



A Proposal Approach for Load Distribution and Resources Sharing in IEEE 802.11 Networks

Issam Jabri, Adel Soudani, Nicolas Krommenacker, Thierry Divoux

► To cite this version:

Issam Jabri, Adel Soudani, Nicolas Krommenacker, Thierry Divoux. A Proposal Approach for Load Distribution and Resources Sharing in IEEE 802.11 Networks. International Conference on Wireless and Mobile Communications, ICWMC'06, July 29-31, 2006, Bucharest, Romania, Jul 2006, Bucarest, Romania. pp.CDROM. hal-00067709

HAL Id: hal-00067709

<https://hal.science/hal-00067709>

Submitted on 5 May 2006

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

A Proposal Approach for Load Distribution and Resources Sharing in IEEE 802.11 Networks

Issam Jabri^{1,2}, Adel Soudani¹, Nicolas krommenacker² & Thierry Divoux²

Laboratoire d'Electronique et de Micro-Electronique
(E μ E) .
Faculté Des Sciences de Monastir, Tunisie.
Email (Adel.soudani@issatso.rnu.tn)

Centre de Recherche en Automatique de Nancy
(CNRS ESA 7039)
Université Henri Poincaré Nancy 1-France.
Email (prenom.nom@cran.uhp-nancy.fr)

Abstract

Recently there is a growing interest in the internet and multimedia wireless networking where the bandwidth and the QoS metrics must profoundly adjusted to the application requirement. However the problem of user bandwidth availability arises as one of the most limit of this solution. In fact, the IEEE 802.11 standards do not provide performed mechanism of loading distribution among different APs of the network. Then an AP can be heavily overloaded leading to station throughput degradation.

This paper focuses on the specification of a centralization solution for QoS management in IEEE 802.11 networks. It, mainly, presents the general architecture of the overall system based on a load balancing server over the AP(s) network resources. In addition, the paper addresses a protocol specification for AP and mobiles interactions intended to provide best resources allocation and efficiency on communication metrics. This protocol is being described and simulated with SDL and MSC tools as a first step before experimentation in real environment.

1. Introduction

In the last few years the IEEE 802.11 technology becomes very interesting. One of its popular uses is its cheap hardware infrastructure price promoting to provide practical and efficient Hotspots environment [1].

The research work [1, 2, 3, 5] carried in this context had proved that additional effort is yet required to build up a system with a high service quality. A specification of further interaction in the IEEE 802.11 protocol between AP and the mobiles mainly in call admission will help to ensure some QoS parameters such as loading distribution and packet losses [1, 2, 4, 19, 20]. A new standard has IEEE 802.11e [21] has been defined to ensure quality of service in Wireless LAN.

This paper presents a protocol specification managing the QoS in the context of Hotspots communication environment. The first part focuses on the description of the general hotspots environment architecture. The second part presents the load balancing algorithm. In the next part we define of new protocol primitives between the mobile and the access point managing QoS metrics. Then we present the description of this protocol with the SDL (Specification and Description Language) language [8, 9] and some MSC (Message Sequence Charts) simulation results of the behaviour of this protocol. We finish by highlighting future contributions in this field.

2. General approach presentation

The QoS management on hotspots environment becomes vital as many new emerging applications such as mobile information access, real time multimedia communications, networked games, immersion worlds and cooperative work require a minimum level of QoS [12, 13, 17, 18].

The hotspots environment can be described as a set of access points covering overlapping cells and offering connection to a variable number of mobile stations. User's applications are not similar in terms of QoS requirements so that a fair distribution of the mobile stations among active access points can guarantee a minimum level of quality of service. The bandwidth effectively offered by an access point is given by the following formula (Shanon). BP is the bandwidth defined by the IEEE 802.11 standard.

$$C_{max} = BP \times \log_2 (1 + SNR)$$

So, due to the wireless environments (interferences, obstacles...) bandwidth is scarce and channel conditions will be time-varying and sometimes highly lossy.

Unfortunately, in the actual IEEE 802.11 protocol, a mobile station is associated to the access point offering the best Signal by Noise Ratio (SNR) independently of the load being applied to the access point by other users. This can cause, in many cases, unbalanced load between access points.

Some access points will be over loaded, others are under loaded. For the first ones applications requirements are not fulfilled. The keystone of our

approach is to associate mobile station to access points with a minimum SNR threshold and offering the best QoS level.

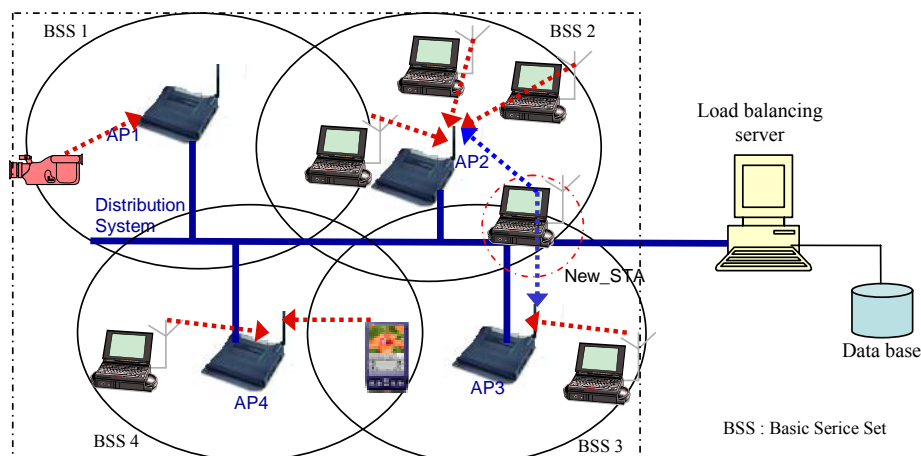


Figure 1. IEEE 802.11 target architecture

Figure 1 sums up the idea we develop in this paper. A new mobile station (New_STA) reaching the WLAN must be associated with an access point. The association procedure is always initiated by the station (mobile-controlled handover) and the station can be associated with only one access point. The New_STA must discover which access points are present and then requests to establish an association with one of them. Thus, first the station initiates a scanning process that can be either active or passive [6]. Once the scanning process has finished, the station has an updated list of access points in range (AP2 and AP3).

This information is used by the station to associate with the access point that provides the higher Signal-to-Noise Ratio (SNR).

Let's suppose that AP2 is chosen by New_STA. The load distribution across access points will be highly uneven [1]. This can cause a performance degradation perceived by the other stations attached

to AP2. Quality of service contracts (bandwidth, loss rate...) may be violated. It will be attractive to associate the new host to AP3 which has lower SNR but is under loaded. So that we fulfill the QoS requirements of both old and recent associated stations: the available bandwidth of the WLAN link depends strongly on the number of active stations and their traffic. To achieve this balancing, in terms of quality of service offered to the stations (load, loss rate...) among access points, we have to compute a balancing algorithm each time a new event such as the arrival of new stations or the mobility of existing stations. This algorithm has to find the best state of associations between access points and mobile stations that offers the best quality of service level for user's applications. Thus, we have to get information on associated stations, traffic coursed by access points and users quality of service requirements (Figure 2). This information has to be exchanged between WLAN entities and stored in an updated data base.

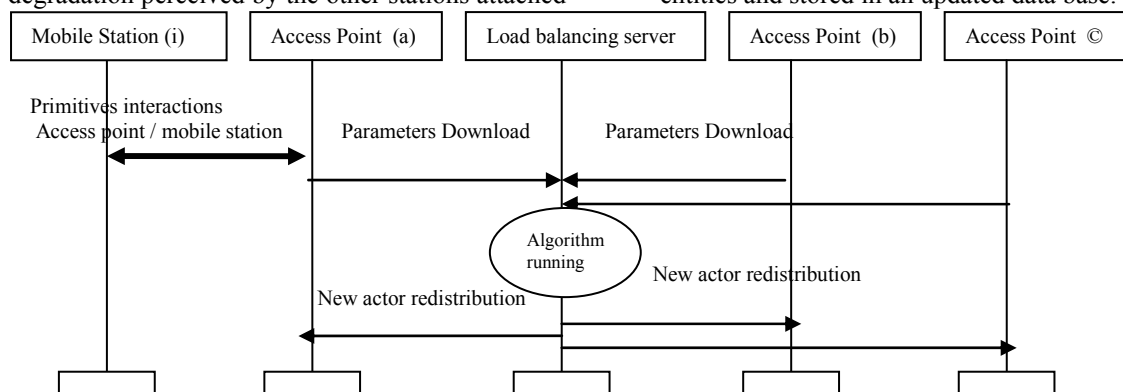


Figure 2. : System protocol interactions

In this architecture the load balancing server should periodically download a set of specific parameters from each access point. It runs up the balancing

algorithm finding the best mobile station sharing among the available access points. The result will then be broadcasted in the system. Then, we have

defined for this architecture a set of new metrics to quantify the quality of service and primitives exchanging these parameters for association and disassociation between mobile station and access point. These primitives that should be inserted into the MAC layer to improve the IEEE 802.11 standard [14] define a new MAC quality of service policy for wireless LANs.

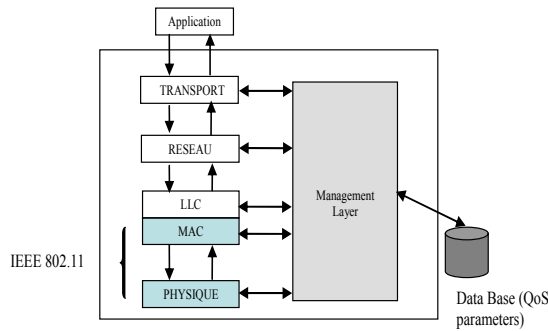


Figure 3. System exchange design

3. Load balancing algorithm description

3.1. Functional description

As shown in Figure 2, the load balancing algorithm [15, 16] is computed by the load balancing server every time a new distribution is needed in the wireless LAN. This will occurred (i) when a new mobile station enters the wireless LAN and aims to associate with an access point, (ii) when an associated station is moving from one to another BSS (iii) and when the applications requirements in a mobile station are changing. The downloaded parameters from the access points and mobile station applications will be useful to find the best distribution of mobile stations among wireless LAN access points.

This algorithm checks if the new distribution is balanced mainly by computing the balance index (β). The balance index appeared in the first time in [11] and it is used in [2, 15] as a performance measure. The balance index reflects the used

capacity in each access point. Let T_i be the total traffic of the AP i . Then, the balance index is:

$$\beta_j = (\sum_i T_i)^2 / (n * \sum_i T_i^2)$$

β_j is the balance index of an overlapping zone j .

T_i is the total traffic of an AP i overlapping with other access points in the zone j .

n is the number of access points overlapping in the zone j .

The balance index varies in the interval $[1/n, 1]$. The proposed distribution of mobile stations is balanced if the balance indexes of all the overlapping cells converge to 1. An AP is overloaded if its load exceed a certain threshold $\delta_1 = ANL + \alpha \cdot ANL$. It is balanced if his load is in the interval $[\delta_1, \delta_2]$, $\delta_2 = ANL - \alpha \cdot ANL$. An AP is under loaded if his load is under δ_2 . ANL is the Average Network Load.

α is a tolerance parameter that define the balancing zone width. To balance the WLAN, stations are moved from the uploaded to the under loaded access points. The question is: witch station to move? A selection policy is to make in place.

Our approach is defined as follow:

- The algorithm calculates the difference Δ between the most uploaded access point and the ANL ($\Delta = T_{AP_{surcharge}} - ANL$).
- The station that the flow is nearest to Δ is the selected station to move.

This work will be repeated until there is no over loaded access point in the WLAN.

At this step, the algorithm has to send the new distribution to the access points which will be authorised to dissociate, associate and reassociate mobile stations.

3.2. Algorithm application

We present an example of wireless LAN with three access points AP1, AP2 and AP3 linked with a distribution system and a set of mobile stations. For each station we have define the number and the traffic load. We suppose that the generated traffic is static.

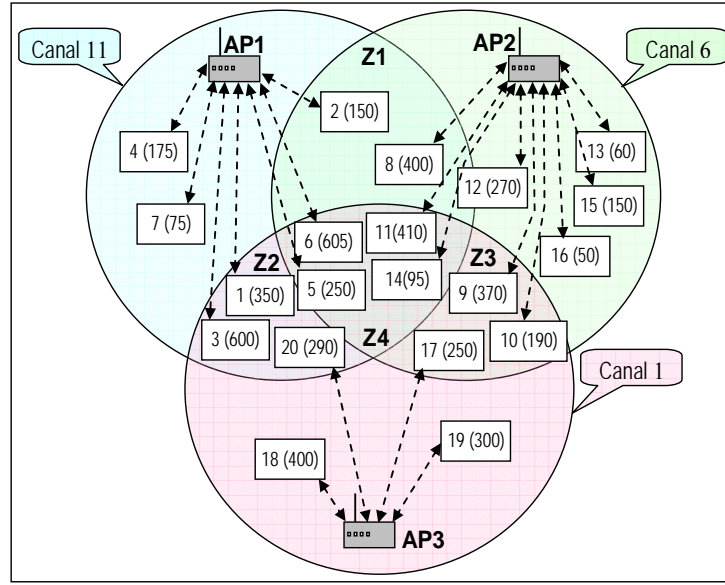


Figure 4. Unbalanced wireless LAN

In table 1, we describe the hot spot architecture. In this hot spot $ANL=1813.333$, $\alpha=5\%$, $\delta_1=1903.999$ and $\delta_2=1722.667$. In this hot spot, there are four

overlapping zones (Z1, Z2, Z3 and Z4). In table 2, we illustrate the characteristics of the overlapping zones.

Table 1. Hot spot description

Access Point	AP ₁	AP ₂	AP ₃
Mobile station identification	1, 2, 3, 4, 5, 6, 7	8, 9, 10, 11, 12, 13, 14, 15, 16	17, 18, 19, 20
Access point load (Kbps)	2205	1995	1240

Table 2. Overlapping zones characteristics

Zone	Z1	Z2	Z3	Z4
Access Points	AP1, AP2	AP1, AP3	AP2, AP3	AP1, AP2, AP3
Stations	2, 8	1, 3, 20	9, 10, 17	5, 6, 11, 14
Balance index of the zone (β)	0.997	0.927	0.948	0.950

In this example we can see that AP1 and AP2 are overloaded and that AP3 is under loaded. Running the load balancing algorithm will give us a new

distribution of the mobile stations among the access points. This distribution is given by the following table (table 3).

Table 3. New distribution description

Access Point	AP ₁	AP ₂	AP ₃
Mobile station identification	1, 2, 3, 4, 5, 6, 7	8, 9, 10, 12, 13, 15, 16	11, 14, 17, 18, 19, 20
Access point load (Kbps)	1795	1900	1745

4. Protocol specification

In this approach, the QoS management is based on the idea that some added primitives must be ensured at the connection level between the mobile station and the access point. Then, each mobile in

the wireless LAN may be able to propose a level of QoS and to modify it when needed.

In this architecture, the mobile station defines four variables managing its QoS state. The communication process will then base its

negotiation with the access point on these parameters to build up clause for service quality.

To ensure QoS management in the WLAN some identifiers should be joined to the parameters describing present and old quality of service states in each mobile. These identifiers are maintained in a specific database both in the access point and the mobile station.

Each mobile station will then discuss the attachment attempt responses of the access point according to its own QoS parameters. These parameters have to be saved in a specific data base managing the whole environment of the wireless device. This database communicates with the other layers defined in the IEEE 802.11 model to ensure coordination in call admission processes.

5. QoS protocol primitives

The IEEE 802.11 suffers from lack of specific QoS primitives. The only parameter on which is based the connection negotiation between the AP and the mobile station is the SNR ratio. The satisfaction of only this parameter in the connection phase don't meet necessary the QoS requirements of the application. So it appears indispensable to specify new protocol primitives to enable the integration of other communication parameters in the connection decision and then in loading redistribution.

We have then, defined a set of new primitives expressing general requirements.

Table 4. Quality of service primitives

Primitives	Access Point	Mobile Station	Parameters
ASK ATTACH.conf	*		(Id _M , Id _{AP} , QoS _{negociated}):
ATTACH.conf:	*		(Id _M , Id _{AP} , QoS _{negociated})
WAIT	*		(Id _M , Id _{AP})
ASK_RATTACH.req:	*		(Id _M , Id _{AP} , liste d'AP possibles)
ASK ATTACH.req		*	(Id _M , Id _{AP} , QoS _{expected})
ATTACH.req		*	(Id _M , Id _{AP} , QoS _{negociated})
ATTACH.req		*	(Id _M , Id _{AP} , QoS _{negociated})
ASK_RATTACH.conf		*	(Id _M , New Id _{AP} , Old Id _{AP})
LEAVE		*	(Id _M , Id _{AP})
OK	*	*	(Id _M , Id _{APa} , Id _{APb})
MOD_QoS.req	*	*	(Id _M , Id _{AP} , QoS _{proposed} , Temps)
MOVE.req	*	*	(Id _M , Id _{AP})
MOVE.conf	*	*	(Id _M , New Id _{AP} , Old Id _{AP})

6. Scenario description

The primitives that we defined in the last section are used to manage the access of the mobile stations to the wireless LAN via access points. Then we check theses primitives with many communications scenarios. Communications scenarios vary from simple to much complex situations. In this paragraph we describe one of the scenarios. This example is presented in Figure 6. M4 enter the wireless LAN and aim to connect to AP2 (Figure 5). AP2 is not able to offer connection to M4 with the requested quality of service level. It asks the load distribution server to find a new distribution to make possible the connection of M4 to AP2. After the computation of the load balancing algorithm, the load balancing server broadcasts the new distribution of mobile stations onto the access points. AP2 have to dissociate a mobile station M2.

This one will be associated to AP2 which is able to give it the required quality of service level. Finally M4 and AP2 complete the connection procedure (Figure 7).

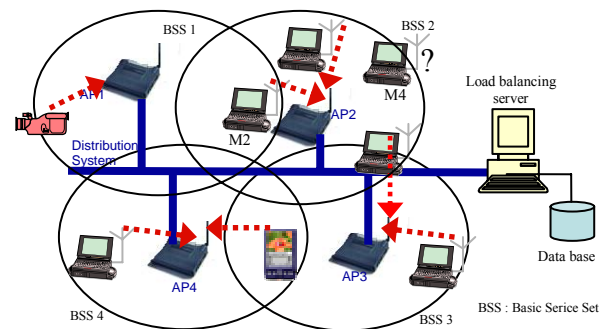


Figure 5. M4 asking for connection

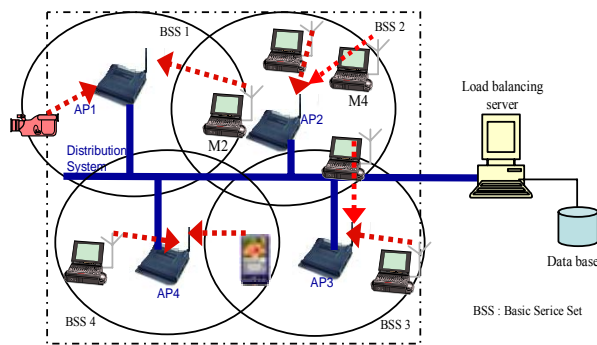
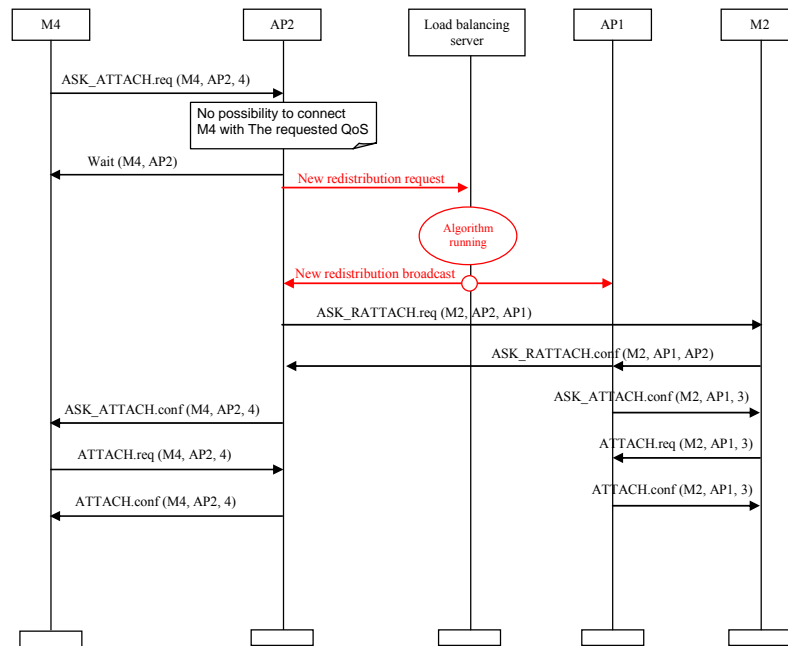


Figure 7. M4 connected to AP2

The scenarios that we have defined will be described and verified with the SDL and MSC languages in the following sections.

7. SDL protocol description

The SDL pattern is an efficient design language for the development of a communication system. It enables a formal description system by defining a static modular architecture and interactions between different blocks [7]. Systems in SDL language are structured into interconnected entities (system, block, process, and channel) where process system description provides dynamic behaviour for internal task execution. It is based on the model of Extended Finite State Machines (EFSMs) [8]. In its dynamic behaviour, each state is reached after asynchronous signal exchange between blocks [9].

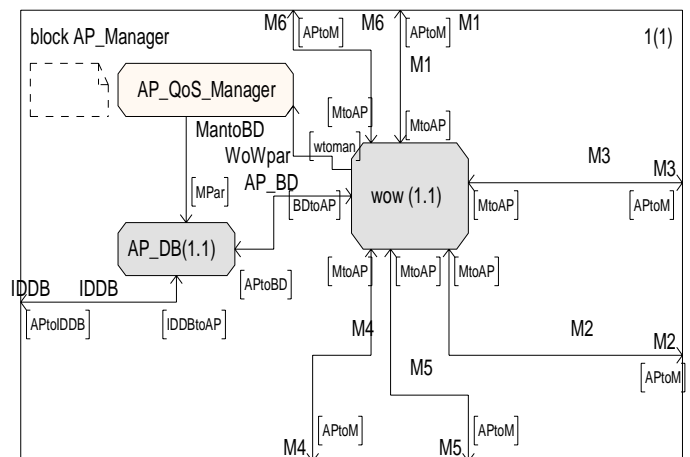
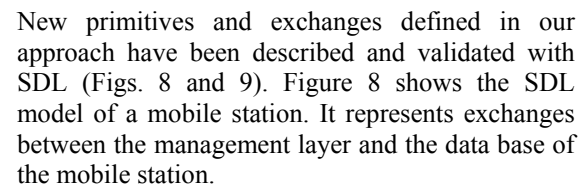


Figure 7. SDL model of a mobile station

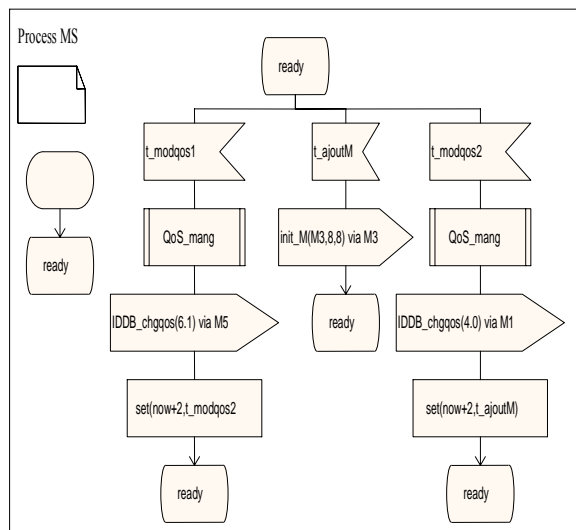


Figure 8. Example of SDL EFSM development

8. Conclusion

This paper addresses the problem of QoS management in the WLAN. It presents a protocol specification between mobile stations and access points to negotiate QoS requirements during the mobile station attachment. This protocol defines some new primitives related to the QoS management that must operate with the IEEE 802.11. The specification of these protocol primitives has been carried out.

The second part of this paper presents an SDL description of this protocol and it shows the behavior verification with MSC simulation.

This work has to be completed with an implementation of this approach in a simulation architecture using an appropriate tool such as Opnet or Network Simulator (NS). This helps to analyze the performances and helps to adjust the parameters of this protocol before the experimentation. Other parameters can be also used to characterize quality of service requirements of the mobile stations such as loss ratio or jitter.

9. References

- [1] A. Balachandran, G.M. Voelker, P. Bahl, and P.V. Rangan, "Characterizing user behavior and network performance in a public wireless LAN", June 15-19 2002, ACM SIGMETRICS international conference on measurement and modelling of computer systems (Marina Del Rey, California).
- [2] A. Balachandran, G.M. Voelker, P. Bahl, "Hot spot congestion relief in public-area wireless networks", June 20-21 2002, 4th workshop on mobile computing systems and applications (Callicoon, NY, USA) pp 70-80.
- [3] D. Kotz and K. Essien, "Characterizing usage of a campus-wide wireless network", September 23-28 2002, 8th annual ACM international conference on mobile computing and networking (Westin

Peachtree Plaza, Atlanta, Georgia, USA), pp 107-118.

- [4] D. Tang and M. baker, "Analysis of a local area wireless network", August 6-11 2000, 6th annual ACM international conference on mobile computing and networking (Boston, Massachusetts), pp 1-10.
- [5] D. Tang and M. baker, "Analysis of a metropolitan area wireless network", March-May 2002, Wireless Networks (Kluwer Academic Publishers), Vol. 8 (2-3), pp 107-120.
- [6] Matthew S. Gast, "802.11 Wireless Networks : the definitive guide", First Edition April 2002 (O'Reilly and associates Inc.), ISBN: 0-596-00183-5.
- [7] R. Gotzhein, P. Schaible, "Pattern-based development of communication systems", 1999, Annales Télécommunication N° 54.
- [8] R.L. Probert, H. Ural, A.W. Williams, "Rapid generation of functional tests using MSCs, SDL and TTCN", February 15 2001, Computer Communications (Elsevier) Vol. 24 No. 3-4, pp 374-393.
- [9] C. Bourhfir, E. Aboulhamid, F. Khendek, R. Dssouli, May 2001, "Test cases selection from SDL specifications", Journal of Computer Networks (Elsevier), Vol. 35, N° 6, pp 693- 708.
- [10] E. Persiali, "Insertion d'une politique de qualité de service au niveau MAC d'un protocole de réseau sans fils", 2003, Rapport de DEA, Centre de Recherches en Automatiques de Nancy, Université Henri Poincaré Nancy I.
- [11] Chiu, Dah-Ming, Jain, "Analysis of the Increase and Decrease Algorithms for Congestion Avoidance in Computer Networks", June 1989, *Journal of Computer Networks and ISDN*, vol. 17, N° 1, pp. 1-14.
- [12] Qiang Ni, L. Romdhani, T. Tureletti, "A survey of QoS enhancements for IEEE 802.11 wireless LAN", 2004, Journal of Wireless Communications and Mobile Computing (John Wiley and Sons Ltd), Vol. 4, Issue 5, pp 547-566.
- [13] C. R. Lin, M. Gerla, "Real time support in multihop wireless networks", March 1989, ACM/ Wireless Networks, Vol. 5, N° 2, pp 125-135.
- [14] IEEE 802.11 WG. ANSI/IEEE Std 802.11 : Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications : medium access control (MAC) Enhancements for quality of service (QoS) IEEE 802.11/D2.0. 2001.
- [15] H. Velayos, V. Aleo, G. Karlsson, "Load balancing in overlapping wireless cells", June 20-24 2004, IEEE International Conference on Communications (Paris, France).
- [16] G. Bianchi, I. Tinnirello, "Improving Load Balancing mechanisms in Wireless Packet Networks", 28 April- 2 May 2002, IEEE International Conference on Communications (New York, USA), Vol. 2, pp 891-895.
- [17] A. Lindgren, A. Almquist, O. Schelen, "Evaluation of quality of service schemes for IEEE 802.11 wireless LANs", November 14-16 2001, 26th Annual IEEE Conference on Local Computer Networks (Tampa, Florida, USA), pp 348-351.
- [18] S. Mangold, S. Choi, P. May, O. Klein, G. Hiertz, L. Stibor, "IEEE 802.11e wireless LAN for quality of

- service”, February 2002, European Wireless (Florence, Italy), Vol. 1, pp 32-39.
- [19] D. Blinn, T. Henderson and D. Kotz, “Analysis of a Wi-Fi Hotspot Netook”, June 5 2005, the International Workshop on Wireless Traffic Measurements and Modelling (Seattle, WA, USA), pp1-6.
 - [20] F. Guo, et Tzi-Cker Chiueh, “Scalable and Robust WLAN Connectivity Using Access Point Array”, 28 June- 1 July 2005, International Conference on Dependable Systems and Networks (Yokohama, Japan), pp 288-297.
 - [21] IEEE 802.11 WG, 2003. Draft Supplement to STANDARD FOR Telecommunications and Information Exchange Between Systems-LAN/MAN Specific Requirements - Part 11: Wireless Medium Access Control (MAC) and Physical Layer (PHY) specifications: Medium Access Control (MAC) Enhancements for Quality of Service (QoS), IEEE 802.11e/Draft 4.2.
 - [22] IEEE Std. 802.11-1999, part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) specifications, Reference number ISO/IEC 8802-11:1999(E), IEEE Std. 802.11, 1999 edition, 1999.
 - [23] H. Zhu, M. Li, I. Chlamtak and B. Prabhakaran, “A survey of quality of service in IEEE 802.11 networks”, August 2004, IEEE Wireless communications, Vol. 11, No. 4, pp. 6-14.
 - [24] W. Pattara-Atikom, P. Krishnamurthy, and S. Banerjee, “Distributed mechanisms for quality of service in wireless LAN”, June 2003, IEEE wireless communications, Vol. 10, pp. 26-34