ITU-T SG13 Q.6 Status of DETNET related Work Items

2022. 3. 22
Taesang Choi
Rapporteur of Q.6
## Introduction of Q.6/13

<table>
<thead>
<tr>
<th>Q6/13 (WP1/13)</th>
<th>Taesang CHOI</th>
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<tbody>
<tr>
<td>Networks beyond IMT-2020: Quality of service (QoS) mechanisms</td>
<td>Rapporteur</td>
</tr>
<tr>
<td>• Terms of reference</td>
<td>ETRI</td>
</tr>
<tr>
<td>• Work Items</td>
<td>Tel: +82-42-860-5628</td>
</tr>
<tr>
<td></td>
<td>Fax: +82-42-860-6858</td>
</tr>
<tr>
<td></td>
<td>Email: choits[at]etrl.re.kr</td>
</tr>
</tbody>
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<table>
<thead>
<tr>
<th>Guosheng ZHU</th>
<th></th>
</tr>
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<tbody>
<tr>
<td>Associate rapporteur</td>
<td>Wuhan Rayton Network Technology Co., LTD</td>
</tr>
<tr>
<td></td>
<td>China</td>
</tr>
<tr>
<td></td>
<td>Tel: Tel: +86-2788666186</td>
</tr>
<tr>
<td></td>
<td>Fax: Fax: +86-2788665505</td>
</tr>
<tr>
<td></td>
<td>Email: zhugs[at]rayton-networks.com</td>
</tr>
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Introduction of Q.6/13: ToR (Charter)

Tasks
Tasks include, but are not limited to:

- Development of new Recommendations or enhancement to existing Recommendations on QoS/QoE support for resource control and management for softwarized/virtualized networks.
- Development of new Recommendations or enhancement to existing Recommendations on QoS/QoE support in networks beyond IMT2020.
- Development of new Recommendations or enhancement to existing Recommendations on AI/machine learning based QoS/QoE assurance mechanisms.
- Development of new Recommendations or enhancements to existing Recommendations which are needed to support QoS/QoE assurance for vertical sector applications.
- Development of new Recommendations or enhancement to existing Recommendations on QoS/QoE support in QKDN.
- Development of new Recommendations or enhancement to provide the optimal resource control and management for achieving end-to-end QoS in a heterogeneous environment involving different QoS mechanisms, network orchestrations, and multiple provider domains.
- Development of new Recommendations or enhancement to existing Recommendations on additional QoS parameters measurement and monitoring.
- Guidance and collaboration to/with other Questions on QoS/QoE matters, especially to a potential new Question(s).

Recommendation ITU-T Y.Sup66:
ITU-T Y.3000-series - Network 2030 services (2020),
Capabilities, performance and design of new communication services for the Network 2030 applications.

Two metrics for Determinism: latency & jitter, as it is defined in Y.Sup66

The key idea in Q6 is to decompose the problem into;
1) first, guarantee latency bound,
2) and then jitter bound
Flow Aggregation + IR ("FAIR")

- {ingress, egress port of an aggregation domain (AD)} based Flow aggregation (FA)
- Schedulers that guarantee FIFO for the FA in the AD
- IR per FA at the boundary
- An AD can cover from a single to multiple nodes
### Frameworks comparison

<table>
<thead>
<tr>
<th>Regulator placement</th>
<th>Scheduler type</th>
<th>Flow-protecting schedulers (e.g. Fair queuing or DRR)</th>
<th>Flow-protecting (e.g. DRR) or FIFO schedulers</th>
<th>FIFO scheduler per class</th>
</tr>
</thead>
<tbody>
<tr>
<td>No regulator</td>
<td></td>
<td>IntServ</td>
<td>FAIR (Y.3113)</td>
<td>DiffServ</td>
</tr>
<tr>
<td>Regulators between AD</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Regulators at Every node</td>
<td></td>
<td></td>
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<td>TSN ATS (Regulator type = IR)</td>
</tr>
</tbody>
</table>

- FAIR with DRR is recommended, since the possible cyclic dependency inside an AD may cause burst accumulation, thus latency bound explosion.
  - If the AD is small enough to ensure no cycles, then FIFO is enough to guarantee the latency bounds.
Based on the requirements and framework specified in ITU-T Y.3113, its scope includes:

- Architecture
- Functional entities and their interfaces
- Procedures for the aggregation domain design, the call setup, the dynamic QoS negotiation, etc.

It is also based on the Y.2111 RACF (resource & admission control function) architecture.
Guaranteeing jitter bound without time-synchronization

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Quantity</th>
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<tbody>
<tr>
<td>$a_n$</td>
<td>Arrival instance of the $n$th packet of the flow to the network</td>
</tr>
<tr>
<td>$b_n$</td>
<td>Departure instance of the $n$th packet of the flow from the network</td>
</tr>
<tr>
<td>$c_n$</td>
<td>Buffer-out instance of the $n$th packet of the flow</td>
</tr>
<tr>
<td>$b_n - a_n$</td>
<td>E2E latency of the $n$th packet</td>
</tr>
<tr>
<td>$c_n - a_n$</td>
<td>E2E buffered latency of the $n$th packet</td>
</tr>
<tr>
<td>$U$</td>
<td>E2E latency upper bound of the flow guaranteed by the network</td>
</tr>
<tr>
<td>$W$</td>
<td>E2E latency lower bound of the flow guaranteed by the network</td>
</tr>
<tr>
<td>$m$</td>
<td>Jitter control parameter of the framework, $W \leq m$</td>
</tr>
<tr>
<td>$g_n$</td>
<td>Processing delay within the buffer of the $n$th packet of the flow. It includes store/lookup/forward delay.</td>
</tr>
<tr>
<td>$g$</td>
<td>Maximum $g_n$ over $n$.</td>
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</table>

Buffer holding rules:

$$c_1 = (b_1 + m - W).$$

$$c_n = \max\{g + b_n, c_1 + (a_n - a_1)\}, \text{ for } n > 1.$$

**Theorem 1** (Upper bound of the E2E buffered latency). The latency from the packet arrival to the buffer-out instances, $(c_n - a_n)$, is upper bound by $(m + U - W)$.

**Theorem 2** (Lower bound of the E2E buffered latency). The latency from the packet arrival to the buffer-out instances, $(c_n - a_n)$, is lower bounded by $m$.

**Theorem 3** (Upper bound of the jitter). The jitter is upper bounded by $(U + g - m)^+$. The jitter between packets $i$ and $j$ is defined as $|(c_i - a_i) - (c_j - a_j)|$. 
Title:
Requirements and framework of Deterministic QoS in large-scale telecommunications networking for IMT-2020 networks and beyond

Motivation of work:

- As the development of IMT-2020 and industrial internet, many new services have brought up critical requirements on bandwidth, latency and reliability to the network [b-FG Net-2030], which boosts the proposing of the Deterministic Networking. This document mainly focuses on the deterministic technical requirements and potential solutions for the large-scale transport network.
- One of the key visions of IMT-2020 is the convergence with the industrial network. However, the current IMT-2020 network and the transport network carry mainly the Best Effort (BE) traffic, and cannot provide strict guaranteed SLA, such as bounded latency, which is often essential in the industrial network.
- More attention should be paid for the deterministic feature of the large-scale transport network as it is one of the important foundations for future network to realize the end-to-end low latency and further the target of “one system fits all”, i.e., the network supporting both the BE traffic and critical traffic.
- Compared with small scale or single domain networks, the large-scale telecommunications network covers multi domains and may cross multi-operators' network, so there are many typical use cases which propose new requirements toward the deterministic QoS network.
**Y.IMT-2020-QoS-Istn-req**

**Scope:**
This draft recommendation presents the functional requirements and framework of Deterministic QoS in large-scale telecommunications networking for IMT-2020 networks and beyond, which is able to deliver deterministic services and provide the bounded latency, bounded jitter and bounded packet loss rate, with good scalability in telecomm operator’s network, and focus on the fixed network parts between RAN and core network, and between core network and data networks.

The following issues of Deterministic QoS in large-scale telecommunications networking for IMT-2020 networks are addressed in this Recommendation.

- Specify the use cases and functional requirements for large-scale Deterministic QoS telecommunications networking, including data plane, control plane and management plane
- Specify the framework of Deterministic QoS in large-scale telecommunications networking.
- Specify the potential solutions of Deterministic QoS in large-scale telecommunications networking.
Framework of large scale deterministic network

The overall view of large scale deterministic network includes three parts: **user side, network side and multiple domain and operator**.

**The user side**: refers to the enterprise network. Taking industry as an example, the internal network of industry is usually divided into IT network and OT network, among which the OT network which is closer to the user's site has certain requirements for time latency. With the development of industrial internet and the trend of TSN + OPC UA, OT network is becoming interconnected and interworking.

**The network side**: refers to the operator network, including backbone, convergence and access network. The rise of edge computing makes the data centre and UPF sink into the convergence/access network of operators. The convergence and access network of operators mainly needs the deterministic technical support of L2/L3. As the backbone network is wide, deterministic method of L3 is the main choice.

**The multi domain**: has the complex situation such as multi operator, even the multi country, and the deterministic forwarding method adopted by each domain is different. Therefore, a distributed cross domain interworking management system is needed to establish effective negotiation and deterministic forwarding mechanism to ensure the timely arrival of service flow.

![General view of deterministic network](image)

Figure: General view of deterministic network
Title: QoS requirements and framework for supporting deterministic communication services in local area network for IMT-2020.

Motivation of work:

- Deterministic communication services supported by local area network can benefit verticals, For example, Smart grid, Smart manufacturing, industrial parks and production lines, especially for the time-sensitive applications, high reliability applications. These services can provide data transmission with more reliable QoS guarantee.

- In practice, in the scenarios of a single local area, multiple network technologies are usually used. For example, in a factory, TSN may be used for the machine control of the production-line; WiFi may be used for cameras; 5G may be used for connecting the TSN system with the cameras.

- Though each network technology is evolving on its own, it is necessary to study the cross network technologies (i.e., heterogeneous network technologies) in order to ensure end-to-end QoS guarantee in the local area network.

- The purpose of the proposed work item is to identify QoS requirements and associated framework in order to help vendors to understand requirements from the operators and their customers for deterministic communication services in the local area network.

Use case example: Belt conveyor monitored control system
Scope:

QoS requirements for the deterministic communication services in the local area network of heterogeneous network technologies are specified. Based on the QoS requirements, the abstracted framework is proposed.

- Introduction on the deterministic communication services in local area network
- Scenarios of deterministic communication services in local area network
- QoS requirements of Framework of deterministic communication services in local area network
- Framework of QoS requirements for deterministic communication services in local area network
Gaps with existing works:
The proposed work item will not propose the specific technologies on deterministic communication services but it will propose a general framework to host these technologies in a technology neutrality way.

Work plan:

- Initiated: 2021.3
- Outline fixed: 2022.3
- To be consented: 2022.7
Invitation to our next meetings

• Q.6/13 will meet at first week of June (Specific dates TBD)
  • This is an interim e-meeting and welcome your participation
  • Will meet for three days and DETNET WI contributions will be consid-
    ered for one day with extra drafting session

• Q.6/13 will meet during July SG13 meeting
  • This is regular study group level meeting
  • Specific dates TBD
  • Some DETNET work items approval decisions are going to be made
  • Your inputs before this meeting will be more useful