Robust Prediction for Intra and Inter-Handoff (RPIIH) Process

Mohamed Ben Haj Frej, Christian Bach

Abstract— The overall performance of mobile nodes is mainly affected by the relatively considerable time spent in the handoff process. Most of the time spent is mainly consumed during the authentication process. This process could be even longer especially when the Access Points (AP's) are busy, which results in delays and/or packets loss. Many handoff techniques have been proposed to shorten the time of authentication however to-date, they have not been fully successful.

This paper introduces a more robust technique for saving the time consumed during authentication. The adopted approach is suitable within the regions that use the intra-handoff technique as well as those applying the inter-handoff technique. To validate our model, we have used ns-2 based simulations and plotted the findings.

Index Terms— CDMA2000, Home Network, Foreign Network, Intra-handoff, Inter-handoff, Mobile devices, Mobility.

1 Introduction

THE advancement in wireless technology has changed the whole internet world. Code Division Multiple Access (CDMA) 2000 is the 3G mobile wireless that regroups a partnership of the five following bodies: TTC and ARIB in Japan, TTA in Korea, CWTS in China and TIA in North America. CDMA2000 has been integral to various wireless networks.

CDMA 2000 is defined as a special digital radio system that has a unique capability of transmitting streams of PN codes. CDMA 2000 has a potential of authorizing various user radios to share the same bandwidth and have a significant impact. It has a remarkable economic benefit compared to the Time Division Multiple Access (TDMA) method. Oldest cellular standards use Frequency Division Multiplexing (FDM).

CDMA 2000 comes with high bandwidth efficiency and multiple access capability allowing it to become a leading technology in the field. As it remediates to the spectrum congestion resulting from the ubiquitous use of wireless data terminals, fixed cellular telephones and wireless mobiles [1] CDMA2000 supports mobile communications and speeds ranging from 144 Kbps to 2Mbps.

There have been many propositions for improvement by reviewing the fast handoff schemes and analyzing their advantages and drawbacks from the quality perspective. Also, using a cross-layer approach, a fast handoff framework which is in concordance with many applications' requirements was introduced [1].

Mohamed Ben Haj Frej is currently pursuing a PhD in computer Science and computer engineering at the University of Bridgeport, USA. E-mail: mbenhaj@bridgeport.edu
Christian Bach, PhD is currently an assistant professor at the University of Bridgeport. E-mail: cbach@bridgeport.edu

The Wireless networks that are based on the IEEE 802.11 protocols are, nowadays, becoming ubiquitous and are offered in shopping centers, coffee shops, airports, libraries, campuses, etc. The connectivity speed offered by Wireless internet based on cellular networks ranges up to 11 Mbps [2] or 54Mbps [3, 4].

2 Related Work

Several mobility techniques have been proposed by various research papers published in the wireless communications networks field. The authors of [7] presented some evaluations and comparisons over the different performances of the handoff techniques. They studied precisely the effect of the mobile stations' speed and their relation with the handoff methodologies' performance. The concert metric is taken as a whole average downlink spectral efficiency, which relies on the downlink carrier to the interference and noise ratio [7].

The authors of [8] proposed a dynamic solution to impressively carry MIH messages applying the SCTP protocol. In IPv4 networks, IETF has introduced the mobility management protocol Mobile IPv4 (MIPv4) [9].

MIPv4 is the protocol that handles the mobility in the IP layer. The Session Initiation Protocol (SIP) was introduced by the IETF RFC 3261 and deals with the mobility at the application layer [11], [12]. The fourth generation networks (4G) was designed to secure the handoff initiation decision based on the signal to interference ratio between the old base-station and its neighboring base stations [5].

The authors of [9] came up with a handoff algorithm that reduces the unwanted effect of the fast fading component by averaging the received pilot signal strength. The drawback of this method comes from the fact that the averaging process could modify the characteristics of the path loss and the shadowing components in significant way, resulting in a considerable handoff delay [7].

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IEEE 802.16.3c proposed a handoff algorithm that uses a multi-level threshold. The resulting performance details showed a tendency to prefer an eight level threshold algorithm over a single threshold algorithm when forced termination and call blocking probabilities are the terms taken in consideration [10].

3 Predictable Intra Handoff Scheme

In our design, the model is characterised with an existing line of sight. The cellular: Mobile nodes (MN) are only one hop from all the access points. The access points operate as relays, and are getting the data from the mobile nodes. This model covers three different terrains. Both, connections between APs and infrareds create automatically the line of sight.

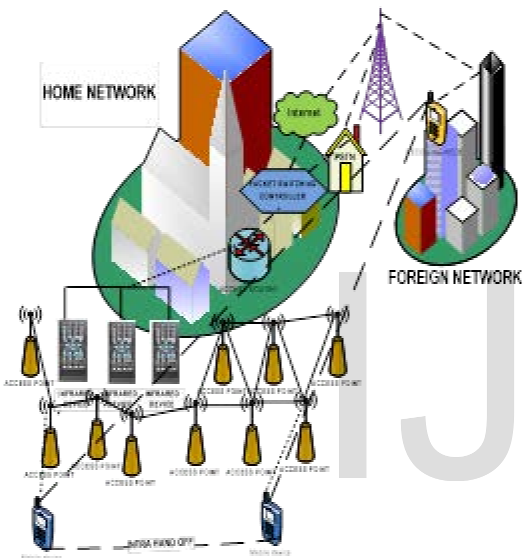

Figure 1. Intra-Hand off Process.

The infrared allows communicating with an access router in the network. The implementation of access routers (ARs) promptly gains control of sending data rate over packet switching controller. After all, the data has been switched into internet under control of Packet switching controller to handoff data to the tower CDMA2000. In the described model, the tower represents the base station (BS). Fig. 1 shows an intra-handoff.

Propagation Model:

In our model, we propose that the relay links stuck between the tower CDMA2000 and the infrared are reliable and in the line-of-sight (LOS). We are also considering that the links between access point (AP) and infrared (IR) are in no line - of- sight (NLOS). We are introducing a new model that is differently analyzed compared to the one that was developed based on experiments realized by IEEE 802.16 [10]. For the access NLOS links. The tests applied in our model proposed under the three terrain categories path loss models recommended and modified in IEEE 802.16.

The median path loss for IEEE 802.16 model is mainly defined as:

$$Los = 20 \log (4\pi d_o / \lambda) + 10\gamma \, Log (d / d_o). \qquad (1)$$

Los: is the median path loss.

For $d > d_o$, where d_o=100m.

λ : is the wavelength in meter (m).

γ : is path-loss component and could be expressed as:

$$\gamma = a - bh_t + c / h_t . \qquad (2)$$

Table I. Land category based of different handoff processes.

Parameter	Land Type A	Land Type B	Land Type C
FBSS (ms)	4.876	3.8	2.85
HHO (ms)	0.0075	0.0065	0.0035
MDHO (ms)	11.56	17.51	22

4 Predictable Inter Handoff Scheme

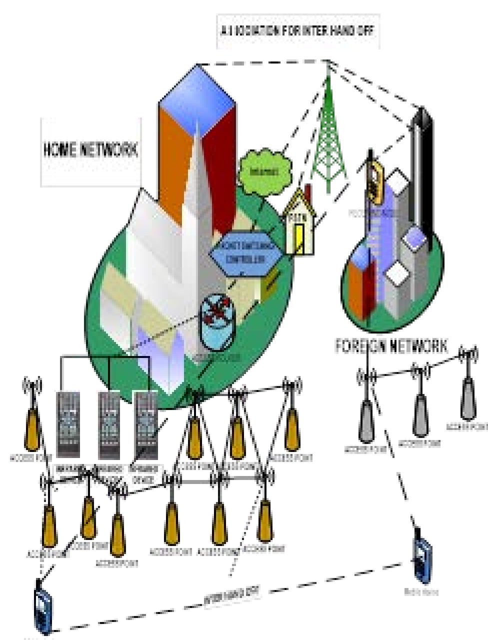

Figure 2. Inter-Handoff Process.

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As it is well known that the simplest topology is based on a permanent link between two endpoints. The primary architecture adopted is based on: the Mobile Station (MS), the Base Station (BS: Tower), and the access link devices (APs). At first, the Base Station is fully connected to the Mobile Cellular (MN). When the mobile node changes its connectivity from the home station to another station (foreign station) it uses the inter-hand off process. In this process, the home station of the mobile node informs to neighbor stations about the identity of mobile node. As a result, the mobile node becomes connected with the new station without facing any authentication problem, since they were previously pre-authenticated. This process saves the time for the mobile node. The inter-authentication process is depicted in Figure 2.

5 Simulation Setup and Results Analysis

The evaluation of a proposed RPIIH scheme is conducted by using ns-2 with Red Hat Enterprise Linux 6.5. We have evaluated RPIIH using three handover techniques based on the IEEE 802.16e and IEEE 802.16j standards. These handover techniques cover the Fast Base Station Switching (FBSS), the Hard Handover (HHO) and the Macro Diversity Handover (MDHO). We have progressively escalated the number of the mobile nodes to reach up to 500. They are randomly placed at the area of 1200m x 1200m. The average distance between the mobile nodes and the access points (AP) is set to 100m.

The mobility of the mobile nodes is set between 1 m/sec to 35 m/sec. The other simulation parameters are given in Table

Table II. Simulation Parameters

Parameter	Value
Cell layout	8 hexagonal cells
Cell radius	1600 meter
Duplex mode	TDD
Carrier Frequency	25 GHZ
Channel Bandwidth	10 MHz
Sub-Channel Bandwidth	262.5 KHZ
Frame time	4 ms
Fast Fourier transform (FFT) Size	1024
Antenna height BS	34 meter
Antenna height RS	17 meter
Antenna height MS	1.6 meter
Antenna gain BS	15.5 dB
Antenna gain RS	13.5 dB
Antenna gain MS	0 dB
Antenna type and Antenna number	Omni-directional & 1 x 1
HHO threshold	5 dB
MDHO threshold	2 dB
Active set size	3
Simulation time	500 seconds
Inter site distance	BS to BS: 2.9 KM
Long normal shadowing	8.2 dB
Fast Fading	Jakes Spectrum
Mobility of nodes	1 m/sec to 35 m/sec
Network Size	1200x1200 m^2
Number of mobile nodes	500

We have used a single mobility based scenario in our experiment. We have focused on the spectral efficiency based on the speed of the mobile nodes. In our scenario, three types of handovers are evaluated their performance has been compared: FBSS, HHO and MDHO. The mobile nodes use intra and inter features during these handovers. Fig.3 shows an average spectral efficiency based on the mobility of nodes. It outlines the handovers using the Down Link (DL) Carrier Interference Noise Ratio (CINR). Where the signal transmitted between the relays is using the Time Division Multiplexing (TDM). The Omni-directional antenna is always used by the Relay station.

The potential mobile node is connected with the best server using AP's (BS, MS or relays). It can be noticed that CINR level at the maximum speed of the node is moderately above than minimum requirement for all three handovers. We have used 1600 meters radius for the BS leading to a sufficient CINR at the cell radius. The analysis showed that the switching points during handovers between the BS and the relay are inside the original cell of the BS. At the maximum mobility, CINR level is still higher than 6.4dB. It shows that RPIIH is bringing a gain in terms of efficiency and optimization as it demonstrated that no data is lost in the communication between the mobile nodes. Since the CINR in the acceptable value of 6.4dB the handovers and data sending rate will not be affected. It also shows that RPIIH leads to an increased CINR at all mobility rates.

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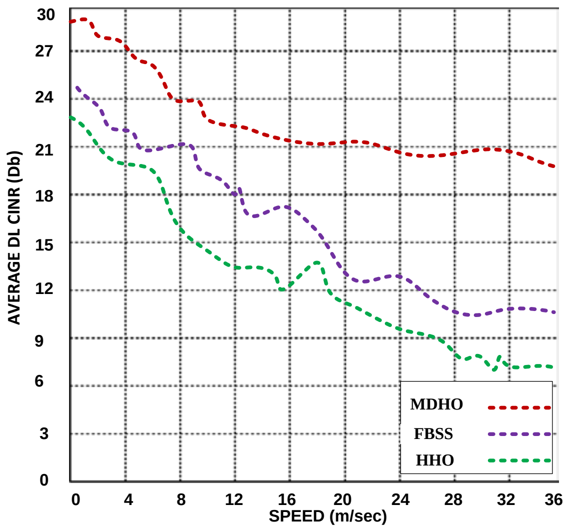

Figure 3. Average spectral efficiency vs. MS speed

In the Figure 4, we have illustrated the probability results for the three handovers based on the cumulative distribution function (CDF) using DL. It shows the probability value of the pre-authentication process. We infer that the real-value with a *given* probability distribution is found less than or equal to epsilon which is a good indication of the success of the authentication. We have also observed that the mobile nodes gain 100% spectrum efficiency for those three handovers at 3.4 to 3.6 spectral efficiency using CDF at DL.

6 Conclusion

In this paper, we have introduced a robust predication intra and inter handoff (RPIIH) process for the pre-authentication of mobile nodes. The existing techniques use the post authentication process for switching the nodes from home station to foreign station which results in a waste the time and a drop in the throughput. The consequences could be even more severe when the mobile nodes are in the extreme mobility process, especially for the cases where communication is vital (military environment or during a remotely assisted surgery to name a few examples). Our proposed solution reduces the wait time for the mobile node and avoids the dropping of the data.

To demonstrate the strength of RPIIH, we have used ns-2 simulator to illustrate its performance and efficiency.

We have also evaluated the spectral efficiency of the channel by using ns2. Based on our findings, we have proved that RPIIH is an optimized technique that successfully achieves complete spectrum efficiency during mobility and cumulative distribution function (CDF) at an average down link (DL).

The proposed concept could be deployed in a realistic scenario to authenticate the mobile node prior leaving the home station.

In the future, we will create several scenarios to demonstrate the effectiveness and the suitability of the introduced method.

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