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An efficient Hash Table-Based Node Identification Method for bandwidth reservation in hybrid cellular and ad-hoc networks

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Abstract

Hybrid cellular and wireless ad-hoc network architectures are currently considered to be promising alternative solutions to the stand-alone cellular or ad-hoc network architectures. In this paper, we propose an efficient Hash Table-Based Node Identification (HTNI) Method using which bandwidth for various flows can be reserved in such network environments. Bandwidth reservation depends on the type of the traffic and its priorities. We define a bandwidth reservation factor for use in such hybrid network environments. We propose a cross-layer-based architecture for bandwidth reservation to maintain Quality-of-Service (QoS). We use a priority re-allocation method for flows which starve for long time. The proposed method is useful for finding the position of nodes with low communication cost.

Keywords: Hash table; Hybrid cellular and ad-hoc networks; QoS; Bandwidth; Priorities

1. Introduction

In the last few years, wireless ad-hoc networks have emerged as a competing solution to infrastructure-based wireless networks (e.g., cellular networks) for personal communication services. The distributed nature of ad-hoc networks makes them more robust to systemic failures, easier to deploy, and flexible to reconfigure than infrastructure-based networks. The requirement to provide various kinds of real-time multimedia traffic along with the regular voice and/or data traffic, and the varying priorities of transmission over wireless ad-hoc networks, have led the research issues relating to offering QoS guarantees challenging [10].

In spite of the last several years of research on wireless ad-hoc networks, massive real-life deployments of ad-hoc networks still remain a challenge. Although the freedom of ad-hoc networks from utilizing fixed infrastructure for offering wireless communication services makes them attractive for fast deployment in application domains such as the military and emergency services, they are limited by their ability to efficiently offer global accessibility and web-based services such as file sharing, messenger services and voice-over-IP [12,38].

Nodes of traditional cellular wireless networks are maintained by a base station manager (BSM) or server for routing. On the other hand, nodes of purely ad-hoc networks behave as routers by relaying messages in order to improve the performance of the network. One of the most important issues in providing ubiquitous communication is mobility management [1], which primarily concerns effectively tracking the locations of the nodes [7]. In case of hybrid networks, BSM can be used for effective mobility management, which can be otherwise more challenging in ad-hoc networks, because of their lack in using a dedicated router/server having a network-wide knowledge of the location of the nodes.

Alternative solutions considering integrated ad-hoc and cellular networks (henceforth, simply referred to as "hybrid

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network," for convenience[1]) have been investigated and are considered to be promising [23,24,35–40]. A hybrid network is formed by integrating traditional wireless networks and ad-hoc networks through existing cellular infrastructures [23,24]. The introduction of hybrid networks overcomes the limitations of cellular networks while allowing various ad-hoc and other wireless networks to get connected for a service. In such hybrid networks, since users are expected to move around during communication sessions, offering QoS guarantees by assuring minimum bandwidth and priority scheduling is challenging [20].

In the case of pure cellular wireless networks, the goal of adaptive call admission control is to ensure that there is sufficient bandwidth reservation for handoff, i.e., for transferring an ongoing call in a cell to another. The reserved bandwidth in a target cell is proportional to the traffic intensity in the surrounding cells [3]. In the absence of sufficient bandwidth for handoff, new connections are subject to getting dropped. One common approach used to reduce the connection dropping rate (CDR) is to reserve some bandwidth solely for handoff use [4].

Guaranteeing QoS in networks has been conventionally proposed using two different models – the integrated services (IntServ) model [RFC 2475], [RFC 2988] and the differentiated services (DiffServ) model [11,13] [RFC 2475]. IntServ uses the per-flow approach to provide guarantees to individual streams, whereas DiffServ provides aggregate assurances for a group of applications. Additionally, a flexible QoS model is proposed in [21] which integrates both the integrated and the differentiated services. But all these approaches fail to solve effective management of bandwidth. In [15], the authors propose having constraints on bandwidth reservation by obtaining neighboring node information, which is critical in reserving bandwidth. We propose the HTNI method, which uses hash tables to obtain neighboring node information with less communication and computation costs. We approach the problem of bandwidth reservation in hybrid networks using the proposed HTNI method.

The rest of the paper is organized as follows. In Section 2, we describe some of the related works relating to bandwidth reservation and policies. In Section 3, we describe the system model we have used for the proposed work. In Section 4, we discuss the proposed solution for bandwidth reservation for hybrid cellular networks and in Section 5, we describe the implementation of the proposed solution and the performance results. Finally, in Section 6, we provide the conclusions from the work.

2. Related works

Bandwidth reservation is an important issue to improve the performance of hybrid networks. There are proposals for bandwidth reservation for both cellular networks and ad-hoc networks, but there are no significant proposals to our knowledge, in the literature, for reserving bandwidth for hybrid networks. In this section, we briefly present some of the relevant pieces of work[2] individually for cellular networks, ad-hoc networks, and hybrid networks.

Choi and Shin [2] proposed a predictive, adaptive bandwidth reservation scheme for cellular networks. In their work, they aimed to offer QoS guarantees, by trying to control the value of the handoff dropping probability below a certain benchmark. They use the information about the aggregate history of handoffs in each cell to gain an understanding of user mobility, the directions of the mobile terminals and the handoff times. These pieces of information further enable to estimate the amount of bandwidth to be reserved for handoffs. They proposed three types of admission control procedures for accepting various flows, which differ in the number of neighboring base station managers that participate when a new call is evaluated for admission. It should be observed that their approach does not reserve the bandwidth for different type's flows, instead it reserves the bandwidth for handoff nodes. In another work on bandwidth reservation in cellular networks, Misic and Bun [3] proposed a bandwidth reservation scheme for wireless multimedia networks for handoff nodes. In their work, they have proposed a solution for bounding the probability of forced call termination under different changing mobility scenarios and call arrival rates. The forced call terminations can happen because of several reasons, one of which is unsuccessful handoffs because of insufficient residual bandwidth in the target cell. The amount of dropped calls because of unsuccessful handoffs is a measure of the QoS guarantee offered. In yet another work, Lim et al. [4] proposed a Differential Bandwidth Reservation (DBR) scheme for effectively handling call handoffs and admission of new calls in multimedia wireless networks. In their solution approach, the possible path of a mobile terminal that spans over a set of cells is divided into a couple of clusters in the form of sectors. The cells in a sector are further divided into two regions, depending on whether they have an immediate impact on the handoff or not. In the region closer to the handoff initiating cell, there is a check for exclusive bandwidth reservation. If the requested bandwidth is not available, then the possibility of sharing the already reserved bandwidth is examined. In the outer region, where the mobile terminal has a lower probability to move, only

[1] We should mention here that although in this article we use the terminology "hybrid networks" to refer to integrated wireless ad-hoc and cellular networks, the hybridization of networks is not restricted to the use of wireless ad-hoc and cellular networks only. Hybrid networks can constitute other types of networks as well.

[2] At this juncture, we feel, it is relevant to mention that the volume of work available on bandwidth reservation in wireless networks is overwhelmingly large. It is, therefore, not feasible to exhaustively mention all the different pieces of the literature that are available. Instead, we mention only a few of the relevant existing pieces of the literature that sufficiently relate to our work and that have motivated this work.