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# THROUGHPUT ANALYSIS OF A CLASS OF SELECTIVE REPEAT PROTOCOLS IN HIGH-SPEED ENVIRONMENTS

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In this paper the performance of a data link control protocol known as check point mode protocol and few of its variations is analyzed. The aim of the analysis is to obtain simple closed-form expressions for the throughput efficiency of the protocol. The approximate results provide insight into the the impact of the protocol parameters on its performance. By means of the formulae obtained, essential protocol parameters such as optimum frame length, check point interval, window and receiver buffer size can be efficiently chosen to achieve optimum performance. The approximation accuracy is validated with simulations. Numerical examples are presented, where comparisons of the throughput efficiency of the CPM protocol with that of go-back-n and ideal selective-repeat protocols for both high-speed terrestrial and satellite high-speed links are given. Results indicate that for a range of protocol parameters a performance close to an ideal selective-repeat protocol can be achieved.

## 1. INTRODUCTION

In a data communication network, the role of data link control (DLC) is to provide an error-free logical link over a potentially error-prone physical circuit. This is usually achieved through grouping the data to be transmitted into blocks or frames, adding redundancy through appending a frame check sequence (FCS), numbering the information frames, and providing a set of protocol rules by which the nodes at either end of the link initialize recovery through retransmissions.

There are three basic classes of protocols which employ error detection with retransmission, commonly called as ARQ (Automatic Repeat Request) protocols [1]: *stop and wait*, *go-back-n*, and *selective repeat* protocols.

The go-back-n data link protocol is mostly used in today's data communication networks. Typical examples of go-back-n protocols are IBM's SDLC [2], DEC's DDCMP, ISO's standard HDLC [3], or IEEE's standard 802.2. In go-back-n protocol successive data frames are transmitted continuously without waiting for an acknowledgement. When a negative acknowledgement for a frame is received or a timeout is expired, the frame in question and all frames following it are retransmitted. The ideal go-back-n strategy has been analyzed extensively [4-6]. Various performance issues such as throughput or link efficiency, delay distribution and receiver buffer behavior [7] for this class of protocol have been studied. The go-back-n procedure with finite n has also been analyzed in the context of a more practical versions such as HDLC [3,8] and ADCCP/SDLC [9].

For communication links for which the propagation delays are comparable to transmission times of data frames, the go-back-n protocol is generally very efficient. However, there are some other communication links such as satellite links and terrestrial links with very high transmission rates, e.g., T1, T2, T3, where number of frames transmitted in a round-trip delay time is very large. As a consequence, the throughput efficiency of go-back-n protocol reduces drastically [10,11]. For these environments selective repeat strategies can be used to enhance the performance [12-17]. The basic idea of selective repeat ARQ procedure is to retransmit only those frames that are negatively acknowledged or whose timeouts have expired. This obviously improves the performance, but since frames may now be received out of sequence, a reordering buffer at the receiving side is needed [18].

Practical data link control protocols employed today use recovery procedure of go-back-n type. The unbalanced mode of HDLC, however, provides as an optional feature, a Selective Reject (SREJ) function within a supervisory frame. In this mode of operation, retransmission of only a single frame in error may be requested by the receiver using its sequence number.

Recently, a practical data link protocol named Check Point Mode (CPM) which employes a special type of selective-repeat protocol has been defined and suggested in [19,20]. In [21], the performance of this protocol and its variations was studied through detail simulation. The subject of this paper is an analytical study of this real protocol and a few of its variants. We obtain an approximate closed-form expressions for the throughput efficiency of the protocol under window flow control mode and receiver discard policy mode. The approximation method provides insight into the the impact of the protocol parameters on its performance. By means of the formulae obtained,

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