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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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 dual 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 dual single frequency bus mode with head and 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.

V. Hayes, NCR Corporation  -2-  Nieuwegein, The Netherlands
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 [1,5]. 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

--- 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.

--- 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:

--- 100100010011101

3.5 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: \( 1 + X^{-4} + X^{-7} \). (1 + X^{-1} + X^{-7})

--- V. Hayes, NCR Corporation
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.

Jan 89

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.

May 89

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 10^8 frames transmitted.

May 89

3.9 Bit Error Ratio

For forward error correction the following measures are under consideration:
1. Intrinsic redundancy of DOQPSK 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.

Apr 89

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 10^-2, a method is required to reduce outage rate to less than 10^-5.

Jul 88

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

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

Jan 89

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

Jan 89
Directions (cont...d)

3.12 Error correction codes
Allowable overhead: 1.2x  Jan 89
Type: TBD  Jan 89
Spectral efficiency: TBD

3.13 Propagation
Office/retail environment:
6 dB/octave under 10 meters  Jan 89
11 dB/octave over 10 meters  Jan 89
Factory environment: TBD  Jan 89
Delay spread parameter TBD
S/N minimum: TBD
Noise:
at .9 GHz 10 dB above thermal  Jan 89
at 2.5 GHz thermal

3.14 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
<table>
<thead>
<tr>
<th>Type</th>
<th>Dates</th>
<th>Place</th>
<th>Objective</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interim</td>
<td>Sep 11-15, 89</td>
<td>Chicago</td>
<td>Presentation Dr. Rappaport Measurement results</td>
</tr>
<tr>
<td></td>
<td>8 half day sessions</td>
<td>Demo simulation model</td>
<td>Distributed Antenna system First draft generation</td>
</tr>
<tr>
<td>Plenary</td>
<td>Nov 6-10, 89</td>
<td>Ft Lauderdale</td>
<td>Draft 1 to 802.4</td>
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<tr>
<td>Interim</td>
<td>Jan - , 90</td>
<td>?</td>
<td>Next draft preparation</td>
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<tr>
<td>Plenary</td>
<td>Mar 12-16, 90</td>
<td>Newport Beach</td>
<td>802.4 Voting draft</td>
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<td>Interim</td>
<td>May - , 90</td>
<td>?</td>
<td>Prepare TCCC draft</td>
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<td>Plenary</td>
<td>Jul 9-13, 90</td>
<td>Denver (CO)</td>
<td>TCCC voting draft</td>
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<td>Interim</td>
<td>Sep - , 90</td>
<td>?</td>
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<tr>
<td>Plenary</td>
<td>Nov 12-16, 90</td>
<td>Maui, HI</td>
<td>Final Draft out?</td>
</tr>
</tbody>
</table>

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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 $10^{-8}$ 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.

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 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