Criteria for 2.4 GHZ PHY Comparison of Modulation Methods

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Introduction

This paper outlines the areas that need to be addressed by all proposals submitted for consideration as part of the 2.4 GHZ high rate task group of IEEE802.11.
These areas will be the basis for trading the various proposals and converging to a solution for the standard.
Incomplete proposals run the risk of unfavorable consideration.
Proposals and presentations must title their material with the exact title as suggested in this paper for each topic.

The proposals under consideration have been approved during the November 1997 meeting . These presenters need to be aware that:

By March 98 the final decision will be presented in front of 802.11, but 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.

ASSUMPTIONS:
The performance data will be brought for packet lengths of both 64 bytes and 1000 bytes for all proposed data rates.

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.

- Implementation.
  - RF/IF complexity relative to the low rate PHYs.
  - Baseband processing complexity relative to the low rate PHY , give gate counts if applicable.
  - Equalizer complexity, provide gate estimates if applicable.
  - ~~Antenna selections.~~
  - Diversity implementation, compare it with your baseline approach, describe performance implications (i.e preamble length required, impact on 802.11 slot time).

<u>Immunity to multipath and noise:</u>

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, and with and without equalization. Multipath analysis must be performed for all proposed rates.
<u>Multipath without noise:</u> 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).
<u>Multipath with noise:</u> 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.
<u>Thermal noise only:</u> 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 nod degrade substantially at the proposed frequency offset.

Overhead related parameters:

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.
Slot size: The slot size for the backoff algorithm will be proposed assuming that a co channel 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 your CCA mechanism and associated timing. Specify time to detect signal from when it appears at the antenna and turnaround time to transmit (at the antenna).
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 turnaroud time. An argumentation needs to be provided that the number is a reasonable implementation strategy and technology.

Spectral Efficiency and Cell Density related parameters

Channelization: Each proposer will suggest a channelization scheme. The out-of-band regulatory restrictions need to be addressed.

Cell Planing:

Present examples of proposed deployments using your approach. Include topology, range (free space propagation) throughput benchmarks for both single cell and multiple cells.

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 and the proposed channelization scheme, without multipath, with reasonably randomized parameters.

Interference immunity: immunity to CW jamming consistent with proposed FCC test for processing gain.

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

Present any other interference immunity tests which you think are applicable (i.e narrow band Gaussian interference).

Present interference immunity from /to the existing 802.11 low rate PHYs.

Critical Points

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

- Extreme sensitivity to phase noise
- Power consumption (DC) relative to the low rate PHYs
- Complexity
- RF PA backoff
- Dependence on antenna diversity/directivity

Intellectual property

Submit the required IEEE letter on IP.

Make clear your IP position if there is one.

Applicable patent numbers.

Point of contact.

Interoperability / coexistence

Explain your proposed interoperability and / or coexistence strategy with the low rate 802.11 systems. Address the following as appropriate:

Interoperability at the data level

- Cost of interoperability (performance and complexity)

Interoperability at the antenna level

- Cost of interoperability (performance and complexity)

Identify low rate PHY(s)

Elaborate on migration path assumptions from the low rate PHY(s), include details on any dual schemes (i.e fast vs. low rate preamble) .

Co-existence

a. ignore.

b. defer one way or two way and if one way identify the direction and the PHY(s) that the deferral applies to.

Cost of coexistence , elaborate on the impact on high rate systems , assuming low rate systems do not detect the presence of the high rate.

<u>Modulation / Robustness</u>

Present an Eb/No vs. PHY PER curve for all proposed data rates (64 and 1000 byte packets)

Provide substantiation that the proposed PER will meet error requirements of the 802.11 MAC performance specifications.

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.

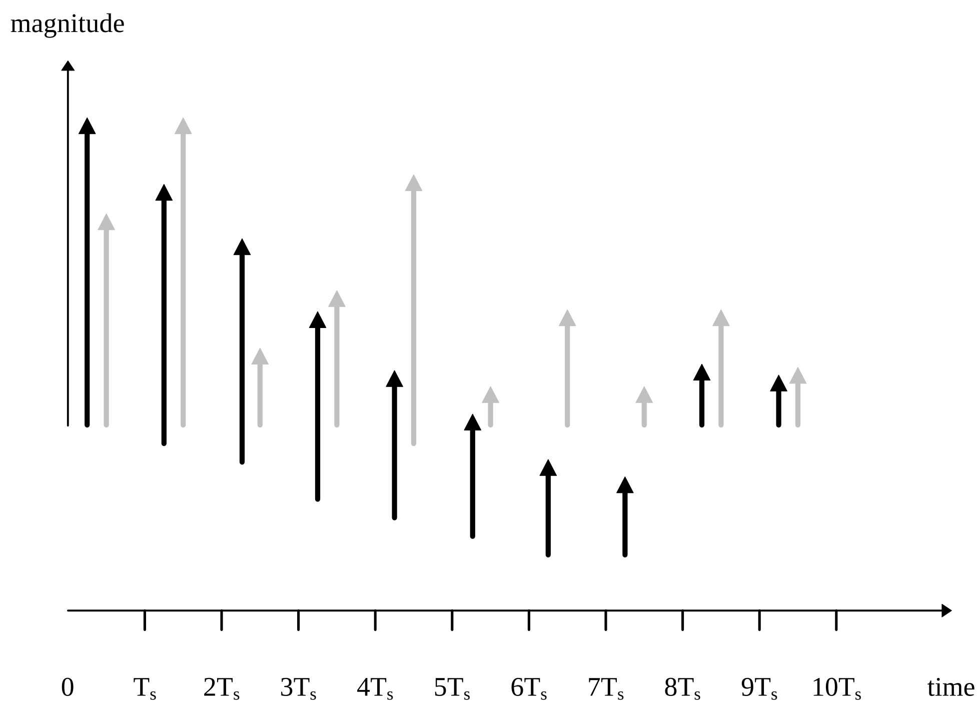

Fig 1: Channel impulse response; black illustrates average magnitudes, gray illustrates magnitudes of a specific random realization of the channel; the time positions of black and gray samples are staggered for clarity only.

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 $N(0,\frac{1}{2}\sigma_k^2)$ is a zero mean Gaussian random variable with variance $\frac{1}{2}\sigma_k^2$ (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 simulation shall be no longer than the smallest 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. $k_{max}=10T_{RMS}/T_s$.