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International Telecommunication Union
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Recommendation

ITU-T Y.3117 (05/2023)

SERIES Y: Global information infrastructure, Internet protocol aspects, next-generation networks, Internet of Things and smart cities

Future networks

Quality of service assurance-related requirements and framework for smart education supported by IMT-2020 and beyond

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Recommendation ITU-T Y.3117

Quality of service assurance-related requirements and framework for smart education supported by IMT-2020 and beyond

Summary

Recommendation ITU-T Y.3117 specifies the quality of service (QoS) assurance-related requirements and framework for smart education supported by the international mobile telecommunications 2020 (IMT-2020) and beyond.

Recommendation ITU-T Y.3117 first provides an overview of smart education supported by IMT-2020 and beyond. It then specifies the QoS assurance-related requirements and a framework. Finally, the QoS considerations for smart education services are described in Appendix I.

History *

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Keywords

Framework, IMT-2020, QoS assurance-related, requirements, smart education.

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The World Telecommunication Standardization Assembly (WTSA), which meets every four years, establishes the topics for study by the ITU-T study groups which, in turn, produce Recommendations on these topics.

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Quality of service assurance-related requirements and framework for smart education supported by IMT-2020 and beyond

1 Scope

This Recommendation specifies the quality of service (QoS) assurance-related requirements and a framework for the smart education supported by the international mobile telecommunications 2020 (IMT-2020) and beyond, the scope of this Recommendation is as follows:

- Overview;
- Requirements;
- Framework;
- QoS 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.3102] Recommendation ITU-T Y.3102 (2018), *Framework of the IMT-2020 network*.

[ITU-T Y.3104] Recommendation ITU-T Y.3104 (2018), *Architecture of the IMT-2020 network*.

[ITU-T Y.3106] Recommendation ITU-T Y.3106 (2019), *Quality of service functional requirements for the IMT-2020 network*.

[ITU-T Y.3107] Recommendation ITU-T Y.3107 (2019), *Functional architecture for QoS assurance management in the IMT-2020 network*.

[ITU-T Y.3109] Recommendation ITU-T Y.3109 (2021), *Quality of service assurance-related requirements and framework for virtual reality delivery using mobile edge computing supported by IMT-2020*.

[ITU-T Y.3130] Recommendation ITU-T Y.3130 (2018), *Requirements of IMT-2020 fixed mobile convergence*.

[ITU-T Y.3158] Recommendation ITU-T Y.3158 (2022), *Local shunting for multi-access edge computing in IMT-2020 networks*.

[ITU-T Y.3170] Recommendation ITU-T Y.3170 (2018), *Requirements for machine learning-based quality of service assurance for the IMT-2020 network*.

[ITU-T Y.3172] Recommendation ITU-T Y.3172 (2019), *Architectural framework for machine learning in future networks including IMT-2020*.

[ITU-T Y.3175] Recommendation ITU-T Y.3175 (2020), *Functional architecture of machine learning-based quality of service assurance for the IMT-2020 network*.

[ITU-T Y.4000] Recommendation ITU-T Y.4000/Y.2060 (2012), *Overview of the Internet of things*.

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

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

NOTE 1 – [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.

NOTE 2 – This definition is based on [b-ITU-R M.2083-0].

3.1.2 Internet of things (IoT) [ITU-T Y.4000]: A global infrastructure for the information society, enabling advanced services by interconnecting (physical and virtual) things based on existing and evolving interoperable information and communication technologies.

3.1.3 multi-access edge computing (MEC) [b-ETSI GS MEC 001]: System which provides an IT service environment and cloud-computing capabilities at the edge of an access network which contains one or more type of access technology, and in close proximity to its users.

3.1.4 quality of experience (QoE) [b-ITU-T P.10]: The degree of delight or annoyance of the user of an application or service.

NOTE – Recognizing on-going research on this topic, this is a working definition which is expected to evolve for some time. (This note is not part of the definition.)

3.1.5 quality of service (QoS) [b-ITU-T P.10]: The totality of characteristics of a telecommunications service that bear on its ability to satisfy stated and implied needs of the user of the service (see [b-ITU-T E.800]).

3.1.6 quality of service assurance [ITU-T Y.3109]: Functionalities or mechanisms that enable service providers to make statements with a degree of confidence that the service meets the quality characteristics or objectives specified elsewhere.

3.2 Terms defined in this Recommendation

None.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

AF Application Function

AI Artificial Intelligence

AN Access Network

AR Augment Reality

CEF Capability Exposure Function

CN Core Network

DN Data Network

E2E End-to-End

FMC Fixed Mobile Convergence

GIS Geographic Information System

HD High Definition

ICM Interactive Classroom

IMT International Mobile Telecommunications

IoT Internet of Things

MEC Multi-access Edge Computing

ML Machine Learning

NACF Network Access Control Function

NFR Network Function Registry

NSSF Network Slice Selection Function

PCF Policy Control Function

QoE Quality of Experience

QoS Quality of Service

RP Reference Point

SE Smart Education

SLA Service Level Agreement

TAL Teaching and Learning

UE User Equipment

UPF User Plane Function

USM Unified Subscription Management

VR Virtual Reality

5 Conventions

This Recommendation uses the following conventions:

The term "is required to" indicates 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.

6 Overview

Use of information technology for education is advancing and improving education quality around the world. Fair, quality, innovative, personalized, and competence-oriented education is a common goal. Smart education (SE) is an Internet of things (IoT)-based educational framework. Its purpose is to enhance learning experience, improve teaching efficiency, and enable high content adaptability to provide digitalized, interactive, and intelligent services with ubiquitous connectivity. Technologies such as Internet, IoT [ITU-T Y.4000], IMT-2020 [b-ITU-T Y.3100], cloud, big data, and artificial intelligence (AI) are promising solutions to create intelligent, intuitive, and ubiquitous education [b-smart-edu].

IMT-2020 and beyond, with the capabilities of high bandwidth, low latency, massive connectivity, is a key enabler for smart education. The introduction of smart education utilizing the IMT-2020 and beyond capabilities will not be straightforward, as education systems have different knowledge sets and speak in different technical languages. It is important for smart education service providers and network operators to be aware of the quality of service (QoS) [b-ITU-T P.10] requirements before deployment of a smart education system. From the network operator point of view, the requirements can be used for efficient network QoS planning, QoS provisioning, QoS monitoring and QoS

optimization [ITU-T Y.3106] [ITU-T Y.3107]. From the smart education service provider point of view, the requirements ensure that the smart education service quality is met.

The representative smart education services and management include: smart classroom, smart campus, smart education analysis and smart education management, etc. These smart education services are supported by a fixed mobile convergence (FMC) [ITU-T Y.3130] system in IMT-2020 and beyond, which is shown in Figure 1.

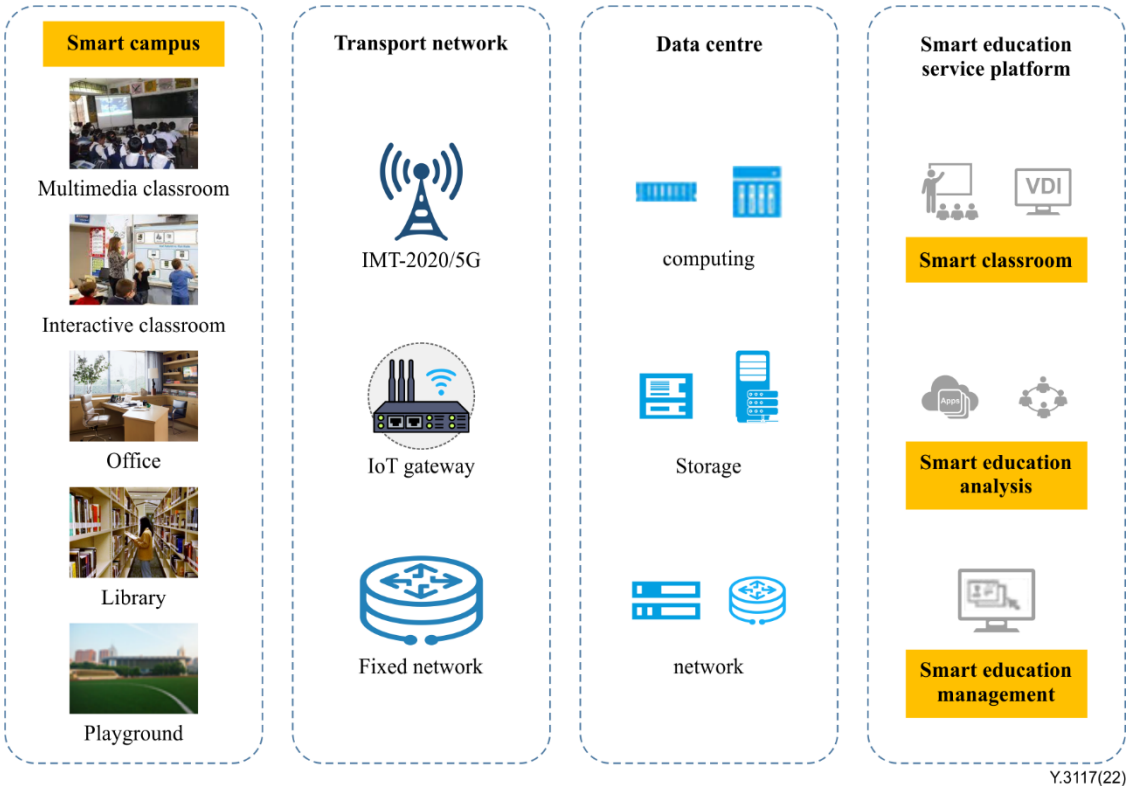


Figure 1 – An example smart education system supported by IMT-2020 and beyond

Smart classroom includes interactive classroom (ICM), virtual reality (VR)/augment reality (AR) classroom and holographic classroom. The interactive classroom relies heavily on video and audio transmission which has strict QoS requirements in terms of number of terminals, bandwidth, latency and packet loss rate. The VR/AR classroom provides students with an immersive learning experience with stringent QoS requirements on network bandwidth (up to 1 Gbps) and delay (10 ms). Holographic classroom uses holographic screens, holographic glasses, and holographic 3D projection products to create a teaching scenario where 3D forms are synchronized. Compared with a VR/AR classroom, the holographic classroom involves access of 30 to 50 VR/AR terminals and higher demands of network bandwidth (up to 10 Gbps) and delay (1 ms) (see Appendix I.1 for details).

Smart campus aims to provide a broadband, safe, and fully-connected campus. IMT-2020 FMC networks provide integrated transmission of multiple services, such as Internet access, video, office application, playground application and IoT. All these smart campus applications and services have strict QoS requirements for network bandwidth, delay, etc. (see Appendix I.2 for details).

Smart education analysis includes big data and AI based analysis of classroom, learning, and sports and teaching activities. Such an analysis system must accurately identify learning and teaching activities which require high video quality associated with strict QoS requirements (see Appendix I.3 for details).

Smart education management includes management of education resources, teaching and learning (TAL) activities, and interactions among teachers, students and parents, etc. Management of

education resources enables more open resources sharing, interaction, and coordination. The smart education management platform must support simultaneous and broadband access for a large number of users by wire or wireless lines (see Appendix I.4 for details).

Based on the high level QoS considerations described above, clause 7 specifies quality of service assurance-related requirements for smart education supported by IMT-2020 and beyond (SE-IMT2020). To fulfil the requirements, a framework of QoS assurances for smart education is specified in clause 8.

7 Requirements

7.1 QoS planning

– SE-IMT2020 is required to support translation of a smart education service level agreement (SLA) into the IMT-2020 and beyond network QoS rules;

– SE-IMT2020 is required to support a capability of network coverage, capacity, bandwidth, and delay estimation;

– SE-IMT2020 is required to support smart education service specific route planning (e.g., fixed or mobile);

– SE-IMT2020 is recommended to support seamless roaming in the fixed and mobile converged (FMC) IMT-2020 network [ITU-T Y.3130].

7.2 QoS provisioning

– SE-IMT2020 is required to support unified and access-agnostic (fixed or mobile access) QoS provisioning from a core network (CN) perspective;

– SE-IMT2020 is recommended to support end-to-end (E2E) QoS provisioning;

– SE-IMT2020 is recommended to support autonomous network management and orchestration with global network view and agile softwarized network functions;

– SE-IMT2020 is recommended to support QoS interworking and mapping among smart education user equipment (UE), fixed/mobile access network (AN), core network (CN) and data network (DN);

– SE-IMT2020 is required to support service specific QoS enforcements enabled by flow classification, marking, congestion avoidance, queue shaping and queue scheduling;

– SE-IMT2020 is recommended to support quality of experience (QoE) with dynamic adaption of QoS policies.

7.3 QoS monitoring

– SE-IMT2020 is required to support QoS monitoring of AN and CN (e.g., capacity, uplink/downlink bandwidth, loss rate, jitter, delay, etc.);

– SE-IMT2020 is recommended to support E2E QoS monitoring (e.g., capacity, uplink/downlink bandwidth, loss rate, jitter, delay, etc.);

– SE-IMT2020 is required to support QoS anomaly detection;

– SE-IMT2020 is required to report QoS events upon detecting QoS anomalies that violate the SLA.

7.4 QoS optimization

– SE-IMT2020 is recommended to support QoS optimization enabled by multi-access edge computing (MEC) [ITU-T Y.3158] [ITU-T Y.3109], machine learning (ML)/artificial intelligence (AI) [ITU-T Y.3170] [ITU-T Y.3172] [ITU-T Y.3175], etc.;

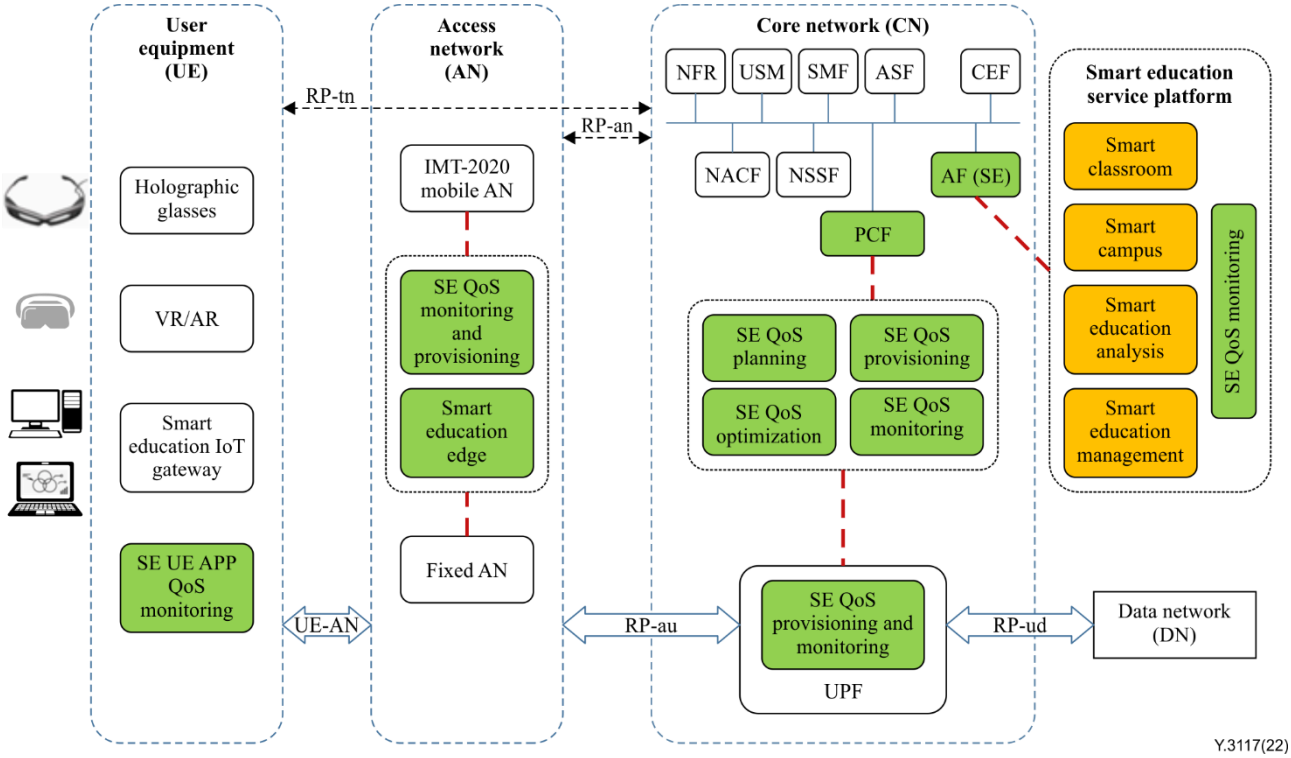
– SE-IMT2020 is recommended to support traffic prediction based on the analysis of collected QoS data;

– SE-IMT2020 is recommended to support routing optimization based on the current smart education traffic status;

– SE-IMT2020 is recommended to support QoS anomaly prediction based on the analysis of QoS data.

8 Framework

A conceptual framework of smart education supported by IMT-2020 and beyond is shown in Figure 2.



CEF: capability exposure function
USM: unified subscription management
SMF: session management function
UPF: user plane function
RP-au: reference point between AN and UPF
NFR: network function registry
NACF: network access control function
ASF: authentication server function
RP-tn: reference point between UE and NACF
RP-ud: reference point between UPF and data network
PCF: policy control function
NSSF: network slice selection function
AF: application function
RP-an: reference point between AN and NACF

Figure 2 – A conceptual framework of QoS assurance-related smart education supported by IMT-2020 and beyond

The framework is built over an IMT-2020 FMC network with smart education QoS assurance-related capabilities. The access network consists of IMT-20220 mobile access network and fixed access network. The smart education service platform supports different smart education services and management functions. The QoS assurance-related capabilities for smart education are distributed among UEs, access networks, core networks and smart education service platforms.

The description of the role of each component is as follows.

– Smart education service platform can be seen as an application function (AF) in IMT-2020. The SE AF can interact with IMT-2020 policy control function (PCF) through service-based interfaces [ITU-T Y.3102] [ITU-T Y.3104]. It can also influence traffic routing by providing service information to the PCF in support of its rule generation.

– E2E smart education QoS control is supported in the IMT-2020 core network (CN). The QoS functionalities (planning, provisioning, monitoring and optimization) are distributed in both the control plane (CP) and user plane function (UPF). The machine learning based AI technologies [ITU-T Y.3170] [ITU-T Y.3172] [ITU-T Y.3175] can be used for smart education QoS optimization.

– The smart education access network is an IMT-2020 FMC network to support various smart education applications with different QoS requirements. Smart education QoS provisioning and monitoring for QoS enforcement and QoS data collection is supported in the FMC network.

– The smart education edge is located near to the smart education UEs. The SE edge is responsible for interaction with the CN and smart education service platform for AR/VR/holographic service optimization. Thanks to the local access, computing, storage and bandwidth provided by the smart education edge, a one-stop solution is available for efficient live video delivery. Consequently, end users can enjoy a fast, fluent and stable experience. Furthermore, the traffic cost of the smart education service platform can be reduced.

– There are many different types of smart education terminals (e.g., video terminals, VR/AR terminal, holographic glasses, office computers, etc.) with fixed or mobile access capabilities which have different QoS requirements (See Appendix I). These terminals are connected to the IMT-2020 FMC network directly. IoT devices for smart education can be connected through a smart education IoT gateway [ITU-T Y.4000].

9 Security considerations

This Recommendation describes the QoS assurance-related requirements and framework for smart education supported by IMT-2020 and beyond, therefore, general network security requirements and mechanisms in IP-based networks and IMT-2020 network should be applied [b-ITU-T Y.2701] [b-ITU-T Y.3101]. The security mechanisms such as authentication, authority, accounting and encryption should be adopted to ensure the security of smart education and the IMT-2020 system.

Appendix I

QoS considerations for smart education support by IMT-2020 and beyond

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

This appendix describes the QoS considerations for the following smart education services and management applications: smart classroom, smart campus, smart education analysis and smart education management [b-smart-edu].

I.1 Smart classroom

Smart classroom supported by IMT-2020 and beyond utilizes video/VR/AR/holographic technologies to implement an interactive and immersive learning experience for students.

Interactive classroom provides an interactive teaching environment in physical classrooms, online classes, and cloud classrooms. It enables interactions between teachers and students. The interactive classroom relies heavily on video and audio transmission which has strict QoS requirements for number of terminals, bandwidth, latency and packet loss rate, see Table I.1.

Table I.1 – Interactive classroom

Service type	Number of terminals	Bandwidth per terminal	Latency	Packet loss rate
Video terminal	3-4 per classroom	≥ 8 Mbit/s	≤ 150 ms	≤ 5%
Teaching terminal	1 per classroom	≥ 2 Mbit/s	≤ 200 ms	≤ 5%

VR/AR technologies can provide for students and teachers a virtual classroom environment to enjoy a more intuitive learning and teaching experience. VR/AR technologies provide courses and training that are difficult or even impossible in the real world. The immersive experience in education and training improves users' perception and retention of knowledge. VR/AR classes involve a large number of terminals and have strict requirements on network bandwidth and delay. Table I.2 lists the requirements of VR/AR classroom for different experience levels, see also [b-ITU-T Y.3109].

Table I.2 – VR/AR classroom

Service type	Number of terminals	Bandwidth per terminal	Latency
Fair-experience	30-50 per classroom	80 Mbit/s	≤ 20 ms
Comfortable-experience	30-50 per classroom	260 Mbit/s	≤ 15 ms
Ideal-experience	30-50 per classroom	1 Gbit/s	≤ 8 ms

Holographic classroom uses holographic screens, holographic glasses and holographic 3D projection products to create a teaching scenario where 3D forms are synchronized. This holographic 3D scenario guides students to fully integrate 3D space, implementing an intuitive and immersive learning experience. Compared with VR/AR classroom, holographic classroom is more intuitive, vivid, and convenient which has increasing demands on network bandwidth and delay. Table I.3 lists the requirements of holographic classroom for different experience levels.

Table I.3 – Holographic classroom

Service type	Number of terminals	Technical specifications	Bandwidth per terminal	Latency
Immersive-experience	30-50 per classroom	8 K (8 bits, 30FPS)	100 Mbit/s	≤ 10 ms
Interaction-experience	30-50 per classroom	6 degrees of freedom (6DoF), real-time interaction	1 Gbit/s	≤ 5 ms
Convergent-experience	30-50 per classroom	Light field, holographic	10 Gbit/s	≤ 1 ms

I.2 Smart campus

Using IMT-2020, IoT, big data, and AI technologies, smart campus builds a fully-connected smart campus to intelligently manage people and things.

Smart campus refers to the construction of campus network infrastructure which supports:

- Wireless coverage in all scenarios: mobile learning, mobile teaching, and mobile office applications, etc.;
- Fully-connected ultra-broadband campus which can meet teaching and office requirements;
- Office collaboration and convergence campus which includes: daily office collaboration, administrative conference, and office desktop applications.

Smart safety campus is a comprehensive safety system which supports high definition (HD) video surveillance, intelligent analysis, personnel and vehicle checkpoint, patrol, access control, alarm, and 3D geographic information system (GIS). Smart safety campus must support:

- Full coverage of high quality video surveillance;
- Intelligent access control and electronic patrol;
- Safe perimeter and intrusion alarm for invalid intrusion of campus;
- Intelligent video analysis for incidence tracking.

Table I.4 lists the transport requirements of smart campus for different service and application.

Table I.4 – Smart campus

Service type	Bandwidth per terminal	Latency	Packet loss rate
Applications (learning, teaching, office)	≥ 25 Mbit/s	≤ 30 ms	≤ 0.01%
HD video surveillance	≥ 8 Mbit/s	≤ 150 ms	≤ 5%
1080P video playback	≥ 16 Mbit/s	≤ 100 ms	≤ 1%

I.3 Smart education analysis

Smart education analysis implements AI-based analysis of students' learning, exercise behaviours, as well as teachers' behaviours.

The students' behaviour analysis system consists of information collection terminals, an analysis platform, and client applications. The terminals and platform are connected over IMT-2020 FMC network.

Teaching behaviour analysis includes evaluation of teaching content, teaching methods, teaching environment, and teaching management. The teaching behaviour analysis system consists of smart

teaching terminals, AI smart analysis systems, and client applications. The terminals and platform are connected over the IMT-2020 FMC network.

The learning, sports, and teaching behaviour management AI systems must accurately identify these activities, requiring high quality video and massive teaching terminals. Table I.5 lists the network transport requirements for smart education analysis.

Table I.5 – Smart education analysis

Service type	Number of terminals	Bandwidth per terminal	Latency	Packet loss rate
Video terminal in classroom	3-4 per classroom	≥ 8 Mbit/s	≤ 150 ms	≤ 5%
Video terminal in playground	4-6 per playground	≥ 8 Mbit/s	≤ 150 ms	≤ 5%
Sensor terminal	6 per playground	≥ 2 Mbit/s	≤ 30 ms	≤ 0.01%
Smart bracelet	30-50 per classroom	≥ 256 kbit/s	≤ 30 ms	≤ 0.01%

I.4 Smart education management

Smart education is all about openness, sharing, interaction, and collaboration. The smart education management enables more open educational resources to be shared, interacted with, and coordinated. This promotes the balanced of education and improves teaching quality.

The smart education management provides comprehensive services for teaching staff, students, and parents. It makes it easier for teachers to perform their duties, students to select their classes, and parents to access teaching information and information on their children's performance.

The smart education management platform should support simultaneous access by a large number of users. The network must support remote fixed-mobile-converged broadband access for teachers, students, and parents.

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