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Information technology — Sensor networks — Generic Sensor Network Application Interface

Technologies de l'information — Réseaux de capteurs — Interface générique pour des applications de réseaux de capteurs

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Foreword

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The committee responsible for this document is ISO/IEC JTC 1, *Information technology*.

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Introduction

Sensor network is a key technology to enable building context aware smart environments for human beings, monitoring health status, cross-reality services, etc. But there are many different sensor network implementations and they are not interoperable. In general, sensor networks are developed according to the sensor network applications' requirements (in which ways sensor network applications use sensor networks) within sensor network hardware constraints.

When it comes to sensor network applications' requirements, they include transport-level requirements, sensor networks' hardware point of requirements, applications' operational requirements, etc. Of these requirements, applications' operational requirements affect sensor network implementations, even though each sensor network supports the same transport protocol and uses the same hardware specification. However, these applications' operational requirements can be generalized and can be used to derive standard application layer interfaces between sensor networks and sensor network service providers.

This International Standard specifies generic sensor network application interfaces based on the generalized sensor network applications' operational requirements with consideration on sensor network hardware constraints.

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Information technology — Sensor networks — Generic Sensor Network Application Interface

1 Scope

This International Standard specifies the interfaces between the application layers of service providers and sensor network gateways, which is Protocol A in interface 3, defined in ISO/IEC 29182-5.

This International Standard covers

— description of generic sensor network applications' operational requirements,

— description of sensor network capabilities, and

— mandatory and optional interfaces between the application layers of service providers and sensor network gateways

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.

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ISO/IEC 29182-2:2013, *Information technology — Sensor networks: Sensor Network Reference Architecture (SNRA) — Part 2: Vocabulary and terminology*

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ISO/IEC 29182-5:2013, *Information technology — Sensor networks: Sensor Network Reference Architecture (SNRA) — Part 5: Interface definitions*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
actuator
device that provides a physical output in response to an input signal in a predetermined way

[SOURCE: ISO/IEC 29182-2:2013, 2.1.1]

3.2
application layer
layer that provides means for the application processes to access the OSI environment

[SOURCE: ISO/IEC 29182-2:2013, 2.3.1.1]

3.3
authentication
act of verifying the claimed identity of an entity

[SOURCE: ISO/IEC 29182-2:2013, 2.6.1]

Note 1 to entry: Entity may include sensor, actuator, or sensor network element.

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3.4
authorization
granting of rights, which includes the granting of access based on access rights

[SOURCE: ISO/IEC 29182-2:2013, 2.6.2]

3.5
continuous mode
sensor data query mode with duration value (*d*) and interval value (*t*)

3.6
event mode
sensor data query mode with event conditions. Sensor networks keep collecting sensor data and send them only, if the conditions are met

3.7
identification
process of recognizing an entity by using its attributes, identifier, etc.

[SOURCE: ISO/IEC 29182-2:2013, 2.7.2]

3.8
instant mode
sensor data query mode for an immediate one- time response from a sensor network

3.9
onTime mode
sensor data query mode with an action time

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3.10
personal area network
network consisting of sensor nodes, communication devices, or networked peripheral devices all in the vicinity of a person

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[SOURCE: ISO/IEC 29182-2:2013, 2.1.4]

3.11
PAN coordinator
device which is responsible for formation and maintenance of a PAN

3.12
pull mode
sensor data delivery mode with an explicit sensor data query

3.13
push mode
sensor data delivery mode without any explicit sensor data query

Note 1 to entry: Push mode sensor data delivery may be triggered by an explicit start request and may be terminated by an explicit stop request. It is an implementation issue.

3.14
sensor
device that observes and measures a physical property of a natural phenomenon or man-made process and converts that measurement into a signal

[SOURCE: ISO/IEC 29182-2:2013, 2.1.5]

Note 1 to entry: Signal can be electrical, chemical, etc.

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3.15
sensor network
system of spatially distributed sensor nodes interacting with each other and, depending on applications, possibly with other infrastructure in order to acquire, process, transfer, and provide information extracted from its environment with a primary function of information gathering and possible control capability

[SOURCE: ISO/IEC 29182-2:2013, 2.1.6]

Note 1 to entry: Distinguishing features of a sensor network can include wide area coverage, use of radio networks, flexibility of purpose, self-organization, openness, and providing data for multiple applications.

3.16
sensor network application
use case of sensor networks, which provides a set of functions to users to meet defined requirements

[SOURCE: ISO/IEC 29182-2:2013, 2.2.2]

EXAMPLE Monitoring forests to detect natural fires; monitoring seismic activity; monitoring pollution levels in environment.

3.17
sensor network client
application software that uses information provided by a sensor network

3.18
sensor network gateway
sensor network element that connects a sensor network to another network with different architectures or protocols, permitting information exchange between them

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[SOURCE: ISO/IEC 29182-2:2013, 2.1.7]

Note 1 to entry: Sensor network gateway functionalities may include address or protocol translation.

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3.19
sensor network resource
entity related to a sensor network which may be a sensor network gateway, a PAN coordinator (if any), a sensor node or a transducer

3.20
sensor network service
set of functionalities offered by individual sensor network elements or the sensor network

[SOURCE: ISO/IEC 29182-2:2013, 2.2.3]

EXAMPLE Generating an alarm signal if the measurement made at a sensor exceeds or drops out of certain prescribed range; providing average sensor measurements over a given geographic area.

3.21
transducer
device converting energy from one domain into another, calibrated to minimize the errors in the conversion process. It could be a sensor or an actuator

[SOURCE: IEEE Std 1451.1-1999]

3.22
user
any person, organization, process, device, program or system which uses services provided by others, and may benefit from the operation of a sensor network

[SOURCE: ISO/IEC 29182-2:2013, 2.8.5]

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4 Symbols and abbreviated terms

This document uses the following abbreviations and acronyms:

CoAP Constrained Application Protocol

DNS Domain Name System

O&M Observations and Measurements in SWE

PAN Personal Area Network

SensorML Sensor Model Language in SWE

SNC Sensor Network Client

SWE Sensor Web Enablement

TEDS Transducer Electronic Data Sheet

5 Conventions

In this part of ISO/IEC 30128:

The keyword "shall" is used to indicate requirements strictly to be followed in order to conform to the document and from which no deviation is permitted.

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The keyword "should" is used to indicate that among several possibilities one is recommended as particularly suitable, without mentioning or excluding others, or that a certain course of action is preferred but not necessarily required, or that (in the negative form) a certain possibility or course of action is deprecated but not prohibited.

The keyword "may" is used to indicate a course of action permissible within the limits of the document.

The keyword "can" is used for statements of possibility and capability, whether material, physical or causal.

6 Overview of sensor network applications

6.1 Communication model

Sensor network applications provide sensor-associated or actuator-associated services for users by interacting with at least one sensor network. When it comes to sensor network service providers, they need to communicate with lots of different types of sensor networks to provide integrated services for users. On the other hand, sensor networks provide sensor network services to multiple sensor network service providers to maximize their benefits. In this context, the communication model between sensor network service providers and sensor networks can be summarized in two cases.

In one case, an interface is defined by a sensor network that provides sensor network services based on the interface. Then, sensor network service providers implement the interface defined by each sensor network to communicate with the sensor network. This case is illustrated in Figure 1. If there is no standard interface between sensor networks and sensor network service providers, sensor network service providers need to implement different interfaces to communicate with different sensor networks. In Figure 1, the sensor network service provider needs to implement interface A, interface B, and interface C altogether to provide integrated services for users. In view of that there are many different sensor network providers in the world, implementing all of these sensor network providers' interfaces is a tedious and time consuming process, and it is definitely not a good solution.

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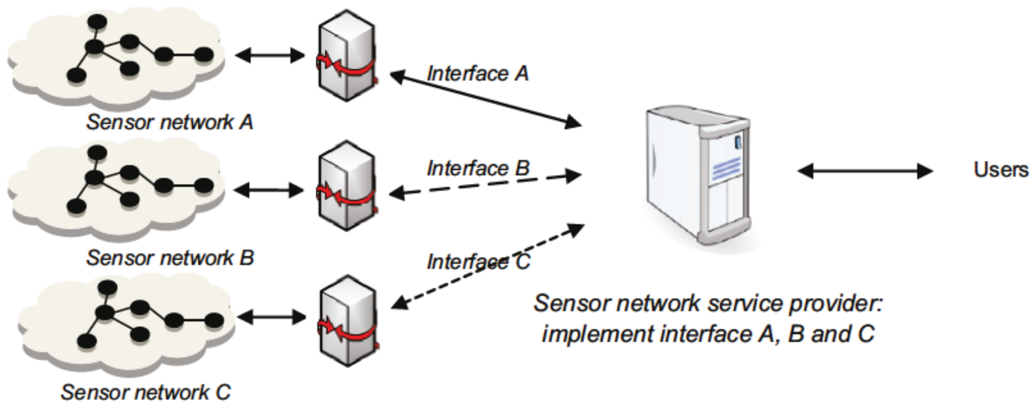

Figure 1 — Communication model: Multiple sensor networks and one sensor network service provider

In the other case, each sensor network service provider defines its own interface. Thus, sensor networks need to implement each interface to communicate with the sensor network service provider. This case is illustrated in Figure 2. If there are multiple sensor network service providers with different interfaces, then sensor networks need to implement each interface provided by each sensor network service provider. From a sensor network providers' point of view, they need to develop a single sensor network that can implement all interfaces or they need to develop different sensor networks for different sensor network service providers to provide the same sensor network services. Both situations are not reasonable from the sensor network providers' perspective, because they increase sensor network development cost and time. As a consequence, this impedes the proliferation of sensor network usage.

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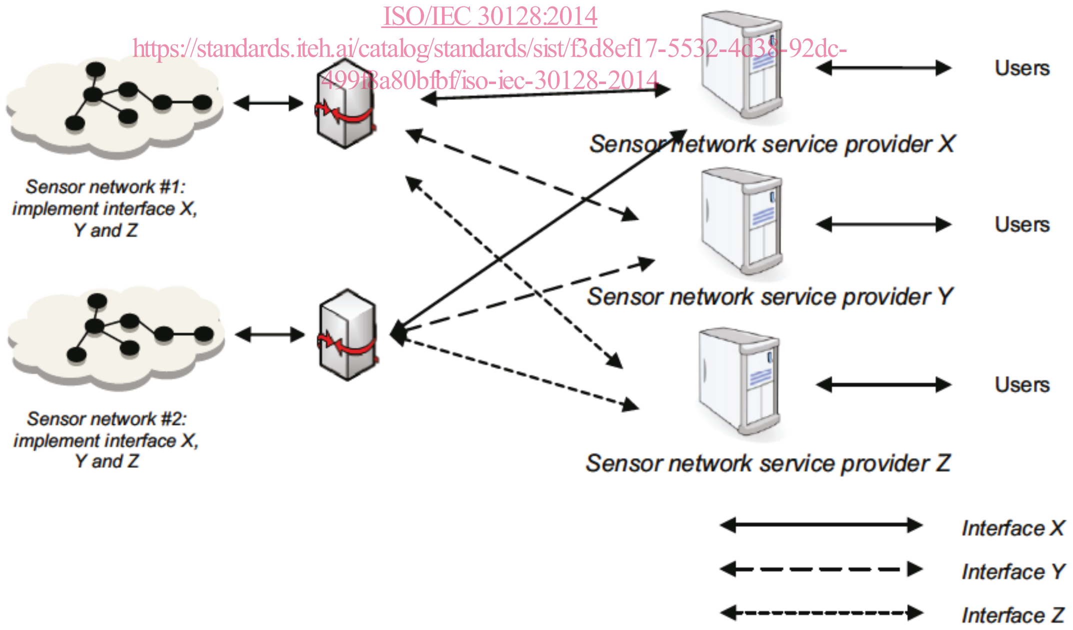

Figure 2 — Communication model: One sensor network and multiple sensor network service providers

In this regard, standard interface specification between sensor networks and sensor network service providers is very important. Moreover, the standard interface enables sensor network implementation free from specific sensor network applications' requirements, so it derives cost-effective mass production of sensor networks.

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From this standard's point of view, the role of sensor network gateways is very important. A sensor network gateway is a front-end of a sensor network, in respect to sensor network service providers. Therefore, if a standard interface between sensor networks and sensor network service providers is defined, the interface will reside between the sensor network gateway and the sensor network providers. In a case where a smart-device plays the role of a standalone sensor node without a separate sensor network gateway, then the smart-device may be regarded as a sensor network gateway and a sensor node at the same time.

Basically, a sensor network gateway translates sensor network service providers' messages into sensor networks' messages (e.g., ZigBee messages, Bluetooth messages, CoAP message, etc.) and vice versa. But in some cases, a sensor network gateway also needs to handle time synchronization to deliver sensor network clients' message to sensor nodes. That is because when a sensor network service provider sends a message to sensor nodes, the sensor nodes may be in a sleep mode for power saving. In this case, a sensor network gateway should know the life cycle of each sensor node in order to keep-and-forward messages to sensor nodes. Or, when a sensor node or a transducer registers itself to a sensor network service provider, a sensor network gateway may need to attach more information on the registration message from a sensor node to include hierarchical topology information. In general, if a gateway is implemented on a high performance machine, the gateway can perform complex operations on behalf of capability-constrained sensor nodes. In this regard, in some cases, a sensor network's computing capabilities means the sensor network gateways' capabilities. In summary, sensor network gateways play a very important role in sensor networks and they are different from other domain's gateways.

6.2 Sensor network client operations

6.2.1 Overview of sensor network client operations

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There are various kinds of sensor network applications: logistics and supply chain management application, energy and utility distribution application, industrial production automation monitoring and controlling application, healthcare, medical application, etc.

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These sensor network applications generally consume sensor data collected by sensor networks and some applications control appropriate actuators to handle observed situation. Other sensor network applications monitor the status of sensor networks and if necessary, they control the sensor networks corresponding to observed sensor networks' status. In this international standard, sensor network application operations are classified into three categories: sensor manipulation, actuator manipulation, and sensor network monitoring and controlling.

Regarding sensor manipulation, there are several ways to collect sensor data. Roughly, sensor network manipulation mode is classified into push mode and pull mode. And pull mode is further classified into instant mode, continuous mode, event mode, and onTime mode.

Regarding actuator manipulation, there may be various kinds of actuators: on/off actuator, text/image displaying actuator, multi-functional complex actuator, etc. All these actuators manipulation is performed by issuing action requests with appropriate parameters. After processing actuators, sensor networks shall respond with an appropriate action status.

Regarding sensor network monitoring and controlling, a sensor network client needs to know the current status of sensor networks and needs to control sensor networks according to the sensor network client's policy. In case of sensor network controlling, it may be triggered irrespective of monitoring process, or may follow after monitoring process. A sensor network client may issue a sensor network control request based on administrative purposes, or may issue a sensor network control request to manipulate monitoring results. Sensor network controlling may include several operations, such as reset, shutdown, and reconfiguration.

In this international standard, a sensor network client (SNC) is referred to as an application software residing in a sensor network service provider.

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6.2.2 Sensor manipulation

6.2.2.1 Overview of sensor manipulation

There are various ways to collect sensor data from sensor networks. From the sensor networks' point of view, it provides collected sensor data in two ways. One way is pushing collected sensor data without any consideration on specific requests from sensor network clients. It is called a push mode. The other way is collecting sensor data and delivering sensor data according to specific requests from sensor network clients. This is called a pull mode. The pull mode is further classified into instant mode, continuous mode, and event mode based on how to request sensor data from sensor network clients' point of view. Sensor network clients may request sensor data only one time (instant mode) or may request sensor data repetitively (continuous mode). In some cases, sensor network clients may request sensor data only some events occur (event mode). In some other cases, sensor network clients may request these pull mode sensor data manipulations with an exact action time when to collect and deliver sensor data. It is called an onTime mode.

6.2.2.2 Push mode

Figure 3 depicts a push mode sensor manipulation.

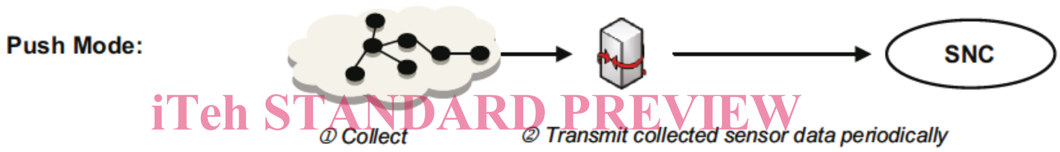

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Figure 3 — Sensor data collection: Push mode

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In case of a push mode, a sensor network collects and transmits its sensor data based on its configuration on collecting and transmitting. From an implementation point of view, a push mode sensor manipulation may be implemented in two ways. The simplest way is in which a sensor network just pushes sensor data when it is connected to a sensor network client. Or, it may be implemented in a way that the sensor network starts pushing sensor data when it receives a "start" command and stops pushing when it receives a "stop" command from a sensor network client. In this case, the "start" and "stop" commands are issued by a sensor network client, but it doesn't change the sensor data collection and transmit configuration of the sensor network itself.

A push mode is used mainly by simple types of sensor network monitoring applications. In this case, the expected computing complexity of sensor networks is very low. Sensor networks just push collected sensor data to a waiting sensor network client and data processing is up to the sensor network client.

6.2.2.3 Pull mode: instant mode

Figure 4 depicts an instant mode of a pull mode sensor manipulation.

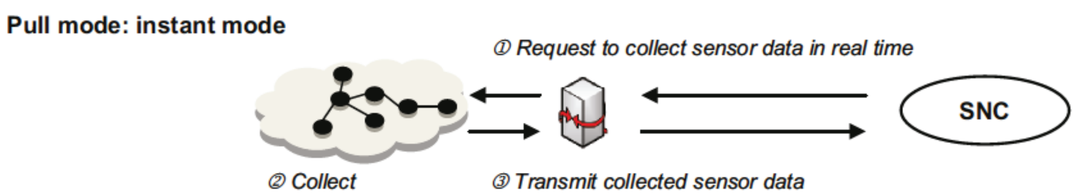

Figure 4 — Sensor data collection: Pull mode-instant mode

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