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Conception of Service over Heterogeneous Network, Experimentation

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ABSTRACT

Mapping between two heterogeneous networks, Multi Protocol Label Switching (MPLS) and IEEE 802.11e is choice of future technology as it has ability to perform traffic engineering and create the corresponds between LSP (Label Switch Path) and AC (Access Category). This paper discusses the mapping between IEEE 802.11 MPLS integration to achieve quality of service on MPLS networks. MPLS and 802.11e is very useful approach for today's internet to ensure the Quality of service the end to end. It talks about different approaches to map 802.11e Access Categories (AC) to Label Switched Path (LSP) and their advantages. It then introduces the concept of encapsulated LSPs to achieve future QoS, which requires further study to examine its practicability.

KEYWORDS

MPLS, 802.11e, Mapping, Access Category (AC),Type of Service (ToS), Forward Equivalent Class (FEC) and Label.

1 INTRODUCTION

The Wireless Applications are increasingly used in the business world and also the transmission of real time and multimedia traffic over the IP network [1][2].

This situation requires the differentiation of services between users by the resource sharing and assigning of priority, consequently the quality of service the end to end assured. Best effort is a IP network service in which the network doesn't provide any guarantees that a data packet is received or that a user is given a guaranteed quality of service level or a priority. IP network is trying to improve its transmission and find solutions to adapt to this growing demand by providing different services like VoIP (Voice over IP) [13] [14], Differentiated Service (DiffServ), and MPLS (Multi Protocol Label Switching), and also provide the new technology that supports quality of service as IEEE 802.11e wireless network. Section 2.1 explains 802.11e. In order to manage the packet data and exploit the backup paths, MPLS gives the differentiated services and the speed of layer 2 switching lacked in IP network. MPLS is a promising solution to take over the next generation IP networks Section 2.2 explains the MPLS. MPLS can be combined with IEEE 802.11e to provide quality of service along with traffic engineering as both have many notions of treatment in common. Section 3 explains the IEEE 802.11e MPLS networks. Section 4: Discussion, describes the concept of encapsulated LSP for future QoS needs. Then section 5 experimentation of model L-LSP_E-LSP and Section 6 concludes the paper..

2 MAPPING CONTEXT

2.1 QoS Support Mechanism of IEEE 802.11e:

To differentiate service depending its priority, there are wireless priority schemes currently under discussion. IEEE 802.11 Task Group E currently defines some enhancements in the MAC level, called 802.11e, which introduces EDCF and EPCF[3]. Stations, which operate under 802.11e, are called enhanced stations, and an enhanced Access Point, which may optionally work as the centralized controller for all other stations within the same BSS, is called the Hybrid Coordinator (HC). BSS includes an 802.11e-compliant HC and stations. The HC will typically reside within an 802.11e AP. In the next paragraph, we discuss 802.11e-compliant enhanced stations by stations. The EDCF is used in the CP only, while the EPCF is used in both phases, which creates this new coordination function hybrid.

Enhanced Distributed Coordination Function

EDCF is an enhanced version of DCF also using the CSMA / CA. The contention access method to the channel is called EDCA (Enhanced Distributed Channel Access)

The enhancements EDCF are described below[3]:

- EDCF provides service differentiation by introducing four access classes AC (Access Category) representing 4 priorities with different parameters, which will be seen in detail later.
- 8 priorities, TC (Traffic Category) according to IEEE 802.1D are mapped on the 4 AC (Fig. 1).
- No stations (specifically entity AC) can occupy the channel during longer than a certain limit. By introducing the concept of TXOP [AC] (Transmission Opportunity) representing a time interval during which backoff entity (corresponding to an AC) has the right to emit. Called the TXOP EDCA-TXOP [4]is defined by its initial time and duration. Its maximum TXOPlimit is uniformly distributed in the QBSS (QoS BSS) in each Beacon. The TXOP can thus limit the transmission times in order provide a certain QoS.
- No entity has the right to exceed the value of TBTT. This means, that during CP transmission of a frame, can only to take place if the complete transmission can to occur before the arrival of the next beacon (separated from the previous TBTT) [5]. In this way the delays beacon will be monitored and the time constraints flows better verified.
- If the same station in the early transmission of two streams of two entities coincide, we have a virtual collision is the priority flow is issued.
- Possibility of direct exchange of frames between two stations without going through the AP, using the protocol DLP (Direct Link Protocol) [6].

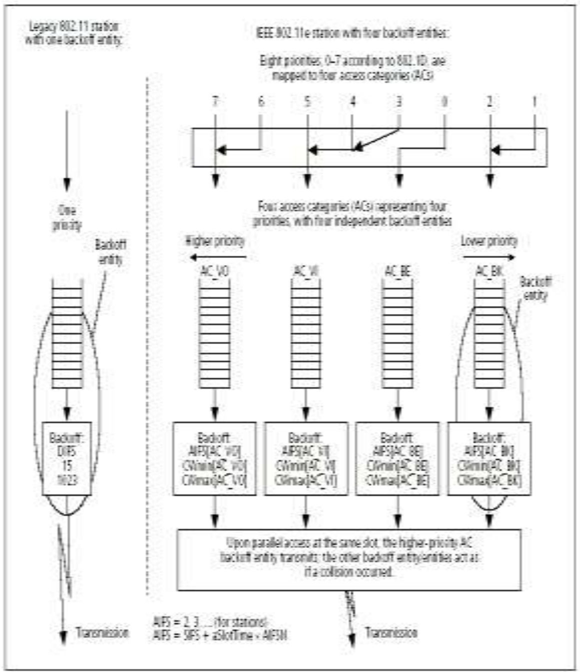

Figure 1. 802.11 and 802.11e stations with four ACs by station

Access Categories (AC) parameters in EDCA

- Four AC with different parameters exist with EDCA, they are designated by the flows that use them: AC_VO (voice), AC_VI (video) AC_BE (Best Effort), and AC_BK (Background).
- Replaces DIFS (Distributed Inter Frames Spacing) by AIFS [AC] (Arbitration IFS), with:

AIFS [AC] =SIFS + **AIFS**N [AC] x SlotTime where **AIFS**N [AC] ≥ 2 , With AIFS [AC] $\geq$ DIFS and AIFSN [AC] has the lowest value for the highest priority (Audio=video <data.) (Fig. 2)

- CWmin [AC] and CWmax [AC] vary with the AC (Audio <Video <Data).
- Persistence Factor PF, in the first, differs by AC, then set the value by 2:

with CWnew = (CWold +1) x PF -1.

As in DCF access, the backoff has to wait for the medium being idle for AIFS, when the medium is determined busy which the counter reaches zero, the counter continue to count down with AIFS again A big difference from the legacy DCF is that when the medium is determined as being idle for the period of AIFS, the backoff counter is reduced by one beginning the last time interval of the AIFS period. however in the legacy DCF, the backoff counter is reduced by one beginning the first slot time after the DIFS period. After any transmission failure attempt a new CW is calculated with using of the persistence factor PF[TC], enlarged CW is drawn, to minimize the probability of a new collision. then in legacy 802.11 CW is always doubled after any failure access as PF equivalent to 2[3].

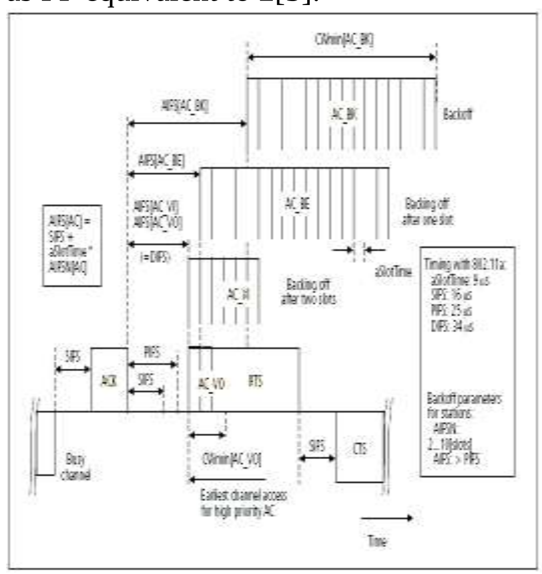

Figure 2. Parameters for different priorities in EDCA

Hybrid Coordination Function

HCF (Enhanced Point Coordination Function) describes more rules than EDCF offering more control of transmissions. The HCF allocates bandwidth and transmission opportunities (TXOPs) using a hybrid coordinator (HC) that gets the highest access priority. HCF uses a centralized polling with a approach similar to PCF. During Contention Period, each TXOP starts as defined by the EDCF rules, after AIFS backoff time, or when the station receives from the HC a special poll frame, assigned as the QoS Contention-Free (CF)-Poll. The HC sends this QoS CF-Poll after it listen for the wireless media to be idle for PIFS. The QoS CF-Poll specifies TXOP, during this time interval the station has the right to transmit. During the Contention Free Period, only the polled station is authorized to transmit. The CFP ends after the time announced by a CF-End frame from the HC or in the beacon frame or[3][6].

HCF is an enhanced version of the principle of the PCF. It has the following additional properties:

- PCF works only for the CFP, while HCF works in the CFP and the CP, hence the name of Hybrid.
- Provides a management policies and a deterministic channel access by controlling the channel by the hybrid coordinator HC (Hybrid Coordinator).
- Detecting the channel as being free for PIFS, is shorter than AIFS, gives the HC high priority on EDCF, which allows it to issue even during the CP.
- HCF model can to provide guaranteed services with higher probability than pure EDCF.
- A signaling protocol can be used to facilitate admission control and to specify the flow needs.

As for EDCA TXOP (EDCF access) is limited so HCCA (HCF access) can provide the better service in the required time. The TXOP in HCCA-TXOP is called polled, it is allocated by the HC, and is limited by TXOPlimit.

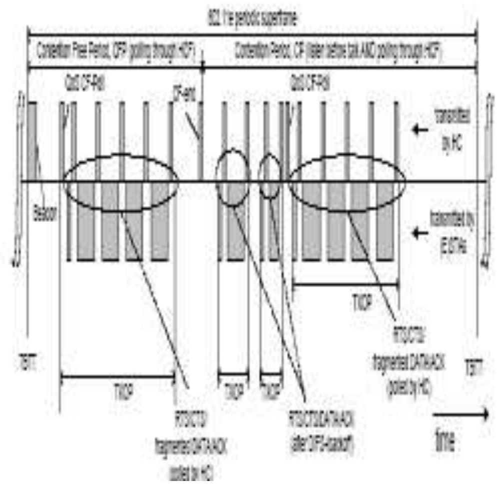

Figure 3. 802.11e superframe. Using TXOP. The polled-TXOP exist in CP and CFP

In order to provide quantitative QoS services, HCF requires a signaling process that informs the HC about the transmission requirements of each traffic stream at each station. Using this information, the HC will determine which stations need to be polled, when, and which TXOP should be granted. TXOP is granted per-station—that is, the HC does not specify which traffic stream should be transmitted on the channel. It is up to the station to select the traffic stream to be transmitted.

2.2 Multi Protocol Label Switching:

MPLS is a new technology, developed and standardized by the IETF, using mechanisms switching labels intended to reduce the cost of routing network layer while giving it better performance, greater scalability and greater flexibility in restoration services network layer. MPLS is a switching technology using labels. In a MPLS network, incoming packets are assigned a "label" by a

"LER (label edge router)" according to their forwarding equivalence class (FEC) [7]. Packets are forwarded along a "label switch path (LSP)" where each "LSR (label switch router)" makes forwarding decisions based solely on the contents of the label, eliminating the need to look for its IP address. At each hop, the LSR takes off the existing label and applies a new label for the next hop. Next hop also decides how to forward the packet by reading just the label on the packet. These established paths, Label Switch Paths (LSPs) can guarantee a certain level of performance, to route around network congestion, or to create IP tunnels for network-based virtual private networks. This technology can more easily integrate technologies such as QoS, VPNs or VoIP, makes it a flagship technologies of tomorrow already appreciated by the majority of Internet service providers as well as by some major companies. This demand has encouraged the evolution of these different networks which at the same time increased the complexity of managing all these networks. In terms of improvements, MPLS allows better management of routing, switching and transfer packages, through networks of new generation.

But that's not all because the MPLS is more able to solve many problems outlined above by improving four major aspects[9]:

- Possibility to define in advance the path that will take data or types of data sent over the network (Traffic Engineering).
- Ease of creating tunnels and IP VPNs (Virtual Private Network) level including Internet service providers, and solving problems related to the multiplication of them.
- Independence protocols layers 2 and 3 of the OSI model with support for IPv6, IPv4 layer 3, and Ethernet, Token Ring, FDDI, ATM, Frame Relay and PPP layer 2 .
- Interaction between the existing routing protocols such as OSPF (Open Shortest Path First) and BGP (Border Gateway Protocol).

The architecture is based on MPLS mechanisms switching labels linking Layer 2 of the OSI model (switching) with the layer 3 of the OSI model (routing). Moreover, switching conducted layer 2 is independent of the technology used.

The networks now use the analysis of headers layer 3 of the OSI model to make decisions on the transmission of packets. however, MPLS is based on two distinct components to reach its decisions: the control plan and data plane.

- The data plan can be used to transmit data packets based on the labels, which carry based on a database of transmission labels maintained by a switch of labels.
- The control plan maintains information transmission labels to groups of switches labels.

Label (20 bits)	Exp (3 bits)	S (1 bit)	TTL (8 bits)

Figure 4. MPLS header

Label is generated according to routing protocol. This label is used to forward the packet. The traffic is encapsulated in MPLS header. MPLS header is 32 bit long and composed of label (20 bits), Exp (3 bits) for experimental use, S (stacking bit, 1bit), Time To LifeTTL (8 bits). (Figure 4) backbone ingress routers examine the MPLS header to make forwarding decision (Label switch Path) and swap the label with appropriate label for next hop. Egress router performs the withdrawal and removes the MPLS header. Two neighboring routers Label known as label distribution peers decide on a label to bind a particular FEC. FEC is used to define the association of traffic with the same distination, the traffic have the same FEC will be assigned by the same label, different FECs and their associated labels are used. In order to transmit packets and establish an FEC, MPLS is based on the following parameters[7][8]:

- Source and/or destination IP address
- Source and/or destination port numbers
- IP protocol ID (PID)
- IPv4 Differentiated Service (DS) code point
- IPv6 flow label.

The assignment of label is made by the downstream LSR by either "downstream-on demand" operation or "unsolicited downstream label" operation. Label binding is local and does not represent the FEC. It is the agreement between two LSRs for binding to a particular FEC. The path through one or more LSRs, followed by packets is called LSP (Label Switched Path)[10]. MPLS uses two methods for choosing the LSP for a FEC, which is called route selection: Hop-By-Hop routing and Explicit Routing.

3 MAPPING BETWEEN MPLS & 802.11E:

IEEE 802.11e and MPLS help solve the IP quality problem. IEEE 802.11e uses the IP TOS (type of service) field to classify traffic into different classes at the boundary node to provide QoS. MPLS also classifies traffic into different FECs with which it can provide QoS. MPLS networks support IEEE 802.11e by mapping IEEE 802.11e ACs (Access Categories) onto LSPs. The ToS of a packet determines the priority of the nodes and MPLS label of a packet determines the route of the packet. MPLS IEEE 802.11e network combines these to features best match traffic engineering and QoS[11] [12].
common factor in terms of quality of service, constituting a real reason to achieve our approach:

- Complexity is pushed to edge routers.
- Classification of traffic at edge routers
- Labeling of packets after classifying them
- Transit routers treat packets according to the labels
- Labels are short and of fixed length
- Aggregation support

When a IEEE 802.11e packet arrives into a MPLS network, ingress LSR examines the TOS field of IP datagram to check the 802.11e priority information. The incoming traffic is mapped to appropriate LSP.
MPLS can map IEEE 802.11e traffic to MPLS traffic in several ways. Multiple ACs can be mapped to single LSP or a single AC is mapped to single LSP. When multiple ACs are mapped to a single LSP, Exp field in MPLS is used to specify PHB. This method is called EXP-Inferred-PSC LSP (E-LSP). When a single AC is mapped to a single LSP, it is Label-Only-Inferred-PSC LSP (LLSP).
E-LSP: EXP field of MPLS header (3 bits) is used to specify ACs. Label can be used to make a forwarding decision and EXP field can be used to determine how to treat the packet. all ACs take the

same explicit path, with a different priority treatment.

L-LSP: A separate LSP can be established for a single FEC AC combination. In this case, the LSR can infer the path as well as treatment of the packet from the label of the packet. The EXP field encodes the drop precedence of the packets.

When a network supporting less than 8 ACs classifications, E-LSP is very useful. It combines the traffic engineering capabilities of MPLS with QoS provided by ToS field. LSR needs to map EXP field to AC. This mapping needs to be configured. L-LSP supports arbitrarily large number of <FEC, AC> combinations. Different LSPs are used for different types of ACs. Ingress router sets the EXP field in accordance with the drop precedence of the packet and sends it on to correct LSP for specified AC. Transit routers read the label along with EXP field and act accordingly. Mapping of Label to AC is signaled and EXP to drop precedence is well known.

4 ANALYSIS

Though L-LSP is the answer for MPLS IEEE 802.11e with many types of PHBs defined. in the other side E-LSP is very useful in a network with limited number of traffic classifications (until 8 classes), E-LSP serves our purpose. Using different trade-off and combinations of techniques, operate in the MPLS network, can provide a quality of service from the end to end and enhanced service.

The main technique is not permanent usage of resources and labels. Labels will be assigned whenever a particular AC uses the network or defined the EXP field.

In future, QoS is going to be must demanding enhanced methods for ensuring QoS. Internet applications require high granularity of QoS, will demand more number of ACs in 802.11e.Internet service providers have many customers, who need intermittent connections. the labels associated with a customer can be used for other, when such customers are not using the network. Thus the total number of labels used will not exeed the scope and will still support more numbers of traffic classifications. MPLS is going to be the technology increasingly used as it provides traffic engineering capabilities and QoS. Currently, if MPLS technology is expanded to embrace new QoS, rather than defining new standards for QoS. 802.11e can be extended to provide high granularity of QoS using MPLS. One approach to provide such high granular 802.11e is the use of encapsulated LSPs; EXP field of LSP deciding the QoS and the other field deciding the path[13].

Labels denoted could be static as well as dynamic. The assumption is the classes of service do not change as frequently as the network itself. In that case, static use of labels, which means the fixed association of label and service, will reduce the processing time of LSRs minimize the memory load. By verifying the E-LSP, LSR knows what how to treat the packet. LSR can then check L-LSP to look up the table just to make forwarding decision. Static Label-Service association will not require LSRs to swap signaling messages with their neighbors[14].

Main policy MPLS of the ISP must define the QoS mapping for the label–Service association. This information is assigned to all other LSR using signaling protocols.

In the case, dynamic labels are used, labels specifying different classes of services should also be exchanged through signaling protocols. For this approach each each MPLS router is composed of two separate databases: one for traffic classes(data plan) and the other for path decisions(control plan). Use of L-LSPs and E-LSPS together eliminate the need establishing different LSPs for different classes thus eliminating the need to maintain large number of labels as label as same labels can be used for denoting different service as well as forwarding decision. E-LSP will determine the service and the L-LSP will determine the path. This approach needs further study to verify its feasibility.

5 Experimentation

in the first, we will present the experimentation of the interconnection that unites two technologies: IEEE802.11e and MPLS. 802.11e that present here a transmission system of data assuring the link between peripherals by the waves radio and MPLS is the technology that permits to simplify the administration of a network backbone by adding new particularly interesting functionalities for the management of the quality of service. We will pass in a second time to give the result of the comparison between the two methods of creation of LSP: E-LSP and L-LSP.

The model of the MPLS-WiFi experimentation is constituted of:

- Three machines: 2LER and a LSR that present the MPLS backbone.
- Two access points WiFi Linksys WAP54G 802.11g (54Mbps) of cisco.
- Two PC Windows that are connected via access points to the MPLS backbone.

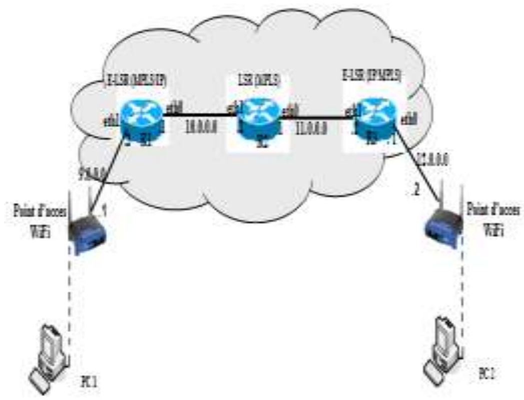

Figure 5. Mapping model

The figure 5 shows names of machines, interfaces and the IP addresses used.
The PC1/PC2 are the machines server/customer that will be used to transfer the FTP/UDP applications, this last will pass by the MPLS backbone constituted by the machines R1, R2 and R3.

5.1 comparison between the E-LSP and L-LSP mechanisms:

- **E-LSP** mechanisms

On the PC1 machine (server) launch two flows video in two ports 1235 and 1236. in the other side PC2 (customer) we configured the opening of these two flows networks by listening to these two ports.

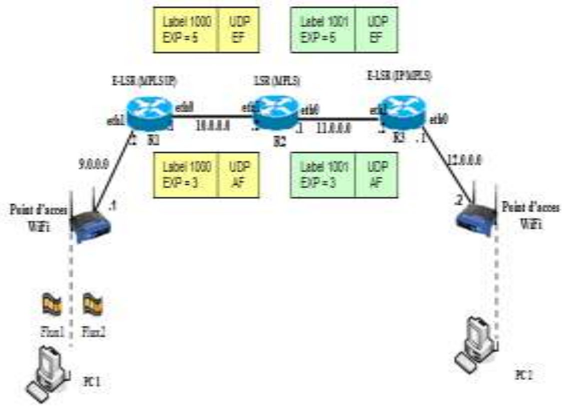

Figure 6. E-LSP mechnism with QoS

Description :

- PC1 sends two UDP flows on the two ports 1235 and 1236 toward PC2.
- The R1 machine is going to make a classification according to the port destination, then the AC-EXP mapping will be established while copying the three bits the most meaningful, finally the label "1000" is added.

The following figure illustrates the parameters used in this scenario.

ToS	EXP	Label	Specified bandwidth	Port source
0x1A	3	1000	2400kbit/s	1235
0x2E	5	1000	4400kbit/s	1236

Figure 7. QoS (L-LSP) configuration of UDP flow

- It will give to the packet (EXP=5) a big priority and to the packets (EXP=3) a minor priority while offering to each a specified bandwidth.
- The R2 machine is going to exchange label 1000-->1001 and may suppress packets in case of congestion according to the priority defined.
- The R3 machine suppresses the label 1001 and routes packets toward the PC2.

The following graph shows the domination of the bandwidth of the flow (port 1236) that has the biggest priority and less packets to compared to the second flow (port 1235).

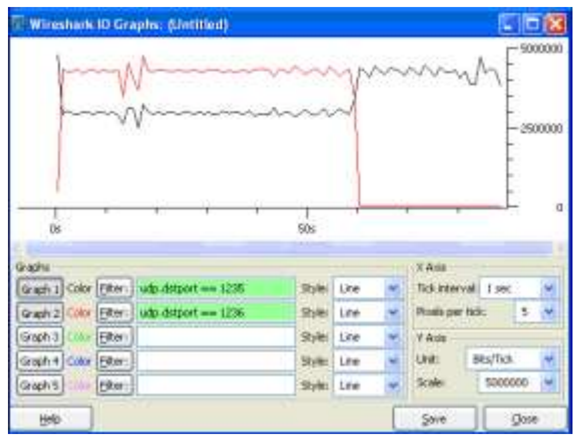

Figure 8 : throughput Variation of two Flows UDP(E-LSP)

While taking the result of this experimentation as a basis, we conclude that the configuration that we adopted to the departure permitted us to give a big priority to the UDP flow (port 1236) in relation to the second flow (port 1235).

- **L-LSP mechanism:**

We exercised the same experimentation, but this time the R1, R2 and R3 machines have been configured to support the L-LSP mechanism, this last can offer the differentiation of service while using the MPLS label, The EXP field contains information of loss solely.

Description :

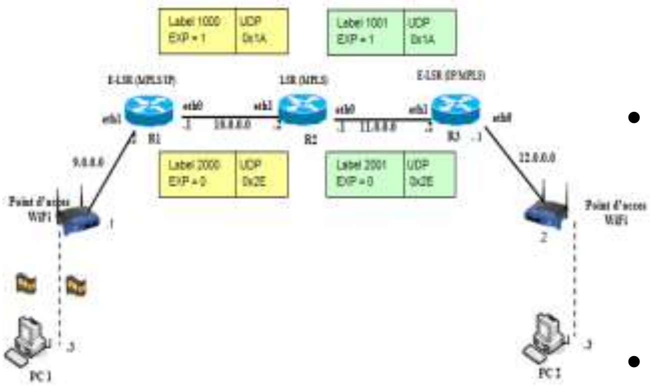

Figure 8. L-LSP mechanism with QoS

- PC1 sends two flows UDP in two ports 1235 et 1236 toward PC2.
- The R1 machine is going to make a classification according to the port destination, then she will add the label "1000" for the first flow and the label "2000" for the second, now the label has a duplicate role: used in the commutation of label to define the destination, and to identify the class of service The EXP field used also to identify the priority of loss.

  The following figure contains the parameters used in this connection.

ToS	EXP	Label	Specified bandwidth	Port source
0x1A	1	1000	١٦٠٠kbit/s	1235
0x2E	0	2000	٤٤٠٠kbit/s	1236

Figure 9. QoS (L-LSP) configuration of UDP flow

- It will give to packet "0x1A" (Label=2000, EXP=0) a major priority and to packets "0x2E " (the label=1000, EXP=1) a minor priority while offering to each a specified bandwidth.
- The R2 machines is going to exchange labels 1000--->1001, and 2000--->2001 and to suppress packets in case of congestion according to the priority (EXP field) has already definite.
- The R3 machine suppresses labels 1001 and 2001 and routes packets toward PC2.

The following graph has the same pace that the one gotten by the E-LSP mechanism, what demonstrates that the two mechanisms offer the same quality of service.

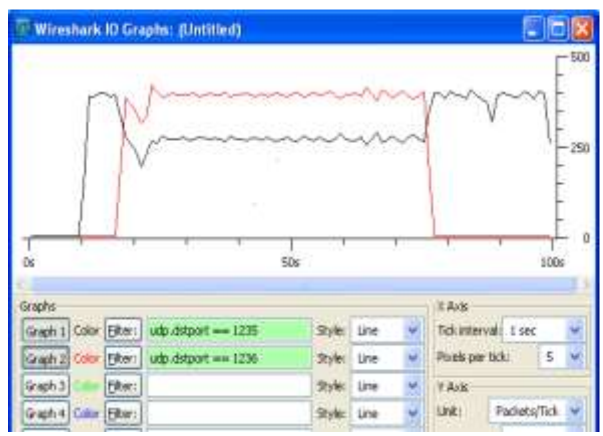

Figure 10. throughput Variation of two Flows UDP(L-LSP)

Although the two E-LSP and L-LSP mechanisms use two manners to differentiate services, they offer the same quality of service.

5.2 Result of the comparison:

- In the E-LSP, the label is a means to indicate the destination of packets, the EXP field is used to specify the class of service.

- In The L-LSP, the label is not used only to determine the destination of the FEC but as the class of service, the EXP field serves to define the priority of loss.
- The L-LSP method is more complex because the LSR must define different LSP toward the same destination.
- The MPLS nodes use MPLS him to distinguish the different classes of the traffic.
- The MPLS network cannot offer a guaranteed bandwidth, but only the minimal passing bandwidth by class of service that can be saturated.

5.3 Service differentiation using MPLS

we will experience here some scenarios using the E-LSP mechanism to better study the impact of QoS services.

- **Scenario 1: Send two streams:**

In this scenario, we send two streams on two different ports 1234 and 1235 via VLC tool, we assigned to each port the bandwidth priority as mentioned in the table below:

AC	EXP	Bandwidth	source Port
0x1A	3	2400kbit/s	1235
0x00	0	400kbit/s	1234

Figure 11. Configuration of scenario

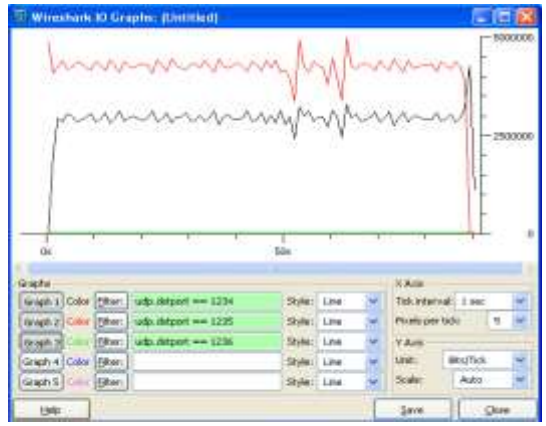

Figure 12. Variation of throughput of two Flows of scenario 1

As we can see in Figure 6, the stream (port 1235) is preferred more than the stream (port 1234), we also found that the number of the lost packets during the transfer of the first stream (port 1234) is greater than that lost by the second stream (port 1235).

- **Scenario 2: Send of three flows streams:**

In this scenario, we distributed three UDP flows on three several ports 1234,1235 and 1236. The R1 R2 and R3 machines have been configured like follows:

AC	EXP	Bandwidth reserved	Port source
0x2E	5	4400kbit/s	1236
0x1A	3	2400kbit/s	1235
0x00	0	400kbit/s	1234

Figure 13. Configuration of scenario

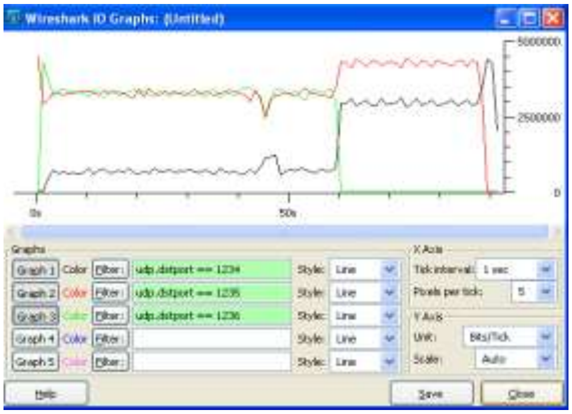

Figure 14. Variation of throughput of two Flows of scenario 2

it is clear that flows (port 1235 and 1236) dominated the bandwidth, whereas the flow (port 1234) that has the minimal priority, took the remainder of the bandwidth until the flow (port 1236) has finished to take more bandwidth. Concerning the number of lost packets, one noticed that the number of packets is proportional to the priority assigned to every flow.

5.4 Result of the comparison:

In the E-LSP, the label is a means to indicate the destination of packets, the EXP field is used to specify the class of service. In The L-LSP, the label is not used only to determine the destination of the FEC but as the class of service, the EXP field serves to define the priority of loss. The L-LSP method is more complex because the LSR must define different LSP toward the same destination. The MPLS nodes use MPLS him to distinguish the different classes of the traffic. The MPLS network cannot offer a guaranteed bandwidth, but only the minimal passing bandwidth by class of service that can be saturated.

6 CONCLUSION

The aim of this paper was to propose a for finding the best mapping between several heterogeneous system by used the flows with different priority, and we described how MPLS and 802.11e work together. It explained different approaches to incorporate the IEEE 802.11e into MPLS networks, and also showed the importance of our approach and its role in providing QoS the end to end. This paper designed to develop mechanisms capable of providing a quality of service between two mechanisms of QoS to accomplish future QoS supporting many types of traffic classification and 802.11e into MPLS networks, and also showed the importance of our approach and its role in providing QoS the end to end. This paper designed to develop mechanisms capable of providing a quality of service between two mechanisms of QoS to accomplish future QoS supporting many types of traffic classification and offered more choices of service according to Access Categories.

6 REFERENCES

1. IEEE 802.11 WG, “Wireless Lan Medium Access Control and Physical-Layer (PHY) Specifications” 1999; standard.
2. IEEE 802.11e, “Wireless Lan Medium Access Control(MAC)Enhancements for Quality of Service (QoS)” 802.11e Draft8.0, 2004.
3. Martin Heusse, Franck Rousseau, Gilles Berger-Sabbatel, and Andrzej Duda “Performance Anomaly of 802.11b” IEEE INFOCOM 2003
4. Stefan Mangold, Sunghyun Choi, Peter May, Ole Klein, Guido Hiertz, and Lothar Stibor, “IEEE 802.11e Wireless LAN for Quality of Service,” in Proc. European Wireless ’02, Florence, Italy, February 2002.
5. Sunghyun Choi, Javier del Prado, Atul Garg, Maarten Hoeben, Stefan Mangold, Sai Shankar, and Menzo

Wentink, "Multiple Frame Exchanges during EDCF TXOP," IEEE 802.11-01/566r3, January 2002.
6. S. Blake, An Architecture for DifferentiatedServices, RFC 2475, December 1998.
7. E. Rosen, A. Viswanathan, R. Callon, "Multiprotocol Label Switching Architecture", RFC 3031, January 2001.
8. Uyless Black, MPLS and label Switching Networks, Prentice Hall, Upper Saddle River, 2002.
9. B Davie, Y Rekhter, MPLSTechnology and Applications, Morgan Kaufmann, San Francisco, CA 2000.
10. P. Trimintzios, and. al., "A Management and Control Architecture for Providing IP Differentiated Services in MPLS-based Networks", IEEE Comunication Magazine, May 2001.
11. P. Trimintzios, and al., "A Management and Control Architecture for Providing IP Differentiated Services inMPLS-based Networks", IEEE Comunication Magazine, May 2001.
12. K. Maâlaoui, A Belghith, J Bonnin, M Tezeghdanti: "Performance evaluation of QoS routing algorithms" IEEE International Conference on Computer Systems and Applications (AICCSA), January 3-6, 2005, Cairo, Egypt. IEEE Computer Society 2005
13. H. Kochkar, T Ikenaga, K. Kawahara and Y Oie: Multi-class QoS routing strategies based on the network state. Computer Communications Volume 28(number 11), pp: 1348-1355 (july 2005).