Minutes of the IEEE 802.4L Working Group

Chicago, Illinois
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Chairman. Vic Hayes

Secretary & Editor. Michael Masleid, Chuck Thurwachter.

Attendance.

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Contributions. If possible, send contributions to Vic Hayes early enough so that he has time to put the information into peoples hands before they come to the meeting.

Approval of minutes. The minutes of the Phoenix meeting were reviewed and approved.

Meeting Plan. The next 802.4L working group meeting is scheduled with the IEEE 802 plenary meeting at the Omni Royal Orleans, (504) 529-5333, during the week of March 13th. One half day will review objectives, media characteristics, and document layout. Another half day will review the MAC protocol. The next 802.4L interim meeting is scheduled for Atlanta Georgia, on May 22nd through May 24th. This replaces the meeting that had been scheduled for Nieuwegein.

Summary.

FCC rules and international standards. References to FCC rules cannot be made in a document that must be submitted to ISO. Frequency allocation is a matter of national concern, it is not a matter of standardizations. No bands are allocated in Europe for this service. It is necessary to put the text of the FCC requirements into the standard. Indicate that the frequency allocations are a recommendation, not part of the standard, and that actual frequencies used are a matter of national concern.

Quasi static mobile equipment. (Contribution by Vic Hayes) Through air LANS are required for mobile equipment (cranes, carriers, AGV's). In addition, through air LANS may be preferred to cabled LANS for semi stationary devices (terminals, printers) and fixed devices (scales, remote sensors and controls), when cable presents problems with safety, installation cost or time, or ease of use. For this reason change the scope document to include any network where cable is not desirable. Change the speed range in the direction document to allow stationary networks.

Discussion. A formal change to the PAR is not needed here. The standard should not be written to preclude mobile networks. If the only functional difference between a mobile and stationary station is that the mobile station requires antenna diversity, and the stationary station does not, then there should be no problem. However, if the standard were written so that mobile stations became impractical, the intention of the PAR would no longer be met.

Doppler shift is not the limiting factor for mobile equipment. The problem is with antenna selection. If the receiver commits to one antenna for a whole frame, and the antenna moves into a 30 dB fade, the frame will be lost. The distance or time between fades is one measure of channel coherence time.

Outage model. (Contribution by Bruce Tuch). The outage model describes what fraction of stations will not have an adequate signal to noise ratio versus distance from the transmitting station. Increasing path diversity with delay spread, or multiple antennas, reduces outage.

Token bus medium access control mechanism. Much time was spent discussing the medium access control mechanism. Section 5 of IEEE 802.4 describes the medium access control mechanism. Read it. Contributions that detail the interaction of the mechanism with features of radio LAN's are needed.

Changes to the MAC. Changes to the MAC, such as limiting frame length, or changing the interface between the MAC and PHY layer, are not allowed. As long as presentation at the interface remains unchanged, there does not have to be a one to one correspondence between MAC and PHY symbols or timing.

Safety. The power levels planned for this service are well below values that may be considered hazardous. A contribution that shows why this is true is needed.

Patents. Contributions needed for development of high speed radio LANS may be patentable. Publication places the contribution in the public domain making the contribution no longer patentable. Paul Eastman can assist in getting critical items published quickly. If an item is patented, license must be available on a reasonable and nondiscriminatory basis. If the patent is not available, then the standard must not require implementations that infringe on the patent.

Interference, desensitization, silence, pseudo silence, bad signal, noise, thresholds, and what to do if you don't want to listen to what you are hearing. The radio LAN is not a closed system. It will receive transmissions that do not originate within the LAN. Some transmissions will be from similar LAN's and may cause complete disruption. Other types of transmission may desensitize or blanking of receivers - making them unable to detect transmissions from within the LAN itself. In some cases, this will cause a second token to be generated, which will also disrupt the network. Some form of security at the physical layer is required.

Silence. When the absolute power detected by the receiver is below the lowest power that could be presented by any member of the LAN, then the receiver may report *silence* to the MAC. The receiver must report as *non-silence* any signal that could cause desensitization or blanking of the receiver. *Silence* must only be reported when it is certain that no station in the LAN is transmitting.

Pseudo Silence. If a radio LAN analogous to a dual frequency broadband LAN is used, and a PHY-symbol for pseudo silence is used, then *silence* should be reported to the MAC when pseudo silence is being received. Reception of pseudo silence that originates outside the LAN will cause total disruption. Once again, security must be implemented at the physical layer so that the origin of the transmission can be validated.

Bad signal. Bad signal should be reported to the MAC when the receiver is responding to a transmission - including pseudo silence - that did not originate within the LAN. Bad signal should also be reported whenever the receiver is desensitized or blanked and not receiving a signal from within the LAN at a high enough power level to be demodulated in spite of the interference.

Noise. Noise can be reported as bad signal. Noise that follows *silence* is reported as preamble in some implementations of 802.4.

Threshold. There was much discussion that relates to the use of a fixed or dynamic thresholds for reporting silence. Fixed thresholds have been used in the other 802.4 physical layers, but those have been closed systems. The use of a fixed threshold in secondary use radio LAN's needs to be examined. (We are a secondary user - as such we must tolerate interference from any primary user.) Some or all of the stations might never report silence. A contribution that shows how the token passing algorithm works under such conditions is needed. It should be noted that if the preamble and delimiters, before spreading, are long M sequence or Barker codes, then correlators in the receiver could substantially improve the ability to detect carrier and ignore interference.

What to do if you don't want to listen to what you are hearing. Those familiar with the art (of radio) are reluctant to send garbage to the MAC when the garbage is known to originate outside of the network. The MAC is smart. It can deal with garbage. If the clock is kept in tolerance, and foreign signals are reported as bad signal most of the time, the MAC should be able to keep it all straight.

Undetected bit error rate. The bit error rate provided to the MAC PHY interface (for bits that are not reported with bad signal) must be less than one in 10^9 bits. Undetected bit errors, with the exception of paired errors, must be statistically independent. Undetected errors must not occur in bursts. Since frames are much shorter that 10^9 bits, any frame error due to an undetected bit error is certainly the result of a single event. Undetected bit errors should be avoided so that undetectable frame errors are extremely unlikely.

Detected bit error rate. The bit error rate provided to the MAC PHY interface (for bits that are reported with bad signal) must be less than one in 10^8 bits. Detected bit errors may be statistically dependent, and may occur in bursts. Since frames are much shorter that 10^8 bits, any frame error due to a statistically independent detected bit error is certainly the result of a single event. Detected bit errors are not as dangerous as undetected bit errors, however, it takes time for the upper layers of the protocol replace the lost frame. Detected errors should be avoided to improve throughput.

Undetectable frame error rate. If several bits are in error in a single frame, it is possible, though not likely, that the FCS will be valid for the frame in error. If bad signal is not reported during the frame, the MAC must accept the frame as valid. This is an undetectable frame error. The probability that an undetected frame error will occur is not more than (and probably 2^{32} times less than) the probability that 4 or more independent undetected bit errors will occur in a frame. The Hamming distance of the FCS is 4. A contribution describing the expected undetectable frame error rate for 802.4 LAN's is needed. The undetectable frame error rate per frames transmitted is assumed to be 1 in 10^{15} for now. **Undetectable frame errors are potentially lethal. If human safety issues are involved, protection is required at the application layer.**

Discussion. Error rates and their consequences are based on the assumption that noise is white gaussian. This implies that errors are random, each error is an independent event. If the media detected bit error rate is 1 in 10^8, then the probability of two errors occurring in the same frame is negligible. A frame in error can be assumed to be due to a single bit in error in that frame. Therefore, a frame error can be counted as one bit error. The broadband working group took this to mean that only 1 frame in 10^8 frames could be in error. The carrier band and fiber working groups took this to mean that only 1 frame in 10^8 bits transmitted (frames times bits per frame) could be in error. This working group will use the less conservative values of 1 frame in error per 10^8 bits transmitted for detected errors.

If the noise is not gaussian, say it comes in bursts, then the frame error rate may not be degraded much even though the detected bit error rate is higher than 1 in 10^8.

Frames can be lost due to synchronization failure. When frame error rate is normalized to gaussian bit error rate, the equivalent bit error rate will be sensitive to packet length. If frames are very long, failure to sync on 1 in 10^4 or 10^5 frames is not significant - more frames will be lost due to bit errors than will be lost to synch errors. If frames are very short, error rates will be dominated by synchronization failure. Tests should be devised to highlight such problems.

Maximum frame length. A 802.4 frame will contain no more than 8191 octets of data. (A claim token frame does not contain data. The data field length in a claim token frame can be up to 6 times slot_time. The range limit for slot_time is 1 to 2^{13}-1 octets (1 to 8191 octets). Therefore the maximum data field length is 49,146 octets.)

Forward Error Correcting (FEC) codes. The digital radio channel is expected to have a high bit error rate (1 in 10^3). A forward error correcting code will be needed to reduce this error rate to acceptable levels. Correction bits must be sent with the data on the radio channel. The correction bits require additional bandwidth. To support three 1 Mb/s channels in the 0.9 GHz band, correction codes using not more than 0.2 bits per data bit transmitted are needed. If the MAC is presenting data at 1 million bits per second, up to 1.2 million data plus correction bits may be sent through the channel.

Block FEC codes. Message length in the 802.4 protocol is not arranged in blocks. If the forward error correction code must work on fixed length data blocks, transmissions must be padded (by extending pad idle?), wasting channel capacity.

Burst errors correction codes. Errors in a digital radio channel may occur in bursts. Contributions that describe the noise environment are needed. The forward error correction code should be able to correct burst errors. FIRE codes are used for burst error correction. Contributions are needed on burst error correction codes, and on the interaction between noise, the data scrambler, burst error correction code, and CRC in the frame check sequence. Does the 32 bit CRC detect all burst errors of length less than 32?

Bandwidth and FEC codes. Once the data rate has been fixed, any attempt to reduce error rates by adding FEC codes requires an increase in signal bandwidth. The receiver noise bandwidth must then also be increased, which increases the error rate. Some thought is needed on this.

Antenna spacing and error rate. If antenna are close together, say 30 meters, error rates of 1 in 10^{12} can be achieved.

Power and distributed antenna. Several antenna with independent transmitters may be used in concert. If N antenna are used, radiated power per antenna may not have to be reduced, or it may have to be reduced to $N^{-1/2}$ or N^{-1}. The FCC will not make a ruling on this without a formal system description. Systems that minimize interference outside of the LAN boundary will be preferred.

The boundary between the Physical Layer and the Media. The antenna will belong to the physical layer (station). This was decided because a diversity antenna array must be closely integrated with the modem. Properties of the media (air) such as attenuation, noise, and delay spread, can be measured with standard antennas and available equipment. The head end, if any, will be treated as a distributed station, an element of the physical layer.

The boundary between the Physical layer and the MAC. The exposed DTE/DCE interface if implemented, will be the boundary between the physical layer and the MAC.

Spreading code. A chip code, or its inverse, is used to represent the symbol being transmitted. Symbols are recovered by correlating received data with the chip code. The correlation with received data should be equal to the chip code length at sampling time, and 1 at all other times. When transmitted data changes, correlation is disturbed. M sequence generated codes show false peaks approximately 1/3 of the code length at the data changes. To use path diversity, it is necessary to integrate correlation at and around sampling time. Greater path delay spreads can be tolerated, and taken advantage of, if the false correlation peaks (periodic odd correlation) are removed.

A chip code 11 bits long has been found by NCR that has good correlation properties. The code was found in a random search for short codes with odd periodic auto correlation of one. The code is 0 1 0 0 1 0 0 0 1 1 1.

Peer networks, single and dual frequency head ends. NCR is currently interested in designing a peer to peer topology analogous to carrier band. The size of such a LAN is limited. A dual frequency system analogous to broadband would allow unlimited network size - but requires additional components, bandwidth, and design. A single frequency head end could be built using a full store and forward approach. Station and head end nodes could be kept segregated by address, or by a key in the preamble. The data rate of a single frequency head end would still be 1 Mb/s, but the throughput will be only 0.5 Mb/s, since all messages must be completed before the head end can begin repeating them. If the maximum token hold time is 2^{16}-1 octets, store and forward memory requirements are small.

Data rate. It may be possible to build radio LAN's that work at 2 Mb/s. This will be considered. IEEE supports any data rate from 1 to 20 Mb/s, and 50 Mb/s for wide area LAN's.

Delay spread measurements. Multipath signals or delay spreading is one of factors limiting data rate. Contributions are needed that measure the delay spread in industrial environments. NCR used two frequencies, 912 and 918 MHz, transmitted from an antenna on a rotating arm. Correlation of fades for these two frequencies was observed with a spectrum analyzer over the coverage area. From this it is possible to calculate the second moment of the distribution. The program is in GW basic.

Noise measurements. It will be assumed that noise at 0.9 GHz is 10 dB above thermal noise, and is man made. It is assumed that noise at 2.5 GHz is thermal noise only. The data that this is based on is very old. New measurement are needed, particularly in industrial environments.

Frame error rate and undetectable frame error rate. A frame error will be considered equivalent to a single bit error. Frame error rates are specified with respect to bits transmitted, not frames transmitted, with the exception of undetectable frame error rates, which are specified with respect to frames transmitted. An undetectable frame error is defined as a frame in error that has no FCS detectable error, has no bad signal reported, and yet has bits in error.

Preamble. *Pad_idle* originated in octets is normally transmitted as data pairs *Zero One*. As long as the receiver reports *Pad_idle* to the MAC PHY interface as data pairs *Zero One*, it does not matter what is sent over the channel, so long as it is agreed upon in the standard. Padding can be put here to allow for block codes or flag stuffing, station and head end ID's can be used for flow management, group and ownership ID's can be used for security. Whatever is done, however, must be agreed on, must be in the standard, and must be mandatory. If it is not, stations will not be interoperable.

Preamble code ID. If station addresses are not administered globally, the a preamble code ID is necessary to prevent accidental token passes between independent LAN's, and to validate frames. If adjacent LAN's have addresses in common undetectable frame error will occur.

Start delimiter, end delimiter, and abort sequence. Sending start and end delimiters using ND symbols will not work in a radio LAN because of the modulation, bandwidth constraints, and the high channel error rate. Several alternatives are being examined. One alternative is to use bit stuffing, with four flags used for the delimiters. The reason why HDLC protocols were abandoned needs to be examined. Another alternative is to run a concurrent demodulation processes. The delimiter process would look for a dead banded transmission constellation rotated 45 degrees with respect to data, and would use a long sequence M or Barker code (chip time equal to MAC-symbol rate) correlation peak to locate octet alignment. More than one code could be used to separate SD, ED, and the E and I bits. Contributions are needed.

Issues and directions. Several changes and additions were made.

Special thanks to Chuck Thurwachter for making arrangements for this meeting.

Referenced papers. The following papers are of interest to the taskgroup members:

Environmental Monitoring for Human Safety Part 1: Compliance with ANSI Standards. By John Coppola and David Krautheimer, Narda Microwave Corporation. - RF Design--.

RF Radiation Hazards: An update on Standards and Regulations. By Mark Gomez, Assistant Editor, and Gary A. Breed, Editor. - RF Design, October 1987

RF Radiation Hazards: Power Density Predeiction for Communications Systems. By Gary A. Breed, Editor. - RF Design, December 1987

Microprocessor Interference to VHF Radios. By Daryl Gerke, PE Kimmel Gerke & Associates, LTD. - RF Design, March 1988

Distributed Antennas for Indoor Radio Communications. By Adel A.M. Saleh, A.J. Rustako, Jr and R.S. Roman. - IEEE Transactions on Communications, Vol. Com-35, No12, December 1987