ISSN 2278 – 0211 (Online)

Performance Evaluation by Handoff Analysis in Wireless Local Area and Wide Area Networks

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Abstract:
Next Generation Wireless networks consist of multiple heterogeneous access technologies such as UMTS, WLAN, Wi-Max etc.The main challenge in these networks is to provide users with a wide range of services across different radio access technologies through a single mobile terminal. Thecurrent trend in wireless data networks is to offer multimedia access to mobile usersby employing the wireless local area network (WLAN) standard IEEE802.11 whilethe user is located indoors, on the other hand, 3rd generation wireless networks(WAN) are being deployed to provide coverage while the user is located outdoors. As a result, the mobile node will require a handoff mechanism to allow the user to roam between WLAN and WAN environments, up to this date several strategies have been proposed (Robert hsieh [34]et al., 2004 and HyoJinet al., [51] 2007) in the literature, however, noneof these have been standardized to date. To support this interoperability, the mobilenode must be equipped with configurable wireless interfaces to support the handoffbetween the WLAN and the WAN networks. In the last work on the subject an algorithm had been proposed to allow a mobile node to roam between a wireless local area network (IEEE802.11) and a WAN base station (UMTS), while employing IP mobility support. The algorithm was implemented in simulation, with the help of Network Simulator 2 using TDD model. [7]. This paper presents the Handoff Analysis based on TDD Model using Network Simulator 2.

Keywords: *WLAN, UMTS, TDD, NS-2*

1. Introduction

A wireless local area network (WLAN) links two or more devices using some wireless distribution method (typically spread-spectrum or OFD Mradio), and usually providing a connection through an access point to the wider Internet. This gives users the mobility to move around within a local coverage area and still be connected to the network. Most modern WLANs are based on IEEE 802.11 standards, marketed under the Wi-Fi brand name.

A WLAN typically extends an existing wired local area network. WLANs are built by attaching a device called the access point (AP) to the edge of the wired network. Clients communicate with the AP using a wireless network adapter similar in function to a traditional Ethernet adapter.

A wide area network (WAN) is a network that covers a broad area (i.e., any telecommunications network that links across metropolitan, regional, or national boundaries) using private or public network transports. Business and government entities utilize WANs to relay data among employees, clients, buyers, and suppliers from various geographical locations. In essence, this mode of telecommunication allows a business to effectively carry out its daily function regardless of location. The Internet can be considered a WAN as well, and is used by businesses, governments, organizations, and individuals for almost any purpose imaginable.

One of the advantages of TDD is the fact that the trans mission rates can be dynamically adjusted in the uplink and downlink, something that cannot be done in FDD model because the links are symmetric. If the TDD downlink needs more slots and the uplink has available slots, the available slots may be transferred from the uplink to the downlink.

The proposed presented in this work differs from the previous approaches in the way the threshold variable (metric) is calculated; the proposed algorithm takes into account four parameters:

a. Cost of the service
b. Available band width
c. Distance to the AP (or BS)
d. Signal strength

2. Related Work

The M. Gudmundson et al. of [2], each AP, instead of the wireless stations, record the neighbouring APs' information in the "neighbour graph" data structure. Then the AP inform wireless stations about which channels have neighbouring APs. The wireless stations need to scan only those channels. Besides, wireless stations need not wait until Max Channel Time if all neighbouring APs' response frames have already arrived. Several mobility management techniques have been proposed for Next Generation Heterogeneous wireless networks. The Y.B. Lin[3], an adaptive transport layer (ATL) was proposed for integrated networks with the capabilities of adaptive congestion control, multimedia support and providing fairness of transmission. The K. Pehlavan [15], a network selection mechanism for 4G wireless networks was proposed. The article J. McNair [33] introduced important performance criteria to evaluate seamless vertical mobility, e.g. Network latency, congestion, service type etc. The I.F. Akyildiz [8], managing mobility and adaptation in IEEE 802.21 enabled devices was proposed.

Vaquera flores et al. [35] dissertation divides wireless networks into three categories according to their topology and wireless service application: traditional cellular phone networks, heterogeneous wireless data networks, and rate adaptive wireless data networks W. Shen et al. [48] developed a transport vertical handoff solution is also presented in [49], called cellular SCTP (cSCTP) that utilizes the dynamic address reconfiguration extension of SCTP. More specifically, cSCTP provides smoother handoffs by sending duplicate data to a hosts' addresses on both the old and new networks during a transition and also lowers the potential for loss. It also uses the mobility management functionality of SIP to enable seamless handoff, a survey concerning vertical handoff solutions at the transport layer can be found in [51] Hyojin et al. [64] paper, the authors presented their recent work on closed form solutions to the blocking and dropping probability in wireless cellular networks with handoff. Firstly, they developed a performance model of a cell in a wireless network where the effect of handoff arrival and the use of guard channels are included.

M.N. Halgamugeet al. [65] presented a new scheme that addresses the call handoff problem in mobile cellular networks. Efficiently solving the handoff problem is important for guaranteeing quality of service to already admitted calls in the network

3. Tool Used for Simulation

NS is a discrete event simulator targeted at networking research. ns name for series of discrete network simulators, specifically ns-1, ns-2 and ns-3.Ns provides substantial support for simulation of TCP, routing, and multicast protocols over wired and wireless (local and satellite) networks. Ns began as a variant of the REAL network simulator in 1989 and has evolved substantially over the past few years. In 1995 ns development was supported by DARPA through the at LBL, Xerox PARC, UCB, and USC/ISI. Currently ns development is support through DARPA with SAMAN and through NSF with CONSER, both in collaboration with other researchers including ACIRI. Ns has always included substantial contributions from other researchers, including wireless code from the UCB Daedelus and CMU Monarch projects and Sun Microsystems. For documentation on recent changes, use the version 2 change log.

4. Methodology

Handoff Procedure between WLAN and UMTS The Handoff (HO) procedure employed by a MN to switch between WLAN and UMTS networks is illustrated in figure 1.

There are four possible actions that may be taken by the MN as a result of the HO algorithm: While operating in the WLAN, the HO algorithm will select option A given that it receives a good signal strength from its current associated AP; option B indicates that the MNis beginning to receive a poor signal strength from the AP and should pre pare to start a HO; option C is when a handoff to the UMTS network is required and there is not another WLAN AP to be selected; option D is selected to trigger a HO procedure to select a new WLAN AP.

The following scenario depicts a MN moving away from WLAN coverage and moving into UMTS cover age:

1. Initially, the MN receives a strong signal from the AP, and the MN is connected to the WLAN network.
2. As the MN moves away from the AP, the received signal strength becomes weaker. The MN is continually analyzing the received signals, looking for abetter AP or BS. The HO algorithm uses the available information to make a decision: to change, or not, to the UMTS network. The connection procedure is started to activate the UMTS wireless interface card.
3. The HO algorithm in the MN decides to disassociate from the WLAN and associate with the UMTS network.
4. The MN gets in touch with the foreign agent (FA) and obtains a COA.
5. The HA in the WLAN is informed about the new COA and be gins the interception of datagrams ad dressed to the MN, it encapsulates them and sends them to his FA. The FA then deencapsulates the datagrams and delivers them to the MN.
6. If the MN moves into the WLAN coverage, it begins a reverse HO.

5. Handoff Algorithm

Almost all known algorithms are based in the received signal power and were designed for HO between the same types of networks (mostly for cellular networks). Other techniques have recently been proposed, like pattern recognition based on neuronal networks or diffuse logic systems, however these algorithms increase the computational cost in the mobile node; in addition, these techniques still employ the RSSI parameter. The work follows a priority strategy for the HO between WLAN and UMTS, and different priorities, cost values and numbers of mobile nodes were pre-established during simulation. The algorithm implemented in this model considers that UMTS and WLAN have different transmission signal strength levels, then it does not make sense to use only the RSSI parameter to decide among them (UMTS BSs generally transmit with a higher power strength than WLAN APs). If only this parameter is used, the

MN will always be connected to UMTS, even if the MN was inside the WLAN coverage area. The use of a single RSSI parameter is appropriate for horizontal HO. In the proposed HO algorithm, a new BS or AP will be chosen (called new agent, NA) if and only if the following two conditions are met

- During a predetermined retention time (Dwell-timer) the new agent metric (metric_ NA) minus a hysteresis margin is greater than the metric of the actual or older agent (metric_ VA) and,
- the actual agent metric (metric_ VA) is smaller than a predefined threshold (Um) value.

The agent metrics are calculated by taking into account several parameters, according to the following equation:

Metric = weight _ Cost(1–Cost)
+weight _Band Width (BW _user)(1)
+ weight_Distance(1–Distance)
+ weight _RSSI(RSII)

A new agent (NA) is chosen if at the end of Dwell-timerthe following in equality holds true:
metric _NA– Hm >metric _VA<Um(2)

Um is a threshold which is used to determine if the metric _VAis poor.
In equation, the variables denoted with the prefix "**weight**" have a value between 0 and 1, and added are equal to one. **Cost** is a value that represents the network charge (from 0 to 1). **BW_User**is the band width that corresponds to the MN, which is calculated by dividing the total bandwidth used in the network by the number of MNs in that network. The **Variable Distance**is the normalized distance that exists between the MN and the BS or AP. Finally, the **RSSI** variable is the strength indicator from the received signal.

To avoid choosing an agent which is received with very low power, a **RSSI _Threshold**is defined, such that the agent metric (i.e. **metric _ NA or metric _VA)** is set to zero when its strength is below the threshold:
if RSSI< RSSI_ Threshold then metric=0(3)

During a HO procedure the MN follows the next sequence of steps:

1) The MN Link-Timeris restarted every 0.5 seconds.
2) The HO-triggerfunction verifies if Dwell-Timeris less or equal to zero. If so, Monitor-timeris reset and returns a HO-TriggerAuthorization. Otherwise, the function returns a HO-TriggerDeny.
3) If the MN is not associated to any network and the HO-Trigger is authorized, the MN sends a HO-Requestto both, UMTS and WLAN networks.
4) The base station receives the Agent Request and answers with an Agent Advertisement.
5) If the third step condition is not fulfilled, the Link-Timeris restarted

6. Simulation Results & Scenario

The TDD model of the Network Simulator (NS-2) was developed at the University of Rom [32] using the ns-2.1b9a distribution, which had to be ported to the ns-2.1b9a version of NS-2.

To simulate a mobile node, a terminal model with a common layer 3 and two different lower layers (one for UMTS and another for 802.11) was considered. The module that performs the interface between the common layer 3 protocol and the two different lower protocol stacks (MAC and PHY sub layers) is called RAMON (Reconfigurable Access Module for Mobile Computing Applications).

RAMONis a project developed at several Italian universities, among them the Palermo
University; it consists of several interfaces added to the original ns-2 MN model, as can be seen in figure1. The primitives sent between layer 3 and layers 2 are handled transparently by means of adaptation layers related to UMTS and 802.11, respectively. The RAMON node model makes use of two sub modules: The Radio Resources Control (RRC) and the Mobility Management (MM), as illustrated in figure 1. To calculate the attenuation of the radio signal, the model employs the Friss free paces propagation model ($1/r2$ where r is the distance) for short distances and an approximation to Two Ray Ground ($1/r4$) in long distances. The approximation assumes that flat earth reflection occurs.

Figure 1: Reconfigurable nod with two interfaces in NS-2

The routing protocol employed for this infrastructure network is NOAH (no Ad-Hoc). The cost and number of users can be established for every network; the band width of every network is divided between the number of users of that specific network. Thenode is auto configurable and before simulation the user can de fine several parameters like weight Cost, weight Distance, _Band Width, weight_RSSI, the number of verifications (num_checks) before executing a HO procedure to avoid the ping-pong effect, and the RSSI_Threshold that will be used to trigger the HOs. The RSSIand RSSI_Thresholdparameters were included into the RAMON model and are part of the contributions of this work.

The routing protocol and the node is auto configurable and before simulation the user can define several parameters like weight _Cost, weight _Distance, weight _Band Width, weight _RSSI, the number of verifications (num _checks) before executing a HO procedure to avoid the ping-pong effect, and the RSSI _Threshold that will be used to trigger the HOs.

Network scenario employed for HO The simulation scenario considers a topology composed by one UMTS and two WLAN networks; the home agent (HA) is located at the UMTS network BS (the NS-2 UMTS module only supports the home network to be located at the UMTS network) and the foreign agents are the routers from the WLANs. The simulation begins with the MN connected to the UMTS network and moving to a WLAN network with a constant speed of 3 km/h (0.8333 m/s). The simulation time is 70 sec. and at t = 0.1 sec. the MN begins to move towards the first WLAN access point (AP or node).

The MN per forms a descendant vertical HO crossing from UMTS to WLAN.

– At t = 30.0, the MN changes its direction and moves towards the other WLAN (AP1), thus executing a horizontal HO. The second WLAN is de noted by node 6 in figure2.
– At t = 50.0, the MN changes again direction towards the UMTS to perform an ascendant vertical HO passing from WLAN to UMTS. The UMTS BS is represented by node 3 in.

During simulation, the MN opens a TCP connection by means of an FTP application; packets are sent from the FTP server (i.e. the correspondent node de noted as node 1 in figure) towards the MN. Data transfer be gins at t = 0.2 sec. There are two inter mediate nodes representing the Internet cloud, as illustrated in figure 2; these two routers are denoted with the node numbers 0 and 2. All the nodes have an associated hierarchical address.

The Agent Advertisement messages are broad casted every second, and the reset time of the monitoring, link and connection timers is 0.5 sec.

The measured parameters in the simulation were: point to point delay, number of packets lost and HO delay. In addition, this section presents a comparative analysis between the results obtained for vertical (ascending and descending) and horizontal HOs

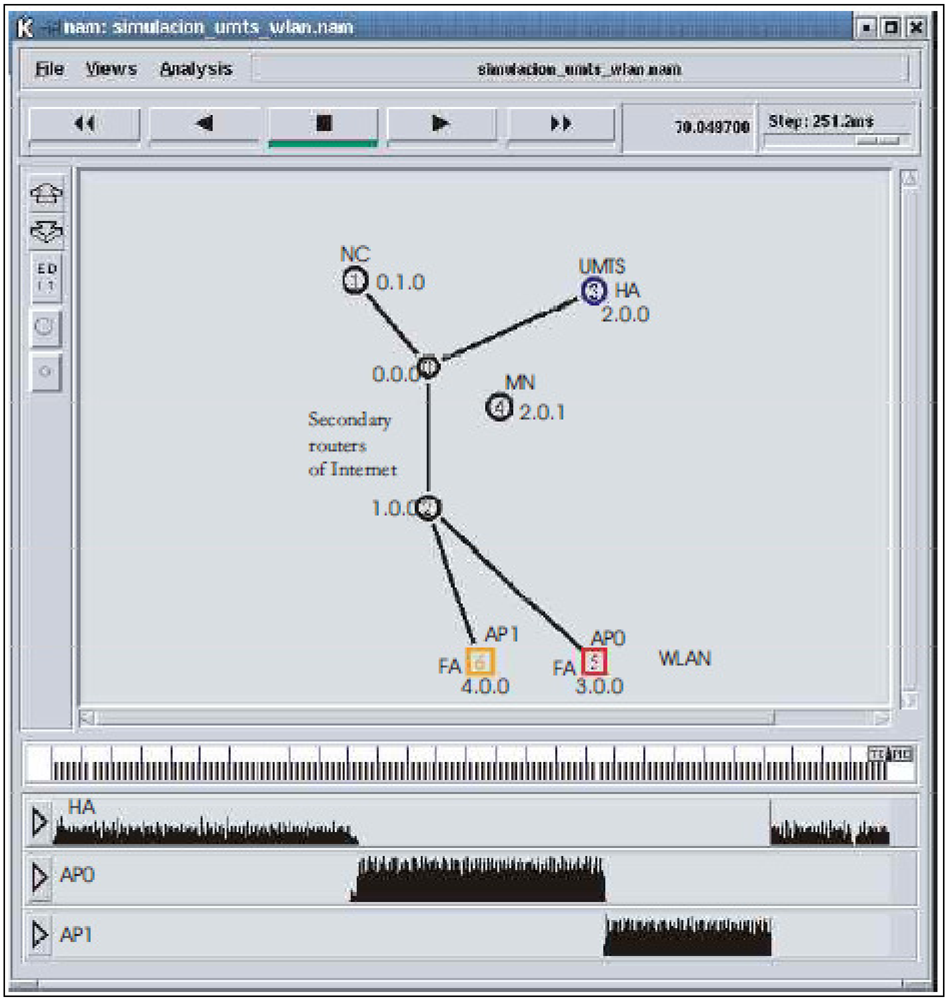


Figure 2: NAM Visualization Screen

a) Simulation parameters defined Network Animator (NAM) visualization of the network topology implemented for simulation in NS-2. The lower section of figure shows the generated traffic between the agents and the mobile node (MN). Table 1 shows the parameters employed for simulations; these values were obtained from [35] and represent a typical example, where the most important parameter is considered to be the associated network cost defined by the weight _Costparameter.

Table 1: Simulation Parameters Parameter Value

Num _checks1
Weight _Cost0.7
Weight _Distance0.1
Weight _Bandwidth0.1
Weight _RSSI0.1
RSS I _Threshold–79.4 dBm

b) Performance results in this section presented the performance results for the point to point delay and the HOs delay. During normal operation conditions there were no packets lost in any of the simulated HO scenarios, except when the operation was under abnormal conditions; for example, a person running at a speed of 20 m/s (72 km/h), and carrying his mobile terminal.

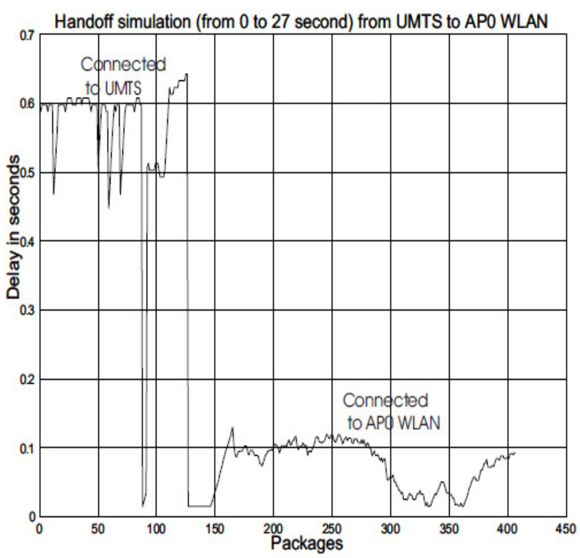
Handoff from UMTS (WAN) to WLAN-

The HO delay can be visualized in table 2; the delay to complete the HO is measured from the time the HO is triggered, until the time the MN finds itself connected to the new network Figure 3 shows the results obtained for the delay of the packets from the CN to MN (end to end); this figure illustrates the delay before and after the HO is made between UMTS and the first WLAN. It is observed that the delay is larger when the MN is connected to the UMTS, then when it is connected to the WLAN. The received signal strength from the UMTS BS and the WLAN AP are shown in figure 4 and figure 5, respectively. Figure 6 shows the results of the RSSI that the MN measures from the UMTS BS; this information is presented as a function of the distance between the BS and the MN. An overlap is observed in (i.e. between distances 64 and 70 meters), this is due to the fact that the MN reaches a maximum distance at around 69 mts. and then it begins to come back closer to the UMTS BS.

Table 2: HO Delay from UMTS (WAN) to WLAN

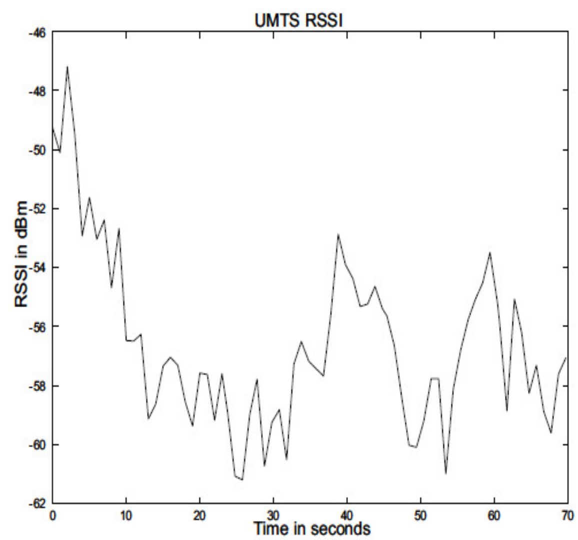
Event Time State Event

23.720026ConnectHO Trigger from distance 57.156366
23.720026HOHO Start from BS 2.0.0
23.768811HOSent MIPT_REG for: 2.0.0
23.768811HOSent MIPT_REG for: 3.0.0
23.784171HOReceived REG_REPLY
23.784171HOHO Execution: from 2.0.0 to 3.0.0
23.784171HODetach from 2.0.0
23.784171IDLEAttach to 3.0.0,MH has new coa 3.0.0
23.801215ConnectSent MIPT_REG for: 3.0.0
Total---0.081189 HO total time



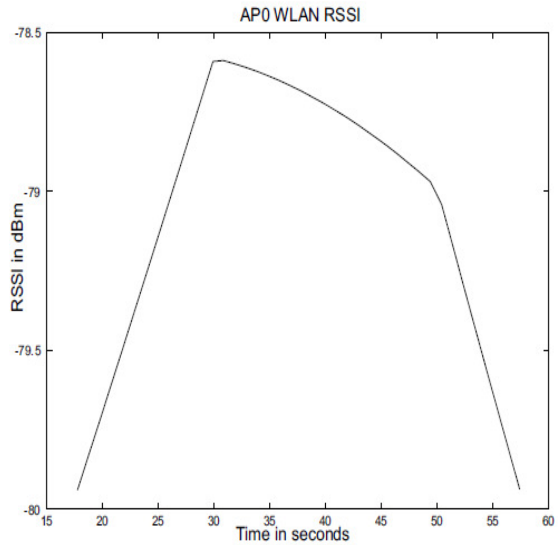
Simulation results of the packet delay metric

Figure 3



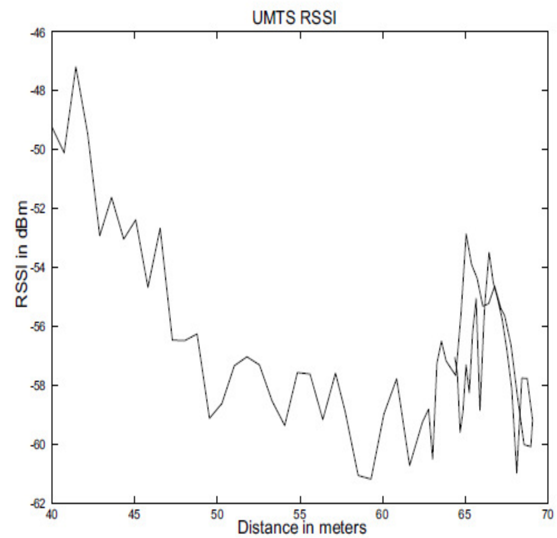
RSSI of the UMTS BS

Figure 4



RSSI of the WLAN AP0

Figure 5



RSSI of UMTS BS as a function of distance

Figure 6

7. Conclusion

Different alter natives for handoff between WLAN and WAN were analyzed. Work implemented [61] a HO algorithm while trying to reduce complexity and provide the best advantages (no coupling MIP based) of other previously reported HO approaches. The vertical and horizontal HOs are performed without losing any ongoing TCP connections and without losing packets. A novel algorithm was proposed, implemented and evaluated to support horizontal and vertical handoffs between WAN and WLAN networks; the HO algorithm relies on several metrics, including the RSSI. Previous works implement various algorithms, some of them even with high computational cost, as those that make use of neural networks, but still they rely on the RSSI metric. It was concluded that the interconnection architecture between UMTS and WLAN by means of MIP represent a viable alternative to enable roaming between networks. The HO delay (with TCP) does not significantly affect the file transfer services, data and email, but it may affect real time applications, since it sometimes exceed the maximum allowed delay considered accept able for voice and video applications (500 msec.).

However, if the HOs do not occur frequently, the introduced HO delay may be considered not so annoying for voice or video applications.

The performance results in this work considered a TDD based WAN network [61]; however, recent extensions to the NS-2 WAN model have implemented the FDD model. Apart from this shortcomings of TDD mode have also been observed. As a result, future work will consider the implementation of an FDD based WAN network.

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