

IEEE P802.11
Wireless LANs

Lucent Technologies and NTT updates

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Abstract

This document readdresses the submission template for TGa. This document is based on documents 97/96r1, 98/57 and on inputs from March 98 plenary meeting. This document is to be agreed by the proposers to serve as an official template.

The performance data addressing all the points in the criteria should be submitted electronically to 802.11 Chair by 12 April 1998, 12:00 UTC.

Follows a short summary of the three proposals being considered by the committee.

Company	Lucent Tech. + NTT	BreezeCom + NEC	RadioLAN
Modulation method	OFDM DBPSK, DQPSK or 16-QAM in each subcarrier	Offset Quadrature Modulation (OQPSK/OQAM)	Differential Pulse Position Modulation (16-DPPM, 4-DPPM)
Pulse shaping features	48 subcarriers out of 64	50% Square-Root Raised Cosine	50% Square-Root Raised Cosine
Error Correction Coding	Convolutional K=7, R=1/2 or R=3/4 Inter-carrier interleaving	Hamming (31,26) with interleaving, uncoded option	Uncoded, option for Reed Solomon (15,13) coded with interleaving
Rates supported	5 Mbit/s (DBPSK, R=1/2) 10 Mbit/s (DQPSK, R=1/2) 15 Mbit/s (DQPSK, R=3/4) 20 Mbit/s (16-QAM, R=1/2) 30 Mbit/s (16-QAM, R=3/4)	21 Mbit/s (OQPSK, coded) 25 Mbit/s (OQPSK, uncoded) 42 Mbit/s (OQAM, coded) 50 Mbit/s (OQAM, uncoded)	10 Mbit/s (4-DPPM) 20 Mbit/s (16-DPPM) 20 Mbit/s (16-DPPM, coded)
Number of channels in U-NII band	5 in 100 MHz, 10 in 200 MHz 15 MHz channel spacing	4 in 100 MHz, 9 in 200 MHz 20 MHz channel spacing	3 in 100 MHz, 7 in 200 MHz 30 MHz channel spacing
Applicable documents	97/92, 97/123, 97/137, 98/02, 98/03, 98/12, 98/71r1, 98/72, 98/73, 98/74,	98/76r1, 98/109, 98/144	97/145r1, 98/38, 98/75, 98/132, 98/133

TGA Performance Template

General Description, Parameters Common for all Rates

Parameter	BreezeCom + NEC	Lucent Tech. + NTT	RadioLAN
Data Rates Supported	list all, specify which are mandatory	30, 20 (mandatory), 15 (mandatory), 10, 5 Mbit/s	list all, specify which are mandatory
Channel Spacing		15 MHz	
Center Frequencies	list for lower, middle and upper U-NII bands	Lower band : 5170, 5185, 5200, 5215, 5230 MHz Middle band : 5270, 5285, 5300, 5315, 5330 MHz Upper band : 5745, 5760, 5775, 5790, 5805 MHz	list for lower, middle and upper U-NII bands
Power Levels	list per channel	5150 - 5250 MHz : 30mW 5250 - 5350 MHz : 150mW 5725 - 5825 MHz : 600mW	list per channel
CCA threshold		-78 dBm	
Clock Rate accuracy		40 ppm maximum	
Carrier Frequency accuracy		40 ppm maximum	
Waveform implementation accuracy specification method		Insensitive	
Implementation Complexity	gates, MIPS, mW @ given technology etc. as judged appropriate by proposer	Hardware size : 173 k gates (Baseband) Power consumption @ 0.35 mm technology 30 Mbit/s : 157 mW 20 Mbit/s : 124 mW 15 Mbit/s : 115mW 10 Mbit/s : 96mW 5 Mbit/s : 83 mW (Full duty cycle)	gates, MIPS, mW @ given technology etc. as judged appropriate by proposer

Per-Rate Feature Summary

Proposal and Rate	ECC method	Interleaving method	Suggested minimal sensitivity	Suggested Adjacent Channel rejection	Suggested Alternate Channel rejection	Implementation Accuracy
LT+NTT 5 Mb	R=1/2, Convolutional	6x8	-84dBm (differential)	23dB (differential)	50dB (differential)	Not sensitive by skipping @ the center subcarrier
LT+NTT 10 Mb	R=1/2,	12x8	-81dBm	21dB	49dB	as above

	Convolutional		(differential)	(differential)	(differential)	
LT+NTT 15 Mb	R=3/4, Convolutional	12x8	-78dBm (differential)	17dB (differential)	46dB (differential)	as above
LT+NTT 20 Mb	R=1/2, Convolutional	24x8	-75dBm (coherent)	15dB (coherent)	50dB (coherent)	as above
LT+NTT 30 Mb	R=3/4, Convolutional	24x8	-72dBm (coherent)	11dB (coherent)	50dB (coherent)	Not sensitive by skipping•@ the center subcarrier
Br+NEC 21 Mb						
Br+NEC 25 Mb						
Br+NEC 42 Mb						
Br+NEC 50 Mb						
RadioLAN 10 Mb						
RadioLAN 20 Mb						
RadioLAN 20+RS						

Per-Rate Performance Summary

Performance in Noise and Multipath

Attach in a Word file the graphs of PER for the following scenarios:

- 1) PER vs. Received Power, one graph for all rates, in a AWGN channel
- 2) PER vs. Received Power, Exponential Profile Rayleigh Fading channel, one graph (with all rates) for each of the delay spread values $T_{RMS} = 25$ nsec, 50 nsec, 100 nsec, 150 nsec, 250 nsec
- 3) PER vs. Received Power, Exponential Profile Rayleigh Fading channel, one graph (with all delay spread values $T_{RMS} = 25$ nsec, 50 nsec, 100 nsec, 150 nsec, 250 nsec) for each of the rates.
- 4) Attach one graph (with all rates) of PER vs. T_{RMS} without additive noise, covering a range of 10 nsec to 500 nsec
- 5) Attach one graph (with all rates) of PER vs. RMS phase noise (without thermal noise), for 1000 byte packet length.
- 6) Attach one graph (with all rates) of PER vs.CCI (without thermal noise), for 1000 byte packet length. The CCI is defined as $10 \log((\text{interferer power})/(\text{desired power}))$, i.e. smaller CCI means less interference.
- 7) Attach one graph (with all rates) of PER vs.ACI (without thermal noise), for 1000 byte packet length. The CCI is defined as $10 \log((\text{interferer power})/(\text{desired power}))$, i.e. smaller ACI means less interference. Set the Backoff according to U-NII regulations.

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.

The Received Power is defined as $-174 \text{ dBm/Hz} + (NF=10 \text{ dB}) + 10\log(\text{Bit_Rate}) + E_b/N_o$. For example, at 20 Mbit/s, at $E_b/N_o=12 \text{ dB}$, $Pr = -174 \text{ dBm/Hz} + 10\text{dB} + 73\text{dBHz} + 12 \text{ dB} = -79 \text{ dBm}$.

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

Proposal and Rate	Pr [dBm] at PER=10%, AWGN, 64b	Pr [dBm] at PER=10%, AWGN, 1000b	Trms at PER=10%, noise free, 64b	Trms at PER=10%, noise free, 1000b	Pr [dBm] @ 20%, with Trms @ 10%, 64b	Pr [dBm] @ 20%, with Trms @ 10%, 1000b
LT+NTT 5 Mb	-90.6 dBm	-89.6 dBm	> 500 ns	> 500 ns	-86.1 dBm*1	-83.1 dBm*1
LT+NTT 10 Mb	-87.5 dBm	-86.3 dBm	> 500 ns	460 ns	-78.2 dBm	-74.1 dBm
LT+NTT 15 Mb	-84.6 dBm	-83.5 dBm	320 ns	240 ns	-71.6 dBm	-68.5 dBm
LT+NTT 20 Mb	-83.0 dBm	-81.0 dBm	300 ns	225 ns	-75.0 dBm	-71.0 dBm
LT+NTT 30 Mb	-79.2 dBm	-77.2 dBm	175 ns	150 ns	-69.2 dBm	-66.2 dBm
Br+NEC 21 Mb						
Br+NEC 25 Mb						
Br+NEC 42 Mb						
Br+NEC 50 Mb						
RadioLAN 10 Mb						
RadioLAN 20 Mb						
RadioLAN 20+RS						

*1 : PER never exceed 10% with T_{rms} of 25 - 500 ns. PER of 20% is assumed instead at T_{rms} of 500 ns.

Performance in Interference

Proposal and Rate	Sensitivity @NF=10 dB, no degr. [dBm]	CCI immunity [dB]	ACI immunity [dB]	CW jammer immunity [dB]	Narrowband Gaussian noise immunity [dB]	Phase noise tolerance, [dBc]
LT+NTT 5 Mb	-90.6 dBm (64b)	-2.3dB (64b)	25.7dB (64b)	3.5 dB (64b)	-3.7 dB (64b)	-6.0 dBc (64b)
	-89.6 dBm (1000b)	-3.1dB (1000b)	23.8dB (1000b)	0.9 dB (1000b)	-5.5 dB (1000b)	-8.0 dBc (1000b)
LT+NTT 10 Mb	-87.5 dBm (64b)	-5.5dB (64b)	22.8dB (64b)	-2.2dB (64b)	-7.7dB (64b)	-10.1dBc (64b)
	-86.3 dBm (1000b)	-6.6dB (1000b)	21.3dB (1000b)	-7.7dB (1000b)	-9.6dB (1000b)	-12.5dBc (1000b)
LT+NTT 15 Mb	-84.6 dBm (64b)	-8.3dB (64b)	19.3dB (64b)	-13.5dB (64b)	-11.9dB (64b)	-11.7dBc (64b)
	-83.5 dBm (1000b)	-9.4dB (1000b)	17.8dB (1000b)	-15.2dB (1000b)	-13.5dB (1000b)	-14.1dBc (1000b)
LT+NTT 20 Mb	-83.0 dBm (64b)	-10.5dB (64b)	17.8dB (64b)	-13dB (64b)	-13.2dB (64b)	-13dBc (64b)
	-81.0 dBm (1000b)	-12.3 dB (1000b)	16.5 dB (1000b)	-15.7 dB (1000b)	-14.3 dB (1000b)	-11 dB (1000b)
LT+NTT 30 Mb	-79.2 dBm (64b)	-13.7dB (64b)	14.2dB (64b)	-18.3dB (64b)	-18.2dB (64b)	-14dBc (64b)
	-77.2 dBm (1000b)	-16.5 dB (1000b)	12.5 dB (1000b)	-20.9 dB (1000b)	19.4 dB (1000b)	-12.5 dB (1000b)
Br+NEC 21 Mb						
Br+NEC 25 Mb						
Br+NEC 42 Mb						
Br+NEC 50 Mb						
RadioLAN 10 Mb						
RadioLAN 20 Mb						
RadioLAN 20+RS						

PA Backoff and Link Budget (see Appendix D for explanation)

@AWGN

Proposal and Rate	Sensitivity @NF=10 dB, no degr. [dBm]	Backoff [dB], average Pt=150 mW, (U-NII regulations)	Backoff [dB], average Pt=150 mW, (restricted regulations)	Loss [dB] at average Pt=150 mW	Loss [dB] at saturated Pt=250 mW, (U-NII regulations)	Loss [dB] at saturated Pt=250 mW, (restricted regulations)
LT+NTT 5 Mb	-90.6 dBm (64b)	5 dB	10dB	112.4 dB (64b)	109.6 dB (64b)	104.6 dB (64b)
	-89.6 dBm (1000b)			111.4 dB (1000b)	108.6 dB (1000b)	103.6 dB (1000b)
LT+NTT 10 Mb	-87.5 dBm (64b)	5 dB	10dB	109.3 dB (64b)	106.5 dB (64b)	101.5 dB (64b)
	-86.3 dBm (1000b)			108.1 dB (1000b)	105.3 dB (1000b)	100.3 dB (1000b)
LT+NTT 15 Mb	-84.6 dBm (64b)	5 dB	10dB	106.4 dB (64b)	103.6 dB (64b)	98.6 dB (64b)
	-83.5 dBm (1000b)			105.3 dB (1000b)	102.5 dB (1000b)	97.5 dB (1000b)

	(1000b)			(1000b)	(1000b)	(1000b)
LT+NTT 20 Mb	-83.0 dBm (64b) -81.0 dBm (1000b)	5 dB	10dB	104.8 dB (64b) 102.8 dB (1000b)	102.0 dB (64b) 100.0 dB (1000b)	97.0 dB (64b) 95.0 dB (1000b)
LT+NTT 30 Mb	-79.2 dBm (64b) -77.2 dBm (1000b)	5 dB	10dB	101.0 dB (64b) 99.0 dB (1000b)	98.2 dB (64b) 96.2 dB (1000b)	93.2 dB (64b) 91.2 dB (1000b)
Br+NEC 21 Mb						
Br+NEC 25 Mb						
Br+NEC 42 Mb						
Br+NEC 50 Mb						
RadioLAN 10 Mb						
RadioLAN 20 Mb						
RadioLAN 20+RS						

@ $T_{rms} = 150\text{nsec}$

Proposal and Rate	Sensitivity @NF=10 dB, no degr. [dBm]	Backoff [dB], average Pt=150 mW, (U-NII regulations)	Backoff [dB], average Pt=150 mW, (restricted regulations)	Loss [dB] at average Pt=150 mW	Loss [dB] at saturated Pt=250 mW, (U-NII regulations)	Loss [dB] at saturated Pt=250 mW, (restricted regulations)
LT+NTT 5 Mb	-85.5 dBm (64b) -82.5 dBm (1000b)	5 dB	10dB	107.3 dB (64b) 104.3 dB (1000b)	104.5 dB (64b) 101.5 dB (1000b)	99.5 dB (64b) 96.5 dB (1000b)
LT+NTT 10 Mb	-81.5 dBm (64b) -78.0 dBm (1000b)	5 dB	10dB	103.3 dB (64b) 99.8 dB (1000b)	100.5 dB (64b) 97.0 dB (1000b)	95.5 dB (64b) 92.0 dB (1000b)
LT+NTT 15 Mb	-74.2 dBm (64b) -69.7 dBm (1000b)	5 dB	10dB	96.0 dB (64b) 91.5 dB (1000b)	93.2 dB (64b) 88.7 dB (1000b)	88.2 dB (64b) 83.7 dB (1000b)
LT+NTT 20 Mb	-76.7 dBm (64b) -72.8 dBm (1000b)	5 dB	10dB	98.5 dB (64b) 94.6 dB (1000b)	95.7 dB (64b) 91.8 dB (1000b)	90.7 dB (64b) 86.8 dB (1000b)
LT+NTT 30 Mb	-69.2 dBm (64b) -54.2 dBm (1000b)	5 dB	10dB	91.0 dB (64b) 76.0 dB (1000b)	88.2 dB (64b) 73.2 dB (1000b)	83.2 dB (64b) 68.2 dB (1000b)
Br+NEC 21 Mb						
Br+NEC 25 Mb						
Br+NEC 42 Mb						
Br+NEC 50 Mb						
RadioLAN 10 Mb						
RadioLAN 20 Mb						
RadioLAN 20+RS						

Interference Limited Aggregate Rate (see Appendix E for explanation)

Indoor (35 log(distance ratio)) propagation model:

Proposal and Rate	CCI immunity [dB]	D2/D1, Interferer to Transmitter dist. ratio, indoor	Fraction of Area covered, indoor	Aggregate rate per AP, single rate, indoor	Aggregate rate per AP, multirate, indoor	Aggregate rate per AP, multirate, multichannel indoor
LT+NTT 5 Mb	3.1	1.23	0.807	4.04	4.04	20.2
LT+NTT 10 Mb	6.6	1.54	0.618	6.18	7.13	35.6
LT+NTT 15 Mb	9.4	1.86	0.490	7.36	9.58	47.9
LT+NTT 20 Mb	12.3	2.25	0.380	7.59	11.48	57.4
LT+NTT 30 Mb	16.5	2.96	0.255	7.65	14.03	70.1
Br+NEC 21 Mb						
Br+NEC 25 Mb						
Br+NEC 42 Mb						
Br+NEC 50 Mb						
RadioLAN 10 Mb						
RadioLAN 20 Mb						
RadioLAN 20+RS						

Free Space (20 log(distance ratio)) propagation model:

Proposal and Rate	CCI immunity [dB]	D2/D1, Interferer to Transmitter dist. ratio, free space	Fraction of Area covered, free space	Aggregate rate per AP, single rate, free space	Aggregate rate per AP, multirate, free space	Aggregate rate per AP, multirate, multichannel free space
LT+NTT 5 Mb	3.1	1.43	0.678	3.39	3.39	17.0
LT+NTT 10 Mb	6.6	2.14	0.406	4.06	5.42	27.1
LT+NTT 15 Mb	9.4	2.95	0.256	3.84	6.70	33.5
LT+NTT 20 Mb	12.3	4.12	0.153	3.05	7.46	37.3
LT+NTT 30 Mb	16.5	6.68	0.068	2.03	8.14	40.7
Br+NEC 21 Mb						
Br+NEC 25 Mb						
Br+NEC 42 Mb						
Br+NEC 50 Mb						
RadioLAN 10 Mb						
RadioLAN 20 Mb						
RadioLAN 20+RS						

Timing and Overhead related parameters

Attach verbal explanation of the assumptions taken for each parameter

Parameter	BreezeCom + NEC	Lucent Tech. + NTT	RadioLAN
aSlotTime		6 μ s	
aCCATime		< 4 μ s	
aRxTxTurnaroundTime		8.8 μ s	
aTxPLCPDelay		<< 1 μ s	
aRxTxSwitchTime		<< 1 μ s	
aTxRampOnTime		Not applicable	
aTxRFDelay		< 8.8 μ s	
aSIFSTime		13 μ s	
aRxRFDelay		4 μ s	
aRxPLCPDelay		7 μ s	
aMACProcessingDelay		< 2 μ s	
aTxRampOffTime		Not applicable	
aPreambleLength		19 μ s	
aPLCPHdrLength	for each mode, if applicable	4 μ s (for 30 Mbit/s) 5 μ s (for 20 Mbit/s) 6 μ s (for 15 Mbit/s) 7 μ s (for 10 Mbit/s) 12 μ s (for 5 Mbit/s)	for each mode, if applicable
aMPDUDurationFactor	for each mode, if applicable	(coding rate) ⁻¹	for each mode, if applicable
aAirPropagationTime		< 1 μ s	
aCWmin		15	
aCWmax		1023	

Compute throughput penalty according to appendix F

Proposal and Rate	1500B MPDU duration (msec)	DIFS + backoff (msec)	1500B packet duration	SIFS	ACK packet duration, same rate	ACK packet duration, basic rate	Efficiency, ACK at same rate	Efficiency, ACK at basic rate
LT+NTT 5 Mb	2400	70	2478.2	13	54.2	30.2	0.91764	0.92614
LT+NTT 10 Mb	1200	70	1249.4	13	39.8	30.2	0.87451	0.88067
LT+NTT 15 Mb	800	70	841.4	13	35.0	30.2	0.83385	0.83805
LT+NTT 20 Mb	600	70	635.0	13	30.2	30.2	0.80192	0.80192
LT+NTT 30 Mb	400	70	433.4	13	30.2	30.2	0.73180	0.73180
Br+NEC 21 Mb								
Br+NEC 25 Mb								
Br+NEC 42 Mb								
Br+NEC 50 Mb								
RadioLAN 10 Mb								
RadioLAN 20 Mb								
RadioLAN 20+RS								

