Exploration of deterministic networking from service provider's perspective

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Deterministic network application scenarios

5G empowers vertical industries and puts forward higher requirements on the quality, reliability, delay, bandwidth, and service capabilities of operators' networks. Operator networks gradually extend from 5G access network technology to edge computing, network slicing, and TSN.

Industry focus ● **Application scenarios** ● **Network technology** ●

Industry focus	Application scenarios	Network technology	
Industrial manufacture	Industrial control	Industry network	cloud computing
Electricity & energy	intelligent monitoring	Network slices	artificial intelligence
Smart harbor	AR/VR assist	Edge computing	AR/VR
Smart transportation	Machine vision	URLLC	Control technology
Hygiene medical	Asset location	TSN	Vision technology
Entertainment	Industry IOT	5G LAN	Sensor technology

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5G

Requirements for network SLA indicators

Industry 5G business applications are gradually extending from auxiliary operation functions to production process control. That leads to make use of the 5G characteristics from EMBB to MMTC and URLLC.

NO.	Business	localization	Speed rate/ bps	Latency	Mobility	reliability
1	Remote control	/	<1M	≦20ms	medium speed	99.999%
2	Multiple data collection	/	<2M	≦100ms	fix	99.999%
3	Video monitoring	/	5M/per path	≦60ms	fix	99.9%
4	Intelligent inspection	1m	<50M	≦20ms	low speed	99.9%
5	video talk-back	1m	<10M	≦20ms	low speed	99.9%
6	AR maintenance assisted	cm	≧20M	≦20ms	low speed	99.9%
7	VR training	/	≧60M	≦20ms	low speed	99.9%
8	Remote video meeting	/	<20M	≦30ms	low 、medium	99.9%
9	Environmental data collection	/	10k	≦1s	fix	99%
10	Mobile machinery/vehicles	1m	10M	≦20ms	Medium speed	99.999%
11	Plant IoT	/	10k	1s~1min	fix	99%

Deterministic network practices

Operators are actively exploring the 5G Industry market, having launched "virtual private network, hybrid private network and independent private network" industry private network products and solutions, aiming to provide differentiated and deterministic network services for industry customers, so that the network can better serve industry applications.
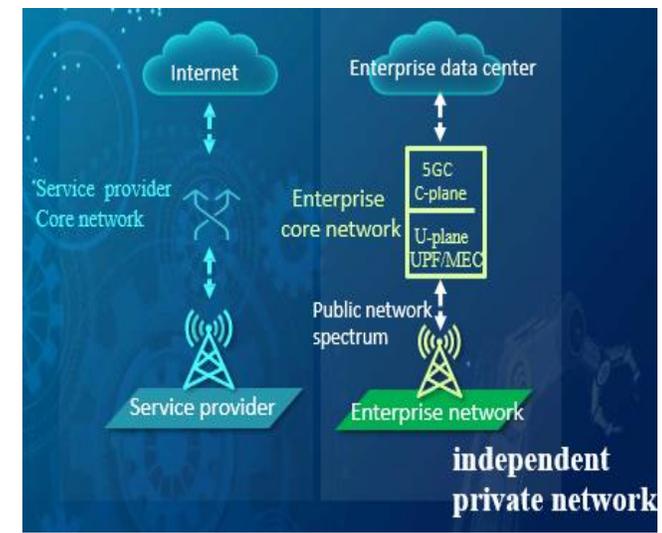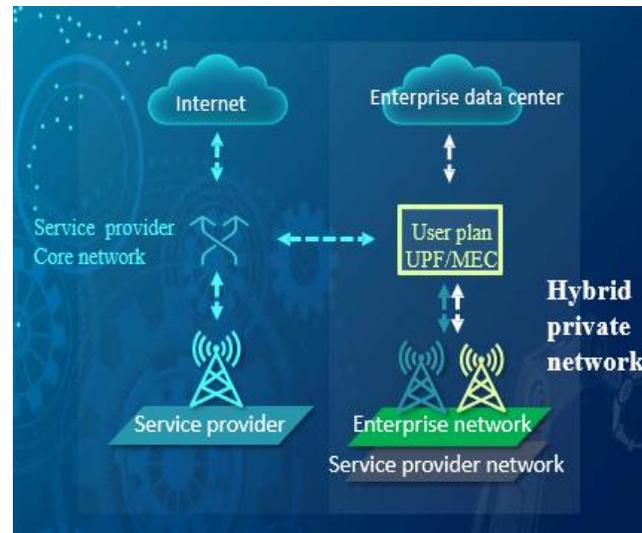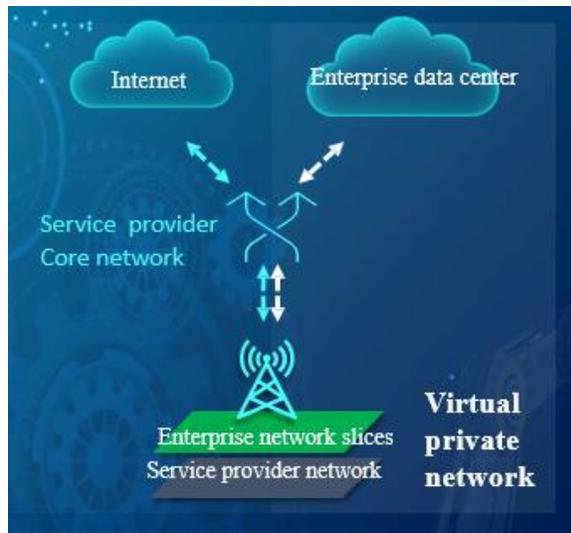
☐ Some industries especially industrial applications, such as industrial control, power differential protection, machine vision detection, etc, have strict requirements on bounded low latency, ultra high reliability, SLA guarantee capability.

☐ Based on the industry private network, Unicom is also exploring the use of QoS, network slicing, 5G+TSN and 5G LAN technologies to provide customers with end-to-end deterministic network capabilities and promote the construction of 5G+TSN test beds.

Deterministic network practice – Crane remote control

- **Unicom has implemented remote control applications of 5G cranes in smart ports, steel, factories etc.**
- **Provide deterministic network services through industrial private network, end-to-end QoS, MEC and other technologies to meet the demands of remote control business, save 75% of labor costs for industrial customers and greatly improve production efficiency.**

Crane equipment — PLC client — Monitor CCTV — NR base station — MEC — PLC server / Video server — Center control room
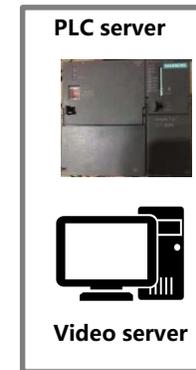
Business characteristics: use 5G + DetNet/TSN network to carry control and video signals, meet the needs of service differentiation indicators and provide deterministic network guarantee.

1）Control signal: end-to-end latency <20ms; low jitter <10us, 99.999% high network reliability.

2）Surveillance video: large uplink rate >80Mbps, delay < 60ms, packet loss controllable.

Currently this scenario is not promoted over large scale network. Hopefully the bounded delay, bounded jitter, and high reliability characteristics of 5G+TSN will further be applied in the field of industrial control, helping 5G industrial control applications mature and large-scale deployment.

Deterministic network practice - Power differential protection

Power differential protection is a key application of the power industry. It has the characteristics of accurate positioning and rapid isolation, and the recovery time after failure can be shortened from hour level to minute or even second level, which can greatly reduce the scope of power failure, improve the sensitivity of fault handling, and improve the power supply quality and new energy access ability.
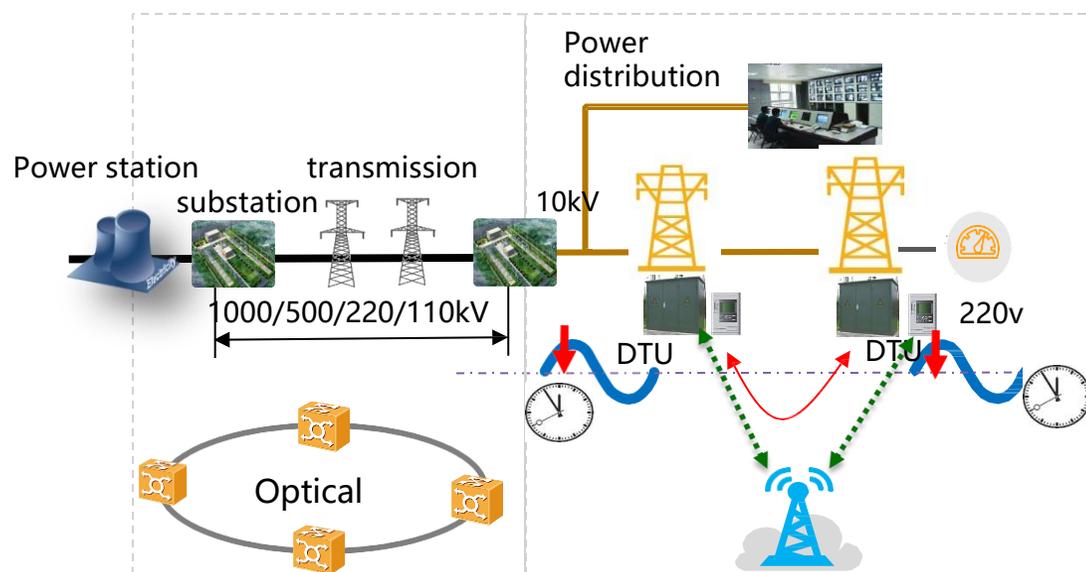
The principle of power differential protection

- Comparison of current values at two or more terminals at the same time (vector) of DTU

- When the current difference exceeds the setting value, the fault is judged to occur and the differential protection action is performed

SLA requirements:
- Bandwidth: 10Mbps
- timing accuracy: 10μs
- Delay: <15ms
- Delay jitter: < 600us
- Reliability : >99.999%

At present, network slicing, MEC and precise timing have been adopted to meet the demand of power differential protection network. We will continue to explore ways to improve the deterministic network guarantee capability of wide area network with lower resource cost through TSN bridge, 5G LAN, Flex E and other technologies.

Problems and Expectations

1. The key technical components are ready, the 5G + Detnet/TSN industry chain is not yet mature, and need more real cases to verify.
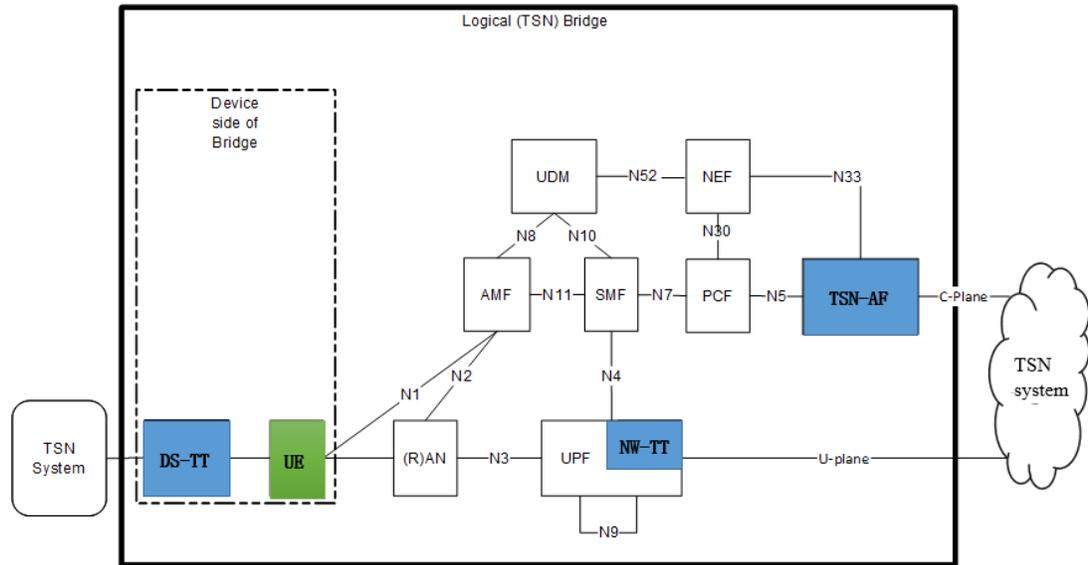
Chips and modules generally can't support R16 URLLC and TSN functions this year

DS-TT, NW-TT have no mature products

difficult to build an end-to-end 5G+TSN test bed for pilot verification.

2. The application side has fragmented demand for deterministic networks. The demand indicators are not yet clear, and there are multiple versions.

3. It is difficult to guarantee the end-to-end certainty of the operator's WAN, difficult to achieve precise control, and the path is too long that may involve the integration of cross-domain technologies.

Through industry-academia-research cooperation, prototype verifications on some key technologies will be carried out, and relevant standards of end-to-end deterministic networks will be developed to promote the implementation of technology applications.

Related discussion on use cases and requirements

Several related projects in ITU SG13

- 《Framework and QoS requirements to support of inter-domain deterministic communication services in local area network》
  - Campus use cases
  - Multi-domain coordination for latency and reliability guarantee and QoS requirements;

- 《Architecture and procedure for latency guarantee in large scale network》
  - Achieving latency guarantee in large scale networks
  - Requirement on latency upper bound with millions of active flows at an output port, for arbitrary topology, scalable to a large scale network.

- 《Requirements and framework of Deterministic QoS in large-scale telecommunications networking for IMT-2020 networks and beyond》
  - Multi-domain coordination for latency and reliability guarantee over large scale networks.
  - Service level consistence on multi-path

Thank you!