IEEE 802.4L
THROUGH-THE-AIR TOKEN BUS PHYSICAL LAYER

Minutes of regular meeting of IEEE 802.4l on July 16, 1987 at 0900 at the Vancouver Hotel, Vancouver, B.C., Canada

OPENING MATTERS

The meeting was called to order by Chan Rypinski, Vice Chairman, who announced that David Greentstein, Chairman, was unable to attend, and had asked him to chair this meeting.

The Chair noted that attendance was light, and he observed that there was a conflict with the main activity of 802.4, now at a critical phase of completing the revisions to the entire standard preparatory to a submission to ballot. Many individuals involved in this effort would have liked to attend the 802.4L meeting. This observation was later repeated by Bob Douglas, Chairman of 802.4, who attended parts of the 802.4L meeting.

The Chair asked those present to introduce themselves and to sign the attendance list. The Chair introduced, Michael Callendar, who is the internation Chairman of CCIR Study Group 8, Interim Working Party 13 and who he had invited to attend. The mission of IWP 8/13 is to develop standards for future digital public land mobile radio services.

The Chair asked Ron Matthews to take notes on the decisions reached in the meeting.

The Chair announced that all present were eligible to vote excepting only those not participating in 802.4L.

The Chair passed out all available submissions and including the Minutes of the previous meeting, 87-006.

A motion was made, seconded and unanimously passed to accept the Minutes of the previous meeting as submitted.

The Chair announced that preparation and approval of a Project Authorization Request (PAR) was a critical responsibility for this meeting.

REPORTS ON ASSIGNMENTS

At the previous meeting, the Chair (D. Greenstein) had asked for contributions to be submitted and the Chair called for these to be presented:

1. Mr. T. Saito reported that he could find very little material on through-the-air optical data transmission at NEC. He submitted a publication from the NEC R&D journal on "Atmospheric Laser Communications Equipment" (which the Chair later marked 87-012).
2. Rick Formeister submitted a complete text of the FCC Rule-making (20 pages) on spread spectrum communication issued May 9, 1986. (which the Chair later marked 87-013).
3. The Chair offered his own submissions:
   A. "FCC Rules and Possible Operating Frequencies" -- 87-007
   B. "System Plan(s), Wireless LAN. . . .", for three different assumptions on frequency availability, bandwidth and modulation parameters -- 87-008, -009 and -011.
   C. "Draft of Preparation for Counsel, Petition for Rule-Making, Industrial Wireless Automation Service" -- 87-010

DISCUSSION OF FCC CONSIDERATIONS

The meeting discussed the FCC aspect. One tentative conclusion was that it is possible that the IEEE group might need to petition the FCC for necessary Rule-Making to support a wireless LAN. The success of such a petition depends upon showing of need, a technical method suited to coexistence with some group of existing users of frequency space and a supporting constituency which as a group can validate a claim to improved economic efficiency for the institutional users.

IEEE 802.4L
THROUGH-THE-AIR TOKEN BUS PHYSICAL LAYER
Report of the Vice-Chairman
Submission of the PAR to 802.4 and 802 Executive Committee

SUBMISSION OF THE PAR TO 802.4

The edited draft PAR from the morning meeting of 802.4L was taken to the 802.4 plenary in exactly the edited, handwritten form from which it had emerged. 802.4 was much taken up with other important matters, but eventually Bob Douglas gave me the floor to present it with cautions on taking excess time.

The group was unsatisfied with poor wordsmanship in the scope section, and was disatisfied with the purpose. I was instructed to leave the meeting, edit, and return with an improved text.

Working by myself, the text was edited to satisfy the objections of that meeting with the following result:

4. *SCOPE: To define an alternative physical layer for through-the-air communication which is part of a local area network using 802.4 media acces technique an which is primarily for mobile environments.*

5. *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.*

Later in the afternoon, Bob Douglas asked me to present the revised PAR. He remarked on the FCC statement, the first of its kind in 802. The revised PAR motion was untabled and passed without dissent in seconds. He took the film for his use, and I kept the original. This PAR is attached and marked 87-014 (2 sheets).

I asked Douglas to poll the meeting to find out who would attend an 802.4L meeting on Monday of the next plenary week, but who could not attend on Thursday morning. There were at least 5 hands.

The PAR was not signed by anybody, and the blank for person delegated to receive communications was not filled in. Something will have to be done about these omissions.

SUBMISSION TO 802 EXECUTIVE COMMITTEE

Starting at 1900, the Executive Committee had a full agenda, much of which was taken up by the complaints of FDDI about overlap in scope with 802.6. Under New Business, 802.4 matters were 5.8 to 5.10. Bob Douglas came to the floor about 1100. He presented the new 802.4L PAR again calling attention to the FCC sentence. The PAR was passed without discussion, again in seconds.

RATIFICATION

I will ask the next regular meeting of 802.4L to ratify these actions and amend the Charter for consistency.

It is also my belief that it would be a good idea to call a Monday AM meeting on Plenary week for an exclusively technical discussion of the problems and solutions.

Respectfully submitted,

Chandos A. Rypinski,
Vice Chairman and Secretary of 802.4L

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C. RYPINSKI

IEEE 802-87*0.xxA

AGENDA & MINUTES - IEEE 802 EXECUTIVE COMMITTEE MEETING

Thursday, July 16, 1987 - 7:00 p.m.

Hotel Vancouver Vancouver, B.C.

1.	MEETING CALLED TO ORDER		7:00 p.m.
2.	APPROVE OR MODIFY AGENDA		7:01 p.m.
3.	✓ TREASURER'S REPORT	- Montague	7:05 p.m.
4.	OLD BUSINESS		
✓ 4.1	TUTORIALS/SOCIAL HOUR	- Rigsbee	7:10 p.m.
✓ 4.2	FUTURE MEETINGS	- Rigsbee	7:20 p.m.
✓ 4.3	DOCUMENT LIST	- Rigsbee	7:30 p.m.
✓ 4.4	MEETING ROOM ASSIGNMENTS	- Rigsbee	7:40 p.m.
✓ 4.5	802.6 FUNCT. REQMTS & CHARTER	- Mollenauer	7:50 p.m.
✓ 4.6	MULTICAST MAC ADDRESSES	- Lidinsky	8:20 p.m.
✓ 4.7	CONFIRMATION BALLOTS	- Graube	8:30 p.m.
✓ 4.8	CONFORMANCE TESTING	- Carlson	8:50 p.m.
5.	NEW BUSINESS		
✓ 5.1	NEW 802.7 CHAIRMAN	- Montrose	9:00 p.m.
✓ 5.2	802.7 DRAFT H MAILINGS	- Montrose	9:05 p.m.
✓ 5.3	802.5 MOTIONS	- Donnan	9:15 p.m.
5.4	802 POSITION TRANSMITTAL TO X3	- Donnan	9:30 p.m.
✓ 5.5	802.2 MOTIONS	- Carlson	9:45 p.m.
✓ 5.6	DADS	- Loughry	10:00 p.m.
✓ 5.7	FUTURE TCCC BALLOTING	- Gibson	10:20 p.m.
✓ 5.8	802.4 PARS	- Douglas	10:30 p.m.
✓ 5.9	BALLOTING EXPENSES	- Douglas	10:40 p.m.
✓ 5.10	NEW 802.4 CHAIRMAN	- Douglas	10:50 p.m.
✓ 5.11	LIAISON 802.0 TO X3T5 ON MANAGEMENT RQMTS	- Lidinsky	11:00 p.m.
5.12	PARTICIPATION IN WED. MORN. TECH. PLENARY	- Lidinsky	11:20 p.m.
5.13		-	11:30 p.m.
5.14		-	11:40 p.m.
5.15		-	11:50 p.m.

802 ARCHITECTURE & MANS

AGEN802D

802.4L APPROVED AT 1100 PM

IEEE 802.4 WORKING GROUP
MEETING AGENDA
JULY 13-17, 1987 Vancouver, BC

Monday, July 13

3:30 - 802.4 Working Group Meeting - Room 227
- Status of ISO IS
- TG Interem Meeting Reports
- Thru-Air Media Charter/PAR
- Redundant Media PAR?
- Distribute comments on Draft G
- Phase-Continuous inclusion?
- new business
  - Request for 802.4J4 from MAP

Tuesday, July 14

8:00 - 802.4H - Fiber Optic WG - Room 227
802.4J1/J3 - Bband/Carrierband Conformance - Garbal.
802.4J2 - MAC Conformance - Room 237

12:00 - Lunch

1:30 - 802.4H - Fiber Optic WG - Room 227
Draft G Physical Editing - Garbal.
802.4J2 - MAC Conformance - Room 237

Wednesday, July 15

8:00 - 802.4H - Fiber Optic WG - Room 227
Draft G Physical Editing - Garbal.
Draft G MAC Editing - Room 237

12:00 - Lunch

1:30 - 802.4H - Fiber Optic WG - Room 227
Draft G Physical Editing - Garbal.
Draft G MAC Editing - Room 237

Thursday, July 16

8:00 - 802.4H - Fiber Optic WG - Room 227
802.4L - Thru Air Media - Garbal.
802.4K - Redundant Media - Room 237

12:00 - Lunch

1:30 - 802.4 Working Group - Room 227

- TG Chairman Reports
- Editor Reports
- Proceed to Draft H?

AGENDA--IEEE 802.4L--JULY 16, 1987
THROUGH-THE-AIR TOKEN BUS

CHAIRMAN: DAVID GREENSTEIN
VICE-CHAIRMAN AND SECRETARY: CHANDOS RYPINSKI

1. Opening
   - A. Attendance
   - B. IEEE Rules
   - C. Introductions
   - D. Receipt or announcement of new submissions

2. Minutes of last meeting at New Orleans

3. Report on presentation of Charter/Objectives to 802.4 and Chair's update on current status — PAR

4. Presentation of Submissions

5. Summary and assignment of new tasks

6. Discussion of interim working meeting

7. Adjourn

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TO DEFINE AN ALTERNATIVE PHYSICAL LAYER ~~[illegible]~~ FOR THROUGH THE AIR COMMUNICATION FOR PRIMARILY MOBILE EQUIPMENTS AS PART OF A LOCAL AREA NETWORK USING THE 802.4 MEDIA ACCESS TECHNIQUE. THE SYSTEM ~~DEFINED~~ MAY REQUIRE ~~DEFINED~~ BRIDGE FUNCTIONS WHICH ARE PECULIAR TO THROUGH-THE-AIR COMMUNICATION

TO ~~FORMULATE~~ PREPARE + FORMALLY TO FILE PETITION FOR RULE-MAKING TO THE FCC ~~COULD BE NECESSARY~~ TO PROVIDE AUTHORIZATION FOR NEW OR ADDED USE OF RADIO SPECTRUM FOR A SERVICE NOT NOW PART OF THE RULES.

To prep. if nec. a petition to FCC for rulemaking which authorizes ~~[illegible]~~ use of radio spectrum for wireless LAN.

STANDARDS PROJECT AUTHORIZATION (PAR)

When completing this PAR refer to instructions in the PAR Submitter's Guide

239

1. July 15, 1987 — Date of Request

Revised PAR [X] Yes [ ] No

12. Standards Board Assigned Project No. ______ Approved: ______ (For Standards Office Use Only)

2. [X] Standard [ ] New [ ] Recommended Practice [ ] ~~Revision of~~ Annexed To 802.4 [ ] Guide

3. Project Title:
Through-The-Air Token Bus Physical Layer

4. Scope of Proposed Standard (use attachment sheet if necessary): To define an alternative physical layer for through the air communication for primarily mobile environments as part of a local area network using the 802.4 media access technique.

5. Purpose of Proposed Standard (use attachment sheet if necessary): To add description of standard criteria for through-the-air transmission parameters and formats with necessary functions to support 802.4 DTE/DCE interface and higher layers. The system defined may require bridge functions which are peculiar to through-the-air communication. To prepare, if necessary, a petition to the FCC for rule making which authorizes use of radio spectrum for wireless LAN.

6. Sponsor Technical Committee: ______ Society: ______

7. Proposed Coordination:
IEEE Communications Society
IEEE Vehicular Technology Society
CCIR (IWP 8/13)

Method of Coordination:
Distribution of minutes and requested documents.
Joint membership US Advisory Group

8. Name of Group that will write the Standard:
IEEE 802.4L

9. Are you aware of any patent issues? [ ] Yes [X] No (If yes, attach a sheet with a complete description.)

Are you aware of any standards or projects with a similar scope? [ ] Yes [X] No (If yes, attach a sheet with a complete description.)

10. Person Delegated to Receive Communications and Conduct Liaison with Interested Bodies:

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11. Submitted by:

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Note: Copies of PAR Submitter's Guide and the IEEE Standards Manual are available from the IEEE Standards Office

11/13/85 :lg

IEEE 802.4L CHARTER

THROUGH-THE-AIR TOKEN BUS PHYSICAL LAYER

To define an alternative physical layer for through-the-air communication for primarily mobile environments as part of a local area network using the 802.4 media access technique.

IEEE STANDARDS COMMITTEE 802.4L

THROUGH-THE-AIR TOKEN BUS ACCESS METHOD

MEETING NOTICE

The attendance of those interested in participating in the selection of a suitable method for providing a wireless environment for LAN access are requested to attend a meeting of 802.4L for technical discussions only:

November 9, 1987 at 0900
Room to be posted at Hotel
Embassy Suites Hotel (802 Plenary location)
Ft. Lauderdale, Florida

The proposed agenda:

Introduction: Current activities in digital radio
Report by C. Rypinski

1. FCC technical constraints
   - A. Frequency band assumptions
     - a. 902-928 MHz
     - b. 2400-2483.5
     - c. 5725-5850
     - d. other
   - B. Licensing or Certification
   - C. Transmitter power and energy spreading

2. System plan
   - A. Multiple radiation point coverage
   - B. Diversity techniques
   - C. Channelization and frequency reuse
   - D. Error correcting/detecting channel coding
   - E. Hierarchical or flat system control
   - F. Channel digital modulation

3. User requirements
   - A. Central administration
   - B. Installation compatibilities

4. Techniques supported by existing knowledge.

We hope to see you and any interested persons you may invite at this meeting.

For David Greenstein, Chairman

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1884 · 1984
A CENTURY OF ELECTRICAL PROGRESS

IEEE JOURNAL ON SELECTED AREAS IN COMMUNICATIONS

JULY 1984 VOLUME SAC-2 NUMBER 4 (ISSN 0733-8716)

IEEE

A PUBLICATION OF THE IEEE COMMUNICATIONS SOCIETY

SPECIAL ISSUE ON MOBILE RADIO COMMUNICATIONS

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IEEE TRANSACTIONS ON

COMMUNICATIONS

MARCH 1981 VOLUME COM-29 NUMBER 3 (ISSN 0090-6778)

A PUBLICATION OF THE IEEE COMMUNICATIONS SOCIETY

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january 1987

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JANUARY

IEEE Communications Magazine

—Vol. 25, No. 6 June 1987 ISSN 0163-6804—

features

departments

This month, we are pleased to present an article by Victor O.K. Li that links the Magazine and a forthcoming issue (July 1987) of the *Journal on Selected Areas in Communications* (JSAC). This is the first time that a guest editor for JSAC has placed an article in the Magazine to serve as a bridge between our Society's publications.

It is hoped that this "bridge" will continue in future issues, so that those members of the Society who do not receive JSAC will still benefit from its tutorial articles by reading a sampling of them in the Magazine. We encourage this cooperation and thank Dr. Li for his article.

As an example, the bit rate of a minimum bandwidth (zero-rolloff) QAM signal transmitted through a Gaussian channel was maximized.

The optimization can be extended to QAM signals with rolloff and the simpler case of one-dimensional modulations, e.g., PAM.

ACKNOWLEDGMENT

I would like to thank an anonymous reviewer for parts of the table.

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Performance of Quadrature Amplitude Modulation for Indoor Radio Communications

REINALDO A. VALENZUELA

Abstract—**The performance of M-QAM for indoor radio communications is evaluated via a realistic model for indoor multipath propagation [1]. It is found that the outage (BER $< 10^{-4}$) is about 0.3 percent at 1 Mbit/s and 20 percent at 4 Mbits/s. Two-antenna predetection diversity reduces the outage from 1.2 to 0.04 percent at 2 Mbits/s. Increasing the signaling pulse rolloff factor from 0.5 to 1.0 reduces the outage by not more than 35 percent.**

I. Introduction

Indoor radio may provide a very flexible support for voice and data services. Thus, it is of particular interest to evaluate, via a realistic channel model [1], what performance can be expected with conventional technology, such as M-level quadrature amplitude modulation (M-QAM), as a reference against which more elaborate systems could be compared.

System performance, in this space- and time-dependent channel is appropriately characterized in terms of *outage probability,* which is the fraction of locations for which, at a given instant, the bit error rate will be below a given threshold. This can be interpreted also as the fraction of time for which a moving terminal will have a bit error rate worse than required. In the work reported here, performance is evaluated for a reasonable "worst case" office which is located furthest from the transmitter and includes extensive multipath propagation, but is not completely in the shadow of a metal structure.

II. System Description

A. Block Diagram

We consider a conventional M-level QAM system with a raised-cosine pulse shaping (rolloff factor α), coherent demodulator, and timing derived through square-law envelope detection and narrow-band filtering, as outlined in the Appendix. For the AWGN channel, the detector signal-to-noise ratio can be written as [3]

$$\rho \equiv \frac{3}{(M-1)} \text{CNR}_0 \tag{1}$$

where $\text{CNR}_0 \equiv P_{av}T/N_0$ is the unfaded carrier-to-noise ratio, the factor $3/(M-1)$ is the penalty associated with using $M > 4$, N_0 is the thermal noise power density times the receiver noise figure, P_{av} is the average symbol power at the detector, and T is the symbol period. The probability of a bit error is upper bounded by [7]

$$P_b = \frac{2}{\log_2 M}\left(1-\frac{1}{L}\right) \text{erfc}\,(\sqrt{\rho}) \leq 0.5\ \text{erfc}\,(\sqrt{\rho}). \tag{2}$$

In the experimental setup reported in [1], the worst case carrier-to-noise ratio is about 40 dB at 1 Mbaud, which is a typical value for a transmitter power of 200 mW and same floor propagation distance of 60 m from the transmitter.

III. The Channel Model

The indoor multipath propagation model, as presented in [1], is based on multipath delay spread (5 ns resolution) and attenuation measurements. In the model, rays arrive in clusters where the cluster arrival times and the ray arrival times are both Poisson processes with parameters Λ and λ, respectively. The complex, low-pass channel impulse response is given by

$$h(t) = \sum_{k=0}^{\infty} \beta_{k,l} e^{j\theta_{k,l}} \delta(t - T_l - \tau_{k,l}) \tag{3}$$

where T_l is the arrival time of the lth cluster and $\tau_{k,l}$ is the arrival time of the kth ray within that cluster. The ray phases $\{\theta_{k,l}\}$ are statistically independent uniform random variables in $[0, 2\pi)$, while their amplitudes $\{\beta_{k,l}\}$ are statistically independent Rayleigh random variables whose mean-square values $\{\overline{\beta^2_{k,l}}\}$ decay exponentially with $\{T_l\}$ and $\{\tau_{k,l}\}$.

For the building considered in [1], appropriate values for the ray and the cluster mean interarrival times are estimated to be $1/\lambda = 5$ ns and $1/\Lambda = 300$ ns, respectively, while the ray and the cluster power-decay time constants are estimated to be $\gamma = 20$ ns and $\Gamma = 60$ ns. A typical worst case room would be located some 60 m away from the central station. With a power loss exponent of 3, the multipath power gain is about -55 dB. Moreover, the formation of clusters is related to the building superstructure (e.g., large metalized walls and doors), so that they do not change significantly within a given room. In fact, based upon the measurements presented in [1], the worst case office is reasonably described as having two clusters, with the first arrival of the second cluster occurring 120 ns after the first arrival of the first cluster. Additionally, the measured rms delay spread within rooms was found to have a median value of 25 ns. In order to obtain curves of outage probability versus required bit error rate, a large ensemble of channel impulse response was generated via Monte Carlo simulation, based on the statistical model, and the bit error rate associated with each realization was computed. The outage probability for a given bit error rate is found simply by dividing the number of times in which that bit error rate is exceeded by the total number of sample responses simulated.

A. Probability of a Bit Error

In the presence of intersymbol interference (ISI), the probability of a bit error is given by (2), but the detector

Paper approved by the Editor for Radio Communication of the IEEE Communications Society. Manuscript received July 22, 1986; revised May 22, 1987.

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IEEE Log Number 8717081.

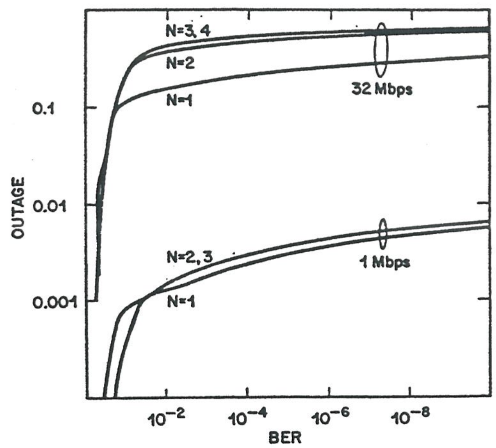

Fig. 1. Number of information symbols contributing to intersymbol interference.

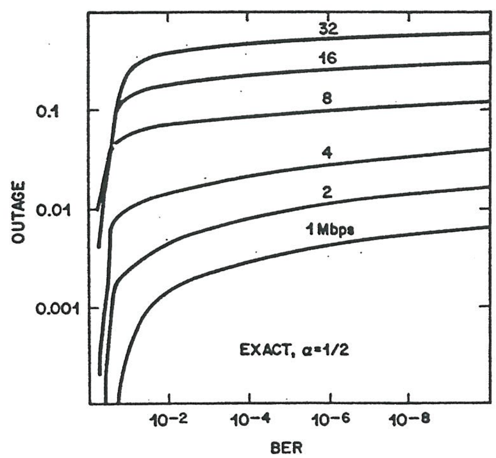

Fig. 2. Outages versus BER at signaling rates of 1–32 Mbits/s.

signal-to-noise ratio is conditioned on the information sequence

$$\rho|\{\tilde{I}_n\} = \frac{3}{M-1} \mathrm{CNR}_0 \left| 1 + \sum_{n \neq 0} (a_{m-n} f_{rn} - b_{m-n} f_{in}) \right|^2 \quad (2)$$

where $\{\tilde{I}_n\} = \{a_n + jb_n\}$ is the information sequence and $\{f_{rn} + jf_{in}\} = \{h(nT)\}$ is the complex-valued system impulse response, sampled at multiples of the symbol period. To remove the conditioning, the probability of a bit error has to be averaged over all information sequences contributing to intersymbol interference. Note that if N symbols on each side of the detected symbol contribute significantly to intersymbol interference, the averaging will have to be performed over M^{2N} information sequences.

IV. Results and Discussion

A. Number of Interfering Symbols

It can be seen from the outage curves given in Fig. 1 ($\alpha = 0.5$) that at 32 Mbits/s, there is nothing to be gained from using N greater than 3. In fact, at $N = 2$, the error in the outage is still only 13 percent. At 1 Mbit/s, there is very little gain in choosing more than one interfering sample on each side of the desired symbol.

B. Effect of Signaling Rate on Outage

There is an approximate threefold increase in outage probability for every doubling in the signaling rate (Fig. 2). In fact, for a required bit error rate of 10^{-4}, the outage is 0.0029 at 1 Mbit/s, 0.021 at 4 Mbits/s, and 0.22 at 16 Mbits/s. These figures are to be interpreted as the fraction of locations that, at a given instant, will have a bit error rate worse than required. The time-variant nature of the channel is essentially due to people or objects moving in the vicinity of antennas. Thus, there may be time-invariant channels, such as in buildings with large, open inner spaces, where static terminals communicate with a central unit located far about floor level. In such channels, the outage number could be translated directly into fraction of locations with unacceptable error rate. In this case, 0.1–1 percent outage probabilities may be tolerable and bit rates of up to 4 Mbits/s (with $M = 4$) at bit error rates not worse than 10^{-4} could be supported. In general, however, if people move while communicating or if the signal paths are likely to be disturbed, the outage number represents a fraction of time, such as seconds per hour, that a link will have an unacceptable bit error rate. In this case, outage could be understood as the fraction of lost bits or, indeed, the long-term bit error rate.

Fig. 3 compares the deterioration resulting from increasing the signaling rate for both, i.e., the indoor multipath propagation model and the flat Rayleigh channel, with identical unfaded carrier-to-noise ratios and a required bit error rate of 10^{-4}. For signaling rates of 1 Mbit/s or less, the channel performance is indeed the same as that of the flat Rayleigh channel. At this rate, the symbol period is about eight times the rms delay spread of the measured building. At lower rate, the outage decreases linearly with the bit rates, and even though it could be reduced to seemingly acceptable levels at very low data rates, the burstiness of the errors makes it more reasonable to attempt to reduce the errors by improving the channel.

C. Space Diversity Gain

For every trial, two samples from the ensemble of channel impulse responses were generated, and the one resulting in the largest in-band energy was selected. The diversity gain is depicted in Fig. 4. It is found that the outage probability is reduced from 0.15 to 0.05 at 8 Mbits/s and from 0.012 to 0.0004 at 2 Mbits/s. This is a factor of 2–3 worse than would have been attained with postdetection decisions, in which case the outage probability is the square of the single-antenna outage probability. This indicates that received energy, albeit simple to measure, is not always an ideal indicator of system performance.

D. Effect of Cosine Rolloff Factor on Outage

For indoor applications, the radio spectrum is not likely to be as tightly controlled as it is for wide coverage systems. Fig. 5 gives the outage probabilities at 2, 4, and 8 Mbits/s for cosine rolloff factors of $\alpha = 0.5$, $\alpha = 0.75$, and $\alpha = 1$. At $\alpha = 1$, a clear outage reduction is observed, resulting from less intersymbol interference associated with the narrower time domain pulse shape. However, the outage reduction is only about 35 percent, from 0.04 to 0.027 from a required bit error rate of 10^{-4}.

V. Conclusions

The performance of M-level quadrature amplitude modulation for indoor radio links has been evaluated using a realistic multipath propagation model. The outage probability, for a required bit error rate of 10^{-4} was found to be 0.0029 at 1 Mbit/s and 0.25 at 16 Mbits/s for $M = 4$. Selection diversity, with selections based on received energy, is found to reduce outage probability from 0.037 to 0.008 at 4 Mbits/s for a bit error rate of 10^{-4} where the more complicated postdetection approach would reduce outage probability to 0.0014. Finally, the outage probability reduction using pulses with a narrower time domain response (cosine rolloff factor of 1 rather than 0.5) was found to be 35 percent at 4 Mbits/s for a bit error rate of 10^{-4}.

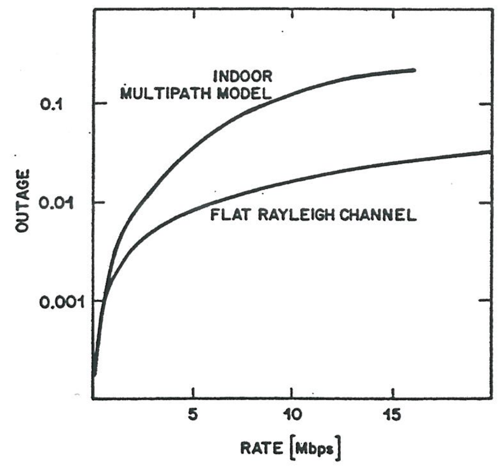

Fig. 3. Outages at required BER of 10^{-4} for flat Rayleigh channel and indoor multipath propagation model.

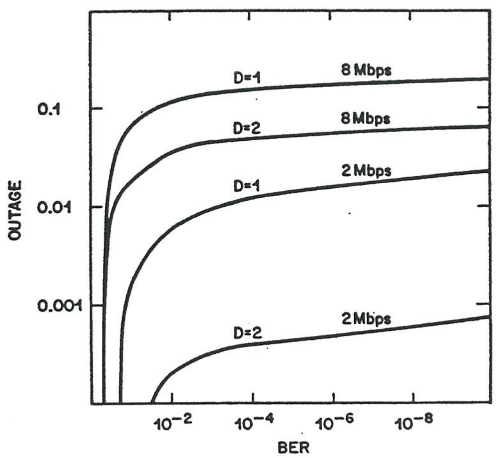

Fig. 4. Space diversity gain at 4 Mbits/s; two antennas, postdetection selection.

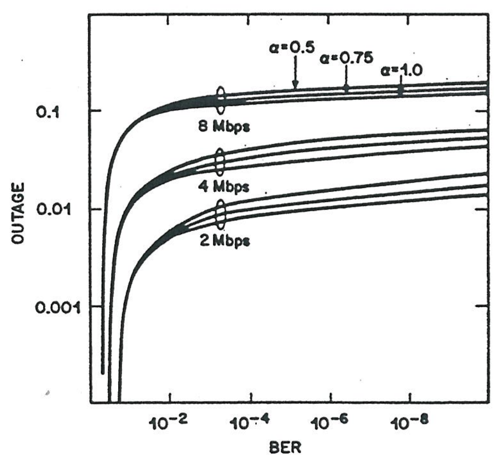

Fig. 5. Outages at 4 Mbits/s for cosine rolloff factor $\alpha = 0.5$, $\alpha = 0.75$, and $\alpha = 1$.

Appendix

The derivation of the timing instant t_d follows the analysis presented in [3] and [8], but applied to the indoor multipath propagation model of [1], and is summarized as follows. The received IF signal is

$$\tilde{v}(t) = k \sum_{n=-\infty}^{\infty} \tilde{a}_n \tilde{f}(t-nT) \tag{A.1}$$

where k is proportionality constant. Squaring and averaging $\tilde{v}(t)$ yields, at baseband,

$$|\tilde{v}(t)|^2 = k^2 \sum_{n=-\infty}^{\infty} |\tilde{f}(t-nT)|^2 \tag{A.2}$$

which is periodic with period T. The timing instant t_d is derived via narrow-band filtering of the first harmonic D_1, the Fourier coefficient of $e^{i2\pi t/T}$, given by

$$D_1 = \frac{k^2}{T} \int_{-\infty}^{\infty} G^*(f) G\left(\frac{1}{T} - f\right) df \tag{A.3}$$

with $G(f) = H(f) * CR(f)$. This is the overall channel transfer function where $CR(f)$ is the cosine rolloff function, with rolloff coefficient α, and the channel frequency response $H(f)$ is found by rewriting the channel impulse response, given by (7), as

$$h(t) = \sum_{k=0}^{\infty} \tilde{\beta}_k \delta(t-\tau_k) \tag{A.4}$$

and taking the Fourier transform

$$H(f) = \sum_{k=0}^{\infty} \tilde{\beta}_k e^{-i2\pi f \tau_k}. \tag{A.5}$$

After some manipulation, D_1 can be written as

$$D_1 = \frac{\alpha k^2}{8T^2} \sum_k \sum_{l=0}^{k-1} \beta_k \beta_l^* \frac{\sin \pi\alpha(\tau_k - \tau_l)/T}{\pi\alpha(\tau_k-\tau_l)/T} \frac{e^{-i\pi(\tau_k+\tau_l)/T}}{1+[\alpha(\tau_k+\tau_l)/T]^2} \tag{A.6}$$

which is of the form

$$D_1 = |D_1| e^{i\phi} \tag{A.7}$$

with the timing instant given by

$$t_d = -\frac{T}{2\pi} \tan^{-1}\phi. \tag{A.8}$$

Acknowledgment

I thank A. A. M. Saleh and L. J. Greenstein for many stimulating discussions and valuable suggestions.

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September 23, 1987

NOTICE: **POSSIBLE EXTRA MEETING 802.4L**

DATES: **Monday, November 9, 0900, or**
Friday, Noveber 14, 1300

PURPOSE: **DETAIL TECHNICAL DISCUSSION**
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Please telephone me if you would be able and interested in attending this extra meeting. If set, a new notice will be mailed.

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IEEE 802.4L--Through-the-air Token Bus Physical Layer

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