Tentative Criteria for Comparison of Modulation Methods

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 criteria as brought here are tentative and are to be finalized in Nov 97 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
- Provide full text proposal by January 98 meeting
- The modulation method selection will be performed in March 98 meeting

By March 98 the data relevant for the comparison should be in front of 802.11, but proposers are encouraged to bring data earlier to enable proper comparison and discussion.

Criteria from September 1997 meeting

All submitters of modulation choices should provide data discussing the following parameters.

Traffic assumptions:
The comparison will be conducted at 20 Mbit/s data rate (net, after channel coding).
The performance data will be brought for packet length 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 apppendix. The comparison will be conducted without antenna diversity.
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.

Overhead related parameters: Preamble and Slot size recommendations:
Proposer of a modulation method will provide data related to following issues:
Preamble length: the proposed length of the preamble will provide for antenna/diversity selection. The assumed synchronization or training methods will be discussed.

<u>Slot size:</u> 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.

<u>Spectral Efficiency</u>
<u>Channelization:</u> Each proposer will suggest a channelization scheme, preferably both for U-NII and Europe. 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.

<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
- Excessive complexity
- RF PA backoff
- Enabling technologies, which are not reasonably widely available.
- Dependence on antenna diversity/directivity

<u>Baseline Channel Model - Exponentially Decaying Rayleigh Fading Channel</u>

The following channel model was agreed to be one of the baseline models 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.

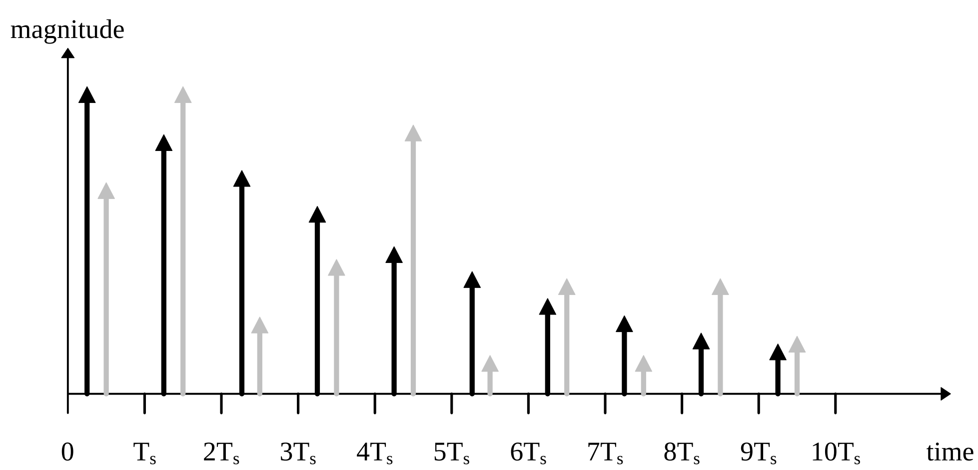

Fig 1: Channel impulse response; black illustrates average magnitudes, gray illustrates magnitudes of a specific random realization of the channel; the time positions of black and gray samples are staggered for clarity only.

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.

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

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

It is assumed that the sampling time T_s in the simulation is shorter than a symbol time (or chip time) by at least a factor of four (typically in simulations it is a submultiple of the symbol duration). The number of samples to be taken in the impulse response should ensure sufficient decay of the impulse response tail, e.g. $k_{max}=10T_{RMS}/T_s$.

Criteria and Requirements Refinement

All the comparison criteria brought here are subject for review and refinement in November 97. In particular, concerns were raised that the baseline propagation model may become inadequate for very high bandwidths. Additional suggestions for criteria, requirements and propagation models in November 1997 are welcome.