IEEE P802.11
Wireless LANs

Sharing Performance Evaluation for TGa PHY Submission

Date: February 23, 1998

Author: NTT Wireless Systems Labs.

Previous proposals from Lucent Technologies and NTT are merged into one proposal that is described by a draft of full document uploaded to the ftp site. Evaluations of the merged proposal are performed in Lucent and NTT. Evaluations of 16-QAM are reported by Lucent, that of DQPSK and DPSK are reported by NTT.

Submission List

1) Sharing Performance Evaluation for TGa PHY Submission (this document)
2) Computer simulation results on view graphs
3) A draft of a merged full document

General Description

(Lucent: 16-QAM (30 Mbit/s and 20 Mbit/s) with coherent detection / NTT: QPSK (15 Mbit/s, 10 Mbit/s and BPSK (5 Mbit/s) with differential detection)

Parameter	Value(s)
Data Rates Supported	30, 20, 15, 10, 5 Mbit/s
Channel Spacing	15 MHz
Center Frequencies	5171.25 + (n-1)x15 MHz [n=1 - 11] 5745 + (n-1)x15 MHz [n=1 - 5]
Power Levels	5.15-5.25 GHz: 30 mW 5.25-5.35 GHz: 150 mW 5.725-5.825 GHz: 600 mW
Sensitivities (NF=10 dB)	15 Mbit/s : -83.5 dBm 10 Mbit/s : - 86.3dBm 5 Mbit/s : -89.6 dBm
CCA threshold (NF=10 dB / interference detection margin from noise level=5 dB)	-88 dBm
Clock Rate accuracy	better than +/- 40 ppm maximum
Carrier Frequency accuracy	better than +/- 40 ppm maximum
Waveform implementation accuracy specification method	insensitive
Power Backoff in RF PA	5 dB for the all rate (Output Back off)
Implementation Complexity	Hardware size : 173 k gates (Base band) Power Consumption : (Full duty cycle) 30 Mbit/s : 186 mW 20 Mbit/s : 124 mW 15 Mbit/s : 93 mW 10 Mbit/s : 62 mW 5 Mbit/s : 31 mW

Per-Rate Feature Summary

Parameter	30 Mbit/s	20 Mbit/s	15 Mbit/s	10 Mbit/s	5 Mbit/s
Data rate	30 Mbit/s	20 Mbit/s	15 Mbit/s	10 Mbit/s	5 Mbit/s
ECC method	r=3/4	r=1/2	r=3/4	r=1/2	r=1/2

	Convolutional	Convolutional	Convolutional	Convolutional	Convolutional
Interleaving method	24 x 8	24 x 8	12 x 8	12 x 8	6 x 8
Suggested minimal sensitivity NF = 10 dB / 1000 Byte packet	--	--	-78 dBm (differential)	-81 dBm (differential)	-84 dBm (differential)
Suggested Co-Channel rejection required CIR of 1000 Byte packet +α	--	--	10 dB (differential)	7 dB (differential)	4 dB (differential)
Suggested Adjacent Channel rejection required CIR of 1000 Byte packet +α	--	--	-17 dB (differential)	-21 dB (differential)	-23 dB (differential)
Suggested Alternate Channel rejection required CIR of 1000 Byte packet +α	--	--	-46 dB (differential)	-49 dB (differential)	-50 dB (differential)
Implementation Accuracy	Not sensitive by skipping the center sub carrier				

Performance

If the receiver implementation complexity can be traded for performance, bring data for typical (simpler?) implementation and for extended (possible, but higher end) implementation.

Performance in Noise and Multipath

Attach graphs of PER vs. Eb/N0, for

1) AWGN channel
2) Exponential Profile Rayleigh Fading channel for T_{RMS} = 25 nsec
3) Exponential Profile Rayleigh Fading channel for T_{RMS} = 50 nsec
4) Exponential Profile Rayleigh Fading channel for T_{RMS} = 100 nsec
5) Exponential Profile Rayleigh Fading channel for T_{RMS} = 150 nsec
6) Exponential Profile Rayleigh Fading channel for T_{RMS} = 250 nsec
7) Attach graph of PER vs. T_{RMS} without additive noise, covering a range of 10 nsec to 500 nsec

The carrier frequency shall be offset by the maximum allowed amount (include Tx and Rx sides) according to the proposed text. The PER data will include the intended acquisition procedure performance.

Bring the graphs for each data rate supported by the proposed PHY, for packet lengths of 64 and 1000 bytes.

Per-Rate Performance Summary

If the receiver implementation complexity can be traded for performance, bring data for typical (simpler?) implementation and for extended (possible, but higher end) implementation.

Differential Detection

Parameter	30 Mbit/s	20 Mbit/s	15 Mbit/s	10 Mbit/s	5 Mbit/s
Eb/No at PER=10%, AWGN, 64b	--	--	7.6 dB	6.5 dB	6.4 dB
Trms at PER=10%, noise free, 64b	--	--	> 600 ns	> 600 ns	> 600 ns
Eb/No @ 20%, with Trms @ 10%, 64b	--	--	16.0 dB*1	10.7 dB*1	10.7 dB*1
Eb/No at PER=10%, AWGN, 1000b	--	--	8.7 dB	7.7 dB	7.4 dB
Trms at PER=10%, noise free, 1000b	--	--	> 600 ns	> 600 ns	> 600 ns
Eb/No @ 20%, with Trms @ 10%, 1000b	--	--	19.9 dB*1	13.4 dB*1	12.7dB*1
CCI immunity [dB]	--	--	8.3 dB (64B)	5.5 dB (64B)	2.3 dB (64B)

			9.4 dB (1000B)	6.6 dB (1000B)	3.1 dB (1000B)
ACI immunity [dB] D/U	--	--	-19.3 dB (64B) -17.8 dB (1000B)	-22.8 dB (64B) -21.3 dB (1000B)	-25.7 dB (64B) -23.8 dB (1000B)
CW jammer immunity [dB] D/U	--	--	13.5 dB (64B) 15.2 dB (1000B)	2.2 dB (64B) 7.7 dB (1000B)	-3.5 dB (64B) -0.9 dB (1000B)
Narrowband Gaussian noise immunity [dB]	--	--	11.9 dB (64B) 13.5 dB (1000B)	7.7 dB (64B) 9.6 dB (1000B)	3.7 dB (64B) 5.5 dB (1000B)
Phase noise tolerance, (BW=50 kHz), rad^2 [dBc] at which PER becomes 10%	--	--	-11.7 dBc (64B) -14.1 dBc (1000B)	-10.1 dBc (64B) -12.5 dBc (1000B)	-6.0dBc (64B) -8.0 dBc (1000B)

*1 : PER never exceed 10 % with T_{rms} of 25 - 600 ns. T_{rms} of 250 ns is assumed instead.

Timing and Overhead related parameters

Attach verbal explanation of the assumptions taken for each parameter

Attribute	Suggested Value
aSlotTime	6 µs
aCCATime	≤4 µs
aRxTxTurnaroundTime	implementation dependent
aTxPLCPDelay	implementation dependent
aRxTxSwitchTime	implementation dependent
aTxRampOnTime	Not applicable
aTxRFDelay	implementation dependent
aSIFSTime	13 µs
aRxRFDelay	4 µs
aRxPLCPDelay	7 µs
aMACProcessingDelay	implementation dependent
aTxRampOffTime	Not applicable
aPreambleLength	19 µs
aPLCPHdrLength	4 µs (for 30Mbit/s) 5 µs (for 20Mbit/s) 6 µs (for 15Mbit/s) 7 µs (for 10Mbit/s) 12 µs (for 5Mbit/s)
aMPDUDurationFactor	(coding rate) $^{-1}$
aAirPropagationTime	<1 µs
aCWmin	15
aCWmax	1023

Appendix: Phase noise generation for a simulation

The phase noise process to be used for comparison of robustness with respect to it was agreed to be a white Gaussian process filtered with single-pole low pass filter. The rationale for using this model is a typical behaviour of phase-locked microwave oscillators. The model ignores the phase noise contribution of the reference crystal oscillator, which typically affects very low offset frequencies and is easily tracked by carrier tracking loops in the receiver. The corner frequency of the LPF was agreed to be 50 KHz, assuming it is a representative value for a large-step synthesizer.

a) generate initial sample of the process. This takes account for infinite past not being simulated.

$$x_0 = N(0,1)$$

b) Assume simulation time step T_s. Generate next samples of a unity-variance LPF process with an IIR approximation to LPF:

$$x_{k+1} = x_k + \alpha(\beta N(0,1) - x_k)$$
$$\alpha = 2\pi F_c T_S$$
$$\beta^2 = (2/\alpha) - 1$$

c) convert the unity-variance LPF process to phase noise with a chosen φ_{RMS} by computing $\exp(j\varphi_k) = \exp(j\varphi_{RMS} x_k)$. Multiply the complex transmitted signal with the phase noise process.

d) simulate with several values of φ_{RMS} . Search for a value causing PER=10%.

Level definitions

Thesuggested minimal sensitivity depends on a system design.