Enhanced Use Cases for Scaling Deterministic Networks

draft-zhao-detnet-enhanced-use-cases-04

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Updates from last versions

- Presented at IETF#118 , Updated at IETF#122 and comments at meetings and on the mailing list are appreciated from :
  - Jinoo, Carlos, Janos and Lou

- The updates from version-00 to -04 are like following:
  - merged the section 3.5 to the section 3.4.
  - updates sub-section " 3.3.1.1. Scientific Research “ to specify typical scenarios of massive data transmission between HPCs .
  - add simulation and testing data for massive data transmission in the appendix .
  - add two co-authors, Muhammad Awais Jadoon from InterDigital and Luis M. Contreras from Telefonica
  - add new use cases "ISAC-Enabled Smart Factoy", “Interconnection of Time Sensitive Domains” and “Intelligent Computing”
  - add sub-section "Requests to the IETF" to each use case
  - add section "Use Case Common Themes" to specify the new requirements with the enhanced use cases for DetNet
  - editorial revison

Version-03 VS. Version-04

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Appendix A. Simulation Results in Scientific Research . .
A.1. Simulation for the Long Distance and Latency . . .
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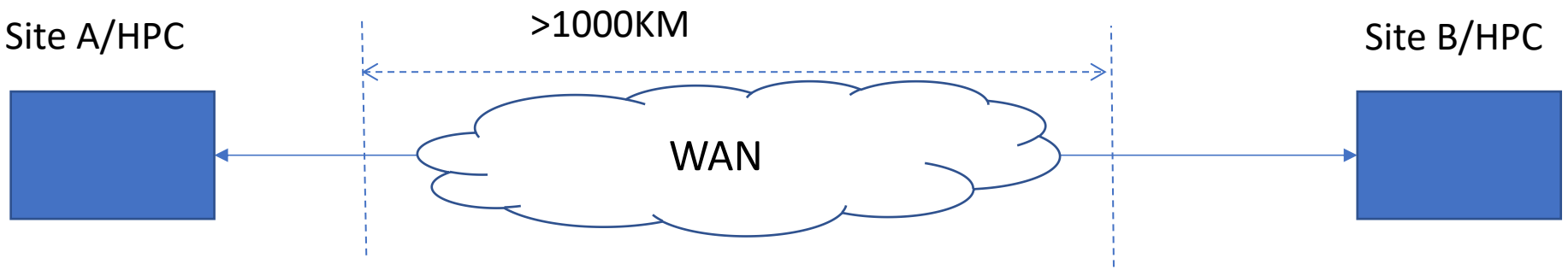
Use case for Scientific Research

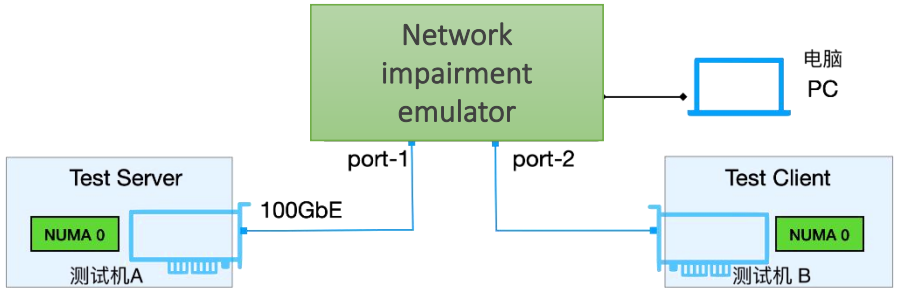
- Long-distance and Massive data transmission:



- Massive research data transmission between HPCs:
  - distance range from 100km to 1000km
  - regularly or in demand, data volume from a few terabytes to several hundred terabytes
  - Balance on Data transmission costs and security
  - The US ESnet6 and the EU EuroHPC ……
- Massive data transmission performance requirements for WANs:
  - deterministic network performance to support high throughput
    - deterministic low or zero packet loss
    - deterministic low latency and low jitter

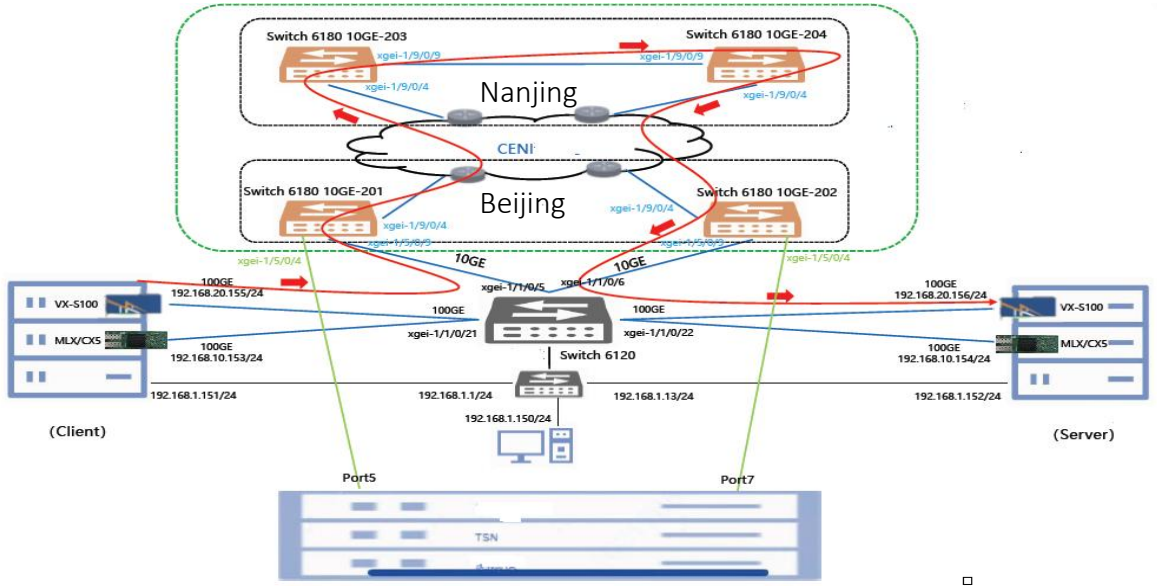
Examples for Lab Simulation and CENI Testing

Lab Simulation



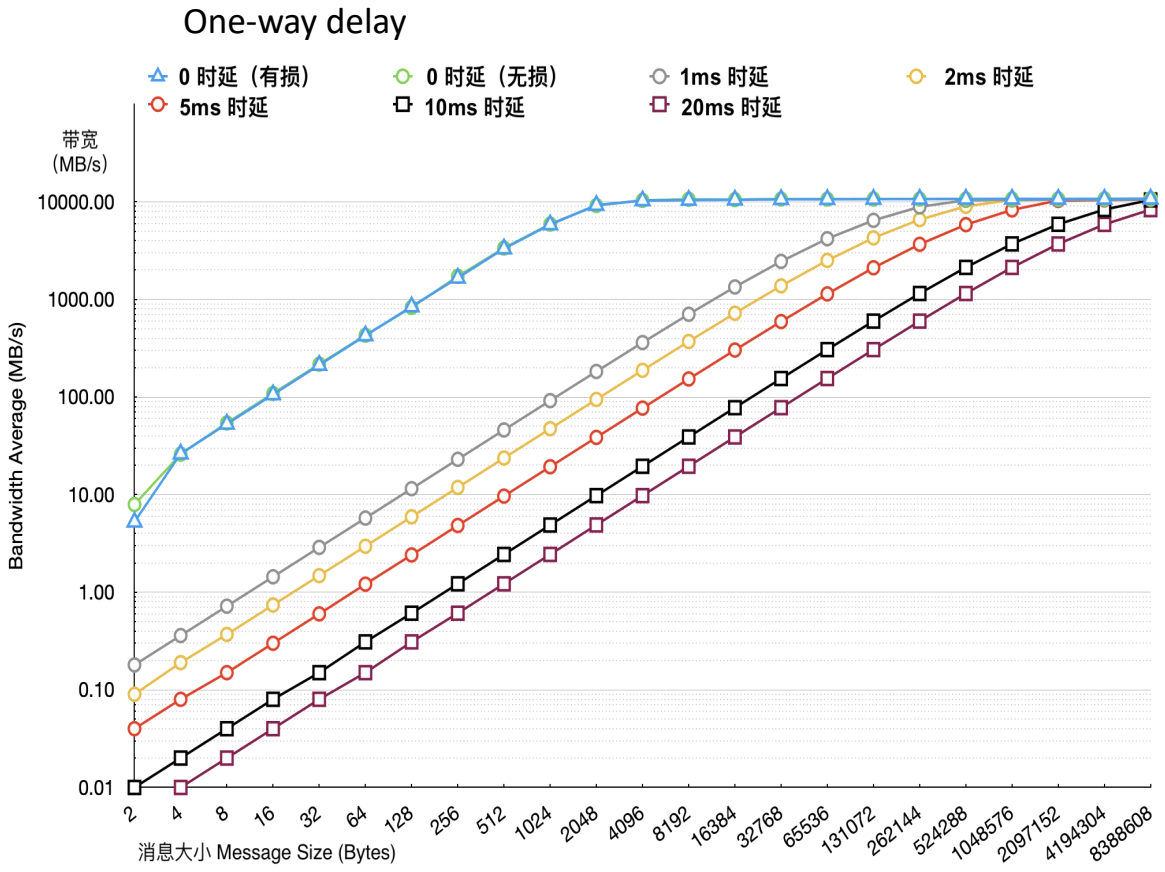
- The lab tests used **network impairment emulator** to simulate:
  - ✓ Variable latency (0-20ms)
  - ✓ Jitter (±0~1ms)
  - ✓ Packet loss ratio (0.001%-0.1%)
- The goal is to test the impact of **deferent latency, jitter, and packet loss combinations** on high-throughput transmission performance(e.g.RDMA).

CENI Testing Topology



- Performed validation testing on 2000km wide-area deterministic network from Nanjing to Beijing.
- Attempted to analyze **deterministic performance thresholds** for:
  - ✓ High-throughput transmission
  - ✓ Low-latency RDMA operation

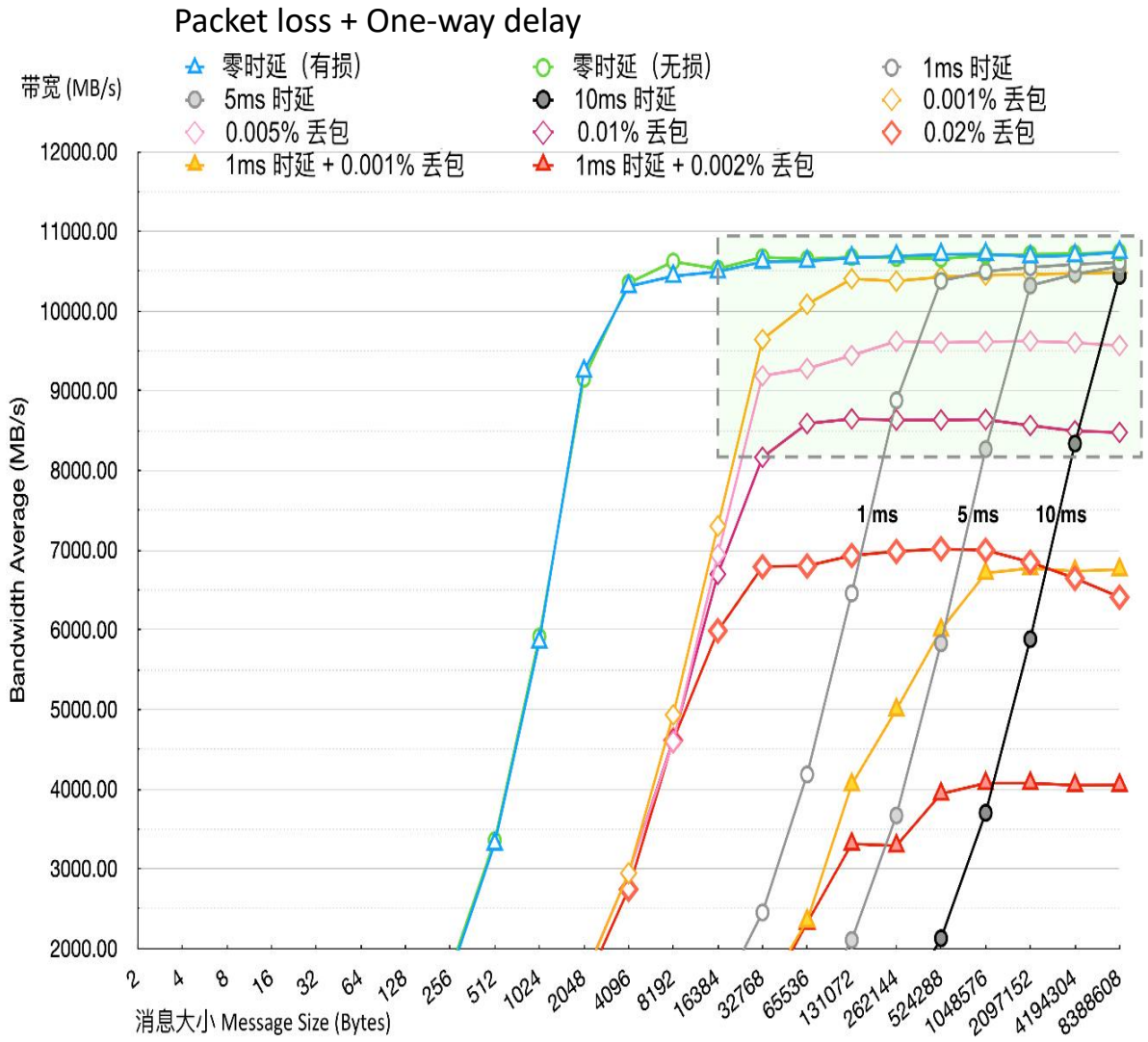
Testing on Long Distance and Latency



RTT latency (ms)	message length (byte)	transmission distance(km)	Throughput (Gbps)
<1	<1 024	<100	>90%@100Gbps
1	≈256 K	100	>90%@100Gbps
2	≈512 K	200	>90%@100Gbps
5	≈1 M	500	>90%@100Gbps
10	≈8 M	1000	>90%@100Gbps

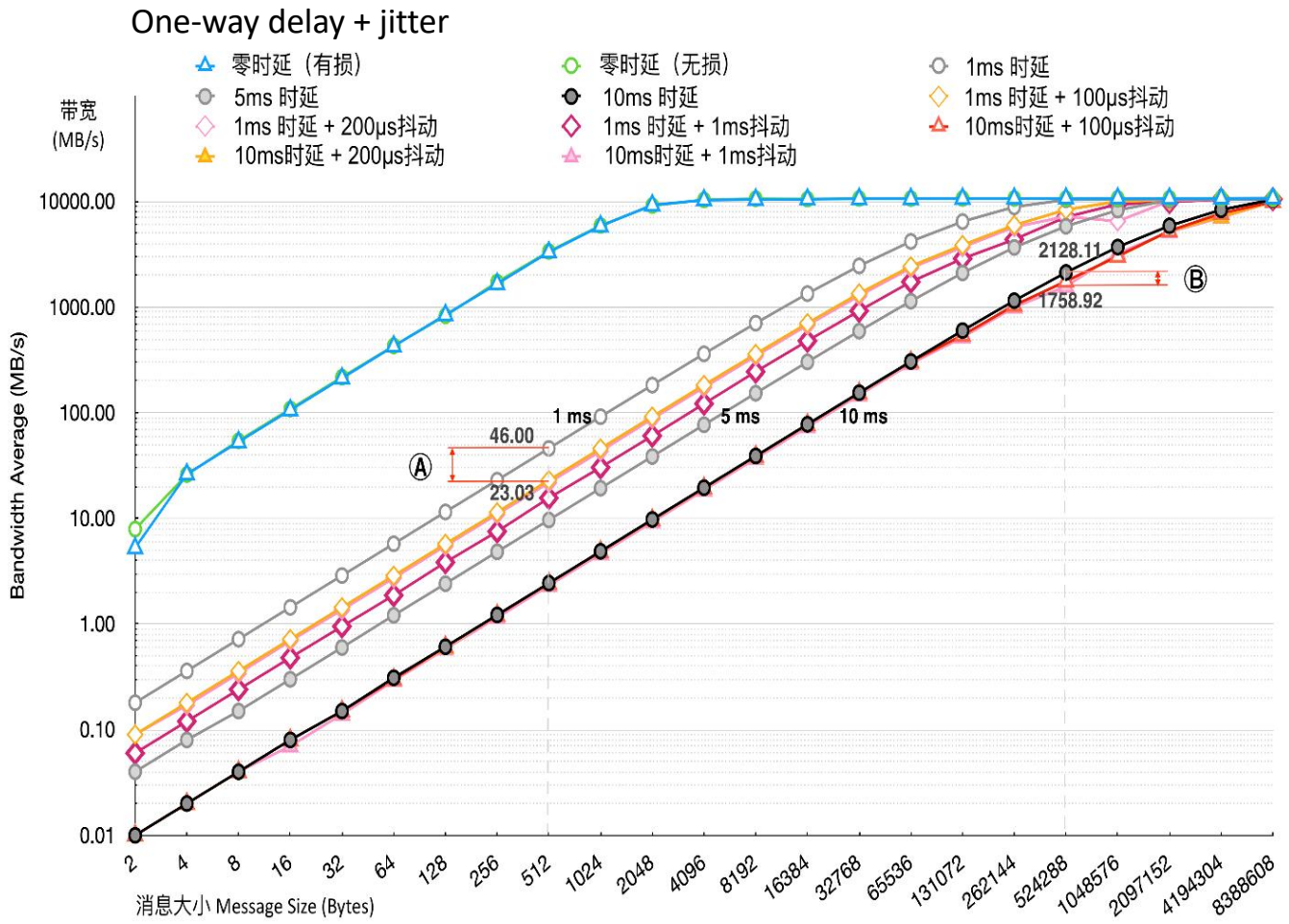
- As latency increases (1-20 ms), the RDMA message size needs to be continuously increased to achieve high-performance transmission with 100% throughput.
- It is required to provide the low latency due to the limited message size .

Testing on Packet Loss and Latency



- It is difficult to achieve the thrughput over 70% when the packet loss rate is less than 0.001%.
- When latency and packet loss coexist and over 90% throughput of a 100G link， the packet loss rate in the data center must be less than 0.005%.
- When latency increases, it require the network to achieve ultra-low packet loss.

Testing on Latency and Jitter



- The simulation results using a network emulator to test 0 ms, 1 ms, and 2 ms latency, plus 1 ms with added jitter (100 µs, 200 µs, 1000 µs) are as following :
  - 1 ms + 100 µs jitter results in overall inferior performance compared to 2 ms latency with zero jitter.
  - For large-message applications (message size > 1 MB), significant performance degradation occurs when jitter exceeds hundreds of microseconds.

Results and Summary

- Deterministic Network Performance Metrics for RDMA over long-distance transmission:

High throughput in WAN (RDMA) ≈ N × message size / ρ(packet loss × latency × jitter)

Distance + Latency Impact Analysis	Latency + Packet Loss Impact Analysis	Latency + Jitter Impact Analysis
☐ Increasing message size, RDMA achieves >80% throughput efficiency at 1000km distances ☐ Message length configuration depends on: • Specific computing-network applications, • Device buffer capacity • Cache threshold settings ☐ Message size is limited due to: Hardware memory limitations Threshold boundary effects	☐ Latency makes packet loss requirements exponentially stricter to achieving > 80% throughput requires: • intra-DC (Packet Loss): • Loss <0.005% • Inter-DC (Latency + Packet Loss): • ultral-low (<0.001%) or zero packet loss	☐ Jitter induces more severe throughput degradation than latency; ☐ To achieve 80% throughput efficiency: • Minimum message size: >512KB • Jitter is less than hundreds of microseconds

- Data-intensive transmission requires high-throughput with ultra-low packet loss, low latency and low jitter.
- Predictable and Deterministic networks reduce the complexity of high-throughput protocols (e.g., RDMA) on algorithm design and parameter configuration

Next Steps

- Ask for WG feedback and suggestions.
- Comments and discussions are very welcome!

Thank You