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DESIGN AND ANALYSIS OF NETWORK PROTOCOL IN MARS-TO-EARTH COMMUNICATIONS

Abstract

Abstract: With the expansion of space exploration scope, the deep space communication has the characteristics of extremely long propagation delay, intermittent connectivity, asymmetric data rates, and high error rates. The traditional point-to-point communication cannot meet the needs of future deep space communication, and the concept of networking is believed to be an effective solution. In the deep space network, the TCP/IP protocol stack is no longer suitable as its severe performance degradation. Therefore, Delay/Disruption Tolerant Network (DTN) emerges. In the DTN, a new network protocol named bundle protocol (BP) is placed on top of lower-layer protocols of the original network protocol architecture, to store and forward the message. Besides, BP supports node-to-node retransmission by enabling Custody Transfer (CT) option, which is optional. The protocol which implements the exchanges of bundles, underlying BP, is called the convergence layer (CL) protocol. As the most critical protocol, the performance of BP in deep space DTN has been studied in some work. However, most of the work was conducted through experiments, and lacked theoretical model. What's more, some did not consider the impact of CT option under the conditions of different CLs. Consequently, an analytical model was built by Feng to study the performance of BP with CT option enabled and UDP as the CL in mars-to-earth communications. Small bundles were suggested to achieve both optimal memory utilization and throughput performance, but the selection of optimal bundle size and the setting of retransmission time-out (RTO) timer were not considered. RTO timer was proposed shorter than round-trip time by Wang for deep

space communications, assuming sufficient bandwidth and power. This leads to unnecessary and frequent retransmissions, which cannot satisfy the demands of limited bandwidth and power in deep space. This work focuses on design and analysis of BP network protocol in mars-to-earth communications. Firstly, the RTO timer is designed to prevent unnecessary retransmission, taking into account the asymmetric data rates and limited bandwidth. Then, the theoretical model of CT performance in mars-to-earth communications is derived. Furthermore, the different effects of bundle size on RTO timer and transmission round number are analyzed, and the optimal bundle size to maximize the throughput is obtained. Finally, through MATLAB simulation, the proposed scheme will improve the throughput effectively in contrast to the scheme with normal bundle size in mars-to-earth communications.

Keywords: Delay/Disruption Tolerant Network; bundle protocol; Custody Transfer; RTO timer; mars-to-earth communications