Tentative Minutes of IR PHY Ad Hoc Group Meeting

Wednesday, March 9, 1994
Vancouver, BC, Canada

Meeting called to order by Larry van der Jagt at 8:48 AM.

Larry called for nominations for chairman of this group.

Tom Baumgartner nominated Roger Samdahl. Seconded by: Rui Valadas.

Vote: Favor - 10 Opposed - 0 Abstain - 0

Roger took the chair. The minutes were taken by Tom Baumgartner

There were no comments on the minutes of the last meeting.

Roger: Goal for this meeting is presentation of additional encoding techniques; after this meeting no other encoding proposals will be accepted.

Rui Valadas presented paper 94/66.

This paper applies the concepts of cellular radio for the first time to optical systems. Use of diversity techniques can yield significant improvement in performance and is recommended for inclusion in the IR standard. Both signal and noise are directional in propagation. Ambient noise is dominant over receiver noise. The model ignores the overlap of sectors and assumes a binary edge to each sector.

Peter Blomeyer: How do you distinguish between noise and signal?

Rui: If ambient is sunlight can estimate noise by looking at average photo diode current. Lamps produce a periodic signal that require filters to determine the average noise current to get an estimate of the noise.

KC Chen: Problem is all lamps are different requiring adjustable bandpass filter. It takes too much time to make this determination.

Rui: Can use a bandpass filter to measure signal level and a notch filter with the same center frequency for noise measurement. During the preamble you can filter the signal and filter the noise and take an estimate of each to determine the antenna sector yielding the best signal to noise ratio.

Manuel Betancor: Light noise is non-directional. Also need very large dynamic range detector.

Rui: There are several papers that say that noise is directional. The noise and signal are in different electrical bands so they can be separated. The idea today is not to go into implementation issues too much the first time this idea is presented.

FOV of 90 degrees means plus and minus 90 degrees. If you have non-directional noise the model of the sectored receiver results in a penalty, not a gain. But he has not yet tried to optimize the sectored receiver design. He assumption in the model of normalization of active area of non-sectored and sectored receivers is too conservative. With sectored receivers lenses are possible to increase the effective active area. If the noise sources are outside the cell there will always be a gain from using sectored receiver. Next Rui is going to try to optimize the sectored receiver design and study the gains in terms of multipath dispersion.

Roger presented paper 94/56.

His intent is low cost system. This paper is based on product Photonics have. The paper clears up some confusion in, and makes some corrections of, previous paper. The MAC/PHY interface is modeled after Ethernet controller interface. He argues for a constant preamble for IR of 2 MHz ON/OFF pattern regardless of data rate or encoding scheme. Need to provide a mechanism to reduce the collision detection time (CCA time?) since long times will result in collisions.

During a discussion is was emphasized that there is a reason to have fixed max. and min. limits on power transmit and receiver sensitivity for inter-operability.

Roger: The proposal uses slower than possible rise and fall times to reduce component costs and to reduce pulse frequency spread. The bandwidth required presently is about 5 MHz (20 dB down).

Rui: 4 MHz is realizable at low cost.

Tom: Del Hansen of HP said that the latest IEC 825 standard may limit the transmit power below the levels we want to use.

Roger: Believes that standard is not a problem but new standard needs to be studied more.

Kamilo Feher: Shouldn't we also spec. signal to noise?

Roger: Currently running 10E-8 BER in Photonics units. But perhaps the standard should not specify 10E-9 because it would be a long test. In testing, Photonics positions the IR ambient noise source such that the current in the detector is equivalent to a -10 dBm signal.

Rui: Conformance testing demands a standard noise source.

Roger: Max. recovery time of 30 μsec could be quicker with a squelch. Recommends that no physical limit be used on receiver FOV; getting significant energy beyond half angle point.

Preamble flag can be used to distinguish one type of system from another. One possible use is when a product could shift from one encoding technique to another. It is also needed for carrier sense detection to operate under the MAC we have chosen. Receiver hardware locks out the transmitter for 2 μsec after every received pulse. The collision detection window is very important in CSMA performance. Roger desires that even the modulated systems would send a baseband preamble so that all receivers could detect carrier. The baseband system detector will see the net IR level of the modulated transmissions; the result depends on the linearity of the system.

Rui: Should chose a longer start of frame delimiter for more robustness.

Roger: There is an inter-operability problem if the standard allows unbounded upper limit of performance. Nodes with too much transmit power will act as hidden node interferer. Conversely, if the node transmitter has much less range it will hear others but not be detected by others so it will be locked out by others that can't hear it. Harder to describe the condition where receiver is more sensitive but will end up with same lockout conditions.

Errors generate illegal symbols in 16 PPM so are easy to detect.

Peter presented paper 94/64.

IEC is driven by consumer uses (TV remote control). The consumer industry will claim entire infrared bandwidth for themselves. Peter trying to make them aware of data communications. Their draft document is IEC 84(Sec)340, "Transmission using infrared radiation." They are attempting to categorize classes of product. They have in mind a kind of Aloha concept. They feel that they can classify based on transmit energy and ignore the receiver sensitivity. They want a label on all IR radiation devices.

Tom: What is the standing of IEC with the governments?

Peter: Very likely that EC will adopt IEC standard.

Kamilo: Moved that this group recommend that Peter Blomeyer be appointed liaison for infrared matters between DKE/CENELEC/IEC and IEEE 802.11, to provide information of what we are doing and bring back information about what they are doing.

KC: Second

Peter: Would be willing to be the liaison.

Unanimously approved.

Peter: Infrared must provide advantages over 802.11 radio implementations. IR should rely on its strengths– low cost and appeal of technically possible future enhancements.

Peter presented paper 94/62.

Multi-channel approach intended to allow multiple applications working in the same area. Cost of semiconductor components low up to 30 MHz operating speed. Today have modulation methods that are efficient (data rate per bandwidth). 600 KHz lower baseband limit is IEC lower limit. FPQSK chosen by Peter also because silicon available to implement. We were asked to ignore all the specific data rates because they now realize that small increments of data rate and odd data rates will not be approved. Could also concatenate the channels to achieve high data rate, possible with semiconductors available today.

Tom: This standard cannot include rates below 1 Mbps.

Rui: Can the modulation method's power be low enough to operate within PCMCIA limits?

Peter: Maybe. Depends upon transmit power.

Kamilo: Modulation will not use more power than baseband in his opinion. Must accommodate MAC re data rates. His impression is we should work on 1 Mbps, 2 Mbps maybe, 4 Mbps and 10 Mbps. Could be 1 and 2 Mbps in baseband frequency. Could have 10 slots at 2.5 MHz. Maybe add coding within PHY to make it more robust.

Tom: Remember inter-operability when making too many options.

F. J. Lopez-Hernandez: To be IEEE compliant will it need both baseband and modulation capability?

Several: Can be baseband only or modulation only.

KC: IR's long range advantage will be higher data rate IR can provide.

Rui: We should progress by steps. Concentrate on one data rate and don't preclude other rates. Best way to get 10 Mbps is baseband not modulation.

Lopez-Hernandez: The spectrum up to 30 MHz in IR is the only spectrum available. If we don't grab it in our standard we will find someone else grabbing it in their standard.

Kamilo [shows page 8 of paper 94/55]: Spectral efficiency calls for using modulation.

Rui: We aren't bandwidth limited, we are power limited.

Kamilo: Modulated schemes are more tolerant of delay spread. Modulated schemes have better power use than baseband.

Rui: Your final numbers are SNR per bandwidth. Have to compare for the same bit rate the amount of optical power required. FQPSK is worse than QPSK by more than 0.5 dB. QPSK is worse than NRZ by 1.5 dB. NRZ is worse than 16 PPM by 7 dB. Conclusion is that FQPSK is worse than 16 PPM by more than 9 dB. Where 16 PPM might be 200 mW, then FQPSK requires 1.6 W. The normalized SNR calculates to be the same but the poor power efficiency of transmitter devices and the IR transmit power safety limits make total optical power the real consideration, not power per MHz.

Kamilo: Need to focus on customer perceived bandwidth and to accommodate more than one system in same area. There is coding gain that we could use. We could get 10 dB from this.

Peter presented paper 94/63.

This paper presents practical implementation of EXIRLAN system. Work still underway so complete results not yet available. Disagrees with Rui that IR is not bandwidth limited. There is a trend to higher data rates and there will be competition for this bandwidth. As soon as we go from switching light on and off and start thinking in frequency domain we find low cost solutions from the radio people. The present silicon can be tailored for EXIRLAN. The frequencies are flexible. The chips are available, we need to figure out what might be the best for this application. The chips take very little power. In block diagram BBP is Baseband Processor. Can use non-linear components.

Kamilo: Can use a hard limiter and the characteristics of the diode are not relevant. Also put in a roofing filter to cut 3rd harmonics.

Rui: But then you need a linear diode or you get harmonics again.

Kamilo: This is not correct. If you remove the only 3rd harmonic then it works.

Rui: Doesn't agree. Must use linear diode.

Kamilo: Not so. Please come to see our demonstration.

Peter: The chip used in the receiver has an amplifier that can connect directly to the PIN diode.

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Peter presented paper 94/65.

Summary of template items. Would combine with the template Roger presented. Peter offered to be an editor of the IR section for the standard.

Break.

Kamilo: Moved that this committee assures through its chairman that there is an issue list item regarding the development and completion of the IR template.

Peter: Second

Unanimously approved.

The Siemens paper was given to HS FH group briefly as part of another presentation.

KC presented paper 94/80.

Due to IBM patent application can't formally release paper containing details of one of the modulation proposal. Had trouble simulating all the modulation schemes because of the phase noise. Did finish all results for direct detect modulation. Consider two diffuse channels–direct path exists, direct path doesn't exist (shadowing). Assumed Guassian noise. There is an IBM patented modulation that has very good results compared to other modulations at 10 Mbps with direct path. The 16 PPM is the worst because of multi-path. Efficiencies are:

Modulation	Spectral Eff.	Power Eff.
OOK	1	.5
RZBI	.96	.625
2 PPM	.5	1
4 PPM	.5	.5
16 PPM	.25	.25
DCGPPM	.22	.5
MRLC	.615	.5

Performance under shadowing at 10 Mbps:

16 PPM is flat curve; DCGPPM is best; 4 PPM is second best

16 PPM is not viable at 10 Mbps and above.

Performance with direct path at 20 Mbps:

4 PPM and DCGPPM are best.

Performance under shadowing at 20 Mbps:

4 PPM and DCGPPM are best.

Performance at 40 Mbps direct path:

OOK and RZBI are best but require so much optical energy not realizable.

Performance with shadowing at 40 Mbps also only OOK and RZBI but same power limitations.

At 100 Mbps only the MRLC can survive with a direct path. None can survive with shadowing.

Conclusion: At low speed power efficiency is dominant concern and 16 PPM is best. At high speed there are other concerns in addition to power efficiencies. Channel capacity is several hundred megabits to 1 gigabits.

Rui: Power efficiency is still main concern at higher rates but there are other things contributing penalties.

KC: Conclusions from our study is we have learned what modulation is possible at various speed. Direct detect modulation is difficult for high speeds. We are the only medium that has the potential to support 10's of Megabits of data. We should go for high speed. Multicarrier is the way to go. Phase noise is concern.

KC: Moves that group adopts the following IR PHY structure: from 0-5 MHz is reserved for baseband, 5-15 MHz reserved for co-existence, 15-30 MHz is reserved for multi-carrier.

Peter: Second.

Discussion:

Roger: Our goal for today was to bring techniques to the table. Not had time to evaluate the proposals. Has questions about the co-existence of baseband and modulation techniques. This goes beyond the goal for today.

KC: Its possible for direct detect modulation to operate at 10 Mbps so he wants to reserve room. Doubts that baseband will go beyond 10 Mbps.

Kamilo: Would people feel more comfortable with adoption of the concept of co-existence of baseband and multi-carrier?

KC: Its unlikely that both systems would work in the same room at the same time at first.

Kamilo: Would like to see this type of motion passed today. Afraid of being excluded from first draft standard because we're late.

Vote: Favor - 8 Opposed - 3 Abstain - 0

Motion passes.

Kamilo: Thinks that bit rate is more important subject. Objective is to get a motion on bit rate.

Peter: Has the MAC decided on number of bits for determining bit rate?

Roger: The bits in his header are used by the PHY, not sent to MAC.

Tom: The MAC would rather not deal with multiple bit rates, even though they will probably be forced to.

Roger: The actions taken this week in other groups was due to ambitiousness of proposal and not being able to make the draft deadline. Concerned that we have just started to do the same thing.

Peter: Thinks AndroMeDa and KC can deliver enough material fast enough.

KC: This is important for MAC interface information, such as we want to channelize.

Tom: Moved to adjourn for full PHY group meeting.

No second.

Kamilo: Need to decide about bit rate. Template commitment by September. Decide on objective of next meeting.

KC: Move that we should consider the 1300 nm wavelength in addition to 800-900 nm wavelength for 802.11 operation.

Roger: This would announce to the rest of the world that we intend to operate in this band. What would this mean to MAC?

Rui: We should work on this after we have a complete standard basis.

Lopez-Hernandez: Second

Roger: The chair rules the motion out of order. Not in line with immediate goals.

Kamilo: Thinking about moving that infrared PHY will adopt 1 Mbps as a basic rate and some multiple of 1 Mbps up to 10 Mbps.

Peter: This would be a statement to MAC that we are working on more than one data rate. They have hardware timers and need fixed multiples of 1 Mbps.

KC: Move that infrared PHY will adopt one or more of the following data rates–1 Mbps, 2 Mbps, 4 Mbps and 10 Mbps.

Betancor: Second

Vote: Favor - 8 Opposed - 0 Abstain - 3

Roger: Let's make a list of PHY proposals (from the best of our recollection):

16 PPM	Photonics, Rui. KC, IBM
EXIRLAN	AndroMeDa
RZBI	Spectrix
Manchester OOK	Spectrix
4 PPM	KC
DCGPPM	KC
MRLC	KC
FSK	IBM
FQPSK	Kamilo

Roger: Next meeting objective: each of the proposals that expect to succeed must have a submission next meeting with a template; to select one for baseband and one for modulated carrier.

Tom: Motion to adjourn

Hussein Mehdi: Second

Adjourned at 5:15 p.m.