IEEE 802.11
Wireless Access Method and Physical Specification

Tentative DSSS PHY Adhoc Group Meeting
Tuesday September 21 and Wednesday September 22

9-21-93 Tues pm DSSS meeting. R. Benton, secretary
Jan Boer and Paul Struhsaker are elected co-chairman
Paul: we must try to meet the PAR of 802.11, so the data rate must be 1Mbps min, however we can allow for lower speed once a link is achieved.
Lets get on with the presentation of the DSSS PHY spec proposal 93/145.
Jan: we would like to present the paper in sequence of sections as presented in paper.
Rob B. Why was the Barker code chosen over other available codes such as the Gold code?
Jan: The barker sequence is the minimum sequence allowed under FCC . This was chosen because it provides the best even-odd and auto-correlation of short sequences for 11 bits. The 11bits is required to get 10.4 dB processing gain.
Ron: The transmit filter mask requires substantial filtering of a signal. Is the shape spec'd for the peak of the 2nd lobe? what about testing? I could easily use an 11 order elliptic filter and still interfere with other channels
Paul: We will amend the spec to show some form of linear interpolation
(discussion on filtering)
Paul: We must use carrier recovery based on my previous experience in order to meet BER for conformance spec.
Kamilo: I think filter spec must be based on integrated PSD
Tom T. Shouldn't the LO freq stability be tested at other than 2450 MHz.
Paul: amend the spec to read "across the band".
Kamilo: Is there an advantage to not scramble preamble?
Paul: there is no need, because code lock is carrier lock. (unlike the FH) Diversity is not precluded either, we just can't have variable length preamble
(More discussion)
Paul: for safety precaution to cover unforeseen needs which may arise, what is minimum of bits required in the preamble?
Kato: If a bit error occurs in S1..4 then you have a problem. Why not make the code for BPSK= 0011 and the code for DQPSK= 1100 to improve hamming distance?
Tom T.:I would like to eliminate the EO bit and add a fixed byte which would remain undefined.
(discussion veers towards the modulation method)
Paul: we do not wish to use OQPSK due to the 10dB requirement on phase noise. (I assume this means integrated phase accuracy required on a clock. -R.B.)
Jan: (question on end delimiter) We reject IBM proposal on HDLS due to hamming distance limitations. NCR would like to use simple end of energy as a delimiter to signal end of packet.
Paul: A lack of correlation is not enough in some industrial settings due to fading, so it is Telxon position that it is desirable to have a deterministic packet end delimiter. We feel a 16 bit length should be inserted at end of frame so we could include Packet length and a 16 bit CRC. A result

of this is that a max packet length of 16bits, so if the length measures ok, then check the CRC, which should detect errors.
(Some discussion concerning a unique word) If word occurs in packet, then it must be detected or else is premature termination of packet.
Dean: The length field would be more reliable, so it seems unnecessary to have a length at end of packet.
Paul: I don't want to have to apply a BCH code to our data.
Tom T. In industrial apps, undetected errors are critical. We need a code applied to CRC and length code
Kato: There is no need to code CRC since it does not reduce the possibility of error.
Tom T : (begins discussion of MAC/PHY separation.)
Paul: NCR believes loss of correlation is sufficient to signal end of data. Telxon believes that CRC and length bytes are needed to show end of data. We may need to modify the PAR in order to get a resolution on this issue. (Discussion on RCVR sensitivity.) Test apparently requires addition of adding in white noise of 18 dB above -174.8dBm with receiver input power of -77dBm. The need to do this is really related to interference susceptibility and not the true definition of receiver sensitivity. (editorializing by Rob)
Paul: RX to TX time needs to be short (10usec) for people who are waiting to get on the channel but TX to RX can be 100usec
Also, on etiquette, It is nice to check on occupied hop channels before xmit
Break:
Kamilo paper: AM to PM of amp will cause sidelobes of -13dBc which fail to meet spectrum mask unless amplifier is at 10 dB backoff.
Paul and Kamilo discussion on relative sensitivity of DQPSK vs OQPSK
Paul :I say OQPSK it takes a higher S/N for a BER of 1e-5 than DQPSK.
Kamilo : I suggest that you take a look at Kato's paper.
Paul: offset QPSK can not be demodulated with simple IQ channel. In DQPSK, one can demodulate data before recovering carrier.
Conversation drifts toward improvements Kamilo made in his ISI by using special filtering of data.
Kamilo: cross correlator is used to reduce sidebands which are generated when amplified by non linear amp.
Dean: doesn't the cross corelator reduce the quadrature of the signal?
Kamilo: yes , but it is 30dB down. The delay is two chips.
Paul: The correlator is difficult to do in analog since it has to have memory. 2 chips is a BAW delay line.
Dean: (after discussion with Kamilo) If there is no memory, then it is a problem since the waveform won't cross exactly at zero.
Paul: It seems use of the corelator would reduce the spreading gain of the data. Are you sure with 11 bits spreading code that this scheme has enough gain to meet FCC regulation?
Kamilo: It isn't much of a reduction in gain.
Kato presents paper. Reverse modulation scheme is covered.
Paul: should do carrier recovery at 13 - 16 dB SNR . Is this a decision directed costas loop?
Kato: no, it is different. let us talk off line.

Paul: how many gates are required to do this chip (referring to LCIC)? How much power is required?
Kato: approx 10000 gates, <10mW
Paul: if you have reduced gate count, then doesn't C/N increase.
Kato : no. It is lower data rate
Dean: I don't know of way of demodulating of OQPSK before carrier recovery.
Discussion on adding OQPSK to spec. It appears that Paul, Jan, Dean don't believe it is possible to recover code before carrier recovery.

Paul: We need to focus on the 33 parts of the PHY spec.
Paul: I move that we close all new submissions. Tom T.: I second. the vote is :
8 for : 2 opposed: 4 abstain
We will have vote on the spec items on Wed am. We will go issue by issue and vote by majority to pass.
Adjourn.

Wed am minutes
Paul: Procedure for meeting vote on sub issue:
1) each person who has presentation on issue has 10min.
2) once discussion is opened on issue, the issue has 15 minutes allowed for discussion
3) at end, a vote will be taken on the issue. It will either be decided to table the issue until nov. or else it will be voted on as a spec.

Jan: here is doc. num 93-83r1. We are concerned with defining the issues in it.
15 members present (Ron,Kato,Kamilo,Ryan T. Tom T.,Jan B., Paul S., Naftali, Dean, Rob B., CR Lomba, P. Pirillo, Wayne M., Nathan S., HC Wang)
section 1: correction to slide: in Europe the freq will be 2.4835 for fmax
Nathan: this is not really a item which can be voted on. It was placed there only for referecne.
Paul: vote is taken, item is closed. Item 2? discussion?
Vote on item 2) 11 for ,3 against
Item 2 is passed.
Item 3) 11 chip barker sequence- Kamilo-moves to close, and anony 2nd. 13 vot for
Item 4a and 5) power:
Dean: I think the spec is unclear: it should clearly state the # of levels required .
Paul: the spec is meant to say that there will be a minimum of 4 levels simply because there are two bits allowed for power control. The only real requirement at this time is to provide a means of dropping power to 100 mW or lower.
Vote 13 for 2 against accepring the issue
Item 6) government law: closed
Item 7,8,9 not applicable to DSSS
Discussion on item 10: Receiver sensitivity spec: Proposals:

Name	Sensitivty	Ber	Data rate
Ron	-80	10e-5	2Mbps
Jan	-77	"	"
Naftali	-85	"	"

Paul: this spec implicitly includes the assumption that you will listen befor xmit..
Call to vote: 14 for ,1 against calling to question - Spec to read :
Sensitivtiy of XX dBm at a BER of 10e-5 and 2Mbps, chip rate of 11Msymbols/sec
Vote for rons proposal of -80dBm - 13 for ,1 against, 3 abstain
Item 11) tabled until Nov
Item 12 a)N/A to DSSS 12b) alternate channel rejection: voted to table the issue until next meeting
Item 14: TX mask: Paul: any proposals:
Kamilo: I propose we relax spec at +-11Mhz to 27dBc, to make some margin for QPSK.
Ron:I have some concern about bandedge rejection at 2.4.
Paul: the spec is designed to give -50dBc at +-22MHz.
Ron :This may not meet FCC spec @ 2.4.
Paul: Kamilo, do you have a suggestion
Kamilo: I think it would be better to go back to the original -30 dBc spec.
Item 15 LO stability: Voted on and approved: Drift over temp to remain as stated in 93-145
item 15b. N/A
Item 16 and 17 and 18 to be considered togather (by consensus)
Presentations are made by Jan, Kamilo, and Naftali.
Jan Boer does a presentation: We propose DQPSK as main modulation format. We think it offers features such as easy phase compensation, despreading is easily accomplished before carrier recovery as required by an FCC requirement

Naftali: OQPSK is a disguised BPSK. It offers better performance with differential detection than DQPSK, and also better robustness with respect to frequency offset, also a 1.4 dB lower Eb/No is required for the same BER.
... an abstract of Naftalis presentation follows:

Proposal for DSSS PHY Modulation scheme
Naftali Chaugat, LANNAIR

Outline:
* Advantages of OQPSK
*How to fit OQPSK into existing Tx and Rx hardware backbone

Advantages of OQPSK
* OQPSK is a disguised BPSK
  - It offers Better performance with differential detectors
  - Better robustness with carrier frequency offsets
* OQPSK (chip level) is more tolerant of saturated power amplifiers

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Tx Structure of OQPSK

The technique of transmitting depends on offsetting the I and Q channels by a 5.5 chip delay for a symbol length of 11 chips as in this case. This requires use of a clock running at twice the chipping rate.

OQPSK- Rx Structure

The receiver structure is that of a QPSK demodulator whose inputs are the IF and LO, and whose I and Q outputs are fed into two correlators whose clock rate is 2*Fchip. The correlator outputs are then fed into a synchronizer and demodulation processor. As an option, IF correlator may be used. For each orthogonal BPSK signal, a "0" = - Pi/2 jump, while a "1" = + Pi/2 jump.

SUMMARY

* BPSK like features:
* requires 10.4 dB Eb/No @ a BER of 10e-5 with differential detection
* Improved tolerance to frequency and noise
  (BPSK vs. QPSK; 0.5 usec vs 1usec)
* Readily fits into existing hardware structure
* Eases meeting the Out-of-Band emissions spec while at or near saturated power output
* NO CARRIER RECOVERY
* No processing prior to despreading

Kamilo: Presents waveform showing FQPSK. Suggest DBPSK for fallback modulation scheme. General substance of presentation:

DQPSK suggested by Telxon/NCR has two drawbacks 1) The ratio of the peak power in the RF signal to the average power is high, maybe 6 dB. Since FQPSK has a fairly constant envelope amplitude, the ratio is much closer to 0 dB. The implications invoolved if DQPSK is chosen are that a) the battery drain will be higher for DQPSK than FQPSK, assuming the same output average power is required in order to obtain the same Eb/No at the receiver b) the devices used will cost more since the peak power handling capability is higher for DQPSK than FQPSK .

A second drawback of DQPSK as compared to FQPSK is the bandwidth required per channel. The sidelobe level of the DQPSK signal when fed through a nonlinear amplifier increases a large amount, and the interchannel interference increases as a result. It is difficult or impossible to filter the sidelobes before the signal goes into the antenna. Use of a constant envelope modulation scheme eases this problem considerably.

I support a choice of DBPSK as the fallback modulation scheme. Presents data showing that the required Eb/No for DBPSK is about 12.5dB, while for DQPSK, the Eb/No ratio is about 16dB. The required transmit power is therefore less for DBPSK to obtain the same BER.

Paul: Now begins discussion before the vote is taken. I will take the 1st spot. OQPSK does allow for low cost but does not have capability of code acquisition before carrier acquisition. Also you degrade IQ quadrature with the correlator in your paper (referring to Kamilo), with the result that processing gain is degraded. This scheme will not have sufficient processing gain to pass FCC requirements. The clock rate is twice as high as for DQPSK, and this will burn more power.
Kato: compares QPSK, pi/4 QPSK to OQPSK. Cost of other than OQPSK is increased power drain on battery. 1) coherent demod 2) no carrier receive code word req'd 3) hardware implementation is easy: CMOS 10 K gates, and 150mW 4) very low C/N is required for good BER. As low as possibly a C/N of 9dB for this application. We have achieved a C/N of 4dB in operation.

Dean: 1) Naftali and Kamilo's presentation appear very similar 2) BPSK appears to be standard.
Paul: yes, it is
Dean: could we reduce the number of proposals for modulation scheme to two?
Tom T. : We have a system already designed. Why should we have to throw out what we have for a system which appears more complex and expensive.
Naftali: It is not that much of a change from the system you already have.
Kamilo: I see other advantages of the FQPSK for you. (regarding comment from paul re use of his patented FQPSK): It is an established practice in 802.11 to use licensed technology.
Tom T. I would like to call the question. All in favor of adopting the modulation scheme as proposed by NCR and Telxon should vote yea. RB. I second the motion
Paul : the vote is 11 against, 4 in favor of NCR proposal.
Kamilo: I am dropping FQPSK from my proposal and siding with Naftali.
Naftali: I motion to accept 5.5chip OQPSK 11 chip sequence with BPSK fallback as a 802.11 DSSS Phy
Multiple simultaneous conversations....
Ron: My concern is I haven't seen enough data to know what is going to happen if I choose either scheme.
Paul: Ok, lets take a vote on use of OQPSK.
The result : 8 vote for OQPSK, 6 vote against. A vote against is vote to table the issue until the next meeting. Summary of OQPSK proposal: The scheme counts on shifting the Q channel 5.5 chips further in time than the I channel. The BPSK modulation @ 1Mbps is used in the preamble, and when the MAC data packet begins, the modulation is switched to OQPSK at 2 Mbps.
Paul: I move that we adjourn until November....

Attendance list (as recorded on Wednesday):

Jan Boer	NCR
Jeff Rackowitch	Intermec
Tom Tsoulogannis	Telesystems
Kamilo Feher	UC Davis
Shuzo Kato	NTT Radio Comm. Sys. Labs
Ron Mahany	Norand
Dean Kawaguchi	Symbol
John Penners	USWEST
Chandos Rypinski	LACE,Inc
Rob Benton	Radiance Com.
Han-Cheng Wang	Radiance Com.
Paul Pirillo	NCR
Cipriano Lomba	Univ. Aveiro
Lawrence H. Zuckerman	Intergrated Circuit Systems
Ryan Tze	Toshiba America
Isabel Lin	Toshiba America
Naftali Chayat	Lannair
Paul Strusaker	Telxon
Wayne Moyers	Wise Comm Inc