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A Message-Oriented Extension to Multipath Transmission Control Protocol (MPTCP) draft-xu-mptcp-momp-00.txt

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Abstract

This memo specifies a message-oriented extension for Multipath TCP (MPTCP) which aims to serve high-bandwidth and real-time applications. By introducing a message mapping to MPTCP, Message-Oriented MPTCP (MO-MPTCP) attaches some message features like boundaries, priority and dependency to bytestream. With such information, MPTCP senders can optimize their transmission.

Table of Contents

1. Introduction....3
2. Conventions....3
3. New Functionalities provided by MO-MPTCP....3
4. Message Mapping....4
5. Operations of MO-MPTCP....6
   5.1. Boundary-Based Packet Scheduling....6
   5.2. Message-Oriented Transmission Optimization....8
6. Interface Considerations....8
7. Security Considerations....8
8. IANA Considerations....9
9. References....9
   9.1. Normative References....9
   9.2. Informative References....9
10. Acknowledgments....9

1. Introduction

With the increasingly demands for bandwidth-intensive services, e.g., high-definition (HD) video, the streaming media data which is massive and delay-sensitive is becoming the main traffic of the network. MPTCP which has been standardized in [RFC6824] greatly improves the throughput of one association by concurrently transferring data on several TCP subflows. Furthermore, the congestion control mechanism provided by MPTCP can enhance its friendliness to other TCP flows. With these advantages, MPTCP has the potential to serve the high-bandwidth and real-time applications. However, as an extension to TCP, MPTCP still has some drawbacks. Notable example is that MPTCP is a bytestream-oriented protocol. The bytestream ignores the boundaries and differences among application messages, which usually makes the transmission blind and inefficient.

This memo introduces a Message-Oriented MPTCP that allows managing the bytestream in the message ways. MO-MPTCP specifies a message mapping to record the information about message boundaries, priority and dependency in the connection level. Based on this mapping, MO-MPTCP offers Boundary-Based Packet Scheduling Mechanism which can avoid unnecessary transmission and Message-Oriented Transmission Optimization which can preferentially ensure the transmission of important data.

2. Conventions

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in RFC-2119 [RFC2119].

3. New Functionalities provided by MO-MPTCP

Making the transmission of stream media as an example, the new functionalities provided by Message-Oriented MPTCP are as follows:

- Boundary-Based Packet Scheduling

In the process of stream media transmission, application layer usually delivers the data to the transport layer frame by frame. Each frame can be seen as an individual message. However, in the transport layer, limited by Maximum Segment Size (MSS) MPTCP tends to segment the big messages and transfer them in TCP packets, which leads to lose the original message boundaries. MO-MPTCP provides a message mapping that can record the features of application messages including boundaries, priority and dependency, etc. This mapping can help the sender to avoid unnecessary transmissions. For example,

stream media can usually tolerate the loss of partial packets, which means the sender can give transmission up and notify the receiver when a packet is considered as time out. This kind of partially reliable mechanism can refer to [PRMP]. In this situation, if a packet which contains partial data of a frame is abandoned by the sender, as a result, this frame cannot be decoded correctly at receiver side with the absence of partial information. Current MPTCP which is based on bytestream fails to perceive this situation, and still transmits the remaining data of this frame which is a waste of transmission resources. In Message-Oriented MPTCP, thanks to the recording of message boundary, senders can abandon the remaining data simultaneously and avoid unnecessary transmission.

- Message-Oriented Transmission Optimization

Traditional transmission ignores the priority and dependency of messages and treats them equally as a bytestream, which makes the transport blindly. Using an IPMH-like [IPMH] interface, MO-MPTCP can get the priority of each message, and record the dependency between them. For instance, in the standard MPEG coding, "I" frames are essential to the recovery of the whole images and can be decoded independently, so they have the "HIGH" priority and Dependency is "NULL". Similarly, "P" frames which are decoded based on a previous frame have "MEDIUM" priority and Dependency is "PRE"; "B" frames which are decoded based on both a previous frame and a latter frame have "LOW" priority and Dependency is "PRE&LAT". Through some rules, TCP packets can determine their own priorities from the messages priorities. The reliability and timeliness of high-priority packets will be guaranteed first when congestion occurs. When a duplicate acknowledgement is received in the subflow level, the sender will execute judgment for the missing packet upon their priorities and duplicate ACK numbers. The sender then will retransmit the packet if needed.

4. Message Mapping

MO-MPTCP sets up a Message Mapping in the connection level. The Message Mapping which is similar to the Data Sequence Mapping can associates message features such as boundary and priority with stream features such as DSN. This mapping which is the foundation of MO-MPTCP can provide useful information for data scheduling in transmission.

The Message Mapping consists of a lot of records, and each record corresponds to an application message. Its structure sketch is show in Figure 1.

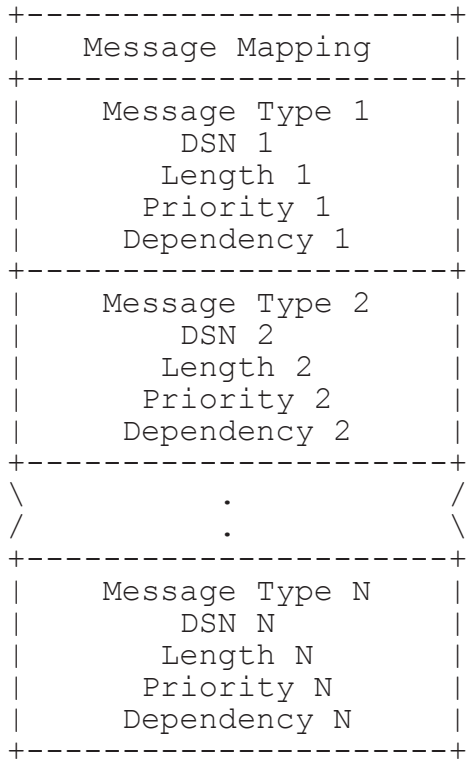

Figure 1 Message Mapping

- Message Type is used to distinguish the classes of message. It can change its meaning depending on the application. For example, in the streaming media transmission, it represents which kind of frame this message is.

- DSN=Data Sequence Number. DSN shows the starting number of this message in the data level.

- Length shows the number of bytes that this message contains.

- Priority shows the importance of this message which usually be divided into three priority: HIGH, MEDIUM and LOW.

- Dependency shows the dependencies between adjacent messages. For example, "NULL" means this message is independent; "PRE" means this message depends on the previous message to be decoded; "LAT" means this message depends on the later message to be decoded. "PRE&LAT" means this message depends on both the previous and later messages to be decoded.

The DSN and Length are used to identify the boundary of an application message. And the rest of the parameters which are unique nature of messages are used to provide information for the transmission optimization.

MO-MPTCP also provides rules for mapping establishment and removal as follows:

- When receiving an application message, the sender SHOULD add a new record containing all necessary parameters to the Message Mapping. However these parameters may have different meaning for different applications.

- A message which is larger than the MSS will be segmented in the transport layer. The record for this message in the Message Mapping SHOULD be retained until all segments of this message are acknowledged.

5. Operations of MO-MPTCP

5.1. Boundary-Based Packet Scheduling

Boundary-Based Packet Scheduling is used in the situations where the applications can tolerate the loss of some packages to meet its requirements for timeliness. [PRMP] proposed a partially reliable extension to MPTCP called PR-MPTCP, which is designed to deal with above situations. However, PR-MPTCP is based on the bytestream and can perform better with the help of MO-MPTCP. For instance, if a packet containing partial data of a message is determined to be discarded, MO-MPTCP can find and discard the remaining data that belongs to or relies on this message. The detailed operating steps are as follows:

a) MO-MPTCP offers a function to the sender. When determining to discard a packet, the sender SHOULD call this function and send the starting DSN and length of this packet as parameters to MO-MPTCP.

b) Every time receiving calling from the sender, MO-MPTCP SHOULD search the Message Mapping and record all the messages involved in this packet.

c) Based on the messages selected by step "b", MO-MPTCP then refers to the Dependency recorded in Message Mapping and extracts some other messages which rely on them to be decoded.

d) MO-MPTCP combines all the messages selected by step "b" and "c", and connects them as one or more bigger messages according to their DSNs and Length. Then the new boundaries of these messages are obtained.

e) MO-MPTCP SHOULD return the starting DSN and Length of these new messages. Then, the sender can continue its original operations and discard the expanded messages according to the new boundaries.

Step "b" can be classified into the following situations:

- Only one message is involved in the packet, which means this packet is just a segment of the original message. In this case, MO-MPTCP SHOULD search the Message Mapping and record this message.

- Two or more messages are involved in the packet, which means this packet contains data comes from different messages. In this case, MO-MPTCP SHOULD search the Message Mapping and record all related messages.

When executing step "c", there are some notes:

- Before starting to search the Message Mapping, MO-MPTCP preferably checks the priorities of the messages provided by step "b", and skips the messages which have LOW priority. Because there is usually no message relies on them.

- Although the parameter of Dependency in Message Mapping only reflects the relationship between adjacent messages, the lost a message with HIGH priority can influence several messages with lower priority. For example, if an "I" frame is decided to be discarded, the following several frames will be influenced. So, the implementation should pay attention to a chain reaction.

5.2. Message-Oriented Transmission Optimization

The Message Mapping records the priorities of the messages. Based on these priorities, each TCP packet can determine its own priority. The basic rules are as follows:

- If the data of a packet comes from only one message, the packet priority is the same with the message priority.
- If the data of a packet comes from several messages, the packet priority is the same with the highest message priority.

Following the above rules, senders can obtain the packet priority, which is an important reference for the transmission optimization. The main operations of the optimization are as follows:

a) Once the sender receives duplicate acknowledgement, it SHOULD obtain the priority of those corresponding TCP packets by searching the Message Mapping.

b) MO-MPTCP determines whether these packets need being retransmitted immediately based on their priorities and the number of duplicate acknowledgments. The higher the priority is and the more duplicate acknowledgments sender receives, the more easily immediate retransmission is triggered.

c) If a TCP packet is judged to need retransmission by step "b", the senders SHOULD retransmit it immediately. Meanwhile, it SHOULD also reset retransmission timer and clear the number of duplicate acknowledgment.

d) If a TCP packet does not need to be transmitted after step "b", the senders can continue their original works until event in step "a" happens.

6. Interface Considerations

MO-MPTCP offers an interface to the upper layer, through which the applications can call MO-MPTCP and assign the parameters like priority and dependency. The ways in which application obtain these parameters can refer to [IPMH].

7. Security Considerations

This memo develops no new security scheme for MPTCP. MO-MPTCP share the same security issues discussed in [RFC6824] with MPTCP.

8. IANA Considerations

There is no IANA consideration for this memo.

9. References

9.1. Normative References

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