The Differentiated QoS Requirements and Architecture of Deterministic Services

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ITU-T study groups13
ITU Workshop on "Future technology trends towards 2030"

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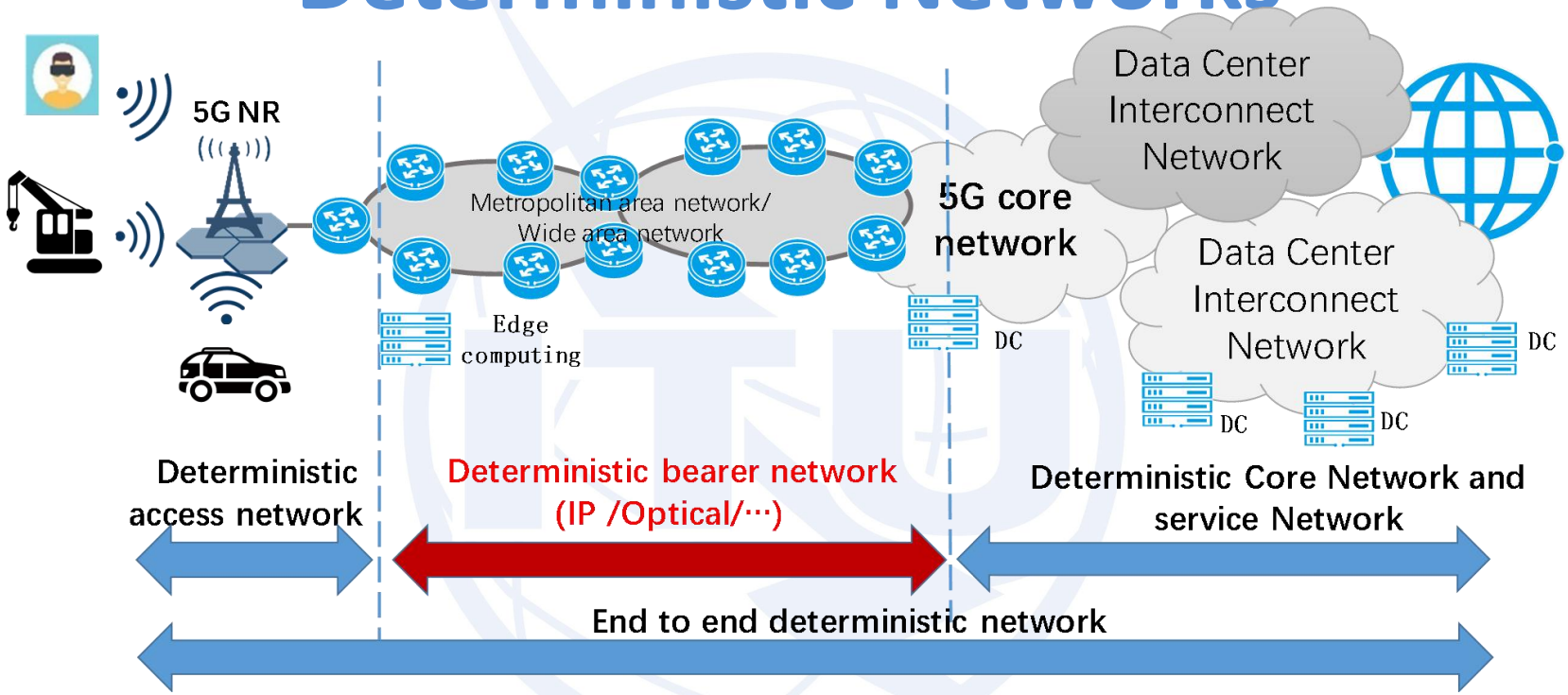
- Diversified QoS Requirements of Deterministic Services
- QoS Analysis for Deterministic Services in ITU-T
- Differentiated QoS Architecture of Deterministic Services
- Consideration about the work in SG13/Q6

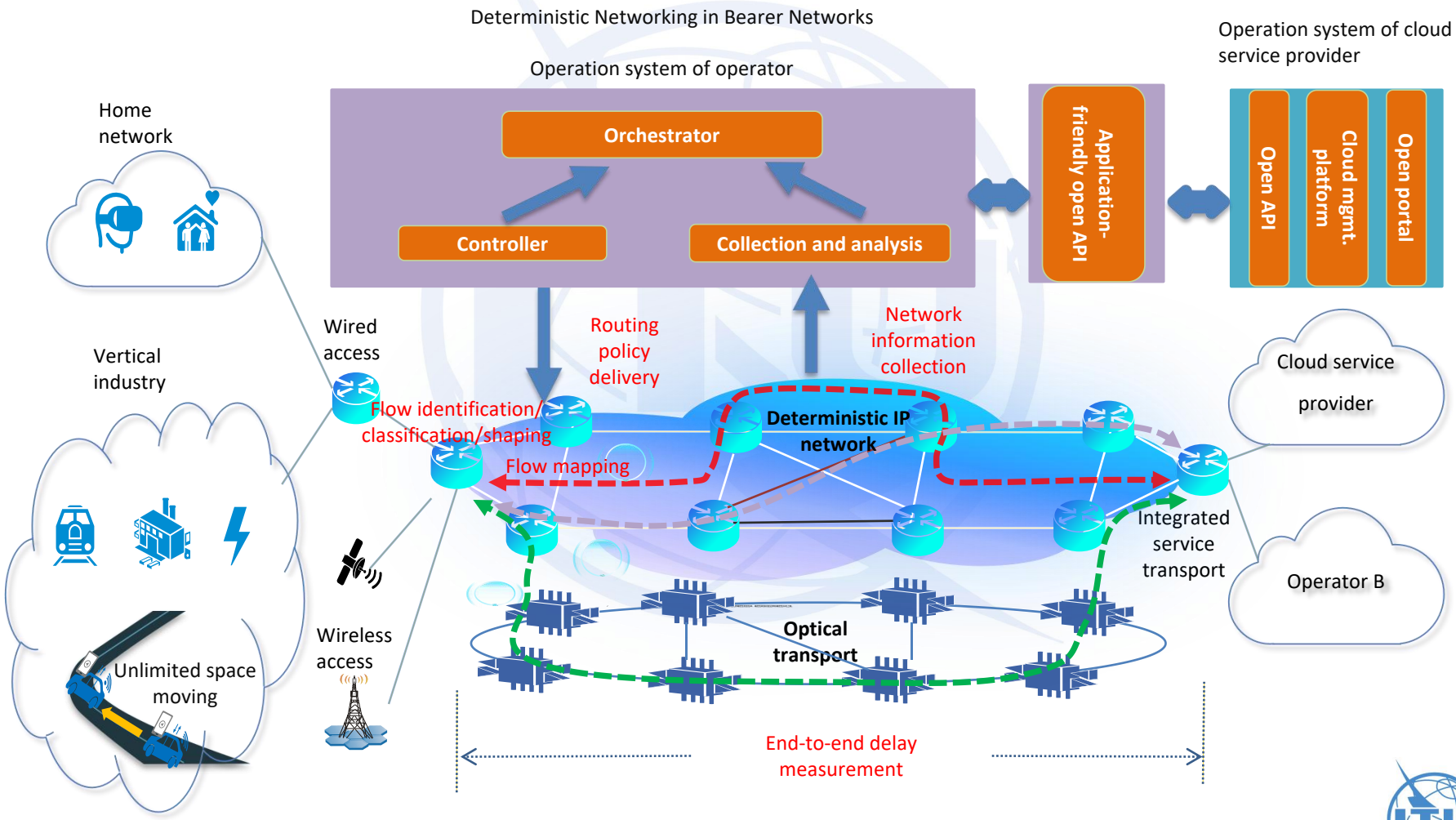
End-to-end Deployment of Deterministic Networks



- **End-to-end deterministic networks:** deterministic wired/wireless access network + deterministic bearer network + deterministic core network and service network;

- **Characteristics of deterministic networks :** deterministic delay + deterministic jitter + deterministic bandwidth + high availability + service isolation .

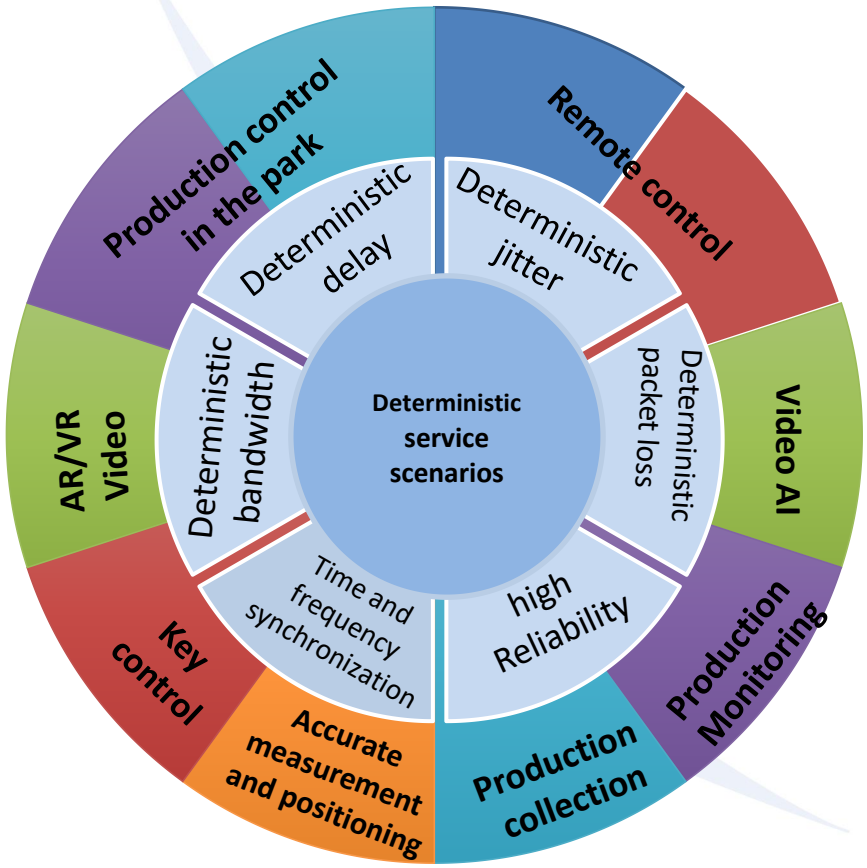
Deterministic Services in Large-scale Bearer Networks



Diversified SLAs Requirements for Deterministic Services

Typical Scenarios	Industry Applications	Bearing characteristics	Differentiated SLA				
			bandwidth	delay	jitter	Isolation	Reliability
1.Production control in the park	Industrial Internet PLC, etc	Local area: low jitter+ low latency+ low bandwidth	<=N*2M bps	<=2ms	<100us	TDM hard isolation	99.9999%
2. Remote control	Industrial Internet Cloud PLC, etc	Local/metropolitan/wide area: low jitter+ low latency+ low bandwidth	<=N*2M bps	<=5ms	<100us	TDM hard isolation	99.9999%
3.Production collection	Industry IoT data collection, etc	Local/metropolitan/wide area: deterministic latency+ large connections+ low speeds	<=N*2M bps	<=50ms	——	Soft isolation	99.9%
4.Production Monitoring	Industry production and safety video monitoring, etc	Local/metropolitan/wide area: determine medium bandwidth+ determine medium latency	<=N*50M bps	<=20ms	<5ms	Soft isolation	99.999%
5. AR/VR high experience video	Industry AR/VR assistance, consumer AR/VR, high experience cloud games, and cloud live streaming	Local/metropolitan/wide area: deterministic high bandwidth+ deterministic low latency	<=N* 100M~1G bps	<=3ms (high quality)	<10ms	Soft isolation	99.999%
6. AI for video	machine vision and high-definition quality inspection for Industry scenarios	Local/metropolitan/wide area: deterministic large bandwidth+ low latency jitter + high reliability	<=N*100Mbps	<=10ms	——	Soft isolation	99.9999%
7.Key control	Physical isolation class of power grid: differential protection, etc., critical control class related to life safety in the industry	Local/metropolitan/wide area: ultra high reliability and isolation	<=N* 100M~1G bps	<=3ms (high quality)	<10ms	TDM hard isolation	99.9999%
8. Accurate measurement and positioning	High precision base station indoor positioning, ten meter and meter level positioning and timing	Ultra high precision time synchronization	The carrier network proposes 10~100 nanosecond level ultra high precision time synchronization for base stations or service systems				

Differentiated QoS Requirements for Deterministic Services



- **Cloud-based applications and remote control :**strict delay/jitter deterministic and high reliability ;
- **Smart grid:** high isolation+low latency+low jitter+high-precision synchronization;
- **Industrial Internet :** low latency+low jitter+high reliability+high bandwidth;
- **Consumer entertainment:** high bandwidth+low latency;

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QoS Analysis for Deterministic Services in ITU-T SG13/Q6

- [Y.IMT-2020-QoS-lstn-req]: Deterministic QoS is refered to the bounded latency, bounded jitter and bounded packet loss rate, with more dimensions of QoS guarantee in large-scale telecommunications networks. **The requirements of differentiated QoS guarantees for multi-services with different traffic classes while utilizing network resources in large scale bearer networks should be considered.**

- [Y.3113][Y.3118][Y.3120][Y.det-fq-rf]: It mainly focus on the jitter and latency guarantee in large scale networks. **It mainly focus on the single SLA indicator such as jitter or latency but not the requirements of diversified SLAs.**

- [Y.3121][Y.det-qos-arch-lan][Y.det-qos-rf-intwk-lan]: It mainly focus on deterministic communication services in local area networks. **It mainly focus on the local area but not the requirements of large scale networks.**

Problems with Differentiated QoS Requirements for Deterministic Services

- Problems with the **differentiated QoS of deterministic services**
  - Diversified deterministic SLAs requirements can not be covered by existing QoS

- Problems with the capability providing differentiated QoS for deterministic services in **large-scale bearer networks**
  - Distributed routes should be established when large-scale deterministic networks **acrossing multi-domains and multi-layers** are interconnected.
  - Multiple queuing and forwarding mechanisms should be provided and scheduled to support **time-based resource with different deterministic capabilities.**
  - **Traffic scheduling** should be provided for large-scale dynamic deterministic flows to reduce the amount of control signaling.

QoS Categories in ITU-T G.1010

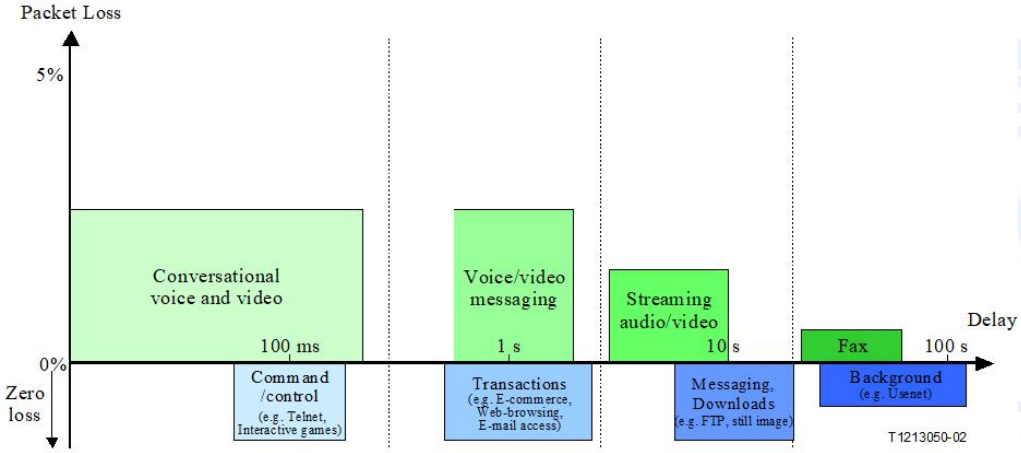

Figure 1/G.1010 – Mapping of user-centric QoS requirements

- Figure 1 : Various applications can be mapped into the classification based on packet loss and one-way delay.
- Figure 2: Recommended model for end-user QoS categories including 8 classes.

- The classification is mainly aimed at multimedia and online services with delay over 100ms, **without considering the emerging deterministic services in future networks with low delay or ultra-low delay requirements.**

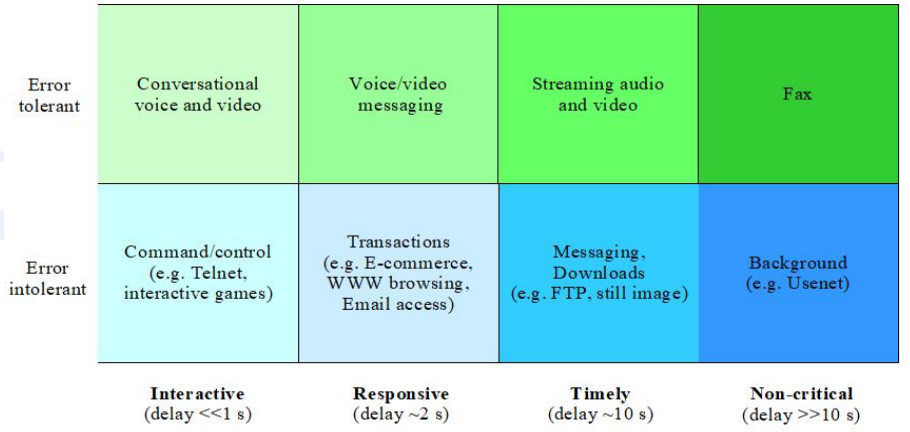

Figure 2/G.1010 – Model for user-centric QoS categories

IP QoS Classes in ITU-T Y.1541

Table 1 – IP network QoS class definitions and network performance objectives

Network performance parameter	Nature of network performance objective	QoS Classes					
		Class 0	Class 1	Class 2	Class 3	Class 4	Class 5 Unspecified
IPTD	Upper bound on the mean IPTD (Note 1)	100 ms	400 ms	100 ms	400 ms	1 s	U
IPDV	Upper bound on the $1 - 10^{-3}$ quantile of IPTD minus the minimum IPTD (Note 2)	50 ms (Note 3)	50 ms (Note 3)	U	U	U	U
IPLR	Upper bound on the packet loss probability	1×10^{-3} (Note 4)	1×10^{-3} (Note 4)	1×10^{-3}	1×10^{-3}	1×10^{-3}	U
IPER	Upper bound	1×10^{-4} (Note 5)					U

Table 2 – Guidance for IP QoS classes

QoS class	Applications (examples)	Node mechanisms	Network techniques
0	Real-time, jitter sensitive, high interaction (VoIP, VTC)	Separate queue with preferential servicing, traffic grooming	Constrained routing and distance
1	Real-time, jitter sensitive, interactive (VoIP, VTC).		Less constrained routing and distances
2	Transaction data, highly interactive (Signalling)	Separate queue, drop priority	Constrained routing and distance
3	Transaction data, interactive		Less constrained routing and distances
4	Low loss only (short transactions, bulk data, video streaming)	Long queue, drop priority	Any route/path
5	Traditional applications of default IP networks	Separate queue (lowest priority)	Any route/path

- The table 1 and table 2 show the **network QoS classes** for the classified appications and the mechanisms based on delay, loss ratio, error ratio, delay variation **without considering the emerging deterministic services in future networks and the development of forwarding technologies in large scale bearer networks.**
- The **differentiated deterministic QoS can follow this way to define different QoS classes for deterministic services** to meet diversified SLAs requirements while using the emerging forwarding technologies such as time-based queuing and scheduling mechanisms.

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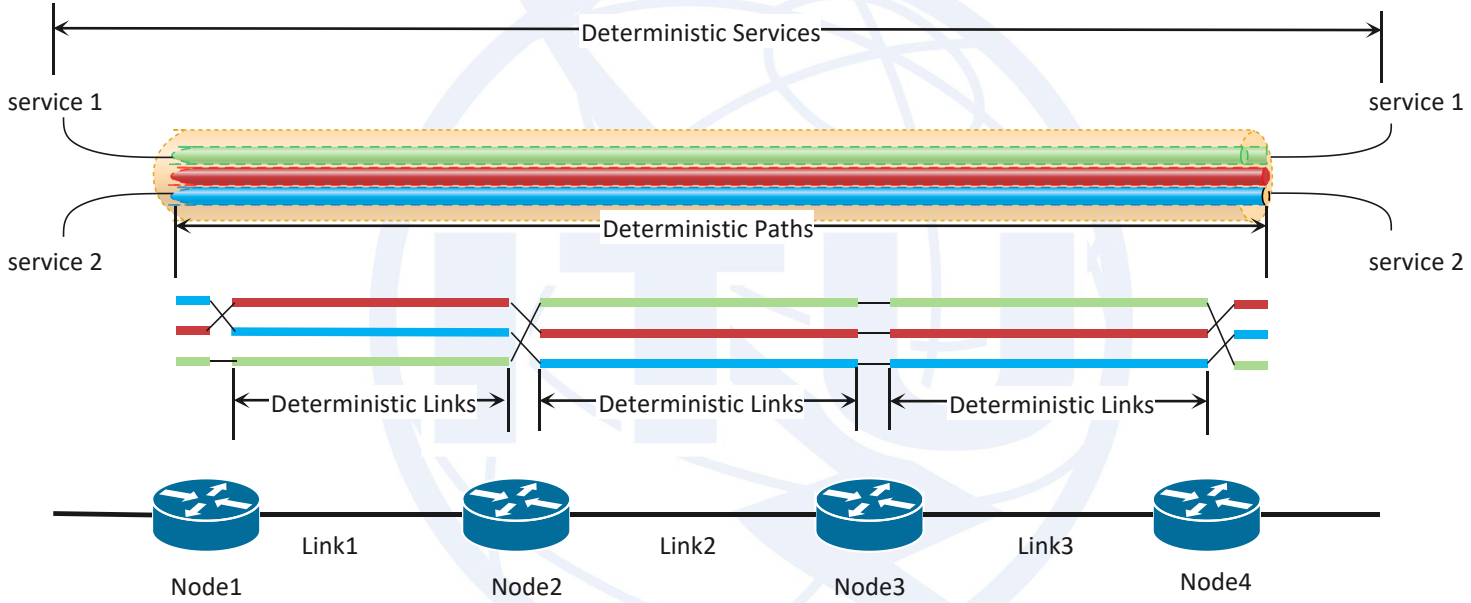
Traffic Classes for Differentiated QoS of Deterministic Services

QoS	Class-0	Class-1	Class-2	Class-3	Class-4
Deterministic services Requirements	Bandwidth Guarantee	Jitter Guarantee	Delay Guarantee	Low Delay and Jitter Guarantee	Ultra-low Delay and Jitter Guarantee
SLAs	N/A	Delay <300ms, jitter<50ms, soft isolation, 99.9%	Delay <50ms, jitter<50ms, soft isolation, 99.99%	Delay<20ms, jitter<5ms, soft isolation, 99.999%	Delay<10ms, jitter<100us, TDM hard isolation, 99.9999%
Applications Examples	Download and FTP services	Synchronous voice services	Video, production monitoring, and communication services	AR/VR, holographic communication, cloud video and cloud games services	Industrial services such as power protection and remote control

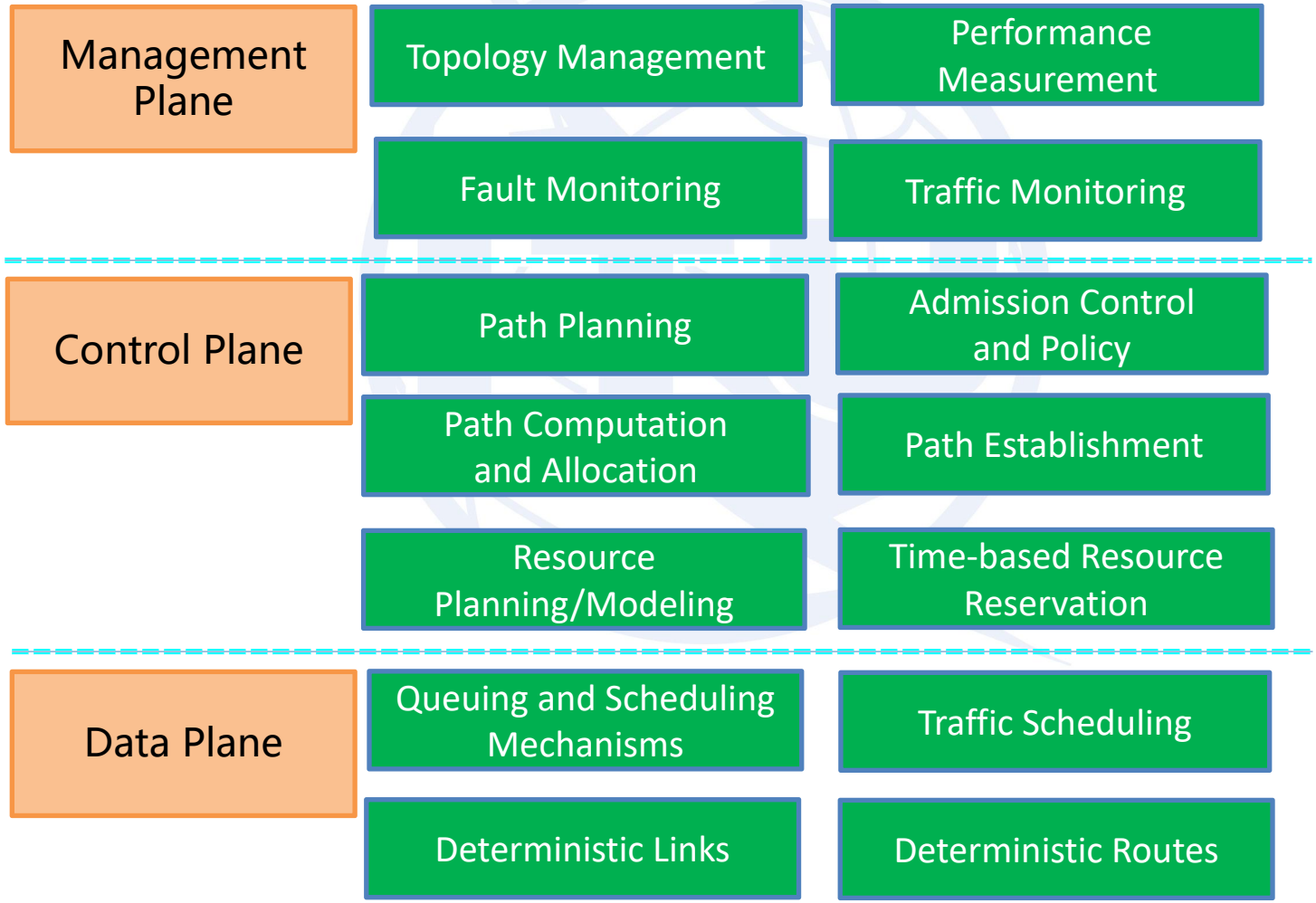
- The **differentiated QoS can be classified** based on the applications in large-scale bearer networks.
- The figure shows an example for **differentiated QoS with 5 traffic classes of deterministic services** based on the diversified SLAs such as bandwidth, delay, jitter, loss, reliability, isolatiion and availablilty and so on.

Layers Model of Forwarding Resources to Guarantee Differentiated QoS



- **Forwarding resources:** indicate the time-based resources with classifed deterministic capabilities to guarantee the differentiated QoS including bandwidth/nodes/links/buffer/queuing and scheduling mechanims acrossing the multi-layers and multi-domains in large scale bearer networks.
- **Deterministic links:** indicate to resolve time-based resources competition among different traffic classes and provide deterministic forwarding capabilities at multiple levels.
- **Deterministic paths:** indicate to resolve time-based resources competition among different paths within the same traffic class.
- **Deterministic services:** indicate to resolve time-based resources competition among different flows on the same path to achieve the QoS guarantees.

Framework and Components for Differentiated QoS



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Consideration about ITU-T SG13/Q6 Work on QoS Mechanisms for Deterministic Services

- Deterministic Communication Services in Large-scale Networks
  - Requirements and framework for jitter guarantee in large scale networks including IMT-2020 and beyond
  - Requirements and framework for lantency guarantee in large scale networks including IMT-2020 and beyond
  - Functional Architecture for latency guarantee in large scale networks including IMT-2020 and beyond
  - Requirements and framework for stateless fair queuing in large scale networks including IMT-2020 and beyond
  - Requirements and framework of Deterministic QoS in large-scale telecommunications networking for IMT-2020 networks and beyond
- Deterministic Communication Services in Local Area Networks
  - QoS requirements and framework for supporting deterministic communication services in local area network for IMT-2020
  - Functional architecture for QoS guarantee of deterministic communication services in local area network for IMT-2020 and beyond
  - QoS requirements and framework of interworking capability for supporting deterministic communication services in local area network for IMT-2020 and beyond
- **Suggest to work on differentiated QoS mechanisms of deterministic services in large scale bearer networks.**

Thank you
Any questions?