RAYSYNC TRANSMISSION PROTOCOL TECHNICAL WHITE PAPER

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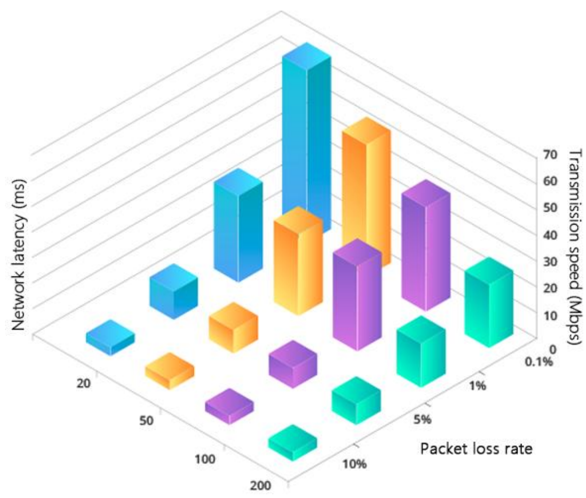
1. Preface

Transmission Control Protocol TCP (Transport Control Protocol) is a transport layer protocol in TCP/IP protocol stack. At present, more than 90% of the global Internet data traffic is transmitted through TCP, while less than 10% is transmitted through other channels, and TCP's share continues to expand in accordance with the statistics of authoritative international organizations. TCP provides reliable data transmission through sequence confirmation and packet retransmission mechanism. Meanwhile, all kinds of widely used operating systems (WINDOWS/LINUX/UNIX/MAC) have built-in TCP protocol stack, POSIX standard defines TCP Socket standard API interface, these factors have promoted TCP to obtain extremely widespread success in the world.

However, this transmission protocol designed more than 20 years ago has become more and more unsuitable for the requirements of the rapidly developing network environment and new applications. Especially in the case of certain packet loss and latency on the network transmission path, the transmission throughput of TCP protocol drops sharply, which often cannot effectively utilize the path bandwidth, resulting in slow transmission speed, long transmission time and poor transmission experience.

2. TCP's Operation in Networks with Different Latencys and Packet Dropouts



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Influence of Time Latency and Packet Dropout on TCP Transmission Throughput

With the increase of network packet loss rate and latency, the bandwidth throughput rate of TCP protocol drops sharply as can be seen from the above figure. The bandwidth throughput rate is less than 1Mbps for a latency greater than 50 milliseconds in the case of 10% packet loss.

3. Brief Introduction of Congestion Detection and Monitoring Technology

Generally speaking, the bandwidth throughput of transmission protocols is determined by congestion detection and control technologies. Distinguish congestion detection processing methods, mainly divided into two kinds:

- Lost-based (packet Loss-based congestion detection and processing)-packet loss is used to detect congestion and adjust transmission speed; Typical representatives of such congestion algorithms are TCP-Reno and TCP-Cubic algorithms.

- Latency-based (congestion detection and processing based on latency)-congestion is detected and transmission speed is adjusted by the change of Round Trip Time, RTT); Typical representatives of such congestion algorithms are TCP-Vegas and fast TCP algorithms.

3.1 Loss-based TCP improvement attempts and limitations

Lost-based TCP improved technology uses packet loss to judge congestion and adjust transmission speed.
Loss-based TCP acceleration improvements are mainly as follows:

- Increase the initial congestion control window (Congestion Window, CWND)；

- CWND is recovered in a more radical way than traditional TCP when packet loss occurs in order to reduce the impact of congestion on transmission speed.

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The improvements can indeed increase a certain rate in some cases, but the Loss-based TCP acceleration technology has the following two serious problems in principle:

1、It is not accurate to use packet loss as a signal for congestion in transmission network paths. Many modern networks will generate packet loss due to non-congestion factors, especially for wireless networks, such as air interface transmission error code/interference of wireless signals and other factors, which do not imply congestion.

2、Modern network equipment usually has a deep cache queue. The device cache transmission queue becomes longer and the transmission latency is significantly increased when congestion occurs, but packet loss does not occur. Loss-based TCP acceleration mechanism will continue to transmit at high speed until the queue is completely full so as to overflow, which will result in the loss of a large number of packets. It not only aggravates the congestion of path nodes, but also takes a longer time to recover from a large number of packet losses, which often leads to transmission block/transmission real-time deterioration.

3.2 Latency-based TCP improvement attempts and limitations

The Latency-based TCP improvement technology overcomes the main defects of Loss-based TCP, and in principle uses the change of round-trip latency to judge the congestion degree and adjust the transmission speed accordingly. Latency-based TCP acceleration technology does not regard packet loss as congestion and can maintain a high rate when packet loss occurs due to non-congestion factors. Therefore, the well-designed Latency-based TCP has a certain improvement in transmission speed over the Loss-based TCP.

However, the Latency-based TCP also has the following defects in use:

1、Whether the queue of node equipment on the path of TCP connection is very shallow, the round-trip latency does not increase when congestion occurs, and congestion is manifested as packet loss in bursts. Latency-based TCP technology does not perceive this congestion and will continue to send data packets at high speed, resulting in a large number of packet losses. The recovery period of packet losses will be very long, resulting in a significant reduction in transmission speed and even transmission block.

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2、The Latency-based TCP technology will misjudge the latency increase caused by non-congestion factors as congestion and transfer it to congestion processing, thus causing unnecessary reduction of transmission speed when the latency of the network path itself varies greatly. Especially in the current mobile Internet era, wireless network latency changes frequently, and some network devices (especially security devices) will occasionally introduce additional packet processing latency.

4. Direction for Improvement of Transmission Protocol Technology

The problem of low transmission efficiency of TCP in WAN transmission has attracted the attention of academia and industry. The researchers and commercial companies have put forward their own improvement schemes since the beginning of the 21st century. The improvement schemes are mainly divided into two categories:

- Redefining brand-new protocol and congestion control mechanism based on IP;
- The new protocol and congestion control mechanism are defined based on UDP.

4.1 Redefining New Protocol and Congestion Control Mechanism Based on IP

SCTP：SCTP was first proposed by telecommunication organizations to transplant SS7 signaling under TDM network to IP network for operation. SCTP has proposed a series of new features to improve the capability of transmission protocols, such as Multi-Homing, Multi-Streaming, Heartbeat over path, NACK, etc. and it was once a dazzling star that may replace TCP.

However, SCTP fell silent after a period of application. The main reasons are:

SCTP is directly based on IP protocol, which is a brand-new transport layer protocol parallel to TCP/UDP. There are a large number of NAT devices deployed in the global Internet that only support TCP/UDP protocol and cannot recognize SCTP protocol, which resulting in computers behind NAT devices being unable to carry out global interconnection through SCTP protocol normally.

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4.2 New Protocol and Congestion Control Mechanism Based on UDP

UDP protocol is consistent with the service provided by IP protocol, only 8 bytes more UDP header than IP protocol; UDP, like TCP, can pass through all existing NAT devices smoothly. Therefore, a large amount of research efforts have been devoted to defining new protocols based on UDP.

- Representative of open source products: UDT（UDP-based Data Transfer Protocol）
- Representatives of commercial products: major domestic manufacturers include the Radium Transmission Protocol of Ruiyun Technology and major foreign manufacturers include the fasp Transmission Protocol of Asperasoft.

5. Main Technical Principles of Raysync Transmission Protocol

Raysync transmission protocol mainly improves transmission efficiency through the following two aspects:

- **More effective congestion judgment and handling;**
- **A recovery mechanism for judging packet loss more accurately and timely;**

5.1 More Effective Congestion Judgment and Treatment

At present, the mainstream congestion judgment is designed based on the network situation more than 20 years ago, and its basic assumption is that any packet loss reflects the network congestion. This assumption is completely divorced from the modern network situation. Packet loss in modern networks is often not caused by congestion factors. This leads to transmission protocols often entering an overly conservative transmission state.

Raysync transmission protocol congestion detection algorithm will automatically collect the existing background transmission information (packet loss, time latency and jitter) on the path, and accurately judge the actual congestion in accordance with the transmission speed. It is neither too conservative nor too radical, and can effectively make full use of the path bandwidth.

5.2 More accurate and timely recovery of packet loss judgment

The standard TCP protocol stack judges packet loss by two means:

- The number of consecutive duplicate acknowledgement packets (Dup-ACK) at the receiving end;
- ACK timeout;

ACK timeout is often used to interpret the timeout and trigger retransmission when there are more packet losses. Packet losses in modern networks are often sporadic, and it is common for multiple packets to be lost simultaneously on a connection. Therefore, standard TCP often relies on overtime to retransmit holes, which often results in a waiting state of several seconds or even ten seconds, causing transmission to stall or even interrupt for a long time. This is one of the main problems affecting the efficiency of standard TCP.

Raysync transmission protocol abandoned TCP protocol’s practice of using transmission message sequence as both byte count and acknowledges mark for reliable transmission, and designed a new ACK data algorithm. The transmitting and sending party can accurately judge the packet loss situation and retransmit the data in the first time without relying on the cumulative acknowledge multiple ACK or the ACK timeout timer to trigger the retransmission of the data in accordance with the ACK information returned by the transmitting and receiving party, thus greatly improving the transmission speed and the transmission real-time.

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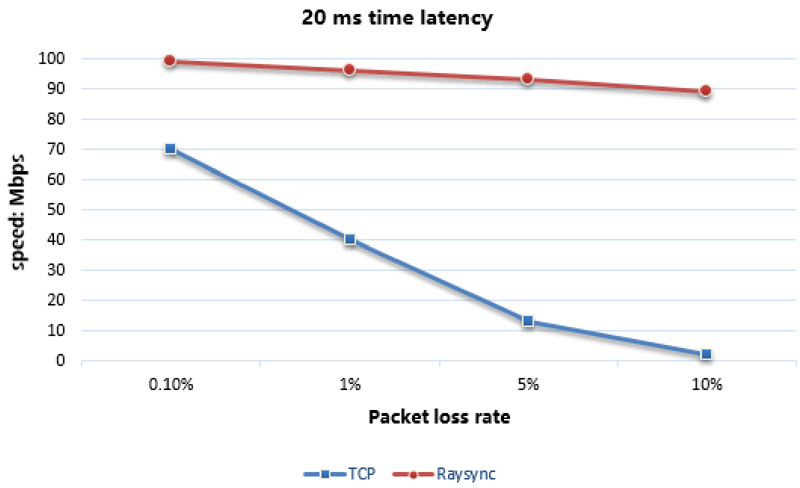
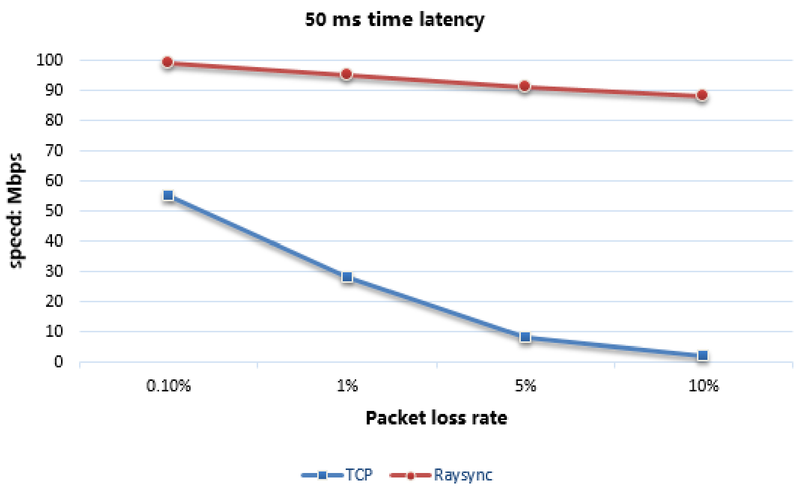
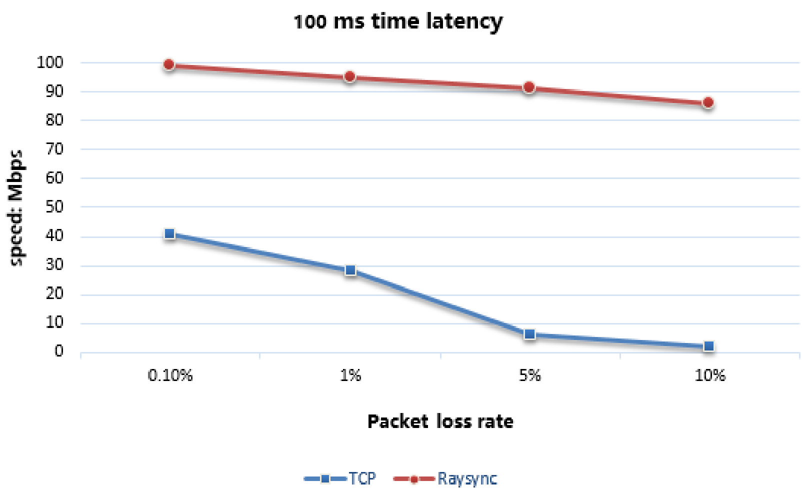
6. Raysync Transmission Protocol Compared with TCP Protocol Test Data







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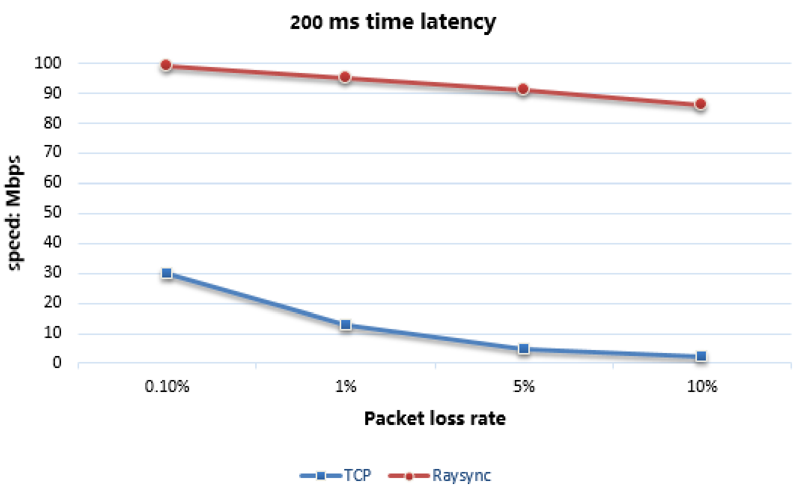

We have tested 4 different time latencys from [20 ms, 50 ms, 100 ms, 200 ms] and compared Raysync transmission protocol with TCP transmission protocol under 4 packet loss rates from [0.1%, 1%, 5%, 10%].

It can be seen that under various tests from the test data shown in the figure, with the increase of packet loss rate, the transmission speed of TCP drops sharply, while Raysync transmission protocol can maintain a reasonable and stable transmission speed continuously.

7. Main Characteristics of Raysync Transmission Protocol

7.1 High Speed Transmission

Raysync transmission protocol can make full use of large bandwidth network to transmit data at the fastest speed. It can help users to complete the big data transmission in the least time in the massive data distribution application scenario.

7.2 Good real-time performance

Raysync transmission protocol supports the multi-channel parallel characteristic of transmission connection. A plurality of irrelevant data streams can be transmitted in

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parallel through the multi-parallel channel characteristic quickly when a user establishes a connection between point A and point B. The transmission of these data streams does not need to undergo the handshake process of connection establishment, thus greatly improving the transmission real-time. The innovative ACK design of Raysync Transmission Protocol helps users to complete data retransmission in the fastest and most accurate way in the environment with packet loss. Help users to achieve the best real-time data transmission in game, live broadcast and other application scenarios.

7.3 Firewall-&NAT Device Friendly

Raysync transmission protocol is based on UDP protocol and can smoothly pass through various NAT devices.

Raysync transmission protocol can run multiple connections on one UDP port. Raysync transmission protocol server can complete connection and data transmission with multiple Raysync transmission protocol clients only by opening one port of user's firewall equipment.

7.4 Easy Integration

Raysync transmission protocol runs in the application layer and user space of the system without modifying the kernel configuration of the operating system. Raysync Transmission Protocol provides a series of easy-to-use SDK (Software Development Kit/Software Development Kit), API (Application Programming Interface/Application Programming Interface) and clear and complete development documents to help users integrate quickly.

7.5 Height Configurable

Raysync transmission protocol provides configuration parameters for users to flexibly customize. The transmission protocol can be best applied to user's application scenarios through different parameter group configurations. For example, large file transmission pays more attention to the utilization rate of bandwidth, and applications such as games/live broadcasting pay more attention to the real-time nature of data transmission. Raysync transmission has been optimized for a variety of common application scenarios, providing multiple sets of configuration parameters for users to choose from.

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7.6 Cross-platform

Raysync Proxy supports mainstream computing platforms such as Windows/Mac/Android/iOS/Linux/UNIX;

8. Reference for Main Transmission Technical Indexes of Raysync Transmission Protocol

8.1 Comparison of Different Packet Loss Rate/Latency Transmission under 8.1 100Mbps Network Bandwidth

network scenarios	packet loss rate/ latency index	TCP transmission speed	UDT transmission speed	Raysync Protocol transmission speed
LANs:	**packet loss rate, 1-10ms latency,**	11MB/s	11MB/s	**11MB/s**
Different cities of the province	**1% packet loss rate , 60ms latency**	less than 1000KB/s	4.5MB/s	**10MB/s**
different provinces in China	**3% packet loss rate, 100ms latency**	less than 200KB/s	2.3MB/s	**9.5MB/s**
different networks of the operators	**5% packet loss rate, 150ms latency**	less than 100KB/s	1.5MB/s	**8~9MB/s**
Transnational network	**20% packet loss rate, 150ms latency**	fail to work	less than 50KB/S	**6MB/s**

Note: UDT refers to the reliable transmission protocol based on UDP, which is influential and widely used in the open source community. See http://udt.sourceforge.net/

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8.2 Maximum Transmission Bandwidth Supported by Raysync Transmission Protocol

- Single Raysync Transport Protocol process/thread supports 1Gbps;
- Load balancing equipment can be deployed for scenarios where the user's transmission bandwidth is greater than 1Gbps. Multiple Raysync transmission protocol processes/threads can be deployed after the load balancing equipment is deployed, which can support horizontal expansion with unlimited transmission capacity.

9. Conclusion

The widely used standard TCP protocol has been difficult to adapt to the complexity and diversity of modern networks. Rayvision Technology Raysync Transmission Protocol solves the core problems of the existing TCP transmission protocol from the design principle, can be rapidly deployed on existing equipment, can help users to quickly transmit their data without heavy investment and repeated investment, and is bound to play a greater role in the era of massive data growth.

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