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The Problem Statement for Precise Transport Networking
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Abstract

As described in [[I-D.xiong-rtgwg-precise-tn-requirements](#)], the deterministic networks not only need to offer the Service Level Agreements (SLA) guarantees such as low latency and jitter, low packet loss and high reliability, but also need to support the precise services such as flexible resource allocation and service isolation so as to the Precise Transport Networking. However, under the existing IP network architecture with statistical multiplexing characteristics, the existing deterministic technologies are facing long-distance transmission, queue scheduling, dynamic flows and per-flow state maintenance and other controversial issues especially in Wide Area Network (WAN) applications.

This document analyses the problems in existing deterministic technologies to provide precise services in various industries such as 5G networks.

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[1.](#) Introduction

[1.1.](#) Overview

5G network is oriented to the internet of everything. In addition to the Enhanced Mobile Broadband (eMBB) and Massive Machine Type Communications(mMTC) services, it also supports the Ultra-reliable Low Latency Communications (uRLLC) services. The uRLLC services

cover the industries such as intelligent electrical network, intelligent factory, internet of vehicles, industry automation and other industrial internet scenarios, which is the key demand of digital transformation of vertical domains. These uRLLC services

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demand SLA guarantees such as low latency and high reliability and other deterministic and precise properties.

For the intelligent electrical network, there are deterministic requirements for communication delay, jitter and packet loss rate. For example, in the electrical current difference model, a delay of 3~10ms and a jitter variation is no more than 100us are required. The isolation requirement is also important. For example, the automatic operation, control of a process, isochronous data and low priority service need to meet the requirements of hard isolation. In addition to the requirements of delay and jitter, the differential protection (DP) service needs to be isolated from other services.

The industrial internet is the key infrastructure that coordinate various units of work over various system components, e.g. people, machines and things in the industrial environment including big data, cloud computing, Internet of Things (IOT), Augment Reality (AR), industrial robots, Artificial Intelligence (AI) and other basic technologies. For example, automation control is one of the basic application and the the core is closed-loop control system. The control process cycle is as low as millisecond level, so the system communication delay needs to reach millisecond level or even lower to ensure the realization of precise control. There are three levels of real-time requirements for industrial interconnection: factory level is about 1s, and process level is 10~100ms, and the highest real-time requirement is motion control, which requires less than 1ms.

1.2. Motivation

The applications in 5G networks demand much more deterministic and precise properties. But traditional Ethernet, IP and MPLS networks which is based on statistical multiplexing provides best-effort packet service and offers no delivery and SLA guarantee. The deterministic forwarding can only apply to flows with such well-defined characteristics as periodicity and burstiness.

Technologies to provide deterministic service has been proposed to provide bounded latency and jitter based on a best-effort packet network. IEEE 802.1 Time-Sensitive Networking (TSN) has been proposed to provide bounded latency and jitter in L2 LAN networks. According to [\[RFC8655\]](#), Deterministic Networking (DetNet) operates at the IP layer and delivers service which provides extremely low data loss rates and bounded latency within a network domain. However, the existing mechanisms are not sufficient for precise performance such as precise latency, jitter variation, packet loss and more other precise and deterministic properties.

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As described in [\[xiong-rtgwg-precise-networking-requirements\]](#), the deterministic networks not only need to offer the Service Level Agreements (SLA) guarantees such as low latency and jitter, low packet loss and high reliability, but also need to support the precise services such as flexible resource allocation and service isolation so as to the Precise Transport Networking. However, under the existing IP network architecture with statistical multiplexing characteristics, the existing deterministic technologies are facing long-distance transmission, traffic scheduling, dynamic flows, per-flow state maintenance and other controversial issues especially in Wide Area Network (WAN) applications.

This document analyses the problems in existing deterministic technologies to provide precise services in various industries such as 5G networks.

[2.](#) Conventions used in this document

[2.1.](#) Terminology

The terminology is defined as [\[RFC8655\]](#) and [\[xiong-rtgwg-precise-networking-requirements\]](#).

[2.2.](#) Requirements Language

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "NOT RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in [BCP 14](#) [\[RFC2119\]](#) [\[RFC8174\]](#) when, and only when, they appear in all

capitals, as shown here.

3. Problem Statement

3.1. Problem with Traffic Scheduling Mechanisms

As described in [[RFC8655](#)], the primary means by which DetNet achieves its QoS assurances in IP networks is to eliminate the latency and packet loss by the provision of sufficient resource at each node. But only the resource itself is not sufficient, the traffic scheduling mechanisms such as queuing, shaping, and scheduling functions must be applied in L3 networks.

The congestion control, queue scheduling and other traffic mechanisms which have been proposed in IEEE 802.1 TSN. But most of them are based on the time synchronization and time cycle, such as IEEE802.1Qbv, IEEE802.1Qch and so on. It will be difficult to achieve precise time synchronization with all network nodes due to deployment and cost reasons. And the shaping and queuing methods

which are not based on time synchronization such as IEEE802.1Qav and IEEE802.1Qcr might not be suitable or available for some L3 networks such as WAN application where multiple dynamic traffic flows may be existed.

Moreover, the requirements of the all nodes in WAN networks to apply the time synchronization and traffic scheduling mechanisms will also lead to the difficulty of network scalability and deployment.

3.2. Problem with Long-distance Transmission Delay and Jitter

In WAN application, long-distance transmission will lead to uncertainties, such as increasing transmission delay, jitter and loss. The link delay of transmission is variable and can not be ignored, and it must be considered in the end-to-end deterministic forwarding mechanisms which are based on time synchronous. So the following problems should be considered.

Precise measurement of the link delay.

The symmetry of bidirectional forwarding of the link delay.

Time cycle alignment in flows aggregation scenario.

3.3. Problem with SLA Guarantees of Dynamic Flows

As described in [[RFC8557](#)], deterministic forwarding can only apply to flows with such well-defined characteristics as periodicity and burstiness. As defined in DetNet architecture [[RFC8655](#)], the traffic characteristics of an App-flow can be CBR (constant bit rate) or VBR (variable bit rate) of L1, L2 and L3 layers (VBR takes the maximum value when reserving resources). But the current scenarios and technical solutions only consider CBR flow, without considering the coexistence of VBR and CBR, the burst and aperiodicity of flows. The operations such as shaping or scheduling have not been specified. Even TSN mechanisms are based on a constant and forecastable traffic characteristics.

It will be more complicated in WAN applications where much more flows coexist and the traffic characteristics is more dynamic. It is required to offer reliable delivery and SLA guarantee for dynamic flows. For example, periodic flow and aperiodic flow (including micro burst flow, etc.), CBR and VBR flow, flow with different periods or phases, etc. When the network needs to forward these deterministic flows at the same time, it must solve the problems of time window selection, queue processing and aggregation of multiple flows.

Moreover, the existing solutions do not consider the characteristics analysis of service requirements, including the impact of dynamic characteristics analysis on the network, mainly about how to ensure the certainty in the case of dynamic flows.

3.4. Problem with Service Isolation

In some scenarios, such as intelligent electrical network, the isolation requirements are very important. For example, the automatic operation or control of a process or isochronous data and low priority service need to meet the requirements of hard isolation. In addition to the requirements of delay and jitter, the differential protection (DP) service needs to be isolated from other services and hard isolated tunnel is required.

The resource reservation in DetNet can only ensure the statistical reuse of bandwidth resources, but it can not guarantee the precise isolation and control of instantaneous burst and can not realize the hard isolation of each flow. The existing solutions cannot achieve the requirements of service isolation.

[3.5.](#) Problem with Precise Resource Allocation

As described in [[RFC8655](#)], the primary means by which DetNet achieves its QoS assurances is to reduce, or even completely eliminate, packet loss by the provision of sufficient buffer storage at each node. But it can not be achieved by not enough resource which can be allocated due to practical and cost reason. The existing solutions can not achieve the precise resource allocation.

[4.](#) Security Considerations

TBA

[5.](#) Acknowledgements

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[6.](#) IANA Considerations

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[7.](#) Normative References

[I-D.xiong-rtgwg-precise-tn-requirements]

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