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Information Technology — Sensor Networks: Sensor Network Reference Architecture (SNRA) — Part 4: Entity Models

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

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The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member 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 29182-1 was prepared by Working Group ISO/IEC JTC 1/WG 7, Working Group on Sensor Networks.

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

Even though various applications and usage scenarios have been identified for sensor networks, there are many commonalities in instantiations of sensor networks that make such applications possible. These commonalities include similarities in the network architecture and the entities/functional blocks used in the architecture. This international standard presents high level models for the entities typically found in sensor networks. After a description of the function and role of each entity, a model for the entity is presented that provides more information on what that entity does. This could include an input-output relationship, some features of the entity that help to characterize its capabilities, a taxonomy of various ways in which the entity may be implemented, etc. This standard also briefly touches upon the interfaces between various entities. A detailed description and specification of the interfaces, however, is the subject of another standard in the same family of international standards.

ISO/IEC 29182 standards comprise of seven parts. This international standard is Part 4 of ISO/IEC 29182. A brief description of the remaining six parts follows:

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

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

Part 3 presents the reference architecture from various viewpoints, such as business, operational, system, technical, functional, and logical.views.

Part 5 provides detailed information on the interfaces among various entities in the reference architecture.

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 design principles for the reference architecture that take the interoperability requirements into account.

These international standards can be used by sensor network designers, software developers, and service providers to meet customer requirements including any applicable interoperability requirements.

Information technology — Sensor Networks: Sensor Network Reference Architecture (SNRA) — Part 4: Entity Models

1 Scope

This international standard presents models for the entities comprising a sensor network according to the Sensor Network Reference Architecture (SNRA).

2 Conformance

This international standard provides information and guidance which is considered to be indispensable for the understanding and application of the multipart ISO/IEC 29182 series. There are no normative requirements in this international standard that can be cited for conformance.

3 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 29182-1, *Information technology – Sensor Network: Sensor Network Reference Architecture (SNRA) – Part 1: General overview and requirements*

ISO/IEC 29182-2, *Information technology – Sensor Network: Sensor Network Reference Architecture (SNRA) – Part 2: Vocabulary/Terminology*

ISO/IEC 29182-3 *Information technology – Sensor Network: Sensor Network Reference Architecture (SNRA) – Part 3: Reference architecture views*

ISO/IEC 29182-4 *Information technology – Sensor Network: Sensor Network Reference Architecture (SNRA) – Part 4: Entity models*

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

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)*

4 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).

Note: It is yet to be decided whether ITU-T Y.2221 (2009) is needed.

5 Symbols (and abbreviated terms)

ADC Analog to Digital Converter

DAC Digital to Analog Converter

FLOPS FLoating OPerations per Second

6 Sensor Nodes

6.1 Sensors

A sensor measures a physical attribute and converts it into an electric voltage/current. This conversion may be direct or indirect. While in the former case the attribute is directly converted into an electric voltage/current, in the latter case the attribute is converted into a sequence of one or more intermediate attributes before finally getting converted into an electric voltage/current. For example, a thermometer may measure temperature and converts it into physical displacement of some object and then convert that displacement into an electric voltage/current. The sensor output voltage/current may be in analog or digital form. In the latter case, an analog to digital converter (ADC) is used to convert the analog electric voltage/current into a finite-length sequence of bits (binary digits) that constitutes a binary representation of the voltage/current.

Therefore, an appropriate model for a sensor with analog output is an input-output relationship that characterizes the conversion from the attribute being measured by the sensor to the output electric voltage/current. The relationship may occasionally be characterized through a mathematical formula or more frequently through an xy-plot.

Note: Need to find one such plot and include it in this clause.

Alternatively, an appropriate model for a sensor with a digital output is a quantizer input-output plot or table. The former is a staircase xy-plot that represents the analog physical attribute on the horizontal axis and the analog value represented by the sensor binary output on the vertical axis. Alternatively, a table may be used to characterize the same input-output relationship. For example, all temperatures between 18 and 18.1 degrees Celsius may be represented by the binary string 10110101, and in turn 18.05 degrees Celsius may be used as the representative value for the temperature range and the binary string specified.

Note: Provide two figures, one for a quantizer input-output plot and another for the corresponding table.

The models presented above are deterministic in nature and as such ignore presence of measurement noise in the sensor. A more appropriate model takes the form

$X = a S + N$

where S is either a deterministic or random variable representing the physical attribute being measured by the sensor, a is a conversion/scaling factor, N is a random variable representing measurement noise, and X is the sensor output electric voltage/current. When using a stochastic sensor model like this, one needs to specify the conversion/scaling factor a and the probability distribution for additive noise N. In case of a sensor with a digital output, the quantizer used by the sensor needs to be characterized per earlier discussion.

In case of all the models discussed above, it is also necessary to specify the range of input values – i.e. the range of values for the physical attribute -- over which the sensor functions. Finally, in case of a sensor node with multiple sensors, a model needs to be provided for each sensor used in the node.

6.2 Actuators

Roughly speaking, an actuator functions in a manner that is the reverse of how a motion sensor functions. It takes an electric voltage/current, in analog or digital form, as input/command and causes some motion, thereby moving an object being controlled by a certain amount. In many cases, the electric voltage/current is first converted to hydraulic pressure and it's the latter that causes motion. This corresponds to the discussion of direct or indirect conversion in the case of sensors.

Given all the discussion under Subclause 6.1, it is straightforward to develop a deterministic model for an actuator. An actuator with an analog input electric voltage/current is modelled by an xy-plot and a range of values for the input. The simplest way to model an actuator with digital input is through the use of a table that shows the motion values for all possible binary input sequences. This would work for small-size tables. If the binary sequence is more than a few bits long, then a functional form would be the appropriate model. In such a case, the function operates on the decimal value represented by the binary input sequence to the actuator and converts that into motion.

Similarly, a stochastic model for an actuator would take the form

$X = a\ s + N$

where s is the deterministic input/command to the actuator, a is a conversion/scaling factor, and N is a random variable characterizing any randomness in actuator performance as the same input may not always result in exactly the same motion.

6.3 Processor

A sensor node, especially if it uses multiple sensors, typically has a processor that is used by two components of the node that are discussed in later clauses in this standard. These two components are:

- Service and Basic Functions
- Application Software Module

A detailed architectural model for the processor is not necessary for characterization of sensor node capabilities. Perhaps all that is needed is a simple characterization using FLOPS (FLoating OPerations per Second) to specify the computational power of the node.

6.4 Memory

The storage capabilities of a sensor node can be characterized with two numbers: the size of its hard drive (slower access memory) and the size of its faster electronic memory.

6.5 Communication Devices

A sensor node may have more than one communication device for communicating with other sensor nodes and/or a gateway. These communication devices may be wired or wireless. A detailed modeling of the communication devices in a sensor node is beyond the scope of this international standard. Such modeling should include at least the Physical and Data Link layers in the OSI protocol stack and possibly the Network and Transport layers. Appropriate standards should be cited to characterize the protocol layers just mentioned.

6.6 Service and Basic Functions

A sensor node may employ various algorithms to process the data acquired by its sensors. Averaging and filtering (linear or nonlinear) are examples of these algorithms. The routing protocol used by a communication device in a wireless ad hoc sensor network and any data compression algorithms used on sensor output data are other examples of such service and basic functions. Some of these service and basic functions are fairly easy to model. Others are more challenging, because there may be many possibilities for each such service or basic function. Inclusion of a taxonomy may be all that can be done.

Note: Before this subclause can be expanded any further, it has to be determined what exactly are regarded as service and basic functions.

6.7 Application Software Module

Data fusion algorithms fall under this component of a sensor node. Data from various sensor nodes may be fused in a centralized manner at a fusion center where the data from all sensor nodes in the network is gathered. Alternatively, nodes exchange sensor measurements locally and some fusion takes place at certain sensor nodes.

Note: It is necessary to clarify the distinction between "Service and Basic Functions" and the "Application Software Module" before proceeding further on this clause and the previous one. Perhaps the distinction is that the Application Software Module handles interactions among sensor nodes and Service and Basic Functions deal with processing of the data acquired by the sensors and control of the actuators at a given sensor node.

7 Gateways

A gateway resides in physical proximity of sensor nodes. It employs three communication protocols, one for communicating with sensor nodes, another for communication with an access network, and a third for communicating with the backbone network. Just as in the case of communication devices used in sensor nodes (Subclause 6.5), a full specification and modeling of these communication protocols is beyond the scope of this international standard. Wherever appropriate, other standards should be cited.

8 Access Networks

The modeling of an access network is beyond the scope of this international standard. Wherever appropriate, other standards should be cited.

9 Backbone Network

The modeling of the backbone network is beyond the scope of this international standard. Wherever appropriate, other standards should be cited.