**Physical Layer Group**
**Meeting Minutes (Minneaolis MN)**
**Prepared by: Orest Storoschuck, General Motors**

Date: July 8, 1992

John McKown presented contribution IEEE 802.11/92-70, Toward a Proper Model of the Portable Indoor Microwave Channel.

- at 18 GHz rf is similar to light
- irregular shapes result in scattering of a plane wave
- flat shapes will reflect plane waves scattered in various directions
- mirrors will result in a scatter of plane waves and deliver power not badly at a far distance
- irregular shapes just scatter so will not deliver power at a distance very well
- important to not use spatial averaging of the channel since this decorrelates phase and amplitude of each discrete path
- walls appear flat and large and reflect very well
- receivers are embedded in a frequency dependent standing wave pattern
- discrete echoes are highly correlated in both time and space and equalizers can exploit these facts
- better to design to an average over an ensemble of channels rather than a spatially averaged channel.
- ray tracing gives a good representation of channel, much better than average type simulators which hide detailed structure of standing wave patterns
- ray tracing does not hide the phase amplitude location time relationships, it accounts for multipath while average or power law type simulators spatially average and do not account for multipath
- several slides were shown of the ray tracing model output showing the standing wave pattern and the effects of omni and directional antennas
- a 120 degree sectional gave larger feature size and better delay spread while a 60 degree eliminated the floor bounce. This is intuitively explainable since the sectional will see less paths than the omni

The following is a list of possible issues arising from the presentation:

1) Should ray tracing be used for simulation/representation of the channel rather than statistical methods?
2) Does diffraction matter at low frequency (causing scattering) or is ray tracing a sufficient representation
3) For ray tracing, how many reflections of the signal are needed? John used two bounces while Michael Masleid used many more. This is highly related to the coefficient of reflection used

Bob Achatz presented contribution IEEE P802.11/92-83, Wideband Propagation Measurements for Wireless Indoor Communication

- Bob presented the results of the measurements of several different types of indoor environments
- a question came up regarding typical coefficients of reflections, Bob stated that S. E. Alexander has listed the values for various typical surfaces in Electronic Letters. He will attempt to acquire a copy with permission to copy for distribution
- possible issue: what doppler speed should be used for repeating impulse response measurements, currently used 5 Hz, how fast will equalizers need to adapt particularly in mobile applications

Bob Buaas presented contribution IEEE P802.11/92-82, Direct Sequence Spread Spectrum PHY

- Bob used format of table in Nathan Silberman's Frequency hopping paper
- **issue**: he hopes a standard format will be adopted
- a few tens of microseconds are required to acquire clock and also for changing from receive to transmit
- appropriate bit error rate is 10 e-7 rather than 10 e-6 for channel error rate, can improve by one order at next layer up reasonably rather than push for an order of two improvement
- power control can help the near/far problem
- **issue**: radio will see all sorts of BER, so at what level should it block the data, is it 10E-7, the answer is no, maybe it would be better to back off the bit rate
- **issue**: what should be done when degradation occurs
- there is room to improve BER with coding, FEC etc.
- desire to make as much improvement to BER at PHI rather than MAC
- why spread only 40 MHz when you can go 80, practical considerations such as clock speed, power consumption, high speed needs more power, also there is a move in pcn to 24 Mchip/sec in 40 MHz, also some potential to frequency channelize or ability to move around narrow band interferers
- why only 1.25 Mbps, number of factors to be discussed at a later time
- SAW vs VLSI, easier to go VLSI, allows changing your mind
- there are programmable SAW correlators but they are expensive and not readily available
- 32 chip sequence, is there a need to synchronize at cell level? no, synchronize at cell level only at start of each transmission
- **issue**: how much preamble is needed for synchronization?
- it would be nice to have a clear band for direct sequence, but this is not the case so **issue**: how much interference must we be able to tolerate?

K. S. Natarajan presented contribution IEEE P802.11/92-84, Selection Criteria for Frequency Hopping Pattern Set.

- **issue**: to get desirable interference characteristics, autonomous cells should chose standard patterns
- interconnected cells could sync patterns but autonomous cells can not, which if allowed to chose patterns with no rules can result in unacceptable interference
- interference can be improved by selecting from a "good" set even though they are unsynchronized. In the 2.4 to 2.483 GHz range the number of frequencies in a set "n" is 75<= n <=83

- there are 5 criteria used in selecting sets

1) equal use of channels
2) direct hits
   (2 adjacent cells using same frequency at the same time)
   - can chose a pattern which with any phasing can always have the same number of hits per sequence, uniform, well bounded
   - random pattern can have varying number of hits per sequence
   - both have the same average but random pattern has much variation while the "good" pattern is constrained and predictable
3) Adjacent Channel Interference
   for any pair of FH patterns to be on adjacent frequency channels at the same time, a good pattern is always 2 at worst case
   randomly selected patterns will vary dramatically from 0 to a large number
4) Temporal Frequency Diversity
   want to have hop to hop to be separated by some lower bound constraint so that hop to hop are not adjacent
5) Avoidance of Contiguous Bad Hops
   want to have bad hops from direct hits or adjacent channels to be spread out through the sequence to ensure that if communication is lost for one hop that it is regained in the next one and not lost for a number of adjacent hops

- how many patterns are there? A few 10s of good patterns are available, should be at least 20
- will use algebraic methods rather than sequential search because it is felt to be the only practical approach
- equal use of channel, over what period of time? 30 seconds FCC regulations used as a guide
- average power transmission, is it per user or everyone? Patterns are always the same, power is not considered.
- can you synchronize hubs to avoid problems? FCC does not allow it but they are receptive to ideas, they are attempting to prevent discrete frequency usage, become uniform equally distributed interferers
- you can not have explicit cooperation between different lans, but you might be allowed implicit cooperation by choosing from the "good" set of sequences

- same algorithm with same criteria can be used in other countries
- FCC will not allow synchronization even if cells are connected, they do not want to allow many hoppers in the same frequency. There is a strong possibility that they will not allow the "good" set of patterns since it will allow more secondary users

Kwang-Cheng Chen presented contribution IEEE P802.11/92-80, Performance Comparison Between Direct Sequence and Slow Frequency Hopped Spread Spectrum Transmission in Indoor Multipath Fading Channels

- this comparison was for a plain system with no equalizers nor diversity
- direct sequence is widely accepted
- FH, slow change of frequency is attractive, fast change is not used commercially and is not trivial
- hybrid systems are not used commercially and might not be viable
- Raylegh fading basically applies when there is no direct path and lots of small multipath arrivals
- Rician fading applies when there is a direct path
- modulation chosen for direct sequence was BPSK, maximum length sequence
- modulation for FH was BFSK
- different modulations will still provide almost the same results
- in figure 6 when L<=63 we can't resolve multipath
- conclusions:
  1) DS is better at high transmission rate
  2) slow FH is good at moderate transmission rates
  3) indoor fading is strong, both DS and SFH have a hard time overcoming this problem
  4) channel is probably somewhere between Raylegh and Rician
  5) there is a desire to have a statistical model but there is the problem of how much direct path actually arrives and how many paths arrive in one chip time
  6) there really is not a good model available
  7) a statistical model is not that good, probably better to use n "typical" channel responses
- **issue**: do you use statistics or do you use impulse responses, if impulse response do we need time and space variant from measured or "ray trace" models
- need to make sure that models match reality
- HDTV uses actual cases rather than statistical models

After the presentation of contributions considerable discussion occurred on the topic of conformance testing

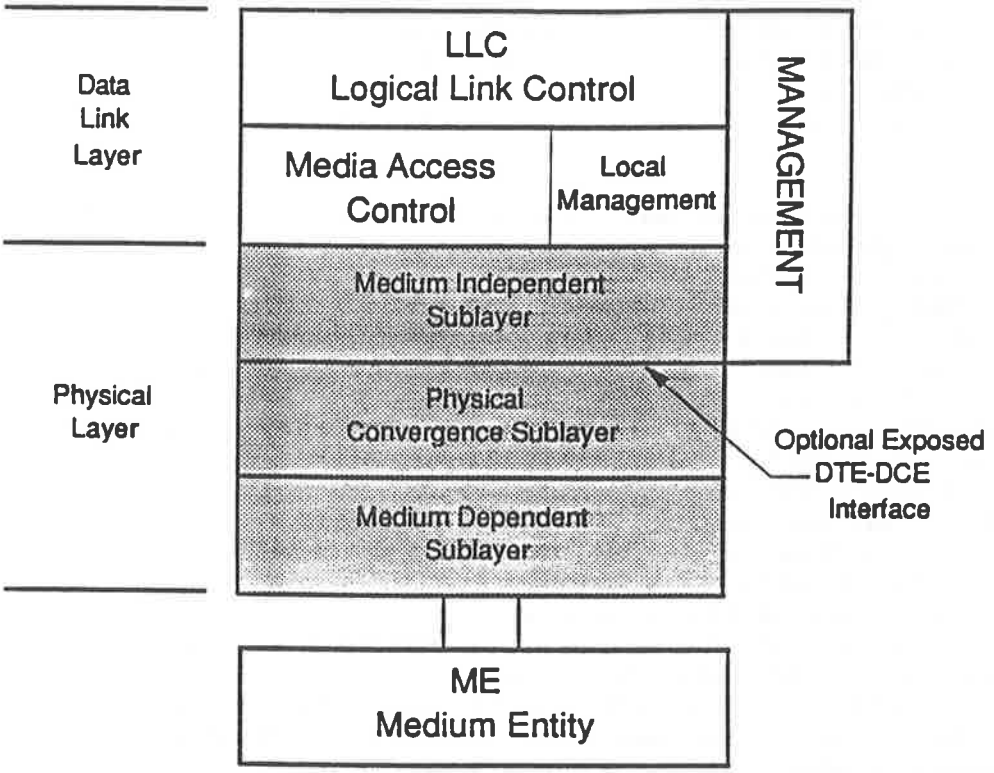
- **issue**: conformance testing, test channels need to be defined, but they need to represent a useful market, need to define what conforment channels are
- **issue**: what is the area of coverage

- need to define a set of signals in the presence of the receiver which the receiver must be able to operate in
- the standard which we are developing must be conformance testable
- how do we coexist with other standards which use the same bands

The next task undertaken was to compile a list of managed objects which the MAC group could take advantage of

- power level TX.req and RX.ind
- name the primitives PH_INFO.req and PH_INFO.ind
- propose to send a PHY type and an enumerated list of options so as not to be locked into a current level of technology
- should have a retry indicator with a retry number
- channel diversity (uses emitter n) (which emitter is active)
- need default values
- need a standard way to say not supported
- a PHY id indicating a particular path which could contain the options used
- tx clock, should there be one?
- is a transmit on needed or use a RTS/CTS or a push to talk
- **issue**: who generates the preamble
- MAC may wish to tell PHY to sleep or maybe use a TX enable, RX enable sleep mode and possibly a disable
- is there a need for full duplex/half duplex
- what happens in sleep mode, do you lose parameters?
- should a sequence number be attached to MAC PHY exchanges? The issue becomes where the functionality and knowledge of the message source, correctness etc. resides, in MAC or PHY

To aid in the discussion the following model was presented




After much heated debate Rich Lee moved to accept this model, Roger Samdahl seconded. Mike Rothenberg offered a friendly amendment to extend the SMT down to the PHY Layer Convergence and Medium Dependent sublayers. Rich accepted.

Paul Eastman called the question 21 yes, 0 no, 4 abst.
Vote 7 yes, 11 no 9 abst.

Paul Eastman moved to vote on original model, Bob Buaas seconded
18 yes, 0 no, 9 abst.

Nathan Silberman presented a table of objects under three headings of PHY, either PHY or MAC, and MAC

| PHY | EITHER | MAC |
|---|---|---|
| Rx on/off | | |
| Tx on/off | | |
| Power level control | Power level decision (dscn) | |
| diversity | | |
| synchronization | | |
| spread spectrum carrier | | |
| bit | | |
| packet | | |
| clock delivery | | |

| | | |
|---|---|---|
| clock recovery to MAC | | |
| signal quality | | signal quality threshold |
| preamble type | | preamble type dscn<br>packet length dscn |
| modulation/demod | | |
| code/decode | | coding type dscn |
| channel quality | | which channel dscn |
| setting of channel | | |
| carrier detect | | |
| signal valid | code selection | |
| jabber control | | |
| sleep mode | | sleep control |
| data rate fallback | | |

Jonathon Cheah presented a PHY independent interface which is described in a separate contribution. The main feature was not needing to specify the objects ahead of time or the functions the MAC needed to perform to control or on behalf of the PHY. These would be loadable on initialization and be phy defined allowing total independence of the MAC from the PHY. A concern was mentioned regarding how a MAC would control an object in the PHY which was not specified by a PHY defined function in the MAC since the MAC would not know how to get at the object.

Following the presentation, an effort was made to identify capabilities that all PHY types could provide to the MAC

- channel quality indication and request
- power: rx power ind, tx power req.
- diversity: rx ind. diversity option in use, tx req. use of diversity option
- signal quality ind.
- data rate ind. and req.
- **issue**: communication between peer MAC layers (local and remote) to indicate remote signal quality req. and ind
- background level ind.
- noise spectral density ind.
- jabber ind.
- sleep mode ind. & req.
- standby mode ind. & req.
- signal valid ind. & req.
- squelch ind.
- phy ready ind.
- in frame ind.
- alignment error ind.
- channel busy ind.
- health status ind.

Having compiled a list of possible candidates, each was examined in detail.

The candidate of number of channels was discussed

- if you have requirements for more than 1 channel, you will rule out inexpensive IR PHY
- if you allow only 1 channel you will eliminate MAC's which need more if only 1 MAC type is allowed
- is it possible to tell MAC that PHY has more than 1 when it only has 1, this will not work for MAC's which use one channel for data and one for access
- PHY is usually not scalable
- **issue:** should there be a PHY to MAC indication of how many channel there are available

Mike Rothenberg: motion - allow n=1 or more channels
2nd: Payne Freret
Rich Lee calls question y n a
19 0 2
motion reworded - all PHY's will support one or more channel operation, operation on more than one channel is optional
y n a
17 1 3 Passed

- **issue:** should PHY always report RX channel currently used

The candidate of Tx power req. and Rx power ind. were discussed

- Mike Rothenberg: Tx power needs a number of levels to select form req. and just a Tx power ok ind. while Rx power can be go/no go or number of levels
- Nathen Silberman: if Rx levels need to be quantified, it will add cost

Payne Freret: **MOTION - All PHY's will report receive signal strength with one level of resolution with the packet, multiple levels are optional**
2nd: Orest Storoshchuk
Mike Rothenberg calls question, Keith seconded
y n a
21 0 0
Vote on motion:
y n a
19 1 0 **Passed**

The candidate of Diversity was discussed

- if there is more than 1 thing PHY can do on a receive basis, but might be better to stay with only one on transmit, what should be done
- diversity gives better chance at using the same channel
- changing diversity does not guarantee improvement and may make things worse
- Bruce: consolidate redundant signal quality
- Mike R.:important to keep distinct
- Larry V.: we should stop and go to next candidate

Mike Rothenberg: **MOTION - Move signal quality to a necessary status**
2nd: Paul Nickolich

- Payne: signal quality is nice, but not necessary, especially in IR
- Mike R.: it is needed to distinguish soft and hard decision systems using signal quality
- Payne: don't see the point
- Mike R.: becomes a signal present indicator
- Whim: signal quality is ideal to control "data rate" (that is data volume/time)
- Dave Leeson: taking action on just signal quality is not good enough
- Payne: agrees with Dave L.
- Roger: important in IR to determine ensemble signal quality
- Rich Lee: retain both signal quality and valid data indication
- Dave L. agrees with Rich that having both is important, must use it properly (not sure MAC is a proper routing point)
- Mike R.: this is actually relative to varying bit error rate
- Mike R. calls question - fails
- Dave L.: likes signal quality and would like to have a strategy to respond
- Nathen S.: useful to know signal to noise Eb/No
- Mike R.: amend signal to modulation quality
- Larry: in DSSS computation of modulation is very intensive
- Payne: valid, but look at the scope - low cost systems. Don't make this a requirement of every PHY
- Dave Waskevich: signal quality indicators per Keith's suggestion are excessively redundant
- Jim R.: getting into too granular of a discussion
- Keith: lets table discussion

  Larry V. lets not vote, we lack representation but instead think about more than one phy in 2.4 GHz rf band

The topic of more than one PHY in the 2.4 GHz band was briefly discussed

- Larry V.: there is a benefit to have both DS and FH, politically there are many intelligent people on both sides. In the ISM band we must put up with all comers anyway
- Nathen: let the market decide

  Dave L.: there already are multiple PHY's, makes sense for both and low power PHY's too

Larry V. closed meeting for the day due to late time.
Date: July 9, 1992

The topic of more than one PHY in the 2.4 GHz band was discussed

- Larry V.: there is always the concern of having a standard with too many options, but we have two main ones of DS and FH, both will be implemented regardless so we are better off if we know what they look like rather than have them be proprietary
- Dave: since regulations for both exist, set standards anyway, feels strongly that it will weaken our position if we make a choice now. In trying t get emerging technology

frequencies, need to make a recommendation in frequency, should have 2. A 15.239 spec is needed too.

- Jan: if 2 PHY, need to make sure they can coexist
  Larry: other PHY's will be there anyways
- Jan: preferable to have only 1 if can not get coexistence
- Steve: too hard to select only 1 PHY,can't even compare, only on a theoretical basis, practical implementations may overcome expected problems, don't commit to 2 standards but commit to 2 proposals, maybe FH in one band, DS in another
- Rich: picture some office having radio LAN's from 2 standards, phone and IEEE, good to have 2 IEEE PHY's to have a better chance that 1 IEEE PHY will survive the phone radio PHY.
- depends on implementation
- Larry: can go a long way to define implementation so both FH and DS can coexist
- Dave: problem is that .11 is not alone in the ISM bands, biggest problem is other interferers, not other .11 guys, in ISM bands certain interference situations favour DS or FH differently in different environments, we should focus effort on emerging technologies (ET) bands
- Steve: keep in mind regulatory requirements have different specs for different countries, need expertise, don't want to make hard decision, if we could agree on 1 PHY it would be great
- John: what is history of .11 on interoperability, why would in one frequency band we have non interoperability between 2 different standards
- Larry: the problem is sometimes FH is better, sometimes DS is better, different markets have different requirements. It is not too bad if two different market applications can't talk with each other
- Nathen: need 2 different PHY's, need to let market decide - don't have enough representation here of both types
- Dave: history shows jamming margin is important - LAN's are secondary users - anti theft are narrow band high energy interferes - regulations have changed so DS vs FH has changed - bottom line, different people committed high investments in both - people are not comfortable with interferers - need to focus on ET bands where there should be only 1 PHY
  **MOTION - IEEE802.11 will support at least the 2 PHY's allowed by FCC in the 2.4 GHz band**
  2nd: Payne
- Rich agrees with the motion - interoperability between the 2 PHY's was never a goal at 2.4 GHz - we can move furthest and fastest with 2 PHY's - it is more work, but will get to end faster - ET bands will be available for regulatory input next year, but 3-5 years before ET bands have products

- there are divergent applications for DS vs FH, market will decide - interoperability doesn't need both PHY's to talk with each other
- Jim: calls question
  2nd: Payne
  y n a
  13 4
  vote on motion
  y n a
  17 1 5 **Passed**
- Steve: important to include UK and Japanese regulations - need to express the PHY to operate under other countries regs - so not to be isolated - need to keep momentum up in other countries,
  **MOTION - add other national and regional administrations**
- Jonathon: we are assuming that DS and FH will be allowed - should be amended .11 will also support PHY's allowed by other bodies - the 2 PHY's are specific to some area
  teve: **AMENDED MOTION - it is the intention of the committee to monitor international regulations and accommodate them where possible**
  2nd: Douglas
- Yasu: people recognize different solutions for different applications, can we recommend which PHY fits where better?
- Jan: do the PHY's coexist
- Larry: would be good if we tried to accomplish coexistence
- Rich: calls question
  y n a
  14 2
  vote on motion
  y n a
  15 1 6 **Passed**
- Rich: **MOTION - form PHY ADD-HOC groups, one for each technology (2.4 GHz DS, 2.4 GHz FH, IR) provided we have volunteers to participate**
  2nd: Nathen
- Rich: this is an attempt to work in parallel to get done sooner
- John: is it proper for subcommittee to make this motion?
- Larry: Plenary needs to bless
- Mike: important step forward to split, should ask plenary - what do we call the groups? - each should have their own par - better to have separate groups for IR vs Radio
- John: what is wrong with just submissions - why need groups?
- Rich: the intention was not to subdivide PHY group, but to allow periods of time for coordination
- Larry: add hoc would be ok
- Roger: would be nice to have straw man for each PHY for next time
- Larry: that would be good - could find what is common
- Dave: called question
  y n a

12 3 6
vote on motion
y n a
17 0 4 **Passed**

ADD HOCK list

IR: Roger Samdahl, Dave Waskevich, Rich Lee, Orest Storoshchuk, Richard, K.C.Chen

FH: Nathen Silberman, Dave Leeson

DS: ????

- There were also possible channel contributions for next meeting from Bob Achatz, John McKown, K.C. Chen
- Mike: would like to make a motion to take Jonathan's MAC-PHY interface as a motion for plenary
- Larry: not yet a document to vote on
- Rich: needs more fleshing out
- Nathen: likes Jonathon's idea, but too soon to endorse it

X **Meeting Closed**