play an important role in the evolution of the Internet¹. The utilization of wireless networks in emergency situations is not related to only voice

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and text messages, but, for example, real-time video and 3D image transmission take place more often. In emergency cases, the delivered content is also often intolerant for errors, such as in the case of the delivery of biomedical data. Thus, the BSs and networks used by emergency vehicles should provide a guaranteed QoS for their applications, even in high-speed mobility.

In this paper, we study how the knowledge of the driving routes of high priority vehicles can be utilized in the handover target selection and preparing the networks to guarantee a satisfying QoS across the route. The current mobile devices are capable of knowing their geographic location within a few meters. Moreover, the driving routes of, e.g., emergency vehicles are often known in advance. This study utilizes a network information service, which allows querying for networks and BSs nearby of mobile stations. Network information services are specified in IEEE 802.21 Media Independent Handover (MIH) Services² and 3rd Generation Partnership Project (3GPP) Access Network Discovery and Selection Function (ANDSF)³ standards. Those standards facilitate cellular network users to seamlessly switch to heterogeneous networks expected to satisfy the required service level. The information services of both standards are observed similar, as studied in⁴. One clear difference is that ANDSF supports Mobile Network Operators (MNOs) to define policies for end system handled network selections. Policies are out of scope of IEEE 802.21. However, neither of the standards allows determining the operational areas of BSs with sufficient precision. Thus, the BS coverage area enhanced information service presented in⁵ and first studied in mobility scenarios in⁶ is exploited in this paper. The goal of the paper is to evaluate the importance of QoS assurance for high-priority data traffic when BSs with different probabilities suffer from congestion, and the BS cell selection to decrease the number of handovers when the driving route is known.

The rest of this paper is organized as follows. In Section 2, the related work is presented. Section 3 introduces the route based mobility solution. Section 4 presents the evaluation results of the solution and Section 5 concludes this paper by outlining also future work.

2. Related Work

Overall, network information service assisted mobility is not thoroughly studied in the open literature. The benefit of IEEE 802.21 information service, known as Media Independent Information Service (MIIS), for improving handover performance through network pre-authentications is studied by Christakos et al. in⁷.

Location based network selection has been studied in many papers. Pawar et al. present a QoS-aware and location based network selection mechanism in⁸. However, their solution does not indicate reliably the coverage areas of networks, much less about individual BS cells. Proactive handover management based on previously recorded data about networks in different locations is studied by Kovacs et al.⁹. The solution predicts handover locations based on earlier experience and utilizes multihoming to minimize the disruption of handovers to QoS. However, the solution proposes that each mobile router maintains its own database, which is not efficient. Moreover, the collected data is not efficiently utilized in the selection of handover target network. Shi et al. have studied navigation based on network quality in¹⁰. The selection of driving route based on networks that can satisfy the required service level can potentially result in longer traveling distances. This trade-off can often be unacceptable for high-priority vehicles, such as emergency vehicles. Dutta et al. have studied location assisted handovers in¹¹. They exploit both mobile device's location information and signal quality in the handover decision making, but use only a relative location of the mobile device with respect to the close-by networks, neglecting the analysis of BS coverage areas.

Many of the location based mobility solutions are related to network selection, not on cell based handover management. Cell selection plays a more essential role in the future wireless networking due to the change of mobile network infrastructure to increasingly favor small cells such as femtocells, picocells and microcells. Cell selection algorithms in a heterogeneous network environment have been studied in a number of papers, however, most of those are based only on the signal strength criterion. The studies carried out by Bai et al.¹², Chowdhury et al.¹³ and Wang et al.¹⁴ observe the challenges posed by heterogeneous networks with different size cells on the optimized mobility.

3. Route Based Mobility Optimization

Fig. 1 illustrates a heterogeneous network environment typical of the future wireless communications. Within large macrocells, several femtocells, picocells and microcells are deployed to sufficiently keep up with regional traffic

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