Criteria for Comparison of 5 GHz High Speed PHY Proposals

Naftali Chayat, Task Group A (5 GHz PHY) Chair

Introduction

The following summarizes the discussion on criteria for comparing modulation methods, held in Sep 97 meeting of 802.11. The revision (b) of the document includes modifications made at November 1997 meeting.

The schedule agreed in Sep 97 meeting states that anybody willing to propose a modulation method to 5 GHz high speed PHY should provide a proposal and skeletal text for the standard by November 97 meeting. At November 1997 Plenary meeting of 802.11 the following skeletal proposals were brought to committee's consideration:

Proposer, Company	Modulation method	Paper with a skeletal description
Richard van Nee, Lucent	OFDM	97/125
Masahiro Morikura, NTT	OFDM	97/137
Kazuhiro Okanoue, NEC	QPSK	97/121
Naftali Chayat, BreezeCom	OQPSK(GMSK)/OQAM	97/111
John Cafarella, Micrilor	Overlaid Biorthogonal	97/131
Reza Ahy, RadioLAN	L-PPM	97/145

According to the schedule agreed in Sep 97 meeting, the proposers should provide full text proposal by January 98 meeting. The proposal should be formatted similarly to PHY sections of the 802.11 standard and will include sufficient details for unambiguous reproduction of transmit waveforms, waveform accuracy specifications, CCA procedure, channelization and performance criteria (sensitivity, ACI etc.).

The modulation method selection will be performed in March 98 meeting. The performance data addressing all the points in the criteria should be submitted electronically to 802.11 Chair by 23 February 1998, 12:00 UTC. The proposers are encouraged to bring data earlier to enable proper comparison and discussion.

Criteria for Comparison of Proposals

All submitters of modulation choices should provide data discussing the following parameters. The relative weight of different parameters is unspecified at the moment and will be resolved by discussions.

Traffic assumptions:
The comparison will be conducted at 20 Mbit/s data rate. The data rate is net, after decoding the channel code; for example, if a convolutional code of rate 2/3 is used, the signaling rate in the channel should be 30 Mbit/s so that the net data rate will be 2/3 * 30 Mbit/s = 20 Mbit/s.

The performance data will be brought for packet lengths of both 64 bytes and 1000 bytes.

Receiver structure:
In order to assess the implementation complexity of the proposal, the proposers should bring a description of the receiver structure used for obtaining the data. In case the complexity can be traded for performance, proposers are encouraged to present performance also with simplified receiver structures.

Immunity to multipath and noise:

Data shall be provided for performance in multipath without noise, multipath with thermal noise and thermal noise only. The multipath models are discussed in the appendix. The comparison will be conducted without antenna diversity. If the proposal supports multiple rates, bring the data for all applicable data rates

Multipath without noise: a curve of PER (Packet Error Rate) will be brought versus T_{RMS} (the RMS delay spread). The lowest delay spread at which the PER=10% (success probability drops to 90%) will be used for comparison (it may happen that at higher T_{RMS} some methods will exhibit an improvement, due to inherent diversity).

Multipath with noise: set the T_{RMS} to the point where PER=10% was obtained. Draw a curve of PER versus average E_b/N_0 (such curve should drop and then flatten at 10%). The E_b/N_0 at which the PER=20% is obtained will be used for comparison.

Thermal noise only: in this case there is no fading channel. Draw a curve of PER versus E_b/N_0 and look for the point at which PER=10%. The E_b/N_0 at which the PER=10% is obtained will be used for comparison.

The PER data will include the intended acquisition procedure performance.

The proposer will suggest a center frequency accuracy. The proposer will demonstrate that the performance does not degrade substantially at the proposed maximal frequency offset between transmitter and the receiver .

Overhead related parameters:

Proposer of a modulation method will provide data related to following issues:

Preamble length and structure: the proposed length of the preamble will provide for antenna/diversity selection. The assumed synchronization or training methods will be discussed.

Slot size: The slot size for the backoff algorithm will be proposed assuming that the a transmission starting in the middle of the slot should be detected by the end of the slot with a detection probability of 90%, with single antenna reception, without multipath. Describe the assumptions regarding the detection mechanism, Rx/Tx turnaround time, processing time and other factors affecting this parameter.

SIFS time: This parameter should take into account the latency induced by receive operation completion, i.e. performing the last FFT/equalization+deinterleaving+decoding+CRC checking+etc, and Tx/Rx turnaround time. An argumentation needs to be provided that the number assumes reasonable implementation.

Spectral Efficiency and Cell Density related parameters

Channelization: Each proposer will suggest a channelization scheme, preferably both for U-NII (all the subbands) and Europe HIPERLAN 1 band (hoping that it will be accessible to us sometimes). The out-of-band regulatory restrictions need to be addressed.

Adjacent Channel Interference: provide ACI rejection performance for the proposed modulation and the proposed channelization scheme, without multipath.

Co-Channel Interference: provide CCI rejection performance for the proposed modulation, without multipath, with reasonable randomization of relative phase, frequency and timing.

Interference immunity:

(a) immunity to CW jamming at randomly chosen frequency within signal bandwidth for each packet.

(b) immunity to Gaussian interference having bandwidth greater than 5% and less than 20% of signal bandwidth, centered on the signal carrier frequency.

The immunities will be tested at 10% packet drop rate.

<u>Critical Points</u>

The proposers will address critical issues with their proposals. Examples of such issues may be:

- Extreme sensitivity to phase noise
- Power consumption
- Complexity
- RF PA backoff
- Enabling technologies, which are not reasonably widely available.
- Dependence on antenna diversity/directivity

Intellectual Property

The proposer shall:

(a) Submit the required IEEE letter on IP.
(b) Make his IP position clear.
(c) Provide applicable patent numbers.
(d) Provide point of contact for obtaining licensing information.

Appendix: Baseline Channel Model - Exponentially Decaying Rayleigh Fading Channel

The following channel model was agreed to be a baseline model for comparison of modulation methods. It's convenience is in its simple mathematical description and in the possibility to vary the RMS delay spread. The channel is assumed static throughout the packet and generated independently for each packet.

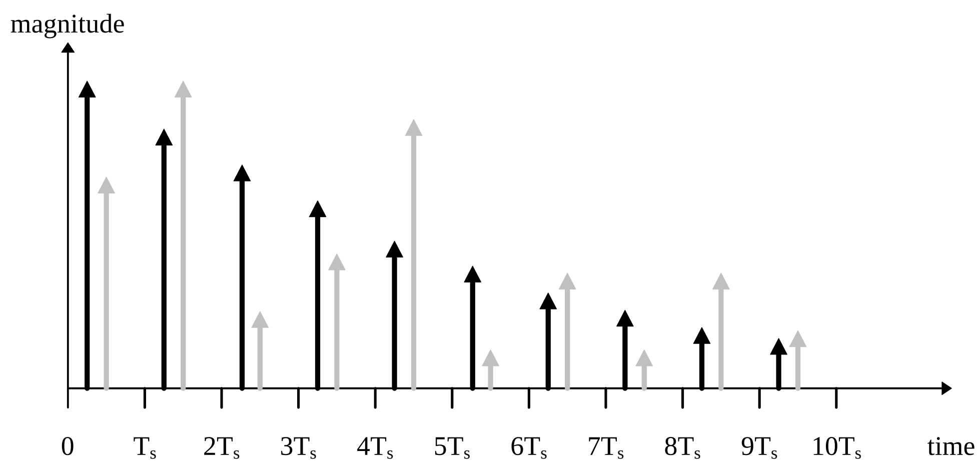

Fig 1: Channel impulse response; black illustrates average magnitudes, gray illustrates magnitudes of a specific random realization of the channel; the time positions of black and gray samples are staggered for clarity only.

The impulse response of the channel is composed of complex samples with random uniformly distributed phase and Rayleigh distributed magnitude with average power decaying exponentially.

$$h_k = N(0, \tfrac{1}{2}\sigma_k^2) + jN(0, \tfrac{1}{2}\sigma_k^2)$$
$$\sigma_k^2 = \sigma_0^2 e^{-kT_s/T_{RMS}}$$
$$\sigma_0^2 = 1 - e^{-T_s/T_{RMS}}$$

where $N(0, \tfrac{1}{2}\sigma_k^2)$ is a zero mean Gaussian random variable with variance $\tfrac{1}{2}\sigma_k^2$ (produced by generating a $N(0,1)$ r.v. and multiplying it by $\sigma_k/\sqrt{2}$), and $\sigma_0^2 = 1 - e^{-T_s/T_{RMS}}$ is chosen so that the condition $\sum \sigma_k^2 = 1$ is satisfied to ensure same average received power.

The sampling time T_s in the performance assessment shall be no longer than the smaller of 1/(signal bandwidth) or $T_{RMS}/2$ (as per motion approved in Nov97 meeting). The number of samples to be taken in the impulse response should ensure sufficient decay of the impulse response tail, e.g. $k_{max}=10T_{RMS}/T_s$.