ЦНИИС

nipa National IT Industry Promotion Agency RFID / USN Center

International Telecommunication Union

Standardization of Sensor Network Reference Architecture

Workshop

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

Moscow

27-29 April 2011

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

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Structure of ISO/IEC JTC1

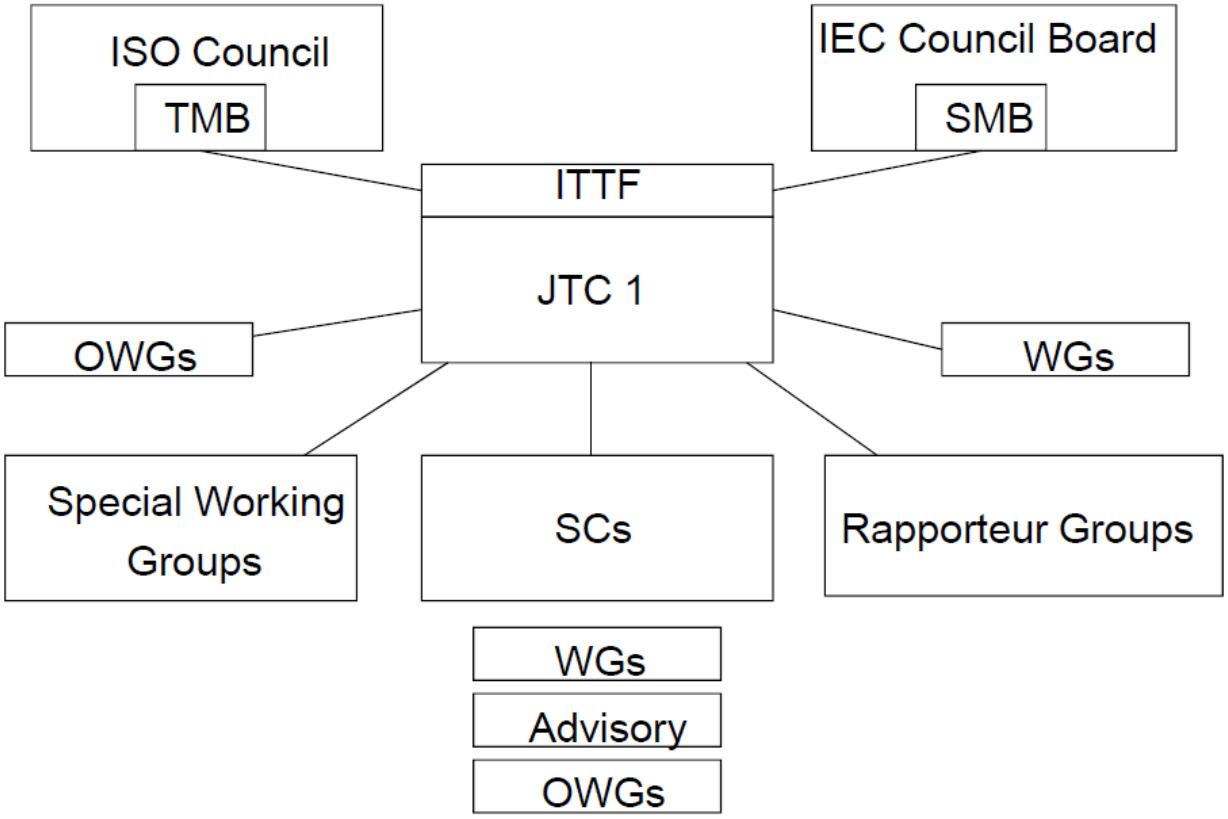

Figure for ISO/IEC JTC1

- 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

ISO/IEC JTC1

- **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 22nd 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
  - 6 Los : JTC1/SC6, JTC 1/SC31, JTC1/SC36, ISO/TC 211, IEC/TC 65, IEC/TC 100

- **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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- **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**

Result of the 1st JTC 1/WG 7 meeting

- **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

- **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

ISO/IEC	Title	Project Editor	Sub Editor
ISO/IEC WD 29182 Part 1	General overview and requirements	Sangkeun Yoo (KOR)	Jie Shen Alexander Pflaum Howard Choe Nader Moayeri
ISO/IEC WD 29182 Part 2	Vocabulary and Terminology	Nan Guo (CHN)	Sangkeun Yoo Howard Choe
ISO/IEC WD 29182 Part 3	Reference architecture views	Howard Choe (USA)	Jie Shen Alexander Pflaum Sankeun Yoo
ISO/IEC WD 29182 Part 4	Entity models	Nader Moayeri (USA)	Sangkeun Yoo Howard Choe
ISO/IEC WD 29182 Part 5	Interface definitions	Jie Shen (CHN)	Sangkeun Yoo Howard Choe
ISO/IEC WD 29182 Part 6	Application Profiles	Alexander Pflaum (GER)	Jie Shen Howard Choe Nader Moayeri Seungmin Lee
ISO/IEC WD 29182 Part 7	Interoperability guidelines	Seungmin Lee (KOR)	Jie Shen Howard Choe

Result of the 3rd JTC 1/WG 7 meeting

- **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

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I. Motivation

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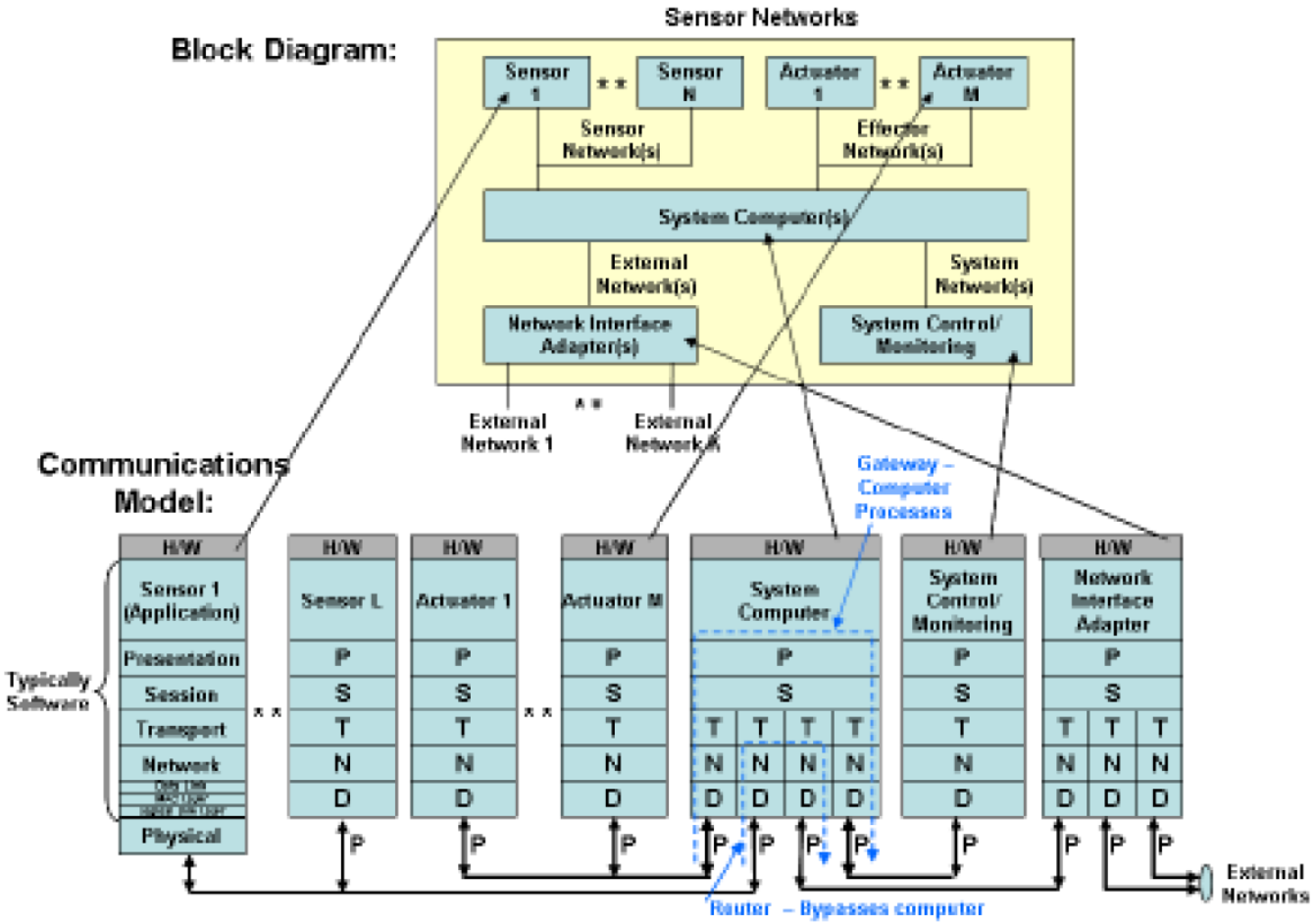
JTC1/WG7 Program of Work

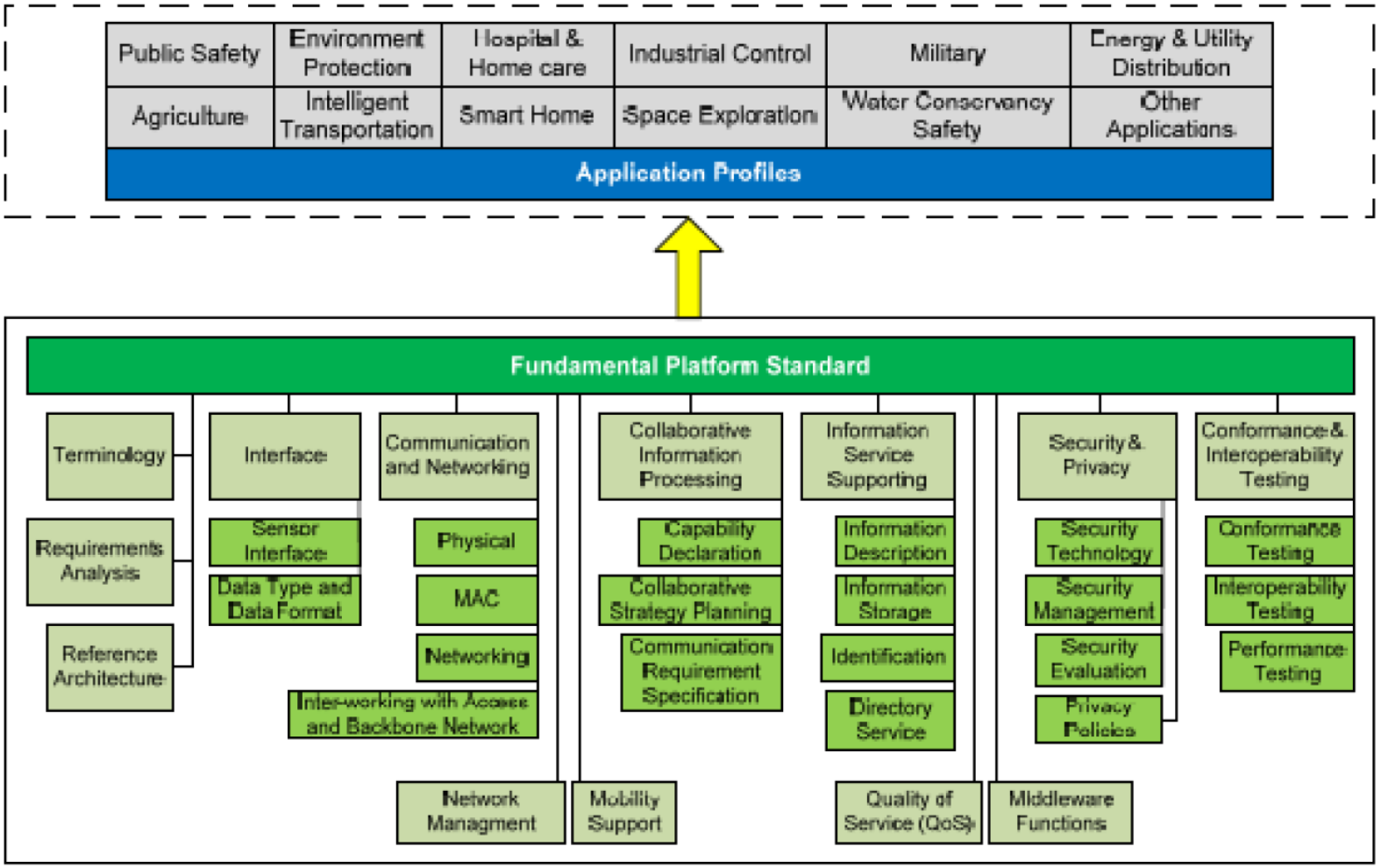
ISO/IEC Designation #	Title	Scope	Current Status
ISO/IEC 29182 Part 1	Sensor Network Reference Architecture (SNRA) – Part 1: General overview and requirements	General overview of and the requirements identified for the Sensor Network Reference Architecture	CD
ISO/IEC 29182 Part 2	Sensor Network Reference Architecture (SNRA) – Part 2: Vocabulary and Terminology	Terms and definition of selected concepts relevant to the field of sensor networks	CD
ISO/IEC 29182 Part 3	Sensor Network Reference Architecture (SNRA) – Part 3: Reference architecture views	Architecture views including business, operational, systems, and technical views which are presented in functional, logical, and/or physical where applicable	WD
ISO/IEC 29182 Part 4	Sensor Network Reference Architecture (SNRA) – Part 4: Entity models	Models for the entities comprising a sensor network according to the Sensor Network Reference Architecture (SNRA)	WD
ISO/IEC 29182 Part 5	Sensor Network Reference Architecture (SNRA) – Part 5: Interface definitions	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	WD
ISO/IEC 29182 Part 6	Sensor Network Reference Architecture (SNRA) – Part 6: Application Profiles	• 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	WD

ISO/IEC Designation #	Title	Scope	Current Status
ISO/IEC 29182 Part 7	Sensor Network Reference Architecture (SNRA) – Part 7: Interoperability guidelines	• Overview of interoperability for heterogeneous sensor networks, • Guidelines for interoperability between heterogeneous sensor networks	CD
ISO/IEC 20005	Services and Interfaces Supporting Collaborative Information Processing in Intelligent Sensor Networks	• CIP functionalities and CIP functional model • Common services supporting CIP • Common service interfaces to CIP	CD
ISO/IEC 30101	Sensor Network and its Interface for Smart Grid System	• 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	NP

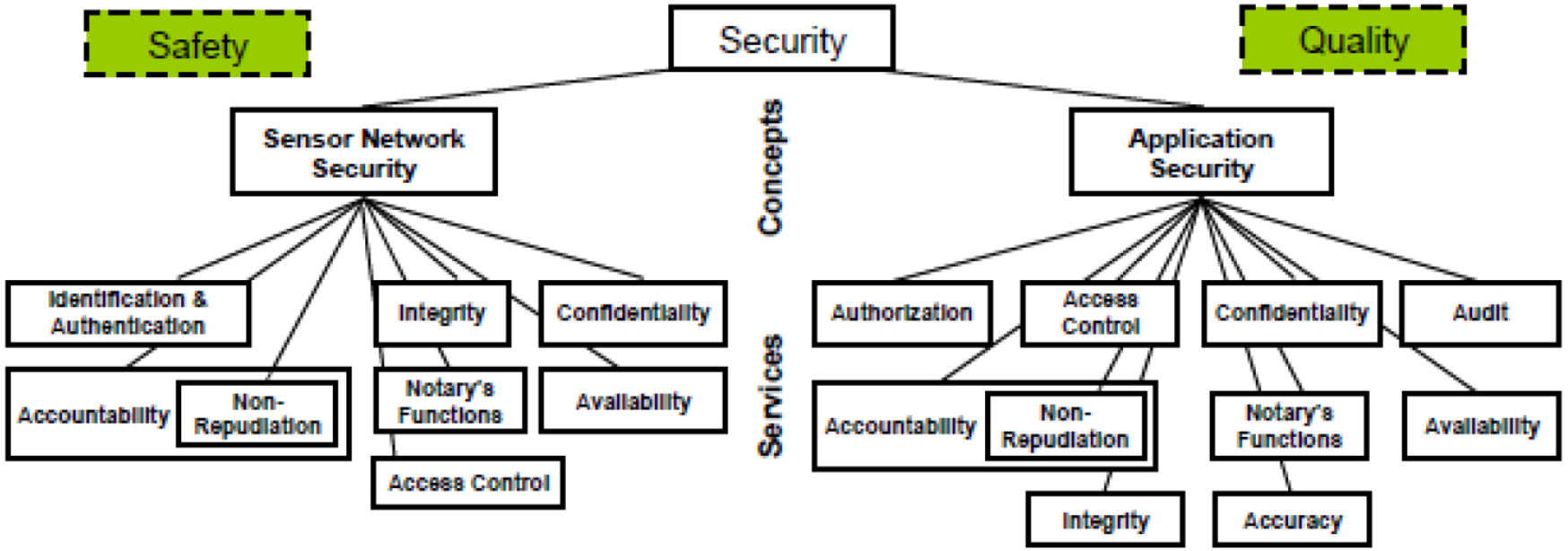
Basic Architecture of Sensor Node



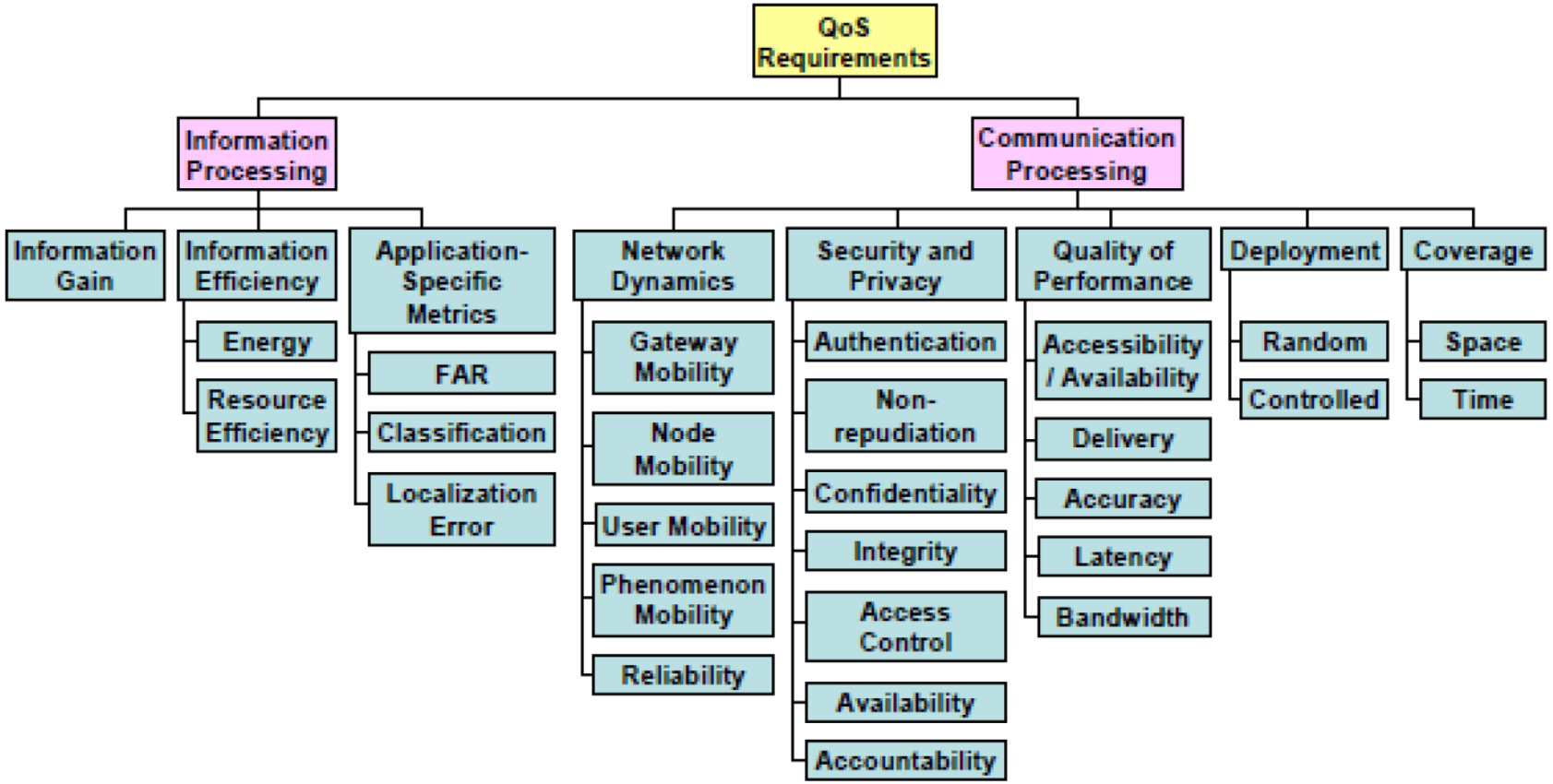
Standard Framework of Sensor Networks



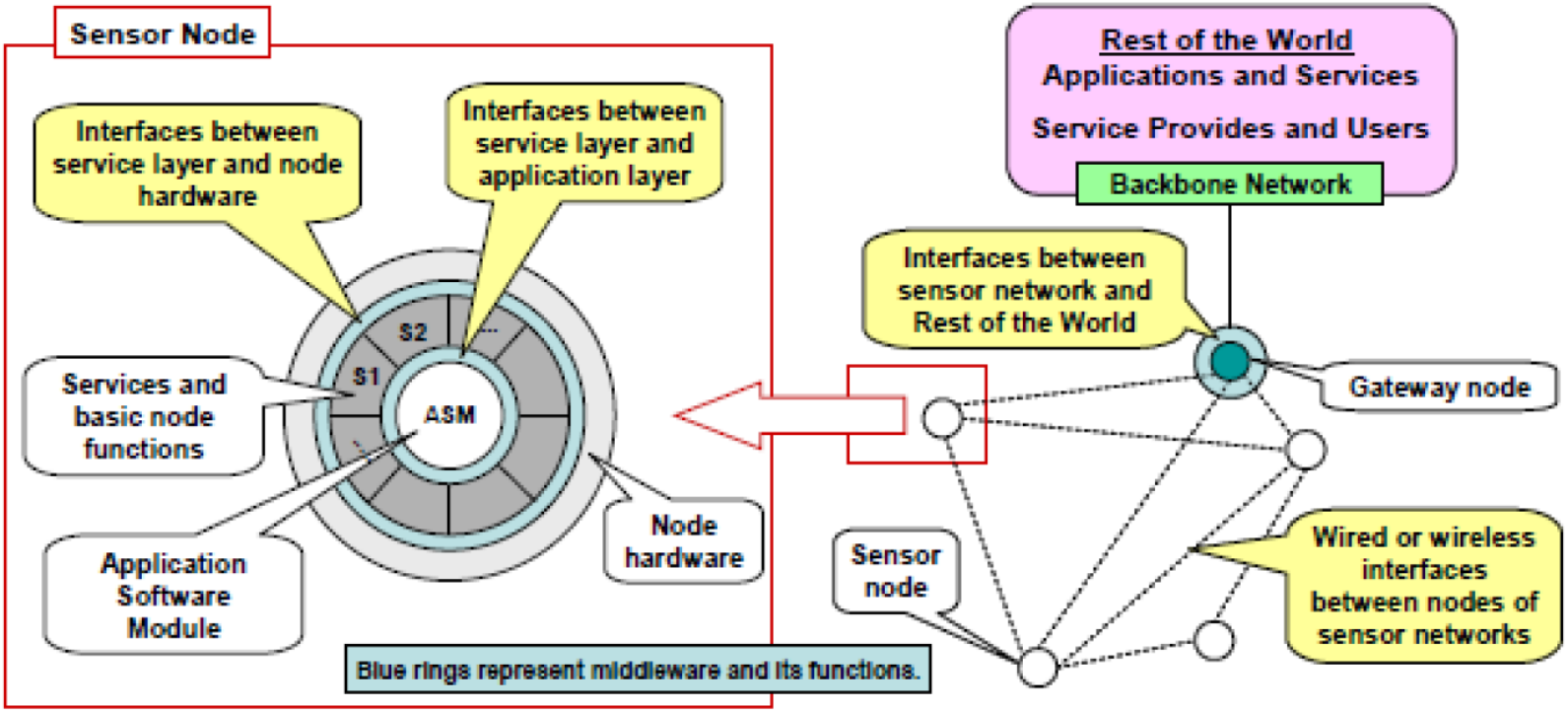
Layered security model of sensor networks



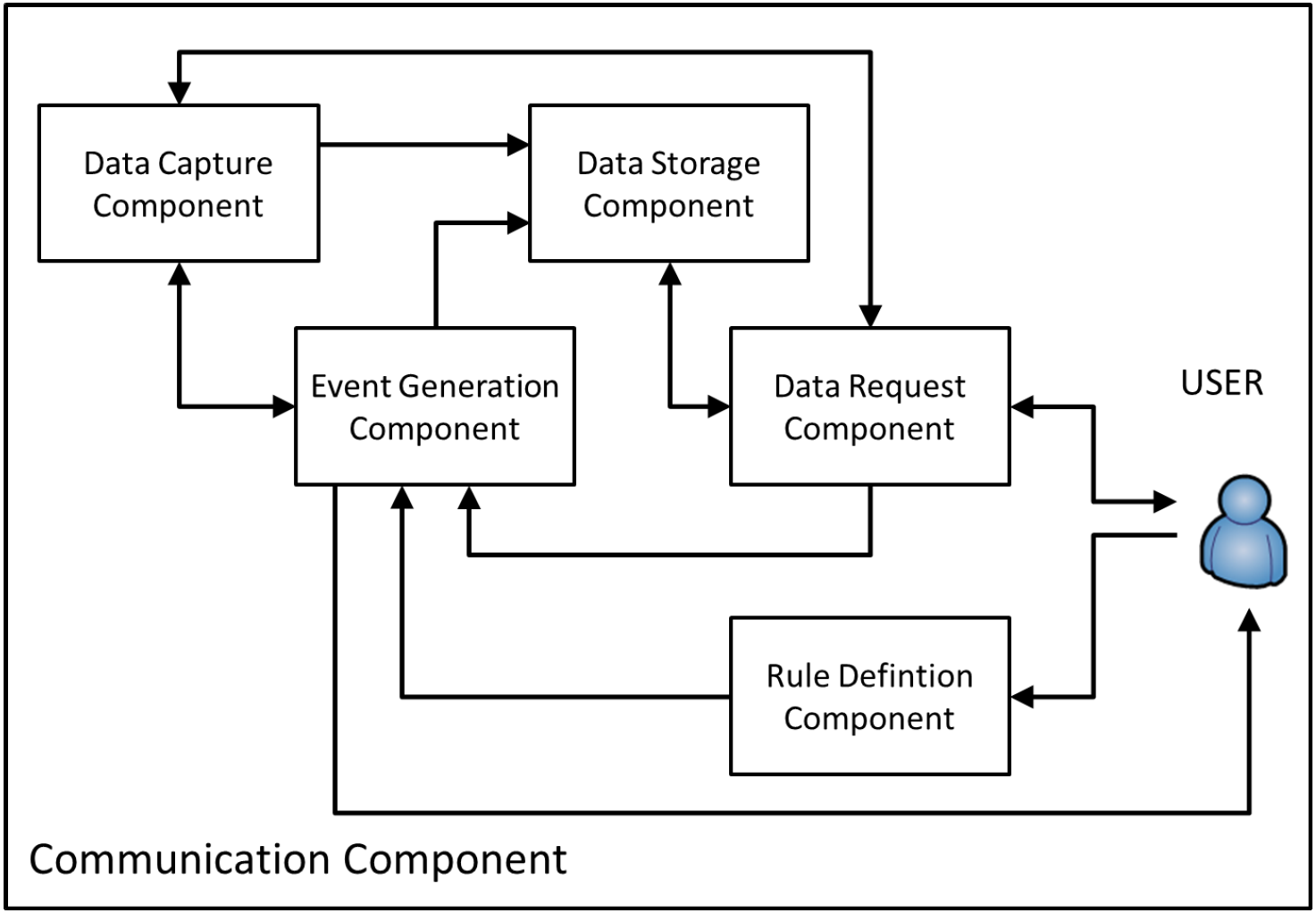
Taxonomy analysis of sensor network QoS



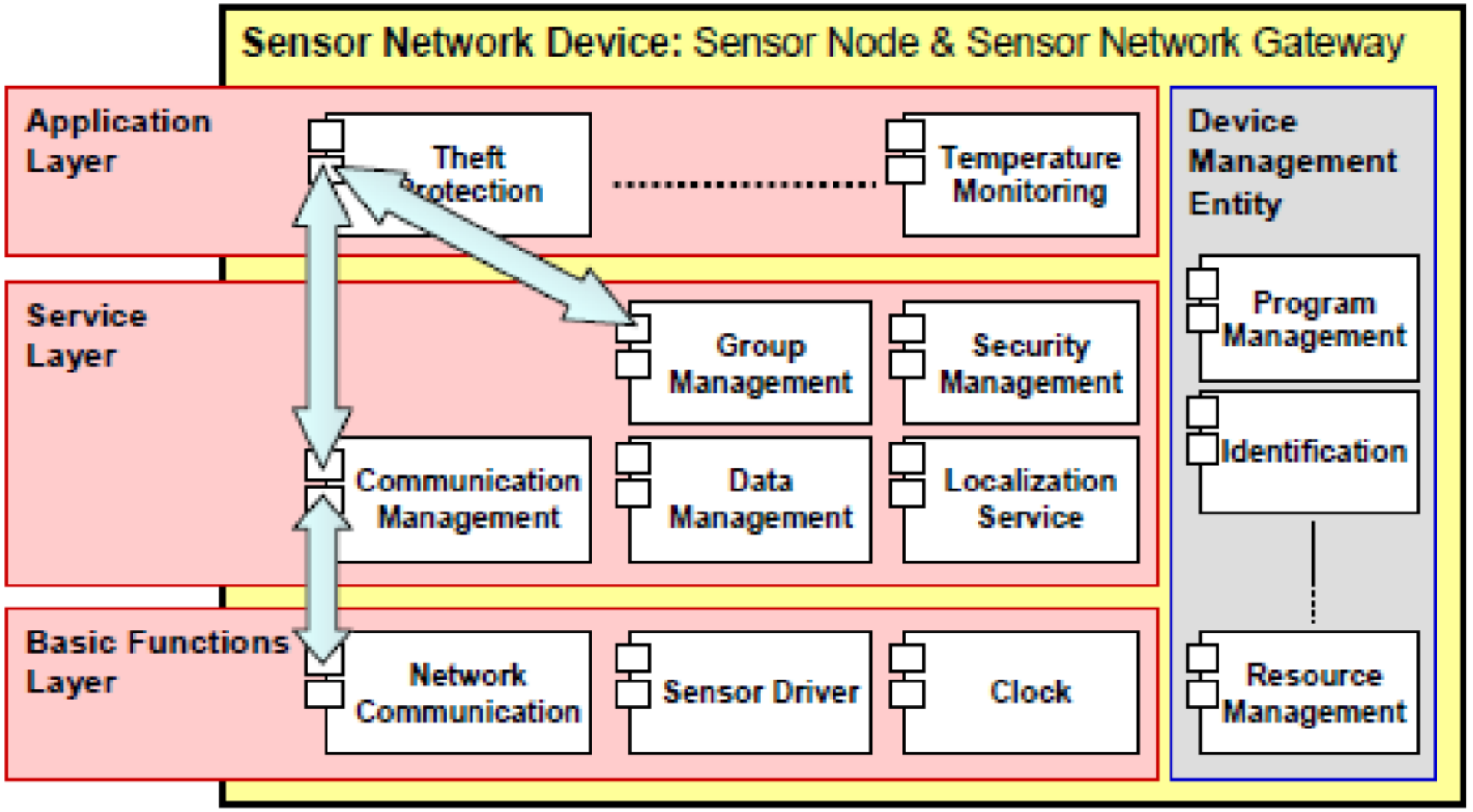
Inside of Sensor Node



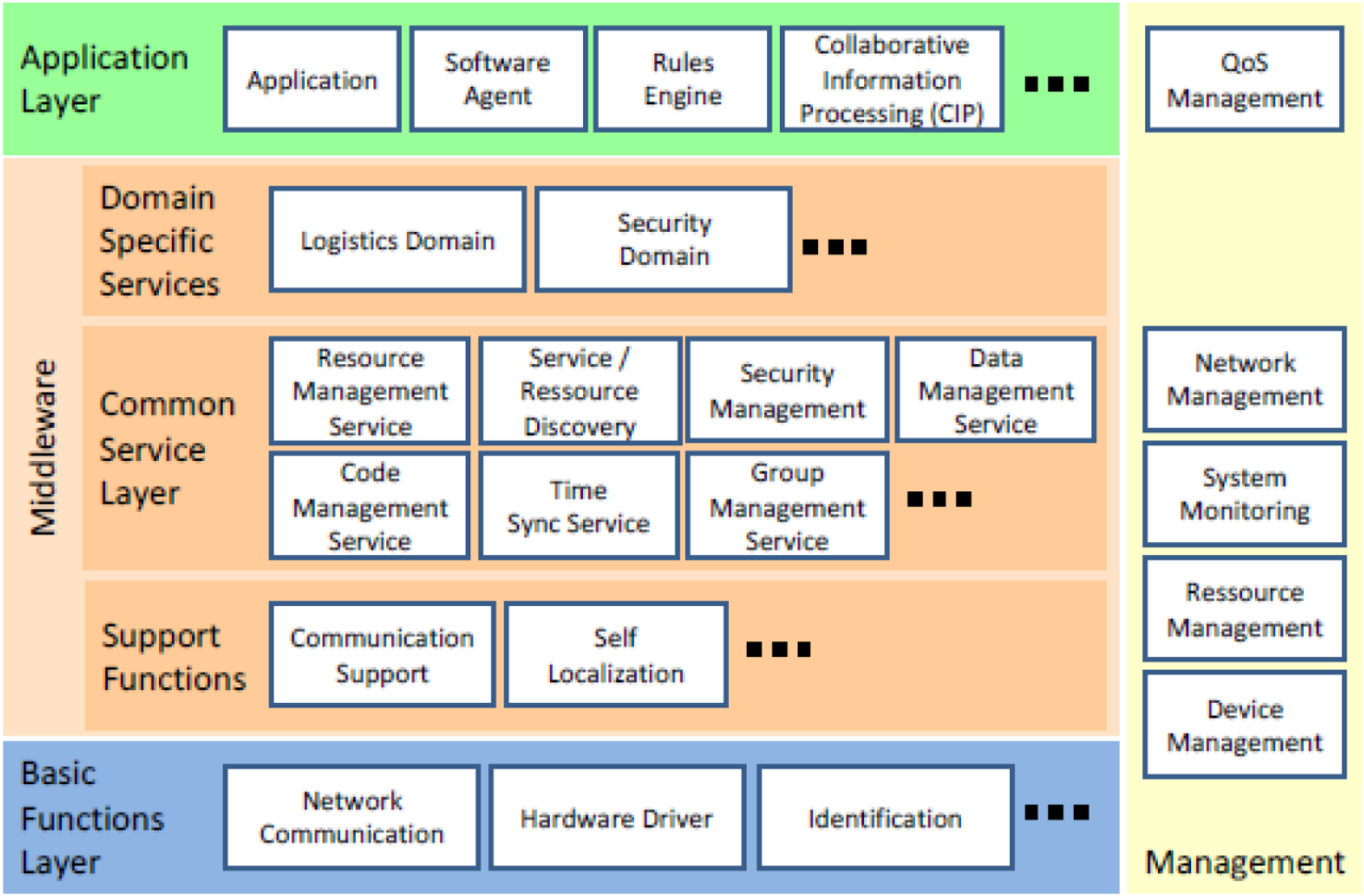
Communication Component



Example of component interconnections via service access points



Functional model of sensor network middleware, its service layers, generic functions



Content

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

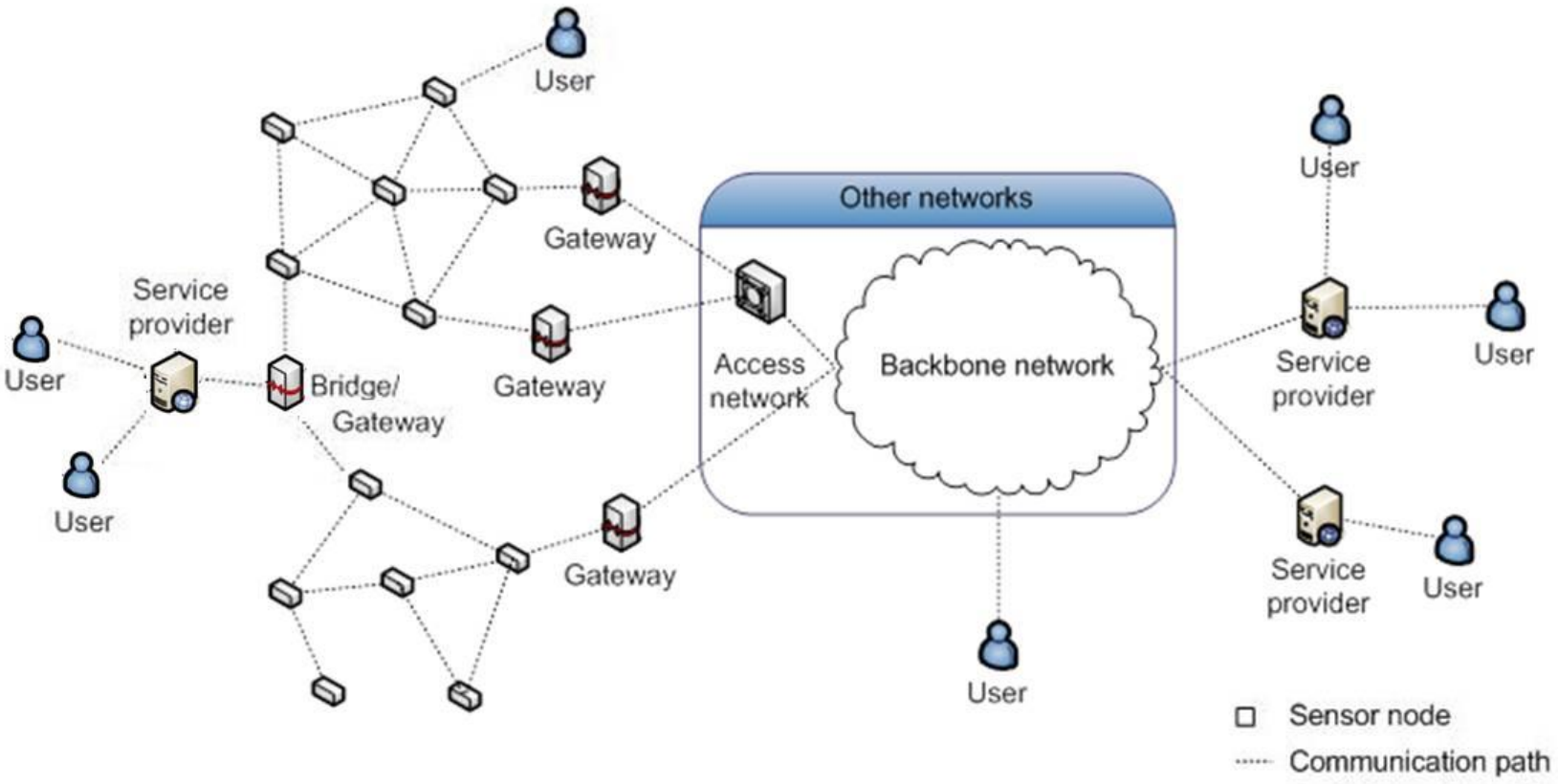
Scope

- **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

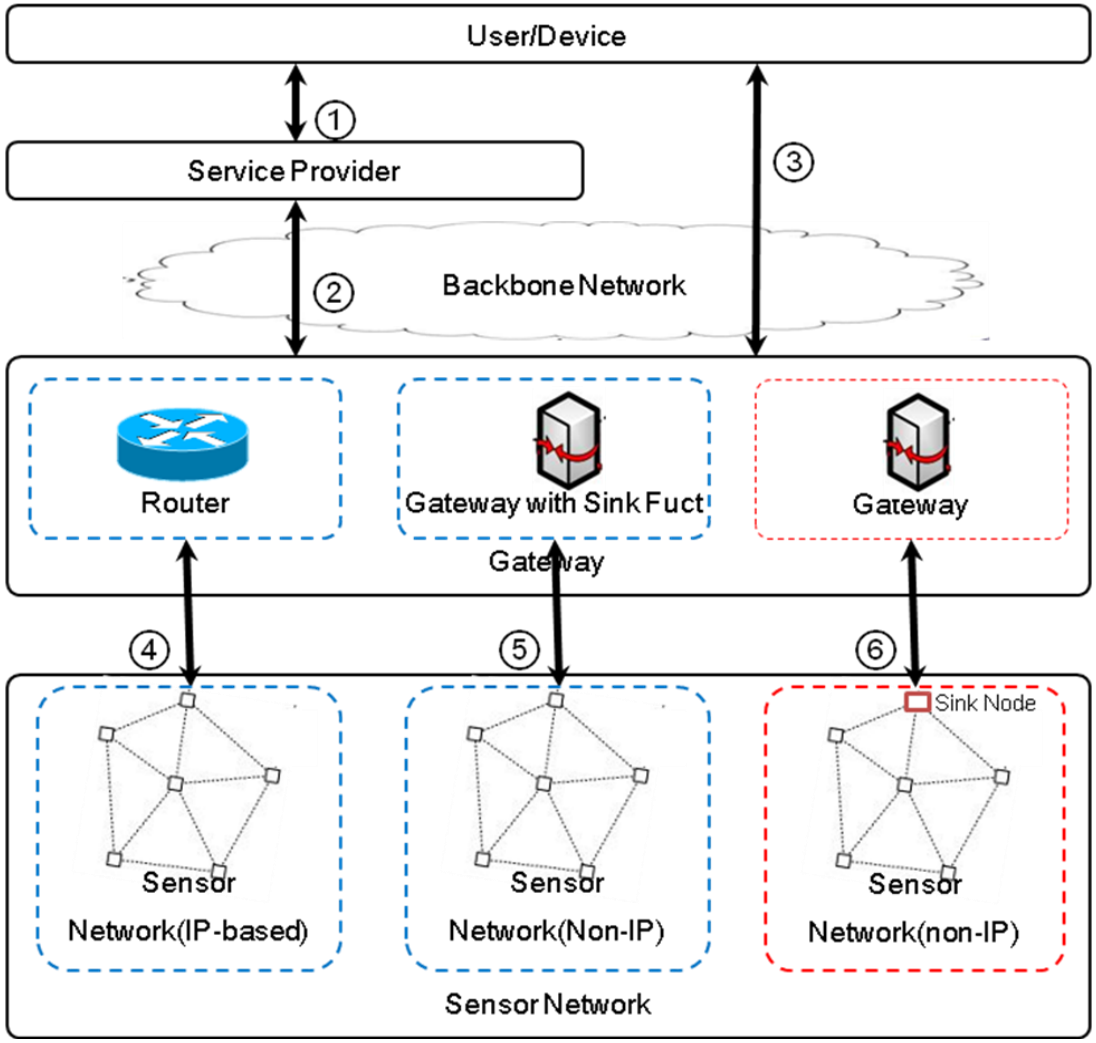
- **component**
  - definition of 3.1.3 in 29182-7
    – significant part of a sensor network service framework with well-defined inbound and outbound interfaces and associated protocols.

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

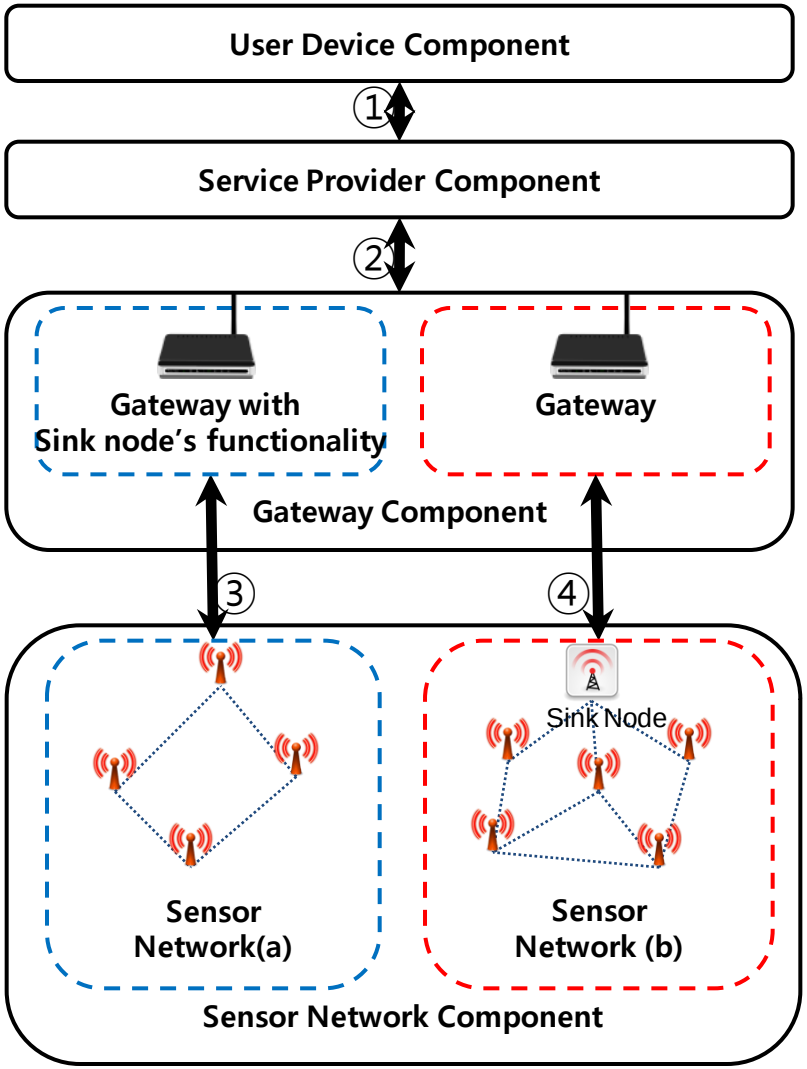
    Note: Components of sensor network service is that consists of a single piece of conceptual, functional entities (e.g., sensor networks including sink node, gateways, service providers, and user devices).

- **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)

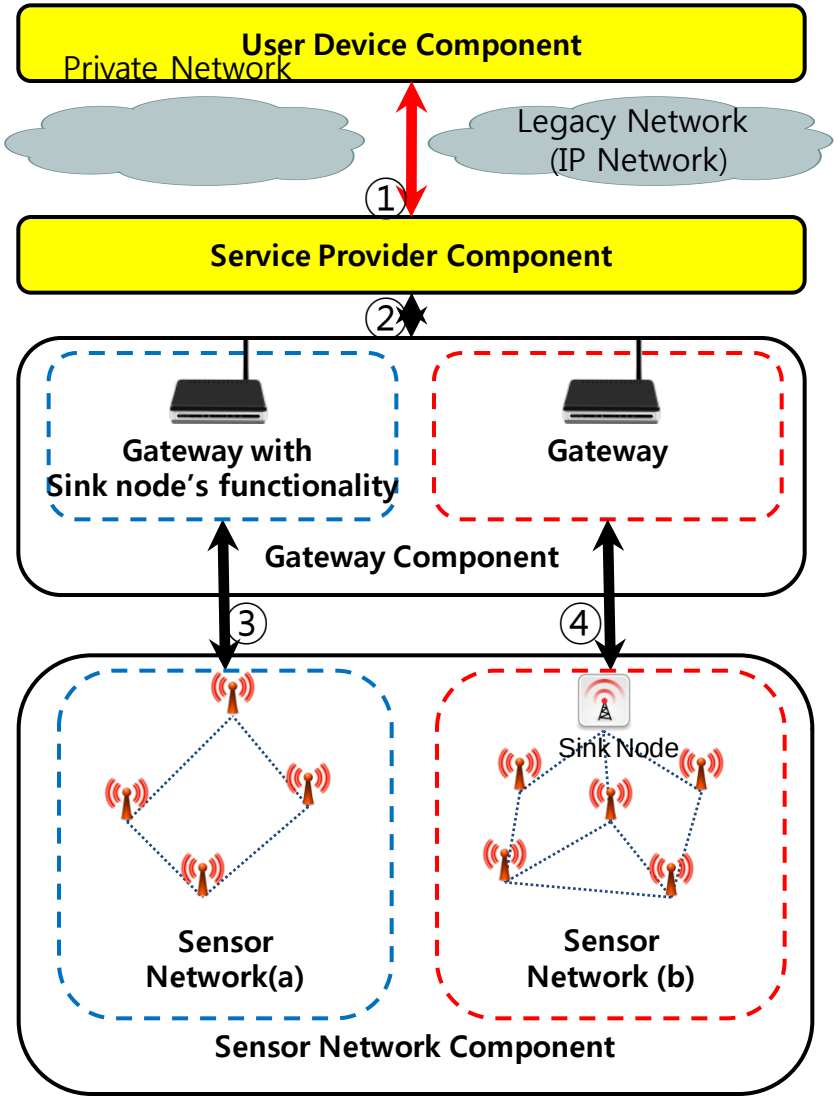


Sensor Network Service Framework(con't)



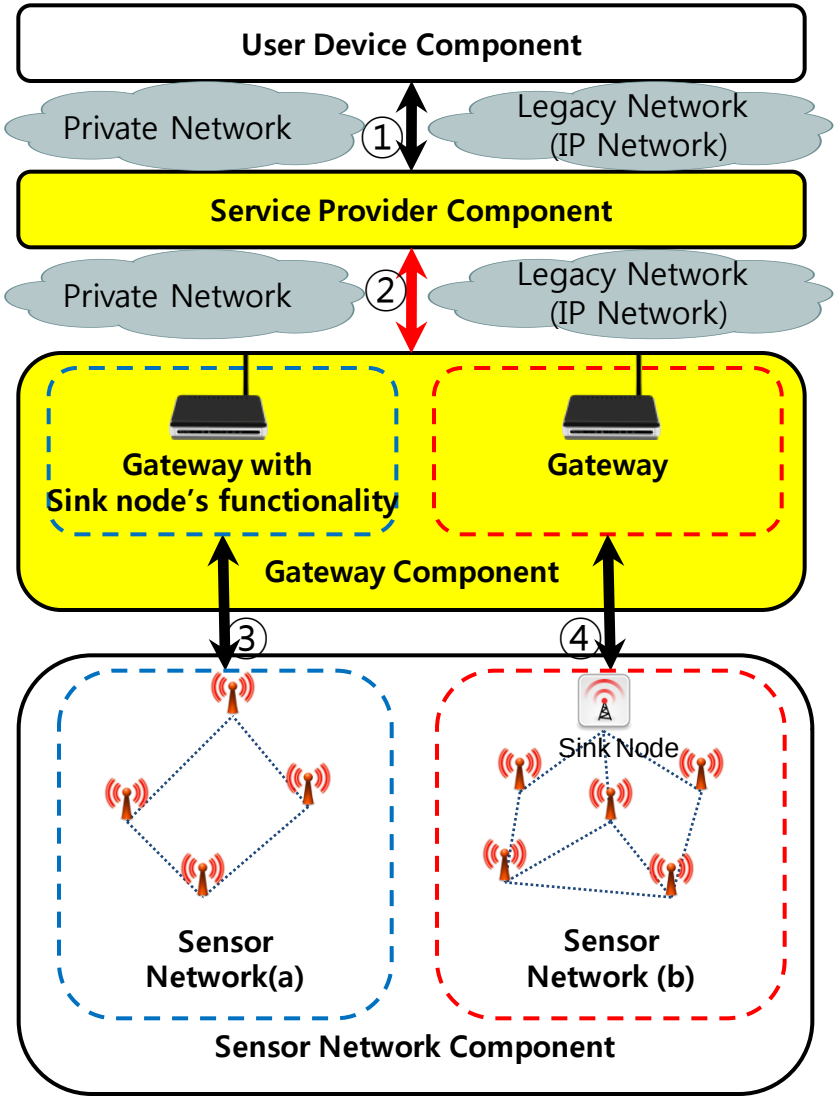
- Framework configuration
  - Sensor Network Component
  - Gateway Component
  - Service provider component
  - User device component
- Interoperability
  - Any components can interwork with any related components
  - Heterogeneous sensor networks can interwork with each other
- Advantages
  - Reduction of overinvestment
  - Extension of sensor network service & functionality
  - Reusability

Sensor Network Service Framework(con't)



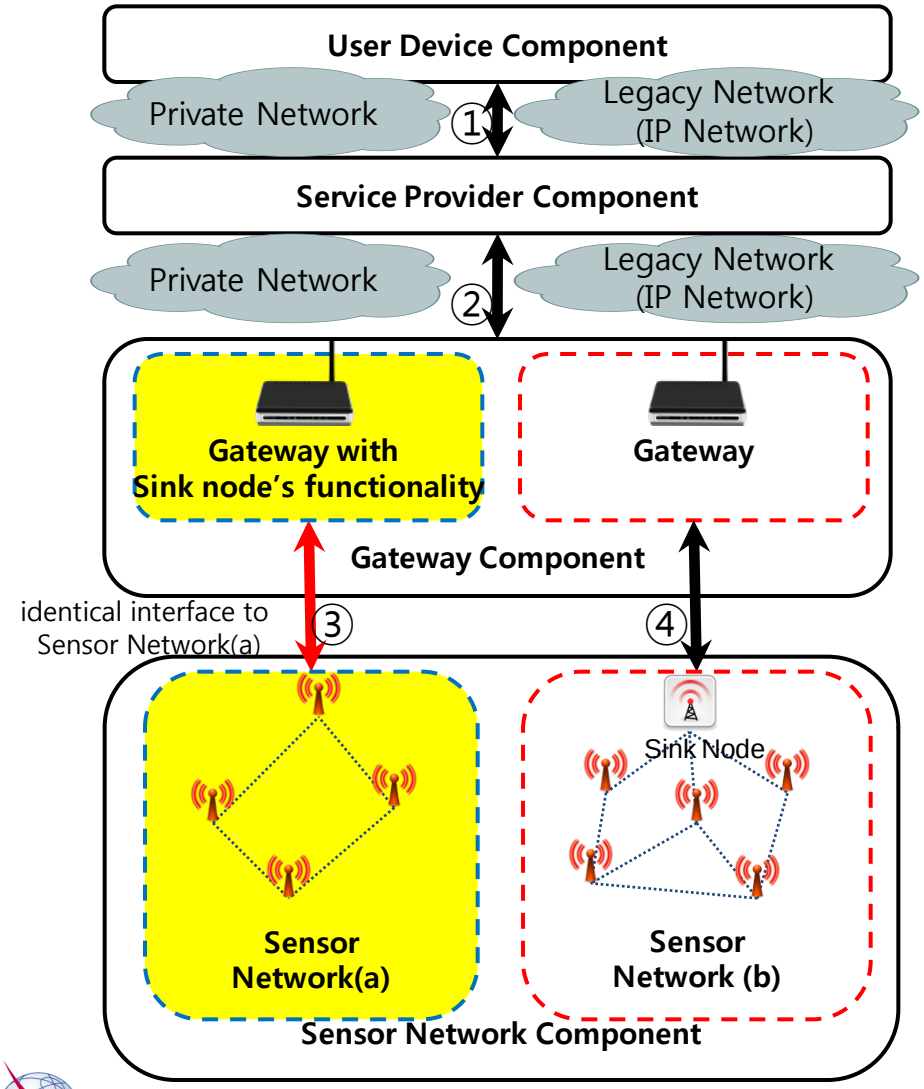
- Interface 1
  - Between service provider and user device component
  - Supporting sensor network service to user device which is offered by service provider through the legacy network, supported on the Internet, and accessed conveniently via a standard web browser
  - Access technologies may be xDSL, Ethernet, Wi-Fi, satellite, GPRS, CDMA, GSM, HSDPA, etc.
  - Interoperability for interface 1 is well defined at present

Sensor Network Service Framework(con't)



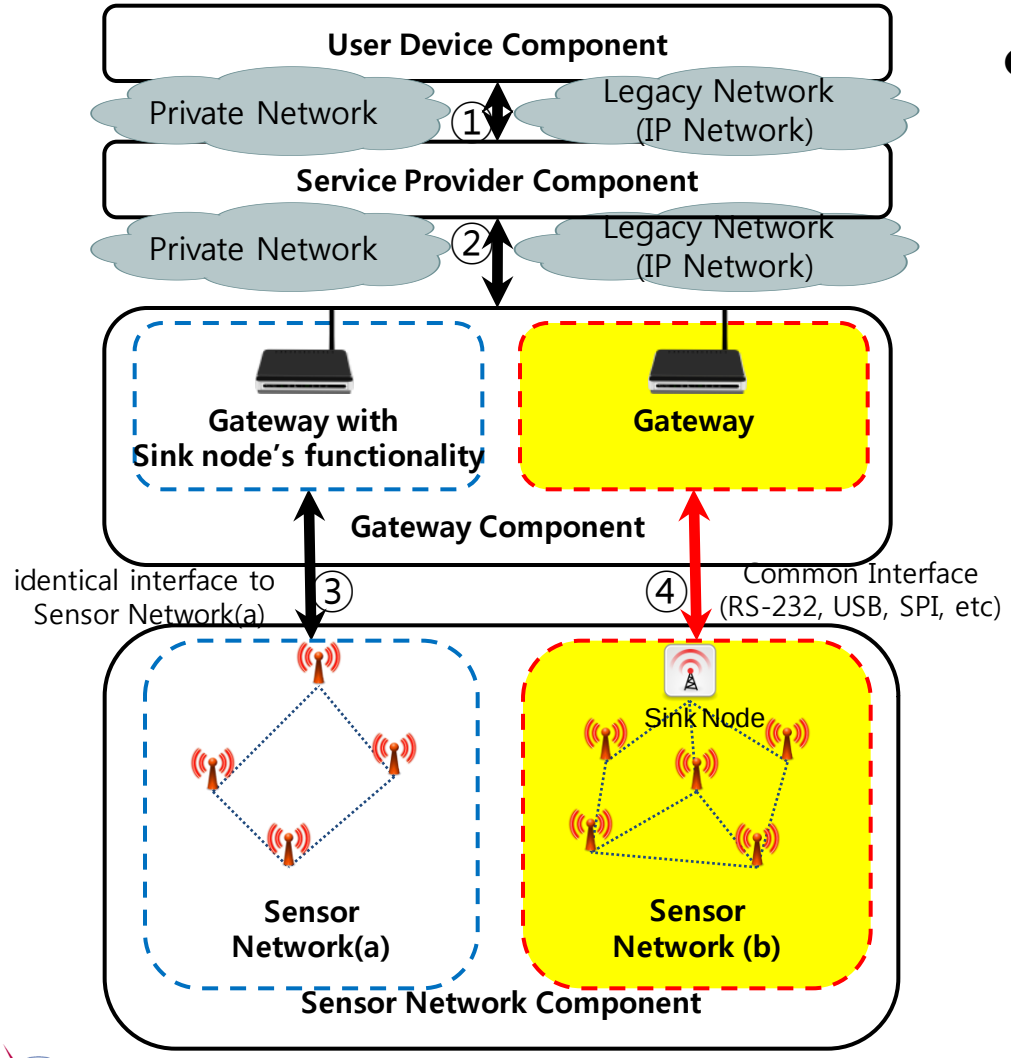
- Interface 2
  - Between service provider and gateway component
  - Supporting data exchange for sensor network service through the legacy network , such as IP network
  - Access technologies may be xDSL, Ethernet, Wi-Fi, satellite, GPRS, CDMA, GSM, HSDPA, etc.
  - Interoperability for interface 2 is well defined at present

Sensor Network Service Framework(con't)



- 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)

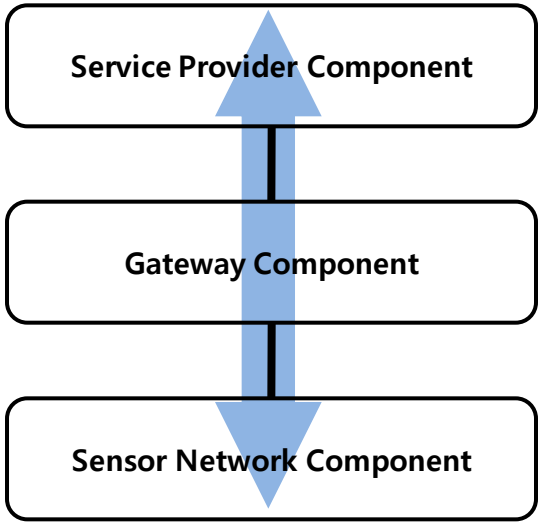
- In conclusion, interoperability can be achieved by
  - defining target of sensor network service information and its properties (e.g. data type, format, etc.)
  - defining communication interfaces between each component in sensor network service framework

  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.

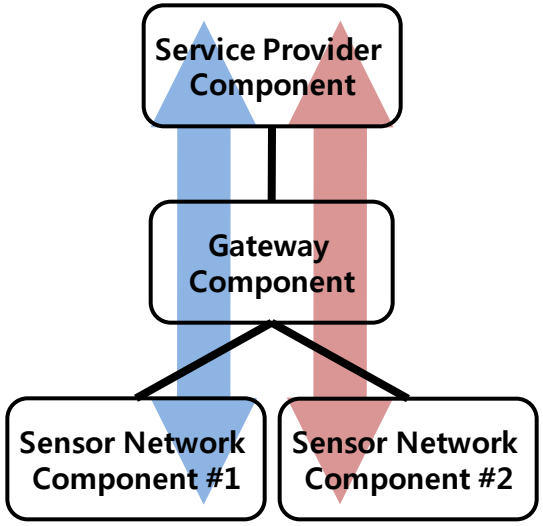
- The effect of interoperability is
  - Interwork with any other related components while following the definition of sensor network sensing data and communication interface.
  - Also, components can be replaced, reused, and cooperated with each other accordingly.

How to Interoperate(con't)

- Example of interoperability between service provider and sensor network



(a) Interworking between components



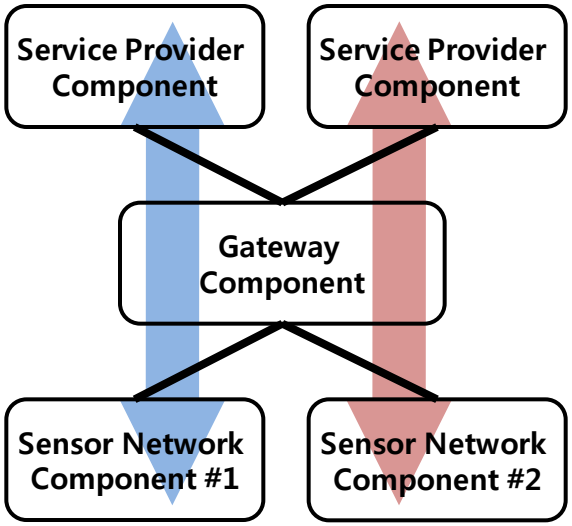
(b) Interworking with heterogeneous sensor networks

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

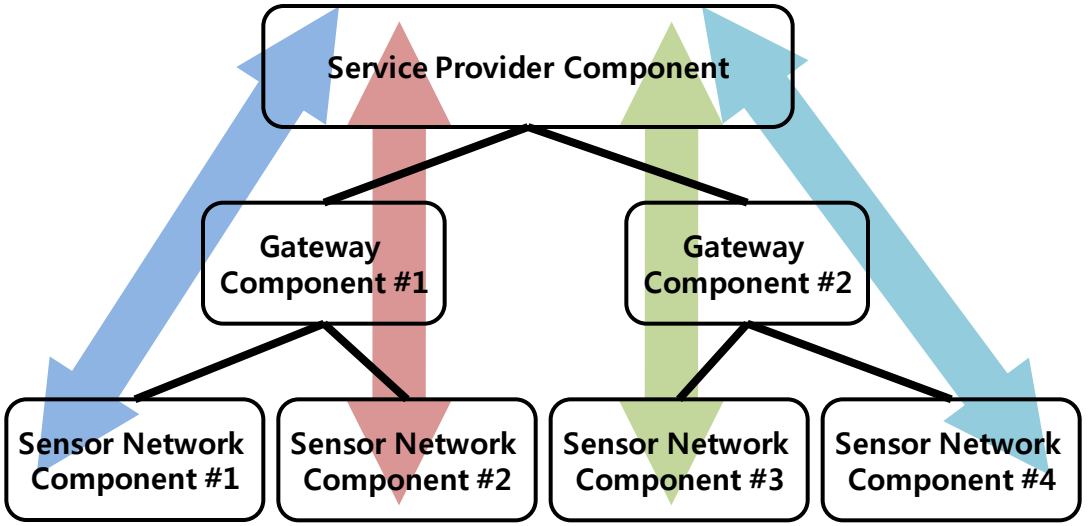
b. The case that heterogeneous sensor networks are connected to one gateway. It implies that gateway has capability of communication with sensor network #1 and #2

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



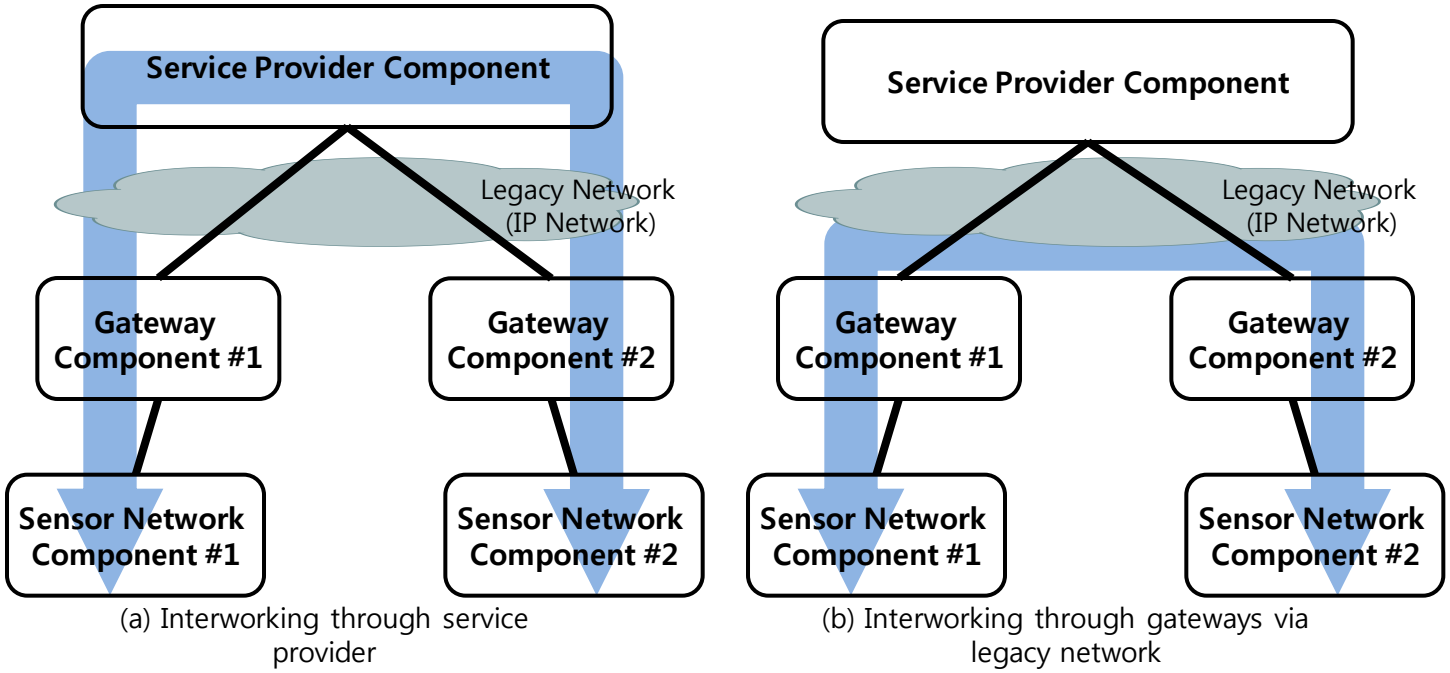
(d) Interworking between multi components

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

d. 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

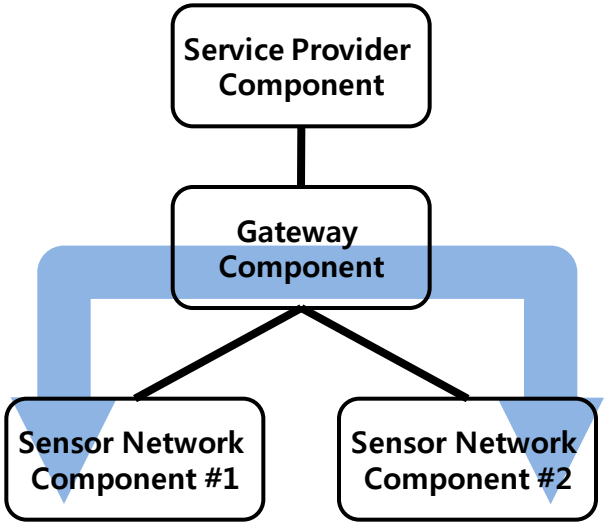
(b) Interworking through gateways via legacy network

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.

How to Interoperate

- Example of interoperability between heterogeneous sensor networks



(c) Interworking through gateway

c. The case that gateway becomes intermediate entity as a relay station. Communication flow doesn't pass legacy network.

Guidelines of Interoperability

- **Standardization of Sensor Network Service Information(con't)**
  - **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**

Type	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

Guidelines of Interoperability

- **Standardization of Sensor Network Service Information(con't)**

  - **Requirements**

Type	Functions
sensor data	Sensed data validation regarding associated measurement units, data types and value ranges
	Application-dependant sensed data filtering
event data	Context-aware rules, alerting data validation regarding associated limitation
management data	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

Guidelines of Interoperability

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

Sensor Attribute (2 bytes)	Sensor ID (2 bytes)	Sensor Value 1 (n bytes)	…	Sensor Value n (n bytes)

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

Name	Attribute	Value	Description
Sensor Property	Temperature(Celsius)	0x0100	Type of sensor
	Temperature(Fahrenheit)	0x0200	
	Humidity	0x0300	
	Vibration	0x0400	
	Acceleration	0x0500	
	Pressure	0x0600	
	boolean type sensor	0x7f00	
	user define(0x8000~0xff00)	0xnn00	
Value Type	unsigned integer 1byte	0x0010	Data type for sensor value
	unsigned integer 2byte	0x0020	
	unsigned integer 3byte	0x0030	
	unsigned integer 4byte	0x0040	
	signed integer 1byte	0x0050	
	signed integer 2byte	0x0060	
	signed integer 3byte	0x0070	
	signed integer 4byte	0x0080	
	Boolean	0x00f0	
Num	-	0x000n	Number of sensor value

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

Sync Byte (1 byte)	Packet Type (1 byte)	Sequence Number (2 byte)	Data Payload (1-n byte)	CRC (2 byte)	Sync Byte (1 byte)

< Packet Frame Format >

Type	Value	Description
Sync Byte	0x7e	Start of packet frame
Packet Type	0x40	ACK Response
	0x41	ACK request
	0x42	Non-ACK
Sequence Number	-	Sequence number
Data Payload	-	Data
CRC	-	CRC
Escape Byte	0x7d	End of packet frame

< Descriptions >

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