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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

Requirements of sensing and data collection system for city infrastructures

Recommendation ITU-T Y.4216

ITU-T

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Recommendation ITU-T Y.4216

Requirements of sensing and data collection system for city infrastructures

Summary

Recommendation ITU-T Y.4216 provides the concept and classification of basic city infrastructures. The sensing and data collection system of a city infrastructure is also described.

City infrastructures are taken into consideration in building smart cities such as energy, transportation, healthcare, cultural, sports and educational infrastructures. This Recommendation identifies these infrastructures and provides the functions and requirements of sensing and data collection system for those city infrastructures. The sensing and data collection system provides a unified management of the sensing devices attached to various city infrastructures.

This Recommendation is also helpful for cities to build smart cities by improving upon the efficiency and resilience of a city infrastructure through the information and communication technology (ICT).

History

Edition	Recommendation	Approval	Study Group	Unique ID*
1.0	ITU-T Y.4216	2022-08-29	20	11.1002/1000/15067

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Cities, information communication technologies (ICTs), infrastructure, Internet of Things (IoT), sensing and data collection system (SDCS), smart sustainable cities (SSCs).

* To access the Recommendation, type the URL http://handle.itu.int/ in the address field of your web browser, followed by the Recommendation's unique ID. For example, http://handle.itu.int/11.1002/1000/11830-en.

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1 Scope

This Recommendation describes the basic infrastructures for smart sustainable cities and defines the functions and requirements of sensing and data collection system (SDCS) for basic city infrastructures. This Recommendation covers:

– Basic infrastructures for smart sustainable cities;

– Functions of SDCS for city infrastructures; and

– Requirements of SDCS for city infrastructures.

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.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.*

[ISO/IEC 29100] ISO/IEC 29100:2011, *Information technology – Security techniques – Privacy framework.*

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

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

3.1.2 personally identifiable information principal [ISO/IEC 29100]: Natural person to whom the personally identifiable information (PII) relates.

3.1.3 personally identifiable information [ISO/IEC 29100]: Any information that (a) can be used to identify the PII principal to whom such information relates, or (b) is or might be directly or indirectly linked to a PII principal.

NOTE – To determine whether a PII principal is identifiable, an account should be taken of all the means which can reasonably be used by the privacy stakeholder holding the data, or by any other party, to identify that natural person.

3.1.4 smart sustainable cities [b-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, the efficiency of urban operation and services, and competitiveness, while ensuring that it meets the needs of the present and future generations with respect to economic, social, environmental as well as cultural aspects.

3.1.5 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 the urban operation and services supporting the functioning of city services, as well as efficiency, performance, security and scalability.

3.2 Terms defined in this Recommendation

This Recommendation defines the following terms:

3.2.1 city infrastructures: 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.

3.2.2 sensing and data collection system: A system that monitors the status and collects information on different kinds of city infrastructures, controls and manages the sensing devices attached to those city infrastructures and provide corresponding information to the smart city platform (SCP).

NOTE – The corresponding information includes sensed information and information about the sensor itself.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

ICT	Information and Communication Technology
IoT	Internet of Things
PII	Personally Identifiable Information
SCP	Smart City Platform
SDCS	Sensing and Data Collection System
SSC	Smart Sustainable Cities

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 to 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 Basic infrastructures for smart sustainable cities

The following are the basic infrastructures for building and operating smart sustainable cities (SSCs).

6.1 Energy infrastructure

At the city-level, it needs to expand infrastructures and upgrade technology to support sustainable energy services to meet SDG 7.b [b-UN SDG-2018].

Facilities, such as gas, heat, and electricity as well as the affiliated facilities, are energy infrastructures that are to be built and improved to meet the needs of production and living in a smart city. These facilities must be operated safely which can be monitored through the ICT.

Implementation of safety detection and monitoring in the exploitation of the energy industry, energy conservation and emission reductions are also needed.

Sensing data such as fire detection can be collected by sensors deployed in these infrastructures.

6.2 Water supply and drainage infrastructure

At the city-level, it needs to develop water facilities to ensure availability and sustainable management of water and sanitation to meet SDG 6 [b-UN SDG-2018].

Water supply facilities for water collection, processing, transmission and finished water distribution facilities are infrastructures to be built and improved to meet the needs of production and living in a smart city. These facilities can be monitored through the ICT.

Drainage facilities for sewage and rainwater collection, transmission, processing, regeneration, and discharge are needed to be built in a smart city. The sewage treatment rate is to be over 90%. The effluent of sewage treatment facilities is to be met the national standard. The long-term operation mechanism of sewage treatment plants is needed to be established, and the supervisory monitoring rate of sewage treatment plants is to be reached by 100%. These facilities can also be monitored through the ICT.

Sensing data such as water-saving or city flood control and irrigation can be collected by sensors deployed in these infrastructures.

6.3 Transportation infrastructure

At the city-level, it needs to expand public transport and improve road safety to meet SDG 11.2 [b-UN SDG-2018].

Transportation infrastructures including road transport, railway transport, water transport, and air transport can be monitored and improved through the ICT. Parking lots on urban roads are set up in accordance with the national standards. The city must vigorously advocate public transport, and the coverage of bus stops to conform to the national regulations or standards.

ICT can be used to promote energy-saving and new energy transportation equipment and improve the intelligent transportation management system. It needs to apply new energy technologies such as solar power generation in wharves and stations and promote the use of new energy vehicles and gradually increase the proportion of new energy vehicles in public transport.

Sensing data such as road traffic control can be collected by sensors deployed in these infrastructures.

6.4 Post and communication infrastructure

At the city-level, it needs to significantly increase access to the ICT and strive to provide universal and affordable access to the Internet to meet SDG 9.c [b-UN SDG-2018].

It needs to develop urban postal facilities to undertake the obligation of the universal postal service in a smart city. Other competitive postal facilities are also supported to be open and commercialized. The city needs to improve its ICT facilities to promote an information society.

Sensing data such as postal mail tracking information can be collected by sensors deployed in these infrastructures.

6.5 Disaster risk reduction infrastructure

At the city-level, it needs to reduce disaster risk to meet SDG 9.1 and SDG 11.b [b-UN SDG-2018].

Disaster risk reduction infrastructures can implement early warnings and predictions to reduce loss and casualties and have a unified emergency response in order to coordinate the emergency rescue work in disasters such as fire control, flood control, earthquake prevention and typhoon prevention.

ICT can be used to support wireless on-site command for disaster relief and event handling through remote video conference, expert consultation, document handling and evacuation announcement, and also provide large-scale network coverage in forest areas in order to understand the forest cutting production and forest land use in real time.

Sensing data such as weather forecast information can be collected by sensors deployed in these infrastructures.

6.6 Cultural, sports and educational infrastructure

At the city-level, it needs to build and upgrade education facilities for children, disabilities and gender sensitivity to meet SDG 4.a [b-UN SDG-2018].

Cultural and educational facilities include kindergartens, schools, museums, galleries, cultural centres, science and technology museums and other facilities. ICT technologies can be used to improve the utilization rate of these facilities. A cultural protection system can strengthen the excavation and protection of the local characteristic culture; constantly improving the protection and inheritance mechanism of the intangible cultural heritage.

Sensing data such as security surveillance information can be collected by sensors deployed in these infrastructures.

6.7 Healthcare infrastructure

At the city-level, it needs to develop the capacity for early warning, risk reduction and management of health risks through infrastructure construction to meet SDG 3.d [b-UN SDG-2018].

Healthcare infrastructures include hospitals, health centres, centres for disease control and other institutions. ICT could be used to rapidly process medical emergency events such as epidemics, disease control, food poisoning, occupational poisoning, etc. and carry out resource scheduling, medical rescue and epidemic prevention. Medical information systems can be used to share medical resources such as hospital beds and medical information, especially electronic health records.

NOTE – The term electronic health records does not intend to include personally identifiable information (PII). [ISO/IEC 29100]

ICT can support telemedicine diagnosis, including the collection of medical parameters and online expert consultations and support drug management to ensure safety and deterioration reminders during production, storage, and use, and also provide health information to the public with timely disease prevention.

Sensing data such as atmosphere poisoning analysis information can be collected by sensors deployed in these infrastructures.

6.8 Social welfare infrastructure

At the city-level, it needs to implement appropriate social protection systems and measures and achieve substantial coverage of the poor and the vulnerable to meet SDG 1.3 and 1.5 [b-UN SDG-2018].

Social welfare facilities include elderly activity centres, nursing homes, welfare homes and other infrastructures. ICT can be used to maintain the information of all kinds of welfare facilities and institutions to guarantee the serviceability to rescue urban vagrants, begging children and disabled people.

Sensing data such as facility utilization rate information can be collected by sensors deployed in these infrastructures.

7 Concept of sensing and data collection system

A smart city aims to promote intelligent urban planning, construction, management and service by using information communication technologies such as the Internet of things, cloud computing, big data, spatial geographic information integration, etc. It makes full use of the new ICT means to sense, analyse and integrate the key information of urban operations and management systems in order to make intelligent responses to the needs of the urban governance, people's livelihood services, business activities, etc., mainly to drive the development of cities with data, and create better urban life for human beings.

ICTs can be used to enhance the functions and performances of city infrastructures. The technologies provide methods to improve the productivity and efficiency of city infrastructures. It is required to establish sensing and data collection systems (SDCS) across different areas of city infrastructures for the sensing and infrastructure providers of smart sustainable cities (SSC). The sensing devices for different areas of city infrastructures can monitor the whole status of the city. With analysis and sharing between different areas of sensing data, it provides better cooperation between different city infrastructures and plays an important role in smart and sustainable cities.

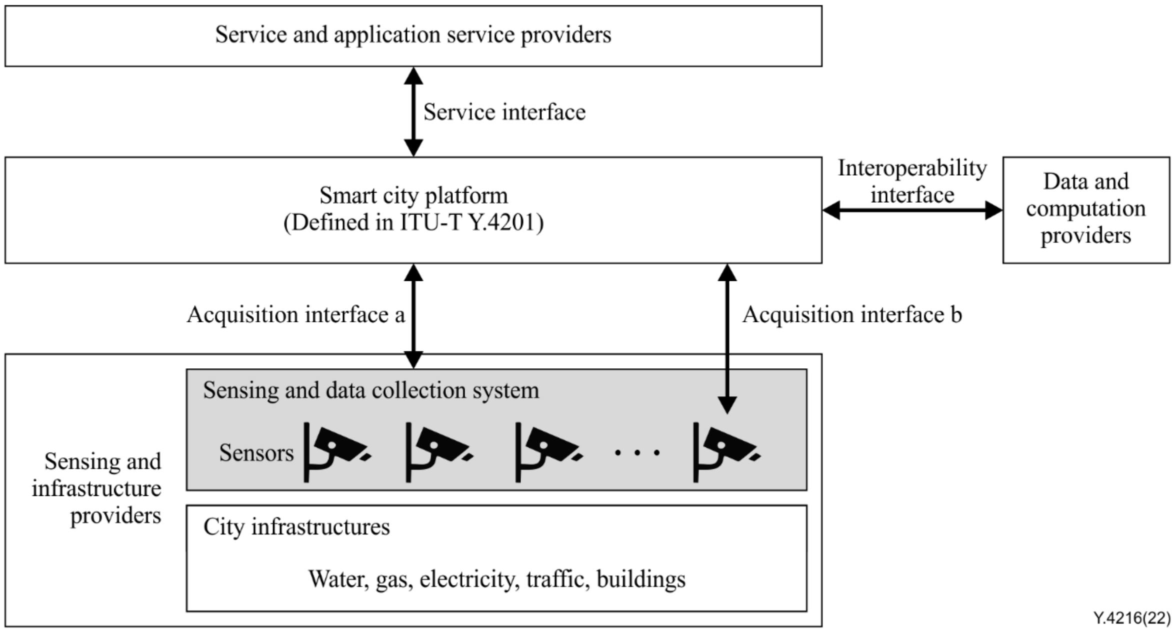

Figure 1 – SDCS for city infrastructure

Figure 1 shows the relationship between SDCS and a smart city platform (SCP). SCP has the ability to acquire data directly from different kinds of sensing devices. However, with large deployments of sensing devices among all kinds of city infrastructures, the SCP is unable to manage all the sensing devices. The SDCS can provide both raw sensing data to the SCP and work as an agent to control and acquire data from the sensing device to the SCP.

When the SCP acquires data directly from the different kinds of sensing devices, there is no need for the SDCS to process the sensing data. In this case, the SDCS is working on a transparent transmission mode and sensing devices transmit data through the acquisition interface b to provide raw sensing data to the SCP.

When there are large deployments of sensing devices among city infrastructures, the SCP is unable to manage all the sensing devices. In this case, the SDCS is required to be used as an agent to control and acquire data for the SCP and together works on an agent transmission mode and transmits the processed sensing data via the acquisition interface a.

It uses unified data management and a standardized open interface to provide support for different vertical applications and is in charge of device control and linkage management for those city infrastructure sensing devices.

8 Functions of the sensing and data collection system

The functions of the SDCS are described in Figure 2. The SDCS provides device control, linkage management, data collection and processing, networking and sensing functions.

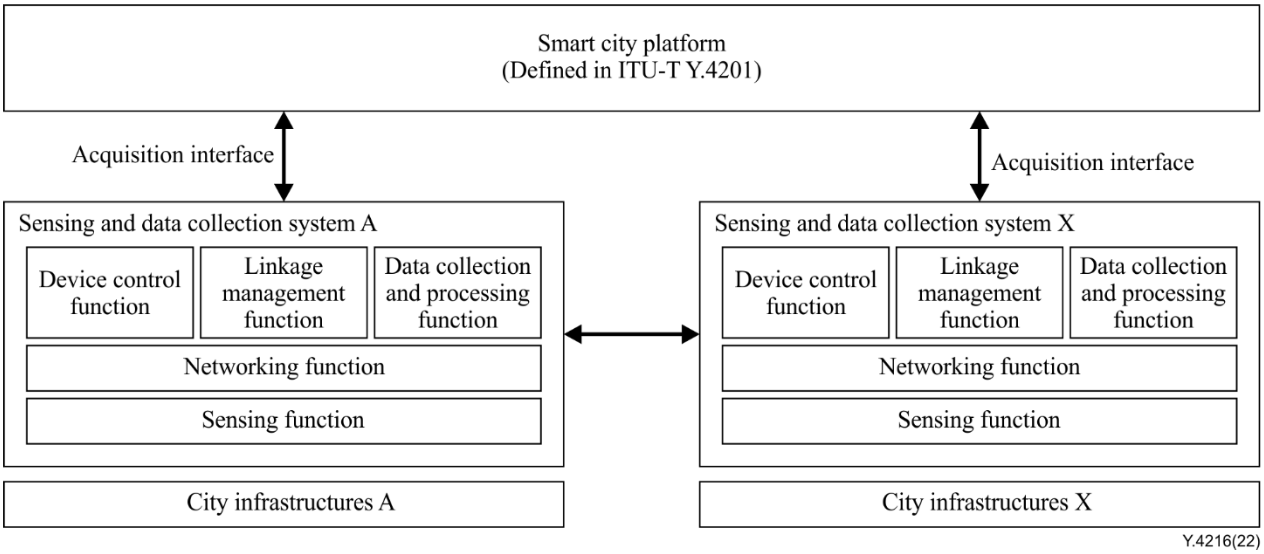

Figure 2 – Functions of SDCS for city infrastructure

One challenge of a highly efficient operation of a smart sustainable city (SSC) is to break the barrier between different city infrastructures and foster better cooperation with each other. Data from different city infrastructures such as transportation and environmental monitoring facilities are needed to be shared and reused, for example, surveillance data of CO_2 emissions in a specific city area from environmental monitoring facilities could be used as the control parameter of transportation infrastructures to restrict the number of motor cars on the road in that area.

For a smart city scenario, the government usually uses SCP on top of SDCS to interact between Internet of Things (IoT) devices provided by different industries or even different suppliers. The SCP is the application enabling platform, whose main focus is the interaction with various industries and cross industry platforms, rather than the direct interaction with sensor and control terminal equipment. The IoT applications of a smart city run on the SCP. The SDCS focuses on the direct interaction with sensor and control terminal equipment and also supports data sharing and exchanges between different vertical industries without SCP.

In smart cities, sectors such as the water industry, waste management, intelligent transportation and energy supply, have their own platforms to manage and control the corresponding industries. The most important thing for application enablers is to coordinate all these industries. The application enabling platform communicates with the SDCS, and integrates the aggregated data information from these systems. The application enabling platform can initiate operation commands to the following SDCS, and these systems then start corresponding the commands to operate the corresponding end devices.

The SDCS can provide safe and reliable full linkage management of all kinds of sensing devices used in one field of a city infrastructure and support various applications of SCP. It has the key function of breaking the barrier between different city infrastructures and making the operation of the smart city more efficient.

The SDCS has the following functions:

– Device control function: provides mechanisms for device identification and establishing equipment database of sensing devices for city infrastructures. They also provide device operations including authentication and authorization, status reports, fault detection, operation log record, remote firmware updating, situation prediction, intelligent scheduling, rapid response and rapid recovery.
– Data collection and processing function: supports the collection and processing of sensing data. They receive data from sensing devices and enable the movement of large amounts of data, and data processing and analysis functionalities to generate new datasets or modify / complete existing ones. They also support data protection, data access control, and information resource sharing and interaction between different SDCS for different fields in the city infrastructures.
– Linkage management function: provides a connection between SDCS and SCP, and supports the acquisition interface defined in [ITU-T Y.4200] and [ITU-T Y.4201]. It supports the interconnection between multiple SDCS of different fields of city infrastructures. It also manages the links for the sensors deployed in the city infrastructures.
– Networking function: provides the available physical links for sensors deployed in the city infrastructures.
– Sensing function: through a variety of information acquisition equipments, sensors, surveillance cameras, GPS terminals, etc, the function provides the ability of having an intelligent perception of the city infrastructures.

9 Requirements of sensing and data collection system for city infrastructures

9.1 Common requirements due to the features of city infrastructures

SDCS has the following requirements due to the features of city infrastructures:

– SDCS is required to periodically inspect city infrastructures through sensing devices to check whether it is in good working condition. In particular, some sensing devices should be able to turn on/off according to the instructions.
– SDCS is required to provide life-cycle management of infrastructures in order to cover the service life of those infrastructures and upgrade it with a replacement in this way upgrading the city infrastructures.
– SDCS is recommended to provide two kinds of sensing data that is related to the facility:
  • monitoring data on the structural health of the facility, to reflect the structural damage or degradation of the facility. The data includes stress, displacement, vibration, deformation and other parameters;
  • monitoring data on environmental conditions of the facility. The data includes environmental parameters such as temperature, humidity, air pressure and harmful gas concentration.

9.2 Requirements of the device control function

Device control function has the following requirements:

– It is required to provide a dynamic information database that includes all the information on working sensing devices of city infrastructures and completes the accurate identification of the sensing devices.
– It is required to realize undisturbed inventory and loophole scans of the sensing equipment.
– It is required to support the authentication that verifies the identity of the users who request to access the sensing device.

– It is required to support the authorization that grants the corresponding authority to be assigned to the users according to its authentication result.
– It is required to retrieve device status and management data of a sensor or controller periodically or with a request.
– It is required to generate exception information or alarms, and correspondingly start/stop /lock/calibrate/recover the sensor or controller when any sensor or controller has an abnormal status.
– It is required to collect the management data and operate the log and transfer it to the SCP.
– It is required to support the sensing device firmware updates and firmware fallbacks, etc.
– It is required to create, modify, and delete the configuration policies of various sensors based on data collecting frequency and period.
– It is required to send configuration policies to the sensors or controllers and start/stop/lock/calibrate/recover the sensors or controllers themselves or the applications on them.
– It is required to perform mask/open, encrypt/decrypt, and delete/restore specific data stored in the sensors or controllers.
– It is required to receive data about the operating status, performance, and fault report of the sensors or controllers.
– It is required to support the automatic notification of the status of sensors and its changes in order to monitor them in a timely manner.
– It is required to support integrity checking of devices, in order to help support the high availability of devices.

9.3 Requirements of the data collection and processing function

Data collection and processing functions have the following requirements:

– It is required to support the storage, retrieval and classification of all the information of sensors.
– It is required to support storage, retrieval, and classification of all the sensing, controlling and configuration data.
– It is required to provide all the sensing, controlling and configuration data protection functions.
– It is required to support the sensing data processing (e.g., data restructuring, etc.) based on the predefined rules and policies.
– It is required to support access control of the sensing data, enabling the ability to control how these data are exposed to the upper layer applications.
– It is required to support integrity checking and life cycle management of the sensing data to provide high availability and reliability of those data.
– It is required to support the sensing data exchange and information sharing between SDCSs of different fields of city infrastructures.

9.4 Requirement of linkage management function

The linkage management function has the following requirements:

– It is required to support interaction between SDCS and the SCP to comply with the interoperability requirement in [ITU-T Y.4200].

- It is required to support the interconnection for delivering sensing data from sensing devices and management, and configuration data to sensing devices using a wired network (e.g., optical or Ethernet network).
- It is required to support the data transmission between SDCS and SCP using a wired network.
- It is required to provide a direct link between sensors and the SCP to transmit raw sensing data and sensor control data when working in transparent transmission mode.
- It is required to support a unified data interface from SDCS to the SCP to transmit processed sensing data and sensor control data when working in agent transmission mode.
- It is required to support stable and safe data transmission for timing-sensitive and wideband sensing data.
- It is required to support the interconnection for delivering sensing management data to the sensing devices using a wireless network (e.g., Wi-Fi or mobile network). Adequate access technology should be selected in terms of usage, affordability and cost-effectiveness.
- It is required to support the interconnection between SDCSs.

9.5 Requirements of the networking function

The networking function has the following requirements:

- It is required to form local networks for sensors to communicate with each other using wired or wireless communication technologies.
- It is recommended to support autonomic networking [b-IETF RFC 7575] of the sensors to adapt to different applications, different communication environments, large numbers and different types of devices.
- It is required to support the configuration of a wired / wireless integrated sensing network in various infrastructures.
- It is recommended to provide the construction of sensors network in an ad-hoc manner in some scenarios which need increased scalability and quick deployment.

9.6 Requirements of the sensing function

The sensing function has the following requirements:

- It is required to detect or measure information related to the corresponding city infrastructures.
- It is required to convert detected information of city infrastructures into digital electronic signals.

Bibliography

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