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| 3GPP TR 28.865 V18.1.0 (2024-06) | |
| Technical Report | |
| 3rd Generation Partnership Project;  Technical Specification Group Services and System Aspects;  Study on Deterministic Communication Service Assurance (DCSA)  (Release 18) | |
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# Foreword

This Technical Report has been produced by the 3rd Generation Partnership Project (3GPP).

The contents of the present document are subject to continuing work within the TSG and may change following formal TSG approval. Should the TSG modify the contents of the present document, it will be re-released by the TSG with an identifying change of release date and an increase in version number as follows:

Version x.y.z

where:

x the first digit:

1 presented to TSG for information;

2 presented to TSG for approval;

3 or greater indicates TSG approved document under change control.

y the second digit is incremented for all changes of substance, i.e. technical enhancements, corrections, updates, etc.

z the third digit is incremented when editorial only changes have been incorporated in the document.

In the present document, modal verbs have the following meanings:

**shall** indicates a mandatory requirement to do something

**shall not** indicates an interdiction (prohibition) to do something

The constructions "shall" and "shall not" are confined to the context of normative provisions, and do not appear in Technical Reports.

The constructions "must" and "must not" are not used as substitutes for "shall" and "shall not". Their use is avoided insofar as possible, and they are not used in a normative context except in a direct citation from an external, referenced, non-3GPP document, or so as to maintain continuity of style when extending or modifying the provisions of such a referenced document.

**should** indicates a recommendation to do something

**should not** indicates a recommendation not to do something

**may** indicates permission to do something

**need not** indicates permission not to do something

The construction "may not" is ambiguous and is not used in normative elements. The unambiguous constructions "might not" or "shall not" are used instead, depending upon the meaning intended.

**can** indicates that something is possible

**cannot** indicates that something is impossible

The constructions "can" and "cannot" are not substitutes for "may" and "need not".

**will** indicates that something is certain or expected to happen as a result of action taken by an agency the behaviour of which is outside the scope of the present document

**will not** indicates that something is certain or expected not to happen as a result of action taken by an agency the behaviour of which is outside the scope of the present document

**might** indicates a likelihood that something will happen as a result of action taken by some agency the behaviour of which is outside the scope of the present document

**might not** indicates a likelihood that something will not happen as a result of action taken by some agency the behaviour of which is outside the scope of the present document

In addition:

**is** (or any other verb in the indicative mood) indicates a statement of fact

**is not** (or any other negative verb in the indicative mood) indicates a statement of fact

The constructions "is" and "is not" do not indicate requirements.

# 1 Scope

The present document studies potential key issues and solutions for provisioning and assurance of deterministic communication services, e.g. management of related network functions, potential new service requirements and new performance measurements, etc. The present document provides conclusions and recommendations on the normative work.

# 2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non‑specific.

- For a specific reference, subsequent revisions do not apply.

- For a non-specific reference, the latest version applies. In the case of a reference to a 3GPP document (including a GSM document), a non-specific reference implicitly refers to the latest version of that document *in the same Release as the present document*.

[1] 3GPP TR 21.905: "Vocabulary for 3GPP Specifications".

[2] 3GPP TS 22.261: "Service requirements for the 5G system".

[3] 3GPP TS 22.104: "Physical control applications in vertical domains".

[4] 3GPP TS 23.501: "System architecture for the 5G System (5GS)".

[5] 3GPP TS 28.541: "5G Network Resource Model (NRM); Stage 2 and stage 3".

[6] NG.116: "Generic Network Slice Template"; v7.0; 17 June 2022.

[7] 3GPP TS 28.552: " Management and orchestration; 5G performance measurements".

[8] 3GPP TS 28.554: " Management and orchestration; 5G end to end Key Performance Indicators (KPI)".

[9] 3GPP TR 28.832: "Study on management aspects of Ultra-Reliable and Low Latency Communications (URLLC) "

[10] 3GPP TS 38.323: "NR; Packet Data Convergence Protocol (PDCP) specification "

[11] 3GPP TS 38.331: "NR; Radio Resource Control (RRC); Protocol specification "

[12] 3GPP TS 37.340: "NR; Multi-connectivity; Overall description; Stage-2 "

[13] 3GPP TS 38.321: "NR; Medium Access Control (MAC) protocol specification"

[14] 3GPP TS 38.331: "NR; Radio Resource Control (RRC); Protocol specification "

[15] 3GPP TS 38.423: "NG-RAN; Xn Application Protocol (XnAP) "

[16] 3GPP TS 37.355: "LTE Positioning Protocol (LPP) "

[17] 3GPP TR 28.833: "Study on management aspects of 5GLAN "

[18] 3GPP TR 28.907: "Study on enhancement of management of non-public networks "

[19] 3GPP TS 28.833: "Management and orchestration; Management of Non-Public Networks (NPN); Stage 1 and stage 2 "

[20] 3GPP TR 28.903: "Study on alignment with ETSI MEC for edge computing management"

[21] 3GPP TS 28.538: "Management and orchestration; Edge Computing Management"

[22] 3GPP TS 23.502: "Procedures for the 5G System (5GS)"

[23] 3GPP TS 23.273: "5G System (5GS) Location Services (LCS); Stage 2"

[24] 3GPP TS 28.530: "Management and orchestration; Concepts, use cases and requirements"

[25] 3GPP TS 28.532: "Management and orchestration; Generic management services"

[26] 3GPP TS 28.535: "Management and orchestration; Management services for communication service assurance; Requirements"

[27] 3GPP TS 28.536: "Management and orchestration; Management services for communication service assurance; Stage 2 and stage 3"

[28] 3GPP TS 23.288: "Architecture enhancements for 5G System (5GS) to support network data analytics services"

# 3 Definitions of terms, symbols and abbreviations

## 3.1 Terms

For the purposes of the present document, the terms given in 3GPP TR 21.905 [1] and the following apply. A term defined in the present document takes precedence over the definition of the same term, if any, in 3GPP TR 21.905 [1].

None.

## 3.2 Symbols

None.

## 3.3 Abbreviations

For the purposes of the present document, the abbreviations given in 3GPP TR 21.905 [1] and the following apply. An abbreviation defined in the present document takes precedence over the definition of the same abbreviation, if any, in 3GPP TR 21.905 [1].

DCSA Deterministic Communication Service Assurance

PLC Programmable Logic Controller

TSC Time Sensitive Communication

# 4 Overview and Concepts

## 4.1 Overview

5G network should satisfy diversified SLA requirements to support different vertical applications. Service requirements are more stringent for deterministic communication services as described in TS 22.261 [2] and TS 22.104 [3], e.g. video monitoring for production environment in a factory, remote control etc. The latency/transmission time of a data package is bounded by a given threshold. There are two typical traffic classes or communication patterns for deterministic communication service: deterministic periodic communication and deterministic aperiodic communication. In clause 5 in TS 22.104 [3], performance requirements for some deterministic communication services are provided. In TS 23.501 [4], QoS characteristics are defined for some deterministic communication services, e.g. some 5QIs for delay critical GBR services. Communication service availability and reliability are more important for these services types. Service experience degradation or violation of the latency requirements such as unstable jitter or unexpected packet loss may result in service interruption or severe consequences. Stable and deterministic communication service experience should be assured.

There are some features in the 5G network to support deterministic communication services, e.g. URLLC related network functions for radio interface and 5GC network, 5GS Integration with TSN and Industrial IoT, high accuracy positioning etc. How to support deterministic communication services from management aspects are investigated in this present document, e.g. provisioning of the related network functions, solutions for the assurance of deterministic communication services such as video monitoring and PLC control, etc.

## 4.2 Concepts

### 4.2.1 Management framework of deterministic communication service assurance

It is assumed that a dedicated management service is used to manage the deterministic communication service assurance. It may also coordinate with other related management services to provide service assurance for deterministic communications when it is needed. Based on the Service based management architecture, Deterministic Communication Service Assurance (DCSA) MnS producer could reside on 3GPP cross domain, RAN domain or CN domain as shown in the following figure. DCSA MnS producer in 3GPP cross domain coordinates with DCSA MnS producers in RAN domain and CN domain.



Figure 4.2.1-1: Deployment of DCSA MnS producer

To investigate how to support deterministic communication service assurance from management aspects, the management framework of DCSA MnS producer is studied. The following figure shows the functional framework of DCSA MnS producer, including processes of data collection, service requirement modeling, network preparation, service and network analysis, optimization and verification. The main functionalities of each process is described as follows:



Figure 4.2.1-1-2: Functional framework of DCSA MnS producer

Data collection: Collects network performance and alarm data, signaling-plane and user-plane measurement information and abnormal events, and collects service experience related network performance information. The collected data is used for as input for other processes.

Service requirement modeling: The three-layer model of service experience, service quality, network performance is used for service requirement modeling. The service experience and service quality targets are analysed to derive the network capability requirements.

Network preparation: Based on deterministic communication service requirements, the DCSA MnS producer prepares network capabilities to ensure the SLA, and provides the corresponding network deployment solution, e.g. deployment of network slice, RAN functions and CN functions related to URLLC, Industrial IoT, TSN integration with 5GS to support deterministic communication service.

Service and network analysis: The DCSA MnS producer evaluates and identifies service and network issues through monitoring and analysis, demarcates and analyses the issues, and provides analysis recommendation for further optimization if needed.

Optimization and verification: The optimization is targeted to improve the service and network performance. For example, the optimization may include latency related optimization for a network slice instance. The optimization solution is applied and verification conclusion is conducted. If the optimization result deviates from the SLA target, the optimization solution is adjusted accordingly and the iterative optimization process is performed.

# 5 Issues and potential solutions

## 5.1 Issue #1: General requirement and performance analysis related to deterministic communication service

### 5.1.1 Description

#### 5.1.1.1 Analysis of requirements related to deterministic communication service

The concept of deterministic communication service is described in TS 22.261 [2], TS 22.104 [3] and TS 23.501 [4] respectively.

**In TS** **22.261 [2]:**

Communication in automation in vertical domains follows certain communication patterns. The most well-known is periodic deterministic communication, others are a-periodic deterministic communication and Smart Grid.

**In TS** **22.104[3]:**

Communication services supporting cyber-physical control applications need to be ultra-reliable, dependable with a high communication service availability, and often require low or (in some cases) very low end-to-end latency.

Communication in automation in vertical domains follows certain communication patterns. The most well-known is periodic deterministic communication, others are aperiodic deterministic communication and non-deterministic communication.

Determinism refers to whether the delay between transmission of a message and receipt of the message at the destination address is stable (within bounds). Usually, communication is called deterministic if it is bounded by a given threshold for the latency/transmission time. In case of a periodic transmission, the variation of the interval is bounded.

In Table 5.2.1 in TS 22.104[3], Periodic deterministic communication service performance requirements are provided for some cyber-physical control services, e.g. Motion control, video-operated remote control etc. The requirements are classified in characteristic parameter and influence quantity parameters.

The characteristic parameters include the following:

- Communication service reliability: mean time between failures.

- End-to-end latency: the time that it 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 [2].

- Service bit rate: user experienced data rate.

- Message size [byte].

The Influence quantity parameters include the following:

- Transfer interval: target value

- Survival time

- # of UEs

- Service area

Some additional requirements may be considered for the provisioning of network functions related to deterministic communication based on existing ServiceProfile defined in TS 28.541 [5].

For deterministic communication, the end-to-end latency requirement is stringent and defined as the service performance requirement in TS 22.261 [2] and TS 22.104 [3]. The latency between the (last) UPF and application server should be considered. It is described in NG.116 [6] but not reflected in existing ServiceProfile in TS 28.541 [5].

According to the requirements defined for periodic deterministic communications in TS 22.104 [3], there are some relationships or constraints among the end-to-end latency, Transfer interval and SurvivalTime. These relationships or conditions may be added. For example, the end-to-end latency should be not greater than the transfer interval value.

According to different activity patterns and communication patterns, the communication means used need to be deterministic since typically an activity response from the receiver and/or the receiving application is expected. The periodic communication pattern has been included in TS 28.541 [5], requirements related to aperiodic pattern may also be considered.

Synchronicity is important for deterministic communication services in the 5G system, it has been included in in TS 28.541 [5]. The 5G system supports enhanced timing resiliency in collaboration with different types of time sources (e.g. GNSS, TBS/MBS, Sync over Fiber) to provide a robust time synchronization. Additional requirements regarding 5G timing resiliency may be considered for deterministic communications. Some new requirements to extend the ServiceProfile may be needed.

- Latency from (last) UPF to Application Server.

The descriptions in NG.116 [6] for this attribute may be introduced:This optional attribute specifies maximum or worst-case one-way latency between UPF, and application server offered by the slice. This does not include latency introduced by the application server. The boundary of the "application server" is defined by the application domain, which may simply be a server, or may for example be front ended by a load balancer provided by the application.

- relationships or constraints among the end-to-end latency, transfer interval and survival time;

The following condition may be added to the ServiceProfile:

(1) The end-to-end latency should be not greater than the transfer interval value.

(2) The survival time is one or multiple of the transfer interval value.

- additional communication patterns related attributes, e.g. requirements of aperiodic pattern.

Aperiodic deterministic communication is without a pre-set sending time, but still with stringent requirements on timeliness and availability of the communication service.

- 5G Timing Resiliency related attributes, e.g. different types of time sources such as GNSS, TBS/MBS and Sync over Fiber, etc.

The 5G Timing Resiliency may be supported to provide a robust time synchronization.

In summary, some additional attributes may need to be included in the serviceProfile in the following Table 5.1.1.1-1:

Table 5.1.1.1-1: Additional requirements in the serviceProfile

|  |  |
| --- | --- |
| Attribute Name | Description |
| endToEndLatency | The definition of End-to-end latency in 1 22.261 [2]. |
| latencyUpfToAppServer | This optional attribute specifies maximum or worst-case one-way latency between UPF, and application server offered by the slice [6]. |
| timingResilience | This optional attribute specifies the different types of time sources such as GNSS, TBS/MBS and Sync over Fiber etc. |

#### 5.1.1.2 Analysis of network functions and management aspects related to deterministic communication service

**In TS** **23.501[4]:**

The definition of TSC is provided as follows:

Time Sensitive Communication (TSC): A communication service that supports deterministic communication (i.e. which ensures a maximum delay) and/or isochronous communication with high reliability and availability. It is about providing packet transport with QoS characteristics such as bounds on latency, loss, and reliability, where end systems and relay/transmit nodes may or may not be strictly synchronized.

In Table 5.7.4-1 the standardized 5QI to QoS characteristics mapping, the delay critical GBR QoS is specified from 5QI value 82 to 90.

Standards related to 3GPP 5G deterministic communications include network aspects and management aspects. The following tables list the main features.

RAN functions related to deterministic communication service:

|  |  |  |
| --- | --- | --- |
| Category | Features | Reference |
| NR URLLC | Management aspects were studied in TR 28.832[9] | TR 28.832[9] |
| Industrial IoT  Note 1: Management aspects related to deterministic communication service will be studied in FS\_DCSA.  Note 2: Some features reuse support from NR URLLC  Note 3: Details of TSC support see below. | PDCP packet duplication enhancements | TS 38.323[10] |
| RAN support for higher layer multi-connectivity | TS 38.331[11], TS 37.340[12] |
| SPS scheduling enhancements | TS 38.321[13], TS 38.331[14] |
| Intra-UE prioritization | TS 38.321[13] |
| NR support of TSC | TS 38.331[14], TS 38.321[13], TS 38.423[15] |
| NR support of 5GS Integration with TSN  Note: Management aspects related to deterministic communication service will be studied in FS\_DCSA. | Synchronization with 5G internal system clock | TS 38.331[11] |
| TSCAI QoS based scheduling | TS 38.321[13] |
| Ethernet Header Compression (EHC) | TS 38.323[10] |
| NR positioning support  Note 3: Management aspects related to deterministic communication service will be studied in FS\_DCSA. | RAT-dependent positioning techniques | TS 37.355[16] |
|  |  |

CN functions related to deterministic communication service:

|  |  |  |
| --- | --- | --- |
| Category | Features | Reference |
| 5G LAN | Management aspects were studied in TR 28.833[17] | TR 28.833[17] |
| NPN | Management aspects were studied in TR 28.907[18], specified in TS 28.557[19] | TR 28.907[18], TS 28.557[19], |
| MEC | Management aspects were studied in TR 28.903[20], specified in TS 28.538[21] | TR 28.903[20],TS 28.538[21] |
| 5G core network to support URLLC  Note 1: Management aspects related to deterministic communication service will be studied in FS\_DCSA. | Redundant transmission for high-reliability communication  - Dual Connectivity based end to end Redundant User Plane Paths;  - Support of redundant transmission on N3/N9 interfaces;  - Support for redundant transmission at transport layer | TS 23.501[4], TS 23.502 |
| QoS Monitoring  - Per QoS Flow per UE QoS Monitoring;  - GTP-U Path Monitoring | TS 23.501[4], TS 23.502[22] |
| Dynamic division of Packet Delay Budget | TS 23.501[4], TS 23.502[22] |
| Enhancements of session continuity | TS 23.501[4], TS 23.502[22] |
| 5GS Integration with IEEE TSN  Note 2: Management aspects related to deterministic communication service will be studied in FS\_DCSA. | 5GS architecture enhancement to support integration with TSN | TS 23.501[4] |
| Time synchronization | TS 23.501[4] |
| TSC QoS control  - delay critical GBR 5QIs  - TSN configuration maps to 5G QoS framework | TS 23.501[4] |
| TSCAI information  - Provide time-sensitive communication assistance information to 5G RAN to support optimal scheduling of time-sensitive services | TS 23.501[4] |
| Enhancement to the 5GC LoCation Services  Note 3: Management aspects related to deterministic communication service will be studied in FS\_DCSA. | General Concepts, e.g. Type of Location Requests, LCS Quality of services | TS 23.273[23] |
| High Level Features, e.g. LMF selection, UE LCS privacy handling; | TS 23.273[23] |
| Location Service Procedure | TS 23.273[23] |

Management aspects for End to end network:

|  |  |  |
| --- | --- | --- |
| Category | Features | Reference |
| Management and orchestration of network slice | Concept of network slice management  Provisioning of network slice | TS 28.530[24]  TS 28.532[25] |
| SLS management (serviceProfile, sliceProfile) | TS 28.541[5] |
| Closed loop SLS assurance | TS 28.535[26], TS 28.536[27] |

Functions related to the management aspects, such as management of network slice, URLLC RAN aspects, NPN, 5G LAN, MEC, etc. are covered in SA5 related studies and specifications. The present document mainly addresses the management aspects of Industrial IoT, 5GS integration with TSN and 5G positioning related to deterministic communication service, e.g. the related requirements, provisioning, performance measurements and fault management etc.

DCSA\_REQ X1: The 3GPP management system should provide the provisioning capability of URLLC related network functions to support deterministic communication service assurance.

DCSA\_REQ X2: The 3GPP management system should provide the provisioning capability of Industrial IoT related network functions.

DCSA\_REQ X3: The 3GPP management system should provide the provisioning capability of 5GS Integration with TSN related network functions.

DCSA\_REQ X4: The 3GPP management system should provide the provisioning capability of NR positioning and 5GC Location Services related network functions.

### 5.1.2 Potential solutions

#### 5.1.2.1 Potential solution #1: Report of achievable reliability information

##### 5.1.2.1.1 Introduction

According to the deterministic communication service requirements, the consumer should be able to obtain the achievable reliability information.

##### 5.1.2.1.2 Description

In TS 22.261 [2], the definition of reliability is as follows: in the context of network layer packet transmissions, percentage value of the packets successfully delivered to a given system entity within the time constraint required by the targeted service out of all the packets transmitted. The attribute reliability is included as one of the requirements in ServiceProfile and SliceProfile in TS 28.541 [5]. There are at least two types of reliability information which may need to be conveyed to the MnS consumer, one type is the reliability fulfilment status according to the reliability requirement, and the other type is the achievable reliability of the service provider when a MnS consumer query the network slice capability.

For a network slice which support the deterministic communication service, its achievable reliability information should be made available to the MnS consumer. The achievable reliability should be different with different conditions of time constraints, capacity and number of redundant links etc., Therefore, the achievable reliability information should be provided to the MnS consumer in combination with the corresponding time constraints, number of users, number of PDU sessions and number of redundant links. MDA may be used to provide some new additional analytics report of the achievable reliability information of the network slice based on the service requirements and available network slice resources. The analytics outputs are listed in the following Table 5.1.2.1.2-1.

Table 5.1.2.1.2-1: MDA analytics outputs of achievable reliability of a network slice

|  |  |
| --- | --- |
| Attribute Name | Description |
| achievableDlReliability | The achievable downlink reliability that a network slice capability could support, the definition of dlReliability requirement is defined in TS 28.541 [5]. |
| achievableUlReliability | The achievable uplink reliability that a network slice capability could support, the definition of dlReliability requirement is defined in TS 28.541 [5]. |

#### 5.1.2.2 Potential solution #2: Service and network analysis

##### 5.1.2.2.1 Introduction

The purpose of service and network analysis is to identify service experience and network performance degradation issues for network optimization. Based on the analysis results, network optimization solutions are used to improve the service experience and network performance, e.g. reconfiguration of network resource and/or parameters to reduce the latency and increase data rates.

3GPP management system should provide the analytical information of service experience and network performance related to deterministic communication service, especially for latency, throughput, and positioning because there are more stringent requirements. MDA capabilities of SLS analysis may be consumed or enhanced for this purpose. MDA capabilities of SLS analysis include service experience analysis, network slice throughput analysis, E2E latency analysis etc.

##### 5.1.2.2.2 Description

The analytics information may include issues and possible causes of the performance metrics that do not meet the deterministic communication services requirements, as listed in the following aspects:

**Latency analytics**:

MDA type of E2E latency related issue analysis in SLS analysis group may be consumed or enhanced for latency analysis, currently the analytics output contains e2ELatencyIssueId, e2ELatencyIssueType and affectedObjects. The e2ELatencyIssueType can indicate the enumerated values RAN latency issue and CN latency issue, further information may be provided as follows:

- Latency issues which are out of time boundary constraints with the applied reliability requirement, e.g. latency of RAN or CN part exceeding the configured PDB (packet delay budget).

- Jitter exceeds the predefined threshold, etc.

- BurstArrivalTime issues, data transfer or reception interval issues, e.g. some of the transfer intervals do not conform to the configured periodic.

- Possible causes of the latency issues, e.g. coverage, interference, and parameter configurations, etc.

**Reliability analytics**:

In TS 22.261 [2], the definition of reliability is as follows: in the context of network layer packet transmissions, percentage value of the packets successfully delivered to a given system entity within the time constraint required by the targeted service out of all the packets transmitted. In TS 28.541 [5], the reliability is included in ServiceProfile and SliceProfile as one of the requirements.

The correlation analysis of reliability and latency should be provided. Reliability fulfilment status should be considered within the survival time constraints rather than the average value for a long duration. The packet loss rate together with the applied latency constraints may be provided. Reliability fulfilment status should be considered from the end to end perspective. The end to end reliability is determined by the least reliability value of all the concerned domains or communication segments. The analytics output of reliability may contain the domain demarcation information, for example, the analysis may indicate whether the reliability issue reside in RAN, CN, both RAN and CN, or other aspects.

**Synchronization analytics**:

In TS 28.541 [5], the synchronizationis included in ServiceProfile and SliceProfile as one of the requirements.

The analytics output of synchronization may contain the following information:

- latency issues caused by synchronization

- synchronization accuracy information

- recommendation of 5G timing resiliency configuration, etc.

**TSN related analytics**:

From the management aspects for DCSA, it is expected that the MDA capabilities support TSN related analysis.

For the support of 5GS integration with TSN for deterministic communication services, the TSCAI information is provided by 5GC to 5G RAN for optimal scheduling of time-sensitive services.

It is expected that the MDA capability of TSN related analysis for DCSA should be able to obtain the service performance information from the TSN AF, TSCAI information from the 5GC, the service experience analysis from the NWDAF etc. Potential information may include:

Service performance data from the TSN AF:

- The service performance data associated with the communication session of the UE with an Application Server that includes: Average Packet Delay, Average Loss Rate and Throughput.

TSCAI information from the 5GC:

- The Periodicity, Burst Arrival Time, and Survival Time.

Observed service experience analytics result from the NWDAF, as specified in TS 23.288 [28].

The MDA performs correlation analysis and may indicate demarcation information of the potential latency issues, e.g. whether the potential issues exist within 3GPP domain or outside of the 3GPP domain.

**Throughput analytics:**

MDA type network slice throughput analysis in SLS analysis group may be consumed or enhanced for throughput analysis. Currently some throughput statistics and predictions are provided. More analytics regarding the guaranteed flow bit rate may be considered.

- Throughput far below the guaranteed requirement or excessive throughput, etc.

**Positioning analytics:**

More accuracy of positioning is required for deterministic communications, the positioning related analysis may be considered.

- Positioning accuracy issues.

The corresponding network are optimized if needed based on the analytical report. The optimization results may be reported to the consumer for monitoring or further processing.

In summary, some additional attributes may need to be provided by the MDA analytics report in the following Table 5.1.2.2.2-1:

Table 5.1.2.2.2-1: MDA analytics outputs of network and service performance

|  |  |
| --- | --- |
| Attribute Name | Description |
| latencyDeterministic | A data type which is used for deterministic latency analytics output container, which may include the issues of latency out of boundary, excessive jitter, unstable transfer intervals etc as described above in this clause. |
| reliabilityDeterministic | A data type which is used for deterministic reliability analytics output container, which may include the reliability issues reside in RAN, CN, both RAN and CN, or other aspects etc as described above in this clause. |
| throughputDeterministic | A data type which is used for deterministic throughput analytics output container, which may include the issues of throughput statistics and predictions that are far below the guaranteed requirement or excessive throughput etc as described above in this clause. |
| synchronization | A data type which is used for analytics output container for synchronization issues that do not meet the deterministic communication services, which may include the latency issues, synchronization accuracy, timing resilience configurations etc as described above in this clause. |
| tSNInfo | A data type which is used for analytics output container for TSN related information, which may include the service performance data from the TSN AF, TSCAI information from the 5GC, observed service experience analytics result from the NWDAF etc as described above in this clause. |
| positioningInfo | A data type which is used for analytics output container for positioning related information, which may include the positioning accuracy issues etc as described above in this clause. |

### 5.1.3 Conclusion - Impact on normative work

The network functions related to deterministic communication service from RAN and core network perspective are studied and summarized in clause 5.1.1.1. Requirements of management capability are identified regarding provisioning of URLLC, Industry IoT and 5GS integration with TSN related network functions in clause 5.1.1.2. Potential solutions regarding the service requirements and analysis of latency, reliability and synchronization aspects are studied in clause 5. 1.2. The management of general aspects for the network functions supporting deterministic communication service should be considered for the normative work:

- New requirements regarding deterministic latency with time boundary constraints, and data packet level reliability within the survival time, e.g. the impacts on serviceProfile, sliceProfile, and the corresponding performance measurements reporting.

- Impacts on MDA capability and the analytics information related to latency, reliability, synchronization, 5GS Integration with TSN, and throughput which are essential for the support of deterministic communication service.

## 5.2 Issue #2: Service assurance for video monitoring

### 5.2.1 Description

In TS 22.104, some UCs are provided, e.g. periodic communication for video-operated remote control, Real-time streaming data transmission (video data) from a mobile robot to the guidance control system. For video operated remote control services, the video backhaul and remote control are performed together.

The use case of video monitoring is a large uplink URLLC service. This type of service features large uplink data packets, high bandwidth, stability of bandwidth and latency. Typical scenarios include remote control of gantry cranes or bridge cranes in smart ports and remote surgery in smart medical care. The service requirements modeling is studied from the frame-level.

The three-layer model of service experience, service quality and network performance for video monitoring is depicted in figure 5.2.1-1.



Figure 5.2.1-1: Service requirement modelling of video monitoring service

Service experience layer: establishes service experience related indicators for video monitoring based on subjective and objective evaluation. Analyses frame-level features and provides experience-layer KQIs.

Service quality layer: studies the relation between KQIs and QoS indicators. The impacts on the guaranteed bandwidth, frame skipping rate and the assumed packet loss rate on the equivalent frame impairment rate are uniformly distributed. It describes the impacts of indicators such as delay jitter, rate distribution, and burst packet loss ratio on the frame arrival time distribution in different scenarios.

Network capability layer: studies the relation between QoS and air interface bandwidth/delay, radio network performance measurements, and core network bandwidth/delay requirements, core network performance measurements and capacity etc.

The above information is used as the assurance objective of the video backhaul service. The deterministic communication service assurance should support network preparation based on the assurance objective. The DCSA MnS producer collects related data, analyses service experience and network performance, optimizes and verifies deterministic communication service experience, and achieving the SLA assurance objective through the above steps. The DCSA MnS producer may need to collaborate with other related management services, such as performance management, fault management, eMDAS, eCOSLA, and provisioning.

DCSA-REQ-VideoMon 1: 3GPP management system should provide service assurance capabilities for video monitoring services.

DCSA-REQ-VideoMon 2: 3GPP management system should provide capabilities to enable consumers to monitor the service requirements fulfilment status and the corresponding analysis information for video monitoring service.

### 

### 5.2.2 Potential solutions

#### 5.2.2.1 Potential solution: Video monitoring service

##### 5.2.2.1.1 Introduction

In the deterministic communication service requirement analysis phase, network requirements (data rate, delay, and reliability) are analysed. Network deployment requirements of different areas need to be considered for network preparation. Deterministic communication services have high SLS requirements. For example, the planning of video monitoring services focuses on uplink coverage, uplink capacity, uplink data rate, and E2E latency etc. It demands on high delay stability of video frame transmission. The network requirements need to be derived based on the application characteristics of specific services. For example, network preparation information, such as network capacity, coverage, reliability, and data rate estimation, needs to be output based on the three-layer service requirement model of the video monitoring service.

##### 5.2.2.1.2 Description

**1. Data collection**

Collect service experience data and network performance data of video monitoring services based on the three-layer service requirement modeling. For example, the following data may collect: latency and throughput related performance data defined in TS 28.552 [7] and TS 28.554 [8]. Abnormal information such as large round-trip delay, large jitter, low data rate distribution, high packet loss rate, and service quality deterioration etc.

Taking the video monitoring services in a large port as an example, it requires high uplink bandwidth, low latency, high availability, mobility, and high reliability. Network preparation is performed to meet these requirements, e.g. deployment and provisioning of the necessary network functions.

**2. Analytics and demarcation**

Service and network analysis of deterministic communication services includes monitoring, poor-QoE identification, demarcation, and root cause analysis. Identify abnormal issues, determine the impact scope, and restore services.

Monitoring and the poor-QoE identification requires two steps:

- Builds the three-layer service requirement model based on service characteristics, including poor experience information.

- Collects experience, service quality, and network-related indicators and abnormal incidents to identify poor-QoE users and services.

Fault demarcation is used to generate service interruption/ poor experience incident when a service anomaly occurs. The E2E network KPI, alarm information, terminal exceptions are correlated and analysed. Demarcation results for video monitoring services are provided accordingly.

For deterministic communication services, the stability and deadline of latency are defined at data packet level from end to end perspective according to TS 22.104 [3]. The service characteristics and requirements regarding service experience, service quality and network performance quality for video monitoring service are described in clause 5. 2.1. The monitoring of the service requirements fulfilment status and the corresponding MDA analysis information for video monitoring service should be provided from management perspective. The abnormal issues should be identified and means should be taken to solve the problems. To support the assurance of video monitoring services, some abnormal issues and some new MDA analysis outputs are as in the following table:

Table 5.2.2.1.2-1: MDA analytics output of abnormal issues which may violate the service requirements

| Attribute Name | Description |
| --- | --- |
| Communication service interruption | The reception failure of an uplink data packet upon the deadline of the survival time. It is used to identify latency issues that may exceed survival time. |
| Excessive RTT | The times that the RTT is greater than a threshold exceed a predefined value within a detection period. It is used to identify end to end latency issues. |
| High packet loss rate | The uplink packet loss rate is greater than a threshold within a detection period. It is used to identify potential packet level reliability issues. |
| Abnormal data rate | The uplink traffic is greater than a traffic threshold and the number of consecutive occurrence periods reaches the threshold within a detection period. It is used to identify issues of guaranteed data rate that do not meet the requirements. |

Some performance measurements are currently available in TS 28.552 [7], e.g. packet drop rate, average packet delay, IP latency measurements, UE throughput etc, which may be used as the enabling data for the above analysis.

**3. Optimization and verification**

**Optimization**:

For video monitoring services, delay-related optimization and uplink data rate optimization are considered. To optimize delay-related problems, it is needed to analysed the average delay, delay jitter, and delay reliability. It can analyse the delay-related factors of the air interface, such as the uplink and downlink slot assignment proportion, air interface resource capacity, and scheduling policy.

Uplink data rate optimization: The coverage, interference, resource allocation policy, and scheduling policy are optimized to make the uplink rate better match the SLS requirement.

**Verification:**

According to the service assurance objective of deterministic communication, that is, the quality of experience indicator of each service meets the deterministic requirement after optimization, it is further verified that the network capability meets the deterministic requirement. Select indicators that reflect video monitoring service experience, such as stalling and interruption, or indicators that reflect network performance, such as packet loss rate, rate, and delay.

### 5.2.3 Conclusion - Impact on normative work

In TS 23.501 (System architecture for the 5G System), the QoS model of Mission Critical Video and "Live" Uplink Streaming were defined. The video monitoring service is a kind of uplink URLLC service which is uplink bandwidth consuming and latency sensitive when used for video assisted mission critical operations.

- The management of general aspects for the uplink focused URLLC service requirements should be considered for the normative work: new requirements for the deterministic aspects for the uplink focused URLLC service: latency of operation response time, uplink guaranteed data rate, distribution of data packet arrival time (or transfer interval) etc, e.g. the impacts on serviceProfile, sliceProfile, and the corresponding performance measurements reporting.

- To support this uplink focused URLLC service, impacts on MDA capability and the analytics output in table D are suggested to be further defined.

## 5.3 Issue #3: Service assurance for PLC control

### 5.3.1 Description

In TS 22.104[3], some UCs are provided, e.g. periodic communication for video-operated remote control, real-time streaming data transmission (video data) from a mobile robot to the guidance control system.

For the use case of video operated remote control services, in which video backhaul and remote control are performed together. Remote control services are mainly characterized by small packet control URLLC services. Typical scenarios include remote control of gantry cranes or bridge cranes in smart ports and remote surgery in smart medical care, wireless external I/O of robots, and differential protection in the smart grid. The downlink control signaling has high requirements on delay and reliability. This type of service features small data packets, low bandwidth requirements, and high latency and reliability requirements. This documentfocuses provides the characteristics and requirements for its service assurance.

PLC control communication services have two characteristics: periodic small-packet interaction (such as data packets for control operations) and burst small-packet transmission (such as device alarms). The stability of the interaction delay is an important factor that affects the service quality. The stable receiving of messages is better than the fast receiving of messages but with great jitter, and is less likely to trigger alarms and service interruptions.

The three-layer model of service experience, service quality and network performance for PLC control is depicted in figure 4.



Figure 5.3.1-1： Service requirement modelling of PLC control service

Service experience layer: establishes service experience related indicators for PLC control based on subjective and objective evaluation. Analyses experience-layer KQIs.

Service quality layer: studies the relation between KQIs and QoS indicators. It describes the impacts of indicators such as delay jitter and burst packet loss ratio etc in different scenarios.

Network capability layer: studies the relation between QoS and air interface bandwidth/delay, radio network performance measurements, and core network bandwidth/delay requirements, core network performance measurements and capacity etc.

The above information is used as the assurance objective of the PLC control service. The deterministic communication service assurance should support network preparation based on the assurance objective. The DCSA MnS producer collects related data, analyses service experience and network performance, optimizes and verifies deterministic communication service experience, and achieving the SLA assurance objective through the above steps. The DCSA MnS producer may need to collaborate with other related management services, such as performance management, fault management, eMDAS, eCOSLA, and provisioning.

DCSA-REQ-PLC 1: 3GPP management system should provide service assurance capabilities for PLC control services.

DCSA-REQ-PLC 2: 3GPP management system should provide capabilities to enable consumers to monitor the service requirements fulfilment status and the corresponding analysis information for PLC control services.

### 5.3.2 Potential solutions

#### 5.3.2.1 Potential solution: PLC control

##### 5.3.2.1.1 Introduction

In the deterministic communication service requirement analysis phase, network requirements (data rate, delay, and reliability) are analysed. Network deployment requirements of different areas need to be considered for network preparation. Deterministic communication services have high SLS requirements. For example, the planning of PLC control services focuses on E2E latency, interactive latency, PLC control period, burst packet loss ratio etc. It demands on high delay stability and periodic deterministic of small data packets. The network requirements need to be derived based on the application characteristics of specific services. For example, network preparation information, such as network capacity, coverage, reliability, and data rate estimation, needs to be output based on the three-layer service requirement model of the PLC control service.

##### 5.3.2.1.2 Description

**1. Data collection**:

Collect service experience data and network performance data of PLC control services based on the three-layer service requirement modeling. For example, the following data may collect: latency and throughput related performance data defined in TS 28.552 and TS 28.554. Abnormal information such as large round-trip delay, large interactive delay, large jitter, low data rate distribution, high packet loss rate, and service quality deterioration etc.

**2. Analytics and demarcation**

Service and network analysis of deterministic communication services includes monitoring, poor-QoE identification, demarcation, and root cause analysis. Identify abnormal issues, determine the impact scope, and restore services.

Monitoring and the poor-QoE identification requires two steps:

- Builds the three-layer service requirement model based on service characteristics, including poor experience information.

- Collects experience, service quality, and network-related indicators and abnormal incidents to identify poor-QoE users and services.

Fault demarcation is used to generate service interruption/ poor experience incident when a service anomaly occurs. The E2E network KPI, alarm information, terminal exceptions are correlated and analysed. Demarcation results for video monitoring services are provided accordingly.

The service characteristics and requirements regarding service experience, service quality and network performance quality for PLC control service are described in clause 5. 3.1. The monitoring of the service requirements fulfilment status and the corresponding MDA analysis information for PLC control service should be provided from management perspective. The abnormal issues should be identified and means should be taken to solve the issues. To support the assurance of PLC control services, some abnormal issues and some new MDA analysis outputs are as in the following table:

Table 5.3.2.1.2-1: MDA analytics output of abnormal issues which may violate the service requirements

| Attribute Name | Data collection points |
| --- | --- |
| Communication service interruption | The reception failure of a data packet upon the deadline of the survival time. It is used to identify latency issues that may exceed survival time. |
| Excessive RTT | The times that the RTT is greater than a threshold exceed a predefined value within a detection period. It is used to identify end to end latency issues. |
| High packet loss rate | The packet loss rate is greater than a threshold within a detection period. It is used to identify potential packet level reliability issues. |

Some performance measurements are currently available in TS 28.552 [7], e.g. packet drop rate, average packet delay, IP latency measurements, UE throughput etc, which may be used as the enabling data for the above analysis.

**3. Optimization and verification**

**Optimization**:

For PLC control services, delay-related optimization is mainly considered. To optimize delay-related problems, it is needed to analyse the average delay, delay jitter, and delay reliability. It can analyse the delay-related factors of the air interface, such as the uplink and downlink slot assignment proportion, air interface resource capacity, and scheduling policy.

**Verification:**

According to the service assurance objective of deterministic communication, that is, the quality of experience indicator of each service meets the deterministic requirement after optimization, it is further verified that the network capability meets the deterministic requirement. Select indicators that reflect PLC control service experience, such as PLC control period, survival time, interactive delay, interruption etc, or indicators that reflect network performance, such as packet loss rate, rate, and delay.

### 5.3.3 Conclusion - Impact on normative work

In TS 23.501[4] (System architecture for the 5G System), the QoS model of GFBR were defined. The PLC control service is a kind of URLLC service with GFBR kind of QoS control. The management of general aspects for the URLLC service with GFBR type QoS control should be considered for the normative work:

- New requirements for the deterministic aspects for the URLLC service with GFBR kind of QoS control: periodic of small packets (transfer interval), survival time, interactive delay, burst packet loss ratio etc, e.g. the impacts on serviceProfile, sliceProfile, and the corresponding performance measurements reporting.

- To support this URLLC service with GFBR kind of QoS control, impacts on MDA capability and the analytics output in the table E are suggested to be further defined.

# 6 Conclusions and recommendations

In this study, new requirements and potential solutions for the analytics output related to deterministic communication services are identified, and it is recommended that the new deterministic communication services management should be considered in normative work, mainly about the impacts on serviceProfile, sliceProfile, the corresponding performance measurement reporting. To support all those services, the MDA capability and the analytics output information are recommended to be updated in further normative work.

Annex A (informative):  
Change history

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Change history** | | | | | | | |
| **Date** | **Meeting** | **TDoc** | **CR** | **Rev** | **Cat** | **Subject/Comment** | **New version** |
| 2022-04 | SA5#142e | S5-222113 |  |  |  | Initial version of TR 28.865 | 0.0.0 |
| 2022-04 | SA5#142e | S5-222676  S5-222677  S5-222678 |  |  |  | Update to implement the agreed pCRs in SA5#142e:  1. S5-222676 pCR TR 28.865 Skeleton proposal  2. S5-222677 pCR TR 28.865 Add scope of FS\_DCSA  3. S5-222678 pCR TR 28.865 Add overview of FS\_DCSA | 0.1.0 |
| 2022-05 | SA5#143e | S5-223614  S5-223615  S5-223616  S5-223617  S5-223618  S5-223619 |  |  |  | Update to implement the agreed pCRs in SA5#143e:  1. S5-223614 pCR TR 28.865 Add framework of FS\_DCSA  2. S5-223615 pCR TR 28.865 Add key issue provisioning of network functions related to DCSA  3. S5-223616 pCR TR 28.865 Add key issue service assurance for video monitoring  4. S5-223617 pCR TR 28.865 Add key issue service assurance for PLC control  5. S5-223618 pCR TR 28.865 Add solution service assurance for video monitoring  6. S5-223619 pCR TR 28.865 Add solution service assurance for PLC control | 0.2.0 |
| 2022-06 | SA5#144e | S5-224055 |  |  |  | Update to implement the agreed pCRs in SA5#144e:  1. pCR TR 28.865 Correct the inconsistence information in concept | 0.3.0 |
| 2023-03 | SA5#147 | S5-232849  S5-233133 |  |  |  | Update to implement the agreed pCRs in SA5#147:  1. S5-232849 pCR TR 28.865 Add requirements for DCSA  2. S5-233133 pCR TR 28.865 Add solution of service and network analysis | 0.4.0 |
| 2023-06 | SA5#149 | S5-234297  S5-234298  S5-234299  S5-234569 |  |  |  | Update to implement the agreed pCRs in SA5#149:  1. S5-234297 pCR TR 28.865 Report of achievable reliability information  2. S5-234298 pCR TR 28.865 Add solution of service and network analysis  3. S5-234299 pCR TR 28.865 Add description on synchronization analysis  4. S5-234569 pCR TR 28.865 Add description on TSN related analysis | 0.5.0 |
| 2023-10 | SA5#151 | S5-237192  S5-237193  S5-237194 |  |  |  | Update to implement the agreed pCRs in SA5#151:  1. S5-237192 pCR TR 28.865 Add conclusion of issue1 provisioning of network functions  2. S5-237193 pCR TR 28.865 Update solution of service assurance for video monitoring  3. S5-237194 pCR TR 28.865 Update solution of service assurance for PLC control | 0.6.0 |
| 2023-11 | SA5#152 | S5-238281  S5-238282  S5-238283 |  |  |  | Update to implement the agreed pCRs in SA5#152:  1. S5-238281 pCR TR 28.865 Add conclusion of issue2 for video monitoring  2. S5-237282 pCR TR 28.865 Add conclusion of issue3 service assurance for PLC control  3. S5-238283 pCR TR 28.865 Add conclusion and recommendations for FS\_DCSA study item | 0.7.0 |
| 2024-02 | SA5#153 | S5-240379  S5-240938 |  |  |  | Update to implement the agreed pCRs in SA5#153:  1. S5-240379 pCR TR 28.865 Rapporteur clean up  2. S5-240938 pCR TR 28.865 Add definitions of terms, symbols and abbreviations | 0.8.0 |
| 2024-03 | SA#103 | SP-240254 |  |  |  | Draft presented for information and approval | 1.0.0 |
| 2024-03 | SA#103 |  |  |  |  | Upgrade to change control version | 18.0.0 |
| 2024-06 | SA#103 | SP-240816 | 0001 | - | F | Rel-18 CR for TR 28.865 Update the references and decriptions of deterministic communication service assurance | 18.1.0 |