

Draft new Recommendation ITU-T Y.DT-NS

Digital twin for network slicing in IMT-2020 networks and beyond

Summary

With the development of IMT-2020 networks and beyond, the network demand changes more dynamically to support diverse services, which increases the complexity of network slicing and puts forward higher demands on the quality of service. Therefore, it is necessary to enhance network slicing mechanisms by digital twin for accurately implementing the demand of real-time resource changes and evaluate network slice performance in advance. Digital twin for network slicing makes a potential solution for addressing high efficient slicing resource utilization issues.

This Recommendation specifies the overview, requirements, framework, network function enhancements, procedures and security considerations of digital twin for network slicing in IMT-2020 networks and beyond.

Keywords

Digital twin, network slicing, IMT-2020

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Draft new Recommendation ITU-T DT-NS

Digital twin for network slicing in IMT-2020 networks and beyond

1. Scope

This Recommendation specifies the Digital twin for network slicing in IMT-2020 networks and beyond.

This Recommendation addresses the following aspects of Digital twin for network slicing in IMT-2020 networks and beyond:

- Overview;
- Requirements;
- Framework and network function enhancements;
- Procedures;
- Security considerations.

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 Y.3100] Recommendation ITU-T Y.3100 (2017), *Terms and definitions for IMT-2020 network*.

3. Definitions

3.1. Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

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

NOTE – [b-ITU-R M.1645] defines the framework and overall objectives of the future development of IMT-2000 and systems beyond IMT-2000 for the radio access network.

3.1.2 network function [ITU-T Y.3100]: In the context of IMT-2020, a processing function in a network.

3.1.3 Digital Twin Network (DTN) [ITU-T Y.3090]: Digital Twin Network is a virtual representation of the physical network, analyzing, diagnosing, simulating 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

This Recommendation uses the following abbreviations and acronyms:

AN	Access Network
DT	Digital Twin
DTN	Digital Twin Network
M&O	Management and Orchestration
QoS	Quality of Service
RAN	Radio Access Network
UE	User Equipment

TBD

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 Recommendation 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" indicate an optional requirement which is permissible, without implying any sense of being recommended. This term is 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 this Recommendation.

6. Overview

Network slicing can provide customized and dedicated network services for various business and social fields. Network slicing based on network softwarization techniques provides flexibility, agility and diversity of network service. However, with the development of IMT-2020 network and beyond, more and more service scenarios and requirements are emerging, which increases the complexity of network slicing and puts forward higher demands on the quality of service. The existing network slicing mechanisms are difficult to accurately meet the demand of real-time resource changes and evaluate slice performance in advance. For example, self-automated driving is a highly dynamic environment where entities (such as vehicles) and requirements (such as data rates or latency) are constantly changing. Traditional resource allocation is often fixed or based on

predetermined rules. This approach may lead to wasted resources or bottlenecks facing the changing network requirements.

Under this circumstance, digital twin can be used to establish a digital twin network(DTN) as a virtual representation of the physical network, and can integrate all existing data to create an accurate digital network simulation in real time[ITU-T Y.3090]. DTN has the advantages of strong visualization, high real-time performance, and high simulation accuracy, which makes it a potential solution for addressing high efficient resource utilization issues. User environments and network slicing can be simulated by digital twin network so as to optimally perform network resources allocation. Therefore, introducing the technical concept of DTN into the orchestration and evaluation for network slicing can be a promising solution to improve the efficiency and flexibility of network slice resource allocation.

TBD

7. Requirements

[Editor's Note] This clause specifies the requirements of digital twin for network slicing in IMT-2020 networks and beyond.

TBD

8. Framework and network function enhancements

[Editor's Note] This clause specifies the framework and network function enhancements of digital twin for slicing network in IMT-2020 networks and beyond.

Figure 8-1 shows the overview framework of digital twin network orchestration and evaluation for network slicing. Referring the digital twin architecture combining it with the characteristics of network slice, the digital twin function can be designed including data collection & processing, digital twin model building, network slicing & service simulation, analysis & evaluation, slicing strategic decision and quality of service assurance, as shown in Figure 8-1. By using digital twin and other technologies, digital twin function builds digital twin model to simulate users' slice requirements and forecast network changes, in order to set configuration parameters, automatically execute resource orchestration and evaluate slicing performance.

Based on DT model and real-time network status, digital twin function can perceive user experience and network slice's performance, and dynamically optimize network slice configuration, so that users' requirements can be satisfied during the whole life-cycle of network slices. Besides, operation and maintenance expenses can be reduced.

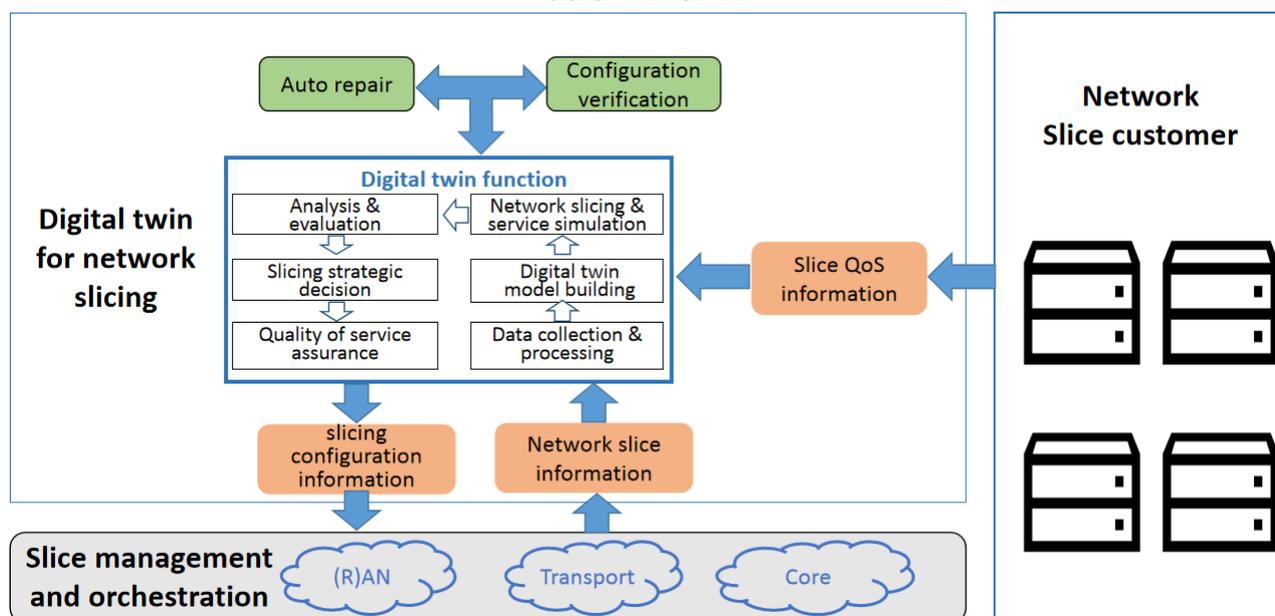


Figure 8-1 – Framework of network slicing with digital twin

Editor's note [20240307]: need further explanation on how digital twin can support network slicing, Y.3153 and Y.3156 can be referred to this new proposal.

The digital twin function acts as a medium for bridging the operator's network and the network slice customers. It collects network slice customer's QoS information and network slice information as data sources, and gives analysis results to the slice management and orchestration (M&O) by using digital twin function.

For example, for network slice resource optimization by using an digital twin method, the digital twin function designs a network resource allocation plan and simulates the networks of slice allocation(e.g., targeted logical/physical resources, assigned bandwidth, an execution schedule latency and user experience rate, etc), which can satisfy the customer's requirements. If the allocation plan is examined its feasibility and safeness by digital twin function, then the slice M&O triggers the dynamic adjustment of network resources.

Data collection and processing: this function is able to collect all types of physical network slicing related data from network slice customer and slice M&O. And this function completes the work of extracting, converting, cleaning and loading the collected data. The data collection mode should be goal-driven (for example, full or partial data collection based on requirements) and support different data collection protocols.

Digital twin model building: this function is able to build the digital twin network model of network slicing based on collected and processed data, and realize the mapping of the digital twin network to the physical network. This includes building network elements and network topology. And according to the requirements, the system should be able to efficiently and flexibly customize the digital twin network of different scale and different network structure.

Network slicing and service simulation: this function is able to simulate and compute network slicing resources, network performance, service requirements and features, etc. It also has the capability to simulate network slicing service faults, and output protection solutions and resource configuration requirements

Analysis and evaluation: this function is able to count and analyse the data of slicing resource, and predict future service requirements, which provides a reference for network slicing resource

allocation. Besides, the function can evaluate network slice allocation performance in advance based on analysis and simulation results.

Slicing strategic decision: this function is able to plan and design end-to-end slicing schemes. It has the ability to optimize network resource utilization efficiency, network reliability and network delay.

Quality of service assurance: this function is able to provide a customized service quality assurance solution for slice customer based on the digital twin network, and monitor network performance and quality indicators real-time. By analyzing and comparing real-time data, network faults and anomalies can be detected in a timely manner to further improve network performance and quality.

TBD

9. Procedures

[Editor's Note] This clause specifies the procedures of digital twin for slicing network in IMT-2020 networks and beyond.

TBD

10. Security considerations

[Editor's Note] This clause presents the security considerations of digital twin for slicing network in IMT-2020 networks and beyond, which include network security, service security, and user privacy.

TBD

Bibliography

[b-ITU-T Y.3153] Recommendation ITU-T Y.3153 (2019), *Network slice orchestration and management for providing network services to 3rd party in the IMT-2020 network.*

[b-ITU-T Y.3156] Recommendation ITU-T Y.3156 (2020), *Framework of network slicing with AI-assisted analysis in IMT-2020 networks.*

[b-ITU-R M.1645] Recommendation ITU-R M.1645 (2003), *Framework and overall objectives of the future development of IMT-2000 and systems beyond IMT-2000.*_

Appendix I

Standardization landscape on digital twin and network slicing

(This appendix does not form an integral part of this Recommendation.)

In recent years, digital twin related topics have been studied in ITU-T, 3GPP, IETF, ETSI and other SDOs, which are as follows.

The existing work items in ITU-T and other SDOs have not addressed digital twin for network slicing in IMT-2020 networks and beyond. The proposed work item specifies the overview, requirements, framework, network function enhancements, procedures and security consideration of digital twin for network slicing in IMT-2020 network and beyond. The proposed work item does not overlap with existing work items on digital twin or network slicing, for the reason that the proposed work focuses on the improvement of network slicing service functions base on digital twin. In this case, the usage of digital twin for network slicing will be a feasible solution to improve the efficiency and flexibility of network slice resource allocation. Therefore, the proposed work item can be researched in parallel with other work items on digital twin or network slicing.

Organizations and projects	Description and applicability	Gap Analysis
ITU-T SG13 Y.3090	<p>ITU-T Y.3090, “ Digital twin network - Requirements and architecture”.</p> <p>This Recommendation describes the definition, requirements and architecture of a digital twin network (DTN).</p> <p>The scope of this work includes:</p> <ul style="list-style-type: none"> • Overview of a DTN; • Requirements of DTN; • Architecture of a DTN. 	<p>Y.3090 specifies the definition, architecture and requirements of DTNs, while how to orchestrate the slicing resources by digital twin is not mentioned.</p> <p>The proposed new work item focuses on DTN for network slicing. Thus, there is no overlap with Y.3090.</p>
ITU-T SG13 Y.DTN-DataFrame	<p>ITU-T Y.DTN-DataFrame: “ Digital Twin Network - Framework and functional requirements of data domain in network digital twin layer” .</p> <p>This Recommendation specifies framework and functional requirements of data domain in network digital twin layer of Digital Twin Network (DTN) system. It mainly addresses the following subjects:</p> <ul style="list-style-type: none"> • Data scope and types in DTN’s data domain • Framework for DTN’s data domain; • DTN data domain’s functional requirements including data collection, data storage, data processing and data management; • Define unified interfaces for data services • Compatibility of DTN’s data domain to accommodate legacy data sources. 	<p>ITU-T Y.DTN-DataFrame specifies framework and functional requirements of data domain in network digital twin layer of Digital Twin Network (DTN) system</p> <p>The proposed new work item focuses on DTN for network slicing, especially for the slicing resources allocation and performance evaluation. Thus, there is no overlap with ITU-T Y.DTN-DataFrame.</p>
ITU-T SG13 Y.IMT2020-DTNMO	<p>ITU-T Y.IMT2020-DTNMO: “ Digital twin network - Management and Orchestration” .</p> <p>This draft Recommendation specifies the management and orchestration aspects of Digital Twin Network and puts forwards the necessities and value of research on IMT-2020 network and beyond. This Recommendation describes the Management and Orchestration of Digital Twin Network. The scope of this</p>	<p>ITU-T Y.IMT2020-DTNMO mainly specifies the management and orchestration aspects of Digital Twin Network and puts forwards the necessities and value of research on IMT-2020 network and beyond</p> <p>The proposed new work item focuses on DTN for network slicing, especially for the slicing resources allocation and performance evaluation. Thus, there is no overlap with ITU-T</p>

	<p>recommendation includes the following items:</p> <ul style="list-style-type: none"> • General requirement • Framework and interfaces of DTN for M&O • Data collection • Security considerations 	Y.IMT2020-DTNMO
ITU-T SG13 Y.EAIAA	<p>ITU-T Y.EAIAA: “ Enhanced AI-assisted analysis for network slicing in IMT-2020 networks and beyond”</p> <p>This Recommendation specifies the Enhanced AI-assisted analysis for network slice management and orchestration in IMT-2020 networks and beyond.</p> <p>This Recommendation addresses the following aspects of Enhanced AI-assisted analysis for network slice management and orchestration:</p> <ul style="list-style-type: none"> • Requirements; • Framework; • Procedures; • Security considerations; 	<p>ITU-T Y.EAIAA mainly specifies the Enhanced AI-assisted analysis for network slice management and orchestration in IMT-2020 networks and beyond.</p> <p>The proposed new work item focuses on network slicing based on DTN, not involving AI-assisted analysis. Thus, there is no overlap with ITU-T Y.EAIAA.</p>
ITU-T SG11 Q.SDTN	<p>ITU-T Q.SDTN: “Signalling and protocol for Digital Twin Network supported for IMT-2020 network and beyond”.</p> <p>This draft new Recommendation is aiming to specify the interface for data exchange among digital twin network, 3rd party application and physical network, procedure of data interaction among physical network.</p>	<p>ITU-T Q.SDTN mainly specifies the interface and procedure of data interaction for IMT-2020 network and beyond.</p> <p>The proposed new work item focuses on requirements and framework of network slicing based on DTN. Thus, there is no overlap with ITU-T Q.SDTN.</p>
IETF NMRG draft-zhou-nmrg-digitaltwin-network-concepts	<p>IETF draft-zhou-nmrg-digitaltwin-network-concepts, “Digital Twin Network: Concepts and Reference Architecture”.</p> <p>This draft presents an overview of the concepts of Digital Twin Network, provides the basic definitions and a reference architecture, lists a set of application scenarios, and discusses the benefits and key challenges of such technology.</p> <p>The scope of this work includes:</p> <ul style="list-style-type: none"> • Introduction and Concepts of Digital Twin Network. • Benefits of Digital Twin Network. • Enabling Technologies to Build Digital Twin Network 	<p>The draft-zhou-nmrg-digitaltwin-network-concepts mainly focuses on concepts, architecture and enabling technologies of DTN.</p> <p>The proposed new work item focuses on DTN for the slicing resources allocation and slicing performance evaluation. There is no overlap with the IETF work draft.</p>
ETSI ZSM Network Digital Twin	<p>ZSM Network Digital Twin</p> <p>This report will describe the Network Digital Twin concept, investigate its applicability for automation of zero-touch network and service management and introduce existing, emerging and future scenarios that can benefit from it. Principles and functionality needed to support and utilize the Network Digital Twin for zero-touch network and service management will be introduced, considering also state of the art.</p>	<p>ZSM Network Digital Twin is aiming to describe the Network Digital Twin concept, investigate its applicability for automation of zero-touch network and service management and introduce existing, emerging and future scenarios that can benefit from it.</p> <p>This proposed work item is aiming to specify digital twin for network slicing. There is no overlap between the proposed work item and</p>

	<p>The report will outline recommendations of additional capabilities needed in the ZSM framework to support Network Digital Twins. The report will identify existing specifications and solutions (both ETSI and external ones) that can be leveraged to maximize synergies.</p>	<p>ZSM Network Digital Twin.</p>
<p>3GPP SA5 Management aspect of Network Digital Twin</p>	<p>3GPP SA5 Management aspect of Network Digital Twin(FS_NDT) This item introduce the digital twin in 3GPP management system, which includes two objectives:</p> <ul style="list-style-type: none">□ WT-1 Investigate and define the terms related to Digital Twin (e.g. NDT) in the 3GPP management system.□ WT-2 Study use cases, requirements and solutions for the use of NDT, e.g., for verification of the network operations. <p>Scenarios may include RAN optimization and service assurance.</p>	<p>3GPP SA5 FS_NDT mainly focus on the use cases, requirements and solutions in 3GPP management system.</p> <p>The proposed new work item focuses on DTN for the slicing resources allocation and slicing performance evaluation. There is no overlap with FS_NDT from SA5.</p>

Annex A

A.1 justification for proposed draft new ITU-T Y.DT-NS on “Digital twin for network slicing in IMT-2020 networks and beyond”

Question:	Q21/13	Proposed new ITU-T Recommendation	Geneva, 4-15 March 2023
Reference and title:	ITU-T Y.DT-NS on “Digital twin for network slicing in IMT-2020 networks and beyond”		
Base text:	SG13-TDxxx/WP1	Timing:	Q4, 2025
Editor(s):	Mingrui Sun, China Unicom, e-mail: sunmr19@chinaunicom.cn Lu Li, China Unicom, e-mail: lil368@chinaunicom.cn Yushuang Hu, China Mobile, e-mail: huyushuang@chinamobile.com Huan Deng, China Telecom, e-mail: denghuan@chinatelecom.cn Yingjun Zhou, ZTE Corporation, e-mail: zhou.yingjun@zte.com.cn	Approval process:	AAP
<p>Scope (defines the intent or object of the Recommendation and the aspects covered, thereby indicating the limits of its applicability):</p> <p>This Recommendation specifies the Digital Twin for network slicing in IMT-2020 networks and beyond. This Recommendation addresses the following aspects of Digital Twin for network slicing in IMT-2020 networks and beyond:</p> <ul style="list-style-type: none"> • <input type="checkbox"/> Overview; • <input type="checkbox"/> Requirements; • <input type="checkbox"/> Framework and network function enhancements; • <input type="checkbox"/> Procedures; • <input type="checkbox"/> Security considerations. 			
<p>Summary (provides a brief overview of the purpose and contents of the Recommendation, thus permitting readers to judge its usefulness for their work):</p> <p>With the development of IMT-2020 network and beyond, more and more service scenarios and requirements are emerging, which increases the complexity of network slicing and puts forward higher demands on the quality of service. The existing network slicing mechanisms are difficult to accurately satisfy the demand of real-time resource changes and evaluate slice performance in advance.</p> <p>Digital twin can be used construct a digital twin network(DTN) as a virtual representation of the physical network, and can integrate all existing data to create an accurate digital network simulation in real time. DTN has the advantages of strong visualization, high real-time performance, and high simulation accuracy, which makes it a potential solution for addressing high efficient resource utilization issues. User environments and network slicing can be simulated by digital twin network, so as to optimally perform network resources allocation for various network slicing. The digital twin function designs a network resource allocation plan and simulates the network of slice allocation, which could satisfy the customer's requirements Therefore, it is necessary to enhance network slicing capabilities with digital twin in IMT-2020 networks and beyond.</p> <p>This Recommendation specifies the overview, requirements, framework, network function enhancements, procedures and security considerations of digital twin for network slicing in IMT-2020 networks and beyond.</p>			
<p>Relations to ITU-T Recommendations or to other standards (approved or under development):</p> <p>ITU-T Y.3090, ITU-T Y.DTN-DataFrame, Y.IMT-2020-DTNMO, ITU-T Y.EAIAA, ITU-T SG Q.SDTN, IETF draft-zhou-nmrg-digitaltwin-network-concepts</p>			

Liaisons with other study groups or with other standards bodies:

ITU-T SG2, ITU-T SG11, IETF NMRG, ETSI ZSM, 3GPP SA5

Supporting members that are committing to contributing actively to the work item:

China Unicom, China Mobile, China Telecom, ZTE, BUPT
