Tentative Minutes of the IEEE P802.11 Working Group

Interim Meeting
Worcester, MA
May 6-9, 1991

Monday, May 6, 1991, Morning.

The meeting was called to order at 8:35 AM, Vic Hayes, chairman of IEEE 802.11[1] being in the chair, Jim Neeley vice chair, Michael Masleid secretary.

1. Opening

1.1 Introduction: All people in the room were invited to mention their names and affiliation.

1.2 Voting rights are obtained in P802.11 by attending two plenary meetings out of 4 consecutive plenary meetings, voting rights are granted at the third meeting attended. One interim meeting may replace one of the required plenary meetings. Attendance at a meeting requires your presence in the meeting room for at least 75% of the time as determined from the circulated attendance list.

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1.3 **Attendance list.** The attendance list is passed around mornings and afternoons. Initial the attendance list at the current morning or afternoon meeting.

1.3 **Logistics.** Document distribution at the meeting is done using pigeon holes (a file system). See Jim Neeley for instruction. Note that you may use the pigeon holes for mail.

If a large number of copies need to be made, it can be done across the street. They do pick up and delivery. The cost will be distributed among the attenders as was done at Gaithersburg. Current estimate is $50.00 per person based on $300.00 for copying, $173.00 for AV equipment, and $8.17 per person for coffee and donuts, minus the $231.00 carry over from Hilton Head. We are not allowed to carry a balance between meetings.

Overnight parking at the hotel is $5.00, or $4.00 for the IEEE (when the toll gate is manned). Validate tickets with the hotel before leaving.

1.5 **Other announcements.** Thursday and Friday there will be an IEEE sponsored meeting at Worcester Polytechnic. It is understood that tutorials are offered Thursday. We are of course familiar with that material.?.

Jim Neeley has received a note from Ken Biba. Ken will not be able to make this meeting. He has a 10 day old baby boy. Ken expresses hope that our work progresses quickly so that his son does not have time to achieve membership. We will send a card.

2. Approval of the minutes of the previous meeting

The minutes were distributed late, they are in your mail slots. We will delay approval of the minutes and matters arising till Tuesday morning to allow time to review.

3. Reports

3.1 **Report from the Executive Committee** meeting Thursday night at Hilton Head. The liaisons are approved for ECMA, ETSI, and T1P1. The comments to the FCC on the Apple Petition were not acted on - the mailboxes were not emptied. The comments were then sent to the Executive Committee for 10 day letter ballot. There were some editorial comments. The IBM attorney reviewed the final document, changed data into digital so as not to restrict scope, then filed the comments on April 4th, in time for the revised deadline for comments.

3.2 **Report from NESCOM.** The New Standards Committee, in charge of all IEEE standards activity, has approved our PAR. Not without changes. They added medium control, MAC and PHY, and deleted coordination with TG10. TG32, SCC28, and EMC have been added for coordination and circulation of drafts. The PAR will be updated and redistributed as doc: IEEE P802.11/91-58.

3.3 **Report from the IEEE Standards editors.** We have received paper work from the IEEE Standards Editors of primary interest to our officers and editors regarding the shape and form for submissions to the IEEE. Copies will be sent to Jonathon Cheah, Michael Maslcid, and Chandos Rypinski.

4. Registration of contributions

New documents, and those with presentations still pending are:

11/HH/18 ***Correlative Minimum Shift Keying (CMSK) Line Signal with Measured Video and RF Spectrum Shapes.*** Chandos A. Rypinski, LACE, Inc. December 27, 1990. Document P802.11/91-18.

11/HH/23 ***A Method for Demonstrating the Impact of Multipath Distortion on Modulation and Demodulation Techniques Proposed for Standardization.*** Larry Van Der Jagt, Knowledge Implementations Inc. Document IEEE P802.11/91-23.

11/HH/25 *A Modest Proposal for a Asynchronous, Data Intensive, Wireless Local Area Network.* Ken Biba and Xircom, Inc. Document IEEE P802.11/91-25.

11/HH/26 ***Digital Cordless Radiotelephones Summary of Canadian Tests to Date.*** Walt Sonneville, Sonneville Associates. Document P802.11/91-26.

Wireless LANs, Chairman ECMA/TC32, Liaison Statement. IEEE 802 Executive Committee. March 14, 1991. Document IEEE P802.11/91-36.

Wireless LANs, Chairman ETSI wireless LAN ad-hoc group, Liaison Statement. IEEE 802 Executive Committee. March 14, 1991. Document IEEE P802.11/91-37.

Wireless LANs, Chairman ASC T1P1, Liaison Statement. IEEE 802 Executive Committee. March 14, 1991. Document IEEE P802.11/91-38.

Before the Federal Communications Commission, Washington, D.C., 20554, Comment of IEEE 802 on RM-7618 ("Apple Petition"). Donald C. Loughry, Chairman, IEEE 802 Executive Committee. Document IEEE P802.11/91-39.

Wireless LANs, Venue, The Worcester Marriott. Vic Hayes. April, 1991. Document IEEE P802.11/91-40.

Wireless LANs, Tentative Agenda, Worcester Marriott, MA, 6-9 May, 1991. Vic Hayes. April, 1991. Document IEEE P802.11/91-41.

Tentative Minutes of the IEEE P802.11 Working Group, Plenary Meeting, Hilton Head Island, SC, March 11-14, 1991. Michael A. Masleid. May 3, 1991. Document IEEE P802.11/91-42.

Similarities Between 802.9 IVD LAN and 802.11. Dale Buchholz, Motorola Inc. March 11, 1991. Document IEEE P802.11/91-43.

A Short Tutorial on CSMA. Paulette Altmaier. May, 1991. Document IEEE P802.11/91-44.

The Case for CSMA. Document IEEE P802.11/91-45, is not available at this time. (and has been declared void -chair)

Limitations of CSMA in 802.11 RADIOLAN Applications. Chandos A. Rypinski, LACE, Inc. May 2, 1991. Document IEEE P802.11/91-46.

Requirements for Wireless In-Building Networks. Mil Ovan, senior Marketing Manager, Motorola, Inc. May 6, 1991. Document IEEE P802.11/91-47.

What do You Mean, Radio? Thomas A. Freeburg, Motorola, Inc. May 6, 1991. Document IEEE P802.11/91-48.

Comments on CSMA. Dale Buchholz, Lee Hamilton, Motorola, Inc. May 6, 1991. Document IEEE P802.11/91-49.

Meeting of CEPT PT Radio-LAN. Vic Hayes. May, 1991. Document P802.11/91-50.

Draft Strawman Infrared PHY Interface Specification. Richard Allen, Wireless Research. April 30, 1991. Document P802.11/91-51.

11/HH/6 ***Interference Characteristics of Microwave Ovens in Indoor Radio Communications.*** J. Y. C. Cheah, Hughes Network Systems. Document IEEE P802.11/91-52.

11/HH/7 ***A Spread Sheet for the IEEE 802.11 Transmission Link Calculations.*** Jonathon Y.C. Cheah, Hughes Network Systems. Document IEEE P802.11/91-53.

11/HH/8 ***A Proposed IEEE 802.11 Radio LAN Architecture.*** Jonathon Y. C. Cheah, Hughes Network Systems. Document IEEE P802.11/91-54.

Australian Spread Spectrum Operation. Nathan Silberman. May 6, 1991. Document IEEE P802.11/91-55.

Comments on "A Short Tutorial on CSMA" (IEEE P802.11/91-44). Chandos Rypinski, LACE, Inc. May 2, 1991. Document IEEE P802.11/91-56.

Access Protocol Methods for Fixed and Adaptive Width Time Slots. Chandos Rypinski, LACE, Inc. May 2, 1991. Document P802.11/91-57.

The following papers are from CEPT:

CEPT RLANs 91/12. ***Report AB/9* (MOD F), Maximum Allowable Performance and Availability Degradations to Radio-Relay Systems Arising From Interference from Emissions and Radiations From Other Sources.*** December 8, 1989. Document 9/1012-E.

CEPT RLANs 91/13. ***Report of IWP 9/6 to JIWP WARC-92.*** December 7, 1990. Document IWP 9/6-40-E.

Discussion:

Dr. Jonathon Cheah argues that it is important for people new to the game to catch up to what is going on. (But not at the expense of progress at the meeting?) There are enough contributions for 3 days of presentations - if only 1/2 hour per contribution is allowed. That is too little time to go through the wealth of information. It is not cohesive. We are always diverging.

Each individual should read the presentation, write comments, and submit those comments to the author. Instead of making a presentation, the author should address the written comments. Written comments are less ad hoc, informal, off the cuff. If comments are written, and the verbal reply is recorded in the minutes, then people may converge more quickly.

Bruce Tuch wants to allow presentation. Don Johnson agrees in principle with Dr. Jonathon Cheah, but argues that **such an approach needs to be phased in.** Papers need to be available well ahead of time. (If there are enough contributions, and contributions are handled first in, first out, the delay due to backlog may provide enough time to review and comment.) Documents would need to be out a few weeks before the meeting, those contributing need to be ready well in advance, not at day of the meeting. Dr. Jonathon Cheah argues that even if the documents are available in advance, they are not read. Requiring written questions forces people to read the papers, - otherwise, the same questions pop up all the time, there is no convergence.

Dr. Tony Shober believes that Dr. Jonathon Cheah is on the right track, but the more serious issue is the scope and size of the group. How can all present be expert on RF, Infrared, Access Protocol, and market requirements? **The officers and the committee should consider subdivision into smaller working groups.** The first three days could be devoted to small working groups, the last day to gaining consensus.

Such a split is premature. There is a problem with dual interests, some people can not be in two places at once. Besides, the tutorial information is of high value to all.

The Chairman says we will have to work in one group until the architecture is on paper. It is necessary to define the interfaces between functional elements, and what passes through those interfaces, before the elements can be worked on independent of each other.

Michael Masleid points out that in Inland's considerable experience in software development, the time spent on scope, and the huge amount of time spent on functional requirements and analysis, actually reduces the total time to product. Any attempt to build code modules before the functional is complete is doomed. The Standard is no different.

James Neeley recounts this story: In 1969, IBM was to do the traffic control system (street lights) for New York City. Shortly after the agreement was signed, the IBM and New York representatives changed. It was 1976 before that was resolved. In all, it took 21 years of programming, 3 years of corrections. Details had been left out - like the requirement that all lights must be green in all directions on March 15th in celebration of St. Patrick's day. The model 1800 computer on which the system was based was no longer in production when the system became operational.

Simon Black likes the introductions. **To actually hear the author's introduction is an aid to useful comments. The introduction and questions for clarification is the important part.**

Dr. Jonathon Cheah agrees in part. New ideas can be presented, but very succinct and abstract, followed by a very limited exchange for clarification - then do the bulk of discussion on written questions.

Not everyone in this group is at the level of (understanding required to comment on) the contribution. For them describe the contribution quickly. For the more in depth questions back and forth argument wastes time. **For in depth technical questions time is needed to ponder.**

Jim Mathis observes that the oral discussion is very enlightening. For those things with which I am unfamiliar, the oral discussion gives me an idea of what is going on, what is easy, where there is consensus.

Randy Rettberg points out that the mailing schedule is too tight. If you don't happen to be in the office the week before the meeting, even a one week lead time on mail delivery is not enough. You should only consider late papers at the subsequent meeting. Dick Allen agrees that a one week limit is too tight.

Michael Masleid questions if it is permitted for the secretary to add comments to the minutes? It is agreed, as long as the comments are clearly marked.

(Don't get too picky about having things done many weeks in advance - that creates a conflict of interests for officers who have contributions to make beyond their assigned duties. Sec.)

Simon Black points out that **at ETSI papers have a longer life. Papers are developed over several meeting. These papers eventually become the standard. A single paper may be under discussion at more than one meeting.** Dr. Jonathon Cheah agrees with this position, but how does it work?

Dave Bagby suggests a process: **The paper, written sometime before meeting 'A', is presented in summary at meeting 'A', with questions and discussion for clarification. Written questions may be sent to the author after the meeting - these can become the IBIS list. At a subsequent meeting 'B', the paper is reintroduced for argumentation.**

Nathan Silberman asks about support for a bulletin board service. NCR's service is not useable at this time since the host computer in the United States needs someone local to manage the BBS - this can not be done from Utrecht.

Nathan Silberman points out that more time would be available for presentations at the meeting if a way could be found to shorten administration time to two hours. Nathan also **suggest that special interest groups meet off line, or at some other time**, then give joint presentations.

Larry van der Jagt points out that dividing the meetings has already been discussed. The Chairman observes that this is possible to do with an older group, but is not a good idea here, when architectural and fundamental issues have not been resolved. **Simon Black points out that holding special interest meetings more often than the bimonthly schedule works to exclude the European group.**

Don Johnson suggests that papers that meet schedule be given priority over late papers. Half of the presentation time should be given to introduction of the paper, the rest to any subjects that are brought up. Don likes the idea of formally presented questions, but doesn't want that to be a requirement for discussion.

Jim Neeley says that we may anticipate something like the FDDI model for architectural. When we reach that point we will see a natural division of labors. Having picked what I am interested in, I will still want to see the side I did not chose. As for special interest groups - we have that already - the California Caucus (Apple, Sun, Toshiba). Their point of entry is at the point of submission of their work.

5. Adoption of the Agenda

This completes the discussion related to papers and meetings - for now. The group sorts through the submissions and fits them to agenda items. Mil Ovan's paper will be presented early to accommodate his schedule. Dr. Jonathon Cheah and others have tutorials to present at Worcester Polytech on Thursday. Thursday will be reserved for editorial work.

They want to know the characteristics or Radio-LAN. They think we transmit all the time as apposed to, say, a 1% duty cycle per station. Why not use voice services, there are so many of those already?

Chandos Rypinski asks if CEPT represents mostly the telecommunication industries. Simon Black replies that this is true historically, but it is being liberated.

7.3 European bodies

We need a paper to the administrations and CEPT asking for harmonization, to be reviewed by the 802 Executive Committee for transmission before July. Simon Black will chair the ad hoc group, including Bruce Tuch, Bill Stevens, Dr. Dave Leeson, and Michael Masleid, which will meet Tuesday evening beginning at 8 PM.

7.4 Australia

Nathan Silberman reports: There is a Spread Spectrum band from 915 to 928 MHz. There is no provision for unlicensed services. There is an annually renewable general category license. They seem very liberal, and may approve almost anything - there seems to be little activity regarding radio in the Department of Transportation and Communication.

Australia has its own regulations, it is not looking for new legislation. We plan an action item to communicate with Australia once we know who the appropriate people are. Nathan Silberman will provide that information.

7.5 Canada

There is no update at this time.

7.6 Japan

James Neeley has some notes from IBM's representative on Japan's Radio LAN committee. They can only make recommendations for spectrum allocation, to be ready in June. Low performance applications will be allocated below 3 GHz, high performance applications will be in the 17 GHz band. There is something in the press regarding CSMA/CD or /CA - the supposition is that a Motorola/Japanese company is involved.

Simon Black reports a United Kingdom newsclip of a Japanese research and development group with 50 companies subscribing at 3,000,000 ¥ for membership. James Neeley reports that they "intend to follow 802.11".

There is some discussion of a Fujitsu wireless LAN for Personal Computers with a 100-200 meter range, that connects to the telephone network. Bruce Tuch thinks that these are GSM modems, not a LAN in the sense that we use the word. We need to write a liaison letter.

Simon Black points out that we can't make a generic liaison letter. Simon will try to address the issue. (The ad-hoc group only had time to work on the CEPT letter. This should be carried as an action item. Sec.)

Hideaki Haruyama reports on the status of Wireless LAN in Japan. There are four activities: The Ministry of Post and Telecommunications, RCR, a study group in IEICJ in the Japanese Academy of Information and Communication, and MITI, the Ministry of International Trade and Industry,

MPT controls allotment and regulation of frequency resources.

There is nothing like the ISM band, no frequency band for high speed wide area wireless LANs. What is allowed is 5800 or 32000 bits/s at 10 mW or 100 mW. New frequency resources are under consideration. Japanese companies are in discussion. What is the best frequency range from the viewpoint of the manufacturer?

6. Review of issues/position list.

No discussion due to lack of input.

7. Liaison with Regulatory Bodies

7.1 USA FCC

The IEEE reply comments on the apple petition were provided to the FCC. There were reply comments from other companies as well, including Apple. There is much support for the proposal for new rule making. Chandos Rypinski observes that there must have been a lot of opposition? Mil Ovan responds: 50 or 60 submissions. Bill Stevens comments that support is very broad, with some opposition from existing band users, and some unexpected, like Compuserve, but not from (for?) the PCS service.

The Chairman points out that there is nothing more for us to do, the 10th of May is the last day for reply comments. The Executive Committee made some editorial changes to the comments, like the number of members. The attorney also changed the word data to digital in several places, since the word data may imply restriction on use of the band. (The presentation by Dr. M. Marcus from the FCC at Worcester Polytechnic on Friday does invite further comment. The FCC remains interested in the voice of the people. Sec.)

Dr. Jonathon Cheah wonders if the implied endorsement of the 40 MHz spectrum allocation is wise. We wanted more. Shouldn't we make a more definitive request? Bruce Tuch suggest that we would need a system paper.

James Neeley observes that the Executive Committee would not accept that kind of extension. IBM calls for a minimum bandwidth, since that impacts the PHY design and modulation. 10 MHz is the minimum required that does not impact the design for a larger bandwidth. Don Johnson says NCR's comments called for at least a 20 MHz slot. Chandos Rypinski points out that calling for a specific number does not have a specific effect. Shooting from the hip has little value. A precise request needs justification and backup.

Dr. Jonathon Cheah reminds us that there is a time limit for the next round. We should concentrate most of our effort for determination of the minimum bandwidth needed now, and what additional bandwidth will be needed to support increasing demand. We need firepower to support our position. James Neeley points out that we wish to initiate rule making. The minimum and maximums will be determined in the rule making process.

This agenda item is abandoned until the FCC takes the next step. Contributions for "Spectrum Requirements" are solicited.

Steve Wilkus wonders, given NTIA in the Department of Commerce, regarding auctioning of spectrum and the Dingle Bill. Should we approach the legislature in favor of the Dingle Bill, and apposed to auctioning of allocation?

7.2 CEPT

Report by Vic Hayes on the Rotterdam meeting, April 24-26th, 1991. (Sec document IEEE P802.11/91-50.) The CEPT PT Radio-LAN is preparing a recommendation for Radio-LAN bandwidth, and is trying to teach the other administrations about Radio-LANs.

Three categories related to data rate are considered. 2 Mbit/s, up to 30 Mbit/s with moderate coverage area, and 30 to 100 Mbit/s with small coverage area. The current thought is to assign the first category to the ISM bands . The second category is placed between 16 GHz and 30 GHz, shared with space to earth satellite services. The third category, at 100 Mbit/s, is placed in the 59 to 62 GHz band.

The European ISM bands are 2.45, 5.8, and 24.125 GHz. The fixed and mobile users at 2.45 GHz are very sensitive. Can Radio-LAN work without coordination, so that end users don't need license?

Spectrum below 3 GHz is considered impossible to get, it can't be done through the frequency managers.

RCR is going to make a Japanese standard in the spring of 1992.

Regarding the study group in IEICJ: The radio communication study group has long history. Now spread spectrum is very popular. In IEICJ there are three classes of study, second class is a minor study, third class is very very minor. Spread spectrum is second class, but this year it is now a first class study group.

MITI has positions regarding equipment.

7.7 New Zealand

Dr. Jonathon Cheah has a contact in New Zealand. They would like to coordinate with P802.11 or Europe. The Pacific group usually works by consensus, following either European or United States standards. (They have Citizens Band - at 26 MHz.) The Chair says any advice regarding who to address, and how to address them is welcome.

The meeting breaks at 12:20, and reconvenes at 1:40 with a presentation by Mil Ovan. Agenda item 9 is out of sequence to accommodate Mr. Ovan's schedule. Agenda item 8 begins Tuesday morning, after agenda item 2.

Monday, May 6, 1991, Afternoon.

9. Establishment of Architecture

9.1a Introduction of contribution by Mil Ovan, ***Requirements for Wireless In-Building Networks.*** May 6, 1991. Document IEEE P802.11/91-47.

We should go beyond looking at secondary markets. We should not be looking at the portable computer market to the detriment of other markets. In Chandos Rypinski's paper, (***Equipment Type Definition and Market Analysis Methods by Type,*** Document IEEE P802.11/91-20), Chandos categorizes four markets. That may be good as a way as any to cluster the markets. I will share some of our findings with you.

We studied both in building and out. The work began in the mid and late 1980s - the first phase was to create focus groups with MIS managers for in building networks, to get an idea of what should be in the survey.

The next phase was quantitative: to get the real requirements and also the tradeoffs customers would be willing to make (battery versus powered, ...).

We anticipate "wireless evolution" over the next 20 years resulting in worldwide untethered communications. According to IDC the worldwide business personal computer installed base will move from more than 40 million units now, to more than 80 million units by 1995. Of those, one third have LAN connections now, by 1995 over half will be connected.

For the in building market it comes down to issues of cabling. Because of the high cost of labor, moves, adds, and changes are the third largest cos component of having networks. In building wire replacement meeds structured (wired) distribution systems

The time required to make the move, add, or change is an important issue, and will continue to be and important issue. Moves can't be looked at on an individual basis anymore. Frequently a whole department moves en masse. A departmental focus for wireless networking is a partial solution for this.

Structured distribution systems are good solution for a number of companies. A fair number have and like structured wiring. For a fortune 500 company there is a heterogeneous mix of buildings. The number of moves, add and change is not high. For fast growing (smaller companies) though, the churn rate (moves adds and changes) is much higher.

Maintaining structured wiring requires vigilance. If you can't keep track of moves adds and changes then you will forsake the original wiring and put in new wiring, this compounds the problem.

Don't look at this as a zero sum game. Wireless LANs may be complimentary to the wired network.

The customers thinks of network size being equal to department size, that is, 1 to 30 users. That is how things are done today, segmented, for maintenance if nothing else.

Portable computers are attractive, but what are you trying to serve? The office requires a different radio infra structure. The office may be 5,000 square feet, with 150 square feet per user. The customers need for speed is dependent on use. For the home base, slow may be ok. For the desktop, the radio must be fast. It is part of the LAN.

This survey was done as a conjoint study of 1000 users so that trade offs could be determined. Unless this is done the answer to a survey is always: It should be fast, cheap, and done yesterday.

Discussion:

Larry van der Jagt wonders if the 10 Mbit/s myth (that 10 Mbit/s networks actually have 10 Mbit/s throughput) is breaking down, are users getting smart? Mil Ovan answers that he doesn't want to say the users are unintelligent. It is really tough.

Simon Black asks if, as the result of research, that you foresee a significant wired LAN replacement market? Mil Ovan replies he'd rather call that wired LAN extension, or enhancement.

Simon Black: What about UTP? Mil Ovan replies that 10 Base T reduces the need, but if the rate of churn is high then wireless is still needed.

9.1b Introduction of contribution by Dale Buchholz, ***Similarities Between 802.9 IVD LAN and 802.11.*** March 11, 1991. Document IEEE P802.11/91-43.

Dale reports that he really did get married. Proposals given at the January 802.11 meeting included isochronous service similar to 802.9 IVD. This contribution provides information on how 802.9 IVD accomplished this, and provides comments that point out what we may want to use from 802.9. There is a nice journal article that shows how they struggled through. (***ISDNs & LANs Unite - The IEEE 802.9 Integrated Voice and Data Standard.*** Gary C. Kessler, LAN Magazine, October 1990.) A more detailed presentation will be given at a later meeting.

The 802.9 access unit is similar in concept to January's proposals - Those based on the Extended Service Area. There is no equivalent of a Basic Service Area in 802.9 since communication directly between devices is not allowed.

Chandos Rypinski comments that this is true, but 802.9 doesn't work for us. The stations are always on - to do frame synchronization. In a radio channel you would not want to do that. Attempts by Dave Bagby and myself to get 802.9 to be radio compatible failed. We do have heritage in this work.

The meeting breaks, to resume at 2:28 with Dr. Jonathon Cheah's presentation. This was prepared for the Hilton Head meeting, but was not presented due to a death in the family.

9.1c Introduction of contribution by Dr. Jonathon Cheah, ***A Proposed IEEE 802.11 Radio LAN Architecture,*** Document IEEE P802.11/91-54, temporary document HH8.

Define an access protocol that may fit the several types of marketing requirements that have been identified so far: The spectrum of users runs from those who need very robust - even though expensive - solutions, runs through those who need to move easily from one place to another - moderately expensive solutions that can't be required to do a site survey, runs through those who need uncoordinated peer to peer communication - that can be enhanced by adding a box somewhere to increase range and connectivity, and finally a fourth category - the lowest level machines.

Table one on page 12 lists the attributes associated with these applications, ranging from heavy industries and factories, through shopping malls and retail stores, to office including desktop and portable computers.

Figure 1 on page 13 is a flow chart of how a Head End Controller, HEC, operate. (Assume that there are several HECs in some area. Assume that some of these HECs can communicate packets data with each other using perhaps a conventional fiber LAN backbone like FDDI-2. Sec.)

In the beginning of time - at power on, the HEC listens for codes (radio transmission - perhaps using code division reuse - by other HECs or stations.).

If the HEC hears no codes, it begins sending Head end Timing Frames, HTFs. The HTF has several components: Poll and Assign SloT, PAST, Remote unit ACKnowledgement slot, RACK, filler packets, SYNC, filler packets, and ALOHA. The HEC listens during RACK, SYNC, and ALOHA. The HEC transmits during PAST. The HEC usually transmits during all the filler packets. The position of SYNC (silence) among the filler packets is random.

(Note that it is possible to identify the presence of an HEC beyond the useful range for communication, just as it is possible to identify human conversation from further away than it is possible to understand human conversation. Sec.)

If the HEC hears codes, the HEC must determine if itself is needed. If each possible code is present at good signal level the HEC will go into standby, locking into the timing of an active HEC as a potential back up. Otherwise the HEC will become active (using whatever code is not in use), The HEC will use its own SYNC time to listen to the other HECs - based on what it hears it will shift HTF timing to match that of the other HECs.

Simon Black asks why the HEC listens during SYNC, why not transmit. (HEC duty cycle tends to be asymmetric, transmitting more often than receiving. Many HECs are transmitting at the same time over a large area. Timing information can be discovered from any part of these normal transmission. Since there are many HECs mostly transmitting, the probability of silence is small. Therefore more knowledge of the network can be discovered by listening, less by transmitting. Sec.)

Dr. Jonathon Cheah continues with the description of the remote: The Remote UNit, RUN, and Head End Controller, HEC, unit share almost identical structure. There is a reason for this.

Figure 4 (Page 16) shows the diagram of a RUN acting as a remote. Since the structure is same as head end, the RUN can make out (volunteer) as an HEC. For portable computers needing to conserve power you have (Station ManagemenT, SMT) that locks out volunteer action. The remote that has enough power and can afford to become an HEC will volunteer and build up the infrastructure. (With a flag set saying that it is coerced. Sec.) If someone then powers up an HEC box that has a plug on it, the new HEC will see the coerced flag set and begin sending HTFs. The RUN that volunteered as HEC will see the new HEC during SYNC, at which point the volunteer will hand off control to the new HEC.

Figure 5 (Page 5) shows the protocol for station RUN1 communicating to station RUN2 through a single HEC. The HEC repeats RUN1's message to RUN2. (The same piece of air carries the same message twice - to be avoided if possible. Sec.) Note that for larger Extended Service Areas, with multiple HECs (Access Points), much traffic off loads from radio spectrum (it goes via the cabled backbone LAN), so this is spectrum efficient. (The same piece of air carries each message only once. The message gets from one piece of air to the next via cable. Sec.) It is OK if the backbone is faster than radio link.

What if a remote is moving from an area controlled by one HEC into an area controlled by another HEC? The sync slot is used to assist in the boundary crossing. (A good method to move from one area of coverage to another is needed because:) You want coverage areas to be as small as possible so that the re use factor is as high as possible. There is a hidden advantage as well, use it (small coverage areas) to cut across complex propagation characteristics, Rayleigh or Ricean propagation profiles. Each service area needs to be kept as small as possible so that a hostile environment can be divided into very docile sections. If each section can be treated one at a time, I can lower power, and do other nice things.

Bruce Tuch wonder hay you go about setting up the basic service area coverage? Dr. Jonathon Cheah answers that the first HEC to power up builds the network. The service area size is not of concern - if doesn't work - put in more HECs.

Dave Bagby ask how this can work given Michael Masleid's multiray model? No matter how small the coverage area, the remote will see many HECs. Dr. Jonathon Cheah responds: spatial isolation. Michael Masleid points out that the model presented is true assuming omni-directional antenna, the problem is ameliorated with directional antenna.

Dr. Kwang-Cheng Chen asks about boundary crossing time. Dr. Jonathon Cheah responds that vehicular speed is small compared to the frame cycle, only two frames are required to cross a boundary. That is similar to but no the same as hand off in cellular telephone.

Dr. Kwang-Cheng Chen wonders if trying to make the cell size as small as possible is related to the frequency band chosen? Dr. Jonathon Cheah responds that it is not frequency dependent.

Richard Allen asks, are you supporting directional antenna? Dr. Jonathon Cheah answers, yes. There are several degrees of freedom.

Don Johnson asks, if there are two HECs up, how do they share? Dr. Jonathon Cheah responds that they use spread spectrum. (Code division is implied here.)

Simon Black asks, if a head end controller has no data to send, what does it do? Dr. Jonathon Cheah responds that it send pads. Simon Black responds: So that hand off works? Dr. Jonathon Cheah responds, yes. A casual listener will see a (constant) common noise environment. It is important to have a predictable interference potential - a fixed predictable noise level.

Simon Black ask, but what if the other LAN is through a wall? Dr. Jonathon Cheah responds that your HECs should have a valid code table, through the wall should use codes not in your table. Then you will not see the LAN through the wall.

Paulette Altmaier asks about coordination of code tables? Not using all of the codes within each jurisdiction is not effective for sharing network bandwidth. Dr. Jonathon Cheah responds that we can get isolation spatial and code isolation to keep the number of neighbors small.

Dave Bagby points out that this protocol is a complex topic - it takes 4 hours to learn. Dave invites Dr. Jonathon Cheah to give a tutorial in the evening.

Michael Masleid notes that many people seem distressed about power consumption, since the HEC transmitters are transmitting most of the time. The fact is that in many cases the receiver requires more power than the transmitter.

Simon Black's observations: If there are multiple head ends in service, then a portable computer should not take over as a head end. DECT receivers only come up now and then. Dr. Jonathon Cheah points out that cellular telephone receivers are up all the time on receive.

Dr. Jonathon Cheah notes that if Chandos" portable computer is not manned, it will not work. (It's turned off!) Rich Seifert says yes you can (must) communicate to an unresponsive (unmanned) station, that is what is done in networks. Rich Seifert you really want to receive any asynchronous (unsolicited) request.

Chandos Rypinski observes that the LAN doesn't store messages, it only offers the opportunity for service. (This implies that a station that is powered down will have no chance to receive a message later, at a scheduled Wake Up. Sec.) Paulette Altmaier observes that there are many different ways to transmit, listen and receive. The normal mode is that you want to be listening. The need to Wake Up to receive is too strange to the normal way of using LANs.

Rich Seifert points out that traditionally stations come and go, but not quickly, it is a matter of hours or days. Here, stations are coming in going in milliseconds. Movement in seconds is not considered (allowed) in the application software.

Randy Rettberg observes that this protocol seems not to be designed to allow power off of receive stations - it seems not to allow this. How about per two second polling? Dr. Jonathon Cheah responds: It is a trade off.

Dale Buchholz points out that the PAR requires the protocol to be compatible with existing LANs. Given the client server model and distributed client server, how do you keep track of the multiple servers? If receivers power down, someone must keep track of who is off when.

Dr. Jonathon Cheah points out that if wake up time is small compared to poll time, then it is a non issue, but requires a longer head end polling time. If the sleeping station is not up in time it causes a mess in application software.

Dave Bagby asks, what about the circle problem? On network initialization, for global synchronization (frequency locking) if the topology is toroidal or other shapes with holes through it, is possible for the ring of synchronization around the hole to chase its tail? This can be fixed by intentional breaking of the topology. At any rate synchronization of the entire topology can afford to be a slow process.

Dave Bagby asks, what about non cooperative users. Dr. Jonathon Cheah replies that it is the same issue Paulette Altmaier brought up. Given the degrees of freedom, power, codes, you will never be caught dead at any spot.

What about the simultaneous use of multiple collocated head ends for more bandwidth. Dr. Jonathon Cheah answers that this is normal operation of the network. If two head ends are up, then bandwidth doubles. If 100 head ends are up - then no. (This is an issue of how many nearly orthogonal codes are available, and in the limit should have the same throughput as a simple short code TDMA network. Sec.)

Dr. Jonathon Cheah: I am trying to make a flexible adaptable system, but bear in mind that tradeoffs must always be made. In trying to adapt Token Bus or 802.3 you get cornered very quickly. This protocol has not been cornered yet. (It will appear to run into difficulties at the tutorial. Sec.)

The meeting breaks at 3:50, resumes at 4:10. The tutorial is scheduled for Wednesday night.

Michael Masleid points out that the powered down receiver is not uniquely Dr. Jonathon Cheah problem. Note that use of a synchronous time slot protocol allows receiver knowledge of when to listen. Dr. Jonathon Cheah notes that the Poll and ASsignmenT slot PAST is used. Keep local timing only. Power up to listen to PAST only to see if assignment is required.

Dr. Kwang-Cheng Chen asks what is the time to recovery, how do you do the carrier and rough timing recovery? Dr. Jonathon Cheah says with DQPSK or something of the sort (for carrier), then by using the code correlator to acquire the correlation peak (for bit and slot timing).

Dr. Kwang-Cheng Chen points out that some assume stations are moving, but stay in one cell for hours. Here mobile stations may be moving very quickly. It is something special to do this for hundreds of simultaneous users. You must be able to update this number with at least satisfactory speed.

Dr. Jonathon Cheah responds that P802.11 has been wrestling with the speed issue for a while. Say you are driving at 15 mph inside of a building. This is 22 feet per second. In terms of microseconds you can be in the same cell for some time. (If spatial coherence is 1/4 wavelength for omnidirectional antenna, then at 1 GHz, coherence distance is 1/4 foot, coherence time is about 10 milliseconds? Sec.)

Dr. Kwang-Cheng Chen responds that it is not a speed issue. It (The problem is that indoor radio) is not cellular. There are no clean boundaries.

Dr. Jonathon Cheah explains how a station moves from a place covered by one HEC to a place covered by another HEC:

The Head end Timing Frames, HTF, contains ALOHA, PAST, RACK, and DATA, with SYNC occurring at a "random" time during data. A Remote UNit knows the signal quality of the HEC that is controlling it. It also listens to other HECs during SYNC (The RUN's controlling HEC is silent during SYNC, so it is possible for the RUN to listen to other codes/frequencies at SYNC time.) Based on what is heard during SYNC, the RUN selects candidate HECs to switch over to. It stays with each HEC until it must be abandoned as unusable.

Dr. Kwang-Cheng Chen asks what about rapid flutter fades. Dr. Jonathon Cheah answers that this is the reason for using wider bandwidth. The more bandwidth, the more frequency diversity (the less likely all frequencies are faded). (If a fade is very rapid error correction codes are effective. Sec.) There is a recovery mechanism, you are allowed to change (to a HEC that is not fluttering) but the Remote is not allowed to change quickly, it needs a damping factor to prevent it from wasting time switching over - so it is designed as an overdamped system.

James (Neeley?) wonders about power saving? How much is feasible using radio? The decisions made for the MAC layer ought to be long lived - we should also push the state of the art for radio.

Dr. Jonathon Cheah comments that his last 1024 channel receiver design used 45 mA at 8.5 volts for a 30 kHz - 10 kbit/s receiver. Assuming that power is proportional only to the square root of frequency, then a 30 MHz bandwidth receiver requires (12) Watts. Maybe it can be switched off.

Actually, a narrow bandwidth receiver does not require as much power, the LO synthesizer takes a bunch, 1 mW for injection is a pain. The digital signal processor for handshake is also a problem. It is not the IF strip that is the big current drain. It is possible that 40 mA will do this (340 mW).

Simon Black points out that there are trade offs regarding the probability of head-end silence overlap (SYNC time for two HECs occurring at the same time), regarding the bandwidth, access time, and the length of the HTF (the longer HTF and the shorter SYNC and ALOHA, the less likely collision, but short SYNC times make code acquisition difficult). Dr. Jonathon Cheah replies that this is silence period collision, the collision of two emptinesses, it results if I'm not constrained to SYNC that is run by a random number generator. There are two silence times, ALOHA and SYNC - those are the two possible silence hits. There are control theory and signal flow analysis problems here to keep those interested happy for awhile.

What happens if silence collides? Dr. Jonathon Cheah replies that if the collision is between adjacent HECs and a Remote UNit is moving between them, then that RUN will not make the best power or switching choice. It is less important to the HECs themselves - it is a problem at switching time.

Bruce Tuch observes that when you have decided what is required (velocity and building), then the requirements give the fading rate, coherence time, power. It will all converge. This is all needed before we attempt to converge on the mA needed.

Dr. Jonathon Cheah says that the speed of the vehicle is one of the key points. To fast and you and you are competing with cellular radio. High vehicular speed should be possible in the protocol but the high cost associated should not be mandatory for all users.

There is an assumption that code diversity and spatial diversity can be used to some advantage. For closed rooms (not free space) the form that spatial diversity takes is bizarre - but it is still spatial diversity. It is microcellular, with cell size 1/4 wavelength for omni-directional antenna, and probably much larger for directional antenna.

Dr. Dave Leeson observes that code division jamming margin is different using frequency hopping instead of direct sequence codes. The assumption that protocol can be implementation independent is probably not good. Dr. Jonathon Cheah replies that we must take that into account, in this system I will plan to reduce power to the minimum required.

Dr. Jonathon Cheah points out that it may be possible to coexist in the microwave oven band. The ovens work at 50% duty cycle, mostly at discreet frequency except when squegging. (A squegging oscillator produces a broadband spectrum. Sec.)

Chandos Rypinski comments that the signal strength model for an empty closed room with reflective walls, assumes a single frequency monochromatic source, for a broad band transmission the nulls will be far less, with absorbers and abstractors it will get nicer. Michael Masleid replies that this is true, but it is partly a matter of scale. The model presented develops the structure shown if the coherence distance of the signal is large compared to the room size. The 1st through 3rd order reflections are coherent if the signal is single frequency for the time it takes to traverse the room 3 times. This can occur using a 20 M chip code in a 5 meter room.

(Unknown speaker.) The ISM bands are what is available now. We must focus on what is available today. We must take interference into account if doing code division between base stations. Qualcom and Milcom are doing tests now, but they are working in a predictable environment. Indoors is different. When capacity becomes the limit, the protocol must not collapse. The protocol must be checked out to see that it doesn't collapse under high load.

Dr. Jonathon Cheah replies that if 1 Mbit/s is the minimum user requirement, the marginal limits can be found. Bruce Tuch points out that we should not reserve codes for non existent co-site users. Make it so that if you don't have to share you are not forced to share with non existent entities. Dr. Jonathon Cheah responds that a way to take advantage of not having to share (with a cost impact) is to have multiple transmitters and receivers. Another way to do it - say there are 16 1 Mbit/s codes - when there is no one else sharing, is to go to reduced length multi M ary codes. Drop to 16 bit spreading codes, or send in the clear if the regulatory bodies allow that. What you want is not always what you get.

Nathan Silberman says that we need to measure against a fixed set of requirements. Rather than argue merits of systems, see how they match to requirements. Response time to the user should be a requirement - it is not now a requirement.

Dr. Jonathon Cheah comments that slotted ALOHA has good efficiency and throughput. Bruce Tuch comments that there are two issues, throughput and response delay. (LATENCY and THROUGHPUT).

Don Johnson points out that slotted ALOHA is a combination of MAC and PHY functions grouped together. How are we to define a MAC that will work with multiple PHYs? Multiple codes is a PHY issue, one of the functions of the PHY. If the function of the MAC only works in this combination, it leads to a MAC that doesn't do all the types of PHY. Dr. Jonathon Cheah responds that this has been a discussion of MAC, not PHY - but without some discussion of PHY as a basis we have no grounding in reality. If we can define a MAC that works with a particular PHY we can expand the concept to see how it works with multiple PHYs - say frequency division, code division, frequency hopping. I must start somewhere to be able to get anywhere. Power conservation must be though of up front also.

The meeting adjourns from 5:34 till 8:30 Tuesday.

Tuesday, May 7, 1991, Morning.

The meeting resumes at 8:36 AM with introductions and circulation of the attendance record. Note additions to the document list: P802.11/91-46a is an update from Chandos Rypinski. The Draft Design Goals is a list prepared by an ad hoc group chaired by Michael Masleid at the January meeting. Presentation and discussion should be 1 hour 10 minutes maximum per paper. Finances are as follows:

Income from the Hilton Head meeting:	$0.00
Balance from Gaithersburg:	$231.00
Total income:	$231.00
Expenses at the Hilton Head meeting:	
AV equipment	$75.00
Total expenses:	$75.00
Remaining balance:	$156.00

The remaining balance is to be used to cover extraordinary audio visual equipment costs at this meeting.

Dr. Jonathon Cheah moves that we accept the financial statement as presented. Dick Allen seconds. (16-0-1)

Dr. Bob Heile will collect $50.00 to cover the cost of this meeting.

2. Approval of the minutes of the previous meeting. This agenda item was delayed to Tuesday to allow time to review the minutes, which were not available in time for mailing before this meeting.

2.1 Approval of the minutes of the Hilton Head meeting. Document IEEE P802.11/91-42.

Dr. Jonathon Cheah's E-mail address is:

oscar!sv.dnet!jcheah@nosc.mil

Change the word functional to function where it occurs on page 7. "A set of 12 functional requirements" to "A set of 12 function requirements" and "What market is driving this Functional?" to "What market is driving these function requirements?"

Change the word photodiodes to LED on page 29. "Chandos Rypinski asks about photodiodes." to "Chandos Rypinski asks about Light Emitting Diodes."

The minutes are approved by consensus with the corrections noted.

2.2 Matters arising from the minutes. The motion on page 6 to accept a 2/3 majority requirement to open or close issues seems at odds with the IEEE 75% agreement rule on technical issues. Vic Hayes accepts resolution of this issue as an action item.

Orest Storoshchuk moves, seconded by Chandos Rypinski that Vic Hayes obtains approval from the ExCom to work with a voting rights rule to the effect that voting rights are lost if members do not attend at least 2 out of the last 4 meetings (interim or plenary) of the working Group. The rule to obtain voting rights remains unchanged.

Dr. Dave Leeson asks what are the rules for meeting announcement? The Chair answers: Meetings must be announced a month in advanced with a published agenda. Required is 75% attendance at the meeting as determined by the sign in sheet.

Chuck Thurwachter states that the purpose of the IEEE rules is to encourage a diverse technical base, to gather up expertise. (Not create barriers preventing their involvement.) The meeting minutes make available knowledge needed to keep up with the group.

Larry van der Jagt says the time spent on voting rights is a waste of time. Follow the IEEE rules. Larry calls the question. Dave Bagby seconds. (15-3-2).

The motion "**Vic Hayes obtains approval from the ExCom to work with a . . .** " fails. (6-12-2)

8.1 Medium Characteristics

8.1A Introduction of contribution by Chandos Rypinski, ***Correlative Minimum Shift Keying (CMSK) Line Signal with Measured Video and RF Spectrum Shapes.*** Document IEEE P802.11/91-18, temporary document HH18.

This work starts a long time ago, in 802.9, for high speed over twisted pair. Last fall, I started work on pure analog for high rates, to get something approaching the simplicity (and low cost) of cordless phones - or to see how close I could get. Part of the concept (to achieve this) is very short reach access points, driven by twisted pair. Then the link back to some equipment room could be done over regular telephone twisted pair. Could the line signal on the twisted pair be used as the RF signal as well? That is the thrust of the paper.

This modulation will be called fixed Manchester. Why fix it? You can't have abrupt transitions in limited bandwidth systems. (Reducing bandwidth increases pulse width. Sec.) The pulse shapes seem to need to cover up to 3 bit times. This can be done with finite impulse response filters.

Refer to page 1 of the paper for highlights of CMSK: (The text shall prevail over my verbal account.) This carrier type modulation is suitable for unshielded telephone twisted pairs, data grade cable or radio subcarrier modulation. The eye opening is pure binary (which is hard to beat). In 802.9 the problem with fast recovery of bit clock is not a problem, here we must get it in one (or two) octets.

Some of the waveshapes are shown on page 2. (The waveshape "looks like" a one is represented by 1 cycle of cosine, a zero is represented by 1/2 cycle of cosine - switching not at zero but at peak values. The switch transition is smooth, so of course these are not "really" cosines. Sec.)

Figures 3 and 4 on page 3 show the power density spectrum and generating pulse shape (Sort of like a sin(x)/x. Sec.) derived from the desired spectrum. The line signal is formed from a succession of overlapping pulses, distorted to compensate for the transmission line.

The spectrum on page 4 shows the **measured spectrum** of the baseband signal. The spectrum on page 5 shows the **measured spectrum** of a 833 MHz carrier FM modulated by the baseband signal (driven by a 9 bit scrambler). Deviation for Figures 8, 9, and 10 is 1.5 MHz, 3.0 MHz, and 4.0 MHz respectively. This assumes that the line signal will be used to FM modulate a carrier at the access point. Side lobe control is an issue. (It is good considering that only simple filtering is used, and the signal is generated from a stair-case digital structure.)

Dr. Jonathon Cheah asks how many samples were used to generate the waveshape? Chandos Rypinski responds that is the designers choice - too few samples requires more (analog) filtering - fewer still and you can't get the shape.

Continuing: The detector is an integrate and dump or matched filter. The pictures on page 6 are done with a memory scope so that a single sample is a black dot. Figure 11 is pure.

Figure 12, at 18.5 dB Carrier to Noise (C/N), shows loss of bit clock. Figure 15, at 19.5 dB C/N has good clock but too much noise. Figure 13 and 14 show 21.5 dB and 20.5 dB C/N respectively. 20 dB C/N is good for low error rate. I thought it would be better than this. I report what I see - not what I wanted.

Note that the RF spectrum is produced from pseudo random data, not random data. The little peaks may be an artifact of that - but I wonder about curves that look smooth with no artifacts.

Conclusion:

A pure FM system is possible. The high FM deviation gives a high occupied band to bit rate ratio. A FM modulation index of 1 to 4 should work as well as spread spectrum for cancelation nulls and frequency dependent fading. I continue to believe that there is another way to achieve same benefits offered by spread spectrum.

Bruce Tuch asks if you are looking for constant envelope here? Chandos Rypinski answers that it is constant envelope, but that is not the only reason to do it this way.

8.1B Introduction of contribution by Thomas Freeburg, ***What do You Mean, Radio?*** Document IEEE P802.11/91-48.

This is Motorola's view on what is radio, and how our product got to be how it is. I have been working 22 of my 27 years at Motorola - starting at 100 bit/s - now at 15 Mbit/s - and seeing 100 Mbit/s in the next half decade. This is only one dimension of a complex subject though, and not the only market. I work half for cellular telephone, half for the computer group - they have some common interest.

When using radio inside a building though, don't think of it as broadcast media - basic cellology. Some of you know better. The pictures (ray traced field intensity) are pretty. Some areas of design are very important,

Required Network Data Rates

What is the needed network capacity for various applications? At 1 Mbit/s you can do file transfer and windowing. Below 2 Mbit/s X-windows is shaky. Up at 10 Mbit/s X-window is not "broke". The computing industry is moving towards distributed computing, and that isn't just distributed mips. There is work group computing - a group working to a common goal - working on the design problem, data base, order base - true work group computing. There is distributed mips, the basic concept of a half dozen products that run, stealing processing power from each other. That is an important direction to be going - but it needs a fast network resource. These sorts of things lead to the need for 100 Mbit/s networks, hence the recent governments requirements for FDDI. Wireless must go as fast as wire.

Carl Hewitt remarks that latency is important. Rich Seifert

comments that the raw speed does not make much difference. Thomas Freeburg continues: Add philosophy and religion. It is like the transition from floppy to hard disk. Once you make the transition from 1 Mbit/s to 10 Mbit/s you will not go back. Is the world divided in 64 kbit/s pieces? What the CPU guys want is one big disk.

(Outdoor) Radio design has been based on statistical rules gathered from oceans and universes of experiments. The customer selected the tower height, the radio systems engineers would predict propagation using those rules. We are now getting to be able to do the theory, but in the old days - 1984 to 1986 - it was a matter of collecting data to make an adequate statistical model.

Cellular telephone is mapped from the transmitter to the 95%/95% contour line. If your phone doesn't work - your the 5%. For a LAN at the 99.95% contour, for fixed stations, it will "always" work. The guy in the chair never notices. If 1% fail, it is catastrophic, 0.05% is a must.

The coverage area has holes in it, and they move. If the holes are do to multipath, they span about 1 wavelength, about a foot for cellular radio at 800 to 900 MHz. One foot holes, moving around. Some are grey holes, some are black. A stationary hole - with your CPU in it - will seem awfully xxxx black.

In 1948 we built 50 MHz - we moved up from 20 MHz - and the engineers were upset about how short the range was. About 5 years later it was the high band - 150 Mhz, in another 5 years - 450 MHz - mobile radio weighing 10 lbs. We did it and it worked! Then we looked at 900 MHz. Same story. The range is too short. The radio has to be gold plated. There was even proof that it would not work!

System change. There are distributed receivers at 450 MHz, a mosaic. To do 900 MHz use distributed transmitters and cellular for 1.5, 1.8 GHz . . . who would go back to 100 MHz? There are a few problems left? Lets solve what we know how to solve.

Path loss is loss due to distance, shadowing, and multipath factor (local cancelation). The first is just gross distance. The second is caused by all the stuff in between - trees, walls. The third is mostly due to reflectors in the immediate vicinity of the antenna - though it is usual to put one antenna in the clear. Let's look at the statistical variation and talk about the impact of each as a random variable - by its standard deviation.

Path loss is usually less than expected for free space, propagation is enhanced by the ground wave. Standard deviation is 4.5 dB. Shadowing has a standard deviation of 6 to 12 dB. Multipath is perhaps Rayleigh, log normal, with 6.5 dB deviation. Indoor shadow loss is 18 dB - this dominates then.

We have to deal with multipath. Do equalization right and it is out of equation. It becomes a gain, not a loss!

There is another myth, carried by radio engineers, regarding path loss - that it has an frequency squared term. This is due to an assumption that the antenna used is a constant fraction of the wavelength. Since they are using an antenna whose aperture or capture area is variable, of course loss goes up with frequency. If you used a fixed aperture antenna, then the path loss is constant with frequency.

Now, what we learned from cellology 15 years ago. With a basic 7 cell pattern the carrier to interference ratio, C/I, is 20 log 5, or 14 dB. This assumes a hexagonal grid as follows:

```
   7 2 6 1
  6 1 3 5 4
 3 5 4 7 2 6
4 7 2 6 1 3 5
 6 1 3 5 4 7
  5 4 7 2 6
   2 6 1 3
```

It will require 48 frequencies to do 3 dimensional space filling. The two dimensional 4 cell pattern, with 9.5 dB C/I is as follows:

```
   2 4 2
  3 1 3 1
 2 4 2 4 2
  1 3 1 3
   2 4 2
```

Dr. Jonathon Cheah asks if Motorola is using a directional antenna? Thomas Freeburg says it is a natural outcome of the problem. Chandos Rypinski asks if this is for 18 GHz or all frequencies. The reply is yes.

Continuing: Typical size LANs have 8 to 15 users. We design for 32 max, with 200 square feet per person including the hall. (European standard is 135 square feet per person.) The required range is 45 feet and 2 office walls. The signal must penetrate typical office walls.

About walls: Three course brick has 145 dB attenuation. If the wall is wet concrete or masonry 2.5 GHz to 18 GHz doesn't go through. We looked at 2,000 building 12 years ago. The exterior wall gave the largest attenuation. Interior walls are of three main categories: Pure plasterboard has little attenuation, though bound water in gypsum may grab 21.7 GHz. Tinted glass sucks up radio. Metal walls are interesting. Metal walls are discontinuous, with joints (with two cracks). 18 GHz crawls through the cracks.

What are we doing with wireless? Use a backbone for the largest range and capacity. Use Wireless for the work group, the meeting room, and the simple terminal alone in a room.

About the issue of licensed or not: There is a need for coordination of Market demands. Banks expect that if they buy a LAN today that it will work tomorrow. When the dentist buys a LAN will the Bank's still work? The bank needs more than a vendors promises (even if ATT&T/NCR). The bank needs legislative teeth,

Should we have gone with 18 GHz or 24 GHz? The 24 GHz band is there folks. But in spite of the allure, you don't have an acceptable product. You need the guarantee of non interference. For some network users the LAN is as much a part of their business as breathing. They don't think about it, but they need it.

"It's Important to Prioritize" Of the issues: reuse, protocol, and modulation, it is important to recognize the costs and benefits. Compared to improvements due to modulation, protocol pays back ten fold, reuse ten thousand times. Protocol adds the least to development cost and product cost. The development cost of reuse and modulation are the same, but product cost for modulation is twice that of reuse, and reuse is almost twice the product cost for protocol. Reuse should have the highest priority.

Larry van der Jagt asks: so modulation is a wash? Thomas Freeburg answers that it effects reuse, but it is not the key to it. Reuse is the most important., it effects reuse, but engineering and protocol also, not key to reuse, and that is the most important. Bruce Tuch observes that protocol also effects reuse.

How well will LANs support telephony? There are numbers of voice services trying to do data. No voice folk are successful at data. Data folk never seem to do voice right, either. In the end technology doesn't take

votes. The token ring, when used for voice, won't do data. Coexistence is a problem. Motorola did it once. No one does it now. Its xxxx tough. FDDI had started that way, then dropped voice. (ASC X3T9.5 continues that effort now in FDDI-2. Sec.)

Now for a discussion of the spectrum as it ranges from RF to white light:

The 900 MHz band is unlicensed and is susceptible to interference. It has good wall penetration - which limits the number of users per area. The modulation must be spread spectrum. Bandwidth available is 24 MHz or 26 MHz, but not available in some countries. It is possible to transmit 2 Mbit/s in this bandwidth, but without many of the benefits to be accrued from spread spectrum.

Next up is 1.8 GHz, the single most active spectrum in the world. This is virgin territory for data, but contains an ocean of point to point services that will have to be moved. It took 14 1/2 years to clear out the cellular band. In Europe there is a major commitment to DECT. The basis of DECT is that it works for all, voice and data, but it was built by voice guys - need I say more. DECT provides a raw 1.1 Mbit/s data rate. The idea of mutual degradation may not be so bad. In fencing there is a gambit, the move of two widows - the desperate lunge that kills both parties. DECT provides data on demand. LANs require instant sharing, not data on demand. (- While this is true of many applications using Ethernet, it is not universally true. Sec.) In the United States astounding stuff is happening in 1.8 GHZ. I note that Bill Stevens (Apple) does not include voice and says it is a good solution. Good luck on getting spectrum - I retire in 14 1/2 years.

The next step up is 2.4 GHz. It is unlicensed. Because of good wall penetration user density must be low. It contains 1 kW microwave ovens. A spreading ratio of 80 is needed to gain immunity to microwave ovens. (Larry van der Jagt points out that the ovens operate at 50% duty cycle more or less. This means that the protocol could work in the holes - but if there are ovens on two or three phases of the line the holes may be closed up. Sec.)

At 5.4 GHz there is 45 to 80 MHz available, you could get 150 MHz. This would allow 10 Mbit/s at reasonable spreading ratios. There are induction and microwave ovens in this band. Wall penetration is moderate, so moderate user density can be supported.

18 GHz has range on the order of 50 feet. With 100 MHz of spectrum available today, it can support 15 Mbit/s now, and could support 100 Mbit/s. Inside wall penetration is good, outside wall penetration is poor, therefore high user density can be supported.

The 24 GHz band has a range of 50 feet, with 45 to 80 MHz available. It requires spread spectrum, but low spreading ratios are ok here. 10 Mbit/s can be supported.

60 GHz is virgin territory. It is line of sight, it doesn't go through walls, so think in terms of support from a backbone network down the hall. This band is on everyone's chart for wireless LANs. It is in the center of a molecular oxygen absorption band so no one else wanted it. There is 175 - maybe 350 MHz available. (This is marvelous. High guarantee attenuation with distance is just what is needed to support huge numbers of users. Sec.)

Infrared has no wall penetration. Diffuse infrared supports short ranges: 50 feet at 1 Mbit/s, 10 feet at 10 Mbit/s. Point to point infrared can do 200 feet line of sight at 10 to 100 Mbit/s. Enough smart people working on lenses can figure out how to improve this.

Discussion

Dr. Kwang-Cheng Chen complains that this is comparing apples and oranges. (RF transmission and Infrared.) Not much time has been spent on infrared. However, RF has become complicated. Ten thousand people have been working on RF for 50 years. It costs a lot still. Thomas Freeburg replies that cost is not just the pieces of the radio - there are other things. It is ok to compare apples to oranges if trying to cure scurvy.

Bruce Tuch observes that to multipath and the coherence time of the channel interact with use of directional antenna.

The spatial coherence of a directional antenna is longer than it is for an omnidirectional antenna. What about the lap top computer constrained to directivity?

Chandos Rypinski points out that if a fixed aperture antenna is used, it becomes more directional with increasing frequency.

Chandos Rypinski claims some experience with inventiveness - the power of and engineer with an idea - and marketeers. Some facts: In Bell labs, in St Petersburg, when RF transistors went 1600 kHz, they said they could do 900 Mhz. To get the frequency space the FCC formed an advisory under commissioner Cox for mobile radio, taking away TV spectrum above channel 69 to make the 900 MHz band. The effort was huge. Jona Cone (sp?), of Motorola, used taxis in Chicago as a model. The concept couldn't be sold in 1964 - however, each game is new. I express thanks for the many points brought up. The technologist must first get marketing, and the managers to go with it. We sometimes try to do it by making committees, without managers to set standards - and sometimes we get bound up in technology (looking for engineering solutions for) what is not an engineering problem. Sometimes a profit (prophet? Sec.) is needed.

The meeting breaks at 11:06 AM. Dr. Bob Heile reports that audio visual expenses will be $660.00, copying is $400.00, cost of refreshments is $8.00 per head. Estimated cost of the meeting will be $55.00 per person. The meeting resumes at 11:34 AM. For those here for the first time - old documents can be obtained. See Victor Hayes for the order form.

8.1C **Introduction of contribution** by Larry van der Jagt, ***A Method for Demonstrating the Impact of Multipath Distortion on Modulation and Demodulation Techniques Proposed for Standardization.*** Document IEEE P802.11/91-23, temporary document HH23.

Thank-you for the bandwidth. I and my other colleagues from 802.4L have some technical experience - and have listened to marketing. We need to know from them now what we need to do. (Specified in a way useful for a designer.) The suite of tests presented here can be used to see what is sane to attempt and what is not. It presents a way to tell what is good, and what is not - a bake off contest if you will.

The purpose of paper is to begin the process of specifying a set of unbiased technical bench marks against which we can evaluate competing proposals. This particular test requires:

1) That the proposed for transmit waveform be modeled and a "test suite" time series be generated.

2) That the "test suite" data pattern be passed through various carefully chosen simple multipath profiles.

3) That the proposer take the time series generated in step two and produce a demodulated time series and evaluation for presentation to the group.

Future work involves different tests designed to verify the "design goals".

What do we need to do first? We need to have a test suite that includes perhaps Michael Masleid's delay spread from hell. The idea is to filter, say in a math-cad program, and examine the models theoretical behavior. Bruce Tuch points out though, that immunity to multipath is not an always thing, there is outage.

What do we need to do first? Take the "design goals" started in Gaithersburg and move them to closure. How do we move to closure? Define tests against which designs can be evaluated. Evaluate submitted designs and select among them. There is a precedence: The Eastman Kodak tests for (GM MAP baseband) to evaluate 802.4 phase coherent and phase continuous baseband signalling.

Dr. Jonathon Cheah remarks that Hughes has a cellular telephone simulator, it can perhaps be extended for use by this group. We must have a way to conformance test. Not so much because people make promises that they can't keep through bad intent, but because we must have a way to prove the promise of a system. The TIA tests have a 2-ray and a 6-ray Rayleigh. The 2-ray is excessive (Michael Masleid claims that it is completely misleading).

Chandos Rypinski asks if Larry van der Jagt's test is based on measured response or from geometry? Larry replies yes. (The paper describes a 4 ray model with the first ray a uniformly distributed r.v. with amplitude less than 1 and delay less than delaymax. Each subsequent ray has a uniform distribution with amplitude less

than 1 minus the amplitude of all preceding, and delay less than delaymax.) The test can be modified to use the GM test data to generate delay spread models.

Bruce Tuch says that we must select a (propagation) model, but before we can select a model we must know what our environment is. Larry van der Jagt replies that we need to start from simplistic models.

Dr. Dave Leeson has a customer with an anechoic chamber and the metal room. Larry van der Jagt remarks that that can be used by sending a pseudo random sequence in both, then strip out the channel (the "difference" between the two).

Dr. Dave Leeson comments that the CRC and other protection is what makes unlicensed operation possible. Larry van der Jagt responds that it boils down to a Bit Error Rate, (BER). Obviously a 1 in 100 BER is going to bedevil any MAC.

There are a couple layers of misunderstanding, one on top of the other - the coded BER before and after Forward Error Correction, (FEC), protocol protection through ARQ, and which error is acceptable to which layer.

Dr. Jonathon Cheah comments that for one method one bit error per packet is bad, for another method not so bad. This needs to be down in black and white - each method and the amelioration.

The meeting breaks for lunch at 11:58 AM, and resumes at 1:37 PM.

Tuesday, May 7, 1991, Afternoon.

8.1D Introduction of contribution by Richard Allen. ***Draft Strawman Infrared PHY Interface Specification.*** Richard Allen, Wireless Research. Document P802.11/91-51.

Its nice to listen to the others, since you get to make new charts! To reiterate why we are doing this (infrared) - we can do it now, we don't have to wait for the FCC or other regulatory agencies - and it fills a market need.

Focus now on diffuse infrared for portables computers. The desktop market is pretty hard to crack - mostly it is already wired anyway. For the portable market wireless is really a must have, it is essential. It is just a question of what kind, how fast, and other requirements. Recalling Ken Biba market data - new shipments of portables are going up while desktop shipments are going down. The market opportunity is for portable wireless, not so much for desktop wireless.

Examine diffuse infrared against market function requirements. Diffuse infrared checks off rather well. Infrared meets many of Dr. Jonathon Cheah's and all but one of Mil Ovan's requirements (that is, it doesn't go through walls). Still, in portable applications diffuse infrared is hard to block, though a well placed book at the access point would do it. The links are robust.

Diffuse infrared equipment is small in size, low power (less than 50 mW, and immune to RF interference. (Some caution is required if the receiver array is not shielded - Sec.) It is safe, secure, and has no licensing delay.

The goals for the infrared common air interface allow but do not require repeaters, minimize power, allow cooperative operation, and permit enhanced operation at higher cost.

Continuing with the nature of diffuse infrared. Operation is at 800 to 900 nm to match silicon photodiodes. Inexpensive optical filters can be used, (as apposed to multilayer dielectric or dichroic filters Sec.). The power must be enough, but must still be safe, so the minimum is 110 mW average, 1.75 Watt pulse. This works, obtaining 20 dB signal to noise. Pulse position (1 of 16) modulation is used, so there are 4 bits per symbol. This improves the signal to noise ratio. Seventy percent of the peak intensity is in a forty five degree cone using (as inexpensive as) jelly bean diodes.

As for the optical pulse specification - the width must be about what we want for a pulse (1/16th the symbol rate). Eight or ten LEDs per unit form the transmitter.

Any transmission at any speed is preceded with a wake up/busy pulse lasting 5 microseconds followed by synchronization, and is ended (immediately following the last data symbol) with a 2.5 microsecond not busy pulse. Synchronization is 60 time slots (symbols) of 0101, followed by 4 time slots of 0010, which signifies end of synch. Code violations are allowed in the packet. (See the document for more details. Sec.)

Bruce Tuch notes that multiple speeds are supported simultaneously. Does that mean that a slow station can hog the channel capacity. Richard Allen responds yes.

Dr. Kwang-Cheng Chen questions the poor spectral efficiency. Richard Allen responds that that is traded off for a gain in signal to noise.

Dr. Kwang-Cheng Chen asks why not a 1 of 4, or 1 of 8 position code? Richard Allen responds that it is a compromise. The 1 of 16 code increases noise bandwidth by 4 and increases signal by 256.

Paulcue Altmaier argues that spectral efficiency is not important, the bandwidth is there to be used. Dr. Kwang-Cheng Chen responds that it costs because of the increased noise bandwidth.

There is a discussion about packet length. Packets should be kept short. It is a matter of bit error rate and packet loss rate.

Dr. Kwang-Cheng Chen asks about other mappings for infrared modulation. Richard Allen that this modulation is proven, simple, inexpensive, and works. Richard invites papers showing another approach.

Steve Wilkus asks if spectrum efficiency needs a narrow band filter? (Given the extraordinary frequency of the carrier, 350 THz, and the sloppy tolerance on the emitter, 20 THz, optical filtering is pointless. The issue has more to do with filters after the detector. Sec.)

What about collision detection with 1 of 16 coding? Richard Allen replies that you can't get it. It might be possible but not worth it. For a large room the repeater begins to get into Time Division Multiple Access, TDMA.

Dr. Jonathon Cheah wonders, given his experience with infrared, why this works at all? Richard Allen responds that it has to do with ceiling height. (You don't always have a ceiling. Sec.) The higher the ceiling, the easier to light. For directed systems, attenuation varies at the 6th power of the cosine of the angle.

8.2 Medium Requirements

8.2A Introduction of contribution by Dr. Jonathon Cheah. ***Interference Characteristics of Microwave Ovens in Indoor Radio Communications.*** Document IEEE P802.11/91-52, temporary document HH6.

When you look at all the available spectrum, you realize only one band is really available to us. The 915 MHz band is not. It is used for too many things already - vehicular identification and theft, store theft detection, and low frequencies are noisy. The 5.7 MHz band requires GaAsP on Al_2O_3 (alumina) substrates. That is expensive. So 2.4 GHz is nice, G10 (fiber glass epoxy) is lossy but it works. It is a nice band - except of course for the microwave ovens - and the smallest is 700 Watts with standards at 1.5 kW. So anyway, 802.4L wanted to see if we could work around it. I went and made the tests. I used a Hewlett Packard 8566 in frequency domain using multiple resolution bandwidths and sweeps.

We saw single line spikes and pulses. What about the spectrum analyzer's pulse bandwidth? A bit hairy. After a month of looking at the data limited conclusions were reported to 802.4L. Since then we have hypothesized what is going on and will substantiate it later. It seems to be this:

Imagine a 1 cycle square wave, at 60 or 50 Hz (standards!). Show first high, then low. High corresponds to power on. If the magnetron oscillated continuously here it would appear as a single line interferer. Sometimes it does - but not always (note that there is no evidence of a single frequency spectrum line). It appears that fundamentally you are seeing many (time domain) spikes coming on during that time. The spike has a very broad bandwidth, much broader then the spectrum analyzer with its 3 MHz filter. Sometimes the spikes collapse into a continuous transmission. Then the FFT gives a nice stable frequency spike. (Time

domain spiking seems to occur as the magnetron starts up and stops each power cycle, and sometime during the cycle. Sec.) Can we work around or overpower microwave ovens?

The maximum lobe in the microwave oven emission pattern is facing normal to the door. It is 80 dB uV per meter per MHz. This is similar to a 350 kV power line, when standing 200 feet from it at 1 MHz. 0 dB uV is about -107 dBm.

There was a discussion of measurement bandwidth. Beware, the best of experimenters come to grief on this one. Emitted power depends on the load, the temperature of load. The measurements took a lot of time.

Hopefully a clever designer can reclaim this band for us. We will have monopoly on band since no one else will be able to figure it out.

Victor Hayes points out that Philips working on Hg UV emission line phosphor conversion(fluorescent) bulbs driven with 2.4 GHz. Radiation at 2.4 GHz is identified as a health hazard at 10 mW per square centimeter, or 1 mW per square centimeter. (Americans have thicker meat.) Now America may also go to 1 mW per square centimeter.

Dr. Jonathon Cheah continues - if we can afford to transmit at 1 Watt, then don't overlook this band.

Dr. Dave Leeson comments that we looked at frequency vs time - I don't remember numbers - but it does drift a lot, these magnetrons don't stay locked, or when the are locked, they are not stable. As for useable band, there is only about 30 MHz overlap in the multiple regulations.

We built modems (1 Watt), put them on top of microwave ovens, 300 feet apart between floors. With the microwave ovens on it works ok. It is not a problem that can't be overcome. With frequency hopping it is possible to be where the ovens aren't. Yes, this is a very useful band. Now one will come and mess you up, or kick you out. (If aeronautical radar moves in, there goes the neighborhood. - But airport radar looks up. Dr. Jonathon Cheah's radar uses Watts in six figures.) Is anyone else in there? Yes Doppler movement sensors, for non data transfer usage.

Dr. Dave Leeson comments that observed propagation differences are not much different from the other bands. Dr. Jonathon Cheah responds that if dynamic range is very big you don't notice propagation. A satellite can see 0.1 dB, 4 dB is lots of signal for VSAT, it locks at -2 dB snr. The sense of proportion is lost going to the indoor environment. This provides a good transition band until we get a real home.

Dr. Dave Leeson point out that there is a catch 22 with the FCC. You must fill the band that you have before getting more - but if you have filled the band, then that must have been good enough. Given an 83 MHz wide spread spectrum - this band may be more robust than you think. The only problem indoors is it must coexist, but only in sense of surviving, the microwave oven.

Victor Hayes asks if this document should be combined with the preceding long document. Dr. Jonathon Cheah responds no, this is nothing new, just equation instead of raw data, keep as a separate paper from the other one.

8.2B Introduction of contribution by Dr. Jonathon Cheah. ***A Spread Sheet for the IEEE802.11 Transmission Link Calculations.*** Document IEEE P802.11/91-53, temporary document HH7.

There is too much hand waving on how much budget is needed. There is too much error in this method - it may cause a fatal 10 dB error. This is a very simple link analysis on Lotus 1-2-3.

Please refer to the paper for details. A 50 meter radius open space is assumed, using free space propagation. Fading characteristics are given for Rayleigh and Gaussian channels. Modulation is assumed to be M'ary DPSK. Transmit power should be 1 Watt for Rayleigh, and 0.01 mW for Gaussian channels. The correct value is somewhere between.

Dr. Dave Leeson asks what about diversity? Dr. Jonathon Cheah replies that you can add that to the spreadsheet.

Bruce Tuch comments that if you are designing at 1 Watt to get past microwave ovens, then the rest is immaterial. (If one Watt is added to the noise power? Sec.) Dr. Jonathon Cheah responds that you have to start somewhere. This is useful if it reduces the amount of handwaving.

3 dB is nothing to get exited about, add appropriate fudge factor for the type of modulation

Chandos Rypinski asks about adjustment for man made noise. Dr. Jonathon Cheah responds - use the value in W. C. Y. Lee's book. The 20,000 degrees Kelvin is for sky noise.

Chandos Rypinski comments that 0.01 to 1000 mW doesn't narrow it down much. It is better to make the environment benign using spatial isolation and directional antenna.

The meeting breaks, to resume at 3:54 PM.

8.3 MAC

8.3A **Introduction of contribution** by Chandos Rypinski. ***Access Protocol Methods for Fixed and Adaptive Width Time Slots.*** Document P802.11/91-57.

(The theme of this work is a comparison of fixed TDMA and adaptive width TDMA, in particular Dr. Jonathon Cheah's SALOHADAMA protocol and Chandos Rypinski's Message-based access protocol, but many other points are touched on. Sec.)

I have long acquaintance with access protocols - but on telephony it wasn't thought of that way - it just didn't work without it. As some know I worked in 1964 on cellular with Bell. I was involved with the original mobile telephone. I had the insight then to know what was known, what was not known, and what something could be done about. It was by comparison with this work simple, but then it didn't seem that way. I have learned a way of looking at things - you need an inventory of what you know and need to know - and then get prejudices. I rather like getting what I need to know digitally - I am not fond of having to read an AGC voltage.

We are trying to come up with an access protocol. Sometimes media and access get confused - time slot and channelization for instance, but I'm beginning to see (a faint) light. I don't want to keep considering new ideas in perpetuity. Soon the work must start.

There are regular (more or less isochronous) time slot proposals, mine is asynchronous - but all are TDMA. I would like to look at the two methods of time division.

- Regarding time slotted systems - not all that are possible are on the table in this group. See the referenced paper by David J Goodman and Sherry X. Wei's. That is different than Dr. Jonathon Cheah's or mine - I don't know Bruce Tuch's yet. I bring this up since you might construe my work as an alternative to his. Actually my way is somewhat out of step with many existing TDMAs.

Contention - two stations occupying the same space at the same time? I am not against contention, the occurrence should be part of the plan - but the probability must be figured and the way to get out of the problem must be part of the plan. All of the TDMAs have contention, but it happens somewhere else than where the data happens, none of the TDMAs will loose transmitted data as the consequence of contention. I agree that contention is (unavoidable), I agree also that it has its place, and that place isn't in the data. Try to reduce the when and why of contention, try to make it improbable, (clearly not impossible). The token passing protocols are roll calls, they are not as efficient as protocols that use limited contention.

(Comment from Sec.: I have studied asynchronous contention resolution and metastable states at very great depth. It all boils down to a decay constant related to propagation time around a positive feedback loop, be it a penny on edge, RS flip flop, or token pass decision. Since the necessary uncertainty persists with high probability for many times the decay constant, it is important to keep the loop short. In a sense token passing algorithms (to pass or not to pass) have put the resolver inside the MAC chip (where contention can be resolved in dozens of nanoseconds). A CSMA/CD protocol puts contention across a couple of MACs, repeaters, and long cables. Of course CSMA throws a couple computers in the loop as well. Remember

fundamentals. Contention happens - the pea is under one of the shells for sure. How well you deal with it determines your ultimate capability.)

Don Johnson asks if you release allocation after access. Chandos Rypinski replies that you use contention to get access - after that you have dedicated allocation. Don Johnson continues: To send 1 meg, do you have to regain access for each fragment? Chandos Rypinski - I can't respond to that right now - I like VERY small transmission packets.

Chandos Rypinski continues. Right now I only address whether time should be variable or fixed. (Note that the request is separate from the data transmission.) The time to start the next service is at the end of the last service. Delay for anything other than synchronization is silly.

In a time slotted system you must allow for round trip delay, for faster system this becomes very important. Included in this must be those circuits that are part of the effective propagation. Worst case can be a very long path indeed, so dedication to the worst case is waste.

End to end negotiation of what slot to use? The D channel layer 3 of ISDN is for slot time negotiation. If you have a pure asynchronous packet, then all negotiation must be in the header of packet, and so you cannot separate negotiation for space (bandwidth) from the data. You NEED to get the necessary facts in the header, not at the terminal ends of the links. Remember that a cascade messes up where the perceived link ends are.

I tried to compare slotted aloha demand assignment multiple access (SALOHADAMA) to the message based access protocol. There are striking similarities.

In SALOHADAMA you may request access (implied invitation to request) in the Aloha time slot. Permission to use which slots (in units of convenience) is granted in the PAST time slot (usually after the head end controller has received acknowledge from the destination station).

In the message-based protocol you may request access after an invitation-to-request (with possible embedded source information so that it can be ignored). The following Grant conveys permission for a time interval equal to the length of message specified in the request - or periodic Grants for packets requiring segmentation or for connection type service.

Many of the same facts are transferred in SALOHADAMA and the message-based protocol. There is much hope of convergence here.

The potential motion, on page 4, but not made at this time, is associated with the decision to allow contention for access only when no possibility of trashing data exists.

There is a discussion about time windows - how long to wait for an event, and how to fail if the event doesn't happen. Dr. Dave Leeson indicates that it is 200 microsecond (? Sec.) in Apple Talk , if it can't do that by then it is not there - fail.

Wait intervals are exposure to abnormality and invite glitches. Dr. Jonathon Cheah says that correct choice for timeouts is important, there is art here. Hang-ups are possible due to failure to anticipate things. A final timeout becomes necessary to save you and get you out - a safety net. If you are out of stack with no options - kill it.

Chandos Rypinski continues: How to do it? Keep messages short, don't add equipment delay and do everything in sequence. I make no assertion that fixed TDMA won't work however.

Michael Masleid asks about application dependent trade offs. Chandos Rypinski responds: I am working to a criteria of worst case access of 6 milliseconds or less, this maintains the possibility of supporting virtual circuits. If no stations has a virtual circuit but there are 50 stations demanding service, if the network is overloaded, then service will be refused to the source, at least for virtuals. The message based protocol runs fast for packet traffic, but has milliseconds of jitter on packet delivery of virtual circuits.

8.3B **Introduction of contribution** by Paulette Altmaier. ***A Short Tutorial on CSMA.*** Document IEEE P802.11/91-44.

I believe that CSMA is a serious contender. I present this material as a tutorial on CSMA - it is meant to be sanitized of opinion and subjective interpretation. The purpose is to provide good qualitative and maybe quantitative information.

It is hard to present the material outside of the context of an architecture. The context for the CSMA discussion includes **autonomous collocated networks.**

Fundamental to the architecture is "networks operated by independent entities not actively coordinated with each other" with no wire between them, either. Autonomous networks are independent, the are not actively coordinated with each other - not by human intervention. Collocated networks are "networks operating on the same physical channel in the same vicinity."

System Assumptions:

A few cells will exist that are code or frequency division multiplexed. The system architecture should exploit the existence of these cells to the maximum extent possible. But - there will not be enough cells to guarantee every autonomous collocated network exclusive use of a cell.

Users will not accept a solution that requires coordination by network engineers for collocated users. It follow that

Spectrum sharing among user communities or independent access points within a cell/channel is an essential requirement for the system architecture.

As a consequence two issues exist:

It must be possible to regulate channel sharing by autonomous collocated networks.

It must be possible to regulate channel sharing by nodes within an autonomous system.

CSMA address both needs at once. Any alternative system architecture must likewise address both issues to be viable. CSMA is not a panacea, it is not toast and bread, but it addresses the needs.

The tutorial. (Please refer to the document for more details. Part of the following is reconstructed from the document. Sec.)

CSMA was first proposed in 1971 for use in packet radio channels. The Darpa Packet Radio Network (PRNET) is CSMA based. In CSMA the channel carries its own control information. Control is distributed among all nodes.

Primary source materials for this presentation are articles by L. Kleinrock, F. Tobagi, S. Lam et al. System assumptions that form the basis of the analysis (that may require serious examination) are propagation delay a small fraction of packet transmission time, a noiseless channel, propagation delay is identical for all source-destination pairs, and no capture (overlap causes destruction of all transmitted packets).

Comparing Aloha - where a node transmits whenever it has a packet ready (regardless of other traffic), and Slotted Aloha - where the node transmits whenever ready, but only at a time slot boundary, shows that throughput is equal to offered load for very light loads. As offered load is increased, throughput increases, but doesn't keep up. For Aloha throughput increases up to an offered load of 50%, at which point throughput is 18%. For Slotted Aloha throughput increases up to an offered load of 100%, at which point throughput is 38%. At higher offered loads throughput decreases.

Comparing CSMA protocols - which listen to the channel before transmitting: There are many variants.

Non-persistent will transmit if the channel is idle. If the channel is not idle, Non-persistent backs off (usually exponential) and checks again latter.

P-persistent will transmit with some probability, p, per mini-slot boundary if the channel is idle. If the channel is not idle, P-persistent waits until it is idle. Boundary conditions are: 0-persistent never transmit. 1-

persistent will transmit at the first opportunity, which guarantees collisions when the channel goes idle if more than 1 station is pending. Ethernet is 1-persistent with collision detect. Without collision detect it is an accident waiting to happen.

The normalized collision window, (a), is defined as propagation time / packet transmission time. (It is the fraction of the packet that can be out on the media without detection. Sec.) In practice the propagation time is the actual propagation time plus carrier sense time plus receive/transmit turn around time. This is dominated by the second two factors. Good representative numbers are 10 microseconds for carrier sense and 10 microseconds for turnaround, so propagation time is approximately 20 microseconds.

For 1 Mbit/s, 50 meter range, 1000 byte packets, a = 0.0025

For 1 Mbit/s, 50 meter range, 100 byte packets, a = 0.025

Many graphs are drawn assuming a = 0.01 - the value has a dramatic effect on channel capacity. Aloha is not sensitive to propagation delay since it doesn't listen.

Most concern is focused at an offered load 2 to 3 times the channel capacity. At higher offered loads throughput usually decreases.

Looking at the graphs: In all cases, for offered load less than 10%, throughput is nearly equal to offered load. **For non persistent CSMA,** peak throughput never reaches channel capacity. For small values of a = 0.001 throughput approaches channel capacity at 3000% offered load. For a = 0.01 throughput approaches 80% of capacity at offered load of 900%. For a = 0.1 throughput approaches 50% at offered load of 300%. For a = 1 the results are similar to Aloha. For higher offered loads throughput decreases.

For a = 0.1 non persistent CSMA peaks at 80% capacity at 900% offered load. **For p-persistent CSMA at a = 0.1** the result is the similar to non persistent CSMA if p = 1, except throughput peaks at less than 60% of capacity at 100% offered load for lack of backoff. As p is decreased to 0.1, throughput rapidly increases to 80% of channel capacity at 300% offered load. Again, at higher offered loads throughput decreases. The optimum value for p is sensitive to both offered load and to the normalized collision window (a).

Bruce Tuch complains that delay is random, what value should be used to compute (a), the minimum or maximum? Paulette Altmaier responds: Use the optimum or mean.

It is commented that exponential back off is an essential part of the Ethernet protocol for stability purposes. Rich Seifert points out that exponential is not the only backoff that works.

The hidden node problem occurs when a station that wishes to transmit is unaware of transmission in progress. CSMA degrades to Aloha as the number of hidden nodes increases. Non-persistent CSMA at a = 0.01 will degrade from 80% throughput to 30% throughput as hidden nodes go from 0% to about 50%. This is worst case assuming no capture..

Rich Seifert claims that this work describes old 3 Mbit/s Ethernet Shock's (Sp?) thesis. Get Dave Bog's (Sp?) ***Ethernet - Myths and Reality.*** Bogs is significantly different, and has more practical aspects like variance in packet size, it shows some throughput roll off below 100%.

Paulette Altmaier continues. Some subjective benefits are its a serious contender. It provides distributed control, simplicity of the system architecture, it is well suited to small cells and work groups, it supports cooperative spectrum use between independent systems, and it supports the portable environment and dynamic topologies.

Don Johnson says that the drawback is that it looses packets. (There is a limit on frame loss rate in the 802.) Paulette Altmaier answers that there is no solution. You must make compromises.

The meeting adjourns at 5:25 PM until 8:30 AM. Simon Black's ad-hoc group meets in this room at 8:00 PM tonight.

Wednesday, May 8, 1991, Morning.

The meeting resumes at 8:50 AM. Announcements: Remember to pay Dr. Bob Heile. There is a Symposium at Virginia Tech. June 3-5, 1991 that is filling up quickly. See Dr. Ted Rappaport. This is on the whole subject of wireless networks, IEEE 802.11 is not the only focus.

There is a discussion with Bill Stevens regarding preferences for the site of the September 1991 meeting. At issue is price and location and access and facilities and copying and phone access. Dave Bagby is concerned that about hotel phone surcharges and excess profit on phone service. The meeting is to be held in the San Francisco Bay area near Apple Computer. The meeting is to be held the week of the 15th, or the 8th to avoid the holiday. Nothing firm has been set up.

Simon Black reports of the ad-hoc meeting. We met as a group last night, particular thanks to Bill, Jim, Michael, and the others, for working past reasonable hours. We still need fine detail editing to make the flow better. The paper explains who we are, what we need, and WARC 92. The paper will be printed and circulated during the break.

8.3C **Introduction of contribution** by Chandos Rypinski. ***Limitations of CSMA in 802.11 RADIOLAN Applications***. Document IEEE P802.11/91-46a.

The revision results from sending out an early copy to very active people to get reactions about three weeks ago. This is about carrier sensing. I don't think carrier sensing, even without collision detecting, will work well in radio. I'm not addressing cable - this is in regard to the radio channel.

Forty years of work on how to use the radio channel, when nothing else is using it, has not found and adequate method. It used to be horizon limited on the radio channel. The stations were so far apart that if you didn't hear it, it won't there at all.

In 1962, it was interference limited systems, where, if the desired station is SUFFICIENTLY larger than the undesired, you had communication. Cellular radio is interference limited. It is not clear that you will ever hear silence in the cellular band.

Page 1 describes radio system properties. Assume that the radio system is designed with a range = 1 (unit of some sort). The range to the nearest reuse may then be 4. In free space attenuation is 6 dB per octave, cluttered is closer to 11 dB per octave, so the dB difference between local and distant stations is 12 to 22 dB. However, the actual dB difference has a large variability. Stations far enough away to provide 22 dB Signal to Interference (S/I) will have easy to detect carriers. It can be expected that carriers can be detected out to 10 units distance.

The interference range is very much larger than the service range (with regard to carrier sensing). In large systems you may assume that the carrier will never go away. I think that the hidden station problem is not as significant as the too many carrier problem.

I use square cells, not hexagonal, because of the natural fit to common building construction. I have taken up several issues here, please read the paper. The round trip transit time has very much to do with the window of opportunity for stations to interfere with each other.

From an historical point of view, the obvious is true. it is better to have an indication that something is available, not an indication that it is not available. At Bell Labs, in 1967, a tone was used with mobile telephone to indicate idle - but it turns out that mobile can hear more than idle tone. The signal that indicates "available" has to become more complex over time. Absence of signal must not be a logic state, because signal-not-there and signal-there doesn't really correlate well with channel availability.

Refer to page 5, Figure 1, of document 91-46A for a comparison of CSMA and the Message-Based Access Protocol. The message-based protocol has more function than is used in this context, but remember that we are designing to include evolution to high performance high capacity systems. That will be challenging when we get into the details.

I have put the text for a motion. . . Dave Bagby interrupts: "Point of order, we adopted procedures at the last meeting for processing technical issues."

Chandos Rypinski continues: I don't know of a way to design radio to achieve CSMA.

Discussion

Richard Allen asks (regarding detection of carrier) about the possibility of using a busy tone, say at the beginning and end of transmission. Chandos Rypinski replies that it may work in the optical case, and in cable that is useable. In radio, which is not a contained medium, it will appear busy when it is not busy. It becomes perpetually locked out, especially during high load. The key this is that radio is interference limited.

Larry van der Jagt interjects that though it is not right time to introduce the subject, but nothing that happened at Hilton Head implied that the motion is out of order.

Discussion of the right to bring up a motion? That is procedural issue. (Another booby trap. Please let me know what is decided on this. Sec.)

Continuing. . .

Dr. Dave Leeson comments that Radio is different, there is multipath, for coherent it is different than for non coherent. We have been through the same kind of thing, the equivalent of busy can be done another way. Chandos Rypinski responds: I didn't want to talk about what the method should be. Obviously I think access should be through a message carrying only what is needed. I think the method should be media independent. Avoid the use of odd things about the media, the hooks into the physical media used by MAC protocols is always a nuisance in the long run.

Dr. Dave Leeson asks Paulette Altmaier if you use Carrier Sense in the narrow or broad sense? Paulette Altmaier answers: In broad sense, which implies layers of understanding. Addressing Chandos Rypinski: Setting carrier sense threshold is a separate issue. Chandos Rypinski replies that in the next paper I take that up, I will add further comments. Paulette Altmaier asks why not combine the three papers so that they can be done in a group, and in parallel send written comments to the authors?

Jim Mathis asks if intermodulation distortion will (cause a) hit (on) error rates? Chandos Rypinski replies that intermodulation makes things appear present when they are not, the application to this context is not clear since it usually applies when using high power transmitters and nonlinearity. (Broadband trunk amplifiers, receivers, Sec.) Dr. Dave Leeson comments that with a 40 db fade margin this will be a problem for us too. Actually your net (the message-based protocol) is also CSMA! (Bus protocols tend to be like that on power up. Sec.)

Chandos Rypinski admits that presence or absence of signal, or carrier, or why not bit clock lock for carrier sense? Not withstanding all those improvements, I still would not like to have to do it (carrier sense).

Bruce Tuch comments: So it could be done, but what of the functional requirements? (Project 802's.) CSMA could work as well as arc net, but if that won't do what we need. . . To coordinate, to do extended areas, may become prohibitive, even though the single pair worked. Chandos Rypinski claims, given the alternatives, skilful control is always better.

Dr. Dave Leeson points out that detecting a signal, versus detecting communication is possible and is the issue. The second is not related to the first.

Larry van der Jagt suggests, say a 2047 bit long code, or say 127 (with stress on imagination) could be used to indicate that something is there. In fact, how about 127 bits long that says everything is alright. Chandos Rypinski responds that there is more that one way to obtain indication. Is the correlator to indicate adjacent cells, or between two in the same cell? Rich Seifert points out, regarding carrier sense, that you have missed the point of adjacent lock out.

Paulette Altmaier responds that we wish to imply a very intelligent carrier sense.

Jim Mathis comments to Chandos Rypinski: Your system is also carrier sense in the use of contention windows. The real issue is centralized vs distributed control. When using the protocol in a dynamic topology, one that is moving slow enough to not be affected by Doppler, but with less than several seconds cell residence time, I have made no decision because I have seen no comparison of capability of the protocols.

Dr. Dave Leeson comments that this (?) is a very sophisticated form of carrier sense, it takes a time that is already in the body of CSMA literature. There is no disagreement on the need to detect presence of or message conveyance capability, the question is what do you do about it. How are we to optimize this? But the message based protocol is an embodiment of CSMA.

Chandos Rypinski address Jim Mathis. I am not wishing to exclude peer to peer, it is a given that must be met, but it is not the only requirement, the protocol must also work in the saturated environment. It must also work in a crowded district. I am not excluding, and do not intend to exclude, peer to peer communication. Don't pretend that an infrastructure can be avoided, there is no precedence in a long history. Networking needs to be possibility, to wired LANs or to go between wireless LANs. Remember that in radio, at the desktop, you can not determine if you can or can not communicate. There are simple common equipments that work (that can determine or ensure communication) for small groups - they are necessary.

Dr. Tony Shober presents some random thoughts regarding distributed versus random (central?) control. We need to determine the direction we want to go in. A completely distributed solution is not likely to function in a broad range of environments. Are we trying to design something with broad applicability to many PHY layers, are we trying to design a common upper layer for many modulations, or are we working to a particular PHY and frequency? The algorithms themselves may not even be usable across many PHYs. I am hearing double digit GHz stuff here. That stuff is very different than what I heard yesterday. There are much more fundamental issues. Don Johnson comments that this needs to be resolved. Paulette Altmaier expresses the same question. Chandos Rypinski replies: I assert that one MAC can do all.

Rich Seifert replies that one MAC for all was project 802's goal too.

Dr. Jonathon Cheah speaks: In distributed control how do you go from one cell to another. A tutorial is not a method. Don't fight for a cause, CSMA is a technique - a tool - it is not a solution to 20% of the requirements. We can look ahead to solutions, and examine their problems. All that Chandos and Paulette have are tools, not architectures. We MUST bear in mind the radio propagation problem. A MAC to solve all problems! This medium is not a wire, you can't put in a second one. The MAC design must deal with the these issues. It should work from sub GHz through double digit GHz (and unto infrared?) Bruce Tuch comments that the MAC must plan for multiple PHYs. Don't make a chip that is obsolete. Nathan Silberman suggest that we take top down approach: Start from the system architecture assuming radio, then find problems we want to solve, then examine characteristics of media. **Chandos Rypinski points out that it easy, using the top down approach, to create insolvable problems.**

Dave Bagby points out that several PHYs and one MAC is required in the PAR. James Neeley suggests a single PHY with multiple PMDs (Physical Medium Dependent).

Chandos Rypinski expresses concern. If the logic will be distributed, what is the degree? The criteria? The station can't decide (if it can transmit) because it doesn't have enough facts. What it can hear is not enough information. To manage access you need to know about the other cells. Control distributed only in stations is a dead end because the station does not have enough facts. Paulette Altmaier responds that you can't define the interface until know what the MAC is going to do.

Dave Bagby requests that we break and refocus. Jim Mathis asks why a station does not have enough information in the cellular environment? Chandos Rypinski responds that the state of adjacent areas confuse the station.

The meeting breaks, and resumes at 11:06 AM. Is there a resolution to 91-46a? Paulette Altmaier observes that if we assume the existence of access points then we have more knowledge, but have also assumed a more central architecture. We must discuss this, perhaps at a later time.

8.3D Introduction of contribution by Chandos Rypinski. ***Comments on "A Short Tutorial on CSMA" (IEEE P802.11/91-44).*** Document IEEE P802.11/91-56.

The previous paper was sent out weeks ago. Having received Paulette Altmaier's paper on CSMA, I undertook to react to that. Since I am declaring the inapplicability of Kleinrock's analysis to our situation, this is not an attack on Paulette's presentation, or even an attach on Kleinrock. It is a matter that ours and his assumptions are not the same. In particular, I have difficulty seeing a way that CSMA can reach high levels of medium utilization - for better or worse it is my belief. I will now go through the Kleinrock papers. I am not saying his conclusions are wrong given his assumptions. I am saying his assumptions do not apply. Regarding the issue of propagation time as fraction of packet length (the constant a)? It is a constant? Packet length is variable, that seems important enough to me to me to not collapse the two into one measure.

There is not much point in reading the paper to you, please read it. (Maybe I have used too strong a way of stating myself in the paper?) Assuming that the radio channel is noiseless is not too good an assumption. To assume propagation delay is uniform? Ok if using arithmetic addition, but using packets the same length then mixing is a problem.

Paulette Altmaier said yesterday that I misinterpret the S factor - the basis of the mistake is in point 6, page 3, quoting Kleinrock, (the belief that S, or throughput, includes damaged or overlapped packets). I may be wrong or inaccurate - but 80 or 90% throughput makes me suspicious. I have listed all the assumptions that I take exception to in one reading. The high channel time utilization is not consistent with my intuition or experience.

Later in paper, on page 5, I take up radio implementation assumptions. I wonder why people hold to their views (so tenaciously). (It seems likely that the views on MAC issues are rooted in assumptions about the nature of radio that Chandos Rypinski does not share. Sec.) There may be assumptions that are made that I don't hold, for instance, that the "on" power is higher than the "off" power?

A 1 Watt transmitter is a significant drain, but is that needed, desirable, or permissible. I concede the need for 10 mW - but above 100 mW? The duty cycle is likely short, anyway. Third factor is just the way the circuits work, the main drain is the receiver in receive mode. That may or may not be true, it depends on the skill of the implementor. I have my opinion.

As to this new factor wake up circuits and sleep mode. I don't like that as a circuit designer. Turn on for a stable oscillator is not a nice process. The dynamics of turn on time is over 2 microseconds for oscillators. Phase locked loops take 1 millisecond to settle, high Q resonators take build up time. It is a main drain. I don't like fast turn on/off of accurate microwave oscillators - others may hold different views.

Carrier sensing circuits? Go back to the beginning - at the start of cellular. It was just another pin on the CA39 chip - not a difficult circuit. If fast response time (on the RF/IF stage) is important and bandwidth is limited then damping and stability is difficult. When and what is the threshold? Somewhere above background noise, but below the level needed by the circuit for communication. That leaves some room for opinion. If hysteresis is used to avoid dropouts, then the inertia leads to slow release.

Bruce Tuch comments that carrier detect should not be based on signal strength. Chandos Rypinski agrees, something like signal to noise, or clock lock should be used. Bruce Tuch believes that it is trivial. Chandos Rypinski comments that it may add to the acquisition time. The dynamic range that must be handled (required for near by lap top computers, say) is a bit of a problem.

There is a comment about carrier sense, signal sense, message detect. Chandos Rypinski comments: I mean signal absence is not a logic state. (There is a reference to Don Cox, February 1991, IEEE Transactions on Communication.)

Jim Neeley comments that it is difficult for us to build to future state markets. We build to our current paradigm. There is a time frame to get spectrum, and to use it. We may get two ore three pieces of spectrum. If we are lucky and get 60 or 70 MHz below 3 GHz, then we must use it fast and well. If we don't get isochronous service up front, we will never have it. Imagine a type A and type B station. Type B may be CSMA, but will bow to the control of a type A station. A type A station can and will, if necessary, take

control as an access point. As to the isochronous decision? That must be determinant on PMD I think, we should do it on band by band basis.

Dr. Kwang-Cheng Chen notes that it is hard to follow Dr. Jonathon Cheah's paper. We need a definition of common terminology. We have to many heuristic arguments. Reply: DECT is at 900 pages and is still arguing definitions.

Steve Wilkus comments about the similarity between CSMA and the Message-Based Access Protocol. Generalizing the idea of carrier sense to looking for a certain message, then there is little difference. We will need to know more than just a pilot tone. We need a base ID and pilot tone - but what about sharing with vastly different services? What about continuously transmitting analog instruments. If we do just a message transaction we will never see a clear channel and so will never transmit.

What about auctioned off spectrum? What are the applications? Applications, software, creative people? Wireless pocket phones are the largest growth market. The big growth of E-mail, file sharing, print sharing? Where's the market for that? Document 91-34?

Jim Neeley comments that one of the inventive ideas is multimedia, that is driving our market. Another one is company news, another is selective use of multimedia over the LAN. That has the same requirements as voice, and it is a humongous market.

The meeting breaks at 12:54 AM for a short lunch, to resume at 2:00 PM.

Wednesday, May 8, 1991, Afternoon.

There will be a tutorial by Dr. Jonathon Cheah from 8:00 PM till 10:00 PM (or latter) on the slotted aloha demand assignment multiple access protocol.

8.3c **Introduction of contribution** by Dale Buchholz (presenting) and Lee Hamilton. ***Comments on CSMA***. Document IEEE P802.11/91-49.

I will assume that CSMA can be done perfectly. You may debate that another time. You are dreaming if looking for 80% protocol efficiency. Don't decide on using CSMA until after listening carefully to Chandos and Jonathon's proposals. Throughput with CSMA is not good. What the market will accept is not so clear.

I show information based on Hammond and O'Reilly. Paulette Altmaier's analysis (Kleinrock and Tobagi) assumes offered loads of 2 to 5 times the capacity of the network. Ok, but I am surprised to hear that. I observe that, with a text processor interleaved on a SUN, that the interim autostore is not unobtrusive to the user. The cursor is frozen. I have to wait. I begin to curse. At 1 Mbit/s throughput, a 1 kpacket takes 1 ms. File transfer will take too long, especially during interactive work. File transfer is one thing. Some applications save and store what is happening on the system's initiative, not the user's initiative. That is obtrusive.

For anything other than very light loads the average normalized delay through the network approaches 2. (At 50% load, at still higher loads delay becomes very much larger.)

Look at turn around time assuming perfect carrier detection, part of what must be included in propagation delay. Turn around time less than 2.5 microseconds is heavy duty electronics. (Turn around faster than 100 microseconds is possible but costly.) This means that normalized propagation delay is expected to be greater than 0.1, not 0.01.

I am a computer science person. Listening to our radio engineers, turnaround of 10 microsecond or faster is expensive. Too expensive for the target applications.

CSMA is good for systems that require less than 30% throughput at an offered load of less than 1. The cost of turn around will probably limit the channel bit rate to 4 Mbit/s or less, yielding throughputs of 1.2 Mbit/s or less. This is unsatisfactory for most office application of tomorrow.

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Dale Buchholz comments: To know the need, the immediate need? Because of wires. There is demand for something that will do this and be easy to install. Wire in buildings is not nice, it is always a problem no matter how well planned. Mil, Tom, and I have bet our careers on this. We think there is a market.

Bruce Tuch comments that we should define the basic to extended service area regarding reuse, but that is not divorce from protocol. The FEC issue my experience? It is not much help. If the ensemble is moving FEC helps. If not moving FEC does not. FEC helps if it is moving.

Dr. Ted Rappaport comments that FEC works in Rayleigh and Ricean deep fade channels. We've simulated Raleigh and the Eb/N0 and it does work. For that application FEC is appropriate.

The meeting breaks and resumes at 4:01 PM. At this point the 75% attendance rule requires attendance at 6 half day sessions of this meeting for purpose of voting rights. This finishes the MAC layer discussion for now. Dr. Ted Rappaport has asked the Chairman's permission to present his work.

Dr. Ted Rappaport reports: At Virginia Tech we have done much good propagation work (good work has also been done at Worcester). This was my doctorate work. I did not realize how fast the technology would become important.

We did measurements for factories, and for offices with hard partitions and soft partition (Herman Miller), and have the amplitude fading and path loss. (To make the data accessible, a computer model was built that essentially duplicates the statistics of the measured data. Sec.)

CIRCIM is a computer radio channel model. It will play back the complex impulse response and fade (of hypothetical channels). This will be in the Journal in May 1991, published in a month. The tool is being used to simulate BER and adaptive models at Virginia Polytech. If you want more information, I can get the information. Unfortunately, the university... This was done at home, a statistical analysis, done as a computer program, done in my basement. I disclosed to the University - they said they own it. It costs $1500 dollars - most goes to University. - But you can reinvent the program from the paper. (This is a bit awkward, I think, because most of the work submitted at the standards meetings is not reimbursed. - but hey, whatever it takes to keep the lights burning. Sec.) The tool is in Turbo Pascal for IBM or clone. (Paulette Altmaier comments that that is the wrong computer.) Ted is moving the program to unix. For $1500 you get the source code, but you can't modify and resell it.

If interested, you can write to me. The old 802.4L documents will also have the data. The original version did not measure phase (complex measurement). The new paper moves to an incremental length of model. This gives the same narrow band (CW) statistics. It recreates narrow band measurements. (In so far as the narrow band statistics implies the complex impulse response of the channel and the incremental model is reasonable the simulated impulse response is reasonable. Sec.)

10. External liaison

10.1 ETSI

Simon Black reports that there is an ad-hoc group to study objective of and to clarify the concept of radio LANs with regards to user requirements. On DECT, RES-3N has one meeting to go, then they are into the public enquiry phase. The liaison statement was had delivered to Andrew Bud.

10.2 T1

Rich Dayam is not here. Jim Mathis is planning to attend all plenary meetings, and will report next time.

10.3 ECMA

ECMA started an ad-hoc group to see what they should do on wireless LANs, the meeting is in Abbingdon in the UK, after the ETSI May 21-22 meeting at 2:00 PM to the next day at 5 PM a joint ECMA ETSI meeting.

Throughput of 30% is typical and agrees with field experience. Field experience indicates in may not be that good. The assumption of offered load = 1 is not real.

CSMA may work for an ad-hoc group, but not for the desk top. Using portable computers changes nature of traffic. I need a replacement in function for the SUN workstation, the workgroup of 32 users. If portables are to fit in that space, they will need wired throughput. In a tightly packed workgroup CSMA is not going to do it. CSMA will work for portable computers and FEW users. It will work there.

Richard Allen comments that the proportionality of file transfer rate to networks speed does not hold because of the other bottle necks. Michael Masleid claims that is due to using broken computers. Better equipment doesn't have that problem.

Dale Buchholz points out Motorola's corporate goal is to make everything wireless. Nathan Silberman says that you can't plan to replace all with wireless. Dale Buchholz admits: Yes it is complimentary, but we still want to replace wired networks.

Bruce Tuch points out that most do not need it now - but we must plan for future. 100 microsecond turnaround? I don't think so but let's define the application space. Yours is not dominant right now. If yours is costly now it won't sell. But lets leave hooks in the Standard so that it doesn't bottom out.

Dr. Tony Shober question Dale's claim of a 10^{-5} error rate. Is that real radio with real techniques that get that for real? What is the raw uncorrected error rate of the underlying modulation? Dale Buchholz replies that at 40 feet range there is no problem. At 50 feet radius, the 95% success rate implies a 10^{-5} BER. Dr. Jonathon Cheah comments that 10^{-5} to 10^{-7} is enough to prime FEC at rate 1/2 codes. Bruce Tuch comments that BER is not so important as coverage,

Richard Allen ask what do we design for? All current networks are lightly loaded, lets not go to gold plate because FDDI is fast. Dale Buchholz answers: In my experience the average load is light, but the peaks are heavy, at times 3 and 4 Mbit/s for significantly great times, such peaks are problematic, that drives the splits. (In other words, CSMA/CD networks are lightly loaded because the don't work otherwise. They get segmented. Good luck segmenting air. Sec.)

Paulette Altmaier comments that we are Working on different marketing assumptions. I am most interested in net when moving around. These are fundamentally different from desktop networks and have fundamentally different requirements. To do 10 Mbit/s and also low power may involve a very different solution. Returning now to Thomas Freeburg's comments: We must focus our energy on reuse. That is the important issue.

Dale Buchholz comments that, at least at Motorola, I get one or the other, not both. It is an economic thing at Motorola. You get something on your desk. If it is only one thing it must do all functions.

Paulette Altmaier: Do we walk before we can run?

Jim Mathis asks how dynamic sharing versus ease of design saves time. All systems have some hidden inefficiencies. A circuit switch that runs 100% efficient pads is not useful compared to 30% of real data.

Steve Wilkus comments on using error correction for 10^{-5} error rates: That is a very steep curve there. If on one side or the other there is no need for error correction.

Paulette Altmaier comments: Lets focus energy on reuse, that is the most important!

Dr. Dave Leeson observes that getting a few feet further, or saving dish size with FEC... In our radio the BER is zero, or it runs as a counter (all errors). FEC is just not useful. As to the high speed computer on the desk, it is interesting, but if it plugs in for power, why not also plug into the fiber?

Dr. Jonathon Cheah comments on FEC (forward error correction): Use it - it appears to not do much - error or no error - as you see from outside. FEC depends on the propagation environment. Use one for a Gaussian, you get the waterfall, but for Rayleigh fading it is a much different environment, and there are good codes - satelite - Viterbi. In cellular you get burned. You need to know what you are doing. Cellular needs 18 dB signal to noise? Wrong. FEC plays a role, you must know how to use it.

presented, Dr. Jonathon Cheah's protocol seems to require a cellular arrangement of HECs. The twin tower problem assumes that glass walled offices of competing companies face each other across a plaza and swimming pool. The path attenuation between buildings is less than the attenuation between offices in the same building, and so the S/I ratio is negative, making frequency or code reuse problematical. Common jurisdiction was offered as a solution over Paulette Altmaier's objections.

Paulette Altmaier comments as follows:

There are four general observations on protocols (that arose from discussion of Dr. Jonathon Cheah's protocol, but we decided are a litmus test for our protocol).

1) Does the protocol quantize bandwidth - how does it degrade?

2) Administrative bounding of a net is needed (signal strength cannot be used for network partitioning).

3) How does the protocol support dynamic and non-deterministic topology?

4) The protocol cannot **depend** on spatial isolation.

Chandos Rypinski moves, Bruce Tuch seconds the following motion:

Vic Hayes shall continue processing the comments to CEPT with appropriate review by the legal and committee entities so that final approval may be obtained at the July 802 plenary. (10-0-1)

Discussion: The following people will be part of the review group: Simon Black, Chandos Rypinski, Bill Stevens or Jim Lovette, and Don Johnson.

Raleigh meeting sites proximate to the airport: Sheridan, Compry, Holiday, Embassy Suites, Marriot. (The Compri room schedule in Gaithersburg was a problem.) Hotel row is on the highway by the airport, so walk in restaurants is a problem. During an ice storm, they cancel the city. Just stay home.

How many think evening entertainment is needed at plenary sites? (NONE)

At Michael Masleid's request, Bruce Tuch makes a ***motion requesting test bed models be presented at the next meeting***. Seconded by Jim Neeley. ***Motion passes*** (10-0-3)

The mailing date for the July 8th meeting, is June 3rd or 10th. If you don't make it bring 75 copies.

As part of the schedule in July, adjourn to watch the solar eclipse on the 11th, Thursday. It is in the day time, 7 minutes.

The Chair wishes to thank Dr. Bob Heile for hosting the meeting. We are at closure. Thanks to Michael and Jim for their persistence. See all in Hawaii. The meeting adjourned at 12:05 Thursday.

(Note from Sec. I must apologies for not being able to attend the next (several?) meetings. I regret this - it is a great pleasure to work on something as important as this. I am allowed to continue the work, but there is no money to attend meetings. I will be allowed to apply for permission again in September or December if business conditions improve.)

Work items.

Michael Masleid. On the multiray display, show the display as a contour map coded in dB. The put blue up 6 dB against the power sum of the others. This will help understanding of the reuse problem.

Contributions for test bed models (environments from hell) are solicited.

Contributions for "Spectrum Requirements" are solicited.

Simon Black's ad-hoc group was charged with writing letters to others besides CEPT, for instance, Japan. There was not time to do this at this meeting.

11. Miscellaneous

11.1 Design goals.

There is an attempt to deal with the design goals collected by the ad-hoc group chaired by Michael Masleid in Gaithersburg (Document W3). This was another free for all discussion recorded on tape. If time permits I will transcribe. The most interesting thing that came out of the discussion is the results of the straw poll showing how much support there is for each of the goals. Some of the results are surprising. The straw poll was cut short by adjournment, but is continued on Thursday. Here are a few comments from the notes.

Nathan Silberman: The goal is to have network management hooks and handles in the MAC. We will eventually need a complete set of managed objects.

About high vehicular speed: It depends on the use of coherent or non coherent receivers. You can stand still and look like you are moving 100 miles an hour if the local oscillators are drifting. This is not something to get hung up about, since you also have to work standing still.

Does roaming imply that implementations must work internationally (frequencies..)?

The meeting is adjourned to Thursday.

Thursday, May 9, 1991, Morning.

The meeting resumes at 9:03 AM. The Secretary points out that because the meeting Wednesday was adjourned during the straw poll, we must continue there, or entertain a motion to return to the orders of the day.

Chandos Rypinski moves that we return to orders of the day, Michael Masleid seconds. (11-0-2)

Document update: Document P802.11/91-45, ***The Case for CSMA***, has not been written yet. P802.11/91-61 is reserved for the draft design goals. Draft to CEPT (5X) will be document P802.11/91-62.

The number of copies that you should bring for presentation at an interim meeting is 60, for a plenary meeting it is 75. If you have documents that you wish to show (that are not part of the normal business of this meeting), comments to the FCC, say, leave the stuff in the back of the room.

There will be a list of documents that are open had outs, including the source, so that the original can be obtained, or the author contacted. About 200 are needed for general mailing, 70 more for minutes and. . .

The meeting continues with the straw poll. The results will be a separate document.

Just before the question: Support for peer to peer operation Dave Bagby ***moves*** that we stop the straw poll, seconded by Daniel Lewis. Larry van der Jagt calls the question (15-0-0). The ***motion to stop fails***. (4-8-3). The vote on peer to peer is (7,1,17). Of some interest is that support for one MAC is (13-2-6), with the opposition being those working on infrared.

The design goal document is a concatenation of a list of noble objectives type design goals and a list of target design parameters type design goals. Having completed the straw poll on noble objectives it is time to stop.

Jim Mathis makes a ***motion to stop***, Dave Bagby seconds. ***Motion to stop passes*** (12-0-5)

Orest Storoshchuk makes a ***motion to form the design parameters into a nice survey form.*** Michael Masleid seconds. ***Motion passes*** (7-0-7). Larry van der Jagt volunteers, Chandos Rypinski volunteers to help. Please direct any suggestions to Larry.

Michael Masleid presents a brief review of issues discovered through Dr. Jonathon Cheah's tutorial. This discussion is on tape and will be transcribed as time permits. Very briefly, two issues. Synchronization of HECs is made difficult because distance causes an apparent phase shift. If all stations slow down to drive the shift to zero, the phase shift will remain unchanged. Unless corrected for this could drive the VCOs to the rails. Michael Masleid suggests a solution based on Malaysian Fireflies. See ***Synchronous Fireflies,*** by John and Elisabeth Buck, May 1976 Scientific American, page 74. The second problem is more severe. As

Appendix 1
Attendance list

Mr. RICHARD ALLEN	Wireless Research	408 354 8190
Ms. PAULETTE ALTMAIER	Apple Computer Inc	408 974 1949
Mr. MICHAEL A. ATTILI	M/A-COM Advanced Programs and Development	617 272 3000 X2816
Mr. DAVE BAGBY	Toshiba America Info Systems Inc	714 583 3846
Mr. SIMON BLACK	Symbionics	+44 223 421025
Mr. CHARLES BRILL	AMP Inc	717 561 6198
Mr. DALE BUCHHOLZ	Motorola Inc.	708 632 5146
Dr. JONATHON CHEAH	HUGHES Network Systems	619 453 7007
Dr. KWANG-CHENG CHEN	IBM Corporation	914 784 7633
Mr. BURCHALL COOPER	LXE	404 4474224
Mr. LUCIAN DANG	Rockwell International	714 833 4352
Mr. TOM FREEBURG	Motorola Inc.	312 622 5146
Mr. DARRELL R. FURLONG	Concord Communications Inc.	508 460 4646
Mr. HIDEAKI HARUYAMA	Toshiba	+81 44 548 5350
Mr. VICTOR HAYES	NCR Systems Engineering B.V	+31 3402 76528
Dr. BOB HEILE	WINDATA Inc.	508 393 3330
Prof. CARL HEWITT	MIT	617 253 5873
Dr.Eng. TOMOAKI ISHIFUJI	HITACHI Central Research Laboratory	+81 423 23 1111
Mr. LARRY van der JAGT	Knowledge Implementations Inc	914 986 3492
Mr. DONALD C. JOHNSON	NCR Corporation WHQ 5E	513 445 1452
Mr. THOMAS LAMBERT	NEEF Consult GmbH	+49 721 8606179
Dr. DAVID B. LEESON	California Microwave	408 720 6215
Mr. JACK LEIB	NCR Microelectronic Products Div	303 226 9591
Mr. DANIEL E. LEWIS	Telxon	216 867 3700
Mr. RONALD MAHANY	Norand Corporation	319 369 3552
Mr. MICHAEL MASLEID	Inland Steel Co. MS2-465	219 399 2454
Mr. JAMES MATHIS	Apple Computer Inc	408 974 8100
Mr. STEVE MESSENGER	Telesystems SLW inc	416 441 9966
Mr. T. MITSUTOMI	Sharp	714 261 6224
Dr. K.S. NATARAJAN	IBM T.J. Watson Research Center	914 784 7844
Mr. JAMES NEELEY	IBM	919 543 3259
Mr. PAUL NIKOLICH	Racal Interlan	508 263 9929
Mr. MIL OVAN	Motorola Inc.	708 632 3102
Mr. ROGER PANDANDA	Fujitsu America Inc	214 997 7635
Dr. THEODORE S. RAPPAPORT	Virginia Polytechnic Institute and State University	703 231 6834
Mr. KEN RATTRAY	AT&T Bell Laboratories	908 949 1099
Mrs. JENNIFER RENISON	Strategies Unlimited	415 941 3438
Mr. RANDALL D. RETTBERG	APPLE Computer	
Mr. ROBERT H. ROSENBAUM	WINDATA	508 393 3330
Mr. JUAN CARLOS RUIZ RUIZ	CRESA	+34 91 248 78 06

Appendix 1
Attendance list (continuation)

Mr. CHANDOS RYPINSKI	LACE Inc.	707 765 9627
Mr. CURTIS JOHN SCHMIDEK	National Semiconductor	408 721 7321
Mr. RICH SEIFERT	Networks and Communications Consulting	408 996 0922
Dr. R.ANTHONY SHOBER	AT&T Bell Laboratories	908 949 7991
Mr. NATHAN SILBERMAN	Symbol Technologies Inc	408 446 2210
Mr. ROBERT SNYDER	Hewlett-Packard Company	617 890 6300
Mr. WILLIAM STEVENS	Apple Computer Inc	408 974 6307
Mr. OREST L. STOROSHCHUK	General Motors of Canada	416 644 6994
Mr. CHARLES THURWACHTER	Square D Compnay	708 397 2600
Mr. BRUCE TUCH	NCR Systems Engineering B.V.	+31 3402 76527
Mr. DAVID J. WASKEVITCH	Spectrix Corporation	708 491 4534
Mr. STEVE WILKUS	AT&T Bell Laboratories	508 960 6033