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.

Table of Contents

1. Scope 2
2. Purpose 2
3. Directions 2
   3.1 Design Principles 2
   3.2 System plan 2
   3.3 System Design Parameters 3
   3.4 Modulation 3
   3.5 Encoding 3
   3.6 Data Rate 4
   3.7 Antenna 4
   3.8 Performance definition 4
   3.9 Bit Error Ratio 4
   3.10 Outage 4
   3.11 Velocity ranges 4
   3.12 Transmission Power 4
   3.13 Error correction codes 5
   3.14 Propagation 5
   3.15 Antenna 6
   3.16 Higher Layer concerns 6
4. Meeting Plan 7
5. Possible Document Outline 8
6. Issues 9
7. Referenced papers.
January 1989

Subject

1. 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.

2. 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.

3. Directions

3.1 Design Principles

- 1. Meet FCC rules - spreading, scrambling, power, etc.
- 2. Meet 802.4 requirements implicit in ISO DIS 8802-4 1-10
- 3. Economy
- 4. Permit adjacent 802.4L-conformant radio LANs
- 5. Provide for both single-channel (direct peer-to-peer) and dual-channel (head-ended) operation
- 6. Single-channel system size: The objective is to permit a system diameter of 300 m. The minimum acceptable system diameter is 100 m.
- 7. Modulation technique must support office, retail and industrial environments.

3.2 System plan

The radio system plan for one community of users is proposed to be a single 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 single 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 3.9 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.

V. Hayes, NCR Corporation

Nieuwegein, The Netherlands
3.2 Directions (cont..d)

3.3 System Design Parameters
Relation to the Objective List in [3.1 ]

1. Use a 7-bit (length-127) scrambler if the adopted chip rate is < 127. [1] The preferred polynomial is $1 + X^{-4} + X^{-7},[1+3]
2. Choose a modulation technique that does not include an amplitude modulation component, for [3] and to lower technical risk.
3. Permit differential demodulation for fast acquisition, to provide robustness for the time-varying (fading) radio channel, and to simplify the receiver [3]. The primary disadvantage of this approach is a 2.3 dB (theoretical) loss in S/N.
4. Use some form of quaternary PSK as a reasonable means of decreasing signaling rate (for multipath) without excessively compromising S/N or [3,7].
5. Spread the minimum amount practical [1,3]. The preferred spreading code is $++++++++++$. This is a known Barker code, with bounded auto-correlation, bounded periodic auto-correlation, and bounded odd periodic auto-correlation, and good spectral properties.
6. Filtering should consider adjacent-channel single-frequency (single-channel) and simultaneous dual-frequency (dual-channel) operation. [4,5]
7. Initial focus should be on 900 MHz band. [3]

3.4 Modulation
Differential Phase Modulation shall be used.

Doc: IEEE 802.4L/89-16 is adopted as the basis for the description of the modulator.

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

3.5 Encoding
The goal is to encode the preamble and the frame delimiters without increasing the signal constellation.

It is suggested to encode the MAC non-data symbol by a different chip sequence (e.g. Barker-11 backwards).
Directions (cont. d)

3.6 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.

3.7 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.

3.8 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 10^6 frames transmitted.

3.9 Bit Error Ratio
The raw Bit Error Ratio (BER) shall be 10^-8 or less, achievable in all but 10^-3 of the area of the spatial coverage of the system.

3.10 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.

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

<table>
<thead>
<tr>
<th>Frequency (GHz)</th>
<th>Velocity (miles/h)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.912</td>
<td>0 - 53.7</td>
</tr>
<tr>
<td>2.45</td>
<td>0 - 20.0</td>
</tr>
<tr>
<td>5.9</td>
<td>0 - 8.3</td>
</tr>
</tbody>
</table>

3.12 Transmission Power
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

For a distributed antenna system, we assume that each transmitter should be measured separately (for complying with the regulation). The transmit carriers should not be phase locked but should be approximately the same frequency.
3.13 Error correction codes
The goal is to avoid the use of Forward Error Correction code, if possible.
  Allowable overhead: 1.2x
  Type: TBD
  Spectral efficiency: TBD

3.14 Propagation
Office/retail environment: 6 dB/octave under 10 meters

<table>
<thead>
<tr>
<th>environment</th>
<th>slope dB/octave</th>
<th>standard deviation dB</th>
<th>exp from max peak</th>
<th>Delay spread (within 20 dB ns)</th>
</tr>
</thead>
<tbody>
<tr>
<td>retail10-13</td>
<td>4-6</td>
<td>3-4</td>
<td>80</td>
<td></td>
</tr>
<tr>
<td>factory5.5-7</td>
<td>8-10</td>
<td>1.8-3.3</td>
<td>100-110</td>
<td></td>
</tr>
<tr>
<td>office7-8</td>
<td>3-7</td>
<td>3.3-3.7</td>
<td>&lt;50</td>
<td></td>
</tr>
</tbody>
</table>

Table 1. Channel characteristics

Noise:
  at .9 GHz 10 dB above thermal
  at 2.5 GHz thermal

Contributions on noise are requested in the following format:

<table>
<thead>
<tr>
<th>Device</th>
<th>Band</th>
<th>distance from source</th>
<th>Power *) level</th>
<th>Number of hits per second Threshold</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-10 dB -20 dB -30 dB -40 dB</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>m dBm</td>
</tr>
</tbody>
</table>

Table 2. Characteristics of impulsive noise generators
Directions (cont.d)

<table>
<thead>
<tr>
<th>Device</th>
<th>Band</th>
<th>Power</th>
<th>Bandwidth</th>
<th>Duty cycle</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>distance</td>
<td>level</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>m</td>
<td>dBm</td>
<td></td>
</tr>
</tbody>
</table>

Table 3. Characteristics of Constant Wave Interferers

NOTES:  
* reference antenna: dipole for the appropriate band  
distance from source > 1 m  
vary measurements over a sphere with  
at least 10 measurements

* for impulsive noise measurements:  
make the measurements in the  
time domain

* for CW measurements:  
include a graph of frequency versus  
time behavior for sweeping  
devices, e.g. microwave ovens.

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

3.16 Higher Layer concerns
When considering the use of the immediate response mode for stations in the outskirts of the coverage area, thus avoiding the higher probability of losing the Token, the implication is that a station can use only the responder services of LLC type 3.

Use of LLC types 1 or 2, or the initiator services of LLC type 3, will cause the station to try to get and later pass the token.
### 4. Meeting Plan

<table>
<thead>
<tr>
<th>Type</th>
<th>Dates</th>
<th>Place</th>
<th>Objective</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interim</td>
<td>Jan 15-20, 90</td>
<td>Parsippany, NJ</td>
<td>Next draft preparation</td>
</tr>
<tr>
<td>Plenary</td>
<td>Mar 12-16, 90</td>
<td>Irvine, CA</td>
<td>802.4 draft</td>
</tr>
<tr>
<td>Interim</td>
<td>May ..-.., 90</td>
<td>?</td>
<td>Prepare second 802.4 draft</td>
</tr>
<tr>
<td>Plenary</td>
<td>Jul 9-13, 90</td>
<td>Denver, CO</td>
<td>Second 802.4 draft</td>
</tr>
<tr>
<td>Interim</td>
<td>Sep ..-.., 90</td>
<td>?</td>
<td>Prepare 802.4 Voting draft</td>
</tr>
<tr>
<td>Plenary</td>
<td>Nov 12-16, 90</td>
<td>Maui, HI or Kauai, HI or La Jolla, CA or Victoria, BC, Canada</td>
<td>802.4 Ballot</td>
</tr>
<tr>
<td>Interim</td>
<td>Jan ..-.., 1990</td>
<td>?</td>
<td>prepare TCCC voting draft</td>
</tr>
<tr>
<td>Plenary</td>
<td>Mar 11-15, 1991</td>
<td>East coast</td>
<td>TCCC Ballot</td>
</tr>
<tr>
<td>Interim</td>
<td>May ..-.., 1991</td>
<td>?</td>
<td>Prepare Final draft</td>
</tr>
<tr>
<td>Plenary</td>
<td>Jul 8-12, 1991</td>
<td>West Coast</td>
<td>Final Draft</td>
</tr>
<tr>
<td>Plenary</td>
<td>Nov 11-15, 1991</td>
<td>Ft Lauderdale, FL</td>
<td>PM</td>
</tr>
</tbody>
</table>

V. Hayes, NCR Corporation

Nieuwegein, The Netherlands
5. 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
6. Issues

1. Is a Bit Error Ratio (BER) of 10^{-8} 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 for start and end delimiter encoding, e.g., use a combination of an alternative constellation and correlation.
5a. What is the characteristic of the impulse noise in the various media?
5b. What are the implications on the LLC when the immediate response mode is required to communicate with stations in the outskirt?
6. How should a distributed antenna system be represented for ruling measurements?
7. What are the trade-offs in data rate vs noise immunity (long vs short codes) [refer to doc: IEEE p802.4L/89-17, pages 6-8]
8. What are the trade-offs of long codes vs short codes at higher frequencies (wider bands) and multiple channels (FDM vs CDM) [refer to doc: IEEE p802.4L/89-17, pages 6-8]
9. What are the noise characteristics for various devices [refer to tables 2 and 3 above]
10. Is table 1 above accurate?

7. 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 Krauthemer, Narda Microwave Corporation. - RF Design-
- RF Radiation Hazards: An update on Standards and Regulations. By Mark Gome, Assistant Editor, and Gary A. Breed, Editor. - RF Design, October 1987