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ITJ

ISSN 1812-5638

INFORMATION TECHNOLOGY JOURNAL

ANSInet
Asian Network for Scientific Information
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan

Information Technology Journal 6 (5): 745-750, 2007
ISSN 1812-5638

Handoff Techniques for 4G Wireless Mobile Internet

Xichun Li and Rosli Salleh
Department of Computer System and Technology,
Faculty of Computer Science and Information Technology,
University of Malay, 50603, Kuala Lumpur, Malaysia

Abstract: In this study, new handoff technique is developed to support wireless mobile bandwidth efficiency and higher data rates. This study will address handoff issues when a mobile node comes into WLAN overlapping region from a CDMA2000 coverage area and the mobile node will be supplied service by these two networks simultaneously through setting up a mix-bandwidth data path between the two networks. The performance of the proposed new data path will be evaluated and compared with current existing scheme through extensive simulations. The cost of the established new data path is also evaluated in terms of throughput and data transmission efficiency.

Key words: Handoff techniques, 4G, mix-bandwidth data path

INTRODUCTION

In the near future, mobile wireless internet is going to create a great demand for mobile communications and computing (Hui *et al*., 2003). Multimedia applications which are currently achieved by wired and fixed internet users will be achieved by mobile internet users as well. To achieve this kind of advanced level of mobile wireless multimedia services requires the development of a wireless network that can provide not only the integrated services, but also the dynamic relocation of mobile nodes (Chaouchi *et al*., 2004).

Recently, fourth generation (4G) systems have been developing to support greater bandwidth services, higher data rates, improved quality and seamless global mobility as compared to the current 3G systems (O'Droma *et al*., 2003).

In order to get this kind of advanced multimedia services in this fourth generation (4G) mobile wireless internets, handoff management (Paint *et al*., 2004) is the most important and challenging problem. It transfers radio link from current active connection to a new channel or a new service area for better resources. There are two kinds of handoffs:

i. Soft/smooth handoff in which a new connection is established before the old connection is stopped.
ii. Hard handoff in which the old connection is stopped before establishing a new connection.

A number of smooth handoff mobility management techniques have been proposed in the last few years (Soliman *et al*., 2002; Dommety *et al*., 2002; Youngsik Ma *et al*., 2004). Providing smooth handoffs without any transmission disruption and network resource efficiency utilization is a challenging task due to the following two factors:

i. Mobile node movement often results in a broken data path and requires the changing of point-of-attachment to the network.
ii. Disparity of available bandwidth in wireless cells may result in congestion or wasting bandwidth resources during handoffs.

In 4G networks, this problem can be solved by integrating different networks to provide ubiquitous connectivity (Ganchev *et al*., 2004). In such heterogeneous wireless network environment, the user faces different wireless access network with different link speed and physical capacity when a handoff occurs. This mismatch in available bandwidths may result in congestion or inefficient utilization of network resource. Therefore, new handoff scheme should be developed for this special situation.

MATERIALS AND METHODS

In this study, the targeted network environment for our research case is an infrastructure-based wireless

Corresponding Author: Xichun Li, Department of Computer System and Technology,
Faculty of Computer Science and Information Technology, University of Malay,
50603, Kuala Lumpur, Malaysia

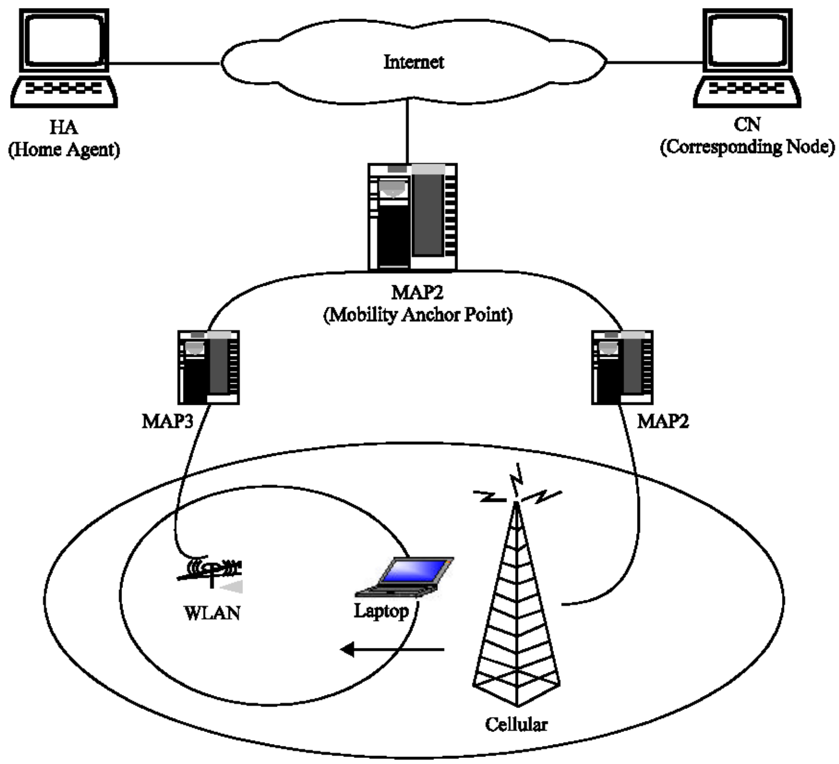

Fig. 1: 4G wireless mobile internet handoff general architecture

network with CDMA2000 and WLAN cell overlapping areas where the WLAN is integrated within CDMA2000 network show in Fig. 1. In this structure, the WLAN appears to the 4G core network as another access network. And its gateway (access router) is between WLAN and CDMA2000 networks (Buffjolpy *et al*., 2003). The function of the access router is similar to PCF, as in the case of CDMA2000 core network. The access router hides the details of the WLAN to the 4G core and implements all the CDMA2000 protocols (mobility management, authentication, etc.) required in a 4G radio access network (Apostolis, 2001).

Before the mobile node can take advantage from the handoff architecture, it must first establish a new data path within the WLAN and CDMA2000 networks. In this study, a mix-bandwidth data path within handoff architecture integrating WLAN and CDMA2000 to serve mobile IP is proposed. In the proposed handoff scheme, two data paths are acquired during handoff period which involve both WLAN and CDMA2000 networks.

RESULTS

Providing seamless handoffs with higher data rates and efficient bandwidth for 4G wireless mobile internet is a challenging problem due to the following factors:

i. The difference in the amount of available bandwidth among different wireless network cells, such as WLAN and CDMA2000 networks.
ii. Internet characteristics, in which uplink communication is one fourth of downlink communication (Lucent technologies, 2001).

Mix-bandwidth Handoff Procedure Model: We have proposed the handoff procedure model and this is depicted in Fig. 2. The handoff procedure model shows that the mobile node accesses both WLAN and CDMA2000 networks simultaneously. When the mobile node comes into the WLAN overlapping region from the CDMA2000 coverage area, the MN request will go through the first connection (MN → MAP2 → MAP1 → CN) and the resulting reply will go through from the second connection (CN → MAP1 → MAP3 → MN). In order to implement this, bandwidth management is needed to distribute different tasks using different paths based on the available bandwidth.

Mix-bandwidth scheme: In this section, the established mix-bandwidth data path for the handoff architecture will be described in detail. In Fig. 3, the proposed system architecture of the mix-bandwidth scheme is presented. It consists of four major components:

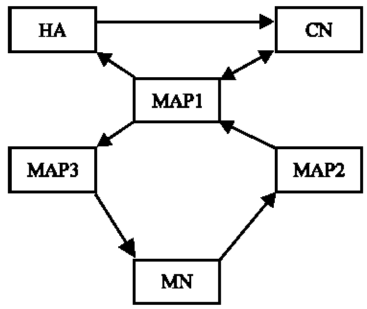

Fig. 2: Handoff procedure model

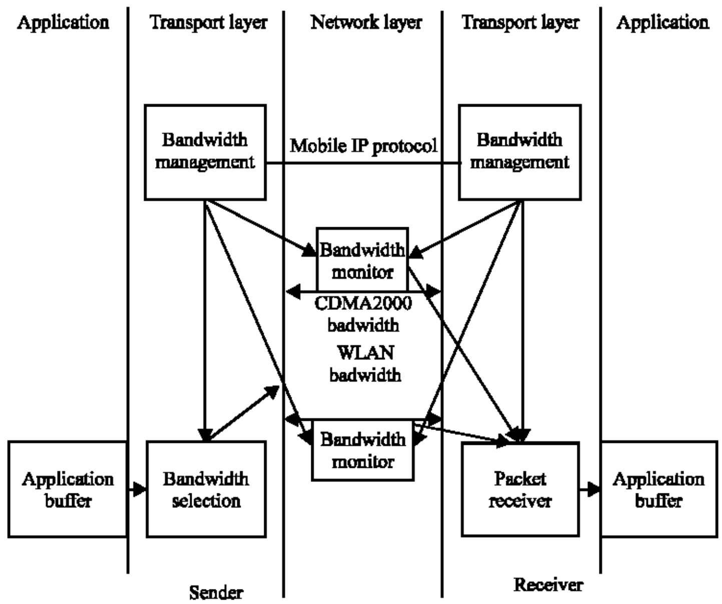

Fig. 3: Mix-bandwidth data path architecture

i. Bandwidth management;
ii. Bandwidth selection;
iii. Packets receiver;
iv. Bandwidth monitor.

The function of bandwidth management is to install and delete bandwidth monitor components dynamically, when it receives indication messages from the mobile IP protocol. The bandwidth management is located at both ends of the sender and the receiver. On each path, there is one bandwidth monitor installed. The function of bandwidth monitor is to monitor the available bandwidth and calculate the proper transmission rates on the corresponding path. The current existing path is informed by the bandwidth management after installing/deleting each bandwidth monitor. The bandwidth monitor will provide the rates information when it receives the current existing path information from bandwidth management. The function of the bandwidth selection is to calculate and report encoding rates to encoder, and then IPv6 applications will be encoded to appropriate paths. The packets receiver accepts incoming packets from the bandwidth monitor, filters and reorders them before sending them to the decoder. A detailed description on each of these four modules is given in the following sub-sections.

DISCUSSION

System design: The system design as depicted in Fig. 4 is based on the following two ideas:

i. Mix-bandwidth data path is supported by both WLAN and CDMA2000 networks simultaneously working on a mobile node; and
ii. Bandwidth optimization through bandwidth reselection, which make handoff rerouting from CDMA2000 network to WLAN network when a mobile node gets reply from its corresponding node.

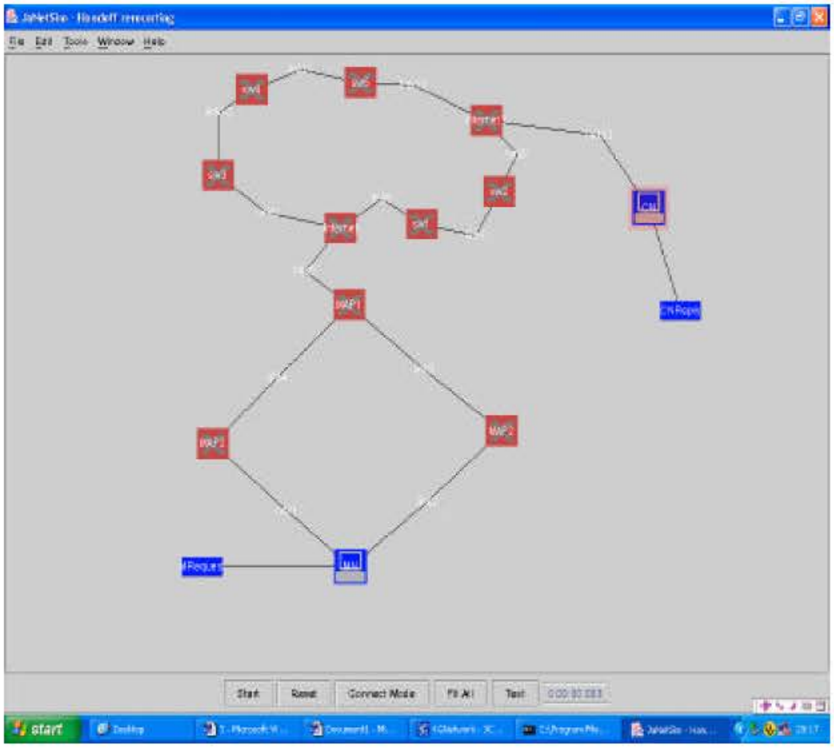

Fig. 4: System design

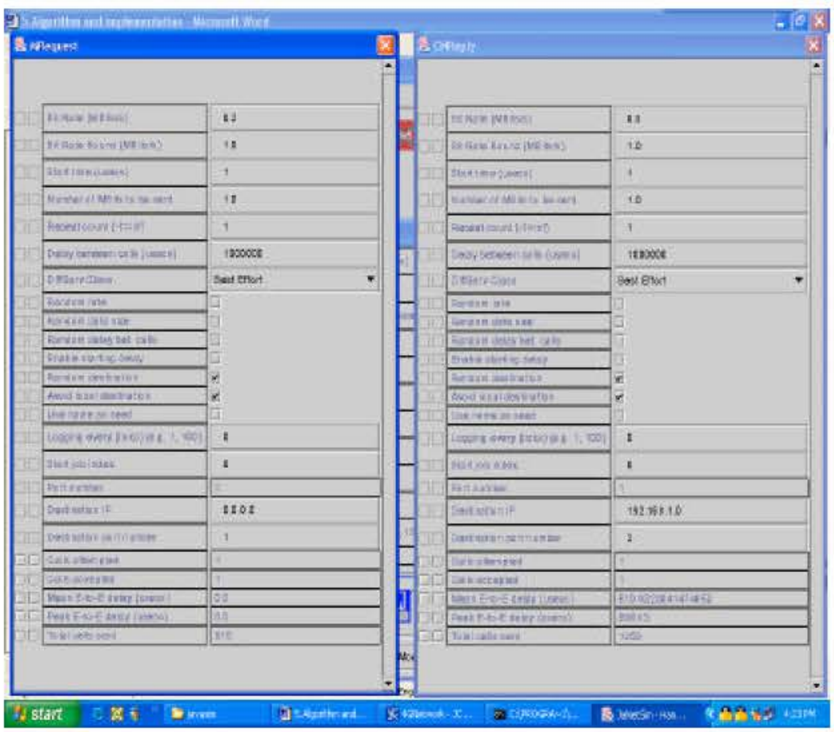

Fig. 5: Mix-bandwidth data path established

The above two ideas are from internet application characteristics and its application requests bandwidth is less than the reply bandwidth.

System implementation: System implementation can be divided into two sections as follows:

i. Message exchanges for establishing new data path and
ii. Data transmission on the established new path.

In the first case, when a mobile node comes into WLAN overlapping region from a CDMA2000 coverage area, it sends requests for better services from WLAN. In Fig. 5, the values of calls attempted and calls accepted are both 1 and it shows that there is one mix-bandwidth data path established between WLAN and CDMA2000 networks for the mobile node.

The second case, after the new mix-bandwidth data path is established, internet session will be transmitted on the data path. Figure 5 furthermore shows that the values of total packets total sent from both of MN request and CN reply. The value of MN requests is much less than the values of CN replies.

System simulation: The performance of the proposed mix-bandwidth data path handoff scheme is evaluated through extensive simulation using JaNetSim (Lim Shiau Hong, 2002). The objective of the simulation is two-fold:

i. To compare the proposed new data path with other current existing data path and
ii. To investigate the impact of various network parameters on the performance of the proposed mix-bandwidth data path handoff scheme.

In this section, the proposed mix-bandwidth scheme is compared with a single data path scheme (Phatak and Goff, 2002) and a multiple data path scheme (Pan *et al*., 2003). Obviously, in single data path scheme, one path only is maintained from source to destination during handoffs and in a multiple data paths scheme, there are several data paths are maintained. In the proposed mix-bandwidth scheme, there are two data paths for the mobile node to maintain from resources to destination.

The system is developed by using Java language under windows system. In this section, we will present the simulation results to evaluate the performance of the proposed new handoff scheme and compare it with a single bandwidth path handoff scheme and a multiple data paths scheme.

Throughput and available bandwidth: Throughput is one aspect that one can measure in order to determine the quality of service of the new data path scheme. Figure 6 shows the throughput of the two different handoff schemes as a function of available bandwidth in a new cell and Fig. 7 shows the bandwidth waste of the two different handoff schemes as a function of the available bandwidth.

The throughput in the proposed mix-bandwidth handoff scheme will increase as the mobile node comes into the overlapping area served by WLAN cells when the available bandwidth in WLAN cell is higher than in CDMA2000 cell shown in Fig. 4-3. Furthermore, the proposed scheme can increase data rate more promptly than the single path handoff scheme because WLAN has much wider available bandwidth than CDMA2000. Therefore, the proposed new data path handoff scheme always has a higher throughput than the single data path scheme.

Data transmission efficiency: Bandwidth is the main cost paid to achieve a higher performance in the proposed new

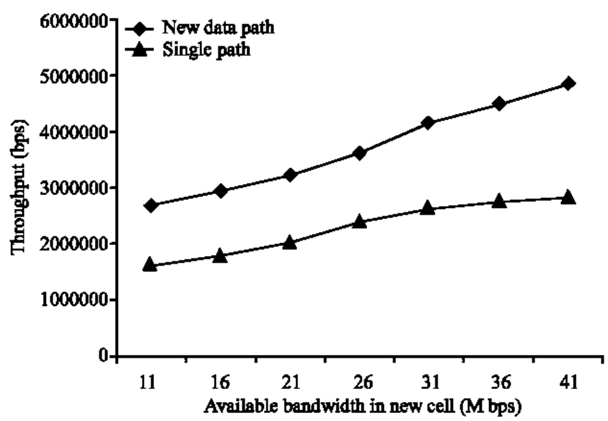

Fig. 6: Throughput vs available bandwidth in WLAN Cell

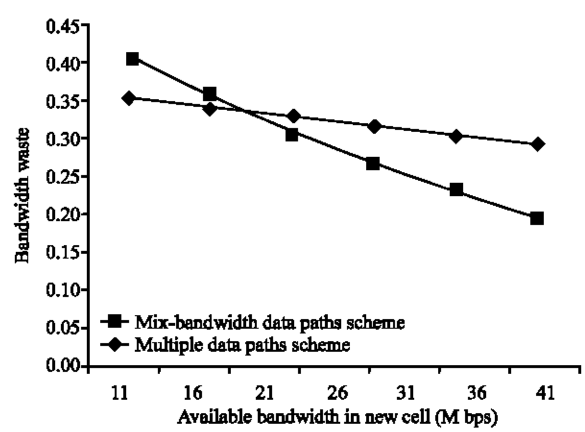

Fig. 7: Data transmission efficiency

data path handoff scheme, as it is able to obtain higher data rates and efficiently utilize both network resources. To evaluate this cost, we have measured data transmission efficiency. Data transmission efficiency is defined as the ratio of the number of unique application packets received to the total number of packets transmitted during the handoff period. Since the amount of data transmissions is mainly determined by the available bandwidth in the WLAN cells, only the available bandwidth in the proposed scheme is varied in this study.

Figure 7 shows the data transmission efficiency of the mix-bandwidth data path and the multiple data path schemes as a function of the available bandwidth in WLAN cell, bandwidth wasting decreases as available bandwidth increases. As the two networks serve the same mobile node during the handoff period, the mix-bandwidth handoff scheme works on both network resources without retransmitting data on multiple data paths and WLAN's available bandwidth is much higher than CDMA2000. Thus, this can result in both network resources utilizing efficiently and getting a much higher data rate for the mobile node. With this cost, the proposed mix-bandwidth data path handoff scheme achieves higher overall throughput by exploiting available bandwidth on mix-bandwidth paths.

CONCLUSIONS AND IMPLICATIONS

In this study, we have presented a new handoff scheme that supports up channel and down channel traffic services with different bandwidth and different networks by the established mix-bandwidth data path in order to utilize bandwidth efficiently and get higher data rates. The performance of the proposed mix-bandwidth scheme has been evaluated through extensive simulation using JaNetSim and the simulation results show that a new data path is established between WLAN and CDMA2000 networks. And CDMA2000 bandwidth supplies for up channel traffic services and WLAN bandwidth supplies for down channel traffic service according to internet characteristics.

The above scheme does not consider issues such as handoff rerouting and bandwidth optimization. There is a need to develop a handoff rerouting algorithm that can support the broad level of network integration promised by the 4G wireless system.

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