ITUPublications
Recommendations

International Telecommunication Union
Standardization Sector

Recommendation

ITU-T Y.4223 (09/2023)

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

Internet of things and smart cities and communities – Requirements and use cases

---

Common requirements and capabilities of smart cities and communities from IoT and ICT perspectives

ITU-T Y-SERIES RECOMMENDATIONS

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

GLOBAL INFORMATION INFRASTRUCTURE	Y.100-Y.999
INTERNET PROTOCOL ASPECTS	Y.1000-Y.1999
NEXT GENERATION NETWORKS	Y.2000-Y.2999
FUTURE NETWORKS	Y.3000-Y.3499
CLOUD COMPUTING	Y.3500-Y.3599
BIG DATA	Y.3600-Y.3799
QUANTUM KEY DISTRIBUTION NETWORKS	Y.3800-Y.3999
INTERNET OF THINGS AND SMART CITIES AND COMMUNITIES	Y.4000-Y.4999
General	Y.4000-Y.4049
Definitions and terminologies	Y.4050-Y.4099
Requirements and use cases	**Y.4100-Y.4249**
Infrastructure, connectivity and networks	Y.4250-Y.4399
Frameworks, architectures and protocols	Y.4400-Y.4549
Services, applications, computation and data processing	Y.4550-Y.4699
Management, control and performance	Y.4700-Y.4799
Identification and security	Y.4800-Y.4899
Evaluation and assessment	Y.4900-Y.4999

For further details, please refer to the list of ITU-T Recommendations.

Recommendation ITU-T Y.4223

Common requirements and capabilities of smart cities and communities from IoT and ICT perspectives

Summary

Smart cities and communities (SC&C) share the goal of achieving urban sustainability without sacrificing the quality of life (QoL) of their citizens. SC&C strive to create a sustainable living environment for citizens using Internet of things (IoT) technologies and information communication technologies (ICTs).

SC&C standardization is ongoing in ITU-T and other relevant standards developing organizations, related to aspects including, but not limited to, SC&C framework, infrastructure, integrated sensing and management systems, platforms, data processing and services and applications (e.g., smart water management, smart buildings, smart residential community, smart tourism and smart parking lots, amongst many others). Based on the fundamental characteristics of smart cities and communities, Recommendation ITU-T Y.4223 specifies common requirements and capabilities of SC&C from IoT and ICT perspectives.

The specified common requirements and capabilities are intended to be generally applicable in SC&C.

History *

Edition	Recommendation	Approval	Study Group	Unique ID
1.0	ITU-T Y.4223	2023-09-22	20	11.1002/1000/15477

Keywords

Characteristics, common capabilities, common requirements, smart cities and communities, SC&C, smart city platform, SCP.

* To access the Recommendation, type the URL https://handle.itu.int/ in the address field of your web browser, followed by the Recommendation's unique ID.

FOREWORD

The International Telecommunication Union (ITU) is the United Nations specialized agency in the field of telecommunications, information and communication technologies (ICTs). The ITU Telecommunication Standardization Sector (ITU-T) is a permanent organ of ITU. ITU-T is responsible for studying technical, operating and tariff questions and issuing Recommendations on them with a view to standardizing telecommunications on a worldwide basis.

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.

The approval of ITU-T Recommendations is covered by the procedure laid down in WTSA Resolution 1.

In some areas of information technology which fall within ITU-T's purview, the necessary standards are prepared on a collaborative basis with ISO and IEC.

NOTE

In this Recommendation, the expression "Administration" is used for conciseness to indicate both a telecommunication administration and a recognized operating agency.

Compliance with this Recommendation is voluntary. However, the Recommendation may contain certain mandatory provisions (to ensure, e.g., interoperability or applicability) and compliance with the Recommendation is achieved when all of these mandatory provisions are met. The words "shall" or some other obligatory language such as "must" and the negative equivalents are used to express requirements. The use of such words does not suggest that compliance with the Recommendation is required of any party.

INTELLECTUAL PROPERTY RIGHTS

ITU draws attention to the possibility that the practice or implementation of this Recommendation may involve the use of a claimed Intellectual Property Right. ITU takes no position concerning the evidence, validity or applicability of claimed Intellectual Property Rights, whether asserted by ITU members or others outside of the Recommendation development process.

As of the date of approval of this Recommendation, ITU had not received notice of intellectual property, protected by patents/software copyrights, which may be required to implement this Recommendation. However, implementers are cautioned that this may not represent the latest information and are therefore strongly urged to consult the appropriate ITU-T databases available via the ITU-T website at http://www.itu.int/ITU-T/ipr/.

Table of Contents

Recommendation ITU-T Y.4223

Common requirements and capabilities of smart cities and communities from IoT and ICT perspectives

1 Scope

This Recommendation identifies the fundamental characteristics of smart cities and communities (SC&C) and specifies SC&C common requirements and capabilities from Internet of things (IoT) and information communication technologies (ICTs) perspectives. The specified common requirements and capabilities are intended to be generally applicable in SC&C.

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.3180] Recommendation ITU-T Y.3180 (2022), *Mechanism of traffic awareness for application-descriptor-agnostic traffic based on machine learning*.

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

[ITU-T Y.4101] Recommendation ITU-T Y.4101/Y.2067 (2017), *Common requirements and capabilities of a gateway for Internet of things applications*.

[ITU-T Y.4200] Recommendation ITU-T Y.4200 (2018), *Requirements for the interoperability of smart city platforms*.

[ITU-T Y.4201] Recommendation ITU-T Y.4201 (2018), *High-level requirements and reference framework of smart city platforms*.

[ITU-T Y.4216] Recommendation ITU-T Y.4216 (2022), *Requirements of sensing and data collection system for city infrastructure*.

[ITU-T Y.4805] Recommendation ITU-T Y.4805 (2017), *Identifier service requirements for the interoperability of smart city applications*.

[ITU-T Y.4900] Recommendation ITU-T Y.4900/L.1600 (2016), *Overview of key performance indicators in smart sustainable cities*.

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1 city [ITU-T Y.4900]: An urban geographical area with one (or several) local government and planning authorities.

3.1.2 city infrastructure [ITU-T Y.4216]: The interconnected structures that enable people to get the resources they need in the city, and the interconnected structures to provide public services for social and economic activities in the city.

3.1.3 data mining [b-ITU-T X.1217]: A computational process to discover patterns in large data sets involving methods of artificial intelligence, machine learning, statistics, and database systems.

3.1.4 smart city platform (SCP) [ITU-T Y.4201]: A city platform that offers direct integration of city platforms and systems, or through open interfaces between city platforms and third parties, in order to offer urban operation and services supporting the functioning of city services, as well as efficiency, performance, security and scalability.

3.1.5 smart sustainable city [ITU-T Y.4900]: A smart sustainable city is an innovative city that uses information and communication technologies (ICTs) and other means to improve quality of life, efficiency of urban operation and services, and competitiveness, while ensuring that it meets the needs of present and future generations with respect to economic, social, environmental as well as cultural aspects.

3.2 Terms defined in this Recommendation

None.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

AI	Artificial Intelligence
CAN	Controller Area Network
ICT	Information and Communication Technology
IoT	Internet of Things
KPI	Key Performance Indicator
OAM	Operation, Administration and Maintenance
QoL	Quality of Life
QoS	Quality of Service
RTD	Resistance Temperature Detector
SC&C	Smart Cities and Communities
SCP	Smart City Platform

5 Conventions

In this Recommendation:

The expression "is required" indicates a requirement which must be strictly followed and from which no deviation is permitted if conformance with this Recommendation is to be claimed.

The expression "is recommended" indicates a requirement which is recommended but which is not absolutely required. Thus, this requirement need not be present to claim conformance with this Recommendation.

6 Overview of smart cities and communities – views and characteristics

6.1 Views of SC&C

Following the definition of a smart sustainable city [ITU-T Y.4900], the development of a smart city should meet the needs of present and future generations with respect to economic, social, environmental and cultural aspects.

NOTE 1 – It is recognized that these needs and SC&C technologies may change.

The key performance indicators (KPIs) for evaluating the performance of a smart sustainable city are recommended to be categorized into six dimensions, as shown in Figure 1 [ITU-T Y.4900]:

– Information and communication technology (ICT);
– Environmental sustainability;
– Productivity;
– Quality of life (QoL);
– Equity and social inclusion;
– Physical infrastructure.

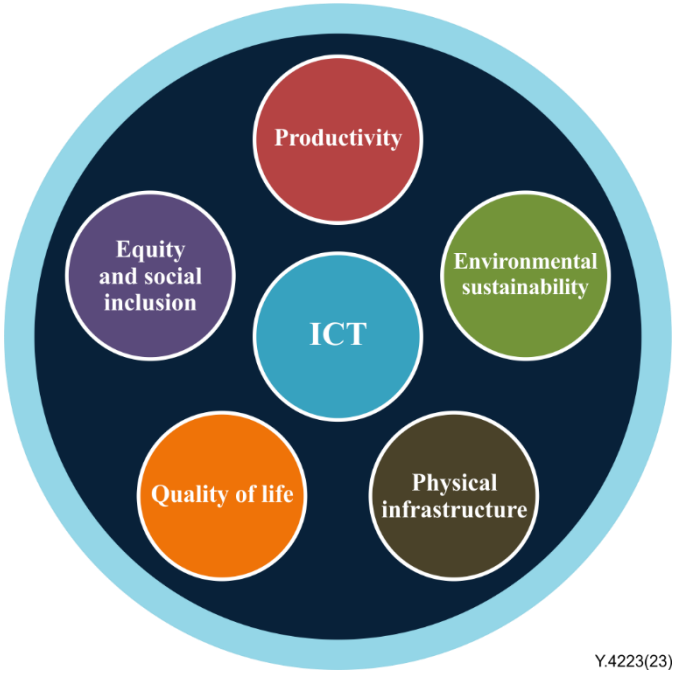

Figure 1 – Dimensions of KPIs for smart sustainable cities [ITU-T Y.4900]

From another point of view, these six dimensions of a smart sustainable city can be adapted to physical space and information space, as shown in Figure 2.

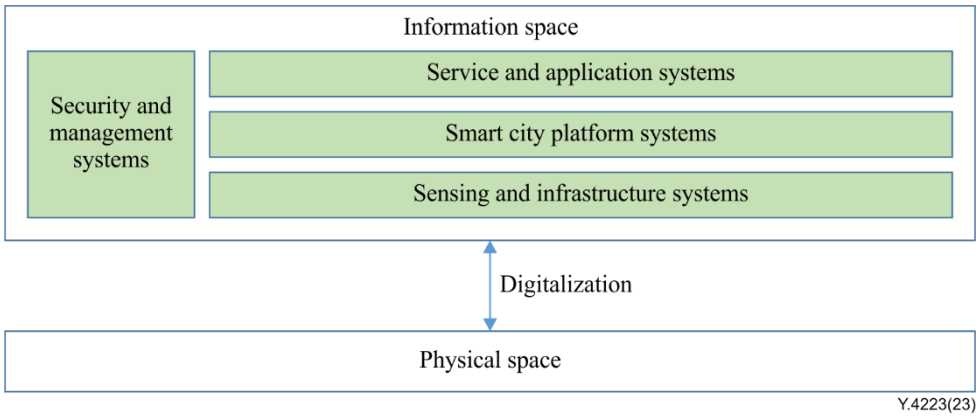

Figure 2 – The two spaces of smart sustainable cities

– Physical space: The physical space in a city can be represented by different physical systems according to location or function, such as land, water, energy, transportation and

environment systems, as well as city infrastructure which includes, but is not limited to, historical heritage, buildings with urban characteristics, and landscape.

NOTE 2 – The management of city infrastructure in the physical space is specified in [ITU-T Y.4216]. From the IoT and ICT perspectives, the requirements and capabilities of the physical space are not within the scope of this Recommendation.

– Information space: The information space is a digital mapping of the physical space using information and communication technologies (ICTs). It can be represented by the following systems: sensing and infrastructure systems [ITU-T Y.4216], smart city platform systems [ITU-T Y.4201], service and application systems, security and management systems.

NOTE 3 – The information space structure is aligned with the structure of the smart city platform as shown in Figure 1 of [ITU-T Y.4201].

The pairing of the physical and information spaces is established through digitalization. All data and information in the information space come from the physical space. There are corresponding relationships between objects in the information space and objects in the physical space at all levels.

6.2 Fundamental characteristics of SC&C from IoT and ICT perspectives

The fundamental characteristics of SC&C are as follows:

– Interconnectivity (represented as "I"): The systems of SC&C are interconnected through ICT.

– Diversity (represented as "D"): SC&C show their diversity, as follows:

  • Diversity of services and applications: The services and applications of SC&C cover all aspects of the urban economy, environment, society and culture.

  • Diversity of data: The data in SC&C includes, but is not limited to, information on population, economy, geography and environment.

  • Diversity of devices and networks: A variety of devices and networks in SC&C systems provide sensing, data processing, interconnection, service and application support, and other functions.

  • Diversity of sensing modes: A variety of perception modalities can be found in SC&C which are consistent with the different characteristics of things.

  • Diversity of management modes: According to the different SC&C systems, the objects and scale of SC&C management vary greatly, and the management mode relies on the various specific applications for operation of the city.

– Intelligence (represented as "C"): The intelligence of SC&C relies on massive data acquisition and data processing and analysis in order to support decision-making for the improvement of city operation effectiveness.

– Evolving and open set of technologies (represented as "O"): The technologies which enable the development of SC&C are in continuous evolution. In addition to the IoT technologies, frontier ICT technologies, such as artificial intelligence (AI), blockchain, positioning and navigation, will be widely used in SC&C.

– Security, robustness and reliability (represented as "S"): SC&C integrate a number of security policies and technologies to tackle the vulnerabilities of the SC&C systems. Robustness and reliability is critical for SC&C systems.

7 Common requirements of SC&C from IoT and ICT perspectives

The common requirements of SC&C specified in this Recommendation are technical requirements of the information space as described in clause 6.2.

NOTE – Detailed requirements, such as interface and protocol related requirements (e.g., for the control and management aspects of SC&C), are outside the scope of this Recommendation. The requirements of the SC&C information space specified in this Recommendation are categorized according to the information space systems described in clause 6.1: (1) service and application systems; (2) smart city platform systems; (3) sensing and infrastructure systems; (4) security and management systems.

Each requirement is categorized with respect to the fundamental characteristics of SC&C described in clause 6.2 and numbered within the respective category.

7.1 Requirements of service and application systems

Service and application systems, in which IoT and ICT play a significant role, meet the needs of city stakeholders, including municipal administrations and urban operations, citizens and enterprises.

NOTE 1 – An extensive list of SC&C application domains is provided in Appendix II.

The common requirements of service and application systems matching the characteristics of SC&C are as follows:

– [I1] Interoperability is required to be ensured among heterogeneous SC&C implementations;

– [I2] Mobility support, which includes service mobility, user mobility and device mobility, is required;

– [D1] The various services and applications of SC&C are required to cover all aspects of the urban economy, environment, society and culture;

– [D2] Scalability is required to be supported in order to connect a large amount of devices, applications and users;

– [D3] Collaboration among services and applications is required;

NOTE 2 – As an example, providing urban flood warning to residents requires the collaboration of services from meteorological stations, hydrometric stations, the telecommunications operator and water conservancy office.

– [C1] The intelligence of SC&C is required to support decision-making;

– [C2] Semantic based services are required to support autonomic service provisioning;

– [O1] Emerging technologies, such as AI, blockchain, positioning and navigation technologies, are recommended to implement new services and applications;

– [S1] High reliability and security are required to tackle security threats, such as threats towards the confidentiality, authenticity and integrity of both data and services;

– [S2] User management, including creation, authentication, authorization and accounting of users, is required;

– [S3] Location based and context-aware services are required to be flexible, user-customizable and autonomic;

– [S4] Services and applications are required to be resilient in order to ensure service continuity and system robustness.

7.2 Requirements of smart city platform systems

Smart city platform systems aim to process comprehensive city information and support all the services and applications of a smart city [ITU-T Y.4201].

The common requirements of SCP systems matching the characteristics of SC&C are as follows:

– [D4] Diversity of sources and applications of data is required to be supported in order to enable processing of information related to population, economy, geography and environment;

– [D5] Data mining and statistical analysis are recommended to support decision-making [ITU- T Y.4201];
– [C3] Entity information is recommended to be extracted from sensing data through semantic processing [ITU-T Y.4201];
– [C4] Super-computation is recommended to be provided by third-party data and computation providers [ITU-T Y.4201];
– [O2] Emerging technologies such as blockchain are recommended to be implemented in data dispatching and delivery;
– [S5] The smart city platform functions are required to be manageable in order to provide service support, interfacing, knowledge acquisition and interconnection [ITU-T Y.4201].

7.3 Requirements of sensing and infrastructure systems

The sensing and infrastructure systems realize perception and monitor the whole status of the city infrastructure. Different sensing and infrastructure systems realize different types of sensing and infrastructure functions.

The common requirements of sensing and infrastructure systems matching the characteristics of SC&C are as follows:

– [I4] Communications are required to take place in the device layer [ITU-T Y.4000] through various kinds of wired or wireless technologies, such as controller area network (CAN) bus, Bluetooth and Wi-Fi;
– [I5] Access management is required to be provided with support of different kinds of sensing device access technologies;
– [D6] Data management is required to be provided in order to process the various sensing data captured in the city. Data management is also required to support storage, retrieval and classification of all the sensing, controlling and configuration data;
– [D7] Various protocols are required to support interworking between devices and communication networks;
– [C5] Data coming from multiple sources is recommended to be pre-processed at the stage of data capture;
– [C6] Auto-configuration of sensing device information is required to provide ubiquitous and intelligent services in different scenarios;

  NOTE – Auto-configuration of sensing device information, involving creating, querying and updating configuration, aims to connect and activate devices to adapt to different applications or users [ITU-T Y.4101].
– [O3] Embedded intelligence such as edge computing technology enabled intelligence is recommended to be provided in sensing devices;
– [S6] Gateways are required to support management functions, including device management, network management, service management and protocol management [ITU-T Y.4101].

7.4 Requirements of security and management systems

As shown in Figure 2, security and management systems provide transversal support to service and application systems, smart city platform (SCP) systems, and sensing and infrastructure systems.

The common requirements of security and management systems matching the characteristics of SC&C are as follows:

– [I6] Security and management systems are required to provide horizontal support by offering services such as monitoring, audits, logging, operation, administration and maintenance (OAM), and configuration [ITU-T Y.4201];

– [D8] Different modes of management and different management levels are required to be supported according to the different domains and scales of SC&C;

– [S7] The identification service is required to satisfy the requirements of applications as described in [ITU-T Y.4805];

– [S8] Integration of different security policies and technologies related to the variety of applications, users, devices and networks in SC&C is required.

8 Common capabilities of SC&C from IoT and ICT perspectives

In alignment with the structure of the information space described in clause 6.1 and the requirements identified in clause 7, the common capabilities of SC&C from IoT and ICT perspectives are composed of the following capability sets, as shown in Figure 3:

– Service and application capability set;

– Smart city platform capability set;

– Sensing and infrastructure capability set;

– Security and management capability set.

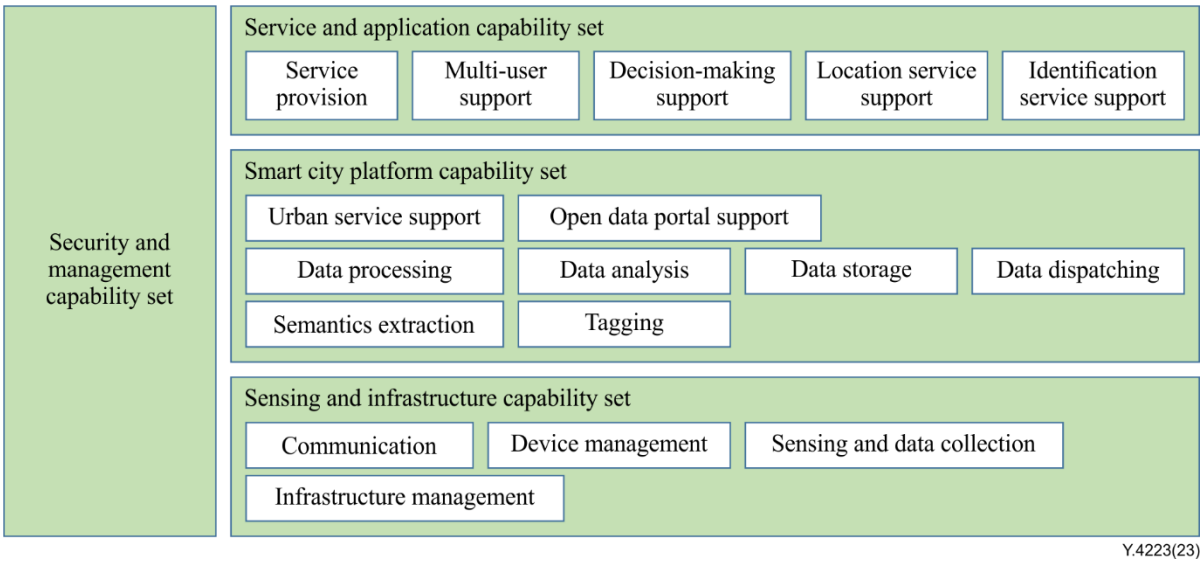

Figure 3 – Capability sets of SC&C

8.1 Service and application capability set

8.1.1 Service provision

According to the requirements of service and application systems defined in clause 7.1, i.e., I1, I2, D1, D2, D3, C2, O1 and S4, SC&C provide the following service provision capabilities:

– Providing services related to urban economy, environment, society and culture aspects to service users;

– Providing integrated services to service users;

– Digitizing traditional services in order to improve the efficiency of services;

– Enabling autonomic service provision in specific scenarios such as natural disaster early warning;

– Implementing new services and applications via adopting emerging technologies, such as AI, blockchain, positioning and navigation technologies;
– Handling massive amounts of devices and data which are increasing exponentially;
– Service continuity, e.g., by using redundant methods in the event of unexpected failure such as power, mechanical or software failure.

NOTE – Redundant methods, which use two or more components to realize the same functions, can help to improve the reliability and availability of a system [ITU-T Y.3180].

8.1.2 Multiuser support

According to the requirements of service and application systems defined in clause 7.1, i.e., S2, SC&C provide the following multiuser support capability:

– Supporting a large number of users, including different types of users, i.e., residents, enterprises, municipal departments.

8.1.3 Decision-making support

According to the requirements of service and application systems defined in clause 7.1, i.e., C1, SC&C provide the following decision-making support capability:

– High-performance computation and intelligence in order to support decision-making.

8.1.4 Location service support

According to the requirements of service and application systems defined in clause 7.1, i.e., S3, SC&C provide the following location-related service support capability:

– Supporting location-related services, e.g., for transportation, disaster relief and land planning.

8.1.5 Identification service support

According to general requirements of service and application systems defined in clause 7.1, as well as requirements in [ITU-T Y.4805], SC&C provide the following identification service support capability:

– Supporting identification service in order that identification of any smart city entity works cooperatively in terms of a global unique identifier [ITU-T Y.4805].

8.2 Smart city platform capability set

8.2.1 Urban service support

According to the general requirements of smart city platform systems defined in clause 7.2, as well as requirements in [ITU-T Y.4201], SC&C provide the following urban service capabilities:

– Supporting urban operation and services;
– Supporting services provided by external third-party providers through interfacing functions [ITU-T Y.4201].

8.2.2 Open data portal support

According to the general requirements of smart city platform systems defined in clause 7.2, as well as requirements in [ITU-T Y.4201], SC&C provide the following open data portal support capabilities:

– Making non-sensitive data publicly available [ITU-T Y.4201].

8.2.3 Data processing

According to the requirements of smart city platform systems defined in clause 7.2, i.e., D4, D5 and C3, SC&C provide the following data processing capabilities:

– Data format transformation between different data formats as required by services and applications;
– Aggregating data from a large amount of different devices and applications;
– Collection or generation of metadata from device-related data and application-related data.

8.2.4 Data analysis

According to the requirements of smart city platform systems defined in clause 7.2, i.e., D4, D5 and C3, SC&C provide the following data analysis capabilities:

– Analytical processing of data using business intelligence;
– Utilizing various data analysis methods such as cluster analysis, regression analysis, neural networks and data mining to analyse data from the population, economy, geography and environment.

8.2.5 Data storage

According to the requirements of smart city platform systems defined in clause 7.2, i.e., D4 and D5, SC&C provide the following data storage capabilities:

– Data storage for data from various sources including devices and applications, as well as smart city internal and external information systems [ITU-T Y.4200];
– Data synchronization between devices and applications, as well as between users and applications.

8.2.6 Data dispatching

According to the requirements of smart city platform systems defined in clause 7.2, SC&C provide the following data dispatching capability:

– Dispatching data to services and applications.

8.2.7 Semantics extraction

According to the requirements of smart city platform systems defined in clause 7.2, SC&C provide the following semantics extraction capability:

– Gathering and refining of data from devices for desired semantic processing.

8.2.8 Tagging

According to the requirements of smart city platform systems defined in clause 7.2, as well as requirements in [ITU-T Y.4201], SC&C provide the following tagging capabilities:

– Transforming the received information to the data structures used in the platform [ITU-T Y.4201];
– Identifying the source of the received data by tagging including identifier and registration information [ITU-T Y.4201].

8.3 Sensing and infrastructure capability set

8.3.1 Communication management support

According to the requirements of sensing and infrastructure systems defined in clause 7.3, i.e., I4, I5 and D7, SC&C provide the following communication management capabilities:

– Establishing and managing communications in device layer [ITU-T Y.4000];
– Gateway supporting different kinds of communication technology in order to connect to different communication networks [ITU-T Y.4101];

– Data transferring between sensing devices and smart city platforms based on quality of service (QoS) policies, e.g., priority of data transferring from devices in different network environments.

8.3.2 Device management

According to the requirements of sensing and infrastructure systems defined in clause 7.3, i.e., I4, I5 and D7, SC&C provide the following device management capabilities:

– Registration of sensing device information;

– Auto-configuration of sensing device information in order to provide ubiquitous and intelligent services with rich real-world information;

– Connectivity for the different types of sensing devices or gateways.

8.3.3 Sensing and data collection

According to the requirements of sensing and infrastructure systems defined in clause 7.3, i.e., D6 and C4, SC&C provide the following sensing and data collection capability:

– Controlling and acquiring data from sensing devices in smart city platforms [ITU-T Y.4216].

8.3.4 Infrastructure management

According to the general requirements of sensing and infrastructure systems defined in clause 7.3, SC&C provide the following infrastructure management support capabilities:

– Indirectly managing urban infrastructure from smart city platforms by sending instructions to connected infrastructure management systems;

– Orchestrating various urban infrastructure systems by unified policies.

8.4 Security and management capability set

According to the general requirements of security and management systems defined in clause 7.4, SC&C provide the following security and management capabilities:

– Providing security mechanisms such as authentication, authorization and ciphering;

– Providing security mechanisms in order that vendors providing the hardware, firmware, and software can be trusted to ensure not misuse user data;

– Monitoring, e.g., collection of information from the SC&C systems;

– Audit, e.g., registration of users who have accessed sensitive information;

– Accountability, e.g., enabling individuals or organizations' responsibility for the outcomes of their activities using ICT within smart cities and communities;

– Logging the accessed sensitive information from the applications;

– Configuring the SC&C systems;

– Operating, managing, and maintaining the SC&C systems;

– Integrating different security standards, policies, regulations and technologies;

– Supporting different modes of management based on the different domains and scales of SC&C;

– Providing a well-defined incident response plan to effectively handle and mitigate security incidents, including procedures for incident reporting, investigation, and recovery;

– Supporting regular vulnerability assessments and implementing patch management processes to identify and address potential security vulnerabilities in the system.

Annex A

List of common requirements of SC&C

(This annex forms an integral part of this Recommendation.)

Table A.1 lists and numbers the requirements identified in clause 7.

Table A.1 – Common requirements of SC&C

SC&C system	Fundamental characteristic of SC&C	Requirement category and number	Requirement description
Service and application systems	Interconnectivity	I1	Interoperability is required to be ensured among heterogeneous SC&C implementations.
		I2	Mobility support, which includes service mobility, user mobility and device mobility, is required.
	Diversity	D1	The various services and applications of SC&C are required to cover all aspects of the urban economy, environment, society and culture.
		D2	Scalability is required to be supported in order to connect a large amount of devices, applications and users.
		D3	Collaboration among services and applications is required. NOTE – As an example, providing urban flood warning to residents requires the collaboration of services from meteorological station, hydrometric station, the telecommunication operator and water conservancy office.
	Intelligence	C1	The intelligence of SC&C is required to support decision-making.
		C2	Semantic based services are required to support autonomic service provisioning.
	Evolving and open set of technologies	O1	Emerging technologies, such as AI, blockchain, positioning and navigation technologies, are recommended to implement new services and applications.

Table A.1 – Common requirements of SC&C

SC&C system	Fundamental characteristic of SC&C	Requirement category and number	Requirement description
	Security, robustness and reliability	S1	High reliability and security are required to tackle security threats, such as threats towards the confidentiality, authenticity and integrity of both data and services.
		S2	User management, including creation, authentication, authorization and accounting of users, is required.
		S3	Location based and context-aware services are required to be flexible, user-customizable and autonomic.
		S4	The services and applications are required to be manageable, including to ensure service continuity and system robustness.
Smart city platform systems	Interconnectivity	None	None
	Diversity	D4	Diversity of sources and applications of data is required to be supported in order to enable processing of the information related to population, economy, geography and environment.
		D5	Data mining and statistical analysis are recommended to support decision-making [ITU-T Y.4201].
	Computation intelligence	C3	Entity information is recommended to be extracted from sensing data through semantic processing [ITU-T Y.4201].
		C4	Super-computation is recommended to be provided by third-party data and computation providers. [ITU-T Y.4201]
	Evolving and open set of technologies	O2	Emerging technologies such as blockchain are recommended to be implemented in data dispatching and delivery.

Table A.1 – Common requirements of SC&C

SC&C system	Fundamental characteristic of SC&C	Requirement category and number	Requirement description
	Security, robustness and reliability	S5	The smart city platform functions are required to be manageable in order to provide service support, interfacing, knowledge acquisition and interconnection [ITU-T Y.4201].
Sensing and infrastructure systems	Interconnectivity	I4	Communications are required to take place in the device layer [ITU-T Y.4000] through various kinds of wired or wireless technologies, such as CAN bus, Bluetooth, Wi-Fi.
		I5	Access management is required to be provided with support of different kinds of sensing device access technologies.
	Diversity	D6	Data management is required to be provided in order to process the various sensing data captured in the city. Data management is also required to support storage, retrieval and classification of all the sensing, controlling and configuration data.
		D7	Various protocols are required to support interworking between devices and communication networks.
	Intelligence	C5	Data coming from multiple sources is recommended to be pre-processed at the stage of data capture.
		C6	Auto-configuration of sensing device information is required to provide ubiquitous and intelligent services in different scenarios. NOTE – Auto-configuration of sensing device information involving creating, querying and updating configuration, aims to connect and activate devices to adapt to different applications or users [ITU-T Y.4101].

Table A.1 – Common requirements of SC&C

SC&C system	Fundamental characteristic of SC&C	Requirement category and number	Requirement description
	Evolving and open set of technologies	O3	Embedded intelligence such as edge computing technology enabled intelligence is recommended to be provided in sensing devices.
	Security and manageable	S6	Gateways are required to support management functions, including device management, network management, service management and protocol management [ITU-T Y.4101].
Security and management systems	Interconnectivity	I6	The security and management systems are required to provide horizontal support by offering services such as monitoring, audits, logging, OAM, configuration [ITU-T Y.4201].
	Diversity	D8	Different modes of management and different management levels are required to be supported according to the different domains and scales of SC&C.
	Intelligence	None	None
	Evolving and open set of technologies	None	None
	Security and manageable	S7	The identification service is required to satisfy the requirements of applications as described in [ITU-T Y.4805].
		S8	Integration of different security policies and technologies related to the variety of applications, users, devices and networks in SC&C is required.

Appendix I

Details of typical city infrastructure sensors

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

This appendix provides details about typical city infrastructure sensors as fundamental tools to collect city sensing data (see Table I.1).

The sensing and infrastructure systems of SC&C use these sensors to collect perception data.

Table I.1 – Typical sensors in the city infrastructure

Application domain	Application sub-domain	Sensor	Sensor function
Energy	Gas	Smart gas meter	Automatically and wirelessly recording the actual gas usage (m^3)
		Gas detector	Detecting a gas leak (m^3)
		Flow meter	Measuring the quantity of gas which moves through a pipeline in a period of time (m^3/h)
	Heating	Wireless temperature and pressure multichannel acquisition terminal	Monitoring the temperature and pressure in heat energy transmission pipelines (℃ and megapascal)
		Wireless remote temperature collection terminal	Monitoring the heating plants for temperature (℃)
	Electric energy	Resistance temperature detector (RTD)	Detecting the temperature of power equipment (℃)
		Smart electric meter	Recording detailed information about energy use on a regular basis (Watt)
	Petroleum	Explosion-proof wireless temperature sensor	Collecting the temperature of oilfield water injection wellhead (℃)
Water supply and drainage	Water resource	Wireless remote pressure acquisition terminal	Measuring the pressure of water supply pipelines (megapascal)
		Wireless remote liquid level acquisition terminal	Monitoring water tank and liquid level of water tank (m)

Table I.1 – Typical sensors in the city infrastructure

Application domain	Application sub-domain	Sensor	Sensor function
Transportation	Traffic infrastructure status	Remote sensor	Recording wavelengths of energy (micron)
	Traffic order	Tilt sensor	Giving information about the horizontal and vertical inclination of the vehicles (degree)
		Velocity sensor	Detecting the speed of vehicles (km/h or mph)
Disaster prevention	Natural disaster	Piezoelectric rain gauge	Measuring the range of rainfall (mm/min)
		3 axis acceleration sensor	Sensing vibrations from all the directions (X, Y and Z)
		Wind direction sensor	Measuring wind direction (m/s or mph)
	Accident disaster	Geomagnetic sensor	Detecting vehicles when waiting for a red light
		Carbon dioxide sensor	Detecting CO_2 in the air (ppm)
		Immunosensor	Detecting C-reactive protein (CRP)

Appendix II

Some detailed considerations related to SC&C applications in different application domains

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

This appendix provides some detailed considerations related to SC&C applications in different application domains.

The service and application systems of SC&C, in which IoT and ICT play a significant role, meet the needs of city stakeholders, including municipal administrations and urban operations, citizens and enterprises. This appendix describes relevant applications of the service and application systems of SC&C.

II.1 Public security applications

In a SC&C, the function of public security applications is of critical value to:

- implement emergency information dispatching;
- improve network coverage and realize mobile electronic policing.

It is expected for public security applications to:

- obtain image resources in public areas such as parks, squares and stations;
- establish intelligence analysis to provide effective decision-making suggestions and an action guide for emergency event handling.

II.2 Traffic and transportation management applications

In an SC&C, the function of traffic and transportation management applications is of critical value to:

- provide supervision of public transportation such as bus, tram, underground railway and taxi in order to maintain traffic security and deal with traffic accidents;
- implement safety monitoring for overloading of freight vehicles, and conditions of road, bridge and tunnels;
- implement emergency handling of dangerous goods vehicles.

It is expected for traffic and transportation management applications to:

- improve the information coverage of the traffic network;
- provide positioning, tracking and monitoring of transportation and logistics.

II.3 Municipal administration applications

In an SC&C, the function of municipal administration applications is of critical value to:

- implement real-time monitoring for street lamps and other municipal facilities;
- implement safety monitoring in municipal construction, such as road paving and bridge construction, as well as automatic management for water pumps in the process of flood control and drainage.

II.4 Water management applications

In an SC&C, the function of water management applications is of critical value to:

- acquire remotely information of water supply and water sources such as rivers, lakes and reservoirs;

It is expected for water management applications to:

- implement automatic monitoring of reservoirs and sluices;
- obtain real-time images and transmitting to the command centre for water conservancy and flood control.

II.5 Public safety applications

In an SC&C, the function of public safety applications is of critical value to:

- handle emergencies such as natural disasters and other events;
- provide safety supervision during the production, storage and transportation of chemicals, fireworks and firecrackers;
- implement safety monitoring for cultural relics, archaeological sites and historical heritage;
- respond to the emergency handling needs of forest fires and emergencies related to wild animals and plants, etc.;
- respond to emergencies such as the occurrence of animal and plant diseases, issues with agricultural safety, agricultural environmental pollution, crop diseases and insect pests;
- complete information resource collection and storage;
- implement early warning and prediction in order to reduce loss and casualties caused by disasters;
- have a unified emergency response in order to coordinate emergency rescue work.

It is expected for public safety applications to:

- support wireless on-site command for disaster relief and event handling through remote video conference, expert consultation, document handling and evacuation announcement;
- provide large-scale network coverage in forest areas in order to understand forest cutting production and forest land use in real time;
- support diverse communication networks (e.g., wired/wireless, cellular, satellite, TV/radio broadcasting) deployed in SC&C to distribute the information to ICT devices used in SC&C for early warning and disaster relief;
- support diverse ICT devices (e.g., mobile phone, digital signage [b-ITU-T H.780], TV, radio, smart display, smart watch) used in SC&C to inform citizens of early warning and disaster relief information;
- support diverse formats (e.g., text, voice, symbol, video) of early warning and disaster relief information for diverse communication networks and ICT devices used in SC&C;
- support adaptive distribution (e.g., via personal devices, in-building equipment, shared display, digital signage, IoT devices) of early warning and disaster relief information to citizens according to their surroundings;
- support intelligent gathering of information for early warning and disaster relief from diverse sensing devices in SC&C.

II.6 Urban plan applications

It is expected for urban plan applications to:

- review the construction planning scheme with three-dimensional modelling and simulation.

II.7 Land resource management applications

In an SC&C, the function of land resource applications is of critical value to:

- implement dynamic monitoring for land resource management by obtaining on-site survey information via vehicles or mobile terminals;

- collect and report information of geological disasters such as mountain collapse and landslide;
- implement monitoring for mineral resources and groundwater level.

It is expected for land resource applications to:

- supervise safety in real estate construction and residential property management.

II.8 Energy management applications

It is expected for energy management applications to:

- implement safety detection and monitoring in energy exploitation;
- apply a wireless network in energy conservation and emission reduction;
- implement automatic monitoring in production processes, etc.

II.9 e-government applications

In an SC&C, the function of e-government applications is of critical value to:

- provide faster, real-time and efficient mobile office services for government staff;
- carry out surveys on satisfaction with e-government, including the processing of public opinions, suggestions and complaints;
- handle government procurement disputes and violations;
- be responsible for the collection, analysis, reporting and filing of intellectual property protection, to handle patent disputes and deal with incidents of counterfeiting.

It is expected for e-government applications to:

- implement on-site evidence collection, expert consultation and audit for government procurement.

II.10 Education applications

It is expected for education applications to:

- enable distance education, as well as regularly carrying out open video classes;
- provide student information such as attendance and status to teachers and parents or guardians.

II.11 Environmental protection applications

In an SC&C, the function of environmental protection applications is of critical value to:

- implement the data collection and statistical management of various environmental factors such as atmosphere, water body, noise, toxic chemicals, automobile exhaust, and solid waste and waste water treatment;
- implement supervision of the city's landscape via technical measures such as remote video applications;
- carry out real-time monitoring of environmental violations and coordinate settlement of environmental pollution disputes;
- be responsible for the collection, statistics, reporting and filing of greening data and environmental engineering data.

It is expected for environmental protection applications to:

- receive reports and complaints easily and in a timely manner, from the public about environmental pollution and events causing environmental damage.

II.12 Health applications

In an SC&C, the function of health applications is of critical value to:

- rapidly process medical emergency events such as epidemic, disease control, food poisoning, and occupational poisoning, and carry out resource scheduling, medical rescue and epidemic prevention;
- directly report to the national epidemic network;
- carry out monitoring and early warning analysis;
- meet the needs of medical service and disease prevention for urban migrant workers, rural communities and families.

It is expected for health applications to:

- support telemedicine diagnosis, including collection of medical parameters and on-line expert consultation;
- support drug management to ensure safety and deterioration reminders during production, storage and use;
- provide health information to the public with timely disease prevention advice.

II.13 Civil administration applications

In an SC&C, the function of civil administration applications is of critical value to:

- maintain the information of all kinds of welfare facilities and institutions to rescue urban vagrant and begging children, and provide employment for disabled people;
- provide availability information for the city's nursing homes and other communities for the seniors;
- be responsible for the collection and statistics of labour and social insurance information, as well as the release of such information.

It is expected for civil administration applications to:

- maintain the safety of the electronic archives of social insurance.

II.14 Citizen-centric service applications

In an SC&C, the function of citizen-centric service applications is of critical value to:

- provide the public with ubiquitous network access at home, entertainment places, hotels, airports, green spaces, conference centres and so on;
- enable citizens to access to public information, e.g., weather warning, announcement and information of emergencies;
- provide public information on medical services such as telemedicine diagnosis, mobile registration, home care for the elderly and children and first-aid.

It is expected for citizen-centric service applications to:

- provide electronic navigation with information such as online map, real-time traffic conditions; lost and found wireless location and tracking;
- provide tourist information such as on tourist attractions, hotels, reservation of flights and other travel tickets, taxi service and driving guide;
- provide personal and ubiquitous medical prevention information reminder and advice;
- provide leisure and entertainment, e.g., online games, online movies, wireless online shopping, wireless music, online chat and entertainment videos;
- provide a personal mobile office environment for work anytime and anywhere.

Bibliography

[b-ITU-T H.780] Recommendation ITU-T H.780 (2012), *Digital signage: Service requirements and IPTV-based architecture*.

[b-ITU-T X.1217] Recommendation ITU-T X.1217 (2021), *Guidelines for applying threat intelligence in telecommunication network operation.*

SERIES OF ITU-T RECOMMENDATIONS

Series A	Organization of the work of ITU-T
Series D	Tariff and accounting principles and international telecommunication/ICT economic and policy issues
Series E	Overall network operation, telephone service, service operation and human factors
Series F	Non-telephone telecommunication services
Series G	Transmission systems and media, digital systems and networks
Series H	Audiovisual and multimedia systems
Series I	Integrated services digital network
Series J	Cable networks and transmission of television, sound programme and other multimedia signals
Series K	Protection against interference
Series L	Environment and ICTs, climate change, e-waste, energy efficiency; construction, installation and protection of cables and other elements of outside plant
Series M	Telecommunication management, including TMN and network maintenance
Series N	Maintenance: international sound programme and television transmission circuits
Series O	Specifications of measuring equipment
Series P	Telephone transmission quality, telephone installations, local line networks
Series Q	Switching and signalling, and associated measurements and tests
Series R	Telegraph transmission
Series S	Telegraph services terminal equipment
Series T	Terminals for telematic services
Series U	Telegraph switching
Series V	Data communication over the telephone network
Series X	Data networks, open system communications and security
Series Y	**Global information infrastructure, Internet protocol aspects, next-generation networks, Internet of Things and smart cities**
Series Z	Languages and general software aspects for telecommunication systems

Published in Switzerland
Geneva, 2023