

Mobility Analysis for Passive Reservations in Vehicular Cellular Networks Based on Dynamic Programming and Roads Compression

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ABSTRACT

The employment of an appropriate Bandwidth Management Scheme (BMS) is needed in wireless networking, given that the main desire of end-users is to take advantage of satisfactory services, in terms of Quality of Service (QoS), especially when a particular charge is paid to meet the requirement. In this paper the authors are interested in investigating how the continuity of services can be guaranteed in QoS networks, when users move from a cell to another one, under an infrastructure cellular coverage. The only way to face this issue is represented by the employment of in-advance bandwidth reservations, although it leads the system to waste bandwidth resources, since they are not used until the mobile host enters the coverage cell where the passive request has been made. A new scheme for predicting user movements is proposed, taking the advantage of the dynamic programming approach, that is able to reduce the number of possible roads to be considered and thereby increasing/decreasing the accuracy/redundancy of the proposed model. Several simulation runs have been carried out in order to assess the effectiveness of the proposed idea.

KEYWORDS

Bandwidth, Distributed, Hand-Over Management, Markov, Mobile Host, Mobility Prediction, Passive Resource Reservation, Pattern, QoS, Wireless Networks

1. INTRODUCTION

With the rapid growth of Internet of Things (IoT) and mobile communications, the need for QoS guarantees has become of primary importance, especially when hand-over events occur by Mobile Hosts (MHs) changing coverage areas during their active sessions; they may find scarce resource availability in new locations and the current active connections can be dropped. To the best of our knowledge, the only way to ensure QoS and service continuity to mobile users consists of making a bandwidth reservation over all the cells that a MH will visit during its active connection. There are many protocols able to ensure early reservations like Next Step In Signaling (NSIS) (Fu, 2005), Dynamic ReSerVation Protocol (DSRVP) (Huang, 2004) and Mobile ReSerVation Protocol (MRSVP) (De Rango, 2009), but a prediction scheme is mandatory in order to know which coverage cells a

user will probably visit during its Call Life Time (CLT). On the basis of previous works (De Rango, 2005; Fazio, 2012), we considered the MRSVP, which gives the possibility to exchange the right communication messages among the predicted coverage cells, achieving the needed passive amount of bandwidth in the cells where the MH will probably hand-in. The same Markov model has been considered, but an optimization on the number of chain states is now proposed: in the previous contributions, only one hand-over direction has been considered for the hand-off event toward a next cell, without considering the roads topology that characterize MH movements. Given that the number of chain states could be very large if all the roads that lead to another cell are considered, an optimization scheme is proposed. In particular, the dynamic programming approach is considered (Shivaram, 1997), having the possibility to choose the right number of states for the Markov model, taking into account the morphology of the considered geographical region. An approximation has been introduced and the associated error has been minimized. Clearly, in order to implement and realize this kind of prediction, a real network operator has to analyse users' mobility, through a statistical treatment. In our case, without access to real data about MH movements, we employed the Citymob for Roadmaps (C4R) mobility generator (Martinez, 2008), in order to appreciate prediction performance when mobility traces are extracted from real roadmaps of different countries (the mobility model has a heavy impact on the obtained results, that may be unsuitable if the adopted mobility model is unrealistic). The integration between the Markov process and the dynamic programming approach leads to a new distributed prediction scheme, called Dynamic Markov Prediction Algorithm (DMPA), tested through extensive simulation studies. The rest of the paper is organized as follows: section 2 gives an overview of the existing related work, section 3 gives a detailed description of the proposed scheme, by considering the environment and the solution. Section 4 shows our simulation results, then section 5 concludes the paper.

2. LITERATURE OVERVIEW

Mobility and resource management are critical for providing QoS guarantees in wireless networks, so it is very important to accurately describe mobility patterns of MHs in wireless cells, especially when a prediction approach is needed. In Lu (2004) the Mobility-Dependent Predictive Resource Reservation (MDPRR) scheme is proposed, that is able to provide flexible usage of limited resource in mobile multimedia wireless networks. Each cell is divided into non-hand-off, pre-hand-off and hand-off zones, so that bandwidth is reserved in the target/sub-target cell as mobile stations move into the pre-hand-off zone. An admission control scheme is also considered to further guarantee the QoS of real-time traffic as, for example, Voice over IP, as proposed in (Rozhon, 2011; Tomala, 2012). The Fixed Bandwidth Reservation (FBR) scheme (Epstein, 1995) can improve the dropping probability of hand-off connections by reserving a fixed number of channels exclusively for hand-off connections. The drawback of this scheme is that the reserved bandwidth is often wasted in the hot spot area. In (Wu, 2011) the authors optimize some system parameters in terms of Call Dropping Probabilities (CDPs) and Call Blocking Probabilities (CBPs) introducing a prediction algorithm based on data mining approaches, in order to implement a distributed Call Admission Control (CAC) scheme, considering also the throttle flag as indication of the usage of each cell. Through estimation of MHs trajectory and arrival/departure times in (Aljadhari, 2001), a group of future cells is determined: it constitutes the most likely cluster into which a terminal will move. Two passive reservation techniques are proposed in (Zhang, 2001), exploiting Wiener prediction and time series theory, making in-advance reservations under non-Poisson and/or non-stationary arrival processes, arbitrary distributed call and channel holding time and arbitrary per-call resource demands. In (Velmurugan, 2012) the authors give a contribution in WLAN infrastructure planning, basing their decisions on mobility prediction: they propose a new method for feature extraction with a novel neural network classifier based on a hidden genetic algorithm, reaching an acceptable prediction accuracy. In previous works (De Rango, 2006), a prediction technique based on the Cell Stay Time (CST) evaluation of a mobile user is proposed. A

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