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Transport Layer Protocol Requirement for LEO satellite
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Abstract

In recent years, high-bandwidth LEO (Low Earth Orbit) satellite networks, such as Starlink and OneWeb, have seen tremendous development and are gradually becoming an important part of the global Internet. However, due to the unique characteristics of satellite networks, using TCP for data transmission faces challenges in multiple aspects, such as high latency caused by long-distance propagation and high error rates due to signal attenuation. This proposal summarizes the basic requirements that need to be considered for designing transport layer protocols tailored to LEO satellites.

Status of This Memo

This Internet-Draft is submitted in full conformance with the provisions of BCP 78 and BCP 79.

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1. Introduction

In recent years, high-bandwidth LEO (Low Earth Orbit) satellite networks, such as Starlink and OneWeb, have seen tremendous development and are gradually becoming an important part of the global Internet. However, due to the unique characteristics of satellite networks, using TCP for data transmission faces challenges in multiple aspects, such as high latency caused by long-distance propagation and high error rates due to signal attenuation. This proposal summarizes the basic requirements that need to be considered for designing transport layer protocols tailored to LEO satellites.

The factors mentioned in [I-D.LEOTransPS], such as bursty packet losses, variable round-trip times, and variable link rates, will greatly impact the performance of TCP.

Various optimizations at the transport protocol level have been proposed, such as end-to-end optimizations like SCPS-TP and MP-TCP, redundancy coding like FEC, cross-layer optimizations like ECN, and congestion control algorithm optimizations like TCP Westwood and TCP Eifel, as well as AI-enhanced congestion control. This gives us some indications on what problem we should focused on.

1.1. Requirements Language

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "NOT RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in BCP 14 [RFC2119] [RFC8174] when, and only when, they appear in all capitals, as shown here.

2. Requirement for transport layer protocol

Given the unique characteristics of LEO satellite networks, the requirements for transport layer protocols should focus on improving the following aspects:

Fast Connection Establishment. In satellite networks, fast connection establishment is crucial for improving communication efficiency. For short-lived communication needs, such as bursty data transmission from mobile users, a slow connection setup process can waste significant time. TCP needs to optimize its connection establishment process by adopting fast handshake algorithms and other techniques to reduce the time required for connection setup and enhance the responsiveness of satellite networks.

High-Bandwidth Support. High-performance transport protocols aim to support the rapid transmission of large volumes of data, such as high-definition video streaming and big data file transfers. When sufficient bandwidth capacity is available in the satellite link, the protocol should provide high-bandwidth transmission capabilities to meet the demands of these applications.

Adaptation to Latency Variations. The latency in satellite networks may fluctuate due to factors such as satellite handovers and signal interference, causing RTT (Round-Trip Time) jitter. Transport protocols need to quickly adapt to this latency jitter to avoid performance degradation resulting from congestion window changes triggered by the jitter.

Error Resistance. Data packet loss in satellite channels can be caused by obstructions, atmospheric interference, and spatial distance. More efficient packet loss detection and recovery mechanisms are needed. For example, redundancy-based encoding methods can be introduced, where the sender encodes data with redundancy, and the receiver can use this redundant information to recover lost packets, reducing the need for retransmissions and enhancing the reliability of data transmission.

Resilience to Network Interruptions. Short-term interruptions in satellite links can easily occur due to sun outages or satellite coverage limitations. During such interruptions, the transport protocol should reduce the sending rate to minimize unnecessary packet transmission. Once the interruption is resolved, the protocol should quickly restore the bandwidth to ensure efficient data transfer.

Reduced Retransmission Rate. Retransmissions increase transmission delay and consume bandwidth, which are particularly valuable resources in satellite networks. Transport protocols need to minimize unnecessary retransmissions through accurate packet loss detection and effective error recovery mechanisms, thereby optimizing the overall efficiency of data transmission.

Improved Out-of-Order Handling. The complex transmission environment in satellite networks can cause packets to arrive out of order at the receiver due to different routing paths and varying transmission delays. Transport protocols must be capable of accurately reordering out-of-order packets to ensure the correct delivery of data.

3. IANA Considerations

N/A.

4. Security Considerations

N/A.

5. References

5.1. Normative References

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5.2. Informative References

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