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Draft new Recommendation ITU-T Y.det-qos-reqts-lan

Frameworks and QoS requirements for supporting deterministic communication services in local area network for IMT-2020

Summary

Keywords

Inter-domain, deterministic communication services, local area network, framework, QoS requirements, IMT-2020

Introduction

<Optional – This clause should appear only if it contains information different from that in Scope and Summary>

1 Scope

Deterministic communication services supported by local area network may benefit verticals. To analysis end-to-end deterministic communication services in the local area network, three scenarios are identified. Then to support the three identified scenarios, a framework for the deterministic communication services in the local area network is abstracted. Based on the abstracted framework, the QoS requirements are specified.

The scope of the Recommendation includes:

- Introduction on the deterministic communication services in local area network
- Scenarios of deterministic communication services in local area network
- Framework of deterministic communication services in local area network
- QoS requirements for deterministic communication services in local area network

2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

[ITU-T E.800] Recommendation ITU-T E.800 (09/2008), *Definitions of terms related to quality of service*.

TBD

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1 IMT-2020 [ITU-T Y.3100]: (Based on [ITU-R M.2083]) Systems, system components, and related technologies that provide far more enhanced capabilities than those described in [ITU-R M.1645].

3.1.2 Bearer service [b-ITU-T I.112]: A type of telecommunication service that provides the capability for the transmission of signals between user-network interfaces.

3.1.3 Teleservice [b-ITU-T I.112]: A type of telecommunication service that provides the complete capability, including terminal equipment functions, for communication between users according to protocols established by agreement between Administrations and/or recognized operating agencies (ROAs).

3.2 Terms defined in this Recommendation

This Recommendation defines the following terms:

3.2.1 local area network: A shared or switched medium peer-to-peer communications network that broadcasts information for stations directly or via a gateway to receive within a moderate-sized geographic area, such as a single office building or a campus. The network is generally owned, used and operated by a single organization. It provides services including those of the physical layer, the MAC layer, and the transport layer. [b-ITU-T H.322]

NOTE 1 – Multiple network technologies, such as TSN, real-time Ethernet, WiFi, 5G etc,. may be used in a single local area network.

NOTE 2 – gateway (s) is used to connect the heterogeneous network technologies in the local area network.

Editor's note: the definition for local area network need to be further improved to reflect the scope and the study objects of the draft Recommendation.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

5G 5th Generation Mobile Communication Technology

HD High Definition

OT operational technology

TD technology domain

TSN time sensitive network

WiFi Wireless Fidelity

5 Conventions

In this Recommendation:

The keywords "**is required to**" indicate a requirement which must be strictly followed and from which no deviation is permitted if conformance to this document is to be claimed.

The keywords "**is recommended**" indicate a requirement which is recommended but which is not absolutely required. Thus, this requirement need not be present to claim conformance.

The keywords "**can optionally**" and "**may**" indicate an optional requirement which is permissible, without implying any sense of being recommended. These terms are not intended to imply that the

vendor's implementation must provide the option and the feature can be optionally enabled by the network operator/service provider. Rather, it means the vendor may optionally provide the feature and still claim conformance with the specification.

6 Introduction on the deterministic communication services in local area network

Editor' note: this section will provide introduction on deterministic communication services and the value of deterministic communication services in the local area network.

It's getting clearer that the verticals need deterministic communication services to support their services or products development. Deterministic communication services are a set of data transmission capabilities provided for vertical industries through local area network. These services can provide data transmission with characteristics of bounded delay, bandwidth, jitter and packet loss rate.

Verticals can get benefits from deterministic communication services. Smart grid is an example. Based on [b-ITU-T Smart Grid], [b-IEEE], [b-Niwas Maskey], [b-Carlos H. Barriquello] and other academic papers, the deterministic communication services may provide the smart grid with more reliable QoS guarantee for network communication, not only in metro and core but also in local area.

Smart manufacturing is another example. Deterministic communication services are needed by levels of automation [b- Rasmus Suhr Mogensen]. Especially time-sensitive applications, high reliability applications in the local area can benefit from deterministic communication services.

To fulfil the requirements for deterministic communication services from the verticals, deterministic related network technologies (TSN, real-time Ethernet, WiFi, 5G as examples), are evolving.

In practice, in the scenarios of a single local area network (the LAN used in a building, a factory, or an industrial park as examples), 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.

7 Scenarios of deterministic communication services in local area network

Editor' note: this section will consider the following two scenarios (it will be pointed that the technologies on intra-domain scenarios are out of the scope):

- *Service scenarios for deterministic communication in local area networks*
  - *Intra-domain deterministic communication services*
  - *Inter-Domain deterministic communication services*

7.1 Deterministic communication services in local area network

Domain: in a single local area network, multiple network technologies (TSN, real-time Ethernet, WiFi, 5G as examples) may co-exist and be connected with each other via gateways. Domains are divided according to these network technologies.

In local area network, deterministic applications can be enabled by deterministic communication services supported by heterogeneous network technologies.

NOTE – in local area network, deterministic application can also be supported by local area network with isomorphic network technology. But the heterogeneous network technologies for support of deterministic communication services in local area network is the focus of this Recommendation.

Basic communication services include bearer services and teleservices [b-ITU-T Q.1743 (09/2016)].

According to [b-ITU-T I.112], deterministic communication services is a type of teleservices with additional capabilities which can ensure deterministic communication performances. Compared with best-effort communication, the performances of deterministic communication have narrower performance ranges which means that the differences between the best performance and the worst performance in these ranges are small.

In this Recommendation, the technology domains (TDs) are divided according to different network technologies. For example, as shown in figure 1, devices (including terminal devices and network devices) supporting TSN together with the TSN network linkages among these devices are divided as the TD 1; devices (including terminal devices and network devices) supporting 5G or WiFi together with the 5G or WiFi network linkages among these devices are divided as the TD 2.

In a single local area network, gateway(s) is used in order to support of deterministic communication service across multiple domains, as shown in figure 1.

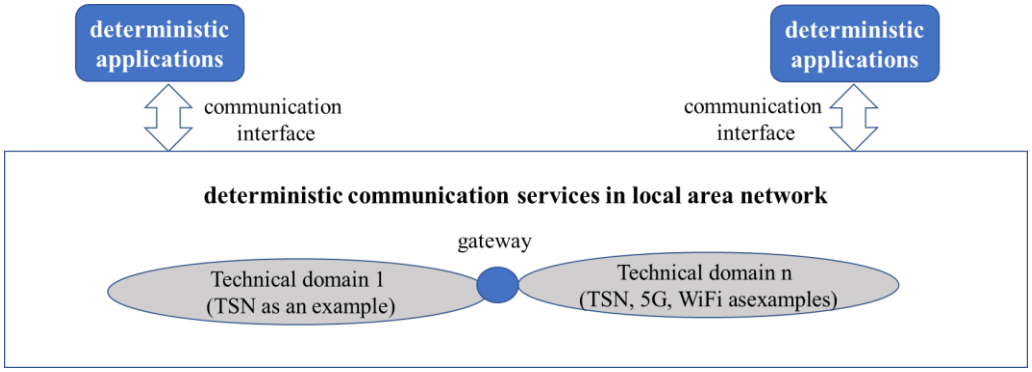

Figure 1 Concept of inter-domain deterministic communication services in local area network

7.2 Deterministic communication service scenarios in local area network for support of periodic control applications

Small packets, low jitter and high reliability for both upstream and downstream are the requirements from the periodic control applications for inter-domain deterministic communication services.

Deterministic communication services can provide periodic control applications with deterministic network performance, including but not limited to bounded latency, low jitter, and low packet loss.

Figure 2 is an example of deterministic communication service scenarios supported by heterogeneous network technologies in local area network for support of periodic control application.

As shown in figure 2, sensors and actuators are deployed in TD A. OT [b-OT] network may be the instance of TD A. Network technologies adopted by OT network include but not limited to TSN [b-IEEE TSN], Profinet [b-Profinet], Real-time Ethernet [b- Real-time Ethernet], and 5G.

Controllers are deployed in TD B. Industrial park network may be the instance of TD B. Network technologies adopted by industrial park network include but not limited to 5G, WiFi and Real-time Ethernet [b- Real-time Ethernet].

NOTE 1 – sensors and actuators may be alternatively deployed in different TDs.

NOTE 2 –Although there are common choices of network technologies for TD A and TD B, but the case that these two TDs using different network technology is the focus.

NOTE 3 - the sensors, actuators, controllers and gateway(s) are logical functionalities.

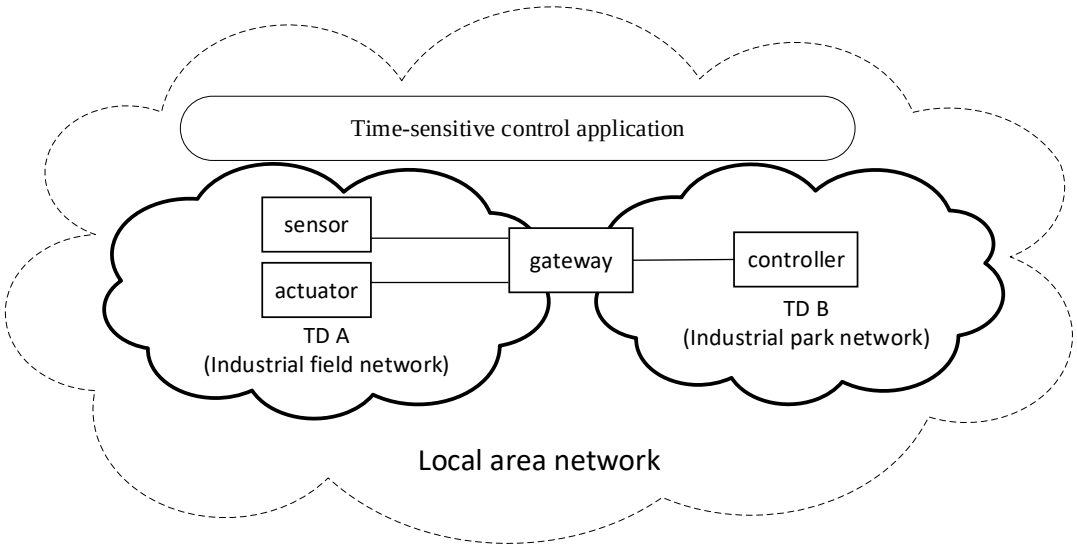

Figure 2 Example of deterministic communication service scenarios supported by heterogeneous network technologies in local area network for support of periodic control application

7.3 Deterministic communication services in local area network for support of high-bandwidth applications

Large packets, low packet loss and high reliability for both upstream and downstream are the requirements from the high-bandwidth applications for deterministic communication services.

Deterministic communication services can provide high-bandwidth applications with deterministic network performance, including but not limited to high reliability, low packet loss and guaranteed high-bandwidth.

Figure 3 is an example of deterministic communication service scenarios supported by heterogeneous network technologies in local area network for support of high-bandwidth application. HD video monitoring, AR assisted operation and machine vision of production inspection may be the instance of Figure 3.

As shown in figure 3, cameras are deployed in TD A. OT network may be the instance of TD A. Servers are deployed in TD B. Industrial park network may be the instance of TD B. Network technologies adopted by OT network and Industrial park network include but not limited to 5G, WiFi , PON,TSN[b-IEEE TSN] and Real-time Ethernet [b- Real-time Ethernet]. NOTE -Although there are common choices of network technologies for TD A and TD B, but the case that the two domains use different network technology is the focus.

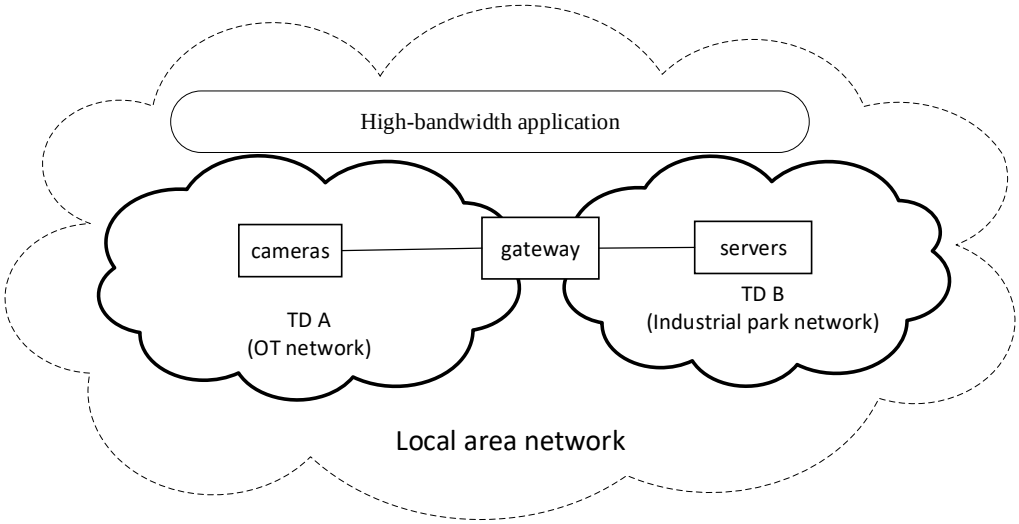

Figure 3 Example of deterministic communication service scenarios supported by heterogeneous network technologies in local area network for support of high-bandwidth application

7.4 Deterministic communication services in local area network for support of time-sensitive and high-bandwidth mixed applications

Large packets, low packet loss for upstream video traffic plus low latency, high reliability for downstream actuator-control traffic are the requirements from the HD video based remote control applications for deterministic communication services.

Deterministic communication services can provide video based remote control applications with deterministic network performance, guarantee the network requirements of both video stream and control stream at the same time, including but not limited to bounded latency, low jitter, high reliability, high-bandwidth upstream and low packet loss.

Figure 4 is an example of deterministic communication service scenarios supported by heterogeneous network technologies in local area network for support of video based remote control application, which can be widely used in smart ports, steel industry, mining industry, factories etc. For example, crane remote control, unmanned driving and coking four carts cooperative remote control in steel industry, remote control of the crane implemented to realize grasping and handling containers in smart ports.

As shown in figure 4, cameras and actuators/PLC may be deployed in different domain of the field. Cameras may belong to the network of domain A and actuators/PLC may belong to the network of TD B. OT network may be the instance of TD A and TD B using different network technologies. Controllers and servers are deployed in central room of TD C. Industrial park network may be the instance of TD C. Network technologies adopted by OT network and Industrial park network include but not limited to 5G, WiFi , PON,TSN[b-IEEE TSN] and Real-time Ethernet [b- Real-time Ethernet].

NOTE 1 – cameras and actuators/PLCs may be alternatively deployed in the same TD.

NOTE 2 –Although there are common choices of network technologies for TD A, TD B and TD C, but the case that the domains use different network technology is the focus.

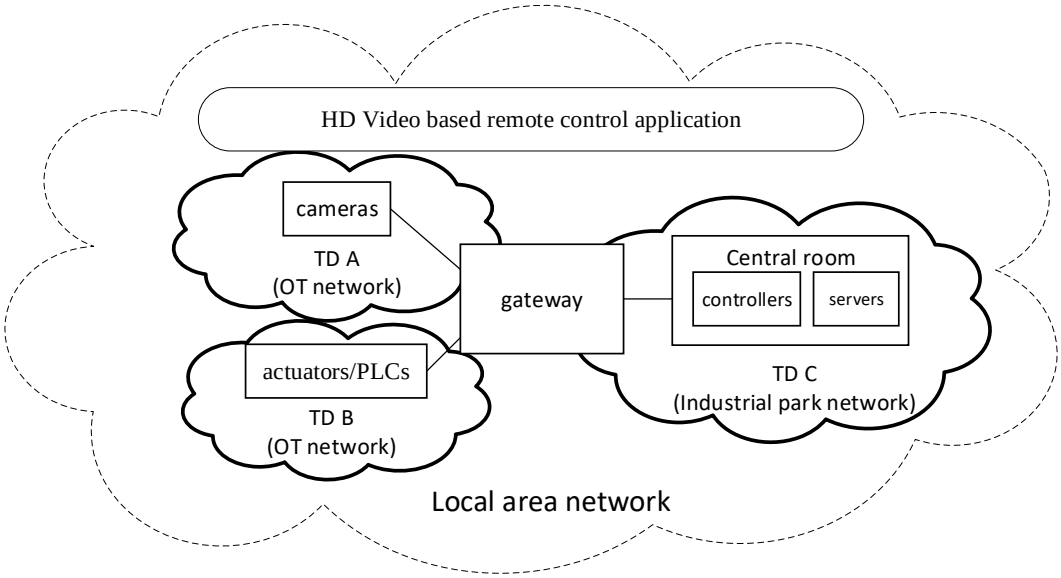

Figure 4 Example of deterministic communication service scenarios spported by heterogeneous network technologies in local area network for support of video based remote control application

8 framework of deterministic communication services in local area network

Editor' note: The order of section 8 and section 9 is an open point for further consideration.

In figure 5, there are two network domain, i.e., TD A and TD B, which use different network technologies inside a local area network.

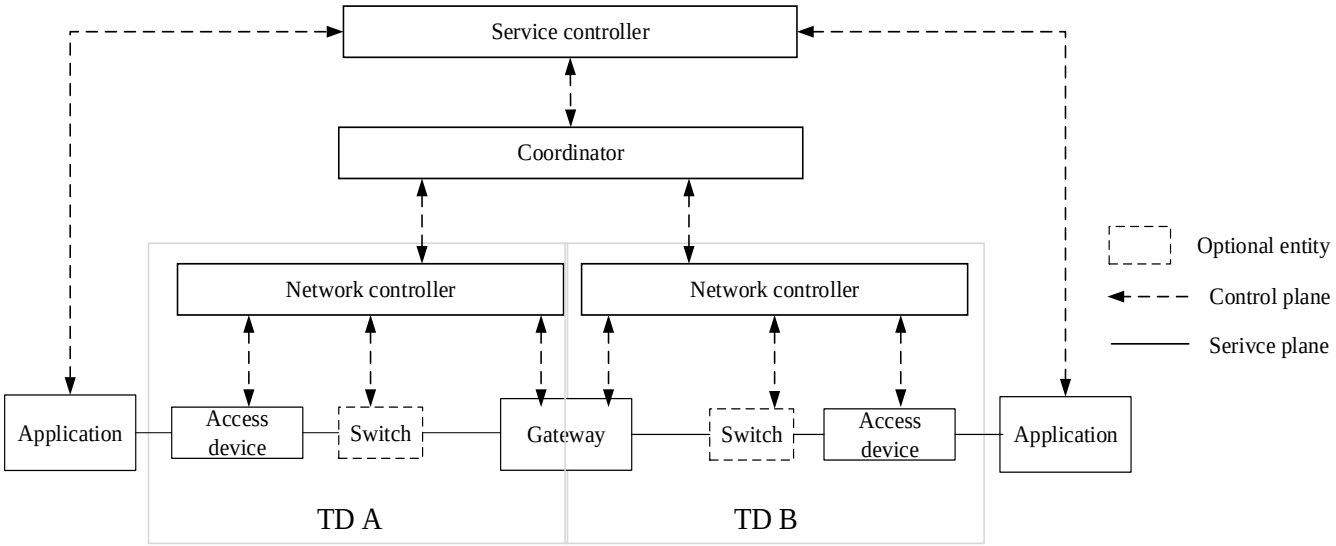

Figure 5 Framework of deterministic communication services supported by heterogeneous network technologies in local area network

- Applications may be industrial automation applications, AR/VR applications, audio and video applications, etc. and can be enabled by deterministic communication services.
- Access device is a network adapter that is used to connect the application to the network， and is the endpoint of deterministic communication network.

- Gateway connects multiple networks adopting different deterministic communication technologies and converts the format of the packet between TD A's protocol and TD B's protocol to guarantee the applications' deterministic requirements cross domains.
- Switch is a multi-port bridge and a data link layer device, which is optional in the TD.

NOTE - switch can be used to support more devices to connect with each other inside a TD.

- Service controller, which mainly has two functionalities:
  - To receive and process the service request from applications
  - To act as an interpreter between application and network, and deliver the service request and related QoS requirements to the inter-domain coordinator.
- coordinator, which mainly has three functionalities:
  - To collect network information and monitor the status of heterogeneous networks, such as buffer state, transmission rate, latency, packet loss rate and so on.
  - To take responsibility for cross-TD policing and controlling, such as transmission path selection and making decision on strategies based on service requests and conditions of heterogeneous networks including but not limited to admission control, resource allocation and reservation.
  - To configure the network controller(s) in different domains according to decisions of cross-TD policing and controlling.
- Network controller, which mainly has three functionalities:

Editor's note: it may be combined with the physical development. Elaboration for further consideration is needed.

  - To collect network information from heterogeneous networks.
  - To take responsibility for resource management, schedule multiple applications according to available network resources (e.g., time slot, buffer and queuing, power, etc.) and decisions from coordinator, which acts as constraints for scheduling.
  - To configure the network devices according to received information from coordinator and itself's resource management.

9 QoS requirements for deterministic communication services in local area network

Editor' note: QoS requirement is a statement of QoS requirements with unique performance requirements or needs [ITU-T E.800]. Based on the frameworks identified in clause 8, the following metrics is planned to be considered for the QoS requirements in this section.

- *end-to-end latency: the time that takes to transfer a given piece of information from a source to a destination, measured at the communication interface, from the moment it is transmitted by the source to the moment it is successfully received at the destination.*
- *minimum end-to-end latency*
- *maximum end-to-end latency*
- *Data processing latency: the time between application and communication interfaces, which is applicable for both sender and receiver*
- *Transimission latency: the time that takes to transfer a packet over a physical link*

- *Forwarding latency: the time that a packet traverses a network element, such as switch and router.*
- *Jitter: the short-term variations of a digital signal's significant instants from their ideal positions in time, jitter is composed of two basic types: random and deterministic.*
- *Random Jitter: Jitter that is not bounded and can be described by a Gaussian probability distribution.*
- *Deterministic Jitter: Jitter with a non-Gaussian probability density function. Always bounded in amplitude and with specific causes.*
- *clock synchronicity: the maximum allowed time offset within a synchronisation domain between the sync master and any sync device. (from 3GPP)*
- *network packet loss rate*
- *communication service availability: percentage value of the amount of time the end-to-end communication service is delivered according to an agreed QoS*
- *communication service reliability (Mean Time Between Failure): ability of the communication service to perform as required for a given time interval, under given conditions.*

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