HAL open science

A threshold profile map definition for improved management of a 802.16 network

David Carsenat, Nour Murad

▶ To cite this version:

David Carsenat, Nour Murad. A threshold profile map definition for improved management of a 802.16 network. The 7th International Conference on Advanced Communication Technology, 2005, ICACT 2005, Feb 2005, Pyeong Chang-Goon, South Korea. pp.330–334, 10.1109/ICACT.2005.245862 . hal-01221997

HAL Id: hal-01221997

https://hal.univ-reunion.fr/hal-01221997v1

Submitted on 15 Nov 2017

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 Threshold Profile Map Definition for Improved Management of a 802.16 Network

David CARSENAT and Nour MURAD
Institut d'Ingenierie en Informatique de Limoges
43, rue Sainte-Anne BP 834 - 87015 Limoges cedex
murad@3il.fr and carsenat@3il.fr

Abstract – IEEE 802.16 standard is designed to support next generation of wireless access networks. Based on a complex MAC and physical layers management, it will offer good QoS performances and an efficient deployment for operators. In order to provide a good network capacity, the 802.16 standard does not exactly define the threshold profile map definition. The aim of this paper is to propose a simple way for the dimensioning of such a system and evokes the development of a discreet event simulator model.

Keywords : 802.16, profiles map, performances, services, QoS, capacity.

1. Introduction

A next generation for wireless access networks for a 10 to 66 GHz band is emerging and is in the course of deployment. It's the IEEE 802.16 standard [1], [2], [3] also used by WIMAX label [4]. Subscriber will require vast improvements in information transfer in terms of higher bandwidth, Quality of Service (QoS) support and connection to a high speed backbone. The new IEEE 802.16 broadband wireless access system is a viable alternative that can meet such requirements. In addition, this network can be swiftly deployed to interconnect the military or public theater, emergency response, and disaster relief operations to the backbone. Due to the diverse multimedia traffic with different priorities and QoS requirements, it is a well know fact that it is imperative to provide QoS support in military and public networks. However, the IEEE 802.16 provides only signaling mechanisms, but does not specify any scheduling or admission control algorithms that ultimately provide QoS support.

The needs of simulations for 802.16 network dimensioning is essential. So, a reliable and precise model is required. Some simulation software exist and allow to simulate this model. These software are classed as discrete event simulator like QUALNET could be used here [ref doc]. Their operation is based on a level model which means that one can program each layer independently.

We are developing a physical and MAC layers model in order to predict capacity of a 802.16 based network. So we were brought to firstly study the physical layer in order to obtain performances in term of SNR and Burst Error Rate (BER) according to the modulation, the channel and the FEC (Reed Solomon, Block Convolutional Codes,...) used.

Then, these simulation results allow us to determine the profile (FEC and modulation pair) threshold usage map and to optimize the choice through this map.

This objective will enable us to specify a map of profiles according to the SNR (as specified in the 802.16 standard) and the desired BER versus the noise environment. Later, this association between profile threshold map and QUALNET simulator will be greatly useful in support of operators for their networks dimensioning.

To the best of our knowledge this is the first work about map of profile construction. So, the aim of this paper is to give reference curves and a chart of bit error rate (ber) versus profile used and SNR. These curves will be useful to define a good and appropriate map and dimensioning such a system in term of capacity according to the received SNR.

Firstly, a fast explanation of 802.16 standard is done. Then, a methodology is given in order to plot a map of profile versus SNR. The necessity to obtain a map for each type of service and a desired BER will be discussed. In the third section, theoretical study and a chart utilization give the capacity of a 802.16 system. A description about more realistic simulation with QUALNET introduces our future works in the last section. Finally, commentary and conclusion are made.

2. IEEE 802.16 standard

The IEEE 802.16 standard specifies the air interface of fixed or point-to-multipoint broadband wireless access systems providing multiple services. The medium access control layer is capable of supporting multiple physical layer specifications optimized for the frequency bands of application. The standard includes a particular physical layer specification applicable to systems operating between 10 to 66 GHz [1].

A choice of profile is used. This profile is a pair of modulation/FEC versus a SNR. The standard stipulates a change of profile according to the measured SNR at the reception part (fig. 1).

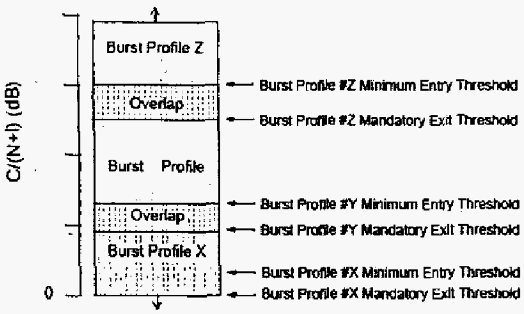

Figure 1. Burst profile threshold usage [1].

In order to manage different subscribers and services offered to them, the 802.16 standard uses connections. Notice that each connection is specified by a service. And this last is directly related to a profile definition. Let's take an example of a connection repartition into diverse profiles as specified in table 1.

	Profile 1	Profile 2	Profile 3	Profile 4	Profile 5	Profile 6
Voice	10	22	17	14	13	52
Video	45	8	6	21	32	62
Data	14	24	52	32	32	45

Table 1. Connection service pack repartition into different profiles.

In this case, there are 10 connections over profile 1 for voice transfer, 6 over profile 3 for video transfer, and so on...
The main philosophy of the management at the MAC layer is that we don't talk about subscribers service notion but about connections service concept. It's to say, one subscriber could wanted voice and data transfer at the same time. Thus, there can be many connections for only one subscriber.

Since each service doesn't need the same QoS and so the same BER, it looks quite evident that a map of profile will depend of the connection service pack being provided. Next section gives a methodology in order to find the best profile map associated to a connection service pack.

3. Profile map definition

Knowing that a profile map must be associated with a specific connection service because the desired BER is not the same. A simple method to define such a profile map versus services used is explained as follow:

- *Step one* consists in obtaining the curves giving bit error rate noted BER versus Signal to Noise Ratio (fig. 3).

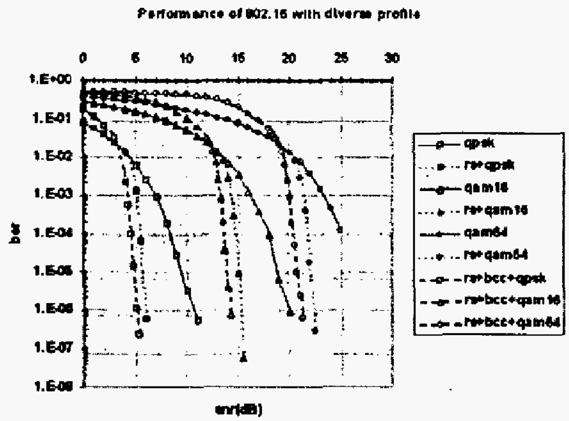

Figure 2. BER vsSNR performances. for diverse profiles

- *Step two* makes the link between the BER specification versus wanted services. By example, for a voice communication and a video transfer, the BER is fixed to 10^{-3} and 10^{-6}, respectively (fig. 3).

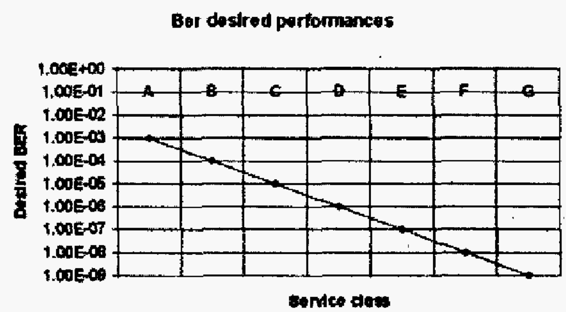

Figure 3. Desired BER for diverse application class.

- *Step three* assemblies the two precedent set of curves in order to give the profile map definition like example above.

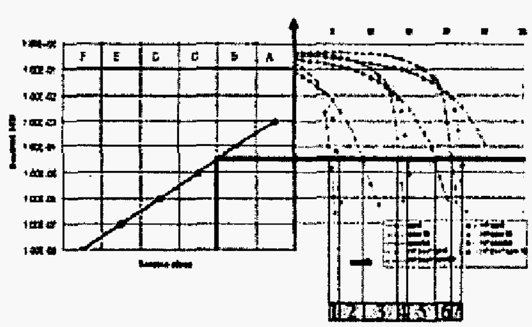

Figure 4. Curves assembly for profile map definition .

A desired service is stipulated first in order to obtain the bit error rate associated. Then, the profile that offer the best efficiency and the best BER performances is taken or the one which is closest. If this action is repeated for each profile, one will obtain the profile map definition exposed at the bottom of the curves (fig. 4).

4. Dimensioning a IEEE 802.16 system

Since defining the diverse profiles, an approximated way for the dimensioning of a 802.16 system is explained. The dimensioning consists to give the capacity of such system in term of connection number.

However,the 802.16 standard provides a constant symbol rate and not a constant bit rate. A 0.5, 1 or 2ms frame duration with a constant symbol number in all frames is provided. So, the maximum number of connections is based on the needed symbol rate for each connection and on the related used profile.

For the sake of clarification, let's assume that the FEC overhead and retransmission MAC protocol are neglected. If one connection type needs 500 Kbits/sec of useful data and uses a simple QAM16 modulation without any FEC, then the total useful symbol rate used for one connection of this type is 500/4 = 125 Ksymbol/sec. Thus, if the system provides 100 Msymbols/sec, it will be able to provide a total of 800 connections simultaneously.

Now, an approximated method allowing to calculate the total capacity of such system is described. And the efficiency of each profile type must be computed first.

In the 802.16 standard the profile corresponds to a pair of modulation type plus FEC type. The standard proposes an outer code as Reed Solomon (RS) code and an outer plus an inner code as the RS plus the Block Convolutionnal Code (BCC) [1]. Here, only the extremum profiles are explained and plotted.

With the RS, one could protected or not the useful data information field. If the MAC layer choices to not protect the data field, then only the efficiency of the modulation $\rho_{modulation}$ take place and is equal to 2, 4, 6 for QPSK, QAM 16 and QAM 64, respectively.

If the MAC protocol choices to maximize the protection with T=16 bytes, then a RS (256,256-2*T) code is set up [5], [6]. So the total minimal efficiency is deduced easily and is given by equation (1) and the maximal efficiency is given by equation (2) with T=0 bytes.

$$\rho_{all} = \rho_{RS}\rho_{modulation} = \frac{7}{8}\rho_{modulation} \quad (1)$$

$$\rho_{all} = \rho_{RS}\rho_{modulation} = \rho_{modulation} \quad (2)$$

In the case of a RS completing by a BCC, as the ρ_{BCC} is constant to 2/3, the minimal and the maximal efficiency are given by equations (3) and (4), respectively.

$$\rho_{all} = \rho_{RS}\rho_{modulation} = \frac{7}{12}\rho_{modulation} \quad (3)$$

$$\rho_{all} = \rho_{RS}\rho_{modulation} = \frac{2}{3}\rho_{modulation}, \quad (4)$$

For each main profile used in the system, figure 5 is obtained in using precedent equation.

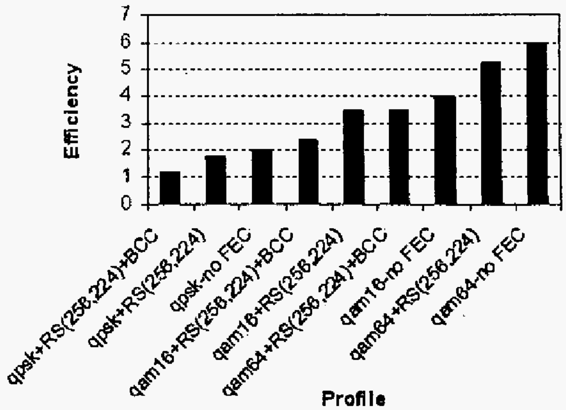

Figure 5. Efficiency of different used profiles.

Now that we have obtained the efficiency of each profile, we can compute the total symbol rate used knowing the number of connection of one type in each profile.

The equation above gives us an approximated way to compute the total symbol rate used.

$$S = \sum_{C=0}^{NbCT}\sum_{P=0}^{NbP} Nbc(P,C)\,\varphi(P)\,D(C) \quad (5)$$

where

S is the **Total symbols rate in Symb/sec,**
C **is the Connection type,**
NbCT is the **Total Connection type number,**
P **is the Profile used,**
NbP **is theTotal Number Of Profiles,**
Nbc(P,C) **is the Number of connections using profile P and connection type C,**
φ(P) **is the Efficiency of profile P,**
D(C) **is the Data rate wanted for connection type C in Bits/sec.**

In order to determine the total capacity of a 802.16 system, a chart based on the equation 5 allowing to specify the bandwidth utilization is elaborated.

Figure 6 exposes the beginning of the chart i.e. for only 3 or 4 profiles instead of the 16 specified in the standard.

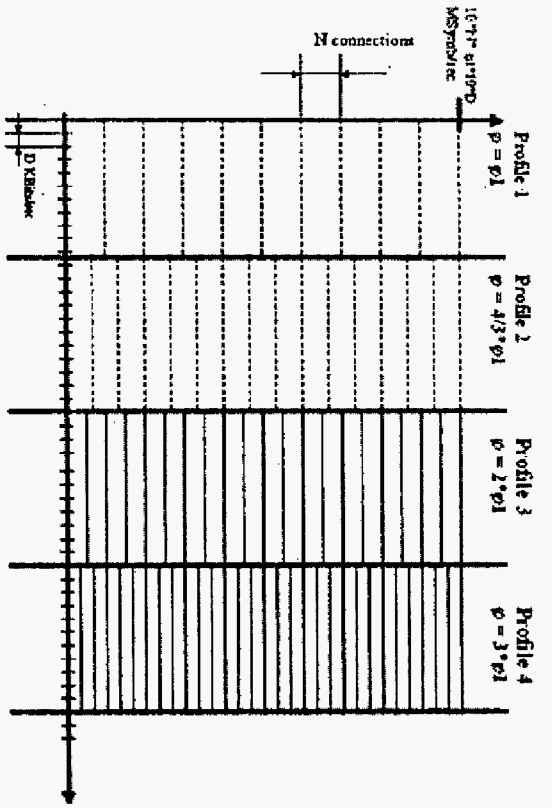

Figure 6: IEEE 802.16 capacity chart.

In order to understand how to use this chart we will show over an example.

First, lets fix the φ_1 value to 2 bits/symbol (like QPSK modulation, without any correction code).

Now we can say that our connections data rate will vary between 100 and 500 Kbits/sec, so we can fix

D =100Kbits/sec.

We suppose we've got a system with a symbol rate equal to 100 Msymbols/sec, so we can trace an horizontal line on the top of the chart representing the 100 Msymbols/sec. Then, we can say that

$$N = \frac{100 \quad 10^{6}}{\varphi_1 \ D \ 10 \quad 10} = 5$$

The first 10 coefficient comes from the number of D unit in one profile, and the second 10 coefficient comes from the number of N unit on the chart.

Finally, all the main parameters to make a capacity study with the chart are obtained. Figure 7 shows an example of how using this specific chart.

First assume 10 connections in profile 1 witch requires 500 Kbits/sec. The starting point is always (0;0). A line is plotted from the starting point to the 10 connections point as noticed by *1* on figure 7. Then, we report the 500 Kbits/sec on line *1* that gives the new starting point for others connections.

Secondly, assume 5 connections requiring 600 Kbits/sec, the operation is repeated from the new starting point witch is marked *2* on the figure 7, and so on for each profiles. Be sure that a simple cross product will be useful if the number of connection does not correspond to a multiple of 5.

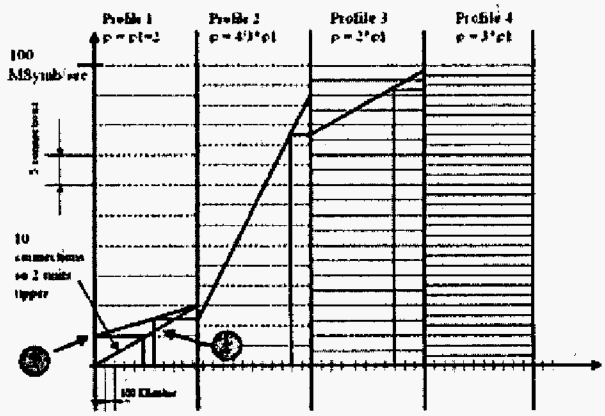

Figure 7: example of chart utilization

Finally when the starting point arrives on the 100 Msymb/sec, the total capacity of the system has been reached.

This chart provides a good way for a 802.16 system dimensioning. One must keep in mind that the formula given by equation (5) doesn't take into account all the specificity of the 802.16 standard and so provides an approximated value.

If one wants more accurate dimensioning, a discreet event network simulator like QUALNET should be used as exposed in the next section.

5. A Qualnet model perspectives

Discreet event simulators permit programming MAC standards with a large precision. They allow testing standard performances in diverse situations with a large number of nodes. Before programming the MAC layer, we first should develop a physical model for the simulator. Our model works like explained above.

The received SNR measures obtained after the propagation channel and antenna processing are provided to our physical model. On receiving a burst (since 802.16 standard send burst and not frames), the physical model computes if it is erroneous or not. In our model, this calculation is done regarding a data base containing the Burst error rate according to SNR. burst size, and the used map profile. If the burst has no error, then it is transmitted to the MAC level. Else, the erroneous burst is computed according to standard and the MAC layer take the hand to retransmit the burst.

It is so necessary to get all performance Burst Error Rate curves in diverse profile configuration in order to make our model working.

The calculation of burst error rate is obtained from results presented in figure 3 with the formula above.

$$\text{Burst\_error\_Rate} = \sum_{k=0}^{N-1} Pe(1 - Pe)^k$$

Where

N is the bit number in a burst,
Pe is the bit error probability.

Figure 8 shows these results obtained with BER computed for figure 3 for a burst size of 500 and 1500 bytes.

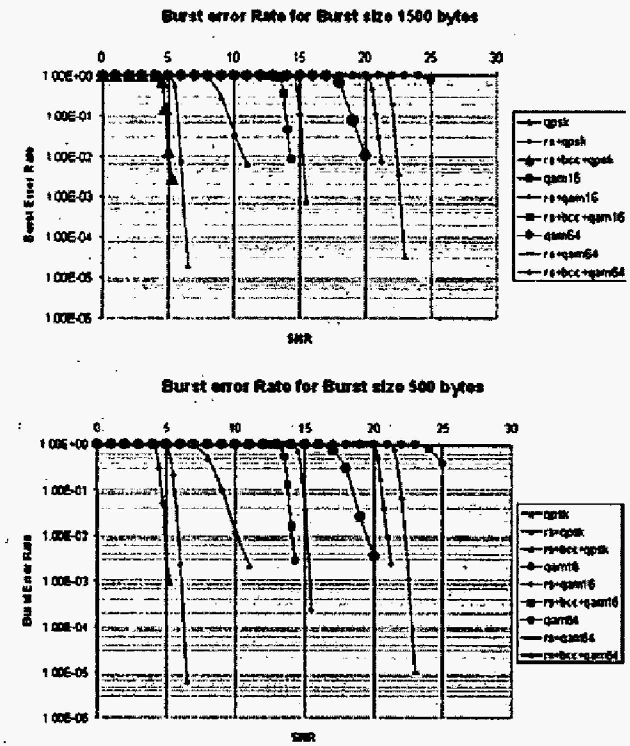

Figure 8: Burst error rate for bursts of size 500 and 1500 bytes

One can see that more the burst is bigger, more the burst error rate is higher.

These results will be useful in the development of our QUALNET model witch will allow the dimensioning of a 802.16 system over, by example TCP/IP layer model. At this time, we are developing our MAC 802.16 model.

6. Conclusion

In this paper, a brief description of the 802.16 standard functioning has been done in order to understand the profile map definition method explained. A simple way to find the profile map for a specified service class has been provided regardless the overlap of the burst profile threshold usage.

Thus, ones the profile map obtained, it is possible to make a 802.16 based system dimensioning in term of capacity. This method is an approximate one since some aspects of the standard have been neglected, This methodology based on a chart gives a good and fast way to help operators deployment.

Finaly, in order to have more realistic capacity measurements, a model under a discreet event simulator like QUALNET will be developed in a future work. This model needs burst error rate instead of bit error rate as computed in the last section.

So, all the methods shown here should be useful tools for easy deployment of a 802.16 based system.

References

[1] IEEE WirelessMan™, "Part 16: Air Interface for Fixed Broadband Wireless Access Systems", IEEE Standard for local and metropolitan area networks; 2001

[2] IEEE 802.16, Working group on Broadband Wireless Access, http://wirelessman.org

[3] IEEE 802.16 Working Group, "Standard Air Interface for Fixed Broadband Wireless Access Systems", http://www.ieee802.org/16/index.html

[4] http://www.wimaxforum.org/home

[5] William C. Jakes, "Microwave Mobile Communications", Wiley-IEEE Press; 2nd Ed edition, May 2 1994, 656 pages, ISBN-0780310691.

[6] John Proakis, "Digital Communications", McGraw-Hill Science/Engineering/Math; 4 edition, August 15 2000, 1024 pages, ISBN-0072321113.