Standardization of Sensor Network Reference Architecture

Workshop
IMPLEMENTATION EXPERIENCE OF NETWORK PERFORMANCE PARAMETERS CONTROL SYST
EMS AND GRANTING REQUIRED LEVEL OF SERVICES QUALITY ON THE OPERATOR NETWORK
S. SENSOR NETWORKS – AS OPTIMIZATION TOOL FOR VEHICULAR TRAFFIC FLOW
Content

I. Motivation

II. Standardization Activities of JTC1

III. Sensor Network Reference Architecture

IV. Part 7: Interoperability Guidelines
Challenges for Sensor Networks

• Communication
  - Transmission media: wireless (RF, infrared, optical, etc.) or wired
  - Bandwidth-limited communication: efficiently move large amounts of sensor data for processing
  - Scheme, e.g., multi-hop wireless communication

• Operation security: Security and privacy solutions

• Scalability
  - Handle high density of nodes
  - Node position may not be pre-determined

• Network topology
  - Node density and mobility, new nodes, loss of nodes resulting in changing topology
  - Autonomous operation, auto-configuration, self-organizing & self-healing
  - Large scale coordination for sensor nodes to act in concert with one another
  - ad-hoc sensor network protocol may be applied
Challenges for Sensor Networks

• Fault tolerant
  - Be robust against individual node failure
  - handle loss of nodes due to lack of power, physical damage, environmental interference

• Quality of Service (QoS)
  - Traditional QoS metrics do not apply
  - Still, service of WSN must be “good”: Right info/answers at the right time

• A variety of deployment options
  - Handle high density of nodes
  - Node position may not be pre-determined

• Wide range of densities
  - Vast or small number of nodes per unit area, very application-dependent
Challenges for Sensor Networks

• Operation lifetime
  - The network should fulfill its task as long as possible
  - lifetime of individual nodes relatively unimportant
  - Require joint optimization process between application and implementation

• Energy-efficient operation: power/energy management
  - Energy limitation: limited transmission, computation, sensing, actuating; data routing; physical, MAC, link, route, application
  - Lifetime of sensor network depends on battery life time (for some cases, replenishment of power is impossible)
  - To recharging large number of sensing node is impossible

• Operation in varying environment
  - Remote, unattended, etc
  - Adjust to operating conditions and changes in application requirements
  - survive and maintain communication, e.g., bottom of an ocean, biologically contaminate, battlefield
Challenges for Sensor Networks

• Data fusion and collaborative/distributed processing
  - Locally carry out simple computation: forward and aggregate data
  - Query for single node or group of nodes based on attribute and/or location
  - Nodes in the network collaborate towards a common goal or goals
  - Need algorithms that are not centralized, i.e. do not require all of the data
  - Real-time computation for certain applications: Must be processed faster than new data is generated

• Deeply distributed architecture
  - Localized coordinate to reach whole system goals, no infrastructure and central control support
Challenges for Sensor Networks

- **Standardization**
  - Integration or Interoperability?

  **Integrated Systems**
  - Tightly-coupled, fixed architecture
  - Homogeneous system
  - Autonomous or stand-alone

  **Interoperable Systems**
  - Loosely-coupled, scalable architecture
  - Heterogeneous components
  - Standard-based interfaces
Content

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Structure of ISO/IEC JTC1
• 43 P/ 43 O members(JTC1)
• 324 liaison relationships
• Total number of active standards – 1941
• Average new work items per year – 240
• average number of active work items per year – 673
• **WG7(WGSN)**: Working Group on Sensor Networks
  
  • SC 02: Coded Character Sets
  • SC 06: Telecommunication and Information Exchange between Systems
  • SC 07: Software and System Engineering
  • SC 17: Cards and Personal Identification
  • SC 22: Programming Languages, their environments and systems software interfaces
  • SC 23: Optical Disk Cartridges for Information Interchange
  • SC 24: Computer Graphics and Image Processing
  • SC 25: Interconnection of IT Equipment
  • SC 27: IT Security Techniques
  • SC 28: Office Equipment
  • SC 29: Coding of Audio, Picture and Multimedia and Hypermedia
  • SC 31: Automatic Identification and Data Capture Techniques
  • SC 32: Data Management and Interchange
  • SC 34: Document description and processing languages
  • SC 35: User Interfaces
  • SC 36: Learning Technology
  • SC 37: Biometrics
  • SC 38: Distributed Application Platforms and Services
Background of JTC 1/ WG 7(WGSN)

• SGSN was established at the 22\textsuperscript{nd} JTC1 plenary held in Gold Coast in 2007 for study of Sensor Network Standardization
  – Convenor : Yongjin Kim(Modacom), Secretary : Jooran Lee(KSA)

• 9 NBs and 6 Liaison Organizations
  – 9 NBs : Canada, China, France, Germany, Japan, Korea, Norway, UK, and US

• 7 physical meetings(June in China and September in Germany 2008, January in Australia and July in Norway 2009, and March in London and September in USA 2010, March in France 2011), 2 workshops(June 2008 in China, April 2009 in Korea)
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• 9 NBs and 6 Liaison Organizations
  - 9 NBs: Canada, China, France, Germany, Japan, Korea, Norway, UK, and US
  - 6 Los: JTC1/SC6, JTC 1/SC31, JTC1/SC36, ISO/TC 211, IEC/TC 65, IEC/TC 100

• 4 physical meetings (June in China and September in Germany 2008, January in Australia and July in Norway 2009) and 2 workshops (June 2008 in China, April 2009 in Korea) for 2 years
The 1st WGSN Meeting: London, UK, March 2010
- 31 participants from 8 NBs and 6 LOs

Change of project title, scope and program of work
- Title: Sensor Network Reference Architecture (SNRA)
- Scope: This multi-part International Standard specifies a generic and generalized reference architecture for sensor networks. It guides both horizontal and vertical applications of sensor networks providing an ability to be tailored to meet specific requirements
- Program of work
  • ISO/IEC 20182 Part 1 – General Overview and Requirements
  • ISO/IEC 20182 Part 2 – Vocabulary/Terminology
  • ISO/IEC 20182 Part 3 – Reference architecture views
  • ISO/IEC 20182 Part 4 – Entity models
  • ISO/IEC 20182 Part 5 – Interface definitions
  • ISO/IEC 20182 Part 6 – Application Profiles
  • ISO/IEC 20182 Part 7 – Interoperability guidelines

Result of the 1st JTC 1/WG 7 meeting
Result of the 1st JTC 1/WG 7 meeting

• JTC001-N-9921
  - Proposed NP for Sensor Network and its Interface for Smart Grid System
  - by USA
  - Passed by voting
  - Waiting for resolving IEC/SMB concerns

• JTC001-N-9791(NP)
  - Proposed NP for Services and Interfaces Supporting Collaborative Information Processing in Intelligent Sensor Networks
  - By China
  - Passed by voting

• New Project candidates
  - Middleware issues
  - By Korea, China, Germany, USA
Result of the 2nd JTC 1/WG 7 meeting

• The 2nd WGSN Meeting: NIST Gaithersburg, MD, USA, August 2010
  – 22 participants from 8 NBs and 5 Los
  – Finland is newly joined

• Liaisons
  – OGC is newly joined – Category C liaison
  – IEEE & ETSI TC M2M are trying to be Liaison orgs
  – Currently, 11 Liaison Orgs:
## Result of the 2nd JTC 1/WG 7 meeting

<table>
<thead>
<tr>
<th>ISO/IEC</th>
<th>Title</th>
<th>Project Editor</th>
<th>Sub Editor</th>
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<tr>
<td>ISO/IEC WD 29182 Part 1</td>
<td>General overview and requirements</td>
<td>Sangkeun Yoo (KOR)</td>
<td>Jie Shen Alexander Pflaum Howard Choe Nader Moayeri</td>
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<td>ISO/IEC WD 29182 Part 2</td>
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<td>Nan Guo (CHN)</td>
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<td>ISO/IEC WD 29182 Part 3</td>
<td>Reference architecture views</td>
<td>Howard Choe (USA)</td>
<td>Jie Shen Alexander Pflaum Sankeun Yoo</td>
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<td>Entity models</td>
<td>Nader Moayeri (USA)</td>
<td>Sangkeun Yoo Howard Choe</td>
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<td>ISO/IEC WD 29182 Part 5</td>
<td>Interface definitions</td>
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<td>Sangkeun Yoo Howard Choe</td>
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<td>Alexander Pflaum (GER)</td>
<td>Jie Shen Howard Choe Nader Moayeri Seungmin Lee</td>
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<td>ISO/IEC WD 29182 Part 7</td>
<td>Interoperability guidelines</td>
<td>Seungmin Lee (KOR)</td>
<td>Jie Shen Howard Choe</td>
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</table>
The 3rd WGSN Meeting: Sophia Antipolis, France, April 2011
- 22 participants from 8 NBs and 5 Los
- Finland is newly joined

Committee Draft
- JTC 1/WG7 Circulation of 1st CD of ISO/IEC 29182 Part 1
- JTC 1/WG7 Circulation of 1st CD of ISO/IEC 29182 Part 2
- JTC 1/WG7 Circulation of 1st CD of ISO/IEC 29182 Part 7
- JTC 1/WG7 Circulation of 1st CD of ISO/IEC 200005
Content

I. Motivation

II. Standardization Activities of JTC1

III. Sensor Network Reference Architecture

IV. Part 7: Interoperability Guidelines
<table>
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<tr>
<th>ISO/IEC Designation #</th>
<th>Title</th>
<th>Scope</th>
<th>Current Status</th>
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<tr>
<td>ISO/IEC 29162 Part 2</td>
<td>Sensor Network Reference Architecture (SNRA) – Part 2: Vocabulary and Terminology</td>
<td>Terms and definition of selected concepts relevant to the field of sensor networks</td>
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<td>ISO/IEC 29162 Part 3</td>
<td>Sensor Network Reference Architecture (SNRA) – Part 3: Reference architecture views</td>
<td>Architecture views including business, operational, systems, and technical views which are presented in functional, logical, and/or physical where applicable</td>
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<td>ISO/IEC 29162 Part 4</td>
<td>Sensor Network Reference Architecture (SNRA) – Part 4: Entity models</td>
<td>Models for the entities comprising a sensor network according to the Sensor Network Reference Architecture (SNRA)</td>
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<td>ISO/IEC 29162 Part 5</td>
<td>Sensor Network Reference Architecture (SNRA) – Part 5: Interface definitions</td>
<td>Definitions of SN interfaces among the entity models in the reference architecture and covers the following aspects: • General description of SN interfaces • Functional requirements of SN interfaces</td>
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<td>ISO/IEC 29162 Part 6</td>
<td>Sensor Network Reference Architecture (SNRA) – Part 6: Application Profiles</td>
<td>• Functional blocks and components of a generic sensor network. • Distinct characteristics of each component. • Generic sensor network reference architecture incorporating the relevant sensor network-related base standards to support interoperability and data interchange</td>
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<td>ISO/IEC 29162 Part 7</td>
<td>Sensor Network Reference Architecture (SNRA) – Part 7: Interoperability guidelines</td>
<td>• Overview of interoperability for heterogeneous sensor networks, • Guidelines for interoperability between heterogeneous sensor networks</td>
<td>CD</td>
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<tr>
<td>ISO/IEC 20005</td>
<td>Services and Interfaces Supporting Collaborative Information Processing in Intelligent Sensor Networks</td>
<td>• CIP functionalities and CIP functional model • Common services supporting CIP • Common service interfaces to CIP</td>
<td>CD</td>
</tr>
<tr>
<td>ISO/IEC 39101</td>
<td>Sensor Network and its Interface for Smart Grid System</td>
<td>• Interfaces between the sensor networks and other networks, • Sensor network architecture to support smart grid systems, • Interface between sensor networks with smart grid systems, • Sensor network based emerging applications and services to support smart grid systems, • Visualization of sensors/devices status and data/information flow in large scalable heterogeneous network systems, for example, geospatial information systems</td>
<td>NP</td>
</tr>
</tbody>
</table>
Basic Architecture of Sensor Node

Block Diagram:

Communications Model:

Typically
Software

Presentation
Session
Transport
Network
Routing
Gateway
Routing

H/W
Sensor 1
Sensor L
Actuator 1
Actuator M
System Computer
System Control/Monitoring
Network Interface Adapter

Typically
Software

Sensor Network(s)
Actuator Network(s)
Effector Network(s)
System Computer(s)
External Network(s)
Network Interface Adapter(s)

Router - Bypasses computer

External Networks
Layered security model of sensor networks
Taxonomy analysis of sensor network QoS
Inside of Sensor Node
Communication Component

Data Capture Component

Data Storage Component

Event Generation Component

Data Request Component

Rule Definition Component

USER
Example of component interconnections via service access points


Application Layer
- Theft Protection
- Temperature Monitoring

Service Layer
- Communication Management
- Group Management
- Security Management
- Data Management
- Localization Service

Basic Functions Layer
- Network Communication
- Sensor Driver
- Clock

Device Management Entity
- Program Management
- Identification
- Resource Management
Functional model of sensor network middleware, its service layers, generic functions

- Application Layer
  - Application
  - Software Agent
  - Rules Engine
  - Collaborative Information Processing (CIP)

- Domain Specific Services
  - Logistics Domain
  - Security Domain

- Middleware
  - Resource Management Service
  - Service Discovery
  - Security Management
  - Data Management Service
  - Code Management Service
  - Time Sync Service
  - Group Management Service

- Support Functions
  - Communication Support
  - Self Localization

- Basic Functions Layer
  - Network Communication
  - Hardware Driver
  - Identification

- QoS Management
  - Network Management
  - System Monitoring
  - Resource Management
  - Device Management
  - Management
I. Motivation

II. Concept of SNRA

III. Sensor Network Reference Architecture

IV. Part 7: Interoperability Guidelines
Introduction

● Main purpose
  ▪ to provide design principles for interoperability
  ▪ guidance on tailoring methods to produce application-oriented architecture while maintaining the interoperability is presented
  ▪ being used as a guidance of developing other parts of ISO/IEC 29182
Scope

● This standard
  ▪ provides the general overview and guidelines for interoperability in order to make heterogeneous sensor networks interact with each other and any service provider within the sensor network service framework
  ▪ covers not only sensor network domain, but also sensor network service domain

● It follows aspects below
  ▪ overview of interoperability for heterogeneous sensor networks
  ▪ guidelines of interoperability for heterogeneous sensor networks

● How
  ▪ interoperability can be secured by standardizing sensor network service information, and communication interfaces for sensor network service framework
Overall architecture for SN service
Terms defined in 29182-7

- **component**
  - definition of 3.1.3 in 29182-7
  - significant part of a sensor network service framework with well-defined inbound and outbound interfaces and associated protocols.

  Note: Component is typically intended to be used in conjunction with other compatible components from a well-architected component framework.

  Note: Components of sensor network service is that consists of a single piece of conceptual, functional entities (e.g., sensor networks including sink node, gateways, service providers, and user devices).

- **sensor network service framework**
  - definition of 3.1.4 in 29182-7
  - cohesive collection of collaborating components that have been architected to work together for sensor network service. This framework defines the components, how they are related, the choice of technology used to connect them, and their specific interfaces.
Sensor Network Service Framework (con’t)
### Sensor Network Service Framework (con't)

- **Framework configuration**
  - Sensor Network Component
  - Gateway Component
  - Service provider component
  - User device component

- **Interoperability**
  - Any components can interwork with any related components
  - Heterogeneous sensor networks can interwork with each other

- **Advantages**
  - Reduction of overinvestment
  - Extension of sensor network service & functionality
  - Reusability
Sensor Network Service Framework (con’t)

- **Interface 1**
  - Between service provider and user device component
  - Supporting sensor network service to user device which is offered by service provider through the legacy network, supported on the Internet, and accessed conveniently via a standard web browser
  - Access technologies may be xDSL, Ethernet, Wi-Fi, satellite, GPRS, CDMA, GSM, HSDPA, etc.
  - Interoperability for interface 1 is well defined at present
Interface 2
- Between service provider and gateway component
- Supporting data exchange for sensor network service through the legacy network, such as IP network
- Access technologies may be xDSL, Ethernet, Wi-Fi, satellite, GPRS, CDMA, GSM, HSDPA, etc.
- Interoperability for interface 2 is well defined at present
Interface 3
- Between gateway and sensor network component
- Gathering information from sensor network through interface 3 which is identical to sensor network(a) in communication technology.
- Gateway should have sink node’s functionality and it must be homogeneous with sensor network(a).
Sensor Network Service Framework

- Interface 4
  - Between gateway and sensor network component likewise interface 3.
  - Gathering information from sensor network.
  - Difference comes from the existence of sink node’s functionality in gateway.
  - Gateway gathers sensor network information through interface 4 which may be most commonly used interfaces, such as RS-232, SPI, USB, etc, due to its lack of sink node’s capability.

Note: Gateway in the case of interface 4 can support interoperability for heterogeneous sensor networks efficiently by standardizing protocol between gateway and sensor node.
How to Interoperate (con’t)

● Purpose of sensor network is to provide services to user.

● From this point of view, service provider only needs the information which is used for sensor network service.

● Therefore, it doesn’t matter what kind of sensor network oriented technology used in terms of sensor network service.

● That is to say, service provider can perform its functionality successfully by meeting the 2 qualifications.
  ▪ Capability of reading and processing the sensor network service information between sensor network, gateway and service provider component
  ▪ Capability of exchange data between sensor network, gateway, and service provider component
How to Interoperate (con’t)

- In conclusion, interoperability can be achieved by
  - defining **target of sensor network service information and its properties** (e.g. data type, format, etc.)
  - defining **communication interfaces** between each component in sensor network service framework

Note: Of course, some of sensor network service doesn’t include service provider or utilize legacy network (e.g. remote controller based on the ZigBee RF4CE profile for controlling smart home equipments such as DVD player, TV, audio set, etc). But this kind of sensor network is stand-alone system, which means it cannot interwork with other heterogeneous sensor networks, unless they become homogeneous. Thus, this case of sensor network will not be considered for interoperability in this standard.

- The effect of interoperability is
  - Interwork with any other related components while following the definition of sensor network sensing data and communication interface.
  - Also, components can be replaced, reused, and cooperated with each other accordingly.
How to Interoperate (con’t)

- Example of interoperability between service provider and sensor network

(a) Interworking between components

Service Provider Component

Gateway Component

Sensor Network Component

(b) Interworking with heterogeneous sensor networks

Service Provider Component

Gateway Component

Sensor Network Component #1

Sensor Network Component #2

- The case of basic form which represents each component can interwork with other related components

- The case that heterogeneous sensor networks are connected to one gateway. It implies that gateway has capability of communication with sensor network #1 and #2
How to Interoperate (con’t)

- Example of interoperability between service provider and sensor network

(c) Gateway as a relay station for multi service provider and multi sensor network

(d) Interworking between multi components

- The case that gateway becomes intermediate entity as a relay station which interconnects appropriate service provider and sensor network each other.

- The case of complex form which represents all cases of a, b, c
How to Interoperate (con’t)

- Example of interoperability between heterogeneous sensor networks

(a) Interworking through service provider

(b) Interworking through gateways via legacy network

a. The case that service provider becomes intermediate entity as a relay station for communication flow between sensor networks.

b. The case that gateway #1 and #2 becomes intermediate entity as a relay station for communication flow between sensor networks. Communication flow passes through legacy network.
c. The case that gateway becomes intermediate entity as a relay station. Communication flow doesn’t pass legacy network.

Example of interoperability between heterogeneous sensor networks

(c) Interworking through gateway
### Guidelines of Interoperability

- **Standardization of Sensor Network Service Information (cont’)
  - Classification of Functional and process model of sensor network service
    - 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

- **Types of Sensor network service information categorized from the function of SN service**

<table>
<thead>
<tr>
<th>Type</th>
<th>Functions</th>
</tr>
</thead>
<tbody>
<tr>
<td>sensor data</td>
<td>Requesting raw sensed data and/or processed data</td>
</tr>
<tr>
<td></td>
<td>Processing received sensed data</td>
</tr>
<tr>
<td>event data</td>
<td>Activating actuators</td>
</tr>
<tr>
<td>management data</td>
<td>Finding appropriate sensor networks to obtain sensed data</td>
</tr>
<tr>
<td></td>
<td>Monitoring sensor network status</td>
</tr>
<tr>
<td></td>
<td>Controlling sensor networks</td>
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<tr>
<td></td>
<td>Authenticating sensor networks</td>
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<tr>
<td></td>
<td>Providing appropriate services to users</td>
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</table>
## Guidelines of Interoperability

### Standardization of Sensor Network Service Information (con’t)

#### Requirements

<table>
<thead>
<tr>
<th>Type</th>
<th>Functions</th>
</tr>
</thead>
<tbody>
<tr>
<td>sensor data</td>
<td>Sensed data validation regarding associated measurement units, data types and value ranges</td>
</tr>
<tr>
<td></td>
<td>Application-dependant sensed data filtering</td>
</tr>
<tr>
<td>event data</td>
<td>Context-aware rules, alerting data validation regarding associated limitation</td>
</tr>
<tr>
<td>management data</td>
<td>Management of QoS by priority order</td>
</tr>
<tr>
<td></td>
<td>Connectivity management of sensor nodes</td>
</tr>
<tr>
<td></td>
<td>Software upgrade of sensor nodes</td>
</tr>
<tr>
<td></td>
<td>Query scheduling for multiple applications and sensor networks</td>
</tr>
<tr>
<td></td>
<td>Query routing to designated sensor nodes</td>
</tr>
</tbody>
</table>
Guidelines of Interoperability

- Example of Sensor Network Service Information
  - Data Format of sensor data of sensor network service information

<table>
<thead>
<tr>
<th>Sensor Attribute (2 bytes)</th>
<th>Sensor ID (2 bytes)</th>
<th>Sensor Value 1 (n bytes)</th>
<th>...</th>
<th>Sensor Value n (n bytes)</th>
</tr>
</thead>
</table>

- Sensor Attribute (2 bytes)
  - Sensor Attribute = 'Sensor Property' XOR 'Value Type' XOR 'Num'

<table>
<thead>
<tr>
<th>Name</th>
<th>Attribute</th>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensor Property</td>
<td>Temperature(Celsius)</td>
<td>0x0100</td>
<td>Type of sensor</td>
</tr>
<tr>
<td></td>
<td>Temperature(Fahrenheit)</td>
<td>0x0200</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Humidity</td>
<td>0x0300</td>
<td></td>
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<tr>
<td></td>
<td>Vibration</td>
<td>0x0400</td>
<td></td>
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<tr>
<td></td>
<td>Acceleration</td>
<td>0x0500</td>
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<tr>
<td></td>
<td>Pressure</td>
<td>0x0600</td>
<td></td>
</tr>
<tr>
<td></td>
<td>boolean type sensor</td>
<td>0x7f00</td>
<td></td>
</tr>
<tr>
<td></td>
<td>user define(0x8000~0xff00)</td>
<td>0xnn00</td>
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<tr>
<th>Value Type</th>
<th>unsigned integer 1byte</th>
<th>0x0010</th>
<th>Data type for sensor value</th>
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<tr>
<td></td>
<td>unsigned integer 2byte</td>
<td>0x0020</td>
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<tr>
<td></td>
<td>unsigned integer 3byte</td>
<td>0x0030</td>
<td></td>
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<tr>
<td></td>
<td>unsigned integer 4byte</td>
<td>0x0040</td>
<td></td>
</tr>
<tr>
<td></td>
<td>signed integer 1byte</td>
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<td>signed integer 2byte</td>
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<td>signed integer 3byte</td>
<td>0x0070</td>
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<td></td>
<td>signed integer 4byte</td>
<td>0x0080</td>
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<td></td>
<td>Boolean</td>
<td>0x00f0</td>
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<table>
<thead>
<tr>
<th>Num</th>
<th>0x000n</th>
<th>Number of sensor value</th>
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</thead>
</table>
### Guidelines of Interoperability

**Example of Communication Interface 4 in Sensor Network Service Framework**

- **Physical Interfaces**
  - RS-232, USB, SPI, etc.
- **Protocol Interface**
  - HDLC encoding for RS-232

---

#### Example of Packet Frame Format

<table>
<thead>
<tr>
<th>Sync Byte (1 byte)</th>
<th>Packet Type (1 byte)</th>
<th>Sequence Number (2 byte)</th>
<th>Data Payload (1-n byte)</th>
<th>CRC (2 byte)</th>
<th>Sync Byte (1 byte)</th>
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#### Type Value Description

<table>
<thead>
<tr>
<th>Type</th>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sync Byte</td>
<td>0x7e</td>
<td>Start of packet frame</td>
</tr>
<tr>
<td>Packet Type</td>
<td>0x40</td>
<td>ACK Response</td>
</tr>
<tr>
<td></td>
<td>0x41</td>
<td>ACK request</td>
</tr>
<tr>
<td></td>
<td>0x42</td>
<td>Non-ACK</td>
</tr>
<tr>
<td>Sequence Number</td>
<td>-</td>
<td>Sequence number</td>
</tr>
<tr>
<td>Data Payload</td>
<td>-</td>
<td>Data</td>
</tr>
<tr>
<td>CRC</td>
<td>-</td>
<td>CRC</td>
</tr>
<tr>
<td>Escape Byte</td>
<td>0x7d</td>
<td>End of packet frame</td>
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**Example of Communication Interface 4 in Sensor Network Service Framework**

- **Physical Interfaces**
  - RS-232, USB, SPI, etc.
- **Protocol Interface**
  - HDLC encoding for RS-232

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