REAL-TIME PERFORMANCE ESTIMATION AND OPTIMIZATION OF DIGITAL COMMUNICATION LINKS

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TABLE OF CONTENTS

Chapter 4 PERFORMANCE OF THE NEW TECHNIQUE FOR VARIOUS MODULATIONS AND CHANNEL TYPES

Chapter 5 LINK PERFORMANCE OPTIMIZATION BASED ON THE EVEREST ESTIMATION TECHNIQUE

Abstract

The subject of this thesis is performance estimation and optimization of digital communications links.

The demand for ever higher data throughput rates and lower error rates drives much communications research. As a result of this research some sophisticated error control strategies and higher capacity modulation schemes have evolved which now make it possible to design excellent digital communications links for which the channel statistics are stable. In contrast, variable quality channels pose a difficult design problem. The design method usually employed is to select the link configuration (modulation, error control, protocol, etc.) to suit the most probable channel statistics and restrict the data rate to give acceptable availability. Clearly, such a link will rarely be operating at its optimum performance. Vast improvements in performance would be possible, however, if performance measurement/estimation is rapid and the link configuration then tracks channel conditions.

In order to improve performance, it was firstly considered necessary to examine what constitutes "performance", how it is defined and determine which metrics of performance should be measured.

Error probability was considered to be the most important metric. However, the review showed that there was not a single technique which could be universally applied to any type of digital link to provide rapid, accurate measurements with minimal (and preferably zero) link overhead.

In response to this deficiency, a new method, which exploits the receiver decision variable more fully and uses a priori knowledge of the types of link condition to be expected was developed. This method coined EVEREST (Extremely Versatile Error Rate ESTimator) which can accurately estimate the decision variable probability density function and hence the probability of error, is the main subject of this thesis.

The theory of the new error measurement technique is developed and supported by an extensive set of simulations investigating the performance of the EVEREST for binary and quaternary signalling schemes with a wide range of channels including AWGN, Rayleigh fading, inter-symbol interference and carrier interference. Simulations are further supported by live High Frequency (HF) link measurements.

EVEREST uniquely offers high accuracy in a time-varying channel for a small number of samples. This characteristic is exploited in an innovative adaptive feedback communication system. It is shown that such a scheme can maximize data throughput whilst maintaining a ceiling on the error probability, thus allowing a guaranteed quality of service for the user or network.

The performance of the adaptive link strategy is simulated for a skywave HF link, using the Watterson channel model and parallel-tone modems. A significant improvement in terms of throughput, end-to-end delay and reliability over conventional coding schemes is demonstrated, supporting the utility of the EVEREST technique.