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Information technology — Sensor networks: Sensor Network Reference Architecture (SNRA) —

Part 5: Interface definitions

Technologies de l'information — Réseaux de capteurs: Architecture de référence pour réseaux de capteurs —

Partie 5: Définitions des interfaces

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Foreword

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International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of the joint technical committee is to prepare International Standards. Draft International Standards adopted by the joint technical committee are circulated to national bodies for voting. Publication as an International Standard requires approval by at least 75 % of the national bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO/IEC 29182 consists of the following parts, under the general title *Information technology — Sensor networks: Sensor Network Reference Architecture (SNRA)*:

— *Part 1: General overview and requirements*

— *Part 2: Vocabulary and terminology*

— *Part 3: Reference architecture views*

— *Part 4: Entity models*

— *Part 5: Interface definitions*

— *Part 7: Interoperability guidelines*

The following part is under preparation:

— *Part 6: Applications*

Introduction

A wide range of applications has been proposed for sensor networks. In practice, however, sensor networks have been built and deployed for a relatively small number of applications. This is partly due to the lack of a business case for certain applications and partly due to technical challenges in building a non-trivial sensor network of reasonable complexity. The main reason for this impediment is multi-disciplinary expertise – such as sensors, communications and networking, signal processing, electronics, computing, and cyber security – is required to design a sensor network. Presently, the design process is so complex that one can leverage little from one sensor network design to another. It appears as if one has to start from almost scratch every time one wishes to design and deploy a sensor network. Yet, upon closer inspection, there are many commonalities in instantiations of sensor networks that realize various applications. These commonalities include similarities in the choice of network architecture and the entities/functional blocks that are used in the architecture.

The purpose of the ISO/IEC 29182 series is to

— provide guidance to facilitate the design and development of sensor networks,

— improve interoperability of sensor networks, and

— make sensor networks plug-and-play, so that it becomes fairly easy to add/remove sensor nodes to/from an existing sensor network.

The ISO/IEC 29182 series can be used by sensor network designers, software developers, and service providers to meet customer requirements, including any applicable interoperability requirements.

The ISO/IEC 29182 series comprises seven parts. Brief descriptions of these parts are given next.

ISO/IEC 29182-1 provides a general overview and the requirements for the sensor network reference architecture.

ISO/IEC 29182-2 provides definitions for the terminology and vocabulary used in the reference architecture.

ISO/IEC 29182-3 presents the reference architecture from various viewpoints, such as business, operational, system, technical, functional, and logical views.

ISO/IEC 29182-4 categorizes the entities comprising the reference architecture into two classes of physical and functional entities and presents models for the entities.

This part of ISO/IEC 29182 provides detailed information on the interfaces among various entities in the reference architecture.

ISO/IEC 29182-6 provides detailed information on the development of International Standardized Profiles.

ISO/IEC 29182-7 provides design principles for the reference architecture that take the interoperability requirements into account.

There are no requirements for compliance in the ISO/IEC 29182 series. Users should ensure that the sensor nodes, and the related sensor network, are compliant with the application or deployment governing body.

Information technology — Sensor networks: Sensor Network Reference Architecture (SNRA) —

Part 5: Interface definitions

1 Scope

This part of ISO/IEC 29182 provides the definitions and requirements of sensor network (SN) interfaces of the entities in the Sensor Network Reference Architecture and covers the following aspects:

— interfaces between functional layers to provide service access for the modules in the upper layer to exchange messages with modules in the lower layer;

— interfaces between entities introduced in the Sensor Network Reference Architecture enabling sensor network services and applications.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO/IEC 29182-2, *Information technology — Sensor networks: Sensor Network Reference Architecture (SNRA) — Part 2: Vocabulary and terminology*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO/IEC 29182-2 apply.

4 Abbreviated terms

SN	Sensor Network
SNRA	Sensor Network Reference Architecture
API	Application Programming Interface
I/F SNHL/BFL	Interface between Sensor Node Hardware Layer and Basic Functions Layer
I/F BFL/SL	Interface between Basic Functions Layer and Service Layer
I/F SL/AL	Interface between Service Layer and Application Layer
I/F CLM/AL-SL-BFL	Interface between Cross-Layer Management and Application Layer, Service Layer, and Basic Functions Layer
I/F CLM/AL	Interface between Cross-Layer Management and Application Layer
I/F CLM/SL	Interface between Cross-Layer Management and Service Layer
I/F CLM/BFL	Interface between Cross-Layer Management and Basic Functions Layer

QoS	Quality of Service
HLME-SAP	Hardware Layer Management Entity-Service Access Point
HLDE-SAP	Hardware Layer Data Entity-Service Access Point
BFME-SAP	Basic Functions Layer Management Entity-Service Access Point
BFDE-SAP	Basic Functions Layer Data Entity-Service Access Point
SLME-SAP	Service Layer Management Entity-Service Access Point
SLDE-SAP	Service Layer Data Entity-Service Access Point
ALME-SAP	Application Layer Management Entity-Service Access Point
PCI	Peripheral Component Interconnect
USB	Universal Serial Bus
TCP/IP	Transmission Control Protocol/Internet Protocol
GPRS	General Packet Radio Service
CDMA	Code Division Multiple Access
GSM	Global System for Mobile communications
TD-LTE	Time Division-Long Term Evolution
UWB	Ultra Wide Band

5 SN interfaces overview

A sensor network (SN) is a system consisting of interconnected (via wireless or wired) and spatially distributed sensor nodes to acquire, process, transfer, and provide information from the physical world and optionally react to the physical world by using an actuator or actuators.

Sensor networks have many different applications in a variety of domains such as environment monitoring, logistics management, industrial automation, intelligent highway system, and perimeter protection. From one SN application domain to another, significant differences exist in service requirements, service types, processing functions, interfaces, operational attributes and so on. These significant differences influence the structure, construction and performance of a SN.

An interface is the shared border between two interactive entities or modules, so interface definition depends on the entities or modules on both sides. An interface can be described in physical or logical form.

The purpose of developing generic and generalized definitions for SN interfaces is to promote the interoperability among modules within a sensor node, between sensor nodes, and other entities. Defining a set of standard interfaces for SN is one of the most efficient approaches to bring the interoperability to sensor networks.

To provide service and implement application in sensor network, sensor nodes and other entities have to exchange messages containing sensor data or command. The messages pass through different functional layers in each entity, and pass from one entity to another. Interfaces between different layers and interfaces between peer modules in functional layers of different entities (e.g. sensor node or senor network gateway) are used to enable sensor network applications and services. Figure 1 illustrates three classes of sensor networks architectures defined in ISO/IEC 29182-1 and gives an overview of interfaces enabling sensor network services and applications. Interfaces between functional layers in a sensor node or gateway, and interfaces between physical entities are shown in the Figure 1.

This standard describes common interfaces which need to be considered when building an SN infrastructure of SN. Specific interface standards and detailed interface implementations such as message format and exchanging mechanism are out of the scope of this standard.

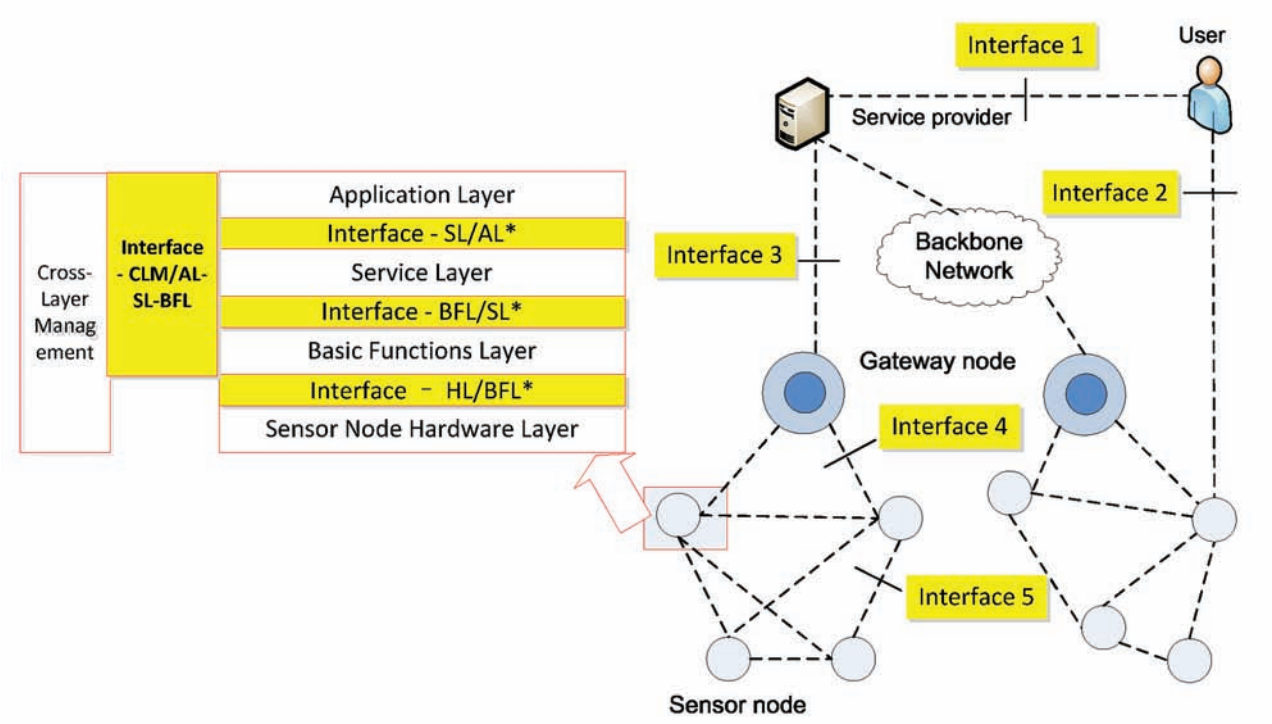

Figure 1 — Overview of interfaces enabling sensor network services and applications

6 Interfaces between different functional layers

6.1 General

From the node's architectural point of view, there are five kinds of functional layers shown in Figure 1. They are:

— Sensor Node Hardware Layer (SNHL);

— Basic Functions Layer (BFL);

— Service Layer (SL);

— Application Layer (AL);

— Cross-Layer Management(CLM)

Sensor nodes and gateways are likely to have similar layers, but modules in each layer may be largely different. For example, sensor node may integrate different sensors in its SNHL, while a gateway's hardware layer will not contain any sensors.

Communication between functional modules in layer is implemented by the interface between these layers, which provides data and management service points. A data entity SAP and management entity SAP are defined in each of interface between layers.

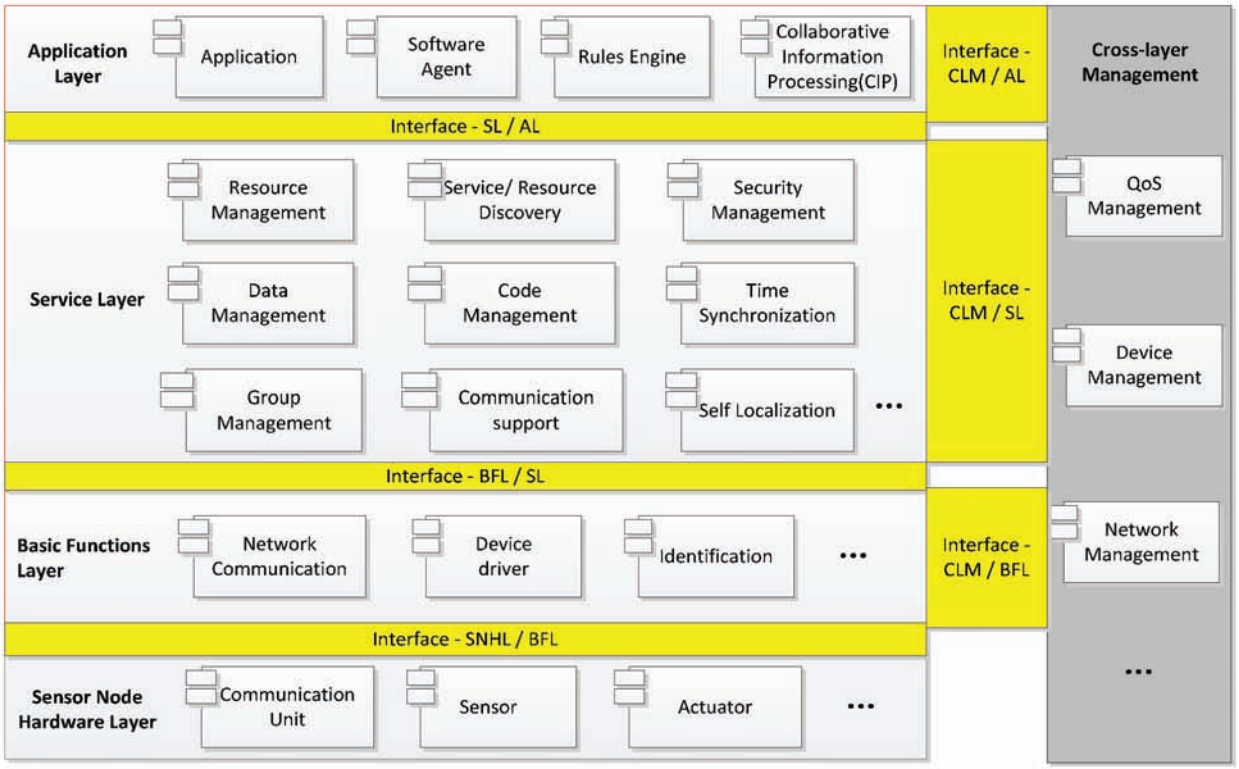

Figure 2 — Interfaces definition between functional layers enabling sensor network services and applications

Figure 2 shows the four primary interfaces between the functional layers, and the abbreviation of each interface is included separately. They are:

— Interface between sensor node hardware layer and basic functions layer (I/F SNHL / BFL);

— Interface between basic functions layer and service layer (I/F BFL / SL);

— Interface between service layer and application layer (I/F SL / AL);

— A set of interfaces between cross-layer management and application layer, service layer, and basic function layer (I/F CLM / AL-SL-BFL), namely CLM/AL, CLM/SL and CLM/BFL.

Cross-layer management can manage hardware in sensor node hardware layerthrough CLM/BFL and SNHL/BFL.

Figure 2 illustrates some function modules in each layer. It is not possible to list all of the function modules in this figure. The modules shown in Figure 2 are common and are defined in ISO/IEC 29182-4. Logically, sensor node design should follow this structure, but due to detailed application requirements differences exist. The designer can choose some of the layers and relative interfaces to build sensor network according to their application scenarios.

6.2 Interface - SNHL / BFL

I/F SNHL/BFL is an interface between the sensor node hardware layer and the basic functions layer which contains the physical (hardware) and logical (software) component in a node. Through this interface, functional models in the basic functions layer interact with the sensor node hardware layer.

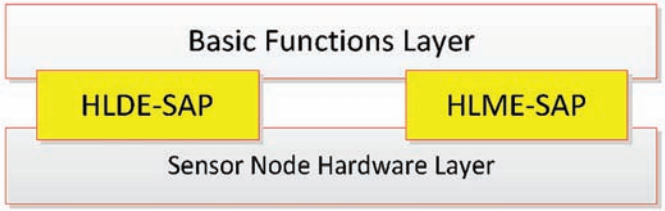

Figure 3 — Service access point provided by I/F HL/BFL

The sensor node hardware layers supplies the infrastructure including a processor, memory, communication device, power supply and other additional hardware. The interface SNHL / BFL provides interconnecting service for the basic functions layer to access and utilize sensor node hardware.

The sensor node hardware layer provides two kinds of services to basic function layer. One is hardware layer data service through the hardware layer data entity SAP (HLDE-SAP). The other is hardware layer management service through the hardware layer management entity SAP (HLME-SAP).The two SAPs are shown in Figure 3. The functional modules in the basic functions layer can use these two SAPs to support the transport of data unit in the basic functions layer between peer functional modules of layers. Modules in the basic functions layer access the data in hardware layer (such as sensor data) by HLDE-SAP, and modules in the basic functions layer manage the hardware modules in hardware layer (such as actuator) by HLME-SAP.

Due to diversity of sensors and their applications, sensor manufacturers define and implement their own physical sensor interfaces. These manufacturer-defined interfaces are rarely compatible with each other hindering interconnectivity and interoperability. Data types and data formats must also be defined in order to achieve interconnectivity and interoperability of data/information from dissimilar sensors.

This interface is described in terms of the mechanical, electrical and logical signals at the interface and the protocol for sequencing them (sometimes called signalling). The requirements to define the interface SNHL/BFL are described below:

— Information exchange mechanisms, primitives and message formats in HLDE-SAP and HLME-SAP between the sensor node hardware layer and different functional modules in the basic functions layer should be defined and developed according to the requirement of the basic functions layer.

— Characteristics of node hardware that are used for upper applications need to be described in the hardware's metadata.

— Interface standard should be developed and consolidated for the basic functions layer to access the sensor node hardware layer based on the node metadata (such as sensor type, measurement unit type), and physical hardware connection types(such as PCI, USB).

6.3 Interface - BFL /SL

I/F BFL/SL is a logical interface between the basic the functions layer and the service layer. The basic functions layer provides basic functions to service layer via I/F BFL/SL. Service layer provides services such as communication support, group management, data management, security management, self-localization, etc.

Interface BFL/SL describes data type and format which is related to modules in the basic functions layer, like type of basic function performed, type of information generated, and structure of transmitted data.

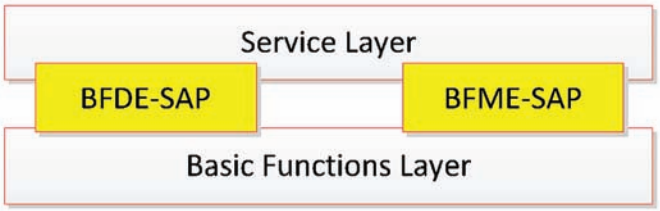

Figure 4 — Service access point provided by I/F SL/BFL

The basic functions layer provides two kinds of services to service layer. One is basic functions layer data service through basic functions layer data entity SAP (BFDE-SAP). The other is basic functions layer management service through basic functions layer management entity SAP (BFME-SAP). The two SAPs are shown in Figure 4. The functional modules in the service layer can use these two SAPs to support the transport of data unit in the service layer between peer functional modules of layers. Modules in service layer access the data in the basic functions layer (such as communication data) by BFDE-SAP, and modules in service layer manage the modules in basic functions layer (such as management data) by BFME-SAP.

The requirements of defining interface BFL / SL are described below:

— Information exchange mechanisms, primitives and message format in BFDE-SAP and BFME-SAP should be defined and developed according to the requirement of service layer.

— Functions in basic functions layer need to be defined in standard API so that these functions can be called by functions in service layer.

6.4 Interface - SL / AL

I/F SL/AL is a logical interface between the service layer and the application layer. The service layer provides services to functional modules in the application layer and cross-layer management. The application layer contains the target application module for the node such as sensor data processing. The application layer can be complex depending on the complexity of SN applications.

This interface SL/AL describes data type and format which is related to modules in the services layer, such as service metadata, including service type, service state information and service management information. The modules in the application layer access the data in service layer (such as network topology data) through SLDE-SAP, and modules in the application layer manage the modules in the service layer (such as network management data) through SLME-SAP.

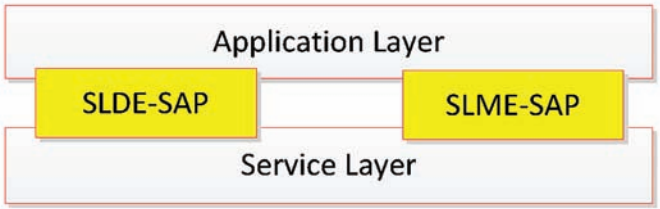

Figure 5 — Service access point provided by I/F AP/SL

The service layer provides two kinds of services to application layer. One is service layer data service through service layer data entity SAP (SLDE-SAP). The other is service layer management service through service layer management entity SAP (SLME-SAP). The two SAPs are shown in Figure 5. Functional modules in the application layer can use these two SAPs to support the transport of data units in the application layer between peer functional modules of layers. Primitives of the interface, which depends on the implementation of modules, are out of the scope of this standard.

Requirements of defining interface SL / AL are described below:

— Information exchange mechanisms, primitives and message format in SLDE-SAP and SLME-SAP between modules in the service layer and modules in the application layer should be defined and developed depending on the requirement of the application layer.

— Functions in the service layer need to be defined in a standard API so that these functions can be called by functions in the application layer. Application programmers will be able to deliver solutions according to users' needs by using these APIs which are considered as "construction modules". So these APIs in the service layer can be called by the application layer.

6.5 Interface - CLM / (AL-SL-BFL)

I/FCLM/AL-SL-BFL is a set of logical interfaces between cross-layer management and the application layer, the service layer, and the basic functions layer. These interfaces cross different layers in the node architecture, but have similar characteristics.

Cross-layer management provides common information and establishes common functions for the application layer, the service layer and the basic function layer in a sensor node such as device management, network management and QoS management. For example, modules in the application layer, the service layer and the basic functions layer have to obey the interface definition of each layer when they access the modules in CLM.

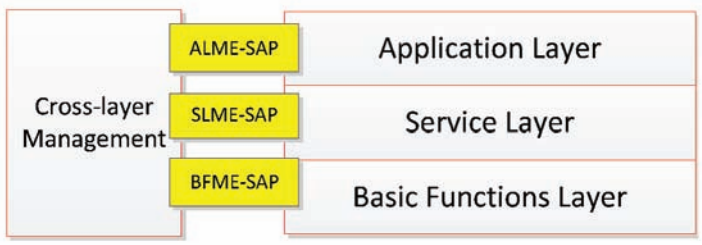

Figure 6 — Service access point provided by I/F CLM / (AL-SL-BFL)

The application layer, service layer and basic functions layer provide management services to cross-layer management. These services are application layer management service through application layer management entity SAP (ALME-SAP), service layer management service through service layer management entity SAP (SLME-SAP) and basic functions layer management service through basic functions layer management entity SAP (BFME-SAP). The three SAPs are shown in Figure 6. Functional modules in cross-layer management can use these three SAPs to support the transport of data unit in different layers between peer functional modules.

Requirements of defining interface CLM / (AL-SL-BFL) are described below:

— Information exchange mechanisms, primitives and message format in ALME-SAP, SLME-SAP and BFME-SAP between modules in different layers (such as the application layer, the service layer, the basic functions layer and cross-layer management) should be defined and developed according to the requirement of cross-layer management.

— A standard API can be developed for cross-layer management and the APIs can be called by modules in other layers.

7 Interfaces between entities enabling SN services and applications

7.1 General

Entities in SNRA use interfaces between layers for exchanging message and use modules in peer functional modules to resolve the message to accomplish the process of communication. Besides the

interfaces between functional layers, interfaces between entities in SNAR are also needed to enable sensor network services and applications.

Peer functional layers in which Information exchange between entities are based on sensor network applications requirement. Interface between entities is a set of protocols of peer functional modules in the same layers. Figure 7 illustrates an instantiated SN architecture which consists of the following entities, and these components are expanded with Figure 2 in Part 3:

— **User**: An entity that use sensor network applications to meet its requirements. A sensor network application is a use case of sensor networks, such as temperature monitoring, home automation or health monitoring. A user can interact with the service provider via standard interface (Interface 1 in Figure 7).

— **Service provider**: A service provider offers services to users, such as a set of generic services, and supports generic data processing, management functions and other common services, including data fusion for data from different gateways, security management, access management, etc. Usually these services can be shared by different applications. A service provider provides these functions to user by a normalized interface (Interface 1 in Figure 7) which can shield the heterogeneous information collected from backbone networks.

— **Backbone network:** A backbone network connects with gateways through different access networks, for example, Ethernet, GPRS, CDMA, GSM, or TD-LTE. Backbone network and access networks work as transport networks which transmit data from the sensor network to the Service Provider.The definition of Interfaces for Backbone networks is out of the scope of this standard.

— **Gateway**: A gateway is a bridge between a sensor network and other networks. The functionalities of the gateway may include protocol translation, local area data gathering or aggregation functions, data processing, etc.

— **Sensor node**: Sensor node is a device that measures and collects data from the physical world. It can also process and transfer the data to another sensor node or to the gateway. Sensor node consists of sensor(s), actuator(s), communication unit, processor, and power source.

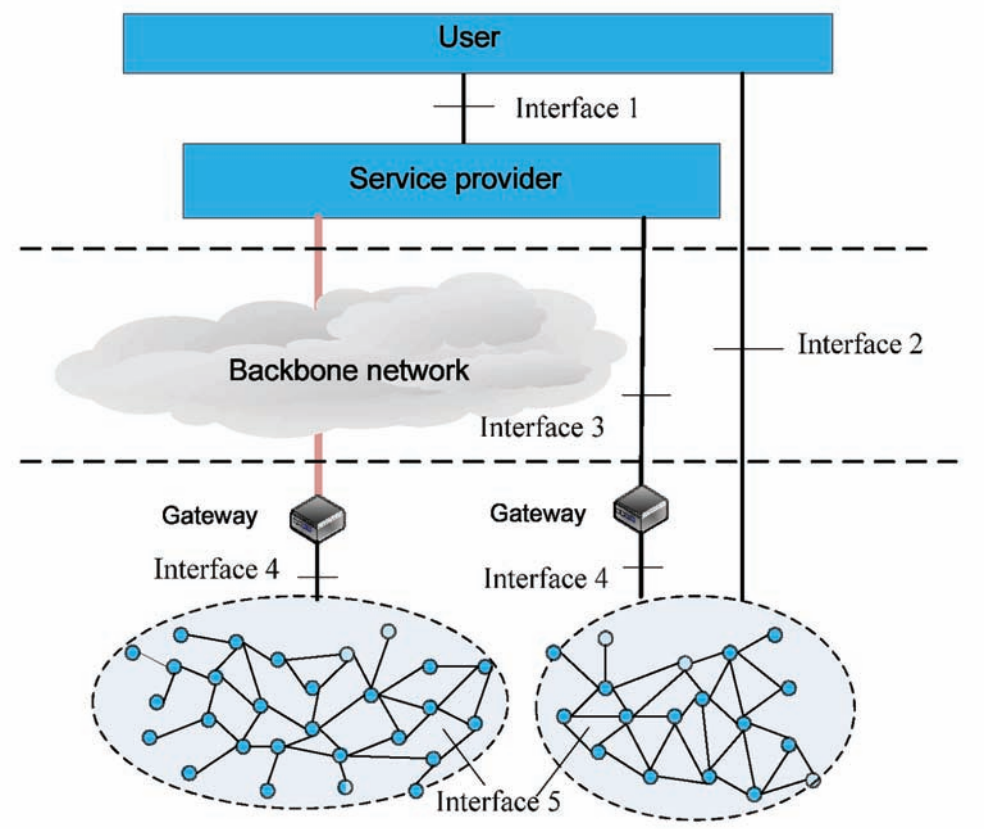

Figure 7 — Interfaces between entities enabling SN services and applications

In a sensor network, components can be replaced by other components with same interface and different function realization. Standard interfaces will shield from underlying technologies and ensure service interoperability.

Figure 7 illustrates five interfaces between entities enabling sensor network services and applications in the scope of ISO/IEC JTC1 WG7, and they include:

a) Interface 1: the interface between user and service provider.

b) Interface 2: the interface between sensor node and user.

c) Interface 3: the interface between gateway and service provider.

d) Interface 4: the interface between sensor node and gateway.

e) Interface 5: the interface between sensor nodes.

Table 1 summarizes the interfaces necessary between the functional layers resident in different entities (e,g, user, service provider, gateway, sensor node). Although the functional layers may not exactly reside on gateway, service provider or user, corresponding functional entities should exist in these entities if some functions need be achieved. For simplicity, since the architecture of functional layers of all entities is out of the scope of this standard, the same name is used for each functional layer as in architecture of sensor nodes in Table 1. This table can be read as, for example, for interface 1, the information exchange mechanism between the application layer of service provider and the application layer of the user need to be developed, and the Information exchange mechanism between the basic functions layer of the service provider and the basic functions layer of user is defined by other standards such as TCP/IP.

Table 1 — Summary of required interfaces and functional layers

	Interface 1 (Service Provider to/from User)	Interface 2 (Sensor Node to/from User)	Interface 3 (Gateway to/from Service Provider)	Interface 4 (Sensor Node to/from Gateway)	Interface 5 (Sensor Node to/from Sensor Node)
Application Layer to/from Application Layer	•	•	•	•	•
Service Layer to/from Service Layer	•	•	•	•	•
Basic Functions Layer to/from Basic Functions Layer	○	•	○	•	•
Sensor Node Hardware Layer to/from Sensor Node Hardware Layer	N/A	○	○	○	○

• means protocols of corresponding layer should be developed or integrated for interface,

○ means protocols of corresponding layer may have been defined and existing standards are available.

7.2 Interface 1

Interface 1 is a interface between the user and service provider. The user sends request to the service provider through this interface in order to obtain the required information, such as sensor nodes' identification and location information, monitoring or observation plan, or controlling protocols for devices or actuators attached to the sensor nodes. The service provider sends processed data or requested information to the application through this interface. Different user can interact with service provider via this common interface. The interface defines functions, such as authentication, communication, and management. For example, when a user wants to acquire temperature of a room, the user sends a service discovery request of the service layer to service layer of the service provider. When the user gets the response from the service provider which is able to provide this service, then the user sends a request to get the real time temperature, and the service provider acquires the sensor data from the sensor nodes and gateway. Finally the service provider sends the temperature data from the application layer to application layer of the user. Message exchange mechanism are different in various functional modules of layers.

Message exchange mechanism in the applications layer and service layer between the service provider and the user are defined by protocol A and protocol B shown in Figure 8.

Requirements of defining interface 1 are described below:

— Interface 1 is basic and mandatory in SN according to the overall architecture of sensor network from the communication perspective.

— Sensor network applications can be categorized into many classes according to data deliver model, such as periodic data report, event-driven application and query-driven application. Sensor network application mode, data exchange protocol, data mark language, frame format in the application layer (Protocol A) and service layer (Protocol B) should be defined in interface 1.

— A message in the application layer and other layers below the service layer is exchanged between the user and the service provider. The message exchange mechanism in the layers below the application layer can use standard communication protocol, such as TCP/IP.

— The message exchange mechanism and application data formats in the application layer between user and service provider needed to be developed for sensor network applications as shown in Figure 8.

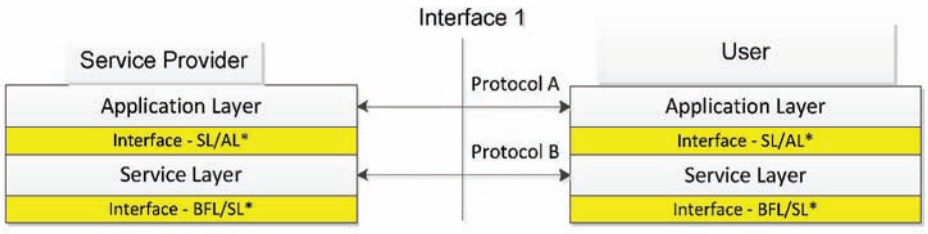

Figure 8 — Information exchange via interface 1

7.3 Interface 2

Interface 2 is a interface between the sensor node and the user. A user can exchange the application information and access the service of sensor node directly through interface 2 without the gateway.

The layer in which a message is exchanged between a sensor node and a user depends on the application requirement. Message exchange mechanism in the applications layer and the service layer, and the basic functions layer between sensor node and user which are defined by protocol A, protocol B and protocol C shown in Figure 9.

The requirements of defining interface 2 are described below:

— Interface 2 is not mandatory in sensor networks according to the overall architecture of sensor network from the communication perspective. If a user needs to read some information from a sensor node or control a sensor node directly, this interface should be defined.

— Message exchange mechanism and data format in the application layer (Protocol A) or the service layer (Protocol B) between the sensor node and the user needs to be developed for interface 2 to provide services and applications in sensor network.

— The message exchange mechanism in the layer (Protocol C) below the service layer can use existing standard or be defined according to application requirements. Communication protocols of interface 2 in the basic functions layers can be the same as in interface 4 or 5, such as IEEE 802.15.4, UWB, and PCI.

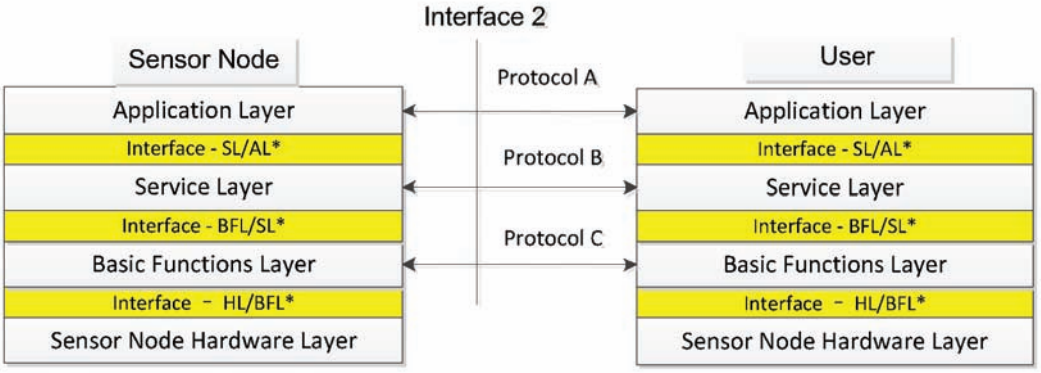

Figure 9 — Information exchange via interface 2

7.4 Interface 3

Interface 3 is a interface between the gateway and the service provider. The gathered data from the local sensor networks and management command message will be exchanged via this interface such as the local sensor network registration and deregistration, data acquirement, device management, etc.

Message exchange mechanism in the applications layer and the service layer between the service provider and the gateway are defined by protocol A, and protocol B shown in Figure 10.

Requirements of defining interface 3 are described below:

— Interface 3 is basic and mandatory in sensor networks according to the overall architecture of sensor network from the logical perspective.

— The message exchange mechanisms and data format in the application layer (Protocol A) and service layer (Protocol B) between a sensor node and a user need to be developed for interface 3 to enable sensor network applications as shown in Figure 10.

— Message exchange mechanism on lower layers below the service layer can use standard communication protocol, such as GSM, ADSL, and WCDMA.

— Protocol A of interface 3 and interface 1 should be compatible and consolidated to setup unified service to user.

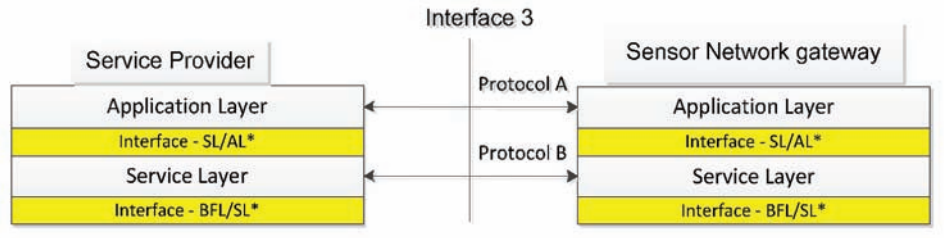

Figure 10 — Information exchange in different layers via interface 3

7.5 Interface 4

Interface 4 is a interface between the sensor node and the gateway. Layers in which messages are exchanged between a sensor node and a gateway depend on the application requirements.

For example, application requests from a user or service provider are handled in gateway, and the gateway arranges task for sensor nodes via this interface. In this case, messages in the application layer and other layers below the application layer are exchanged between the sensor node and the gateway.

In the case of sensor nodes reporting sensor data to gateway without data processing via this interface, only messages of the functional modules in the service layer and the basic functions layer are exchanged between the sensor node and the gateway.

The message exchange mechanism in the applications layer service layer and basic function layers between a sensor node and a gateway are defined by protocol A, protocol B and protocol C shown in Figure 11.

The requirements to defining interface 4 are described below:

— Interface 4 is basic and mandatory in sensor networks according to the overall architecture of sensor network from a communication perspective.

— Whether message exchange mechanisms and message format in the application layer or service layer between a sensor node and a gateway needs to be developed depends on application requirement. If modules in the application layer (Protocol A) or service layer (Protocol B) need be developed and used to exchange information for interface 4, message exchange mechanisms and message formats in the application layer or the service layer between sensor nodes and the gateway need to be developed, and vice versa. For example, if a new module of localization is needed for a sensor network service, message exchange mechanism and message format in the service layer need to be developed.

— The communication protocols (Protocol C) of interface 4 in the basic functions layers can be developed or use standard protocols such as IEEE 802.15.4, ISA 100 and Wireless HART. Interface

4 and interface 5 may use the same communication protocol, but they usually have different functional models and accomplish different functions. For example, network management and security management are needed on interface 4 for a sensor node gateway to control sensor nodes, and these functions may not be needed in interface 5.

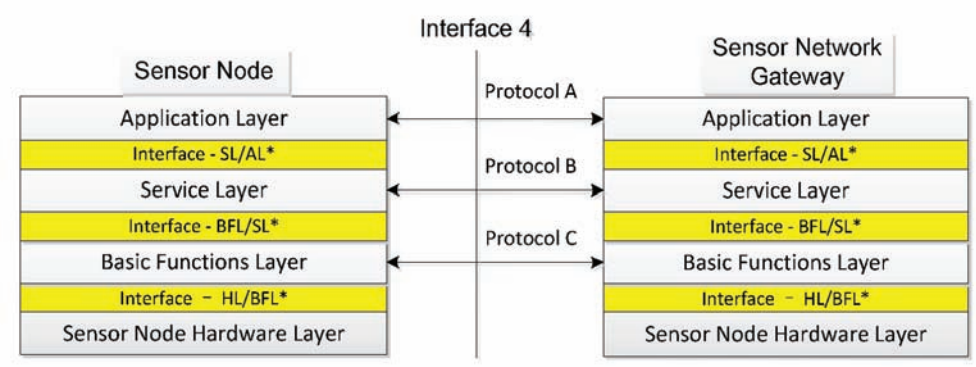

Figure 11 — Information exchange in different layers via interface 4

7.6 Interface 5

Interface 5 is a interface between sensor nodes. Sensor nodes exchange network topology information, control information and sensor data via this interface.

Message exchange mechanism in the applications layer, service layer and basic functions layer between sensor nodes are defined by protocol A, protocol B and protocol C shown in Figure 12.

Requirements of defining interface 5 are described below:

— Interface 5 is basic and mandatory in sensor networks according to the overall architecture of sensor network from the communication perspective.

— Whether message exchange mechanism and data formats in the application layer (Protocol A) or service layer (Protocol B) between sensor nodes needs to be developed for a sensor network applications depends on application requirement. If exchange of information between peer functional modules in the service layer or application layer is needed, then message exchange mechanism and message format in the application layer or service layer between sensor nodes need to be developed.

— Communication protocols (Protocol C) of interface 5 in the basic functions layers can be developed or use standard protocols. Various standard protocols can be used for interface 5 depending on the application requirements and the ability of sensor nodes, for example, IEEE 802.15.4 and IEEE 802.11p.

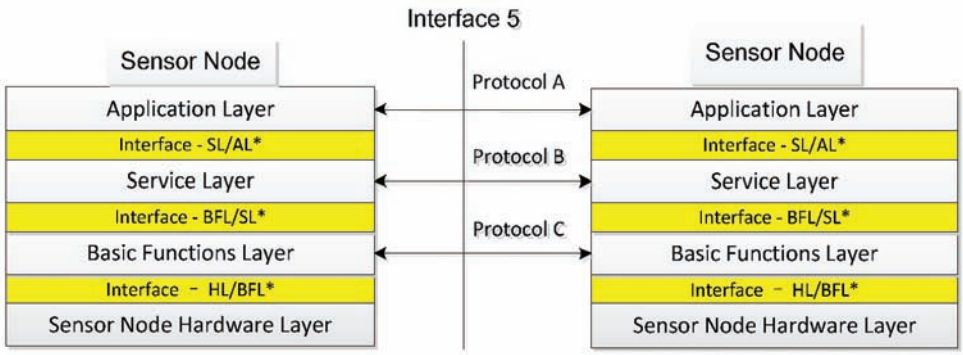

Figure 12 — Information exchange in different layers via interface 5

Bibliography

[1] ISO/IEC JTC1 SGSN N149, *SGSN Technical Document Version 3*

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