# Unapproved Minutes, PHY subgroup
# Agoura Hills, January 11-14, 1993

These are minutes of the "PHY" subgroup meetings of IEEE 802.11 in Agoura Hills CA, prepared initially by John McKown and subsequently edited and augmented by Larry Van Der Jagt. Systematic distortions and conceptual errors are undoubtedly present.

**Monday AM, 11 January,** LVDJ presiding

Larry: Let's set the agenda. Our goals will be to

(1) discuss the IBM and Motorola responses to California Microwave's hopper draft and try to narrow the range of possibilities;

(2) formulate advice on error rates to the MAC group and

(3) refine the medium model we started last time in La Jolla.

At La Jolla we decided to form two subgroups, (Sync and Acquisition) and (Modulation and Coding). We may or may not activate these groups this time.

Tomorrow we will hear from NCR and Lace on DSSS, and Motorola and IBM on frequency hoppers. Wayne Moyers and John McKown will attempt minutes.

Ken Biba: Xircom will host a cocktail party tomorrow from 5 to 7 pm.

All: Hurrah!

The group accepts the agenda and agrees the subgroups will not meet before the hopper discussions.

Wayne Moyers: How can we advise the MAC group on error rates without first creating a baseline medium?

Jan Boer of NCR: delivers his presentation on 93-5 which concludes a CDMA case is inferior to FDMA for three 2 Mb channels in the 2.4 GHz ISM band.

Larry: CDMA might have fared better if you had used Gold codes.

Jan: I examined that case too and it didn't help much.

Larry: When will NCR propose a DSSS PHY?

Jan: Perhaps in March 93.

A discussion of Jan's presentation occurs. Topics include the importance of power control, aspects of TDMA and the likelihood of objections from Quaalcomm.

Alan Jacobson: What power law did you use to characterize attenuation with distance?

Jan: 3.5 but the conclusion about the relative merits of the two systems is insensitive to the power law.

Bob Steenberge: Did you address cooperating interferers?

Jan: No.

Chandos Rypinski of Lace: comments on submission 93-6. Opines that omni-to-omni designs are unlikely to provide commercially adequate data rates.

Larry: We must decide whether we want to use worst-case channel models and formulate advice to the MAC group. Should the PHY fragment packets?

Chan: No.

Larry: Should the PHY perform error correction?

Apparent Consensus: No. Yet any FEC should be in the PHY because it is very specific for both medium and implementation.

Wayne Moyers: (to John McKown) Does Altair do FEC on addresses?

John McKown: (should have said) No.

Larry: Why would MACS do FEC?

Chan: Battery drain and cost rule out FEC (full stop). Retransmission is better.

John McKown: Right. You can't error correct your way out of a null.

Larry: makes a (rude) comment about nudging one's PC until a light quits blinking.

A discussion occurs on the tendency of indoor channels, when they are bad, to be horrid. Arc welders are mentioned. The discussion turns to means of characterizing this time behavior for the (assumed) benefit of the MAC group.

Chan: We shouldn't worry too much about welders (implying they won't be present in much of the market).

Larry: Maybe not welders but there are a lot of impulse interferers that you would not expect. Childrens toy helicopters generate serious impulse noise for instance.

Larry: Ideally, the MAC does fragmentation. Otherwise the MAC has nothing to do except control access to the medium.

Chan: That's a lot. The mood of the crowd seemed to be that FEC is not a terrific idea but if it's done it's done in the PHY.

**LUNCH BREAK**

**Monday PM, 11 January,** LVDJ presiding

Nathan Silberman: Anyone having problems with the California Microwave bulletin board should call Bobbi (spelling assumed) at 720-6477. There is now a new "conference", number 5.

Larry: Let's review Rappaport, Seidel and Takamizawa, Trans. Comm. May 1991 and see to what extent it meets our needs. Bob Aschatz of NTIA is making his propagation data more portable. Larry will exploit it in Mathematica.

Nathan: Mathematica costs a lot more than $99 as was reported last time.

Larry: Yes, I knew that was wrong when I heard it. I am distributing prices I recently negotiated with Wolfram.

Larry with John Mckown's assistance led the group through a fairly detailed review of Rappaport, et al, employing transparencies of the article. John pointed out various inappropriate statistical characterizations and retold the Parable of the Glass House as it appears in 92-77. The group considered goals and possibilites.

Among the goals were

(1) accurate modeling of correlated echo phase changes due to motion and

(2) freedom from proprietary data bases.

We provisionally settled on the following loosely-described model, expecting it to be rapidly developed and reconsidered at the next meeting.

Let 0 <= n <= N-1 index N initial scatters and let P(N) be the (Gaussian) probability density describing the building ensemble (there might be different means and variances for each of severalbuilding-types of interest). Similarly, let P(t) be the(exponential?) probability that a scatterer provides delay t (given that it exists) and let P(a) be a density for "effective reflectivity"

a. Then with infinite time resolution the baseband channel impulse response has the form

$$h(t) = k \sum_{n=0}^{N-1} \frac{a_n}{(t_n)^2} d(t-t_n)$$

where d(t) is a delta function. After choosing N and then, for each scatter, a and t, "virtual scatterers" are deployed at specific locations in the manner of Larry's submissions, (which follow Rappaport, et al in this respect). To account for motion of transmitter, receiver or scatterers, we will explicitly model their kinetics and recalculate delays, time slice by time slice. Further, to account for the edge effects made evident by the Glass House Model, we may provide the scatterers with a probability of disappearance or appearance at each time slice. Finite bandwidths of interest will be obtained by convolving the impulse response above with appropriate smearing filters.

For practical reasons, we expect to choose our densities by means ofenlightened intuition rather exhaustive measurement. We thus,

in effect, utilize coherent ray tracing to insure realistic phase behavior.

**Tuesday AM, 12 January 1993,** LVDJ presiding

Larry: We still wish to narrow modulation options and prepare input to the MAC group on channel error characteristics.

Francois le Maut of CER IBM La Gaude presents 93-4 as a "working session" with the intimate involvement of Nathan Silberman so as to facilitate Nathan's incorporation of changes to the hopper draft. Much of this discourse was beyond the capabilities of the recorder but is of course captured in 93-4 and the old and new drafts of the hopper spec. The new draft is expected next meeting. At Nathan's request, a working group will form to produce the next draft. This will include California Microwave, IBM and Motorola, as well as all other vitally interested parties.

There was much discussion of power control. We noted an apparent conflict between the concept of robustness testing, which involves a standard channel and therefore implies a minimum power for comformance, and the concept that very short-range applications should not contaminate the environment and thus reduce user densities. The problem may be restated "should certification for interoperability involve a minimum range regardless of the application?" We distinguished between interoperability and interchangeability, the latter meaning you can replace both ends of an RF link with equipment from another manufacturer and expect communication to continue at the same range.

The discussion inspired Wayne Moyers to move appoximately as follows, seconded by Bob Buaas:

The MAC should reserve a 3-bit field for RF power specification which shall not be required for use by products whose maximum output is 1 mW or less. Allowed steps shall start from a minimum level of 10 mW during negotiation and no tolerance shall be specified.

The vote was FOR=9, OPPOSED=11, ABSTAIN=6. The motion failed.Several thought the various questions might be separated.

**BREAK FOR LUNCH**

**Tuesday PM, 12 January 1993,** LVDJ presiding

Officially, Francois is still presenting. Consensus seems to favor a spec on absolute power levels for out-of-band emissions. We discussed scramblers, the length of preambles and temperature ranges.

Francois concluded and Jim McDonald of Motorola presented 93-11. Overall, Motorola argued on the side of hardware simplicity and the deletion of several line items in the Cal. Micro. draft. Motorola proposed binary GMSK.

Larry: Agrees that the .39 premodulation filter is necessary to meet the FCC emission mask if you want to go 1 Megabit/second but

notes that we should plan on a bit error rate of around 10^-3 if we adopt this approach.

Jim: It will be better than that.

Larry: I'll get you some references I have recently been examining and then maybe you'll change your mind.

Some: 1 Mb is too slow for the market.

Others: No it isn't.

**Wednesday AM, 13 January 1993,** LVDJ presiding

Larry: I'm distributing three references on GMSK modulation and demodulation. I want to resolve as many issues as possible, especially modulation type and power control.

There was a discussion on whether a higher hop rate interferers less or more with another system (no conclusion). Should the fact that a system can execute more hop rates than the spec mentions make it noncompliant? Consensus: no. We assume 1 frame per hop.

Colin Lanzl: We must consider the effects of hop rate on the MAC.

Jim McDonald: If we allow more than one hop rate within the spec, will we specify how they're to be automatically coordinated? That sounds incredibly complex.

Various: No it isn't.

Jim: wants the spec draft to explicity show we presume automatic management of the hop rate, if we in fact do.

Wayne: Agrees.

Jim: Wants us to teach how to do this.

Wayne: We must meet FCC equal-visitation requirements.

Tom Siep: Since the maximum hop rate is set by the maximum frame size, let's just note this and move on to frame/packet/fragment size.

Various: Where does transmission size get set? Where is fragmentation done? Bridges fragment now.

Tom: MAC-layer bridges affect upper levels. Fragmentation must be done higher than the PHY.

Larry: Normally it's a link level function.

Colin: Let's bracket the worst and best cases.

Nathan: At the cost of overhead we can hide repacking from the upper layers.

Various: Maximum transmission size is determined either by efficient compatibility with upper layers or by efficient use of the channel.

Nathan: We have an access protocol so interference (collisions during hops) is a minor issue. I am worried about access time.

Tom: Why should hop rate affect access time?

Nathan: Do we need a range of hop rate?

Jim: Let's just have one.

Bob Buaas: These are MAC-level issues or higher.

Wayne: We should do our own reasoning before communicating with the MAC group. -- wants to avoid over-simplifying --

Larry: We can and must consider MAC issues.

Bob: speaks for early involvement with MAC group.

Someone: wants to take partial information to the MAC.

John: -- speaks for simplicity --

Mel Farrer: -- speaks for enough complexity to allow flexibility; wants windows (ranges) for parameters --

Colin: How does the FCC measure visitation?

Nathan: They average over 2 seconds.

Nathan: They are reasonable men who may change their procedures if we make the case.

Bill: Agrees.

Here section 247 is located and read aloud (and later distributed).

Wayne: At 2.5 hops/sec, you may have to keep track of frequencies you've killed until they time out and are reaccessible.

Various people discussed what the rules mean. Larry proposed a structured series of votes. These votes are intended to be used !**ONLY AS LEADING INDICATORS OF FUTURE DECISIONS!**

Larry distributed his 3 references:

Simon & Wang, VTC Nov 84;

Korn, J. Sel. Areas Comm., Apr 92;

Tshung et al., Trans Comm Nov 86.

Larry also reported on his continuing communications with Wolfram Research regarding a bug in the "notebook" reader for Windows.

Bob Buaas and Rob Carl requested the votes be conducted by secret ballot and we extended him this courtesy.

Motion 1: The 2.4 GHz frequency hop physical layer draft specification shall require exactly 1 hop rate.

YES = 10, NO = 12, ABSTAIN = 1: Motion 1 failed.

Motion 2: The 2.4 GHz frequency hop physical layer draft specification shall require exactly 1 power level.

YES = 7, NO = 16, ABSTAIN = 0; Motion 2 failed.

Motion 3: The 2.4 GHz frequency hop physical layer draft specification shall require exactly 1 data rate.

YES = 8, NO = 14, ABSTAIN = 1; Motion 3 failed.

Thus the PHY group is on record as favoring multiple powers, hop rates and data rates but has not yet considered whether they should be mandatory or optional.

Motion 4: The 2.4 GHz frequency hop physical layer draft specification shall require transmit power level control above a TBD level of transmit power.

YES = 15, NO = 6, ABSTAIN = 1; Motion 4 passed.

Motion 5: The threshold level referenced in Motion 4 shall equal 1 mW = 1 votes, 10 mW = 8 votes, 100 mW = 11 votes; the threshold shall be 100 mW.

Motion 6: The 2.4 GHz frequency hop physical layer draft specification shall be able to transmit at least a TBD level of power to conform to the standard.

YES = 21; NO = 1; ABSTAIN = 0; Motion 6 passed.

Motion 7: The level referenced in motion 6 shall be 1 mW.

YES = 15, NO = 6, ABSTAIN = 0; the level shall be 1 mW.

Motion 8: When power control is required, then the number of bits provided to specify transmit power shall be

1 bit = 2 votes, 2 bits = 9 votes, 3 bits = 5 votes, 4 bits = 1 vote; TBD = 1 vote; 2 bits shall be provided.

**BREAK FOR LUNCH**

**Wednesday PM, 13 January 1993**, LVDJ presiding

Nathan: Hop rate is important and should be optimized. It's too early to vote on hop rate.

Larry: Why have more than 1 rate?

Burchall Cooper: It affects sync acquisition.

Nathan: It affects throughput.

Jim: You may want to use it to adjust the data rate.

Burchall: We don't need an adaptive, dynamic hop rate --- we'll just set it according to the application.

Various: Does the MAC tell the PHY when to hop?

Nathan: No.

Larry: The IBM MAC is the only one which controls hop.

Wayne: asks for comment on chaining hops. (gets none)

Burchall: There is an alternative: define a fixed number of sequences such that one message defines the hop sequence.

Various: You can throw out a few bad channels so long as you load 50 evenly.

Larry: Shall we pursue something else besides the number of hop rates?

Burchall: It should be chosen from an approved set.

Larry: Should it be fixed for a given BSA?

Burchall: Yes.

Bob: Shall configurable mean set by the management?

Various: Configurable should mean nonadaptive.

Nathan: Hop rate should be set at registration time.

Various: Peer-to-peer networks require 1 node to emulate an access point.

Wayne: We may be losing the ability to adjust hop rate to the environment.

Nathan: Should we tie hop rate to data rate?

John: If it's all manual then when you move to a new BSA you may lose service.

Wayne: Someone has to call the shots when a new portable enters a BSA.

Tom: We voted it can be changed. Now the question is shall it be through the MAC or manual.

Someone: Surely we don't want to impose adjustments on the user.

Various: --agree strongly.

Motion 9: The hop rate shall be configurable in the MAC but fixed within a given BSA. It does not have to adapt.

YES = 20, NO = 1, ABSTAIN = 1; Motion 9 passed.

Motion 10: The MAC will tell the PHY when to hop.

YES = 10, NO = 12, ABSTAIN = 0; Motion 10 failed.

Nathan: This implies the MAC is responsible for sync. Was it agreed yesterday that the MAC tells the PHY when to transmit?

Larry: That is the very definition of a MAC.

Tom: The MAC doesn't know how much time is left in a hop.

There occured here a discussion on various aspects of the fact that hopper (and other radio) PHYs have a periodicity not present in wired LANS and thus arises the question "How are clocks in the MAC and PHY related?" Conceivably, one might feed a master clock up or down across the interface or provide FIFO buffering so as to maintain independent clocks. Various conceptual oxen get gored.

Don Johnson: Don't forget sleeping nodes must keep track or resync.

Burchall: And remember the logical and electrical interfaces need not be the same.

Larry: There is (most likely) no physical MAC/PHY interface.

Motion 11: The PHY shall not fragment frames/packets supplied by the MAC.

YES = 16, NO = 3, ABSTAIN = 2; Motion 11 passed.

Mel: This is a burden on newcomers.

Wayne: If you have a short message people can enter on the rest of the hop.

Motion 12: The 2.4 GHz frequency hop physical layer draft specification shall require the MAC to maximize the use of each hopinterval.

YES = 15, NO = 4, ABSTAIN = 3; Motion 12 passed.

Motion 10 Again: YES = 13, NO = 5, ABSTAIN = 0. Motion 10 passed.

**Thursday AM, 14 January 1993**, LVDJ presiding initially.

Larry: Let's consolidate gains and set an agenda. I'll leave after the 10:00 break and Bob Buaas will preside.

Colin: More votes on the decision tree?

Larry: -- expresses concern about the FCC's mask and how we should use the issues list.

John: Is more work required to define a message to the MAC group regarding channel error rate?

Tom: 1e-3 is too low to be useful. We should not consider such ranges.

Here occured a discussion of means to characterize the channel errors. It was inconclusive. Some even wondered if there was any way the MAC group could benefit from quantitative information, even if it could be created, and preferred a simple plea "to set mood." Larry drew a tree of decisons embodied in the 12 Motions.

The goals set for the next meeting were (

1) detailed analysis of modulation techniques,

(2) continuation of work on thechannel model and

(3) extention of the "decision tree".

John reviewed the status of the channel model.

**Break** - During the break it was determined that the Wolfram Research problem was one of font incompatability between Mac and Windows environment. The windows version is now on Mathsource as 0204-534-0033.

Bob took the chair. There was more discussion on assuming a PHY-dependent MAC or MACs in order to design a PHY. That is, we would consider the MAC/WHATEVER interface and push appropriate functions across it as necessary.

Nathan: In 92-140 we formally approved a phy-independent mac.

John: Surely we should first identify functions and then second place them.

There occured a discussion between Nathan and Tom about differences between PHYs but I didn't capture it.

Bob: -- appeals for discussion of sync and acquisition.

John: -- appeals for discussion of diversity management.

Francois -- diversity management goes in the medium-dependent layer of the MAC.

Bob: -- wants Nathan to contribute a MAC.

Nathan: -- would rather work on the PHY spec first.

Bob and John resolved to investigate e-mail reflectors and news groups as aids to 802.11 discussions between meetings and document distribution and maintenance. There was some additional discussion regarding physical versus logical interfaces.

Nathan: -- again expressed concern that votes were being taken too early.

**FINAL ADJOURNMENT OF THE PHY GROUP**

Note: These Decision Trees represent only a leading indicator of the future direction of the group and are subject to change