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Reference architecture for sensor network applications and services —

Part 3:
Reference architecture views

Architecture de référence pour applications et services de réseaux de capteurs —

Partie 3: Vues de l'architecture de référence

ICS 35.110

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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.

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

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.

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ISO/IEC 29182-3 was prepared by Working Group ISO/IEC JTC 1/WG 7.

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

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: 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*

ISO/IEC 29182-6 *Information technology – Sensor Network: Sensor Network Reference Architecture (SNRA) – Part 6: Application profiles*

ISO/IEC 29182-7 *Information technology – Sensor Network: Sensor Network Reference Architecture (SNRA) – Part 7: Interoperability Guidelines*

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 family of International Standards (ISs) 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 family of standards 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 family of standards is comprised of seven parts. Brief descriptions of these parts are given next, followed by an introduction to Part 4.

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

Part 2 provides definitions for the terminology and vocabulary used in the reference architecture.

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

Part 4 categorizes the entities comprising the reference architecture into two classes of physical and functional entities and presents models for the entities.

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.

Information technology — Sensor Networks: Sensor Network Reference Architecture – Part 3: Reference Architecture Views

1 Scope

This International Standard (IS) provides Sensor Network Reference Architecture (SNRA) views. The architecture views include business, operational, systems, and technical perspectives, and these views are presented in functional, logical, and/or physical views where applicable. This IS focuses on high-level architecture views which can be further developed by system developers and implementers for specific applications and services.

This International Standard provides reference architecture views consistent with the requirements which are defined in Part 1 (General overview and requirements) and can be utilized more effectively with other Parts, especially with Part 4 (Entity Models) and Part 5 (Interface Definitions).

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 29182-1, *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 29182-4, *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*

ISO/IEC 29182-6, *Information technology –Sensor Network: Sensor Network Reference Architecture (SNRA) – Part 6: Application Profiles*

ISO/IEC 29182-7, *Information technology –Sensor Network: Sensor Network Reference Architecture (SNRA) – Part 7: Interoperability guidelines*

3 Terms and Definitions

The terms and definitions used in this document are provided in ISO/IEC 29182-2 – Vocabulary/Terminology.

4 Symbols (and abbreviated terms)

1D	One-dimensional
2D	Two-dimensional
3D	Three-dimensional
BFL	Basic Function Layer
CIP	Collaborative Information Processing

CLM	Cross Layer Management
CPU	Computer Processing Unit
GHL	Gateway Hardware Layer
GPS	Global Positioning System
NOAA	National Oceanic and Atmospheric Administration
IS	International Standard
PV	Physical View
RA	Reference Architecture
SL	Service Layer
SNHL	Sensor Node Hardware Layer
SNRA	Sensor Network Reference Architecture
SOA	Service-Oriented Architecture
SV	System View
TS	Technical Standards

5 Purpose of Sensor Network Reference Architecture

A Reference Architecture (RA) is a *generalized* architecture of several end systems that share one or more common domains, giving direction downward and requiring compliance upward. Therefore, an architecture for a certain application will contain some, most, or all of the reference architecture. In other words, the developer can reuse entities and elements in the reference architecture that fit his or her application architecture and ignore the rest of entities and elements in the reference architecture. In addition, the RA provides standards and policies for building a specific architecture.

RAs provide a *consistent point of departure* for implementing solutions so that each implementation:

- Follows a consistent decomposition and design pattern;
- Reduces cost by exploiting opportunities for reuse of services, products, data definitions, etc.;
- Reduces schedule by starting with a core architecture to be tailored for implementation; and
- Reduces risk by:
  - Incorporating required global capabilities; and
  - Taking advantaged of lessons learned and related expertise.

The Sensor Network Reference Architecture (SNRA) outlines "what" the overall structured approach is for facilitating interoperability and, through the details of this structure, indicates "how" the architecture and its entities will operate through the development of interface standards. In short, the SNRA provides rules and guidance for developing and presenting architecture descriptions.

This standard provides not only multiple perspectives of SNRA (e.g., business, information, and technical) but also multiple views of the technical architecture (e.g., physical, system, operational, etc.) describing a sensor network (e.g., business, information, application, and data). The combination of these architecture perspectives and views forms a comprehensive architectural description of the sensor network system. The reference architecture perspectives and views are to:

- Show how Sensor Networks operate in a homogeneous or a heterogeneous system;
- Show the systems of equipment and the flows of information that support the sensor networks; and
- Show the technical rules and guidelines that allow these systems to interoperate.

Typically, a developer begins depicting an architecture with desires and needs for the data/information that could be provided by a sensor network or sensor networks and that could meet the desires and needs (e.g., then translated into a set of requirements). Additionally, the developer needs to have an understanding of the technology available and also the roadmap of technologies to come. For example, the desires and needs could be a computer and a set of sensor nodes (thus, a sensor network) in a car to monitor and control subsystems, or alternatively they could be a large system of systems, such as the sensor networks by National Oceanic and Atmospheric Administration (NOAA) to monitor worldwide weather in order to predict weather patterns and to provide warnings if necessary. Each developer will have specific requirements concerning the capabilities that a sensor node or sensor network should have for target applications and services. The developer also needs to make many decisions in developing a sensor network architecture including whether a sensor network will perform data processing to provide high level information to a user, or a sensor network will make the raw data available to a user who will use its own applications to process the raw data. The Sensor Network Reference Architecture (SNRA) can provide the developer with various options and understanding for the developments, and more importantly, SNRA provides the developer with the architecture starting point.

The SNRA supports the development of interoperating and interacting architectures. It defines the multiple perspectives of SNRA and the multiple views of the technical architecture. Each view is composed of sets of architecture data elements that are depicted via graphic, tabular, or textual products. The SNRA also clearly defines the relationships between these architectural views and the data elements they contain.

6 Overview of Sensor Network Reference Architecture

Sensor network is a system of distributed sensor nodes communicating with each other and also interacting with other sensor networks that monitors environments external to the sensor network in order to acquire, process, transfer, and provide information extracted from a physical world.

This Sensor Network Reference Architecture (SNRA) consists of a set of domains which are concerned with gathering raw data from each domain's physical environment, processing raw data into information, and delivering information to a user or users. The user can be a human or a machine/software (e.g., automated command and control system). In cases where a sensor network has a sensor node or sensor nodes equipped with an actuator or actuators, information in the forms of a decision can flow from the user to the actuator(s) attached to the sensor node to provide an actuation command.

Each sensor network consists of various entities such as sensor nodes, actuators, a network, processing (at a local sensor node, a gateway, and/or fusion centre), applications used by the sensor nodes, applications used by the users[1], and finally the user. Figure 1 shows a high level physical view of multiple sensor network domains although there are other domains not captured in the figure. Most sensor network domains are designed to be dissimilar and disparate as each sensor network focuses on its own specific application. This figure is to emphasize the importance of interoperability among dissimilar networks, sensors, and disparate data contents and formats. Figure 1 also shows that sensing can occur in all geospatial expanses (e.g., space, air, maritime, ground, and subsurface (e.g., underground, and below ocean/lake/river surface)). In each geospatial expanse, there are many capabilities that sensor networks can provide as shown in the figure. In space, a sensor network formed by the sensor nodes in a constellation of satellites can provide data and information about Earth's weather, air pollution, oceanic current movements, and so on. In the air, air traffic control cannot be performed without sensor networks (e.g., radars). In maritime, ships rely on GPS for navigating the oceans. The sensor networks can also be effectively used for maritime container tracking, tagging of, and protection for the contents of the containers, On the ground, many different sensor networks are found as there exist many different applications, (e.g., intelligent highway, transportation, supply chain management, medical, military, industrial, finance, first responders, governmental, home, environmental monitoring, perimeter protection and intrusion prevention, health/situation monitoring of elderly or patients, and so on).

[1] [When the user is a person] Personal information belongs to individuals. It shall be implemented any protection means when personal information is connected to networks. [Reference: NIST-IR7628, Smart Grid Cyber Security Vol.2 "Privacy and the Smart Grid", and OECD: "Privacy Principles"]