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Information technology — Sensor Networks: Sensor Network Reference Architecture (SNRA) — Part 7: Interoperability guidelines

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Contents

Page

Foreword

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ISO/IEC 29182-7 was prepared by Working Group ISO/IEC JTC 1/WG 7, Working Group on Sensor Network.

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/Terminology*

— *Part 3: Reference architecture views*

— *Part 4: Entity models*

— *Part 5: Interface definitions*

— *Part 6: Application profiles*

— *Part 7: Interoperability guidelines*

Introduction

There are a number of sensor network applications, with a variety of sophisticated functionalities such as burglar alarming, fire alarming, structural health monitoring and meteorological information gathering. Recently sensor network applications are being evolved by new technologies such as wireless sensor networking, context-based processing, global standards, open service environment, nationwide integration, etc. The aim of Sensor Network Reference Architecture (SNRA) is to give an overall understanding that can support this variety of sensor network applications and services.

ISO/IEC 29182 standards comprise of seven parts.

Part 1 provides the general overview and the requirements identified for reference architecture.

Part 2 part provides the definitions of all the terminology and vocabulary used in the sensor network reference architecture.

Part 3 provides the reference architecture views, e.g., business, operational, systems, technical as well as different presentation of the architecture, e.g., functional, logical, etc.

Part 4 provides the description of entity models, e.g., system, subsystem, component models, with their interfaces, functional descriptions, and how they are used in the reference architecture and for implementation.

Part 5 provides detailed, supportive information on the interfaces among the entity models in the reference architecture. The interface definitions include the data/information descriptions, system level specifications, and so on.

Part 6 provides the application profiles that are derived from studies of use cases, scenarios, etc., for sensor network based applications and services.

Part 7 provides the design principles for interoperability based on the reference architecture which is developed with interoperability requirements.

These International Standards can be used by sensor network designers, software developers and service providers to meet customer requirements and the organization’s own requirements for interoperability.

Information technology — Sensor Networks — Sensor Network Reference Architecture (SNRA) — Part 7: Interoperability guidelines

1 Scope

This international standard provides the general overview and guidelines for interoperability between heterogeneous sensor networks and covers the following aspects.

- Overview of interoperability for heterogeneous sensor networks
- Guidelines for interoperability between heterogeneous sensor networks

2 Normative references

The following referenced documents are indispensable for the application of this document. 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 Network: Sensor Network Reference Architecture (SNRA) – Part 2: Vocabulary/Terminology*

ITU-T Recommendation F.744, *Service description and requirements for ubiquitous sensor network middleware (2009)*

ITU-T Recommendation Y.2221, *Requirements for support of Ubiquitous Sensor Network (USN) applications and services in NGN environment (2009)*

3 Terms and definitions

For the purposes of this document, the terms and definitions are given in ISO/IEC 29182-2 and ITU-T Y.2221 (2009).

3.1
heterogeneous sensor network
sensor networks that are not able to interact with each other due to non-of-interoperability due to their radio signal, network protocol, application profile, etc.

3.2
sensor network application/service provider profile
data or information lists required by service provider(applications) in order to provide sensor network service to users

3.3
applications/service providers
type or group of system which acquires appropriate information from the sensor network and provides sensor network service to users directly

3.4
sensor network middleware
intermediate entity which provides functions commonly required by different types of sensor network applications and services

4 Symbols (and abbreviated terms)

IUT Implementation Under Test
QoS Quality of Service

5 Overview of interoperability for heterogeneous sensor networks

5.1 General

Many types of standards in sensor network, such as, radio signal, network protocol, and application profiles have been widely developed without the concern of interoperability as shown in Table 1. Nevertheless non-of-interoperability among the heterogeneous sensor networks causes overinvestment and reusability problems of sensor network system as sensor networks are extended in market. Therefore it is required to support Interoperability among the heterogeneous sensor networks.

Table 1 – Sensor network standards (Examples)

Layer	Standards
Network Protocol	ZigBee, 6LoWPAN, etc
PHY/MAC	ISO/IEC/IEEE 8802-15-4, WIBEEM, B-CDMA, etc

Sensor network reference architecture consists of four layers and interfaces between each and its adjacent layers.

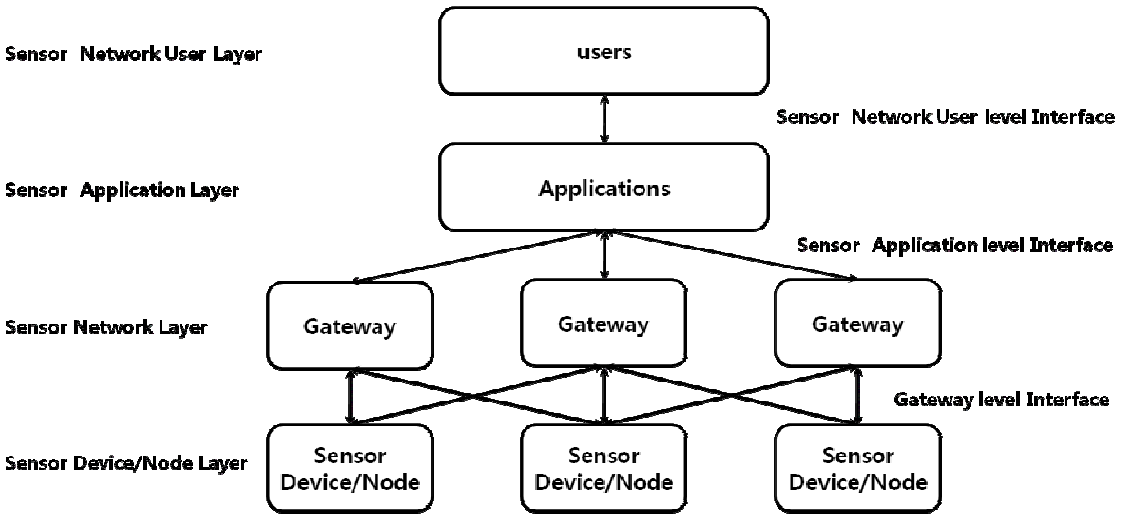

Figure 1 - Interoperability for heterogeneous sensor networks

The simplest way for establishing interoperability is to develop standard, which covers every ***layer*** from sensor networks to users. However, it is almost impossible to establish sensor network standards due to existence of too many sensor network applications and sensor network systems.

Therefore, there are specific functions requires between each layer to ensure interoperability among the heterogeneous sensor networks. Using sensor network middleware is one of solution for the interoperability.

In this manner, there are 4 different types can be applied.

5.2 Type 1 — User level interoperability

The sensor network end user layer consists of a number of sensor network end users. It is implemented on the network (intranet, internet, and other types of network connected to the end user) with hardware, typically PC-based, to run the software. The numerous users may be human beings or other software applications.

For the interoperability at this level, standardizing the sensor application interface consists of a set of sensor application software providing sensor network services.

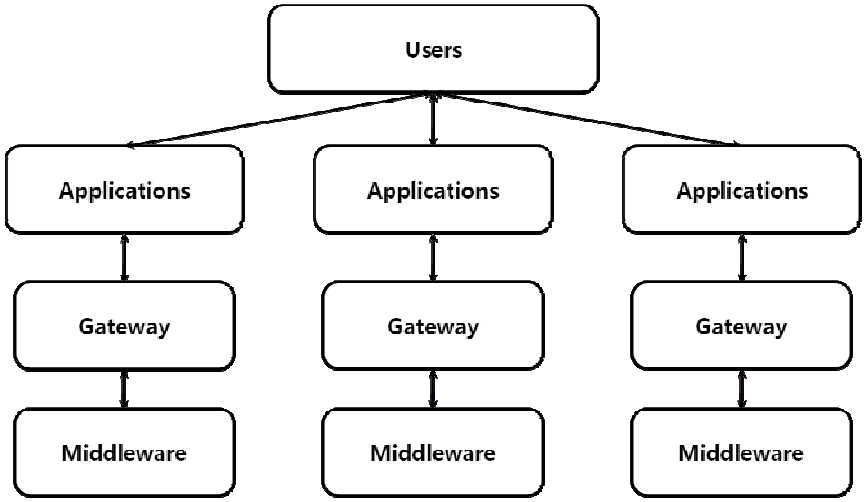

Figure 2 – User level Interoperability for heterogeneous sensor networks

5.3 Type 2 — Application level interoperability

For the Interoperability at the application level, standardizing sensor network interface or using sensor network middleware is required. The sensor network interface connects numerous sensor gateway devices with sensor applications via a set of services, e.g. internet and web services. Therefore standardizing sensor network interfaces is one method to ensure interoperability. Also, using sensor network middleware could give interoperable connection from any middleware to any application and from any gateways to any middleware.

Both of them, gives gateway an advantage to be able to interacting with any application. And it implies that any heterogeneous sensor network system, for example ZigBee, 6LoWPAN, could be adapted to any applications either. It is efficient and effective for establishing interoperability because they don't care about the heterogeneity of device architecture, radio signal, network protocol and application profile of sensor networks.

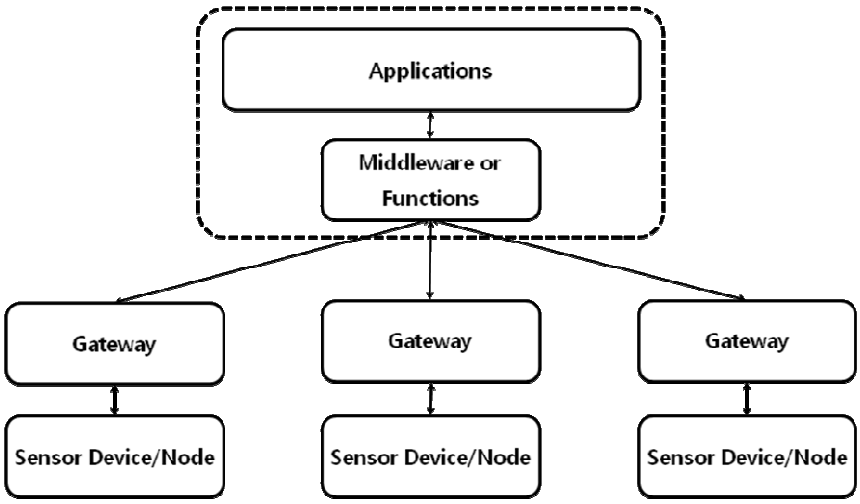

Figure 3 – Application level Interoperability for heterogeneous sensor networks

5.4 Type 3 — Gateway level interoperability

For the Interoperability at the gateway level, standardizing sensor node interface is required. Sensor node interface typically transmits sensed data in a compact digital binary format from the sensor nodes to the sensor network gateway. The interface specifies a protocol and connection to facilitate communication between sensor node and a gateway. This interface may be in the form of a simple internal wired and wireless connection.

Interoperability at the gateway level, could give interoperable connection from any heterogeneous sensor networks to any gateway. This manner gives heterogeneous sensor networks to be able to interacting with any gateway. And it implies that any heterogeneous sensor network system could be adapted to any gateway either.

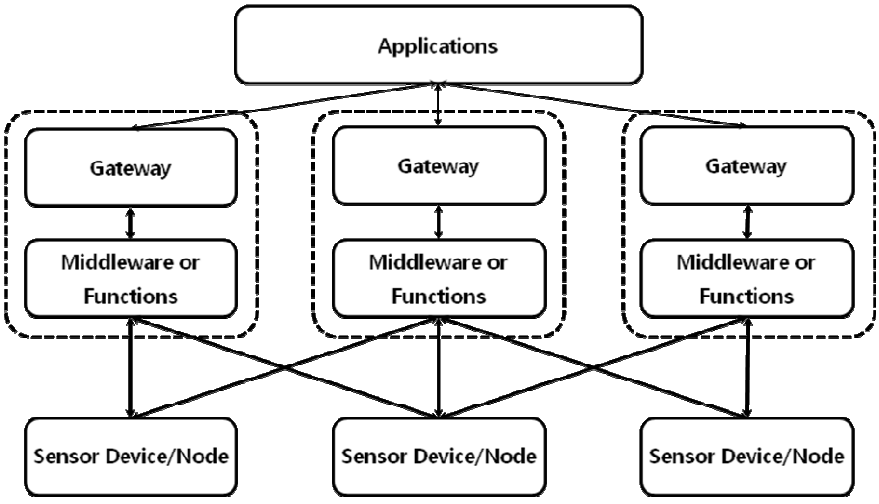

Figure 4 – Gateway level Interoperability for heterogeneous sensor networks

[To be added]

5.5 Type 4 — Sensor device/node level interoperability

Interoperability among the heterogeneous nodes of sensor network by standardizing interfaces between service layer and node hardware(sensor and/or actuator), application layer.

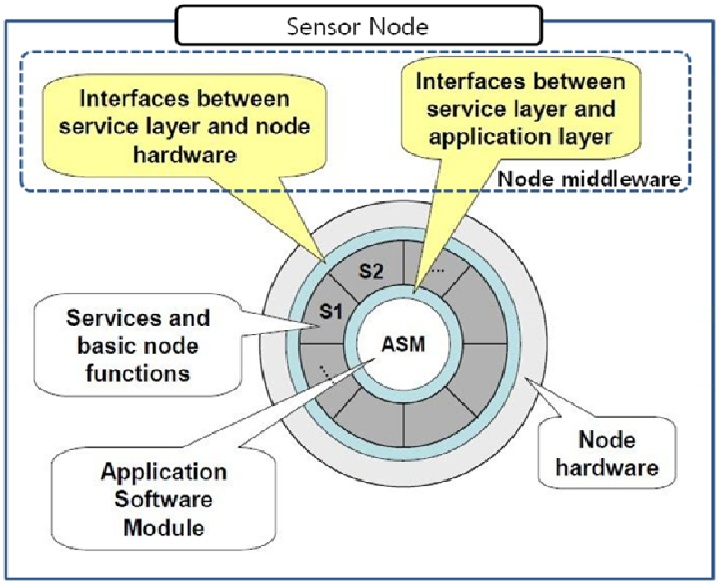

Figure 5 – Sensor node level Interoperability for heterogeneous sensor networks

[Editor's Note] This diagram will be revised after to align with SNRA document.

6 Guidelines for interoperability between heterogeneous sensor networks

6.1 General

A set of existing standards need to be identified which, when used together, fulfil the requirements of interoperable sensor network systems.

In this section, categorize the different requirement for the various components of a complete sensor network for the interoperability between heterogeneous sensor networks.

6.2 Guideline for user level interoperability

TBD

6.3 Guideline for application level interoperability

Sensor network application service has specific characteristics with different service requirements and functional requirements from each other [ITU-T F.744]. Therefore the sensor network service profile for sensor network service could be categorized by classifying functional and process model. Finally analyse the sensor network service profile which supports interoperability by the view of application service.

Using sensor network middleware at application level can be one of the solutions.

6.3.1 Classification of functional and process model of application service

The function of sensor network application services can be summarized below in order to define the key information [ITU-T F.744]:

- Finding appropriate sensor networks to obtain sensed data
- Requesting raw sensed data and/or processed data
- Processing received sensed data
- Activating actuators
- Monitoring sensor network status
- Controlling sensor networks
- Authenticating sensor networks
- Providing appropriate services to users

These functions above are commonly required by many types of sensor network application services.

The process of application service can be distinguished into three processes from the functional model defined above as shown in Table 2.

Table 2 – Process model

Process	Functions
sensor data	Requesting raw sensed data and/or processed data
	Processing received sensed data
event data	Activating actuators
management data	Finding appropriate sensor networks to obtain sensed data
	Monitoring sensor network status
	Controlling sensor networks
	Authenticating sensor networks
	Providing appropriate services to users

In other words the key information of application service is the data of sensor, event and management. Therefore the interoperability among the heterogeneous sensor networks can be established by standardizing these sensor network service data profile. Concerning complexity, scalability and cost-effectiveness, it would be beneficial to support interoperability by standardizing sensor network service profile

[To be added]

6.3.2 Requirements of application service data profile description

The following are the description of application service data profile.

- Sensor data
  - Define sensor properties, such as sensor data types, value ranges and measurement units
- Event data
  - Define data used for the generation rules of event, such as application-dependant context-aware and events based on the raw sensed data
- Management data
  - Define management data as following the rules of application-dependant management for sensor nodes, such as QoS, sensor node connectivity, software upgrade, network topology, etc

The following are requirements for the application service data profile

6.3.2.1 Sensor data

There are many kinds of applications, which use sensors, for example, temperature, humidity, vibration, acceleration, etc. And each of them has different requirements of sensor data types, resolutions, value ranges and measurement units.

Therefore designing flexible sensor data profile for different applications should carefully select sensor data types, resolutions, value ranges and measurement units.

- Sensed data validation regarding associated measurement units, data types and value ranges
- Application-dependant sensed data filtering
- Sensed data aggregation and integration based on an application policy

[To be added]

6.3.2.2 Event data

Event is one of the sensor network service function that responses against to the result of context-aware, alerting data validation regarding associated limitation, etc.

- Context-aware rules, alerting data validation regarding associated limitation
- Control actuators

[To be added]

6.3.2.3 Management data

There are many kinds of sensor networks and sensor nodes which have different protocol-dependant management rules.

Therefore management data standard should consider flexibility and scalability to manage network and device.

- Management of QoS by priority order
- Connectivity management of sensor nodes
- Software upgrade of sensor nodes
- Query scheduling for multiple applications and sensor networks
- Query routing to designated sensor nodes

[To be added]

6.4 Guideline for gateway level interoperability

Sensor node interface typically transmits sensed data in a compact, digital binary format from the sensor devices/nodes to the sensor network gateway.

For the interoperability at gateway level, the interface specifies a protocol and connection to facilitate communication between sensor devices and a network device must be defined. This interface may be in the

form of a simple internal wired and wireless connection. Using sensor network middleware at gateway level can be one of the solutions.

[To be added]

7 Conformance/Compliance and interoperability testing

7.1 General

Sensor networks should be tested for the requirements of a target application. Any interoperation protocol for the target application requires conformance/compliance and interoperability testing to evaluate implementation results. Conformance/compliance and interoperability test cases should be specified according to inter-operation protocols. In addition to the conformance/compliance and interoperability testing, performance testing should be performed.

7.2 Conformance/Compliance testing

Conformance/compliance testing is to confirm the consistency of Implementation Under Test (IUT) and standard. The general approach is to compare the actual and expected output of a black box test using a group of test case sequence under specific network condition. The existing test methods are ISO/IEC 9646 series.

7.3 Interoperability testing

Interoperability testing is to confirm whether a required functionality is supported by the target equipment. The test is accomplished by evaluating the correctness of protocol standard specified for interoperation between target implementation and the connected relative implementation under network interoperating environment. Interoperability testing provides important interconnection information, and is commonly used as testing between multiple manufacturers during R&D stage or the model selection test for system developers.

Bibliography

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