HiperLAN/2 performance effect under different channel environments and variable resource allocation

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Abstract: This paper aims to provide an evaluation about HiperLAN/2 system's performance. These will be shown by simulating the physical model under different channel environments which are defined in ETSI/BRAN standard. The other parameter that will be investigated is the system's throughput.

1. Introduction.

Wireless technology have enjoyed an increase demand from the general public as well as from business and other professional users, these range from cellular phones to high-speed digital networks supporting high speed computer communications.

HiperLAN/2 (H/2) is an upcoming standard, which is being specified by the ETSI/BRAN project. High Performance Radio Local Area Network type 2 (HiperLAN/2) is one of the wireless broadband access networks, shall provide high-speed communications between mobile terminals and various broadband infrastructure networks. HiperLAN/2 system operates at the 5GHz region. The frequency allocation in Europe is: 5.15-5.35 GHz, lower band (indoor use only) and 5.47-5.725 GHz, upper band (indoor and outdoor use). HiperLAN/2 can be used as an alternative access technology to a 2nd and 3rd generation cellular network. One may think of the possibility to cover hot spots (airport, hotels, etc.) and city areas with HiperLAN/2 and the wide area with GSM and W-CDMA technologies. In this way, a user can benefit from a high performance network wherever it is feasible to deploy HiperLAN/2 and use GSM, W-CDMA elsewhere.

One of the main features in HiperLAN/2 system is the high transmission rate that could get up to 54 Mbps **[1].** Orthogonal Frequency Division Multiplexing (OFDM) is a type of multi-carrier modulation which uses overlapped orthogonal signals to divide a frequency-selective channel into a number of narrow-band flat-fading channels. Instead of transmitting the data symbols sequentially at a high symbol rate on a single carrier, a block of symbols is encoded using the Fast Fourier Transform (FFT), and transmitted in parallel over a number of sub-channels. The sub-carriers are spaced by the inverse of the symbol period, so making them orthogonal. Individual sub-channels will have a symbol period longer than the multipath delay spread, therefore OFDM is useful for avoiding multipath interference. If a particular sub-channel has high noise then it can be de-activated, hence reducing the effects of fading and interference. By increasing the number of transmitted carriers the data carried on each carrier reduces and hence the symbol period increases.

The air interface of HiperLAN/2 is based on time division duplex and dynamic time division multiple access (TDD/TDMA), which allows for simultaneous communication in both uplink and downlink within the same time frame called MAC frame. The duration of the MAC frame is 2ms and comprises of transport channels for broadcast control (BCH), frame control (FCH), access control (ACH), downlink (DL) and uplink (UL) data transmission and Random access (RCH).

The channels that are transmitted in downlink direction are: broadcast channel, frame control channel and Access feedback channel.

The *broadcast channel*, 15bytes long, contains control information that is sent in every MAC frame and reaches all mobile terminal (MT). Information such as the power levels, starting point and length of the FCH and RCH, network and AP ID.

The *frame control channel*, multiple of 27 bytes frames depending on the number of MT requests of resources, contains the exact description on the allocated bandwidth, in DL and UL, for the requested users in current MAC frame.

Access feedback channel, 9 bytes long, conveys information on previous access attempts made in the RCH.

Uplink and *Downlink channels*, which is bi-directional, consists of Protocol Data Unit (PDU) trains to and from MTs. A PDU train consists of DLC user PDUs (U-PDU of 54 bytes with 48 bytes of payload) and DLC control PDUs (C-PDUs of 9 bytes) to be transmitted or received by one MT. The C-PDUs and data PDUs are referred to as short and long transport channel respectively.

The *random access channel*, uplink only and it is 9 bytes long. Used by the MTs to gain bandwidth from the AP in the next MAC frame so data could be transmitted.

In order to improve the link capability due to different interference situations and distances of terminals to the access point (AP), a link adaptation scheme is applied **[2],** by using various modulation schemes on the sub-carriers and puncturing of convolutional codes, the data rate can be varied. Seven physical layer modes are specified **[3],** of which the first six are compulsory, where as the last which uses 64 QAM is optional.

Mode	Modulation	Code rate	Bit rate	Bytes/symbol
1	BPSK	1/2	6Mbps	3.0
2	BPSK	3/4	9Mbps	4.5
3	QPSK	1/2	12Mbps	6.0
4	QPSK	3/4	18Mbps	9.0
5	16QAM	9/16	27Mbps	13.5
6	16QAM	3/4	36Mbps	18.0
7	64QAM	3/4	54Mbps	27.0

Table 1, Physical layer modes of HiperLAN/2

HiperLAN/2 Access points (AP) will be installed in hotspot areas where there are crowded by people who want to connect to the core network. Such places are train station, airport, office buildings and shopping malls. Each environment has its own instinctive channel model where the difference will be in the delay spread. exhaustive simulations have been conducted for selecting the parameters and performance analysis **[4].** Table 2 shows the channel models that were standardised for HiperLAN/2.
Channel environment has a direct influence on systems throughput. The environment in large office with non-line-of-sight propagation and large open space non-line-of-sight, train stations for example, are the most common channel environments where HiperLAN/2 Access Points would be installed. That is why these three channels were used in simulating system's performance and also look at the effect of the delay spread that is associated to a particular channel.

Channel model	r.m.s delay spread	Rice factor on first tap	Environment
A	50 ns	-	Office NLOS (no light of sight)
B	100 ns	-	Open space / Office NLOS
C	150 ns	-	Large open space NLOS
D	140 ns	10dB	Large open space LOS
E	250 ns	-	Large open space NLOS

Table 2, Channel models for HiperLAN/2

2. System performance.

Figures 1 and 2 show how the system reacts to different channel environments. Channel A is the most typical environment for large office with non-line-of-sight propagation, where as channel E is typical environment for large open space non-line-of-sight like train stations for example.
It can be seen that as the delay spread increases the performance is improved until the delay spread becomes very large (channel E) that could not be eliminated by the guard period (800ns) of the OFDM symbol and so ISI and ICI would not be eliminated completely and hence degradation is system's performance. the delay spread problem could be reduced as HiperLAN/2 support sectorised antenna and so eliminating ISI. The Eb/No requirement increases as the higher modulation type used. This has a direct effect on the transmission power required which in turn would reduce the effective battery life time of the laptops and this is not appreciated by the user. This is where the Link Adaptation Technique

is used in order to choose the optimum modulation type to increase the throughput and reduce the required Eb/No.

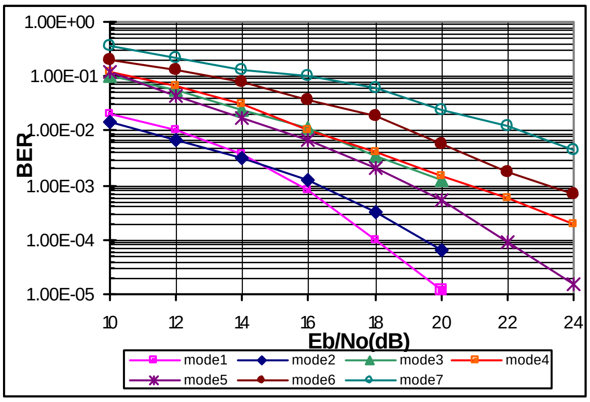

Fig.1 System’s performance in channel “A” environment.

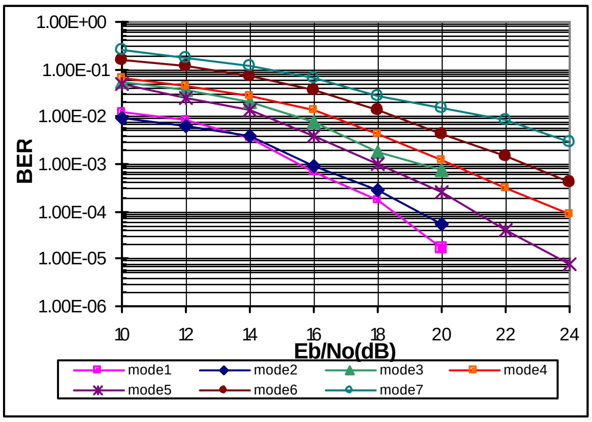

Fig.2 System’s performance in Channel “E” environment.

The throughput performance of HiperLAN/2 standard has been evaluated in relation to overhead. The source of overhead are header fields and preamble. Figures 3 and 4 show system’s throughput related to the number of wireless users connected to a singular AP. As could be visualised from the throughput figures the NET throughput is totally inversely proportional to the number of MTs. This is mainly due to more overhead is needed for the FCH slot as the number of MTs increase. There is a limit to the number of MTs which could connect to the AP and still have a reasonable throughput, this number is about 250 mobile users.

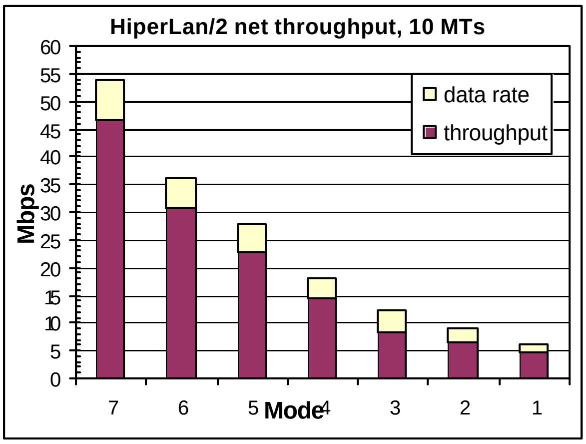

Fig.3 net throughput, 10 MTs.

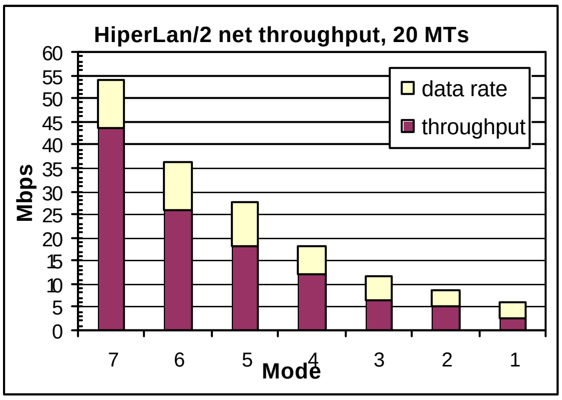

Fig.4 net throughput, 20 MTs.

The other factor that had been looked at is the effect of connections number per user upon the throughput. Figure 5 shows the result of having single MT with multiple number of connections with singular AP. The transport channels except DL and UL phases were assigned the most robust mode which is mode 1 with physical bit rate of 6 Mbps. The net throughput is totally dependent on the number of connection per MT and the mode used.

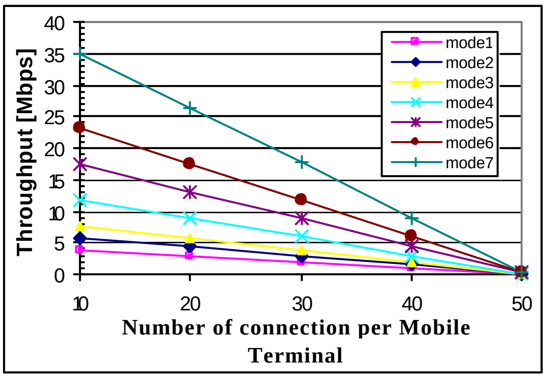

Fig.5 the number of connection effect on the throughput.

3. Conclusion

Two different channel environments were used for simulation to investigate the effect of the delay spread upon the BER. As the delay spread increased the performance improved until the delay spread becomes very large (channel E) that could not be eliminated by the guard period (800ns) of the OFDM symbol and so ISI and ICI would not be eliminated completely and hence degradation is system's performance. the delay spread problem could be reduced as HiperLAN/2 supports sectorised antenna.
Other graphs were also included where they showed the effect of the number of users connected to an AP and the number of connections per MT on system's throughput. As number of users increased the overhead increased too and hence effecting the throughput directly. Also as the number of connections per user increases the lower the throughput gets. Using robust PHY modes for MAC signalling instead of modes with higher service rates reduces the capacity further. But using the most robust mode is more preferred in unstable channel environments in order to have proper operation.

References

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