use cases and requirements for packet loss rate guarantee in WAN

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Introduction

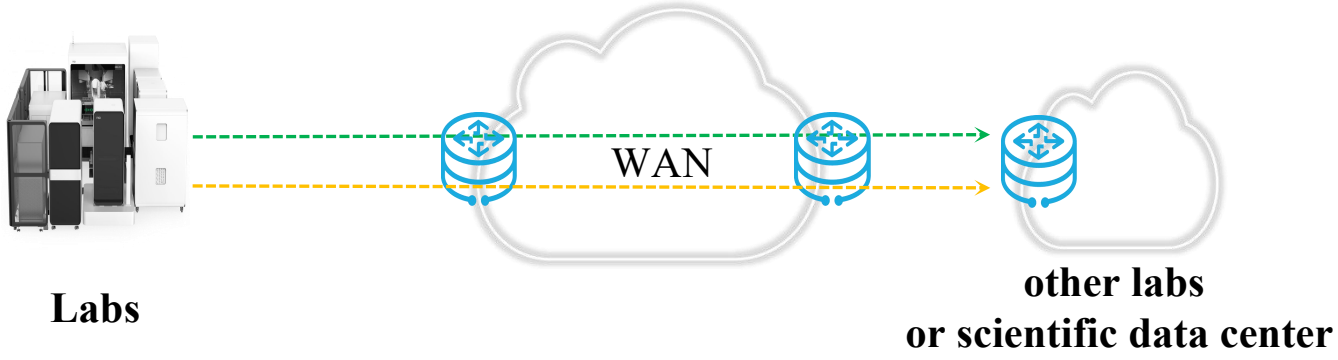
With the rapid development of big data and intelligent computing, applications have growing demand for efficient and reliable data transmission.

This contribution will introduce related use cases of massive data transmission in large-scale networks. Analyse why extremely low or zero packet loss rate guarantee is necessary. Then, Discuss the existing problems and challenges in WANs. In the end, consider enhancing capabilitie of WANs to support future data-intensive applications by implementing lossless techniques or other solutions in WANs.

Use Cases 1 High-Performance Computing (HPC) for scientific research.

- The Collaboration between scientists across different geographic regions is common, which need to share and analyze massive data sets effectively. The study of PSII proteins, generates 30 to 120 images per second and results in 60-100GB of data every five minutes, requiring data transmission from its lab to other labs for analysing.

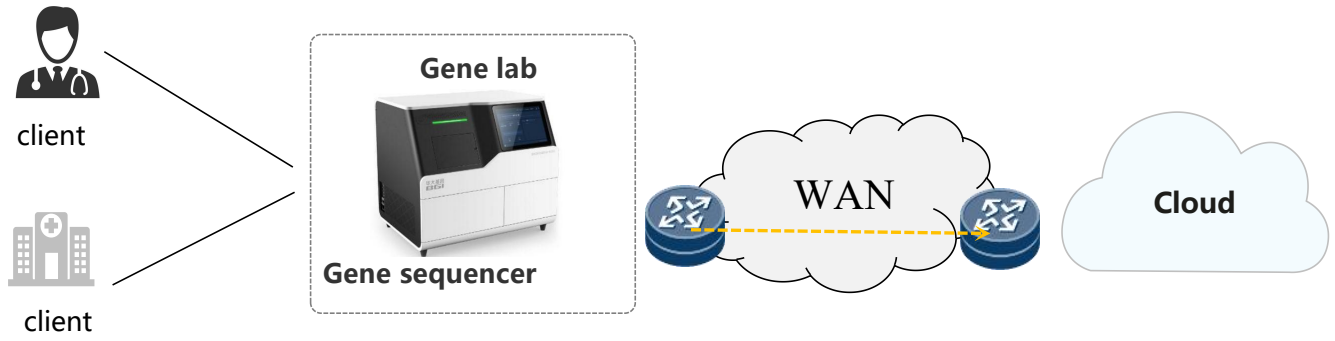
- The relevant scientific data management regulations require that the data generated by scientific research needs to be submitted to the scientific data center for archiving and backup. For some projects, the data is about 50~300PB every year.



Use Cases 2 Genetic Sequencing for timely medical services

- The application of gene sequencing technology is increasingly widespread, and the lack of efficient and low-cost solutions for raw data transmission is difficult to meet the "24-hour precision medicine".

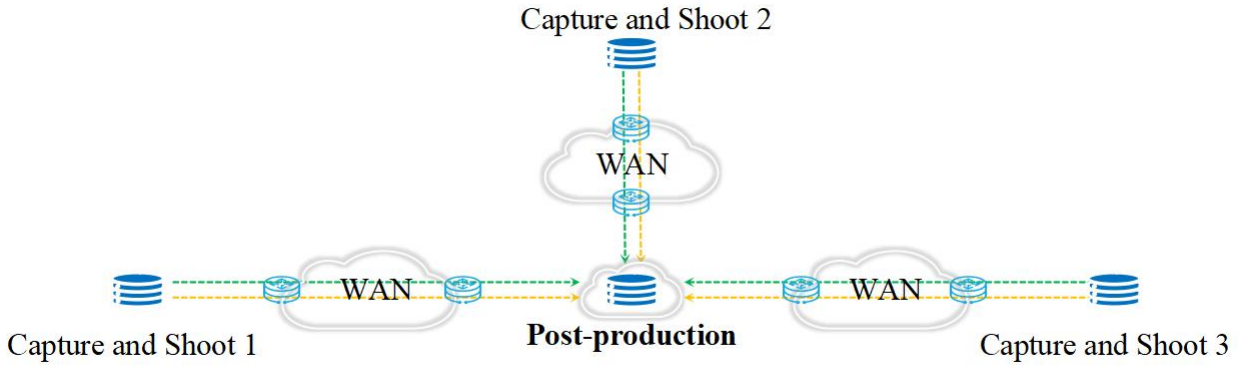
- For example, sequencing a single human genome produces 100GB to 200GB of data. With daily data production rates reaching 6TB to 12TB and annual data management needs surpassing 1.6PB, which need secure, efficient, on-demand massive data transmission services.



Use Cases 3 Audio/Video Data Migration for multimedia content production

- The short-video industry and 4K ultra-HD channels are widely popular, but the competition is fierce, especially in the aspect of multimedia content production. Capture and shooting, cloud post-production, and terminal presentation are independent. A large amount of audio and video data need to transmit across WANs.

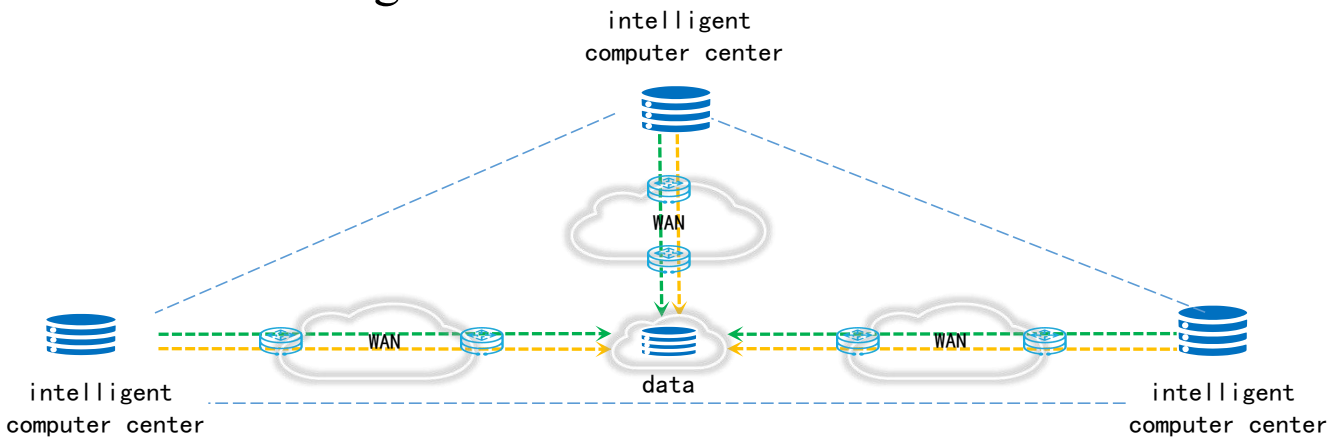
- For example, a camera crew generating 2TB of data daily upload to the cloud for later post-production. Traditional methods of data transmission, involving physical media and manual transfer, are time-consuming and inefficient.



Use Cases 4 AI Distributed training across multiple intelligent computing center

- With the increasing demand for computing power in AI large-scale model training,the AI training clusters expands from single data center to multiple DCs. Distributed training can improve computational efficiency, accelerate model training speed, and utilize more data resources.

- A large model training templates requires uploading TB/PB level data to the data center. For example, a real-time sentiment analysis application using distributed training, the latency of less than 10 milliseconds might be desired to maintain the accuracy and timeliness of the model's learning.

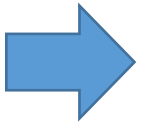


Use Cases Analysis

According to the usecasess, we want to send massive data to a long-distance location through the WANs efficiently and reliably.

➢ Timely service

- High-Performance Computing (HPC) for scientific research
- Genetic Sequencing for timely medical services
- Audio/Video Data Migration for multimedia content production

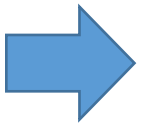


High-throughput

- latency: hours/ days bounded
- Maximize effective bandwidth
- Improve bandwidth utilization
- packet loss rate:
  extremely low
  satisfy service needs.

➢ Real-time service

- AI Distributed training across multiple intelligent computing center



High-performance

- latency: ms bounded
- jitter : ms or even us bounded
- Maximize effective bandwidth
- packet loss rate:
  0, No retransmission

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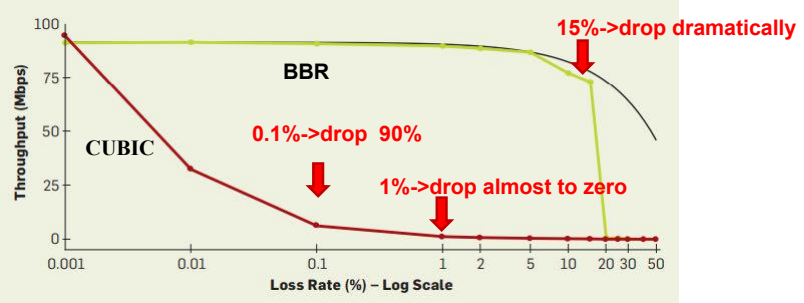
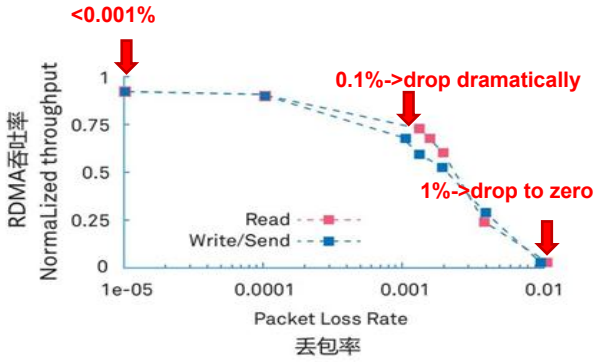
Problems Analysis

- The reliance on traditional transmission protocols like TCP or RDMA [RoCEv2] is common. However, both protocols are adversely affected by packet loss, especially over long-distance transmissions.



TCP



RDMA

- Generally, the packet loss rate of IP bearer network in WANs is between 0.1% ~ 0.006% . The load of the WANs continues to rise, and the micro-traffic burst frequency is high. It's difficult to predict and ensure the packet loss rate under burst congestion.

Challenges

- The quest for lossless data transmission in WANs is confronted with significant challenges.
  - Various type of service
  - High burst intensity
  - Complex and arbitrary network topology
  - Long RTT

- The lossless technologies for data centers,such as priority flow control (PFC) and explicit congestion notification (ECN) have problems when applied to WAN
  - Backpressure from PFC: can lead to head-of-line blocking, deadlocks, and congestion spreading. degrade network throughput.
  - Limitations of ECN-based Congestion Control: effectiveness diminishes over longer distances, prolonged control loops, difficult to quickly alleviate congestion.

Requirements

- Provide high-throughput and high-performance transmission services in large-scale network for data-intensive applications.
- For the entire WAN, continuously enhance the capabilities of bearer network and constantly reduce the overall packet loss rate to nearly 0.
- For some critical business, guarantee packet loss rate can still meet the the business requirements even when there is burst congestion in network .
- Implementing lossless techniques in WANs: Improving PFC and ECN for lossless data transmission in WANs.
- Any other solutions? Deterministic forwarding, resource reservation solution, etc?