TSN Techniques in Service Provider Networks

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Outline

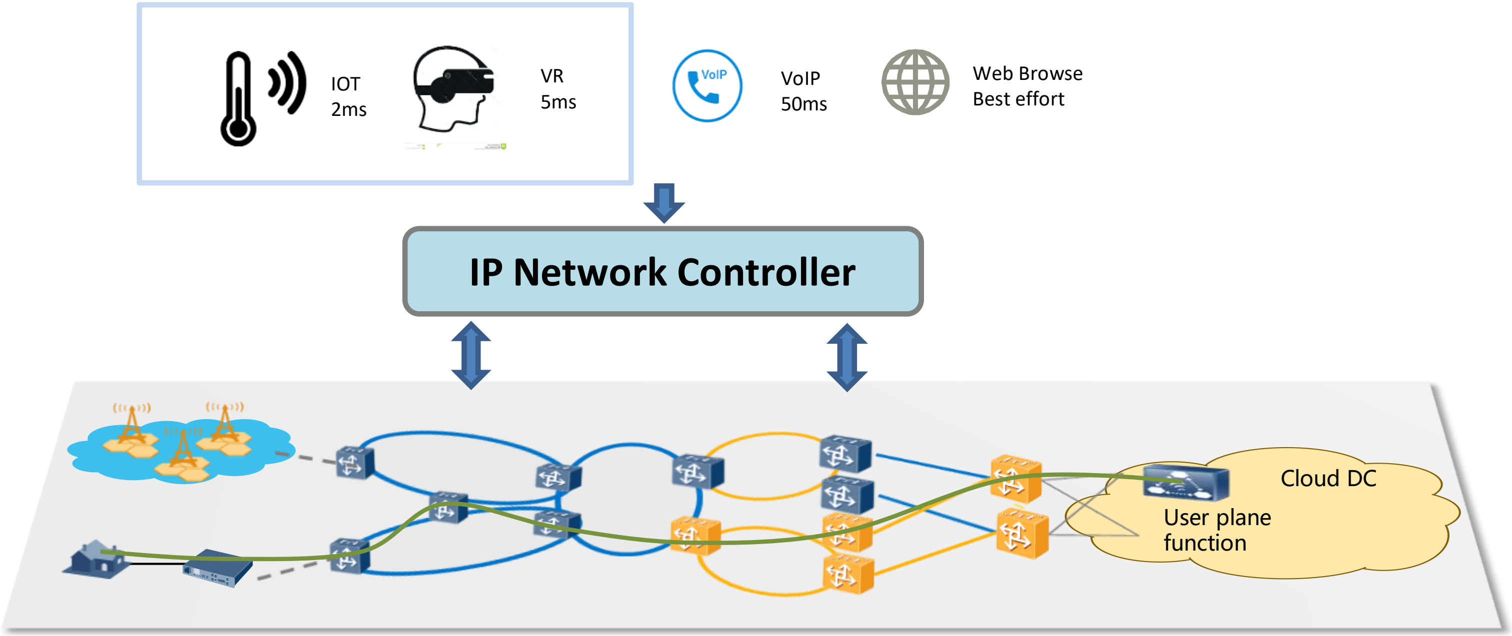
- Use cases over Service Provider(SP) Network in Exploration
  - Smart Grid Scenarios;
  - Cloud VR(virtual reality) Scenarios;
  - High Reliability Scenarios;
- Thoughts on TSN techniques for SP networks

http://www.ieee802.org/1/files/public/docs2018/detnet-tsn-wang-for-servcice-provider-networks-1118-v02.pdf
http://www.ieee802.org/1/files/public/docs2019/df-wangtt-bounded-latency-use-cases-0119-v01.pdf

Differentiated SLA(service level agreement) Applications Over Service Provider Networks

Need : to provide differentiated SLA in future Service provider networks, enable 5G URLLC(ultra reliable low latency communications) applications, including various vertical applications. E.g. Smart Grid, Cloud VR, etc.

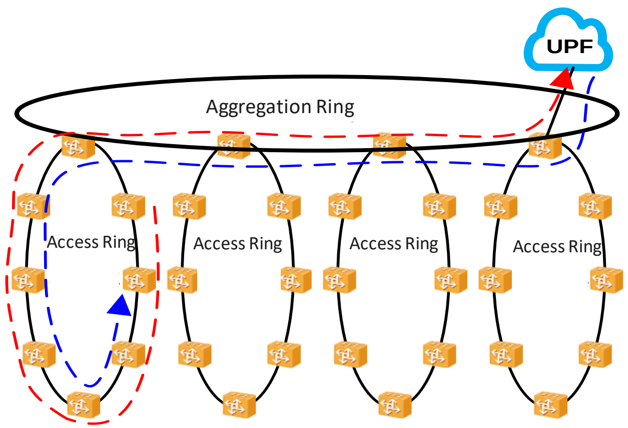
Early Demonstration: provide bounded latency with ingress shaping, per hop resource reservation and strict priority scheduling;



http://www.ieee802.org/1/files/public/docs2019/df-zhangjy-bounded-latency-calculating-0119-v01.pdf

Bounded Latency Analysis for ※Smart Grid Applications

- DTUs (Distribution Terminating Units) communicate with its neighbors, via UPF(User Plane Function).
- A packet transfer through access ring, to aggregation ring then to UPF.
- Link between CPE(Customer Premise Equipment) and Access switch is 10GE.
- Link Rate: access ring: 1GE
- Link rate: aggregation ring 10GE. With 4 nodes on aggregation ring.
- Processing delay per device: d_P , link delay per hop: d_T , interference delay in a burst: d_S, hop number between i and j : $h^{i,j}$;



Use *Network Calculus methodology to setup traffic model and network model and evaluate the latency performance.

- Use Arrival curve to model Tspec;
  - $\alpha(t) = \left\lceil \frac{t}{T} \right\rceil NL,\ T = 5\text{ms}, N = 14, L = 400\text{B}$
- Use simple 802.1 Scheduling methods： SP/FIFO
  - Service curve: $\beta(t) = R(t - L/R)$
- E2E delay evaluation (over carrier network) can be evaluated and used in network planning;

$$d_{\text{E2E}}^{i,j} = d_{Q-\text{ACCESS}}^{i} + d_{Q-\text{AGG}}^{i} + (d_P + d_T) \times h^{i,j} + d_S$$

※https://www.huawei.com/en/press-events/news/2019/4/huawei-sgcc-first-5g-sa-power-grid-slicing;
* http://www.ieee802.org/1/files/public/docs2018/new-leboudec-network-calculus-for-tsn-0118-v04.pdf;

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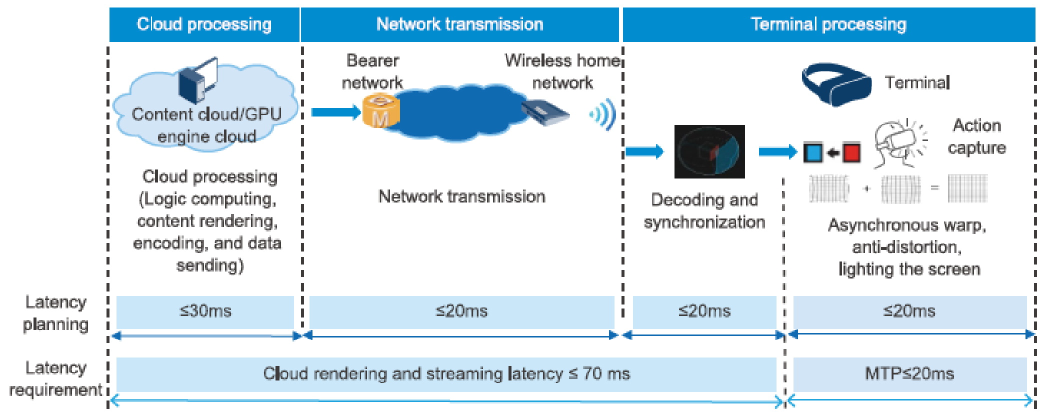
Bounded Latency Analysis for Cloud VR Applications

The following figure shows the E2E latency of strong-interaction Cloud VR services.

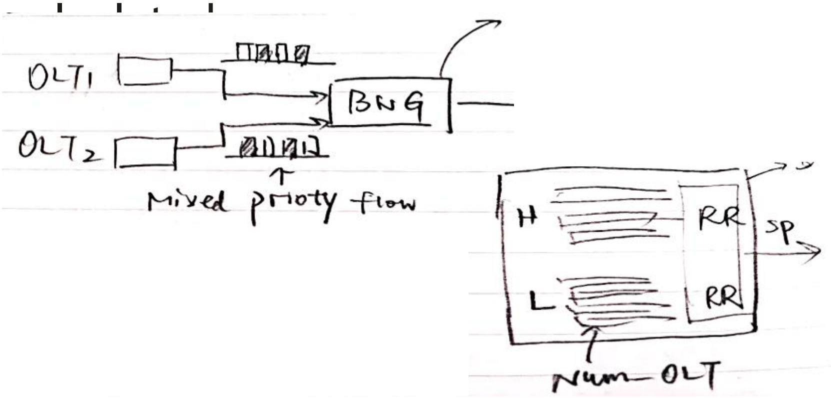


Network KPI Requirements

Service Scenario	Indicator	Reference Value
Strong-interaction VR service	Bandwidth	≥80Mbit/s
	Round trip time (RTT)	≤20ms
	Packet loss rate	1.00^{-5}
Multi-service concurrency	Internet access, VR strong interaction services, and screen mirroring	260Mbit/s

Table 2-2 Network KPI requirements for strong-interaction Cloud VR services

1. E2E latency for *Cloud VR service decompose to multiple segments;
2. Use 802.1 scheduling mechanisms and shapers, E2E latency over Service Provider network can be



3. Evaluate E2E latency(over carrier network) and test it.

Network KPI requirement (Strong interactive/ VR video)

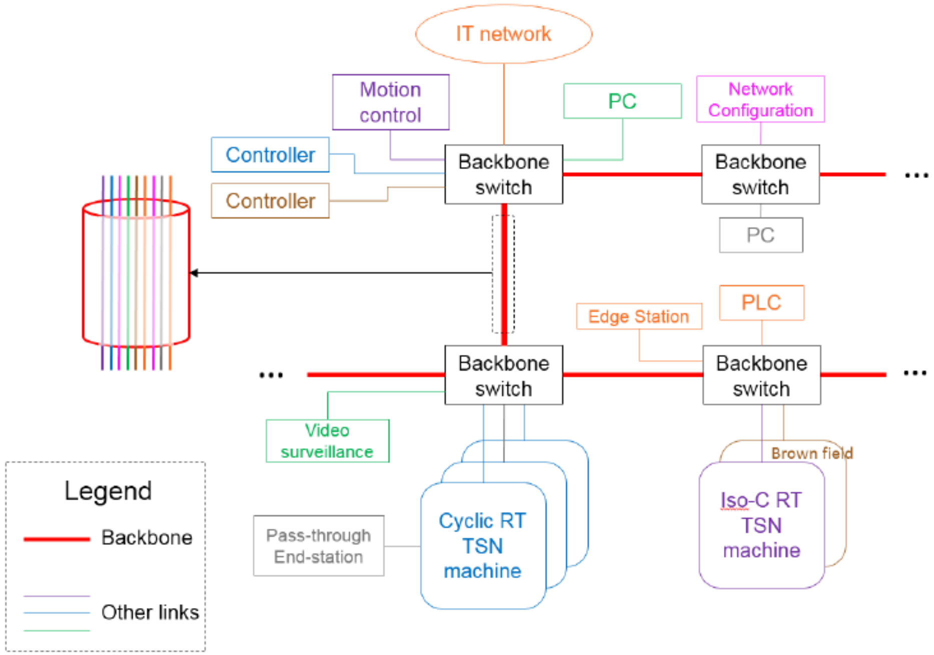
- Delay: 15ms/20ms, RTT, less than 8ms over bearer network.
- Bandwidth: 60/ 80Mbps per client (40Mbps symbol rate)
- Packet Loss rate: 9e-5/ 1e-5

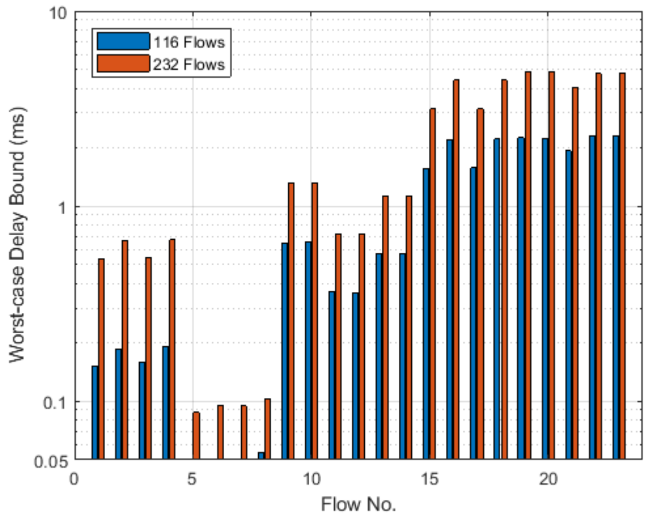
*https://www.huawei.com/minisite/pdf/ilab/cloud_vr_solutions_wp_en.pdf
*https://www.itu.int/dms_pub/itu-d/md/18/sg01/td/190318/D18-SG01-190318-TD-0019!N3!PDF-E.pdf

Theoretical Delay Bound for Industrial Automation

Flow	Traffic Type	Scheduling method	Priority	Delay requirement
$f_1 \sim f_8$	Isochronous	Strict Priority	highest	1~2 ms
$f_9 \sim f_{20}$	Cyclic	CBS-Class A		10 ms
$f_{21} \sim f_{23}$	Audio/Video	CBS-Class B		
$f_{24} \sim f_{27}$	BE	BE	lowest	

Time Sensitive Networking (TSN) Ethernet is becoming a primary industrial networking technology, since it provides bounded latency capability with broad reaching ecosystem, supporting both real-time communications and non-time-critical communications in a factory. QoS-based shaping and scheduling is a core technology for TSN to provide the latency bound. Meanwhile, tools like network calculus is vital for analyzing the worst-case behavior of network under various scenarios, so as to predict the upper latency bound that TSN can guarantee for any specific time-sensitive flows.





Delay upper bound under different load (116, 232 flows), satisfying all the flows' delay requirement.

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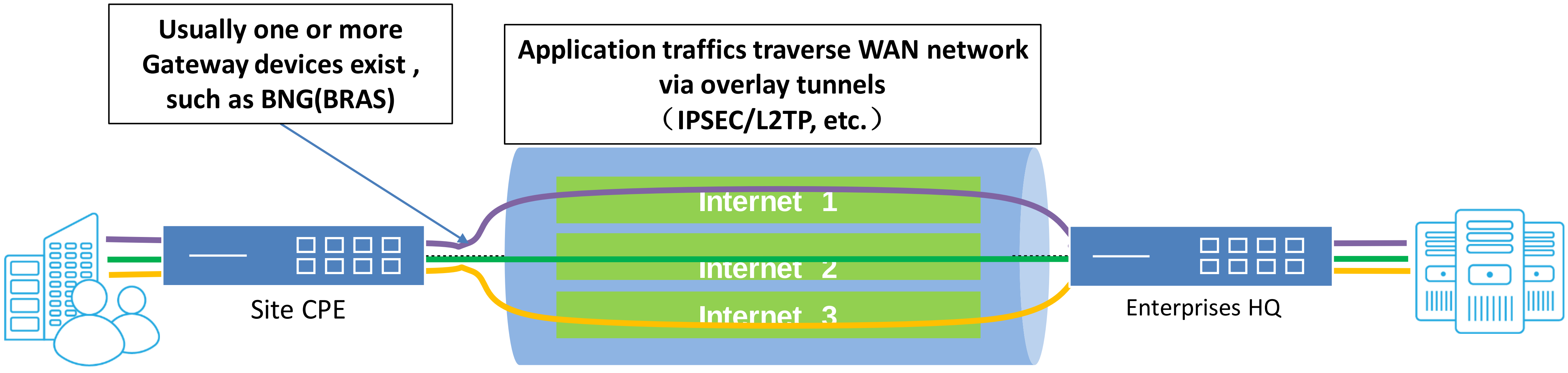
Higher Reliability with FRER over Redundant Paths



- Improvement on high reliability is appealing for service providers to enable new applications.
  - High resolution video conference;
  - 8K video surveillance;
- May need extra buffers on converged nodes to compensate large difference between multiple redundant paths.

http://www.ieee802.org/1/files/public/docs2019/df-rbh-highReliabilityRequirement-0719-v03.pdf

Conclusions

- These time sensitive scenarios use TSN techniques to provide bounded latency service, which can be used as example use cases to extract requirements;
- Bounded latency is most crucial requirement, not much about jitter;
- P802.1DF use 802.1 shapers and scheduling to ensure upper bound of latency, and give mathematical evaluations;
- Hardware designer may use more complex schedulers than the abstract descriptions in 802.1 specification, while P802.1DF gives a framework and suggestions of how to ensure bounded latency with TSN techniques in service provider networks.

Thank you.

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