APPLICATIONS OF PROPAGATION MEASUREMENT RESULTS TO DIGITAL MOBILE-RADIO SYSTEMS PERFORMANCE STUDIES

Jean-Yves Chouinard, Michel Lecours, Gilles Y. Delisle
Electrical engineering department,
Université Laval, Québec, Canada

I. Introduction

An adequate knowledge of the transmission channel is required in order to establish relations between propagation conditions and communication systems performance. This question is presently of particular interest due to the rapid development of digital mobile radio systems and the need to predict their performance in given environments without having to perform extensive measurements.

This paper presents work carried out concurrently on propagation measurements for a 910-MHz mobile radio channel in the Ottawa region, and on the simulation of the mobile radio channel. The objectives are to relate signal strength measurements to a Rice modelization of the channel and to the performance of a digital mobile radio transmission system for different coding and bit interleaving schemes. This paper describes the type of results available at this time as far as the propagation measurements and the methods used for the digital mobile-radio systems performance predictions and measurements are concerned.

II. Channel modelization and performance studies

In the course of this study, the interest has been centered on the modelization of a digital mobile-radio system where the transmission rate would be relatively low - of the order of 1200 kbits/s; for such a rate, the impulse response of the channel has a negligible influence and the channel can be characterized essentially as a function of signal strength.

The changes in Signal to Noise ratio have a direct influence on the transmission error probability. For a channel with stable propagation conditions, the different modulation techniques (coherent and noncoherent FSK, CPSK, DC-PSK and so on) may offer significant differences in performance. In a mobile radio channel, however, propagation conditions are an overwhelming limiting factor. In this work, the error probability associated with non-coherent FSK has been taken as a reference.

Performance studies can be carried out using direct signal strength measurements. Or the signal strength measurements can be used to validate a statistical model; an interesting candidate for such a model is the Rice channel in which the received signal is considered to be the sum of a direct component

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corresponding to line-of-sight transmission and of a Rayleigh component representing multipath transmission. In the case of a dense urban area, one can suppose that the envelope of the received signal will be constitued essentially of signals reflected by obstacles; in the case of a suburban or an open area, one will admit a significant line-of-sight component.

Performance studies are made on the basis of digital error sequences [1]. One can obtain such error sequences directly from experiments, as has been done by Aulin [2], who has also made a statistical study of the sequences transition error probabilities. Figure 1 illustrates transmission error probability curves obtained by simulation of a rician channel. All curves relate to a 1200 bits/s non-coherent binary FSK transmission on a 800 MHz channel with a 90 km/s vehicle speed; those in full line give the bit error probability for different line-of-sight to multipath (L/M) power ratios; those in dashed lines relate to word error probabilities for a line-of-sight to multipath ratio of -60 dB, for a simple (3,1,1) repetition code and different depths D of bit interleaving.

This model has also been tried with a selection of BCH codes. The results show that it is interesting to use such block codes when their properties are such that transmission with near zero error rate is possible; otherwise, since each error affects a whole block instead of a single bit, the advantage of coding is lost very rapidly. Bit interleaving permits to maximize the benefit of coding by breaking error bursts and spreading errors over longer intervals. The depth of bit interleaving is of course the determining factor and must be longer than the durations of the fadings and error bursts; the performance achieved also depends on the transmission rate, the operating frequency and the speed of the vehicle.

All these factors must be related to actual propagation conditions on real channels, which leads to the next section of this paper.

III. Channel measurements

Propagation loss measurements at a frequency of 910 MHz were taken in the course of summer 1984 in the Ottawa region, Canada, through the technical support and facilities of the Communications Research Center (CRC). Some earlier measurements taken in 1983 have already been reported by the authors in a paper dealing with propagation loss prediction methods [3]. For all these measurements, the base antenna was located on top of one of the CRC buildings, at a height of 33.5 meters above ground level; the receiving antenna was located on top of a mobile unit at a height of 3.8 meters above ground level.

During the summer of 1984, experimental propagation measurements have been taken over 9 different paths, 15 to 30 km long, extending radially in different directions from the CRC site. The CRC buildings are located near the Ottawa river in an open area some 17 kilometers away from the city center. On the Ottawa side of the river, the terrain is rather smooth, the CRC site and the center of Ottawa being more or less at the same elevation with a depression of the order of 10 meters in between; the other side of the river is characterized by hilly and rugged terrain. Signal strength and vehicle speed measurements have been taken at 910 MHz with a sampling rate of 100 Hz. At each kilometer along the 9 paths mentioned above, 6000 data samples were recorded with the vehicle traveling at reduced speed and immobilized. As an illustration, figure 2 gives the mean propagation losses measured at each kilometer along two of these paths, with the vehicle in movement: one of the paths crosses flat urban and suburban areas, while the other can be classified as hilly suburban. A more elaborate report and interpretation of these and other experimental results will be given at the conference.

IV. Conclusion

All the recorded data is now being processed with the view, first of all, of using it to validate and calibrate the Rice channel modelization described above. From this, digital radio-mobile systems performance studies are being conducted as outlined, with a view of generating widely valid and comprehensive digital systems performance prediction techniques.

Finally, in parallel with these studies, a new data acquisition system is under development, to be used for the next measurements in the course of summer 1985. Instantaneous signal and noise levels will be recorded with a sampling rate of 10 kHz, as well as error sequences resulting from the comparison of transmitted and received PRBS sequences.

In the longer term, it would be of great interest to undertake digital mobile radio system performance studies for higher bit rates, including eventually spread spectrum systems [4].

References:

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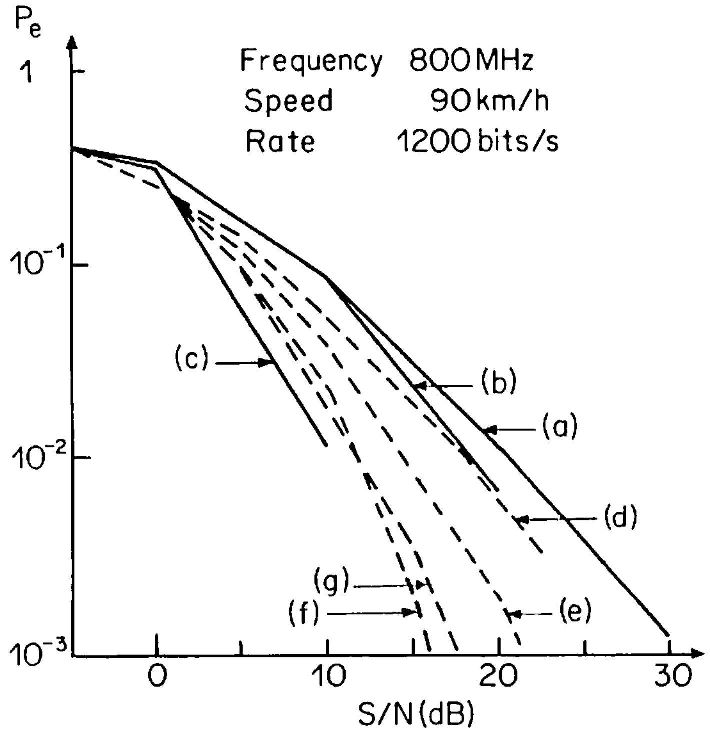

Figure 1. Error Probability Predictions for non-coherent FSK

a,b,c: bit error probability for Line-of-sight to Multipath ratios L/M of -60 (a), -20 (b), 0dB (c)

d,e,f,g: Word error probability for a (3,1,1) repetition code for L/M = -60 dB and for bit interleaving depths D of 1 (d), 4 (e), 16 (f), 80 (g)

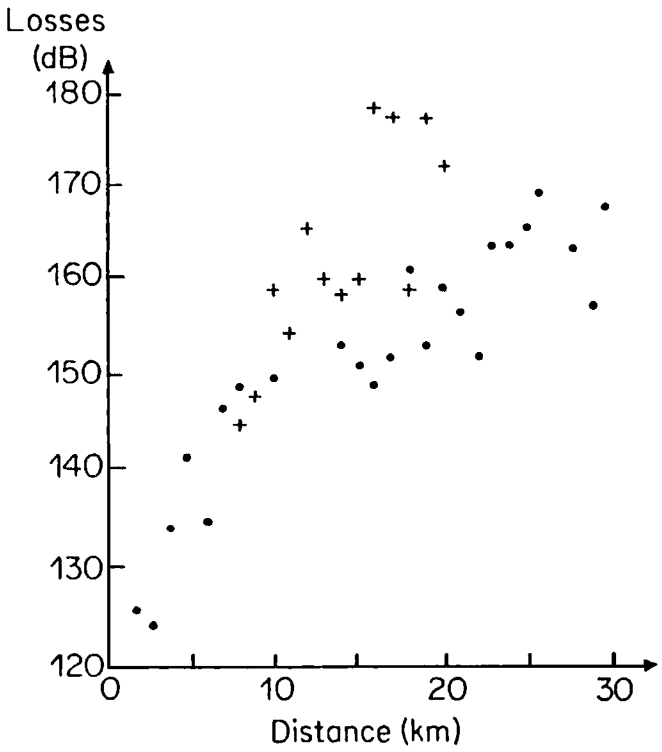

Figure 2. Mean propagation losses measured at 910 MHz

. flat urban and suburban area

+ suburban hilly area