IEEE 802.11
Wireless Access Method and Physical Specification

Title: **Comments On Proposal for 2Mbps 802.11 DSSS PHY**

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1. INTRODUCTION

Telxon and Telesystems have studied the March 1993 proposal by NCR for the 802.11 DSSS PHY specification. Based on this analysis, we are in general agreement with the principle features presented in the proposal.

We do, however, take exception to some areas of the proposal. These exceptions and alternate recommendations are made to eliminate what Telxon and Telesystems views as implementation dependent features of the NCR proposal. The goal is to make the 802.11 specification acceptable to the widest possible audience of potential developers.

This paper will concentrate on the areas of spreading sequence, symbol rate, modulation, data scrambling, and the radio header. A separate paper will cover the area of frequency band use and channelization. The comments and recommendations presented here are divided into CORE and OPTIONAL capabilities. Core capabilities represent the minimum requirements a DS radio must meet to be compliant. Optional capabilities are provided as fallback modes for high interference / multipath industrial installations.

2. GENERAL COMMENTS

The design and development of a direct sequence spread spectrum radio provides the design engineer a wide array of techniques and options to achieve a functional radio. As an example, consider the following partial list of functions and applicable techniques required to develop a DSSS demodulator:

- Antenna diversity
  OPTIONS: no diversity, threshold on RSSI, threshold on correlation level, hybrid use of RSSI and correlation
- Carrier tracking
  OPTIONS: passband data independent (COSTAS LOOP), baseband data independent (PLL), baseband data/training dependent (decision directed PLL)
- Gain Control
  OPTIONS: active AGC, Limiter, hybrid AGC / limiter
- Despreading/Decorrelation
  OPTIONS: baseband hardware matched filter correlation, baseband or passband active correlator with integrate and dump
- Timing recovery:
  OPTIONS: matched filter /PLL, early/late gate, Tau dither loop

When properly designed, a DS radio could use any combination of these techniques and achieve adequate performance. But that is only true if the specification is written so that it is implementation independent. If the specification contains implementation dependent features, the DSSS radio design will be forced to use the techniques favored by the proposal.

The point here is simple: the DSSS PHY specification should be as implementation neutral as possible while maintaining adequate communications performance.

3. SPECIFIC PROPOSAL COMMENTS

The following subsections will cover specific areas presented in the NCR proposal. This will include areas in which Telxon and Telesystems are in full agreement with the NCR proposal and comments and alternatives where they are appropriate.

3.1 Carrier Sensing

We agree with the use of CSMA/CD "listen before talk" as the CORE capability for packet collision avoidance as described in sections 3.0 and 7.1.

We also agree that correlation should be used to establish that the channel is "clear". The principle concern is to avoid collision with a DSSS 802.11 packet. The use of RSSI of the RF/IF without despreading will degrade the receiver sensitivity in the presence of low level RF interference. The MAC will have to provide a mechanism for scheduling retransmissions if the channel is occupied (not part of this discussion).

3.2 Power Control

Power Control, as discussed in section 3.0, is an open issue and may not be practical in some industrial/high interference network installations. A CORE capability of nominal 250 to 1000 mW TX power should be supported. The selection of TX power should be based on meeting channel bandwidth, spectral occupation, and spurious emissions specifications (see channel plan paper).

An OPTIONAL capability for dynamic power control for a "remote" user would be desirable for battery / power savings. As a minimum, a high / low (high –10dB) could be implemented. The use of passive power control techniques by remote units based on RSSI or similar measurement of base station strength is advised. The base station transmit power level should remain fixed at the nominal high power level to ensure communications with all remote units in the cell.

3.3 Frequency Bands, Channelization, and Shaping Filters

These topics are covered in a separate paper.

3.4 Spreading Sequence

The 11 chip Barker sequences described in section 4.0 and 8.3 should be supported as CORE capabilities.

Telxon and Telesystems take exception to the use of multiple codes as delimiters within a transmitted packet (section 7.6). Alternative codes have a practical use in providing additional isolation (through decorrelation) between adjacent channels in a muti–channel or multiple 802.11 LAN environment.

OPTIONAL support for 22 (two concatenate 11 bit codes) and 31 chip codes for additional processing gain and physical installation isolation. In shopping malls and high density office building environments, alternate spreading codes can be used to minimize interference and inadvertent cross talk between networks which are meant to be isolated from each other. The decorrelation property of orthogonal PN codes can minimize "adjacent network" interference.

Codes and code lengths are fixed for each network installation. The capability to use alternative codes does not imply dynamic code selection for a network. Choice of codes, modulation, etc. will be set by the LAN administrators and will work in conjunction with other layers of the protocol stack to allow LAN access, routing, data access, and data security.

3.5 Symbol and Chip rates

The 1 Mbaud symbol rate with 11 Mchip PN code rate described in section 8.0 should be supported as the CORE baud and chip rates.

OPTIONAL support of 0.5 / 5.5 and 2.0/ 22.0 Mbaud/Mchip should be provided. FCC and ETSI regulations favor DSSS systems for increased data rates over frequency hopping systems. Based on QPSK modulation 4 Mbps and potentially 8 Mbps DSSS LANs could be placed in service in the near term. The option for 2 Mbaud/22.Mchip is defined for near term high speed high quality DSSS LANs. At the other extreme, lower baud and chip rates may be required in poor quality high interference environments where the LAN is installed to specifically avoid RF interference by minimizing spectral occupation and locating the channel away from interference signals.

The use of optional chip rates (5.5 and 22 Mchips) will impact channel usage. For lower chip rates the CORE channel plan can be used. For higher Chip rates, only alternate channels can be used.

The Chip Rate for a given LAN installation if fixed. The symbol rate is based on the spreading code and code length chosen when the LAN is installed. The capability to use alternate chip rates and spreading codes does not imply dynamic chip rate and code length selection in the network.

Dynamic chip rate and code selection between base stations and remote units should be considered as a future extension of the DSSS 802.11 MAC

3.6 Modulation

The differential BPSK and QPSK modulation formats described in section 8.2 should be supported as CORE capabilities. QPSK modulation should be primary standard with BPSK used as an optional fallback rate. The choice of modulation scheme is fixed for each network installation. The capability to use alternate modulation formats does not imply dynamic modulation selection.

Dynamic modulation selection between base stations and remote units should be considered as a future extension of the DSSS 802.11 MAC

3.7 Carrier Tracking

Carrier tracking is not necessary in differential PSK systems provided the LO is highly stable. As a practical matter, carrier tracking is necessary to improve system performance. The requirements for carrier tracking circuits are based on the acquisition time available and the stability of the transmitter and receiver LOs.

Telxon and Telesystems take exception to the use of DELIMITERS and special carrier training sequences as proposed in section 7.6 and 8.4. We recommend that the LO accuracy be improved (see next section) so that one of a wide range of "train on data" carrier tracking techniques can be used. This eliminates the need for any specific training sequence to be imbedded in the radio packet header or the need for a delimiter to "queue" the receiver to begin carrier training.

3.8 Timing and LO Accuracy

The LO accuracy of 50 ppm as described in sections 4.0, 6.2, and 7.3 is unacceptable. Low cost 10 to 15 ppm VCXO devices are currently available to replace the older 50 ppm VCXOs.

We recommend improving the LO accuracy to better than 15 ppm as a CORE specification.

3.9 Self Synchronous Scrambler / Descrambler

The $1 + x^{-4} + x^{-7}$ self synchronous scrambler described in section 8.1 should be supported as CORE scrambling capability.

The purpose of a "self synchronous" scrambler is to eliminate specialized circuitry to initialize or synchronize the scrambling process. There is no need to load or reset the initial value of the scrambler as described in sections 8.1 and 8.4. If a fixed header pattern is scrambled and transmitted, the receiver should lock up and provide adequate time to fill the scrambler and provide error free output.

3.10 Radio Packet Header

Telxon and Telesystems takes exception to the header format detailed in section 7.6, 7.7, and 7.8. A number of features described in the radio header are implementation dependent and should be modified to create a more general PHY radio header specification.

First, the use of delimiters based on alternative codes should be eliminated. A more appropriate use of any alternate code would be to provide increased isolation by using the code in adjacent channels as part of the frequency plan.

Second, the use of a Network ID is not necessary. The internal header of the MAC packet will provide source and destination information which is more appropriately handled by OSI layer 3 (NETWORK LAYER) for packet routing and relay. If network isolation is desired, use of alternate spreading codes on adjacent LANS automatically suppresses reception of undesired DSSS packets by 6 to 10 dB depending on the code used.

Telxon and Telesystems recommends increasing the header length to 256 symbols (256usec) and using scrambled all 1's for the radio header. This should provide adequate time for:

- Diversity antenna selection
- AGC
- PN code acquisition and timing recovery
- Carrier recovery
- Initialization of the descramabler (self–synchronous)

The increased header length should be adequate to support the standard 11 bit code as well as the optional 22 and 31 length codes proposed in this paper.

4. CONCLUSION

Telxon and Telesystems are in general agreement with the major elements of NCR's proposal. The comments and recommendations in this document were provided to minimize or eliminate features of the NCR proposal which, in the opinion of Telxon and Telesystems, are implementation dependent. These comments are provided in the interest of making the proposed specification acceptable to the widest audience of potential DSSS radio developers.

Communications needs and environmental interference levels vary greatly across the spectrum of users (industrial, retail, office, school, etc.). We included recommendations for optional capabilities to allow for flexible LAN installation to meet the broad range of needs of potential 802.11 DSSS users.

DSSS systems have the ability to deliver 4 and potentially 8 Mbps performance using QPSK modulation. This is a tremendous advantage over the limitations imposed on frequency hopping systems. DSSS radio developers should keep the goal of increased chip and associated baud rates in mind as our discussions on the PHY specification evolve.

A summary of the original NCR specification and the proposed CORE and OPTIONAL specification described in section 3 of this document are summarized in appendix A.

Appendix A

Parameter	NCR Proposal	CORE Proposal	OPTIONAL Proposal
Frequency Range	2.4 to 2.4835 GHz 902 to 928 MHz	n/a (see alternate paper)	n/a
Number of parallel channels	3 @ 2.4 GHz	n/a (see alternate paper)	n/a
Spreading Sequence	11 chip barker with DELIMITER	11 chip Barker (2) NO DELIMITER	22 and 31
Data Rate	2 Mbps	2Mbps	1 and 4 Mbps @ 11 chips Other rates based on alternate code lengths
Symbol rate	1 Mbaud	1 Mbaud	0.5 and 2 Mbaud @ 11 chips Other baud rates based on alternate codes
Modulation	DQPSK	DQPSK	DPSK
Channel bandwidth	11 Mhz	n/a	n/a
Spurious emissions	–20 dB in US –60 dB/100KHz @ 1 to 10 GHz –66 dB/100Khz @ 30 MHz to 1 GHz	n/a	n/a
Transmitted Power Level	nominal 1000mW	250 to 1000 mW set by spectral occupation and spurious emissions	as required to support Power Control
Power Control	optional	n/a	Passive techniques in remote units only Base Stations TX at full power
Receiver sensitivity	better than –70 dBm	better than –70 dBm	better than –80 dBm
Carrier sense threshold	selectable	selectable	Combination RSSI and correlation with selectable threshold
Adjacent channel rejection	50 – 55 dB	n/a (see alternate paper)	n/a
Max received signal power	10 dBm	10 dBm	n/a
Tx/Rx frequency stability	< 50 ppm	< 15 ppm	n/a
Clock accuracy	< 50 ppm	< 15 ppm	n/a
Preamble length	146 symbols (146usec)	256 symbols (256 usec)	n/a

Clock Recovery	Rx should follow TX	Timing recover on RX to meet BER and Sensitivity (design driven)	n/a
Carrier response time (RSSI detect + switch to TX)	< 30 usec	< 100 usec	n/a
Switching time Tx to Rx	faster than the gap between messages	<50 usec (allow time for VCO to stabilize)	n/a
Demodulation	DQPSK optional DBPSK	DQPSK DBPSK	n/a
FER frame error rate	$5*10^{-5}$ for 576 byte frame –70dBm RX (18dB SNR) NOTE: 10^{-8} BER	10^{-8} BER with –70 dBm at RX	n/a
Dynamic capture ration	8 dB	8 dB	n/a
Channel availability	99.5%	99.5% based on proper LAN installation	n/a
antenna port impedance	50 ohm	50 ohm	n/a
VSWR	shock resistant Operational VSWR < 2.5	shock resistant Operational VSWR < 2.5	n/a
interface lines	see NCR spec.	NOT APPLICABLE	n/a
Data line/clock jitter	TBD	TBD	n/a
PHY–MAC network management info/control variables	see NCR spec.	TBD	TBD
Safety requirements	TBD	TBD	TBD
DTE/DCE	TBD	TBD	TBD
ACK protocol support	TBD	TBD	TBD