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Mobility Management in Ambient Networks: Performance Optimization of Homogeneous Wireless Network

Abdessadeq Fettouh[1], Najib El Kamoun[2], Adnane Latif[3], Abdelaziz El Fazziki[4]

[1]LISI Laboratory FSSM Cadi Ayyad University Marrakech,
2390, Bd Prince My Abdellah, 40000 Marrakesh, Morocco
a.fettouh@skm.ma

[2]STIC Laboratory Faculty of Science Chouaib Doukkali University,
2, avenue Med Ben Larbi Alaoui, B.P.299, 24000 El Jadida, Morocco
elkamoun@gmail.com

[3]TIL Laboratory ENSA Cadi Ayyad University,
BP 575, avenue Abdelkarim Khattabi, Gueliz, Marrakech, Morocco
latif_adnane@yahoo.fr

LISI Laboratory FSSM Cadi Ayyad University Marrakech Morocco
2390, Bd Prince My Abdellah, 40000 Marrakesh, Morocco
elfazziki@ucam.ac.ma

***Abstract*: Ambient networks are envisioned to be a combination of diverse but complementary access technologies. Internetworking these types of networks will provide mobile users with ubiquitous connectivity across a wide range of networking environments. The composition of existing and emerging heterogeneous wired/wireless networks requires the design of intelligent networks components to enable mobile users to switch network access and experience uninterrupted service continuity anywhere, anytime by keeping the same connection performance as before. We focus on WLAN performances analysis and optimization techniques this based on advanced network simulator, OPNET modeler. Many practical issues are considered with proposed solutions. Experimental results with Opnet Modeler under different scenarios are presented. The test-bed is first described, followed by the results and analysis. We concluded the paper with a summary of the key results of the work.**

***Keywords*:** Ambient Networks, Mobility, WLAN, Handoff, Performance.

I. Introduction

In present world, telecommunication operator feels the pressure to provide the best service to their customers. So, the implementation of heterogeneous networks is thus very much realistic to them. As a consequence of its heterogeneity, heterogeneous network requires mobility implementation. In these heterogeneous networks,

Internet Protocol version 6 (IPV6) will be played a vital role for multimedia traffic as well as data traffic. IPV6 already includes basic mobility support. So in order to provide mobility support we required efficient Handover mechanism with the increasing number of user's scalability is another issue which is to be focused on. Wireless data networking technology is ideal for many environments, including homes, airports, and shopping malls because it is inexpensive, easy to install (no wires), and supports mobile users. As a result, we have seen a sharp increase in the use of wireless over the past few years. However, using wireless technology effectively is surprisingly difficult. First, wireless links are susceptible to degradation (e.g., attenuation and fading) and interference, both of which can result in poor and unpredictable performance. Second, since wireless deployments must share the relatively scarce spectrum resources that are available for public use, they often interfere with each other. These factors become especially challenging in deployments where wireless devices such as access points (APs) are placed in very close proximity. In the past, most dense deployments of wireless networks were in campus-like environments, where experts could carefully manage interference by planning cell layout, sometimes using special tools [12]. However, the rapid deployment of cheap 802.11-hardware and other personal wireless technology (2.4GHz cordless phones, Bluetooth devices, etc.) is quickly changing the wireless landscape.

The goal of using homogeneous wireless network is because WLANs provide network connectivity in difficult wiring areas; they provide flexibility to move and extend networks or make changes. WLANs allow mobile users to work with traditional wired applications. In fact WLANs are the only LAN devices that allow true mobility and connectivity. WLANs provide connectivity for slow mobility (walking speed) with high throughput for both indoor and outdoor environments, so the study of performance of such Network is an interesting and useful opportunity, where distribution of Access Points (AP) is the only possible and adequate solution for achieving full coverage.

II. Related Works

In ambient networks, mobile users enjoyed the benefit of mobility while they are moving during subnets or domains in the network a new architecture as well as associated functionalities introduced the concept of handover. In early stages of mobile networks mobility management was rather a simple operation. The concept of mobility management is enhanced increasing both flexibility and complexity covering a large variety of scenarios. The fact is providing IP connectivity to users on the move becoming the major challenges both research as well as from business point of view. In such environment mobility management get quit complex and the requirements of real time application such as VOIP also get complex.

III. Backgrounds

A. All-IP networks and Ambient Network

All-IP networks: Ambient Networks are based on all-IP based mobile networks and can be regarded as the outcome of a continued adoption of Internet design principles. All-IP based mobile networks can be characterized by – among other aspects - a clear separation between transport and control related tasks. The functions concerned with either of these tasks are grouped in two distinct layers to ease the independent development in both areas. Additionally, the transport layer is supposed to be IP based, i.e. IP packets are the smallest denominator of all transport layers. The Ambient Network concept adapts these tenets and assumes the presence of a layer to ensure basic connectivity between different networks, constituting diverse addressing domains, participating in the creation of the Ambient Networks federation. This layer will remain based on the Internet Protocol. [1]

Ambient Network: Ambient Networks extend All-IP networks by several innovations. The extensions build on the demand for enabling communication between different social and economical realms as identified by the Internet research community. The three main innovations are network composition (beyond simple internetworking), enhanced mobility and effective support for heterogeneity in networks.

Network Composition: One basic mechanism of our approach is the dynamic, instant composition of networks. Composability as required for ambient networking goes beyond what the Internet and mobile networks provide today. Internetworking shall happen not only at the level of basic addressing and routing, but additional functions for incorporating higher layer support (such as content distribution or service control functions) are required. Ambient Networks will deploy a universal framework for network composition, as an approach for building a unified communication support out of the resources of individual networks, which can be specialized for particular types of access technologies or business models. Network composition in Ambient Networks has to function across operator and technology boundaries, provide a security framework and has to be executable without user involvement. In addition, the execution of the composition process has to be rapid in order to follow fast topology changes as expected for example for mobile Personal Area Networks (PAN). Another example where instant network composition is relevant is the joining of operator networks, which today are based on explicit, human-negotiated and executed agreements and are therefore too slow and cumbersome to setup for, e.g., rapid service roaming. Rather, access, interconnectivity, and service level will be associated on the fly between two networks.

Quality of Service: It describes an important aspect of the formation and communication between ANs as well as legacy networks. Therefore QoS shall be guaranteed by the AN, even when composing with other ANs or interfacing to legacy networks. The ANI shall be able to communicate the parameters needed at any one time for the establishment and maintenance of a service across and between any networks [6].

How to build Ambient Networks: The vision of ambient networks is that users and operators can jointly exploit available radio and network resources for a broad range of services. To enable this vision, the concept builds on a common set of control functions, dynamically (re-) configurable and universally available.

B. Design principles for Ambient Networks

To evolve today's mobile networking into this vision; the current systems need to be analyzed, especially from a user's perspective as outlined above. Currently, the lack of commonly available and configurable control functions and dependence on network technologies and ownership is a major obstacle to further rapid growth. Ambient networks takes up the challenge of defining an essential set of universally available and usable control functions. To achieve this, it defines a conceptual framework including the control functions necessary to achieve the required network capabilities. This framework is based on the following three principles. [1]

1) Principle I

Open connectivity and open networking functions: One basically new way of defining networking in Ambient Networks is to remove architectural restrictions on whom or what can connect to what. Compared to existing internetworking, the goal is to enable all networking services for connected networks instead of connected nodes, e.g. quality of service or media delivery support. This is motivated by the observation that current, node-centric designs fail for many scenarios including PANs, moving networks or sensor networks, when connecting such networks to other networks. In general, we will always assume a network at the end of the communication flow. Hence, we talk about "end-environments" rather than end nodes. The Ambient Networks concept defines a set of support functions required to satisfy the business needs of the operators of such end-environments, where operators can be commercial entities as well as end-users. For such an end-environment, capability offerings are broken down to their nucleus, which is the end-to-end relationship between control functions. The challenge is to provide suitable mechanisms to enable any such relationship regardless of whether the partners reside in an operator's network or an end user's terminal. [3]

2) Principle II

Self-composition and self-management: while composing networks is an easy task when only packet forwarding is concerned, advanced end-to-end functions like QoS and security as well as mobility are currently very difficult to establish across network boundaries. Ambient Networks treat network composition and reconfiguration in a self-managed way as a guiding design principle for the research work. The goal is to use network composition and self-management as basic, locally founded building blocks of a networking architecture. This includes self-composition across different business domains. These features will broaden the business case for the operator and enable a fast introduction of new services in all connected networks.

3) Principle III

Ambient Networks functions can be added to existing networks: In today's networks, there is a large degree of homogeneity on the very basic connectivity/packet forwarding functions, but the network control is distributed over multiple layers and specific to network technology, operator and even implementation. As a starting point for Ambient Networks, the connectivity and control level are logically separated. The control level, referred to as the Ambient Control Space, can enhance existing technologies with distinct control functions, which are compatible across all domains of an Ambient Network. With the above design principles, Ambient Networks will provide end-to-end services for such a **composition** of heterogeneous networks.

C. Mobility

Existing IP-based mobility solutions target either intra-domain mobility within static network architecture or roaming solutions across domain boundaries. Ambient Networks focus on integrated mobility concepts not only applicable for both of the above scenarios, but also integrating localized communications, e.g. in PANs, and device-device interactions. In dynamically composed network architectures, mobility of user group clusters can support effective local communication. Furthermore, mobility must interact efficiently with the control interfaces needed to enable quality of service and optimal routing and re-routing of individual multimedia flows. An Ambient Networks mobility solution will have to work well across business and administrative boundaries, which requires solutions for the security issues of inter-domain operation.

D. Heterogeneity

Ambient Networks will be based on a federation of multiple networks of different operators and technologies. On the one hands, this leads to increased affordability of ubiquitous communication, as the user has full freedom to select technology and service offering and the investment needs for new networks are reduced. On the other hand, networks will have to integrate the capabilities of different technologies to an end-to-end, seamless and secure solution for the user. Ambient Networks takes a new approach to embrace heterogeneity visible on different levels, such as link technologies, IP versions, media formats and user contexts. Diversity of access links, especially of links provided by mobile networks, is supported by a generic link layer concept, which will efficiently enable the use of multiple existing and new air interfaces. Ambient Networks also consider the implications of heterogeneous wireless systems on the overall network, especially the impact on end-to-end QoS and multimedia delivery. In particular, the novel concept of network composition will include the negotiation between different networks regarding their capabilities, e.g. regarding quality of service. Ambient Networks provide an integrated framework for enhanced support of multimedia delivery in heterogeneous environments by embedding novel media flow routing and transport functionalities into the overall Ambient Network architecture

E. Handover Management

According to handover management the characteristics that makes a big difference amid straight handover and straight down handover as follows:

Horizontal Handoff: Handoff within the same access networks; actually it referred to as the intra-handover.

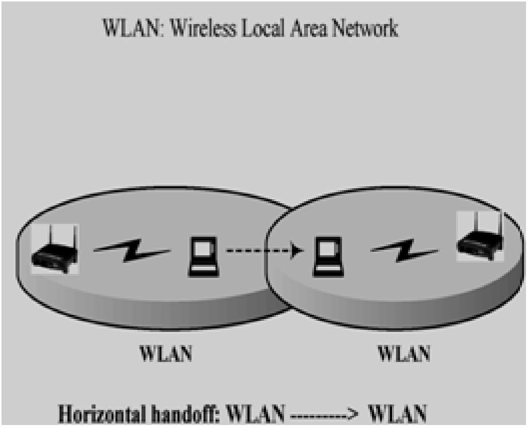

Figure 3.6 a Horizontal Handoff

Vertical Handoff: Handoff across heterogeneous networks, actually it referred to as the inter-handover. It is specially noted that horizontal and vertical handoff has different requirements and techniques to allow handover.

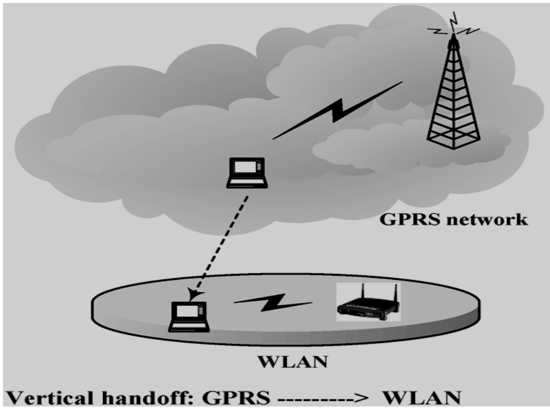

Figure 3.6 b Vertical Handoff

F. Horizontal Mobility

The principle concern of horizontal handover is to maintain ongoing service by changing the IP address due to the mobility of MN. Maintaining ongoing session is done by hiding the change of IP address or dynamically updated the IP address. To hide the IP address changing during the movement of MN, MIP keeps two types of IP address, one permanent IP address which is known as home address might be used under transport layer. The majority of the proposed handover techniques might be included in horizontal or homogeneous handover because they focus on maintain ongoing session and only the IP address is changed. Figure 3.6 a shows the concept of horizontal mobility.

G. Vertical Mobility

It is happened when a MN travel across heterogeneous access networks. Apart from horizontal handover, it requires changing of the access technology and IP address, it is happened because the MN moves dissimilar access network which utilizes different access technology. For this, the principle concern for vertical handover is to maintain ongoing session even though the change of IP addresses and interface of the network, QoS etc. Figure 3.6 b shows the concept of vertical mobility.

It is worth noted that handover techniques for horizontal handover could not be used in vertical handover [8] [9]. Horizontal handoff can solve the trouble of the change IP address; they could not maintain ongoing session while network interfaces or QoS characteristics are changed. To allow vertical handover, the modifying of Mobile IP is needed [10]. The major capabilities of vertical handover as compared to horizontal can be given as follows:

- Dissimilar access medium
- Numerous network interfaces
- Numerous IP address
- Numerous QoS parameters
- Numerous network connections

Mobility management for horizontal handover has many restrictions because of having the MN has only distinct network interface, distinct IP address, distinct IP address and distinct network connection at a time. In horizontal, break before make is that a MN can create a new network connection before disconnecting the aged connection. In vertical handover, we have many IP address, many network interfaces, and many network connections we can develop a mechanism based on make before break. It is a process that a MN can create a new network connection before disjoining the old connection. So handover latency time could be decreased or eliminating permanently. Also, soft handover could be available in vertical handover.

H. 802.11 WLAN overview

WLAN provides a wireless way to access the Internet, as LAN does through a wired way. WLAN standards are specified by the Institute of Electrical and Electronics Engineers (IEEE). Currently there are three standard versions for WLAN, 802.11a, 802.11b and 802.11g [12]. Among them the most mature one is 802.11b which operates at the frequency band of 2.4GHz with a maximum throughput of 11 Mbps. 802.11g is an upgraded version of 802.11b. It operates at the same frequency band as 802.11b with an improved throughput. 802.11a operates at 5.4 GHz with a maximum throughput of 54 Mbps. Today the WLANs employed in the market are mostly 802.11b because it is cheaper and more technically sophisticated. In this paper, the discussion of mobility does not distinguish between these versions. We use 802.11 to refer to all these variant standards mentioned above. And WLAN refers to IEEE802.11 WLAN.

I. Mobility, Location and Handover management in WLAN

Mobility: The 802.11 specification addresses mobility so simple compared to the third generation mobile networks. There is no distinction between location management and handover management.

Location Management: When a station is associated to an AP BSS or ESS, the DS knows the position of the station in the basic service area or extended service area. As long as the station remains in basic service area (if BSS) extended service area (if ESS), the station is capable of transmit and receive frames to an AP [5].

Handover management: 802.11 manage the handover in terms of transitions. There are 3 different types of transitions: no transition, BSS transition and ESS transition.

No transition: as the station remains in the AP service area, it makes no transition.

BSS transition: if a station was originally located in the basic service area of an AP1 and associated with this AP1, leaves this basic service area to enter the basic service area of AP2 of the ESS. The station then uses the service re-association for associating with the AP2, which then starts to send frames to the station. BSS transition request a communication protocol between APs through the protocol IAPP. Indeed, during the re-association, AP2 must notify AP1 that the station is now associated with it. In this type of transition, the basic service area of the APs must overlap in part to ensure the mobility of stations.

ESS transition: an ESS transition corresponds to the movement of a station in a ESS1 to a separate ESS2. 802.11 supports this type of transition in the sense that the station can associate with an AP of ESS2 leaving the extended service area of ESS1 but no guarantee is made to maintain the connection. In practice, the connection is supposed to cut. This means that the connections between network layer and upper layer are broken. To keep the network layer connections, the use of mobility protocols is required.

IV. Simulation

Here OPNET modeler is used to analyze and simulate the concept of mobility in WLAN, as well as problems related to satisfied performance of mobility. We will describe the configuration of these scenarios in the following section.

A. Scenario Description

These networks have 7 wlan_ethernet_slip4_adv WLAN used as APs will operate on with maximum data rates of 54 Mbps and a router_slip64_dc, a device that was created using the device creator utility and contains 64 slip IF/Port Count technologies, to witch all 7 APs are connected and positioned in the center of Cells (Hexagon) in order to build a WLAN infrastructure the Wireless network is deployed into a subnet for which we specified location coordinates. Concerning the technology, 28 Wireless Stations nodes models that represent an IEEE802.11g wireless LAN Stations. The node model consists of Attributes as shown in (figure 4.2).

The Wireless Stations move from one AP to another in random way defines in specific manner the name of an ASCII trajectory file that specifies the times and locations that a mobile node will pass through as the simulation progresses. To perform a handover the roaming capability permits the STA to scan for other APs and switch APs when the signal from the connected AP becomes weak, roaming is not supported in an ad-hoc BSS or in a BSS in which PCF is enabled. As you can see the figure 4.1 shows that only mobile nodes from cells 1 through 3 are designated with VC101, VC102, VC103 through VC112 and the APs AP1,AP2 and AP3 respectively with BSS ID 1,2 and 3 will be tuned and analyzed. Other nodes are there to affect Wireless performance and influence the connectivity for some designated nodes in order to simulate one of an Ambient Network situation.

To generate voice Traffic for each nodes we have configured an Application definition named “codec definition «Voice encoder schemes specifies encoder parameters for each of the encoder schemes used for generating Voice traffic in the network. For the reason that we use an real time

Application such as VoIP, the implementation of a Quality of services is needed, "Queuing Profiles": Defines different queuing profiles such as FIFO, WFQ, Priority Queuing, Custom Queuing, MWRR, MDRR and DWRR. The QoS configuration for all links connecting the Cloud named Backbone with all APs is set to priority Queuing.

B. Experiment setup and results

While the voice clients named VC101 through VC112 move simultaneously between access points the others voice clients are traveling also in one hand to generate traffic in the other hand to affect the Results of the handoff time, delay and load in our experiment. A snapshot of the Animation of the movement of the mobile clients can be seen in (Figure 4.3.) We will begin our study by testing the performance of the topology and observe the influences of moving elements between each other. But before we begun to analyze the graphs there is an important thing to know, namely how Opnet trace APs Connectivity for the nodes Stations.

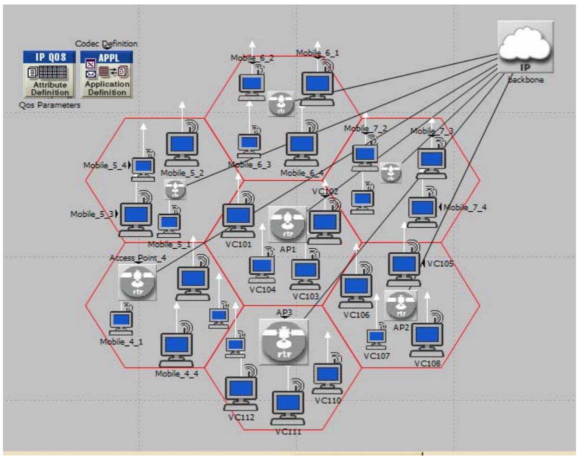

Figure 4.1 Scenario's Topology

Type: station

	Attribute	Value
?	⊟ Wireless LAN Parameters	(...)
?	BSS Identifier	5
?	Access Point Functionality	Disabled
?	Physical Characteristics	Extended Rate PHY (802.11g)
?	Data Rate (bps)	54 Mbps
?	⊞ Channel Settings	(...)
?	Transmit Power (W)	0.005
?	Packet Reception-Power Threshold...	-95
?	Rts Threshold (bytes)	1024
?	Fragmentation Threshold (bytes)	1024
?	CTS-to-self Option	Enabled
?	Short Retry Limit	7
?	Long Retry Limit	4
?	AP Beacon Interval (secs)	0.02
?	Max Receive Lifetime (secs)	0.5
?	Buffer Size (bits)	1024000
?	Roaming Capability	Enabled
?	Large Packet Processing	Fragment
?	⊞ PCF Parameters	Disabled
?	⊞ HCF Parameters	Not Supported
	Mobility Profile Name	Random Waypoint (Auto Create)_1

Figure 4.2 Wireless Stations Attributes

Indication of whether the WLAN MAC is connected to an AP or not. When the MAC is disconnected from its current AP a value of "-1" is written into this statistic, and when it is connected to a new AP then the "BSS ID" of the new AP is recorded. The MAC is assumed to be unconnected while it is in scanning mode, during which it searches for an AP with a satisfactory connection quality.

If this WLAN MAC belongs to an infrastructure BSS but roaming is not enabled for it or if the MAC itself is an AP, then the MAC will never enter into the scanning mode. Hence, the statistic will again contain a single value recorded at the beginning of the simulation, which will be the "BSS ID" of the MAC's BSS. The Figure 4.3 shows that the AP connectivity for the mobile clients VC101, VC105, VC109 and VC112.

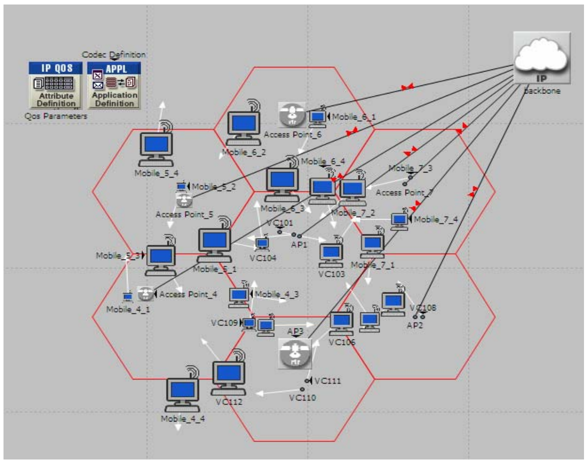

Figure 4.3 Snapshot of the Animation of the movement of mobile stations between APs

C. Improving WLAN Performance with RTS/CTS

The RTS/CTS handshaking provides positive control over the use of the shared medium. The primary reason for implementing RTS/CTS is to minimize collisions among hidden stations. This occurs when clients and access points are spread out throughout the facility and we are finding a relatively high number of retransmissions occurring on the wireless LAN. The two wireless 802.11 stations (Station VC101 and Station VC112) and the access point AP1. Station VC101 and Station VC112 can't hear each other because of high attenuation, but they can both communicate with the same access point. Because of this situation, Station VC101 may begin sending a frame without noticing that Station VC112 is currently transmitting (or vice versa) This will very likely cause a collision between Station VC101 and Station VC112 to occur at the access point. As a result, both Station VC101 and Station VC112 would need to retransmit their respective packets (Fig. 4.4), which results in higher overhead and lower throughput.

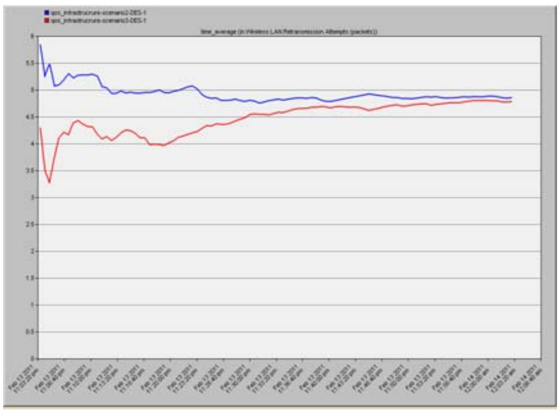

Figure 4.4 Time Average Retransmission Attempts (Packets)

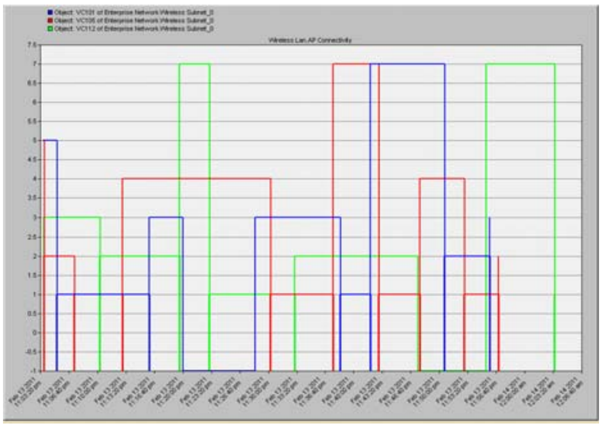

Figure 4.5 Access Point connectivity RTS=256

The RTS/CTS handshaking provides positive control over the use of the shared medium. The primary reason for implementing RTS/CTS is to minimize collisions among hidden stations. This occurs when users and access points are spread out throughout the facility and we are finding a relatively high number of retransmissions occurring on the wireless LAN. (Fig. 4.4)

Rts Threshold (bytes)	1024
Fragmentation Threshold (bytes)	1024
CTS-to-self Option	Enabled
Short Retry Limit	7
Long Retry Limit	4
AP Beacon Interval (secs)	0.02
Max Receive Lifetime (secs)	0.5
Buffer Size (bits)	1024000
Roaming Capability	Enabled
Large Packet Processing	Fragment

Figure 4.6 Enabling RTS/CTS

If we enable RTS/CTS (Fig. 4.7) on a particular station, it refrains from sending a data frame until the station completes a RTS/CTS handshake with another AP, A station initiates the process by sending a RTS frame. The access point receives the RTS and responds with a CTS frame. The station must receive a CTS frame before sending the data frame. The CTS also contains a time value that alerts other stations to hold off from accessing the medium while the station initiating the RTS transmits its data.

Rts Threshold (bytes)	256
Fragmentation Threshold (bytes)	1024
CTS-to-self Option	Enabled
Short Retry Limit	7
Long Retry Limit	4
AP Beacon Interval (secs)	0.02
Max Receive Lifetime (secs)	0.5
Buffer Size (bits)	1024000
Roaming Capability	Enabled
Large Packet Processing	Fragment

Figure 4.7 Changing RTS Value

The probability of sending RTS frame increases in case of 256 byte threshold rather than 1024 byte threshold. Obviously the frequent reservation of channel in the network reduces the WLAN (Fig. 4.8).

Fragmentation mechanism increase the overall WLAN delay (Fig. 4.9). When sending a data packet as multiple fragments, it is reassembled at the destination after a period of time. When the fragmentation threshold is 256 byte, more packets are fragmented and this produce higher WLAN delay.

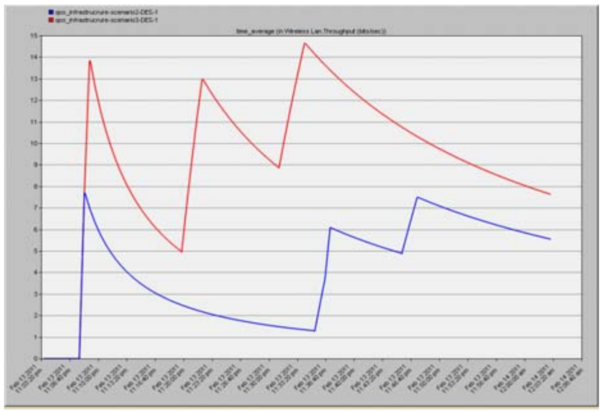

Figure 4.8 Time Average Wireless LAN Throughput

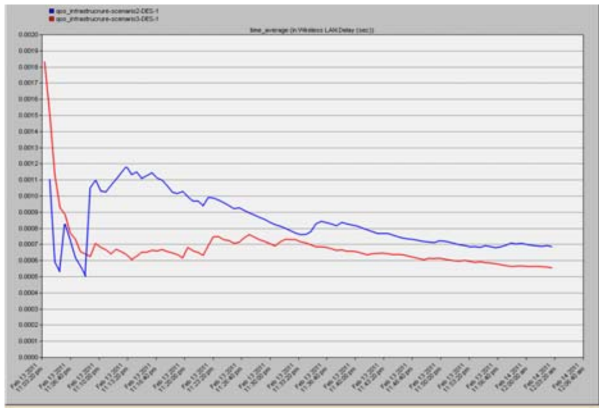

Figure 4.9 Wireless LAN Delay

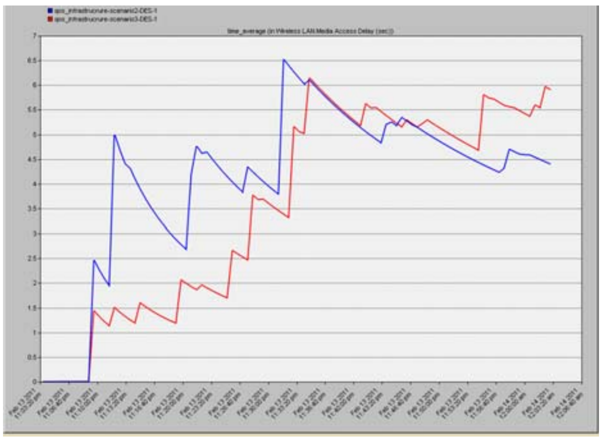

Figure 4.10 Media Access Delay Wireless LAN

When a packet is fragmented in certain nodes, other packets have to wait until sending all the fragments of the previous packets, so the fragmentation process increases the media access delay in each node (Fig. 4.10).

V. Conclusion and Future Works

In this Study, Opnet simulator results indicate that we can improve the WLAN performance. But we should be careful when implementing RTS/CTS, because an increase in performance using RTS/CTS is the net result of introducing overhead (i.e., RTS/CTS frames) and reducing overhead (i.e., fewer retransmissions). In this case, the additional RTS/CTS frames cost more in terms of overhead than what we gain by reducing retransmissions.

The use of RTS/CTS reduces collisions and increases the performance of the network if hidden stations are present. Fragmentation threshold in another parameter used to enhance the throughput of the WLAN. Simulation results shows that increasing this parameter will reduce the throughput unless the RTS/CTS mechanism is employed

A. Future Works

Future Ambient networks required self management, for this reason a future work could study a solution that centralizes the management of all the wireless APs on the network, the tuning for example of RTS/CTS parameters could be managed in a centralized manner . We can also study the Performance Optimization of a Heterogeneous Wireless Network.

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Author Biographies

Abdeassadeq FETTOUH received his Engineering Diplomas in Electrical Engineering with specialization in Telecommunications and Computer Science from the University of Applied Sciences in Aachen North Rhine Westphalia Germany since 1999. He has extensive skills in All Area Networking, Informatics and Telecoms, OPNET Modeler, NS-2 and Operating Systems. He is A Cisco Academy Instructor; Microsoft certified Trainer, MCT CCNA, CCNP, MCSE and IT Manager. He Worked as Consulting Engineer for Computercenter, the Europe's leading independent provider of IT infrastructure services (1999-2004) and GE CompuNet in Germany. He was a Visiting Professor at the Faculty of Science Semlalia, National School of Applied Sciences in the Cadi Ayyad University Marrakech and at Faculty of Science and Techniques University Hassan the First in Settat, Morocco. He Supervised Master, Engineers and Bachelors Students. He is currently a PhD Student, LISI Laboratory Cadi Ayyad University Marrakech, Morocco. His research interests include High Speed Network Architectures (MPLS), Ambient Networks (Mobile IP, MMPLS, Ad Hoc and Sensor Networks), Wireless Communications (Protocol enhancements for 3G/4G cellular wireless networks) and Quality of Service (QoS) and Traffic Engineering for computer and telecommunication networks.

Najib EL KAMOUN, Ph.D in Networking, currently Professor Researcher at ICT laboratory Faculty of Science University Choaib Doukkali El Jadida Morocco. With over 15 years of expertise in distance education, he has conducted several thesis and overseas missions in e-learning. His current research interests focus on mobility management and QoS in emerging networks (MANET, VANET and WSN)

Adnane LATIF was born in El Jadida, Morocco, in 1973. He received the PHD degree in Telecommunications and Microwave from the Cadi Ayyad University, Marrakech, Morocco, in 2005. He is now professor in National School of Sciences Applied, Cadi Ayyad University Marrakech, Morocco. His research interests include the: Antennas, Mobile Communications, Wireless Communications and Microwave.

Abdelaziz ELFAZZIKI, Born 17/12/1956 in Marrakech. Professor at the Cadi Ayyad University of Marrakech since 1985, PhD in computer science 1985. Head of Master of Information Systems Engineering since 2006 Director of computer systems engineering laboratory.