MAC/PHY Joint Meeting Minutes
Wednesday, March 11, 1993

The meeting was called to order by Vic Hayes at 8:35 AM. Carolyn Heide secretary.

(1) Announcements

Document Distribution - via pigeon holes managed/assigned by John McKown. Please register with the 802 registration office if you haven't (and pay). Please sign the 802.11 attendance book each morning and afternoon.

Non-.11 Meetings- 11 AM Tutorial

A copy of the Attendance List will be circulated, please proof read your entry carefully.

Security

There is Federal Wireless User's workshop scheduled in May. Anyone wishing to attend or make a presentation contact one of the people mentioned in the handout announcement which was in the pigeon holes.

(2) Presentation of Submissions

MAC Interaction with a FH PHY, P802.11-93\13, by Phil Belanger, Xircom

There has been a lot of PHY progress on agreeing on a frequency hop (FH) PHY layer. In January there was a discussion about how MAC and PHY would interact on a FH'er and little was agreed upon or settled. These presentation touch on assumption that people seemed to have made and agreed on.

Hopefully, we can use this as a discussion vehicle and make some progress on MAC interaction with frequency hopping PHYs at our next meeting.

Discussion:

Tom Baumgartner: disagrees with point 4. Possibly there is a concept here that the PHY does not include software and this has to be a software function. This is not a good assumption.

Larry van der Jagt: PHY including software is not a concern. The only one who has the information to determine when to hop and to adjust hop times is the MAC. A PHY group member has been charted to present how to manage hop times to the MAC group.

Tom B: it's true the PHY doesn't know what the error rate of packets is. The MAC should say to the PHY "I'm not getting good data make an adjustment".

Phil: you have to be in sync with other stations when you make this decision.

Tom B: in direct sequence the PHY gives MAC something like a CTS signal and the FH could do the same.

Bob Crowder: the point says the STA has this knowledge, so this discussion is irrelevant. These things that you call MAC may be side management things. Let's think about the function to be done and not who has to do it.

Dave Leeson: but it is not sensible to require decoding of the packet in more than one place.

Phil: it is important that the MAC group has to deal with this somehow - the PHY group is making progress and MAC has to get ready to support this.

Chandos Rypinski: this is relevant - we are trying to decide if MAC is impacted by an FH PHY. Decoding packets is a religious point - the contents of messages between delimiters must be done in the MAC. If it has a response to what was in there it sends it down to the PHY. The MAC must not know anything about the hopping time - generic indication between the MAC

and the PHY can take into account hopping and other PHY items. If it is a management function we have the same problem because the PHY won't have links to management. It will get management from the MAC.
Peter Chadwick: if all stations must maintain sync - do different networks get slipped in phase, although each is in sync in itself? What about the accuracy of integral clocks?
Phil: different BSS's in the same ESS are not assumed to be in sync. They are within the BSS.

Chan: objects to point 5, without explanation. Feels this is not necessary.

Phil: in point 6, this field could be available for different use according to PHY type.
Chan: alternative: in an MPDU there could be a specifying parameter, like channel number. It is impossible to make a MAC that knows about hop and hop times. It is possible to have a download able parameter - in the message is a pointer to what the pattern is. There is a set of parameters and a specification of that set is in the MAC frame.
Phil: disagrees that it is impossible to make a MAC that knows about hop times.
Chan: maybe not impossible, but it is unwise.
Vic: is this a field in all MPDUs.
Phil: yes - it could be a generic field that has PHY specific information in it. Different PHYs put different information in that field - such as antenna selection or power level.
Wim Diepstraten: there are other ways this could be done. When the STA needs timing, it doesn't need to be in every MPDU.
Larry: MAC to MAC communication is going to have to have PHY specific information. The information is correlated to who sent the information, so it must be associated with the source address and that must be in the MPDU and not decoded by the PHY.
Peter: there needs to be some way in PHY of knowing how to determine things like what antenna to use. A degree of intelligence is needed somewhere or there will have to be a training sequence every time a STA comes up.

Richard Ely: in point 7, if you visit other frequencies, this conflicts with sleep - when you wake up they may have gone to another frequency.
Phil: you must be able to change to another frequency for many reasons (like roaming). The PHY must allow the MAC to tune to some other frequency not in the hopping sequence.

Dave L: with respect to point 8, there should be a group of generic or primitive commands, do a, do b, etc. and the PHY interprets these to be do x action according to what PHY it is.
Phil: if the MAC says do a, is it going to be logically the same thing across PHYs?
Dave L: it could be a null command for some. It would make the MAC more generic. Reference Jonathan Cheah's paper on the parametric MA/PHY interface [sec: doc 92/99].
Chan: there can be a generic set of commands and range of values.
Bob C: in the PHY group we are working on specific proposals and trying to form commonality. A common proposal for FH and for DS and comparing them will work better than wasting a lot of time trying to form generic versions of these specific things for FH talked about here.

Phil: with respect to point 12, note that sleep mode and FH are two completely different functions. Power consumption has a variety of requirements (maybe application driven) which should not be tied to hop times.
Dave L: quick initialization when going from one BSS to another when roaming - is there a way that the MAC can be able to advise the PHY so that a full search not be required when roaming?
Phil: perhaps the APs could help with information in that regard.
Dave L: that would be useful information in the MPDU header - info about other BSS's.
Phil: if you can make roaming work in an FH PHY you can probably make it work anywhere.

Wim: accuracy of timers needed for the function in point 13.x

Phil: depends on dwell time. Have to guard against a system where the hop timing information is in the MPDU and STAs copy that into there own timers. What happens in that case when someone comes in with a rouge timer? Don't have any great idea about timing - maybe a millisecond clock is OK with a 100 millisecond hop size.

Tom B: in the conclusions you said keep the PHY "simple" - do you mean low cost? Software does make it complicated.
Phil: doesn't want to have to have a processor. Would like to silicon the whole thing eventually.
Tom Siep: in Leon's presentation yesterday he had a drawing [sec: doc 93/28 slide 12]. This is different from what you just said. This drawing is consistent with a drawing already in the draft standard.
Bob C: points 16 & 17 - a point co-ordination is not required, but for the timing issues in point 13 a single time source and synchronization between time sources may be required. While sleeping and FH are not unrelated, sleeping should be an integral multiple of hop time.
Phil: sleep is completely separate, it may even be controlled by the device to which you are connected.

WLAN MAC Protocol: PHY Layer Transparency, P802.11-93\30, by Frédéric Bauchot, IBM

This submission further specifies how the MAC protocol proposed by IBM could accommodate many PHYs.

Discussion:
KC Chen: for cell isolation to be maintained more information must be included. Have you calculated bandwidth utilization - it is difficult to find code which provides good cross-correlation properties. 40% of the energy can be used determining code division.
Frédéric: channelization can be used on top of many PHY techniques. Have made no assumptions about code length.
unidentified: for IR implementation you are assuming channelization?
Frédéric: is saying channels can be supported by this MAC if that is what you want to do. To separate cells the PHY must have the capability to ensure cell isolation. Not prepared to describe how this can be done but to claim that the MAC can support this if the PHY is doing it.
Mike R: on use of a universal header for the MAC frame to achieve MAC independence from PHY - even if the header is the same in the MAC layer you need to know what kind of PHY you have because you need to choose what information to put in there. You are saying what Phil just proposed, except that maybe you represent that information in fewer bits. We get to the same deadlock - you can't operate the MAC without knowing what PHY you have.
Frédéric: what we should consider is that if you look at the information carried by the MAC, the PHY dependent part is concentrated in a very small portion.

Re transmission Probability & Throughput of SFH in Rayleigh Fading Indoor Channel of Multi-Cell Environment, P802.11-93\36, by Tomoaki Ishifuji, Hitachi

This submission examines: error control scheme; retransmission probability; the relationship between retransmission probability and retransmission unit length; the relationship between retransmission probability and number of cells; and then does some throughput evaluation.

Correction: page 1, point (c) should say "at least one failure" instead of "more than one failure".

Figure 2 - assumptions: Raleigh fading indoor channel; mutli-cell environment; signal strength is flat over unit length because fading period is longer that retransmission unit length.. This figure means that the probability density is flat over a wide range of bit error rates. This means a flat probability of retransmission over a wide range of unit length.

Figure 3 shows retransmission probability is almost independent of retransmission unit length.

The graphs in figure 4 show when Eb/No is greater than 25 dB, for retransmissions due to collisions of FH, values higher than 25 dB cannot improve collisions.

Discussion:
Peter Chadwick: why assume Gaussian noise on a Raleigh fading channel? Retransmission probability is the probability of collision and Gaussian noise on these figures, but this is not a Gaussian channel - it is a Raleigh fading channel.
Mike Rothenberg: when you retransmit the cells go through other frequencies. When you jump frequencies you have to adapt because you haven't the same frequency. You are receiving a kind of fading that is not Gaussian. He is saying that if one of the cells has been hit by noise you retransmit on another group of frequencies.
Tomoaki: not another group of hop frequencies. In a different cell you use a different hop pattern.
Mike R: in figure 1 the retransmission unit - is it single frequency or multi-frequency?
Tomoaki: if retransmission occurs the data is retransmitted on the next hopping frequency.
Peter: that's why it's Raleigh not Gaussian and this could affect the results drastically.
Tomoaki: the signal strength of the retransmission is independent of the original.
Bob C: yesterday in the PHY group we allowed 300 microseconds settling time so one will not affect the other. The fading will not change on each transmission, each will be independent.

Figure 5 shows that error correction has almost no effect on the retransmission probability in these cases.

Figure 6 shows the retransmission probability caused by collision, but the trend of the curves is almost same as figures 4 and 5.

Figure 7 allows conclusion that almost 4 times higher data rate by using QPSK.

Discussion:
Nathan Silberman: BFSK - what kind is used? Is this practical compared to other modulation schemes? Continuous space modulation is more practical. You may be off by a significant number of dB.
Larry: the probability of error equations are too simplistic.

Wim: throughput - is that per cell?
Tomoaki: yes.
Peter: any collision sensing - this would have fewer retransmissions. How would that affect the throughput?
Tomoaki: you are right but this system has very synchronized clocks so they can synchronize even if a collision occurs.
Peter: if all STAs know the hop pattern they know what frequencies are going to have collisions and they can avoid them anyway.
Tomoaki: they may not be synchronized between cells.
Larry: if a quaternary modulation system was used would the conclusion be the same? There is something associated with QPSK other than the quaternary approach that helps - you tried binary and quaternary and quaternary works better?
Tomoaki: yes. Can calculate for many modulations with changing the parameters.
Mike R: performance may be improved dramatically if detection of error is done using soft decision techniques rather than hard as assumed here. The soft decision benefit will be seen stronger in this Raleigh fading environment. Better designed error detection techniques may result in better performance.

Vic asks the PHY group to check the parameters of Tomoaki's paper.

(3) PHY group: what the MAC should know about frequency hopping, by Dick Walvis

Dick presented the following slides.

HOP RATE CONSIDERATIONS

• When a frequency hopping PHY is used one of the parameters is the hop rate. This is the number of hops per second. Its inverse is the hop duration, i.e. the time that a group of stations uses a specific RF frequency for communication. For successful communication all stations in a net have to be tuned to the same RF frequency.

• The PHY group expects that the management of the frequency hopping is carried out in a higher layer. This includes:

- Next RF frequency to use

- When to hop to the next frequency

• The PHY group lists a very large range for the hop rate that can be implemented. When discussing what hop rate to recommend, the discussion returned to higher level considerations such as efficiency, delay, acceptable times for drop-outs, etc. and their relative importance for each application. Very few PHY layer considerations could narrow down the hop range conclusively.

SOME FREQUENCY HOPPING PROPERTIES

• When hopping to a new RF frequency the communication is interrupted for several hundred microseconds, at present this is specified at 300 microseconds.

• The fact that communication between two stations is possible at the present RF frequency is no guarantee that communication is possible at the next RF frequency, and vice versa.

• Multiple "packets", "frames", "transactions" can occur during a single hop from multiple transmitters. Transmitter will only be active to transmit data or associated overhead.

HOP RATE CONSIDERATIONS

• Summary:

Longer Hops provide higher efficiency and slightly less critical synchronization

Shorter hops minimize the impact of lost hops

SLOW HOP RATE LONG HOP DURATION	FAST HOP RATE SHORT HOP DURATION
ALLOWS LONGER PACKETS	MINIMIZE DELAY IN RESPONSE TIME WHEN AT BAD HOP
HIGH EFFICIENCY RELATIVE TO SWITCHING TIME	MINIMIZE IMPACT OF BAD HOP DURING ISOCHRONOUS SERVICE
LESS SYNCHRONIZATION ACCURACY REQUIRED	AS A REFERENCE: PCS IS USING 10 MSEC
UPPER LIMIT ON HOP DURATION SET BY FCC TO LIMIT INTERFERENCE ON OTHER SYSTEMS	

Discussion

Dick: Rates could be from as slow as the FCC allows to as fast as the radios will tolerate. the application will drive the choice of hop rates. Hop rate = # hops per sec. 400 ms to 5 ms (inverse of rate). units must be at same frequency to comm. Importance of the impact of lost hops is up to the application packet size is not associated with the hop time except that it cannot be longer than the hop time.

Dave Leeson: question of synchronization time either in a start-up or a roaming situation. This may be related to hop length too. The longer the hops are the longer it may take to synchronize.

Dick: synchronization is more related to how often hop information is available on the channel.

Larry van der Jagt: the PHY group reached tentative conclusion that we don't care from a PHY design point of view, within limits, how fast you hop. We can build a PHY that can go any speed, because it has no cost impact. But it may impact on how well the system works so the MAC may have to use it to optimize how well the channel works. One channel has different error characteristics than another, so if the retransmission strategy is to try again when it doesn't work, you may have to try again on the next hop for efficiency. Hop rate from a system point of view is out of the PHY realm.

Phil Belanger: how does this all relate to the model shown earlier [sec: model from page 2-2 of the Draft Standard 93/20]. You say 'a higher level' for these decisions, where is that?

Dick: tried not to address this. That is a separate discussion, I am not the right person to lead the discussion on that issue.

(4) General discussion: "where is this done", led by Larry van der Jagt

Dave Bagby: the PHY at the bottom and the MAC at top of our realm, this falls somewhere in the middle. A sublayer in the middle is of particular importance because of the goal of MAC independence of PHY. Since we work as two groups, who wants to tackle the middle layer is the question.

Phil: that diagram [sec: model from page 2-2 of the Draft Standard 93/20] is supposed to be a closed issue. Does the decision the PHY group made affect that diagram? Or only the line along the side that shows where the separation between the MAC and the PHY is?

Larry: doesn't affect the line on the diagram. What we are after here is changing channels in a periodic way to accomplish FH. If we build that into the MAC in a general way how often the MAC changes the channel could be never. It could be applied to the roaming. The MAC is going to have to have a channel changing mechanism.

Nathan Silberman: issue of defining what functions go where, not changing the borders between sublayers. Need to keep it as generic as possible.

Larry: the channel changing function belongs in the media independent layer.
Dave B: PHY group has decided that pieces of information come from something above the PHY. That diagram shows 3 layers in the PHY. Does the PHY group think of all of those layers as PHY?
Larry: still thinks of this as the model. Sees mapping of functions at each level.
Dave B: has semantic problems with the use of the word channel. We have a requirement to work with only channel.
Larry: channel is "an instance of media use that can coexist with other instances of media use for the purpose of transporting MPDUs". As far as operating with a single channel - you can set the channel changing mechanism to never change. If there's a socket in the MAC the PHY can upload, or station management can download the channel changing strategy.
Dave B: if that diagram still holds, then a PHY specification would include that media independent layer and the MAC is not going to see any of that. The MAC is not going to see any difference between PHYs.
Larry: if you're not worried about doing a good job then don't worry about difference between PHYs. When the MAC gets a tool kit to work with you need to use it appropriately for the PHY below.
Dave B: then your just reflecting the dependence through the interface.
Bill Stevens: sees some sense to layering the control of FH when it involves the passing of information among stations that has to travel in the network if information needs to go into MSDUs that controls this. Maybe we need a PSDU for encoding this information.
Dave L: (1) operational definition of channel is not a frequency channel. A single channel is a pipe from one end to the other. (2) a fundamental rule of system design - systems are best when there are maximum interconnections within modules and minimum between them. The MAC should tell the PHY just go, don't bother me with the details. Those separations will get blurred in implementation. (3) PHY specific information in MSDU headers. In roaming you would like to not have to so re-acquisition in a new BSS. Roamers could come back with information about places they have been. A priori information can be made use of. Roaming needs to be optimized, re-acquisition knowledge needs to be transferred fast. (4) who does what - the two groups should set the rule that there is a minimum number of interconnects and the MAC shouldn't know PHY specific things. (5) the decision to change channels due to error rate is the decision to change hopping patterns, that is an asynchronous decision that belongs to the MAC. The PHY specific requirement for periodic frequency shift within the channel is a PHY decision and none of the MAC's business. MAC can say go to another hop sequence, but should not provide the frequency matrix and hop commands. This violates the minimum interface rule. There are all kinds of different strategies that the PHY might use to determine frequency sequence. (6) also the PHY should not have to decode anything.
Peter Chadwick: you have a MAC and a PHY manager. The PHY manager has to do more than just change the frequencies. He has to look at 'is the channel occupied' and other things. These can't go in the MAC because they are PHY dependent. But you have media dependent information that can only be decoded with knowledge. In order to implement this at the convergence layer you need a mechanism that checks if what the MAC told it to do can be done then says OK MAC do it. If you find you have a bad frequency, do you abort it, or just wait for the end of the hop. These are PHY management, not MAC management. If the MAC has to be media independent then some intelligence is going to be required in the PHY.
Bob Crowder: (1) this model is not an implementation model, it is a work division model. You will not see these divisions in your code and your ASIC, etc. Regardless of what layer contains the table of FH frequencies, it will be in the same memory in your system. It is a partition of a problem not a partition of implementation. Agrees with minimum primitives crossing divisions. (2) remember that the MAC/PHY interface is never exposed - there are no exposed interfaces in the first implementation. (3) the media independent layer and MAC management function are specifically to handle things like this. (4) MAC management can send its own frames and normally does. Likes Bill's idea about special frames, instead of padding out all frames with

information. Things like network id, PHY FH pattern and time to hop could go into specific frames - the only issue is how often you have to send that to optimize roaming. It would also allow no overhead on MACs that don't need it. (5) rather than multiple MACs, we could have multiple classes of the same MAC. The classes get defined by the MAC management. Management to management frames contain this information, and it goes to a different MSAP without involving the MAC. Let's just decide which committees where going to decide which things and move on.

Wim Diepstraten: thinks MAC should be sensitive to what the PHY needs. MAC PHY boundary should drop and the MAC needs to be more aware of what PHY we are dealing with.

Tom Siep: if it is just a division of work then the people best qualified to make the decisions about PHY dependent things are the PHY people.

Tom Baumgartner: concerned about the use of the side management box. Don't shove on-line functions to the side management function.

Mike Rothenberg: its is a good practice to have little information pass between boxes. More intelligence needs to go into the PHY to make it more independent from the MAC.

Larry: if the information I need to be intelligent is something that comes from decoding the frame then that information must come from the MAC. If not you violate ISO layering. The MAC can give the PHY that information but the PHY must not have to get it itself.

Dave B: don't assume that a MAC layer does everything instantly - it must parse information first and then flow that information to other places to be processed.

Motion #1: **to consider the model to be for the purpose of division of work not to represent technological divisions.**

Moved by: Bob Crowder
Seconded by: **no second**

Motion #2: **that the division of work be such that the independent layer be defined by the PHY group and the that the PHY group ~~take the lead~~ accept primary responsibility for ~~on~~ defining the MAC management.**

Moved by: Bob Crowder
Seconded by: Bill Stevens

Motion Discussion:

Phil: this is a bad idea. In the extreme all the MAC guys can go home, or it is a very dumb MAC.

Wim: agrees.

Bill: the wording "primary responsibility" is critical. The PHY group is not accepting the job of doing it all. They will have to do it with the MAC group but someone needs to be responsible for moving the work ahead.

Dave B: there are two things here - one thing says where the media independent layer gets defined and the other says the PHY group will do the MAC management box. One side of the media independent layer is PHY so who else could do it. But the second part is too open ended because we don't know what the box is yet. Speaks against the motion.

Motion #3: **to amend motion #2 to read:**
that the division of work be such that the media independent layer be defined by the PHY group and that the PHY group accept primary responsibility for defining **the PHY related requirements of** the MAC management box.

Moved by: Dave Bagby
Seconded by: Bryan Hartlen

Motion Discussion:

Peter:: getting muddled because there are 2 management boxes required - PHY management and MAC management. We should be talking about a PHY management box.

Bob C: that diverges from the model we have accepted and is not necessary, as this model covers it. MAC management was put there to accomplish MAC independence.

Peter:: the work separation between groups becomes much more difficult.

Nathan S: it is obvious we need to work together between the groups. Which part of MAC talks to the side management box?

Dave L: the flavor of this motion is that PHY guys have more experience designing PHYs, and MAC guys designing MACs. The medium has to be the driving element that is why 802.11 was created. Supports the motion.

Wayne Moyers: call the question on the motion to amend, seconded by tom Siep (32, 0, 3)

Approved: 35	Opposed: 0	Abstain: 5	***Motion to amend #3 passes***

Amended Motion #2 **that the division of work be such that the media independent layer be defined by the PHY group and that the PHY group accept primary responsibility for defining the PHY related requirements of the MAC management box.**

Dave L: calls the question on the main motion, seconded by Tom Siep (33, 0, 0)

Approved: 33	Opposed: 2	Abstain: 6	***Motion #2 as amended passes***

Larry reports that the PHY group took a straw vote on what raw bit error should be provided. The value decided upon was 10^{-5}. Suggested values ranged from 10^{-3} to 10^{-7}. No one supported 10^{-7}; the bulk supported 10^{-5}; and a few supported each of the other values.

Motion #4: **to adjourn**

Moved by: Dave Bagby
Seconded by: Tom Siep

Approved: a lot	Opposed: 0	Abstain: 0	***Motion #4 passes***

Meeting adjourned: 12:15 PM