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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 and capability framework of smart environmental monitoring

Recommendation ITU-T Y.4207

International Telecommunication Union

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Recommendation ITU-T Y.4207

Requirements and capability framework of smart environmental monitoring

Summary

Recommendation ITU-T Y.4207 provides the requirements and capability framework of smart environmental monitoring (SEM). As a smart application of Internet of things (IoT) in the field of environmental monitoring and protection, SEM is an important means to enhance environmental management level and develop environmental protection.

The provided requirements and capability framework are intended to be generally applicable in environmental monitoring.

History

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Recommendation ITU-T Y.4207

Requirements and capability framework of smart environmental monitoring

1 Scope

This Recommendation specifies requirements and capability framework of smart environmental monitoring (SEM). As a smart application of Internet of things (IoT) in the field of environmental monitoring and protection, SEM is an important means to enhance environmental management level and develop environmental protection.

The scope of this Recommendation includes:

– overview of smart environmental monitoring;

– requirements of smart environmental monitoring;

– capability framework of smart environmental monitoring.

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

[ITU-T Y.4401] Recommendation ITU-T Y.4401/Y.2068 (2015), *Functional framework and capabilities of the Internet of things*.

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1 device [ITU-T Y.4000]: With regard to the Internet of things, this is a piece of equipment with the mandatory capabilities of communication and the optional capabilities of sensing, actuation, data capture, data storage and data processing.

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.

NOTE 1 – Through the exploitation of identification, data capture, processing and communication capabilities, the IoT makes full use of things to offer services to all kinds of applications, whilst ensuring that security and privacy requirements are fulfilled.

NOTE 2 – From a broader perspective, the IoT can be perceived as a vision with technological and societal implications.

3.1.3 sensor [b-ITU-T Y.4105]: An electronic device that senses a physical condition or chemical compound and delivers an electronic signal proportional to the observed characteristic.

3.2 Terms defined in this Recommendation

None.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

API Application Programming Interface

GNSS Global Navigation Satellite System

IoT Internet of things

SEM Smart Environmental Monitoring

SMS Short Message Service

5 Conventions

In this Recommendation:

The keywords "is required to" indicate a requirement which must be strictly followed and from which no deviation is permitted if conformance to this document is to be claimed.

The keywords "is recommended" indicate a requirement which is recommended but which is not absolutely required. Thus this requirement needs not be present to claim conformance.

The keywords "can optionally" and "may" indicate an optional requirement which is permissible, without implying any sense of being recommended. These terms are not intended to imply that the vendor's implementation must provide the option and the feature can be optionally enabled by the network operator/service provider. Rather, it means the vendor may optionally provide the feature and still claim conformance with the specification.

6 Overview of smart environmental monitoring

Environmental monitoring describes all processes and activities that need to take place to characterize and monitor the quality of the environment. Environmental monitoring is used for environmental impact assessments, as well as for circumstances in which human activities carry a risk of harmful effects on or from the environment.

Real-time environmental monitoring systems that are capable of collecting and analysing all information relevant to the environmental status are essential for efficient environmental monitoring and protection. In general, there is air monitoring, water monitoring, and soil monitoring, because air, water and soil are three essential factors among many environmental resources. The collected data are stored and analysed for further use in forecasting weather status, measurement of pollution, consequence assessment of natural resource management, etc.

IoT technologies are key to enable more flexible real-time environmental monitoring, diagnostics, and finally protection of further serious degradations. By integrating IoT devices in the environment itself, the level of environmental monitoring could be substantially raised, giving environmental monitoring many new, intelligent features. These features are primarily self-monitoring and self-protecting with the possibility of not only reactive but also proactive actions.

SEM is a self-monitoring and self-protecting environmental monitoring application that is aware of current environmental status with the possibility of automatic alarm rising when appropriate. SEM provides not only environmental monitoring, but also data analysis which can be used for management.

Figure 1 shows the overall conceptual diagram for SEM.

A SEM device usually consists of one or more type of sensors, edge computing facilities and gateway facilities for interconnection to the SEM platform. SEM devices measure environmental status, such as air quality, water quality or soil quality.

The network enables the interaction between SEM devices and the SEM platform.

The SEM platform is responsible for collecting and managing environmental data, mainly for environmental protection purposes. It provides the resulting environmental information to SEM users, including other platforms as shown in Figure 1.

NOTE – Concerning other platforms, the SEM platform may interface with them for exchanging mutually beneficial information. In some scenarios, the SEM platform may also be integrated within a larger scope system, typically a smart city system.

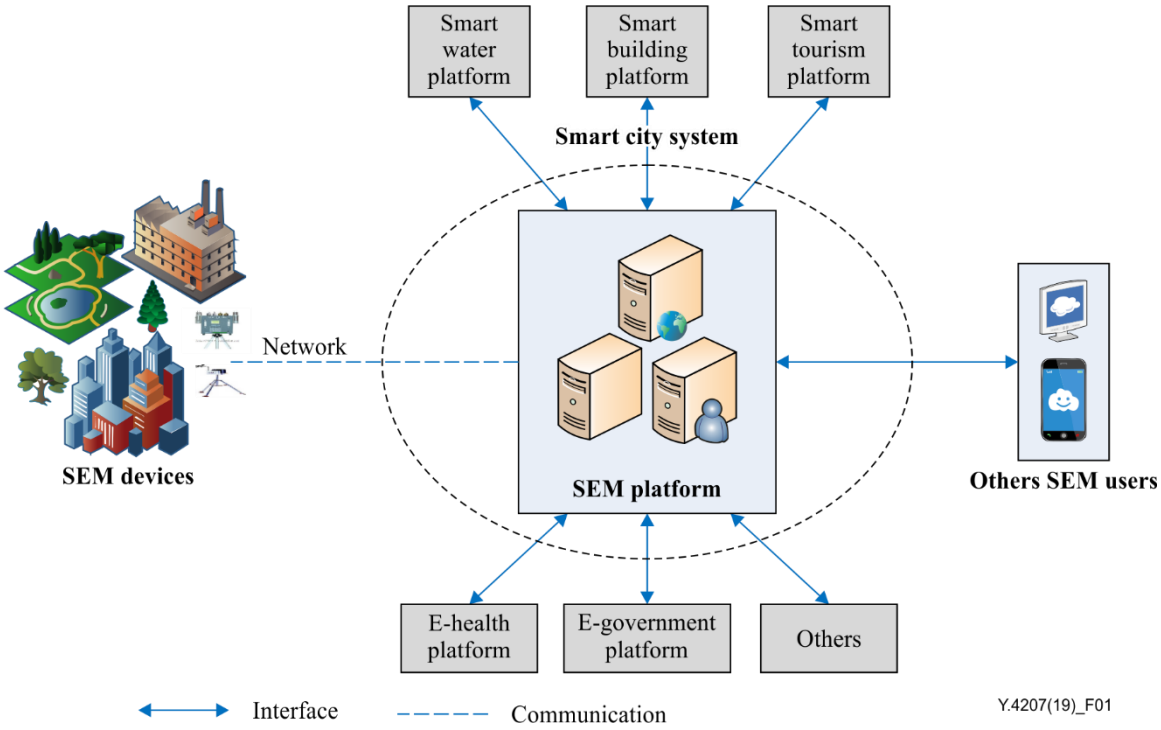

Figure 1 – Overall conceptual diagram for SEM

7 Requirements of smart environmental monitoring

This clause categorises SEM requirements with respect to the SEM platform, SEM devices and the network.

7.1 Requirements of SEM platform

– SEM platform is required to provide environmental information, such as air quality, water quality, soil quality, etc.;

– SEM platform is required to provide real-time environmental warning when the environmental warning preset conditions are reached;

– SEM platform is required to send environmental warnings to relevant personnel, in an appropriate time, according to the specific scenario of the warning generation;

NOTE 1 – Examples of warning transmission modalities include telephone, short message service (SMS) and e-mail.

– SEM platform is required to share appropriate information in the event of an environmental emergency;

NOTE 2 – This includes sharing information with relevant personnel on emergency management, operations, planning, etc.

– SEM platform is recommended to locate the sources that cause observations to exceed the threshold;

– SEM platform is recommended to provide support to the identification and analysis of the origins that cause observations to exceed the threshold;

– SEM platform can optionally provide environmental reports based on the acquired environmental data;

– SEM platform is recommended to provide suggested actions, including how to improve environmental quality;

– SEM platform is required to provide capabilities of presenting data through interfaces to SEM users;

NOTE 3 – Examples of data presentation modalities include Web portal and mobile applications.

– SEM platform is recommended to expose open application programming interfaces (APIs) for environmental information usage by third-party applications;

– SEM platform is required to provide interfaces for other platforms to exchange information as appropriate;

NOTE 4 – Examples of information provided by the SEM platform include environmental information, environmental warning service information, environmental emergency service information, etc. Examples of information received from other platforms include weather condition and other environment related information.

– SEM platform is recommended to have the ability to be integrated within smart city systems;

NOTE 5 – This includes provisioning of open APIs for its integration.

– SEM platform is required to identify the location of SEM devices as appropriate;

– SEM platform is required to present SEM device-related information through interface to SEM users as appropriate;

– SEM platform is required, where possible, to locate a faulty SEM device, present fault information, and remotely command troubleshooting of the faulty device;

– SEM platform is recommended to send measurement settings to SEM devices;

– SEM platform is recommended to configure measurement settings of specific SEM devices;

– SEM platform is recommended to configure measurement settings of SEM devices according to their location;

– SEM platform can optionally manage SEM devices' maintenance records and can optionally send reminders to relevant personnel when scheduled maintenance procedures are needed.

NOTE 6 – For example, the platform can enable management of device cleaning records, replacement records, calibration records and accuracy requirements.

7.2 Requirements of SEM devices

– SEM devices are required to monitor environmental information, such as air quality, water quality and soil chemical components;

– SEM devices are required to transfer the acquired environmental information to SEM platform;

– In case of a lost connection to the SEM platform, SEM devices are required to store data and upload data automatically once the connection is recovered;

– SEM devices are recommended to be time synchronised with SEM platform;

– SEM devices can optionally obtain their locations via appropriate device capabilities, utilizing different techniques, such as Global Navigation Satellite System (GNSS). Location accuracy depends on different types of devices and applications;
– SEM devices are required to receive, store and execute measurement settings;
– When an SEM device is faulty, the SEM device is recommended to detect the abnormal status where possible, and then report the fault information automatically to SEM platform.

7.3 Requirements of the network

– The network is recommended to have the ability to obtain the location of SEM devices.

8 Capability framework of smart environmental monitoring

Based on the IoT reference model specified in [ITU-T Y.4000], Figure 2 illustrates the SEM capability framework, which consists of four layers and two cross-layer capability groups. In this figure, a specific zoom is provided on SEM platform and SEM devices, illustrated by two outside rectangles with detailed capabilities. In addition to capabilities specified in [ITU T Y.4000] and [ITU-T Y.4401], additional specific capabilities are required for SEM platform, SEM devices and the network, as shown in Figure 2 via yellow highlighted rectangles.

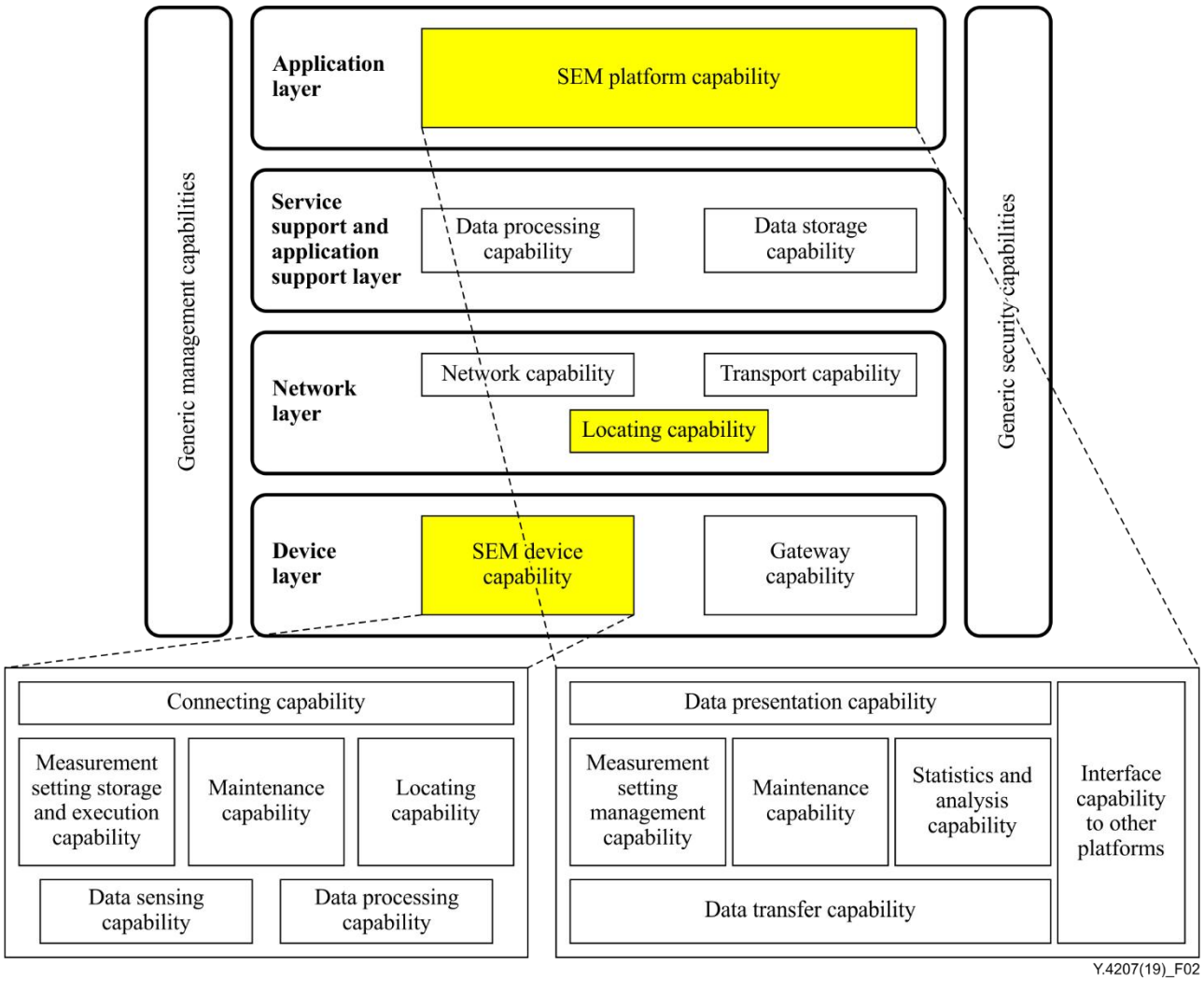

Figure 2 – Capability framework of SEM

The following clauses describe the specific capabilities of SEM.

8.1 Capabilities of the application layer

According to SEM requirements described in clauses 7.1 and 7.2, the capabilities of the application layer include data transfer capability, measurement setting management capability, maintenance capability, statistics and analysis capability, data presentation capability and interface capability to other platforms. The details of these capabilities are described in the following clauses.

8.1.1 Data transfer capability

Data transfer capability transfers data among different capabilities in SEM platform. It includes but is not limited to:

– sending the measurement, identity, type of SEM device to maintenance management capability, statistics and analysis capability;

– sending the measurement settings from measurement setting management capability to SEM device.

8.1.2 Measurement setting management capability

Measurement setting management capability manages the creation, modification and deletion of measurement settings. It includes but is not limited to:

– creating measurement settings based on the location of a device and environmental factors;

– creating measurement settings to configure control degree, such as location control of device;

– receiving information from statistics and analysis capability and creating measurement settings accordingly. For example, if a negative environmental event is predicted, devices within the region of interest could increase their measurement frequency to provide better observation;

– modifying and deleting measurement settings;

– sending measurement settings to data transfer capability.

8.1.3 Maintenance capability

Maintenance capability maintains SEM devices. It includes but is not limited to:

– recognizing and detecting the identity, type, operating status of SEM device from data transfer capability;

– automatically generating fault reports from operating status;

– automatically triggering alarms, and then informing the maintenance staff.

8.1.4 Statistics and analysis capability

Statistics and analysis capability generates environmental reports, produces environmental warning events and identifies possible sources that cause observations to exceed thresholds. It includes but is not limited to:

– analysing environmental quality based on the environmental raw data, utilizing the data analysis capability in service support and application support layer. The results may be provided to users directly or stored in service support and application support layer;

– producing environmental warning events based on the results of environmental quality analysis and informing specific users of these events in various ways, including telephone, SMS, e-mail;

– analysing the changing trend of environmental parameters (e.g., air quality, water quality and soil quality), to identify the possible sources that cause observations to exceed the thresholds and providing suggested actions for solution.

8.1.5 Data presentation capability

Data presentation capability presents the environmental quality information. It includes but is not limited to:

– providing interface to authorized SEM users to present the environmental measurement data. Environmental measurement data presentation is recommended to include presentation of raw data at each given location (of one or more SEM devices) and presentation of processed data derived from raw data according to SEM users' requirements;

– providing interface to authorized SEM users to present the physical distribution of all SEM devices, and maintenance status of each SEM device as well;

– providing interface to authorized SEM users to present the physical distribution of faulty SEM devices with their fault information.

8.1.6 Interface capability to other platforms

– As other platforms may need to exchange information with SEM platform, application layer is required to support open APIs.

8.2 Capabilities of the device layer

According to SEM requirements identified in clause 7.2, the capabilities of the device layer include connection and sleeping capabilities as already specified in [ITU-T Y.4000], as well as the following specific capabilities: data sensing, data processing, connecting, measurement setting storage and execution, maintenance and (device based) locating capabilities.

8.2.1 Data sensing capability

Data sensing capability senses the environment. It includes but is not limited to:

– sensing environmental conditions and obtaining the raw environmental data, including but not limited to air, water and soil.

NOTE – It is recommended to integrate multiple sensors in a single physical SEM device, to sense multiple environmental data by just one device at a certain location.

8.2.2 Data processing capability

Data processing capability processes data. It includes but is not limited to:

– deriving target parameters for environmental monitoring from the raw environmental data, with tools such as filtering and format conversion;

– provide g time synchronization with SEM platform;

– preparing the data with message composition to make it suitable for communication.

8.2.3 Connecting capability

Data connecting capability enables SEM devices to communicate with SEM platform. It includes but is not limited to:

– setting up the communication between SEM devices and SEM platform;

– receiving the measurement settings from SEM platform;

– sending the measurement settings to measurement settings storage and execution capability;

– regularly reporting the collected parameters from maintenance capability to SEM platform;

– reporting fault information from maintenance capability to SEM platform.

8.2.4 Measurement setting storage and execution capability

Measurement setting storage and execution capability manages measurement settings. It includes but is not limited to:

– receiving and storing measurement settings from connecting capability;
– automatically executing the measurement settings if preset conditions are reached;
– automatically executing the measurement settings of a specific SEM device.

8.2.5 Maintenance capability

Maintenance capability maintains SEM devices. It includes but is not limited to:

– monitoring the working status of SEM devices;
– detecting abnormal measurements and reporting the fault information automatically to connecting capability.

8.2.6 Locating capability

Locating capability collects location information. It includes but is not limited to:

– collecting the location information of SEM devices.

NOTE – SEM needs to be aware of the location of most devices. Though such awareness can be achieved by marking every device and placing it to a fixed location, deployment flexibility and scalability will be impacted in such case. Alternatively, devices can optionally be able to obtain their locations via the device-based locating capability utilizing different locating techniques, such as GNSS. Locating accuracy depends on different types of devices and applications.

8.3 Capabilities of the network layer

SEM does not need additional specific capabilities of the network layer in terms of networking and transport capabilities. However, network-based locating capability is recommended.

8.3.1 Locating capability

Locating capability collects location information. It includes but is not limited to:

– collecting the location information of SEM devices.

NOTE – Locating devices by marking every device and placing them in a fixed location generally impacts deployment flexibility and scalability, and device-based locating techniques increase the cost and power consumption of devices, thus network layer is recommended to have the ability to obtain the location of SEM devices.

Appendix I

Use cases of smart environmental monitoring

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

I.1 Water quality warning service

SEM users use the water quality warning service to monitor water quality. Water quality sensing devices transmit the collected organic or inorganic pollutant concentration to the SEM platform, where the monitoring data are stored in a database for statistical analysis. When the pollutant measurement value reaches a threshold value, the SEM platform sends warning information to users to prevent water pollution and protect human health.

As shown in Figure I.1, water quality sensing devices collect water quality data of surface water, underground water and sewage draining exit, and then transmit the data to the SEM platform, where the data are stored and analysed. Users can receive the water quality warning on PC and mobile apps.

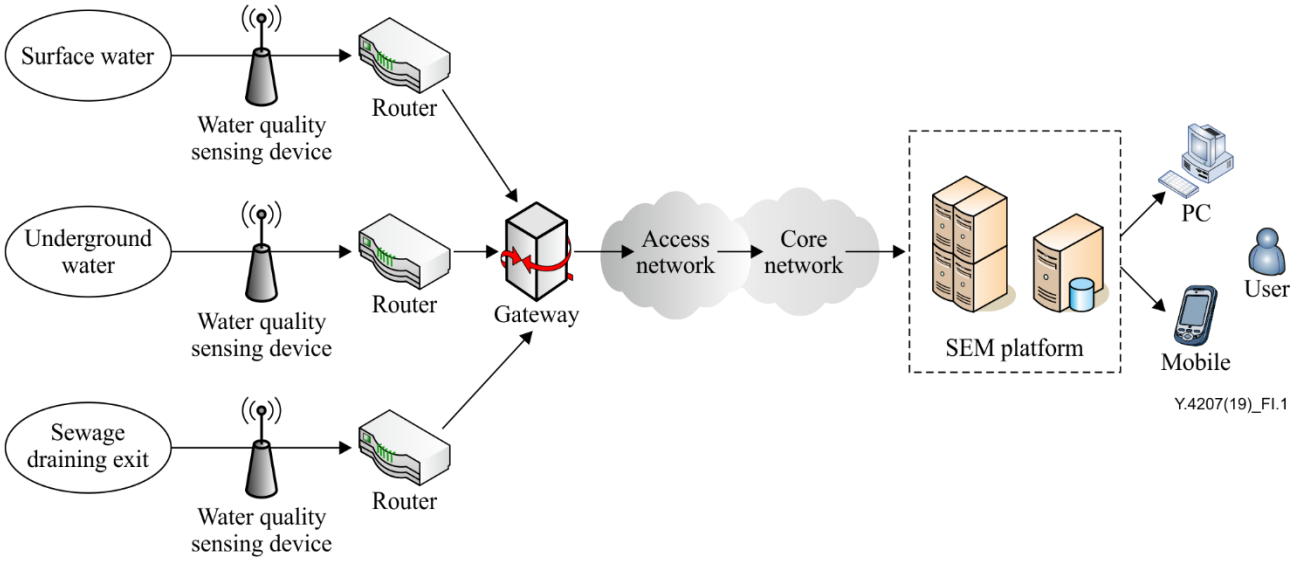

Figure I.1 – Water quality warning service scenario

The water quality warning service provides the following three functions:

1) information release: water quality sensing devices carry out regular or continuous monitoring of the water environment, obtain the monitoring data and sending them to the SEM platform. Users can query the data through the web portal or mobile app;

2) warning service: when the measured value reaches a preset threshold, the SEM platform automatically triggers alarms at different alarm levels, and sends the alarms to the user by telephone, SMS, e-mail;

3) data management: the SEM platform carries on the statistical analysis of the monitoring data, and provides the obtained results to relevant personnel in order to make a corresponding management plan.

Bibliography

[b-ITU-T Y.4105] Recommendation ITU-T Y.4105/Y.2221 (2010), *Requirements for support of ubiquitous sensor network (USN) applications and services in the NGN environment*.

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