IEEE P802.11
Wireless LANs

TGb proposal comparison matrix

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This document is an update of the comparative matrix of the modulation techniques being consideration by the TGb (high data rate 2.4GHz PHY) subgroup. The basis of this matrix is the evaluation criteria described in document "97157r1.doc". Document "9854.doc" describes how this matrix will be used in the selection process.

The proposers have completed this matrix for their individual proposal as well as for any derivative proposals that make performance, complexity and interoperability trade-offs.

General description:

	Alantro	Lucent/Harris	Micrilor
Modulation Technique	QPSK	CCK complementary code keying 8 complex chip spreading	16-ary DBOK, 16-ary DBOK with (15,13) R/S FEC, 4x4-ary DBOK
Data Rate(s)	1,2,2.75, 5.5, 11, 14 1/3, 16.5, 17.6, 18 1/3, 19.25 Mbps	1,2,5.5 and 11 Mbit/s	10 Mbit/s (primary) and 18, 8.7, 2, 1 Mbit/s
Sensitivity	88.9 dB Depends on data rate. As reference look at a receiver N.F. of 10 dB (not very aggressive). Then sensitivity can be calculated from KTB+B.W.+N.F.+SNR. Where KTB is -174 dB, B.W. is 30 Mhz and N.F. is 10dB and SNR is QPSK demodulation- Processing gain. For the primary rate of 11†Mbps we would get -174 dB+74.77dB+10 dB +(13-12.7)=88.9 dB.	-91 dBm @ 5.5Mbit/s -88 dBm @ 11Mbit/s	-88 dBm @10 Mbit/s -90 dBm @8.7 Mbit/s -83 dBm @18 Mbit/s
Reference submissions	98/24, 98/83, 98/84, 98/85	Harris MBOK doc 70254, 70867, 71447, 80467B, 80477B, 97/124 Lucent PPM doc 98/10r1 98/11 98/99 98/100 Combined doc 98/246 new doc 98/264 draft text	9750.ppt 9751.ppt 9752.ppt 9753.ppt 9782.ppt 9783.ppt 97116.doc 97117.doc 97118.doc 97119.doc 97120.doc 97128.ppt 97129.ppt 97130.ppt 97131.ppt 98016.doc 98017.doc 98018.doc 98019.doc 98117.ppt 98018r1.doc 98117r1.ppt 98206.ppt 98207.ppt 98209.ppt 98016r1.doc 98117r2.ppt

Receiver structure:

	Alantro	Lucent/Harris	Micrilor
Receiver structure description	Receiver states are as follows: Antenna w/ diversity 1st Down converter IF filter 2nd Down convert (could be quadrature) A/D converter Equalizer/demodulato BCC decoder MAC interface	Matched filter Decoding simple with Hadamar transforms simple DFE possible to increase performance	ML for Rayleigh channel; correlators for demodulation; correlator for acquisition; matched filter for CSMA; non-coherent receiver.
RF/IF complexity relative to current low rate PHYs.	Similar to low rate DS PHYs Requires slightly lower phase noise on oscillators.	Same as low rate PHYs	Same as low rate PHYs
Baseband processing complexity. relative to current low rate PHYs. (Gate Count, MIPS)	76-97k gates	twice low rate PHYs for moderate complexity receiver, with MF (not required) complexity trade off for performance	Similar: approximately 40k gates including channel matched filter
Equalizer Complexity and performance impact (if applicable).	44-55k gates	40K gates. Will improve delay spread from 100 ns to 300 ns. This is roughly double the gate count	Not required; equalizer or MLSE techniques could be added for enhancement
Antenna Diversity and performance impact.	System performance may be improved by use of multiple antennas, but multiple antennas are not required to meet the PAR requirements.	Same possibilities as low rate PHY with long PLCP header.	1 or 2 dB improvement in SNR; adds 4 µs to preamble.

Multipath and Noise performance:

	Alantro	Lucent/Harris	Micrilor
PER vs. multipath rms delay spread (no noise). Delay spread @ 10% PER for 64 and 1000 byte packets.	64 byte packets: 550 ns 1000 byte packets: 420 ns (11 Mbps)	**11 Mbps** <u>RAKE</u> 64 byte: 90 nsec 1K byte: 65 nsec <u>RAKE-ISI Equaliser</u> 64 byte: 144 nsec 1K byte: 87 nsec <u>RAKE-ICI/ISI Equaliser</u> 64 byte: 333 nsec 1K byte: 226 nsec **5.5 Mbps** <u>RAKE</u> 64 byte: 273 nsec 1K byte: 225 nsec <u>RAKE-ISI Equaliser</u> 64 byte: 509 nsec 1K byte: 430 nsec <u>RAKE-ICI/ISI Equaliser</u> This configuration is not needed	**10 Mbit/s** 64 byte: 360 ns 1 kbyte: 280 ns
PER vs. thermal noise w/ multipath @ 10% PER. Eb/No @ 20% PER for 64 and 1000 byte packets.	64 byte packets: 10 dB Eb/No 1000 byte packets: 14 dB Eb/No (11 Mbps)	**11 Mbps** <u>RAKE</u> 64 byte: 15.2 dB 1K byte: 17.5 dB <u>RAKE-ISI Equaliser</u> 64 byte: 15 dB 1K byte: 17.5 dB <u>RAKE-ICI/ISI Equaliser</u> 64 byte: 15.5 dB 1K byte: 17.7 dB **5.5 Mbps** <u>RAKE</u> 64 byte: 14.8 dB 1K byte: 18.5 dB <u>RAKE-ISI Equaliser</u> 64 byte: 16 dB 1K byte: 19 dB <u>RAKE-ICI/ISI Equaliser</u> Not needed	**10 Mbit/s** 64 byte @ 360 ns: 26 dB 1 kbyte @ 280 ns: 24.5 dB
PER vs. thermal noise (no multipath). Eb/No @ 10% PER for 64 and 1000 byte packets.	64 byte packets: 3.2 dB Eb/No 1000 byte packets:	**11 Mbit/s** <u>RAKE</u> 64 byte: 5.5 dB	**10 Mbit/s** 64 byte: 5.5dB 1 kbyte: 6.7dB

	4.2 dB Eb/No (11 Mbps)	1 kbyte: 7 dB RAKE-ISI Equaliser 64 byte: 5.5 dB 1 kbyte: 7 dB RAKE-ICI/ISI Equaliser 64 byte: 5.5 dB 1 kbyte: 7 dB **5.5 Mbit/s** RAKE 64 byte: 5.5 dB 1 kbyte: 7 dB RAKE-ISI Equaliser 64 byte: 5.5 dB 1 kbyte: 7 dB RAKE-ICI/ISI Equaliser 64 byte: 5.5 dB 1 kbyte: 7 dB	**18 Mbit/s** 64 byte: 8.5dB 1 kbyte: 9.7dB **8.7 Mbit/s** 64 byte: 4.5dB 1 kbyte: 5.0dB

Carrier and Data frequency accuracy:

	Alantro	Lucent/Harris	Micrilor
Required Carrier frequency accuracy.	± 25ppm	25 PPM = low rate PHYs	±20 ppm; Recommend specify @ 10 ppm
Degradation at worst case carrier frequency offset.	< 1dB	Negligible with carrier tracking Similar to low rate PHYs Easy carrier tracking, but non coherent processing OK	<.2 dB @ 20 ppm; negligible @ 10 ppm; no tracking required in any case
Data clock frequency accuracy.	±25ppm	25 PPM	10 ppm to reduce stress on tracking
Degradation at worst case data clock frequency offset.	< 1 dB	CMF gives optimal timing Tracking circuits should compensate	< .3 dB @ ≈1/8-chip time-tracking error

Overhead related parameters:

	Alantro	Lucent/Harris	Micrilor
Preamble length	Two preamble lengths supported. The first preamble length is identical to that of the low rate PHY, which is 2112 symbols or 192 µs. (I would also propose appending of training sequence after the data rate field if a high data rate frame is to be received. This maintains compatibility with the current system but allows the benefits of the high data rates if they are coexisting) A second, improved performance preamble may be used with a length of 200 - 500 symbols, or 18.2 µs - 45.5 µs	Long preamble + header = 192 microseconds Short preamble + header = 75 microseconds	24 us
Does the preamble length include receive antenna diversity? Yes or no.	Yes	Long preamble, same as low rate PHY: yes Short preamble: yes 30 Microseconds (1.5 slottime) reserved for diversity	Yes
Does the preamble length include equalizer training? Yes or no.	Yes	Long preamble: yes Short preamble: yes (24 microseconds reserved)	Includes training of channel matched filter
Slot time.	20 µs	= low rate PHY 20 microseconds	10 us
CCA mechanism description.	Energy detect and Baud rate detection	= low rate PHY	Detect 1-/2-Mbps DS or FH at –80 dBm
Co-Channel signal detection time.	10 µs	Energy detect time = current PHY 15 microseconds	2 us for all DS TBD for FH
RX/TX turnaround time.	3-6 µs	= low rate PHY 5 microseconds.	2 us
SIFS.	9.6 - 16 µs	= low rate PHY 10 microseconds	10 us

3-4 dSpectral efficiency, Cell density related parameters:

	Alantro	**Lucent/Harris**	**Micrilor**
Channelization scheme	Uses the same channelization scheme as the low rate DS PHY. The available bandwidth is divided into 14 overlapping channels of 30 MHz each with 5 MHz spacing. Overlapping channels are not used simultaneously.	= low rate PHY	= low rate PHY (frequency); plus many code channels
Cell planing scheme	Since three non-overlapping channels of 30 MHz may be selected, a hexagonal tiling of cells may be used such that no two adjacent cells use the same 30 MHz frequency band.	= low rate PHY 3 independent channels	= low rate PHY 3 independent frequency channels; code channels used to isolate BSAs for frequency re-use
Adjacent channel interference rejection.	Analog bandpass filters may be used to effectively get rid of ACI. This is possible due to the large excess bandwidth.	32-35 dB	35 dB
Co-channel interference rejection.	Co-channel interference is greatly reduced due to the use of a constant PN generator that modulates the output of the BCC. In addition CCI is reduced by good cell spacing.	6dB	12 dB
S/J where CW interference gives 10% PER.		8 dB at 11 Mbit/s, 5 dB with 5.5 Mbit/s	2 dB
Other interference immunity tests.	None performed	GFSK immunity is the same as CW	Same
Co-Channel signal detection time.	10 microseconds	= low rate PHY	2 us
Total number of channels in 2.4GHz band.	3 non-overlapping 30 Mhz channels	= low rate PHY, 3 colocated channels for FCC or ETSI Total tuneable channels: FCC: 11 ETSI: 13 MTP: 1	Identical to low rate DSSS PHY; 3 colocated channels for FCC or ETSI
Aggregate throughput.	0.87 Mbps to 16.9 Mbps per channel, times 3 for total throughput.	Dependent on cell topology. e.g. three channels in one cell gives 3 * throughput or 33 Mbit/s	Dependent on cell topology. e.g. three channels in one cell gives 3 * throughput or 30 Mbit/s; at short range could be 3*18=54 Mbit/s

Misc. critical performance factors:

	Alantro	Lucent/Harris	Micrilor
Phase noise sensitivity	Residual phase noise should be around 3 to 5 degrees. Clearly more phase noise will effect your RX sensitivity.	Comparable to low rate PHY (QPSK)	N/A; noncoherent Rx
RF PA backoff	To meet FCC we usually back the PA off about 6dB from compression	4-5dB	2-5 dB
DC power consumption	Just the RF section (no PA) runs about 100mA. The PA can run from 50 to 300mA for a 23dBm output. The digital section (excluding PHY) will take about 150 to 180 mA. PHY chip will vary but I would estimate with an equilizer to be 110†mA. So totals would be 360 to 390†mA in receive and 410 to 690†mA in transmit.	Comparable to low rate PHY PCMCIA form factor and spec. TX < 300mA @ 3V RX < 250A @ 3V	Same as low rate PHY PCMCIA form factor TX < 300mA @ 3V RX < 250A @ 3V

Interoperability:

	Alantro	Lucent/Harris	Micrilor
Interoperability / Co-existence strategy with current low rate PHYs	Incorporate low rate PHY demodulation ability within the high speed PHY. Run the network with the low speed PHYís PLCP and shift to high speed for PDU portion of frame. Include a High speed only PLCP for using in high speed networks to avoid overhead of low speed PHY	Long Preamble: interoperable and coexistent Optional short preamble: low rate PHY is coexistent with transmitter using short preamble And high rate receiver recognises both long and short preamble : interoperable Interoperable with FH using FH header	Prefix legacy preamble to enable CCA by FH or DS 1-/2-Mbps equipment. **Multisignal CCA (ref: 97/128) enables CCA of FH and DS legacy transmissions.** Thus, interoperable or coexisting when required, but single high-rate preamble.
Is the proposal Interoperable at the data level?	Yes	Yes	Yes
Is the proposal Interoperable at the antenna level?	Yes	Yes	Yes
Performance penalty due to Interoperability / Coexistence.	Yes	Long preamble: 192 micro PHY overhead Short preamble: overhead reduces with factor 3	192 us preamble added for DS interoperability mode when needed; not part of high-rate PHY.

General Information:

	Alantro	Lucent/Harris	Micrilor
Has the submission of the required IEEE letter covering IP been made? Yes or No	Yes	Yes	Yes
Applicable patent numbers	TBD	None	Pending
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