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Enhancing WLAN/UMTS dual-mode services using a novel distributed multi-agent scheduling scheme

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ABSTRACT

WLAN services are inexpensive and have a high bandwidth, while UMTS services provide wider coverage area and high mobility. Based on intelligent deduction, this study presents a novel service scheduling scheme for WLAN/UMTS dual-mode networks. The proposed system, Distributed Multi-Agent System (DMAS), consists of a set of problem-solving agents that autonomously process their own tasks and interoperate with one another by a shared database to reach a suitable schedule for dual-mode network services. A two-level control mechanism comprising local-control and meta-control is presented to achieve a high degree of goodness in service scheduling. Simulation results indicate that the Quality of Service (QoS) of the proposed discipline in terms of average delay and jitter is better than that of the pure UMTS network by 25% and 10%, respectively. The scheduling discipline can improve the service quality in multiple-mode networks.

1. Introduction

The ability of 3G (Universal Mobile Telecommunication System; UMTS) networks to operate seamlessly with existing WLAN (IEEE 802.11 Network) is critical for their widespread adoption [1]. Mobile nodes will adopt 3G networks to browse the Internet or communicate with one another [2]. Hence, multiple standards coexist in the same service environment, otherwise a combined multi-function system is generated for future wireless communications systems (see Fig. 1). Therefore, the interworking of systems must be optimized. Various systems have their own properties. High-tier systems like UMTS have a high mobility and low transmission bandwidth. Conversely, low-tier systems such as WLAN have low service costs and low mobility [3,4]. This study presents a novel discipline for service scheduling in WLAN/UMTS dual-mode networks to achieve optimal service quality.

A dual-mode node in a two-tier hierarchical architecture can choose either a WLAN or a UMTS as its access network. A dual-mode node can adopt WLAN as its access network, in which case the data traffic is sent through the wireless Access Point (AP) to the Internet. Mobile nodes have high data service rates and low service cost in this scenario. However, when the mobile user moves frequently between the WLAN APs or leaves indoor environment, the mobile node can adopt the UMTS signal to access the network service, and can thus avoid frequent handoff between different APs. Although possibly losing the high data rate and the low service cost, the mobile node obtains the highest mobility effect [5]. In the proposed two-tier hierarchical architecture, the UMTS network is called the high-tier network, and the WLAN is called the low-tier network. If a dual-mode device, the mobile node can choose the better network as its access network to connect with IP

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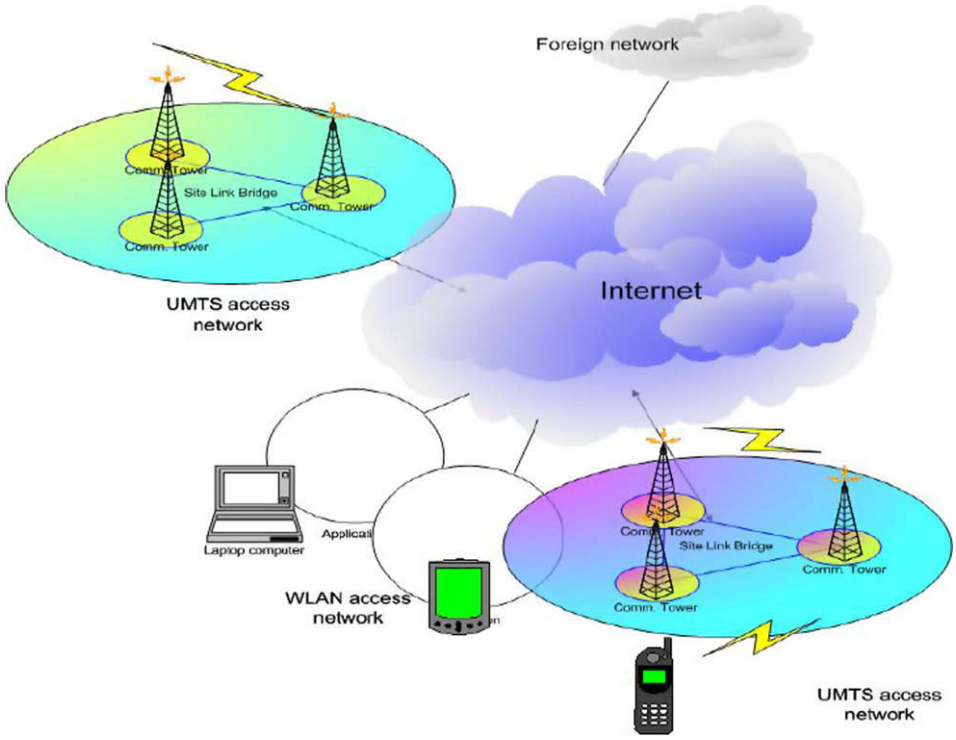

Fig. 1. Dual-mode access networks.

networks. However, few decision mechanisms are available to indicate to mobile nodes how to choose the suitable network to access and what time to handoff to the other one. This study presents a novel scheduling mechanism and cost function to resolve these issues [6].

This study presents a Distributed Multi-Agent System (DMAS) to resolve the above issues. The DMAS system consists of semi-autonomous problem-solving processing agents that can solve large and complex problems, and cooperate with other agents [7]. The advanced computer technology and inherently spatial characteristics of intelligent-based applications mean that the DMAS is very important in the application domain. Hence, this study presents DMAS to solve the scheduling problem of dual-mode networks. The designed multiple agents form a group of knowledge modules collaborating with each other by a shared database to reach an optimal service scheduling solution for dual-mode networks. Additionally, a two-level control mechanism described later is embedded in the DMAS system to handle the service scheduling issue.

The remainder of this paper is organized as follows. Section 2 describes the service scheduling issue in a dual-mode network. Section 3 then describes the construction of DMAS system. Section 4 presents the performance evaluation, and discusses a real dual-mode network service. Section 5 draws conclusions.

2. WLAN/UMTS interworking scheme

Although providing wide-area coverage with high mobility, UMTS networks suffer from a low data rate. Conversely, WLAN networks offer high-speed transmission and a small coverage area with low mobility. A dual-mode node generally accesses a WLAN, and obtains a high-speed data service where WLAN coverage is offered. A UMTS network is provided to access Internet services when no WLAN coverage is available [8–10]. Many issues, like interworking architecture, QoS, and handoff, must be solved to achieve this goal [11].

2.1. Interworking system architectures

Integrated UMTS and WLAN network architectures are classified into three categories, i.e. loose coupling, tight coupling and peer networks [12]. Tight coupling is the architecture in which the fewest changes are made from the original UMTS network [13]. Traffic transmission is more efficient in loose coupling, since it does not pass through the UMTS core network. The UMTS signal can be carried over WLAN networks in both the tight and loose coupling architectures. Handoff is more efficient in tight coupling than loose coupling architecture. Integrated WLAN/UMTS networks adopt multiple mobility management schemes.