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Impact of Qos Mechanisms on the Performance of Dynamic Web Services in Heterogeneous Wireless Networks (802.11e and 802.16e)

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Abstract

The quality of service in heterogeneous wireless networks is increasingly demanded by customers and by Internet access providers. This paper studies and evaluates the impact of quality of service and the improvements induced on web-oriented services. The heterogeneous wireless networks studied in this paper are: 802.11e and 802.16e. Several scientific research work has been conducted evaluating the performance of heterogeneous wireless networks taking into account the quality of service. According to our research, no work has been done taking into account the convergence of two networks with mobility constraints. This study carried out under OPNET Modeler 14.5, varying the 802.11e QoS mechanisms (DCF, PCF, HCCA, EDCA) and 802.16e (Best Effort, nRTPS). The criteria of evaluation are: TCP delay, TCP retransmission count, HTTP Response and Database Page Response Time.

Keywords: 802.11e, 802.16e, Database, HTTP, OPNET Modeler, QoS, SMTP, Web-Based

1. Introduction

Industrial networks, traditionally using wireline technologies, have turned to wireless because of the ease of installation and the flexibility that these technologies bring. However, the interconnection between the intermediate equipment (Wi-Fi Access Point or WiMax antenna) and the final equipment (PDA, Tablet, Notebook) must be carried out with caution. The two concepts of security and QoS are not defined explicitly; however these two concepts constitute the major needs of each user.

Since the QoS mechanism applied by default is the Best Effort, WiMax and Wi-Fi have their own OSI model layer 2 QoS mechanisms. These mechanisms offer the user the requested quality while respecting a Service Level Agreement between him and the service provider.

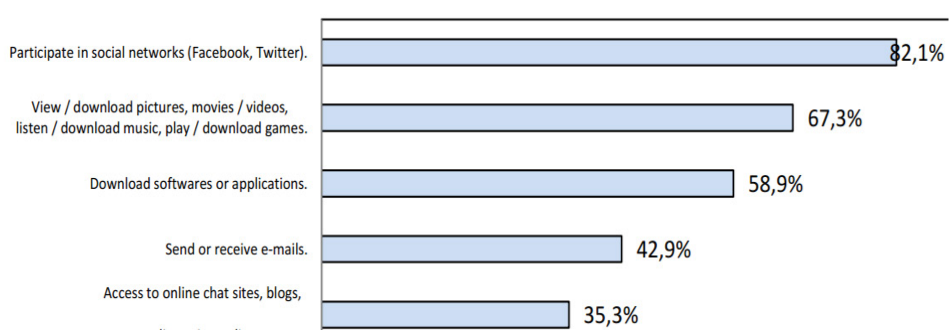

Figure 1. Internet uses during the last three months (Internet users aged 5 years and older)[1].

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The services required increasingly, by users in Morocco and around the world, are dynamic web services.

The figure below, according to the latest statistics conducted by ANRT (The National Telecommunications Regulatory Agency) illustrate the most requested services by Moroccan Internet users, as shown Dynamic Web services ranks first.

In this paper we will study the different QoS mechanisms of layer 2 of the Wi-Fi and WiMax heterogeneous wireless networks and we will then measure the impact of these mechanisms on the performance of dynamic Web services.

The rest of the paper is organized as follows: In the second section, we will conduct a study on the QoS mechanisms of heterogeneous Wi-Fi and WiMax wireless networks. In the third section we will present dynamic web services and their architecture.

Through the fourth section we will present the environment of the simulation and the criteria of the evaluation. The interpretation of the results will be carried out in the fifth section. And we will conclude.

2. QoS on Wireless Heterogeneous Networks

Quality of Service (QoS) is the ability to convey a particular traffic type, in good conditions, in terms of throughput, transmission delays, availability and packet loss rate.

In the heterogeneous networks context (WiFIand WiMAX) the QoS mechanisms implementation is essential, especially since these networks are open access, so a network access management is paramount.

2.1 IEEE 802.11e

WIFI is an international standard describing the wireless LAN characteristics (WLAN). In general, it's the name of the IEEE 80211 standard[2].

The 802.11b protocol allows a throughput of 11 Mbits to 22 Mbits per second, while the 802.11g protocol allows to reach a theoretical throughput of 54 Mbps.

IEEE 802.11e[3] is an enhanced version of the IEEE802.11 introducing QoS at the MAC layer for the transport of voice, audio and video traffic through the WLAN.

To ensure adequate quality of service in wireless networks, the IEEE 802.11 standard defines two channel access methods:

- Distributed Coordination Function (DCF)[4,5]: Stations can randomly access the transmission channel. Before any transmission, the station must listen to the channel to ensure that it is not already taken. If the channel is free in an interval greater than DIFS (Distributed Inter Frame Space), the station can transmit immediately. If the channel is busy, the user must wait for DIFS after the channel is released, and then start a random timer. It can only transmit when this timer reaches zero.
- Point Coordination Function (PCF)[6,7]. It consists of defining a Point Coordinator (PC) in the access point. This PC can then give turns to each station to enable it to transmit. This is the principle of polling.

The 802.11e standard aims to provide QoS capabilities at the data link layer (HCF Hybrid Coordination Function). Its purpose is to define the different packets needs in terms of bandwidth and transmission delay in order to allow better transmission of voice and video.

In this standard, two new QoS mechanisms have been defined:

- EDCA (Enhanced Distribution Channel Access)[8,9]
- HCCA (HCF controlled channel access)[10]

2.2 IEEE 802.16e

WiMAX means Worldwide Interoperability for Microwave Access. It's a set of technical standards based on the 802.16[11] radio transmission standard allowing the transmission of broadband IP data over the air. The maximum theoretical throughput supported by the WiMAXis 70 Mbit / s over a theoretical distance of several tens of kilometers.

In other words, the WiMAX is an alternative solution for the broadband networks deployment in the territories, whether or not covered by other technologies such as ADSL or cable. The WiMAX makes it possible to use both sedentary and nomadic broadband network.

IEEE 802.16e[12,13], this standard was validated in September 2004 and uses the frequency band from 2 to 6 GHz. In practice WiMAX allows a broadband connection while moving at less than 122 km/h. The WIMAX mobile would be a real alternative for transport networks.

The IEEE802.16e WiMAX standard offers four categories for traffic prioritization:

1. Unsolicited Grant Service (UGS)[14]: This service is designed to support services depending on jitter delay or latency such as VoIP (Voice Over IP). It offers a strict guarantee of throughput and latency
2. Real time Polling Service (rtPS)[15]: This service is designed to support services depending on jitter delay or latency such as VoIP (Voice Over IP). It offers a strict guarantee of throughput and latency
3. Non-real-time Polling Service (nrtPS)[16]: This service guarantees only the throughput, it's intended for applications that do not depend on the latency time (such as Email)
4. Extended real time Polling Service (ertPS)[17]: is intended to support real-time data streams characterized by a variable packets size received periodically
5. Best Effort (BE): This service gives no guarantee, but offers all possibilities for any application. It's mainly intended for applications like web access

Handover in wireless networks is the ability to change one access technology to another without the interruption of service[18]. There are two types of handover; Horizontal and Vertical Handover (Figure 2).

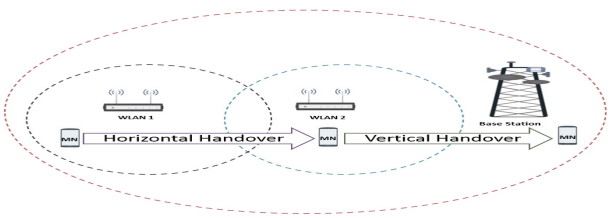


Figure 2. Horizontal and Vertical Handover.

3. Dynamic Web Services

A web application can be manipulated through a web browser. In the same way as websites, a web application is usually placed on a server and is manipulated by operating widgets using a web browser, via a computer network (Internet, intranet, LAN, etc.). Web messaging, content management systems and wikis are dynamic web services.

Dynamic Web services belong to the layer7 of the OSI model. However, these applications are transported through the TCP protocol of the OSI model transport layer.

The TCP protocol, considered as the reliable protocol, opens a session before the data exchange. The session opening, called three-way handshake, allows to reserve the resources between a client entity and the other server. The TCP protocol, through sequencing mechanisms, can detect retransmission errors and send only lost segments in the network. This protocol can be evaluated according to the session opening delay and the retransmission number.

A dynamic web page is a web page generated on demand, as opposed to a static web page. A dynamic web page content can vary based on information (time, user name, form filled out by the user, etc.). Conversely, the static web page content is in principle identical at each visit.

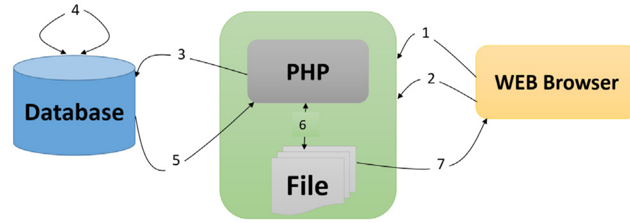


Figure 3. Illustrates an Example of Dynamic Web Operation.

Figure 2. Principle of Dynamic Web Operation.

Step 1: The client first opens a TCP session (on three phases) with the Web server.

Step 2: The client prepares the HTTP request to send to the server, this query often contains a parameter, thanks to it the page will be built.

Step 3: The Web server logs on to the database server, and returns a request formed by the parameter requested by the user of phase two.

Step 4: The database server executes the query.

Step 5: The database server sends the request result from phase three.

Step 6: The web server generates a new page containing the DB request result.

Step 7: The server delivers the generated page to the client.

4. Related Works

The work[19] performs a study on the enhancement induced by quality of service mechanisms in an 802.16 network; the author has deployed a variety of applications but has not adopted the nrtps model for Email and FTP applications, which is far from acceptable.

The work[20] performs a comparative study between different IEEE 802.11 standards, such as b and g, using HTTP traffic. This study was carried out taking into account the scalability, but the author did not introduce the DCF and PCF methods, which are currently indispensable for obtaining quality communication.

The work[21] performs a comparative study between the two Wireless and Wired technologies without taking into account the quality of service or the applications diversity.

According to our research, no scientific work has been done, comparing the effectiveness of web-based applications with the quality of service presence in a heterogeneous network (WiMAX and WiFi) in a vertical handover context.

Taking into account all our remarks about the related works, we will complement and enhance them by:

- Showing the QoS interest in a vertical Handover;
- Evaluating the different QoS mechanisms in 802.11e and 802.16e networks;
- Taking into account the node mobility;
- Diversifying applications (HTTP and database);
- Showing where the QoS is the most influencing.

5. The Evaluation Environment

To conduct our studies, we used the OPNET Modeler tool[22], several simulators can be used, such as NS2[23], NS3[24] and OMNET[25]. OPNET Modeler is currently considered as one of the best simulators in the wireless networks field compared to other simulators[26].

5.1 The Evaluation Scenarios

The scenario chosen in the evaluations is shown in Figure 4

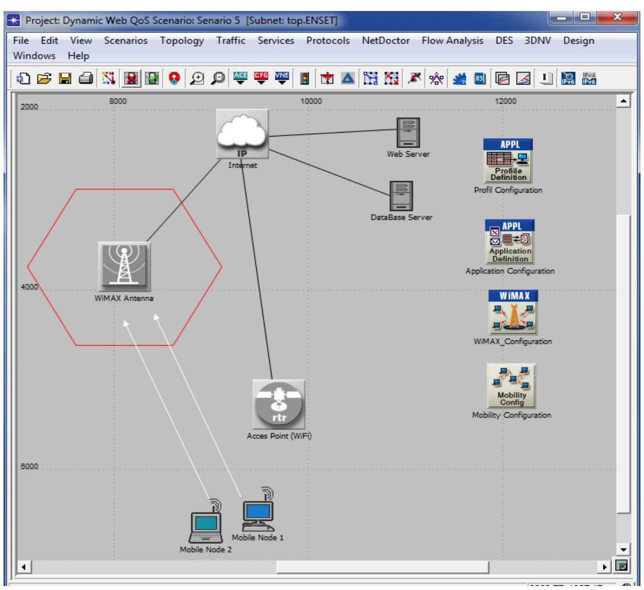


Figure 4. Evaluation Simulation Model.

Based on this model, we have created five scenarios Table 1.

Table 1. Simulation Scenarios

	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
EDCA					
PCF					
nRTPS					

5.2 The Simulation Parameters

The following are the settings used for the WiMAXantenna (Table 2):

Table 2. Base station parameters

Parameter	Value
Antenna Gain	15 dBi
Maximal transmission power	500 mW
PHY profile	OFDM
The resource retention time	200 msec

The simulation parameters used in Wi-Fi scenarios are listed in the below Table III:

Table 3. Access Point Parameters

Parameter	value
PHY mode	Extended Rate PHY
Throughput	11 Mbps
Transmission power	0.005 W
Beacon interval	0.02 Secs
Buffer size	256 Kilobits

5.3 Application Parameters

Applications parameters used and evaluation criteria are listed in the tables IV, and V.

Table 4. HTTP Parameters

Parameter	Value
Traffic	HTTP
Object size	10000 bytes
HTTP Specification	1.1
Type of Service	Background

Table 5. Database Parameters

Parameter	Value
Traffic	Database
Object size	32768 bytes
Transaction MIX (Queries / Total Transactions)	100%
Type of Service	Background

5.4 Evaluation Criteria

Evaluation criteria are:

1. TCP Delay (Sec): Delay (in seconds) of packets received by the TCP layers in the complete network, for all connections.It's measured from the time an application data packet is sent from the source TCP layer to the time it's completely received by the TCP layer in the destination node.
2. TCP Retransmission : Total number of TCP retransmissions in the network. Written when data is retransmitted from the TCP unacknowledged buffer.
3. Database Response Time (Sec) : Time elapsed between sending a request and receiving the response packet. Measured from the time when the Database Query Application sends a request to the server to the time it receives a response packet. Every response packet sent from a server to an Database Query application is included in this statistic.
4. HTTP Response Time (Sec): Specifies time required to retrieve the entire page with all the contained inline objects.

6.Obtained Results

Figure 4 illustrate the opening delay of a TCP session and the retransmissions number. According to these results, the DCF mode delay is the highest compared to the other scenarios:

- 79.59% compared to PCF;
- 576.92% compared to EDCA or nRTPS;
- 486.66% compared to EDCA and nRTPS.

DCF offer the lowest retransmissions number compared to other scenarios. This is because in DCF no classification is guaranteed, so all packets will be treated with the same preference level. On the other hand, in the EDCA mode, a pre-classification is carried out. In the WiMAX network, the delay and the retransmissions number are too small given that WiMAXis a broadband network.

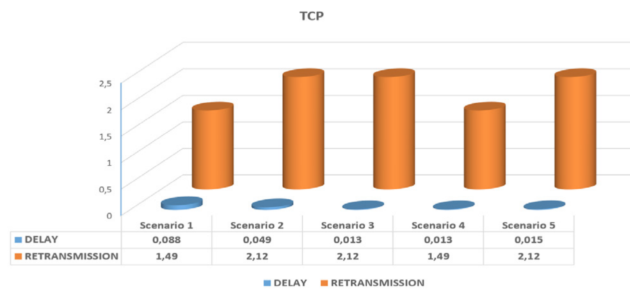
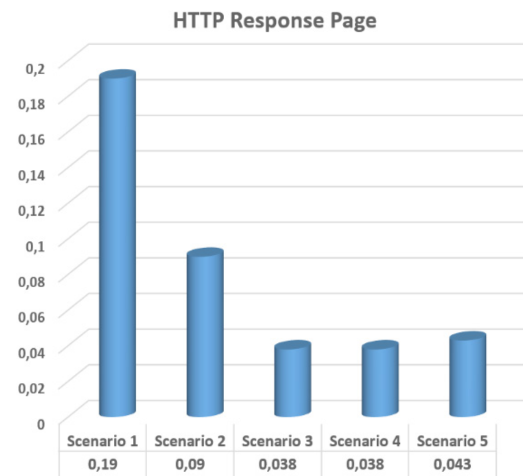
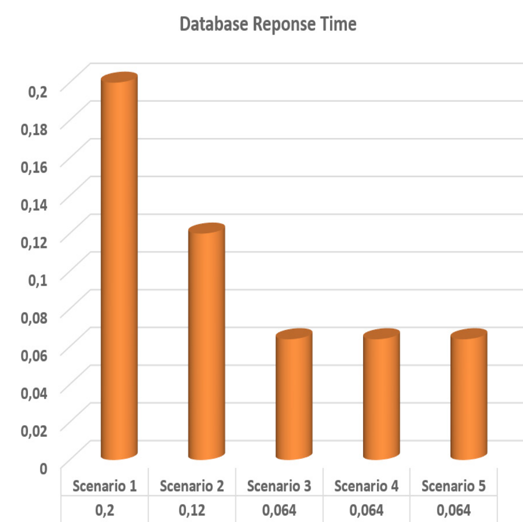


Figure 5. TCP Delay and Retransmission.



(a)



(b)

Figure 5. HTTP Response Page (a) and Database Response Time (b).

Figure 5 shows the obtained results of HTTP and database traffic. Concerning the dynamic web services, HTTP (a) and Database (b), we conclude that the HCF mode offers the best results compared to the PCF and DCF modes. This is justified by the fact that PCF uses pooling but does not perform service differentiation in contrast to HCF mode.

HTTP response delay on DCF mode is the highest compared to the other scenarios by a factor of:

- 111.11% compared to PCF;
- 400% compared to Scenario 3 and 4;
- 341.86% compated to EDCA + nRTPS
- Database delay on DCF mode is the highest compared to the other scenarios by a factor of:
- 66.66% compared to PCF;
- 212.5% compared to Scenario 3, 4 and 5.

7. Conclusion

In this paper we carried out a study on the different QoS mechanisms of WiMax and Wi-Fi networks. We also evaluate their impact on dynamic Web services.

The evaluation was conducted on five different scenarios: The first without QoS, the second set by the PCF mode, the third by the EDCA mode, the fourth with DCF and nRTPS in WiMax and the last with EDCA and nRTPS. The results obtained showed that the first scenario offers a high delay, but a number of retransmissions partially lower than the other scenarios, on the one hand, on the other, scenarios including QoS deployed WiMax are very favorable.

In the next work we will study the scalability, increasing the traffic load.

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