INTERNATIONAL TELECOMMUNICATION UNION

TELECOMMUNICATION STANDARDIZATION SECTOR

STUDY PERIOD 2022-2024

SG11-TD1085/GEN

STUDY GROUP 11

Original: English

Question(s): 13/11 Geneva, 1-10 May 2024

TD

Source: Editors

Title: Output – draft new Recommendation ITU-T Q.MMPS "Requirements and Reference Model of minimum monitoring parameter set generation of Multi-modality communication services in Digital Twin Network" (Geneva, 1-10 May 2024)

Contact: Weihao Yu, China Telecom, China — Tel: +86 20 38639366, Email: yuwh3@chinatelecom.cn

Contact: Cancan Huang, China Telecom, China — Tel: +86 20 38639366, Email: huangcanc@chinatelecom.cn

Contact: Yongsheng Liu, China Unicom, China — Tel: + 86-18601106253, E-mail: liuys170@chinaunicom.cn

Contact: Zhiruo Liu, CAICT, MIIT, China — Tel: +86 10 62300069, Email: liuzhiruo@caict.ac.cn

Contact: Hyunjeong Lee, ETRI, Korea(Rep.of) — Tel: +82-42-860-1213, E-mail: hjlee294@etri.re.kr

Contact: Changkyu Lee, ETRI, Korea(Rep.of) — Tel: +82-42-860-6157, Email: changkyu.lee@etri.re.kr

Abstract: This document is the output of draft new Recommendation ITU-T Q.MMPS "Requirements and Reference Model of minimum monitoring parameter set generation of Multi-modality communication services in Digital Twin Network". It includes the discussion results in the Q13/11 sessions during the SG11 meeting, Geneva, 1-10 May 2024.

This document is the output of draft new Recommendation ITU-T Q.MMPS "Requirements and Reference Model of minimum monitoring parameter set generation of Multi-modality communication services in Digital Twin Network".

The following table shows discussion results for input documents.

Document Number	**Source**	**Title**	**Meeting results**
C362-R1	ETRI	Q.MMPS: Proposed updates on clause 6	Accepted.
C412	China Telecom	ITU-T Q.MMPS "Requirements and Reference Model of minimum monitoring parameter set generation of Multi-modality communication services in Digital Twin Network" - Proposal to modify chapter 4 and chapter 9	Accepted with modifications. 1.Merge the new added description of interactions between components into the content of whole process in clause 9.1.

Draft new Recommendation ITU-T Q.MMPS

Requirements and Reference Model of minimum monitoring parameter set generation of Multi-modality communication services in Digital Twin Network

1 Scope

The scope of this Recommendation consists of:

(1) Requirements of minimum monitoring parameter set generation of Multi-modality communication services in Digital Twin Network;

(2) Methods of minimum monitoring parameter set generation of Multi-modality communication services in Digital Twin Network;

(3) Reference Model for minimum monitoring parameter set generation of Multi-modality communication services in Digital Twin 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 Y.3090] Recommendation ITU-T Y.3090 (2022) "Digital twin network – Requirements and architecture".

[ITU-T Q.PMMC] Recommendation ITU-T Q.PMMC "Protocol for traffic flow coordination of multi-modality communication".

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1 Digital Twin Network [b-ITU-T Y.3090]: A virtual representation of a physical network. It is useful for analysing, diagnosing, emulating and controlling the physical network based on data, model and interface, so as to achieve the real-time interactive mapping between physical network and virtual twin network..

3.2 Terms defined in this Recommendation

This Recommendation defines the following terms:

TBD

4 Abbreviations and acronyms

DTN	Digital Twin Network
NETMCS	Model of Network Element and Topology of Multi-modality communication services
MMPSGM	Minimum Monitoring Parameter Set Generation Model
MPEAM	Monitoring Parameters Effect Analysis Module
MPRAM	Monitoring Parameters Relationship Analysis Module
MPRPR	Monitoring Parameter Relationship Patterns Repository
MPSAM	Monitoring Parameters Selection and Aggregation Module

5 Conventions

6 Background

6.1 Introduction to digital twin

A digital twin is a fit for purpose digital representation of an observable object with synchronization between the object and its digital representation. An observable object can move across multiple industrial domains such as manufacturing, medical, farm, and city, and have different roles depending on the domain. Configuring an observable object into a digital twin involves creating digital twins with different characteristics depending on their purposes and roles for each domain.

Digital twins, which started in the manufacturing domain, is being used in all industries due to operational efficiency and cost saving effects, and are also beginning to be applied to network domain. By representing network resources and environments as digital twins, the digital twin network is expected to provide low-cost testing of functions and procedures, intelligent decision-making, efficient innovation and predictive maintenance.

6.2 Introduction of Multi-modality communication services

Multi-modality communication services is defined in ITU-T Q.PMMC "Protocol for traffic flow coordination of multi-modality communication". It quotes from Q.PMMC as below:

"Multi-modality communication services require network for ultra-low latency, high reliability and security to ensure multi-modality interactions. The typical network services are video, audio, sensor information and haptic senses. It has been used in varies scenarios widely, e.g. remote human interaction, tele-operation, social network of robots, industry and commercial IoT services."

6.3 Current network monitoring parameters and their drawbacks in Multi-modality communication services

Currently, there is a great quantity of network monitoring parameters to describe network image and conditions. These parameters are reflecting different side faces of the network with different scales. The types of parameters could be roughly sorted by two classes "objects" and "protocols (services who use the parameters)". Normally, different classes of parameters are manually assembled and combined to evaluate a give network services by administrators based on long term historic experience or standards.

6.3.1 Monitoring parameters classified by object (MPCO)

Monitoring Type	Monitoring paramters	Tools	Methods	
FM	CC (Continuity Check)	Ethernet LB/IP ping/MPLS LSP ping/SRv6 SID ping	Active	Bi-direction: Request-path: SRv6 segment path

(Fault Management)	CV (Connectivity Verification)	Ethernet Linktrace /IP traceroute/MPLS traceroute/SRv6 SID Traceroute		Echo-path: IP path calculated by default routing protocols
Performance Management	Delay, Loss and Throughput	TWAMP, Color-based(IPFPM)	Passive	Uni-direction: SRv6 segment path

Table-1 Monitoring parameters and their related tools classified by their objects (MPCO)

The network monitor parameters could be divided into two major types based on their targets. One is fault management, the other is performance measurement (see table-1).

(1) FM (Fault Management) includes two types of parameters:

a. CC (Continuity Check) parameters are used to describe the reachability of a destination address. The related tools include Ethernet LB/IP ping/MPLS LSP ping/SRv6 SID ping etc.

b. CV (Connectivity Verification) parameters are used for path verification and fault allocation. The related tools include Ethernet Linktrace/IP traceroute/MPLS traceroute/SRv6 SID Traceroute etc.

(2) PM (Performance Measurement) parameters are used for describing the performance of network links and nodes:

a. Delay is used for describing the delay of dedicated packets/traffic flow.

b. Loss is used for reflecting the loss rate of dedicated device and traffic flow.

c. Throughput is used for representing the throughput of networks routers/switches.

The related tools for PM include TWAMP, IPFPM and telemetry etc.

The main drawback of the MPCO is “superficial and fragmentize”. It classifies the parameters by the superficial features of network, not by the insights/context/nature of the network. For example, the reachability, throughput, delay and jitter are multiple sides of the surface. So, the MPCO parameters are scrappy and their number is large. To figure out the cause of the network failure, the administrators need to launch huge number of tools to obtain the values of the parameters. Inevitably, the tedious cooperation among the tools leads to low efficiency.

In the multi-modal network scenario, the diverse surface features may have inner connection and may share the same model structure in the hidden layer constructed by the network’s underground logic. For example, path A and path B are unrelated in surface topology, but they are related to the hidden topology. It is possible that the performance parameter measured by PM tools of one “congestion” path A could be used to predict the “breakdown” status of path B, vice versa. In this scenario, the performance parameter of path A is enough to figure out the problem and FM parameters of path B are not necessary to be collected.

To conclude, the “superficial different” nature of MPCO parameters is not resonating with the “hidden related” nature of the multi-modal network.

6.3.2 Monitoring parameters classified by services (MPCS)

The ISO model designed a generalized structure of 7 hierarchical layers for all the network services. The deployment of a dedicated network service is an integrated project of choosing one protocol from each layer and assembling them.

These protocols are isolated and could do not talk to each other. For example, the IP ping/traceroute tools are designed to manage the network service based on IP protocol. Similarly, the Ethernet LB/Link traceroute tools for services based on Ethernet and MPLS LSP ping/MPLS traceroute tools for services based on MPLS.

Each protocol has its own set of parameters with different objects (MPCO) to reflect its related status. Consequently, the MPCO parameters are further divided to MPCS to fit diverse protocols.

The main drawback of measurement parameters for specific protocols/layer is isolated. The "isolated/layered" nature of parameters is conflicting with the "integrated" nature of network service. When a network failure happens, we often start the trouble shooting from the top to bottom of the ISO model. The administrators have to use separated tools to collect the value of the parameters in order to find out the root cause layer by layer within the ISO model. This leads to large time consuming and extremely low efficiency with the following reasons:

1) More deeply the root cause hidden from the surface, the larger number of parameters the administrator is required to collect from layer to layer. And inevitably, much more switching time among the measurement tools will be consumed.
2) Different ISO layer is operated by different operation department. The administrators are often experts in one dedicated area but not very much professional in other area. A simple failure may drag many operating departments in. It will spend lots of manpower and time.

To conclude, the "isolated/layered" nature of MPCS parameters is not properly coordinating with the "integrated" network service. It cannot match the high efficiency requirements of network measurement in failure debugging.

6.3.3 Monitoring parameters assembling

Currently, different classes of parameters are manually assembled and combined to evaluate a give network services by administrators based on expert experience. In the scenario of multi-modal network, because each service has its distinct characters, the administrators have to manually group different parameters to monitor the service one by one. Nowadays, diverse network services emerge in very high speed, to generate a precise parameter set for each service in a given short time is far exceed the operators capabilities.

6.3.4 Drawbacks Summary

There are multiple side faces of network. In other words, there are multi-modal network parameters to describe the network statuses and performance.

1) Firstly, these parameters are distinct from each other on the surface, ignoring the inner relationships among them in the hidden logical layer of the network. Inevitably, the parameters are large in number and have great deal of redundant and duplicated information.
2) Secondly, the separated Internet ISO layers for a dedicated network service sub-divide the scrappy parameters into much more fine-grained particles and even worsen the situation by ignoring the inner relationship and connection between the layers.
3) Thirdly, there are unique customized parameters set for different services. The time-consuming experts' experience and standardization process cannot resonate with the high speed emerging of new network services.

This draft recommendation describes the requirements, the method and the reference model of minimum monitoring parameter set generation that can cope with the challenges of monitoring requirements of multi-modality communication services, while minimizing the human intervention and cost towards the runtime operation.

7 Requirements of minimum monitoring parameter set generation

The "superficial" and "isolated" nature of current network parameters introduce a large quantity of redundant and duplicated information. Instead of helping the fault allocation and debugging, these fragmented parameters reduce the efficiency and increase the COPEX.The requirement of the smallest size set guarantees that the parameters within this set are dead on the target, directly point

to the problem and with no redundant and useless information to the greatest extent. And the minimum monitoring parameter set generation could save the manpower to the largest extends.

***REQ-1*:** The minimum monitoring parameter set generation is required to generate the minimum set of parameters to describe the most comprehensive picture of the network services.

***REQ-2*:** The minimum monitoring parameter set generation is required to endogenously generate the monitoring parameters with the minimum or without the human intervention.

EDITOR NOTE: REQ-1 and REQ-2 are the general requirements of the reference model. More specific requirements will be added as the work item is progressed,such as closed-loop, self-supervised and etc. Contributions are invited.

8 Reference Model of minimum monitoring parameter set generation

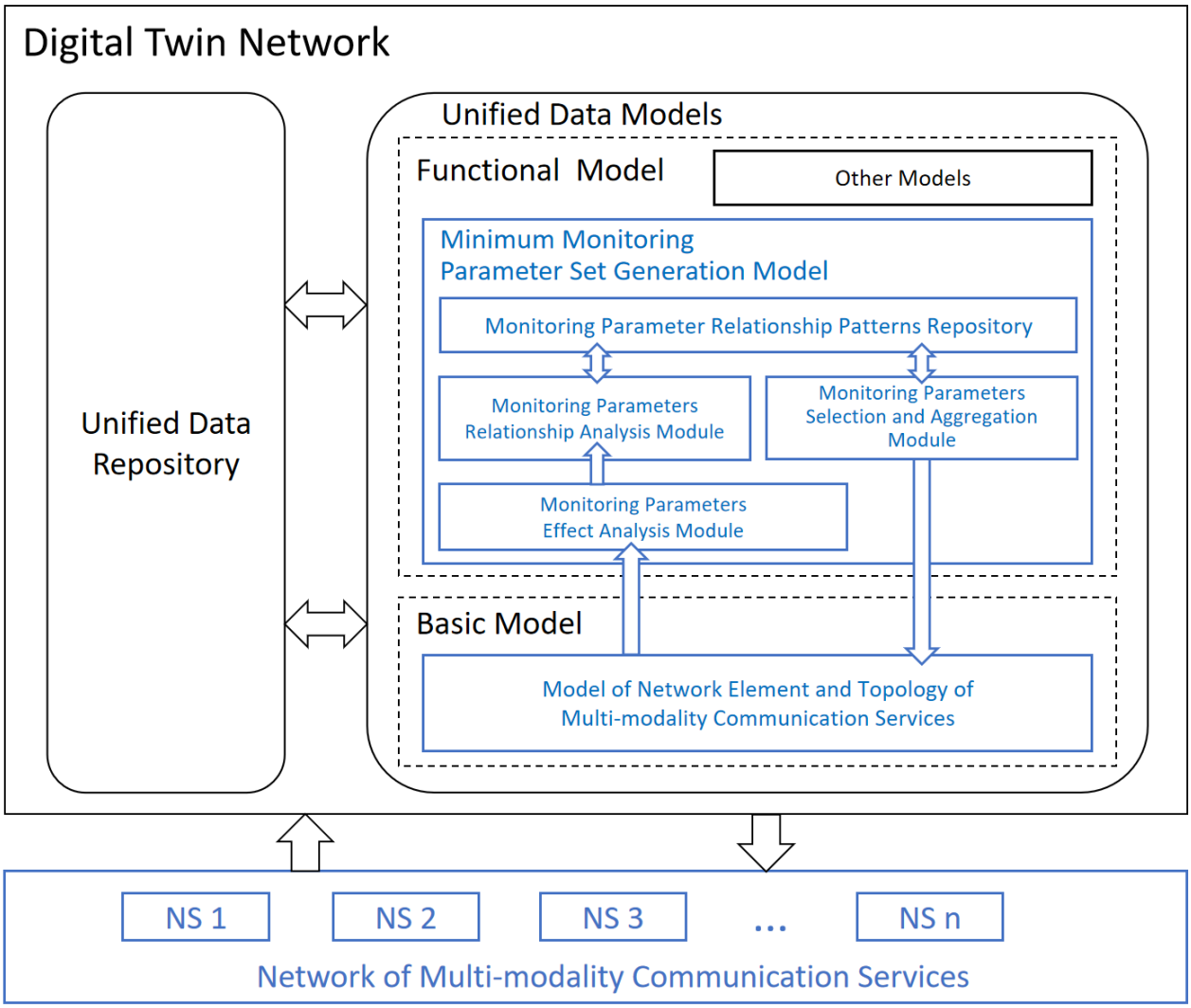

Figure 8-1 Reference Model of minimum monitoring parameter set generation for multi-modality communication services in DTN

The reference model of minimum monitoring parameter set generation for multi-modality communication services in DTN is depicted in Figure 8-1.

(1) A “Minimum monitoring parameter set generation model” is added to the functional model part of DTN;

(2) A "Network Element and Topology of Multi-modality communication services model" is added to the basic model part of DTN;
(3) The DTN interacts with the Network of Multi-modality Communication Services.

The newly added modules and the interactions among the modules within this reference model are described as below:

-**The network of multi-modality communication services.** It is described in ITU-T Q.PMMC.

- Model of Network Element and Topology of Multi-modality communication services(NETMCS). This model is based on the network element model and network topology model located in the basic model part of the DTN. This model emulates the real network of multi-modality communication services, while provides the functions of verify and emulate the updated minimum monitoring parameter set, so as to ensure the effectiveness of the change before it is applied to the real multi-modality communication services. It outputs the network status to MPEAM and receives the monitoring parameter set as input from MPSAM.

- Minimum Monitoring Parameter Set Generation Model (MMPSGM). The model uses the MPEAM, MPRAM, MPSAM and MPRPR modules to figure out the minimum sets of monitoring parameter.

- Monitoring Parameters Effect Analysis Module (MPEAM). This module is responsible for collecting network status from the network, calculating the monitoring effect of the new monitoring parameter set applied in the network, and determining whether to trigger the minimum monitoring parameter generation process based on the monitoring quality.

- Monitoring Parameters Relationship Analysis Module (MPRAM). This module is responsible for mining the inherent relationships such as correlations, dependencies and associations within the monitoring parameters, generating monitoring parameter relationship patterns and saving them to the MPRPR.

- Monitoring Parameters Selection and Aggregation Module (MPSAM). This module is responsible for selecting and aggregating the monitor parameters to form a minimum set based on the parameter relationship patterns provided by the MPRPR.

- Monitoring Parameter Relationship Patterns Repository (MPRPR). This module is responsible for storing the monitoring parameter relationship patterns calculated by the MPRAM and generating the relationship graph of monitoring parameters. The parameters could be roughly divided into three categories.The overall high order common parameter patterns, the higher order common parameter patterns for mutli-modality communication services of multiple degrees and the low order individual parameter patterns of dedicated services. These three types of parameter patterns could cover almost all the relationships of the monitoring data in a comprehensive degree.

9 Procedures of minimum monitoring parameter set generation

9.1 The procedure of MMPSGM

The procedure of MMPSGM firstly determines the monitoring effect of the current monitoring parameter set, while using the parameter set to monitor the status of the target network. If the monitoring effect does not meet the preset requirements, the method determines the relationship between various monitoring parameters in the current monitoring parameter set. Then, the new monitoring parameter set is generated based on the relationship between various monitoring parameters and distributed to the target network. Subsequently, the target network enables network status monitoring based on the new monitoring parameter set.

The whole process is described as follows:

Step 1: The MPEAM in MMPSGM collects the network status from the target network after configuring the current monitoring parameter set to the network.

Step 2: The MPEAM determines the monitoring effect of the current monitoring parameter set for the target network, according to monitoring complexity, monitoring coverage and the monitoring result gap between the previous and current monitoring parameter sets. If the monitoring effect is below the preset threshold, the MPEAM determines that the monitoring effect of the current monitoring parameter set does not meet the preset requirements, and sends a triggering signal to MPRAM. Once the MPRAM receives the triggering signal, it will send a acknowledge signal to the MPEAM for confirming. In this case, the process of discovering the relationship between various monitoring parameters will be triggered in the MPRAM. Otherwise, this process will not be triggered.

Step 3: After triggering by the MPEAM, the MPRAM discovers the inherent relationships ~~such as correlations, dependencies and associations~~ within the monitoring parameters in current monitoring parameter set based on data mining methods such as association analysis algorithm, clustering algorithm, causal analysis algorithm, etc.

Step 4: The MPRAM generates the relationship tuples based on the inherent relationships of any two monitoring parameters, and sends these tuples to the MPRPR for saving. ~~saves the all of relationship tuples to the MPRPR.~~

Step 5: Once the MPRPR completes receiving the relationship tuples, it will send a acknowledge signal to the MPRAM for confirming. After receiving relationship tuples, the MPRPR generates the relationship graph based on the monitoring parameter relationship tuples~~triplets~~.

Step 6: The MPSAM sends a data requset signal to the MPRPR, and acquires monitoring parameter relationships from the MPRPR. After receiving the request signal, the MPRPR will response the required relationship tuples to the MPSAM. The MPSAM selects appropriate monitoring parameters and forms the new monitoring parameter set, according to the monitoring parameter relationships.

> ~~*Editor's note: some descriptions to describe the interactions between each component in the process of method of MMPSGM.*~~

9.2 The procedure of MPEAM

9.3 The procedure of MPRAM

9.4 The procedure of MPSAM