This document provides a base for the discussions of the IEEE 802.4L Working Group. Each decision will be marked in this document along with the reference to the motion on which the decision has been based (column Base) and with the reference of the document on which the present decision is based (Doc no). After each meeting a new document will be prepared to reflect the decisions made at the meeting.

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June 1989

Subject

scope
To define an alternative Physical Layer for Through-the-air communication, which is part of a local area network using 802.4 media access techniques and which is primarily for mobile environments.

Purpose
To provide LAN access to moving automatic machines and other stations for which wireless attachment is appropriate.
To add description of standards criteria for through-the-air transmission parameters to support Physical Layer Service.
To prepare, if necessary, a petition to the FCC for rule making which authorizes use of radio spectrum for wireless LAN.

Directions

System plan
The radio system plan for one community of users is proposed to be a dual frequency bus mode with head end, but will accommodate single frequency station-to-station operation for small systems. The physical layer including the head end and radio system shall support the existing 802.4 MAC. (Among other things, this implies that when any station is transmitting, all stations must hear something.)
In the dual frequency bus mode with head end normal token rotation shall be used, only for stations in the outskirt, immediate response mode will be considered. (see issue 5)
Whatever plan is evolved, it shall be suitable for use under current FCC part 15 regulations, in particular the three bands, 0.912, 2.45, and 5.9 GHz.
The 0.912 GHz band will be used in the first standard. At least 2 channels will be accommodated in the band.
To separate transmissions of stations of nearby networks the preamble will contain a Network Identification.

Modulation
We will consider modulation methods and bandwidths which are within the frequency allocation and spectral power density limits of FCC 15.126.
Differential Phase Modulation shall be used.
The first modulation technique to be investigated is DOPQSK (Differential Offset Quadrature Phase Shift Keying) with greater-than-Nyquist filtering of the baseband signal.
The encoding of the PHY symbols is as follows:
- 0 and 1 from MSK like DOPQSK,
- Non-data (for the delimiters) from intentional code violations (multiple errors) from omitting a single phase change, and later another single phase change within an octet.
Direct Sequence Spread Spectrum shall be used.

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Directions (cont'd)

For the spreading sequence at least 10 and not more than 15 chips shall be used. This provides a processing gain of between 10 and 15 allowing frequency division multiplexing of co-located LANs.

The following 11 chip sequence is considered for its good characteristics in correlator output and frequency spectrum: 01001000111.

Scrambler

For the scrambler the following two polynomials will be considered for their properties in conjunction with the encoding and FCS polynomials:

First choice: 1+X**-4+X**-7 (1+X**-3+X**-7)
Second choice: 1+X**-6+X**-7 (1+X**-1+X**-7)

Data Rate

The data rate for comparison purposes shall be 1 Mbit/s. We can only consider the IEEE data rates of 1 to 20 Mbit/s.

Antenna

The design model shall assume a 16 antenna array in a square grid. For purpose of analysis, it will be assumed that the antenna array is driven by one power splitter with equal length loss less cable from the splitter to each antenna.

Definition of Bit Error Ratio

The working definitions are as follows:

- Undetectable frame errors must be below 1 in 10^8 of frames.
- Undetected bit errors must be below 1 in 10^6 of bits.
- Detected bit errors must be below 1 in 10^8 of bits.

-where:

---bits are to be read as bits transmitted between SD and ED.
---an undetected error is defined as a frame containing an FCS error (so may have been caused by a burst) and no bad signal reported.

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Directions (cont'd)

- A detected error is defined as a frame containing 1 or more bad signal hits,
  - the frame length being equal to the smallest frame used by the MAC.
- An undetectable frame error is defined as a frame in error that has no FCS error and no bad signal reported.

Performance definition The performance of the Token Bus standard will be expressed in the number of MAC Service Data Units with undetected errors per time unit, at 0 frame overhead.

The performance requirement is: less than one MSDU with undetected errors per year at 200 bit data units.
The frame loss rate shall be less than 1 per 10^8 frames transmitted.

Bit Error Ratio

Since the radio medium is known to have a bit error ratio of the order 10E-3 the system shall incorporate the level of diversity and forward error coding required to support the detected error rate of 10E-3 and undetected error rate of 10E-9.

For forward error correction the following measures are under considerations:

1. Intrinsic redundancy of DQPSK to combat isolated errors,
2. Multi-symbol interleaving of chips to combat impulse noise, and
3. Extra redundancy in the form of an additional FEC precoding. This alternative is to be avoided.

Outage

MAC protocol assumes the communication channel is always available. Since the radio medium is known to have an outage rate on the order of 10E-2, a method is required to reduce outage rate to less than 10E-5.

Velocity ranges

The following are the ranges for the velocity of the stations:

- 0.912 GHz 0 - 53.7 miles/h
- 2.45 GHz 0 - 20.0 miles/h
- 5.9 GHz 0 - 8.3 miles/h

Definable parameters

XMTR power output: 1 W max
Station antenna gain: TBD
Station antenna directivity: TBD
Receiver noise figure: 6 dB at 900 MHz
8 dB at 2400 MHz
10 dB at 5900 MHz

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Directions (cont...d)

**Error correction codes**
- Allowable overhead: 1.2x
- Type: TBD
- Spectral efficiency: TBD

**Propagation**
- Office/retail environment: 6 dB/octave under 10 meters
- Factory environment: TBD
- Delay spread parameter: TBD
- S/N minimum: TBD
- Noise:
  - at 9 GHz: 10 dB above thermal
  - at 2.5 GHz: thermal

**Antenna**
If the antenna is located 7 to 10 feet above ground it has 25 dB antenna gain over an antenna in a pocket.

Jan 89
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Possible Document Outline

20. Radio Bus Physical Layer
   20.1 Nomenclature
   20.2 Object
   20.3 Compatibility Considerations
   20.4 Operational Overview Single Frequency System
   20.5 Operational Overview Dual Frequency System
   20.6 General Overview
   20.7 Application of Network Management
   20.8 Functional, Electrical and Mechanical Specifications
   20.9 Environmental Specifications

21. Radio Bus Medium
   21.1 Nomenclature
   21.2 Object
   21.3 Compatibility Considerations
   21.4 General Overview
   21.5 Functional, Electrical and Mechanical Specifications
   21.6 Environmental Specifications
   21.7 Transmission Path Delay Considerations
   21.8 Documentation
   21.9 Network Sizing
   21.10 Guidelines
June 1989

Issues

1. Is a Bit Error Ratio (BER) of 10^-8 detected and 10^-9 achievable with operation with a dual frequency head-end distribution system.
2. Is the BER described in issue 1 achievable for direct station-to-station operation and what is the condition to achieve this BER.
3. What Forward Error Correcting Code (FEC) is suited for channels with burst errors characteristics.
4. Considering the agreement that non-data will not be encoded as a PHY symbol: Find a method of start and end delimiter encoding, e.g., use a combination of an alternative constellation and correlation.
5. What is the characteristic of the impulse noise in the various media.
6. What are the implications on the LLC when the immediate response mode is required to communicate with stations in the outskirt?
7. How should a distributed antenna system be represented for ruling measurements.

Referenced papers.

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