National Institute of Information and Communications Technology

APAN 29th Meeting - Sensor Network Workshop

Toward a Federated Framework for Sensor Overlay Network

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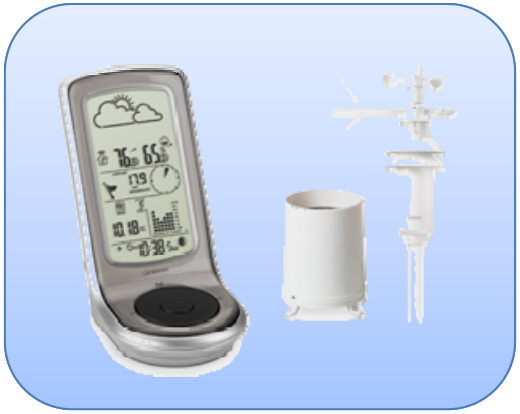
Agenda

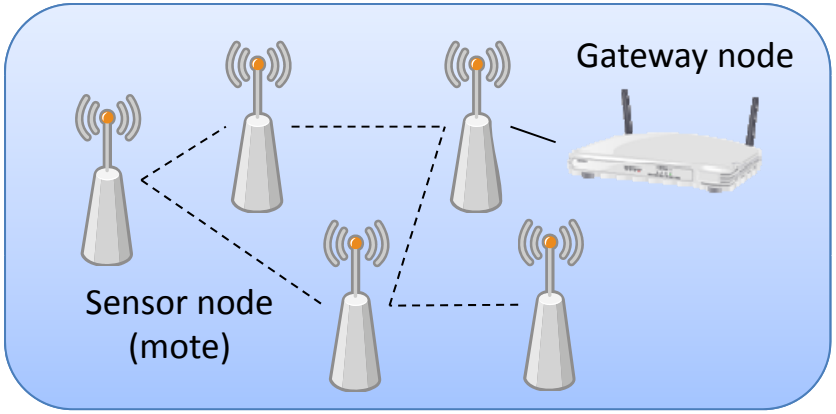
- **Definition of Sensor Network and Sensor Network Federation**
- Proposal of a Federated Framework for Federation

Background

- IP-based sensors are popularized
  - Weather station, wireless sensor network that includes tiny sensor nodes etc. is available
    - Wired sensors tend to have many functions,
    - whereas wireless sensors tend to be simple and a wired gateway node collects sensing data from them.



Weather station

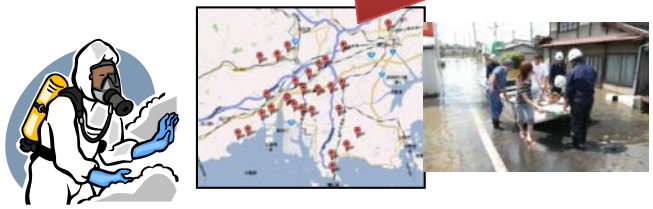


Wireless Sensor Network (WSN)

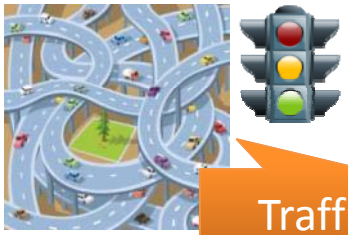
Sensor Networks as Infrastructure

- Sensor Networks (SNs) are an essential infrastructure in the ubiquitous/pervasive environment

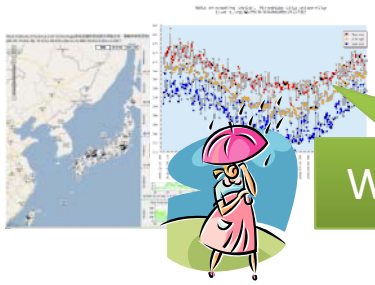
Disaster Management



Facility Management



Traffic Control



Weather Observation

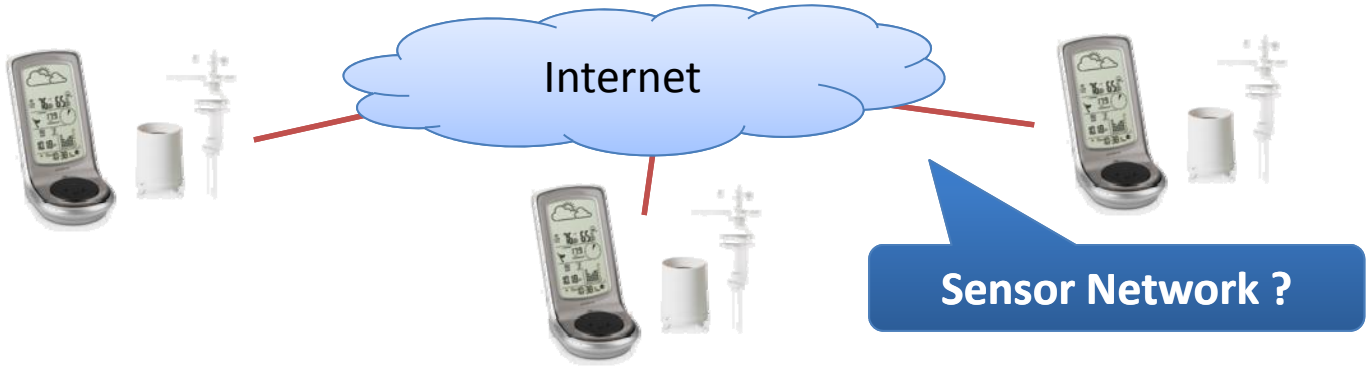
Needs of Sensor Network Federation

- Ubiquitous/pervasive services require sensing data as much as possible
  - Various kinds of many sensors will enable the services to estimate users' context through these sensing data
  - Observing over wide-area and for a long period will enable to analyze world-scale phenomenon
- However, deploying and managing SNs requires an enormous cost

What is a “Sensor Network”?

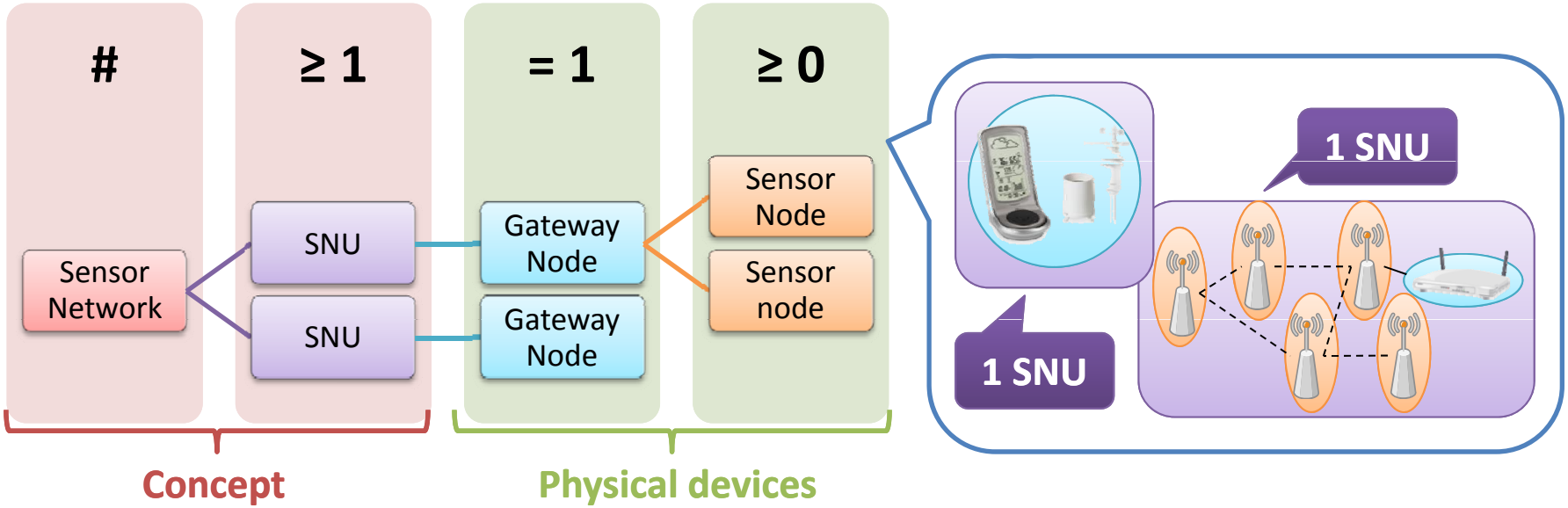
- WSN is a form of SN, but not all
  - Sensors that are connected in the same manner and behaves like a chunk of the sensors will be also called as a **Sensor Network**, *even if they are connected only by wire*

➔ **SN should be a concept that multiple sensors form a network and collect sensing data**

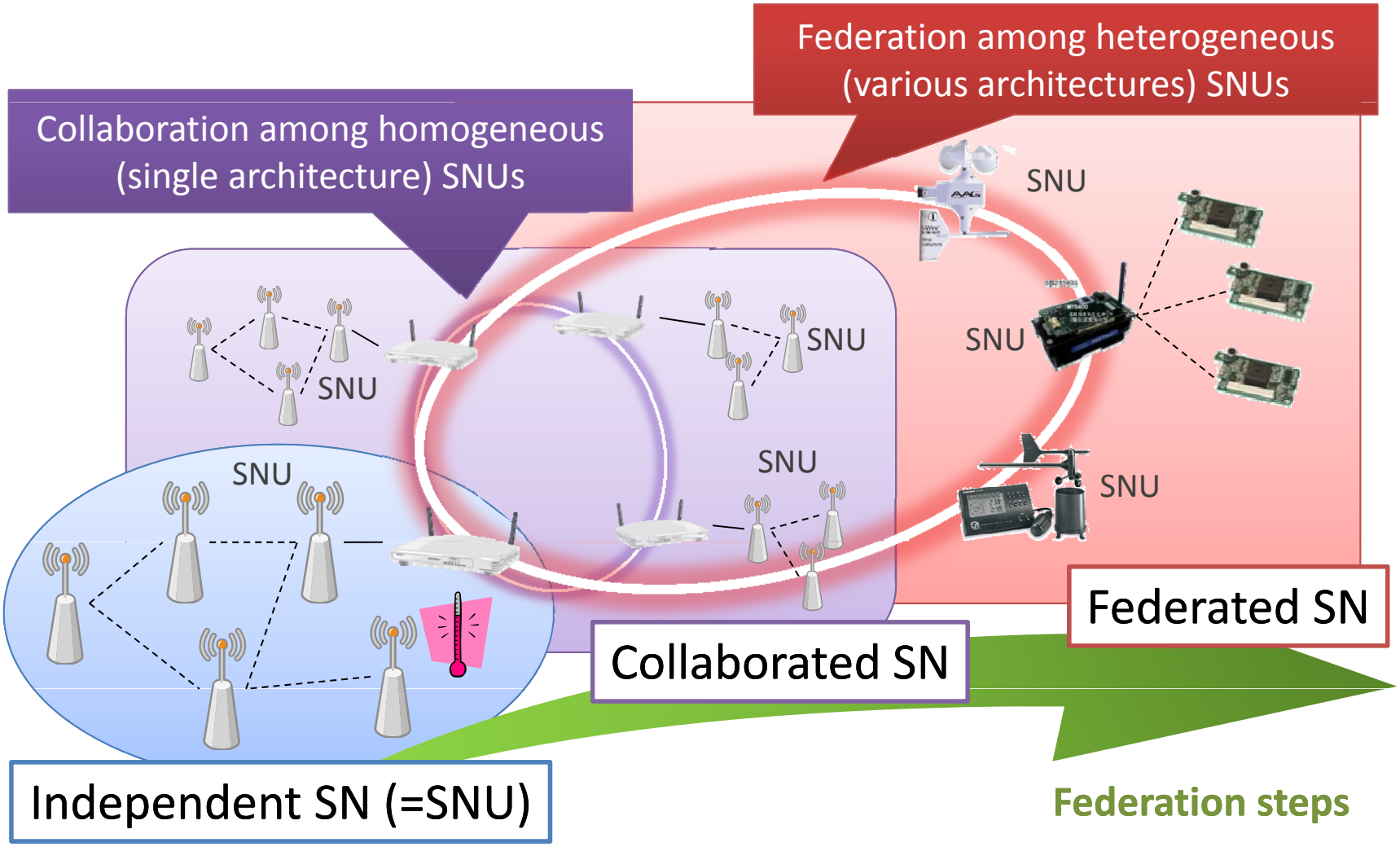


Basic Unit of SN: Sensor Network Unit

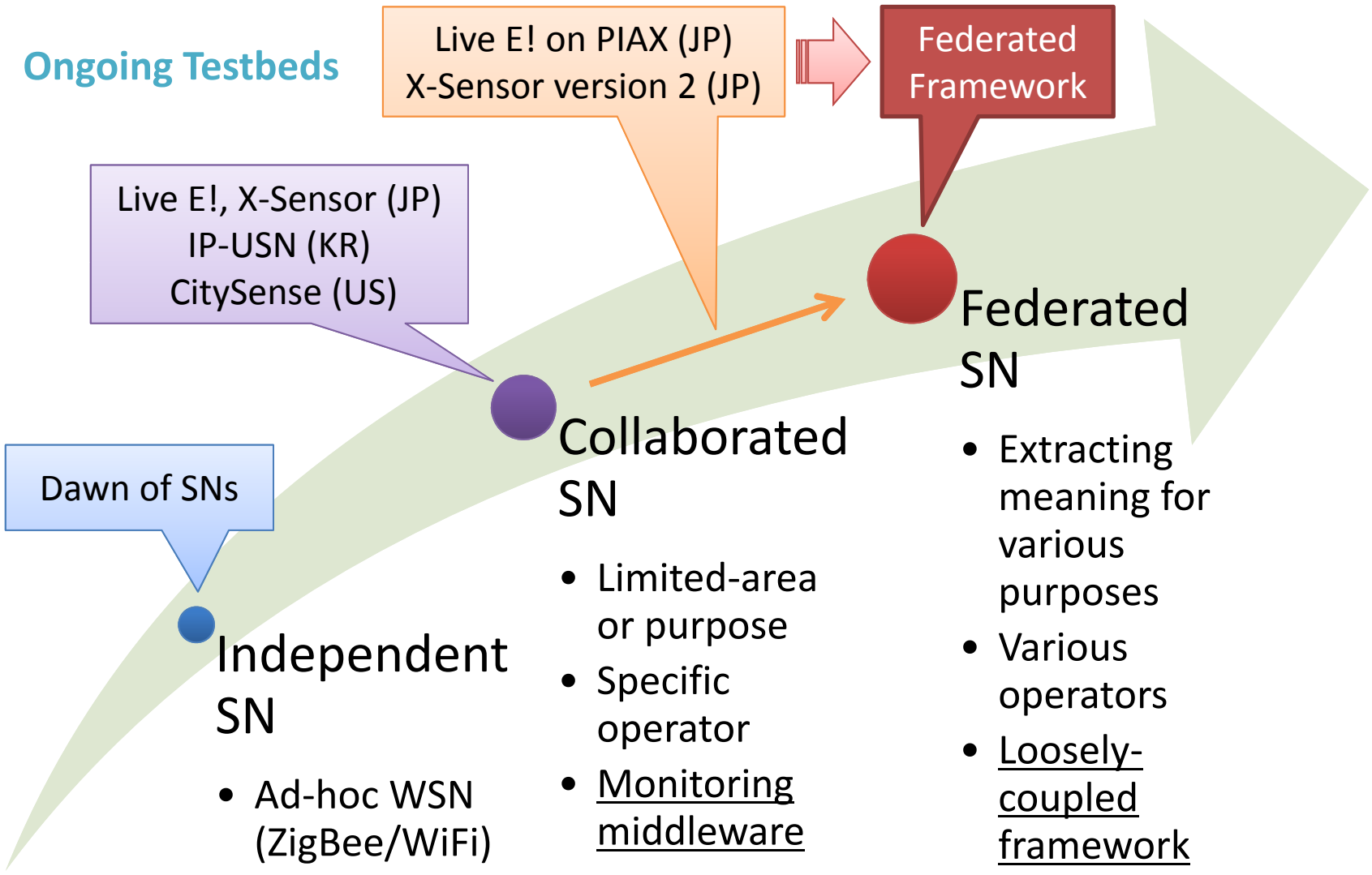
- Definition of a Sensor Network
  - A SN = one or more Sensor Network Units (SNUs)
  - A SNU is a group of sensor(s) that has **ONLY ONE gateway node**, and **MAY have sensor nodes** (motes)
    - Gateway node MUST be accessible from others via network



Federation of Sensor Network (1/2)



Federation of Sensor Network (2/2)



Agenda

- Definition of Sensor Network and Sensor Network Federation
- **Proposal of a Federated Framework for Federation**

Our attitude toward Sensor Network Federation

Application (developers/users)

- Intelligent services that utilize sensing data

Data Sharing Platform for Sensor Network Federation

- Management platform for storing, aggregating, and retrieving of sensing data

Standard for Sensor Network Federation

- Access method and policy each for sensor network
- Metadata for sensor specification and sensing data

Sensor Network (physical)

- Wireless Sensor Network, Sensor Network Testbed

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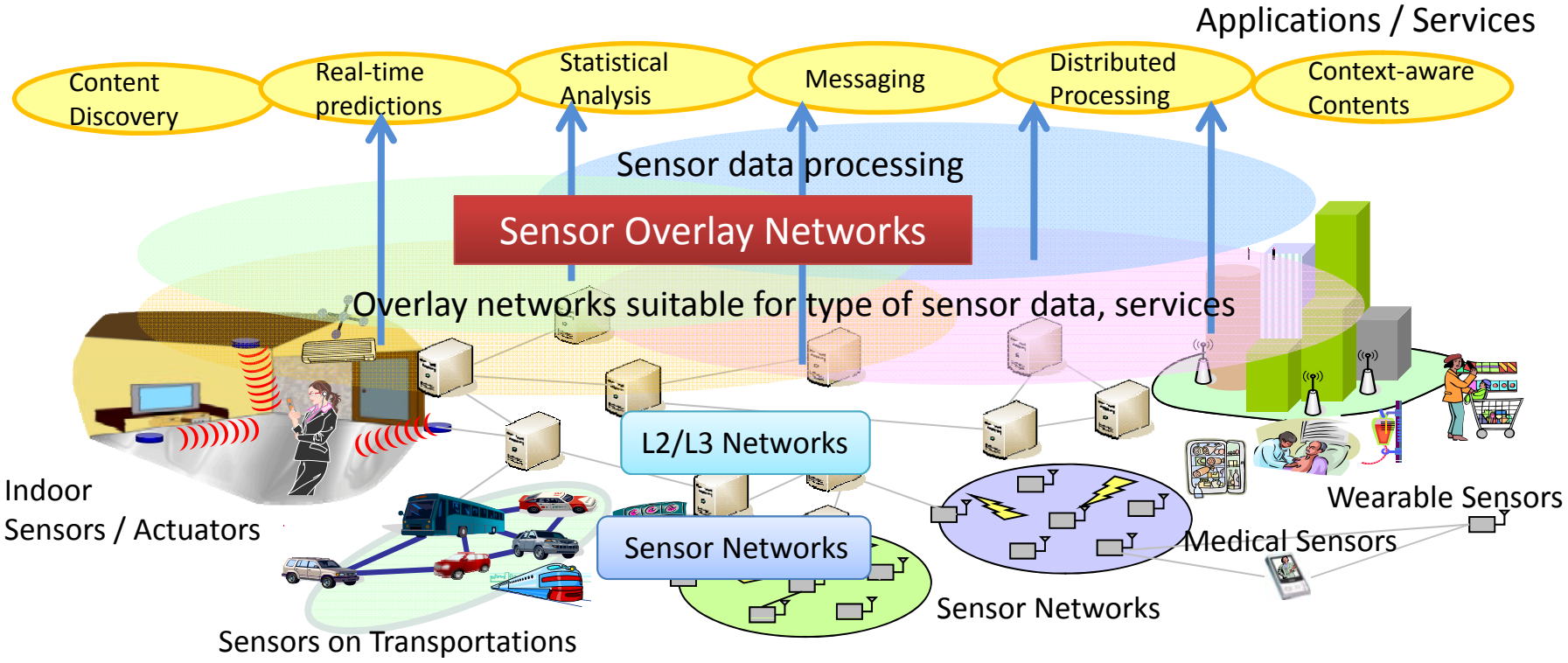
Sensor Overlay Networks

- SNs should be federated in loosely-coupled P2P management architecture
  - Each SN is managed by a different organization, so sensing data should be mutually transferred to share



Requirements for SONs to Federate (1/2)

- Interoperability between heterogeneous SNs
  - Difference of management policy of each domain
    - Owner of each SN wants to manage their sensing data with their own customization and management policy at their own timing
  - Difference of specifications
    - Specification of data type, observation method, access method, data management method etc. is not the same between the products

Standard of the description of access policy and metadata of sensing data/method is required

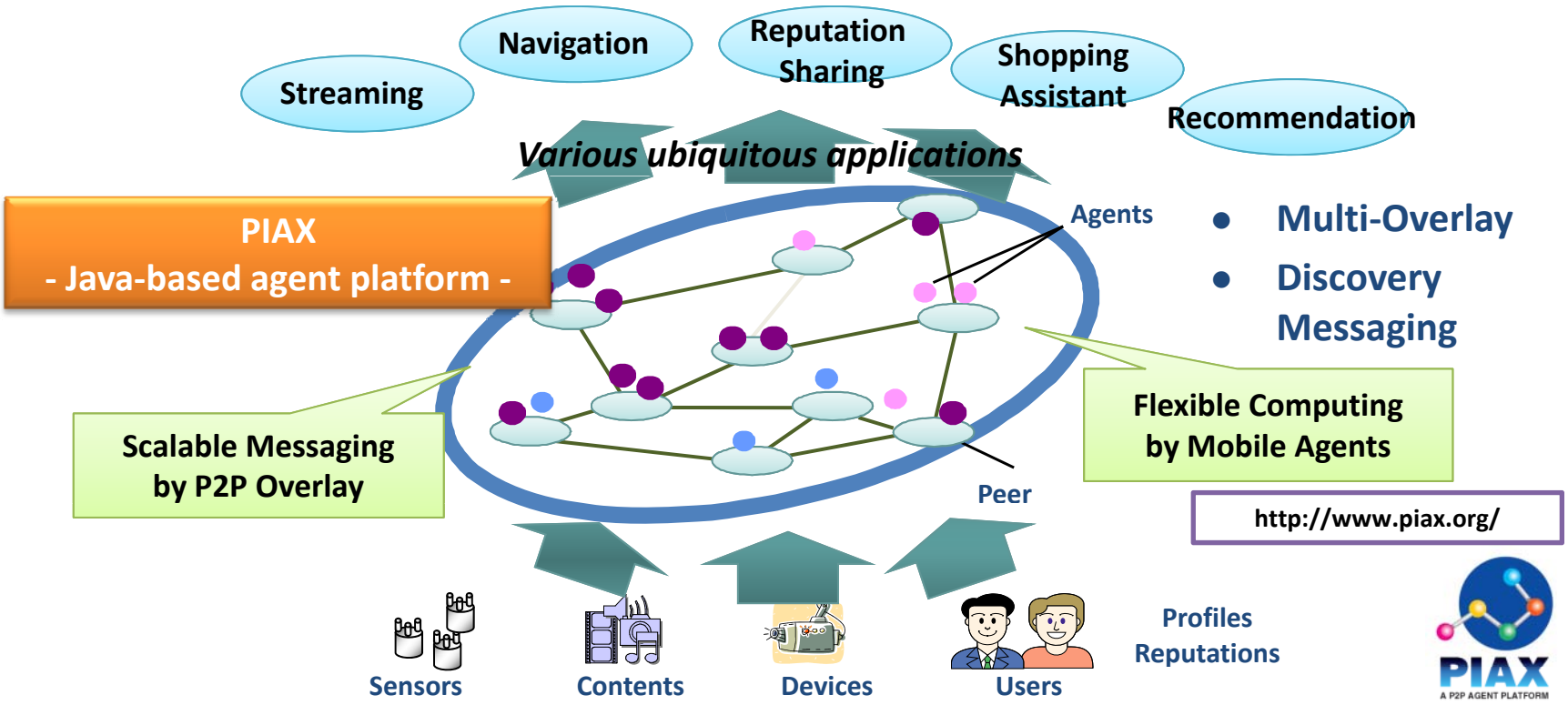
Requirements for SONs to Federate (2/2)

- Data management for distributed sensing data
  - No one manages the entire of SNs, so that sensing data is distributed in each SN

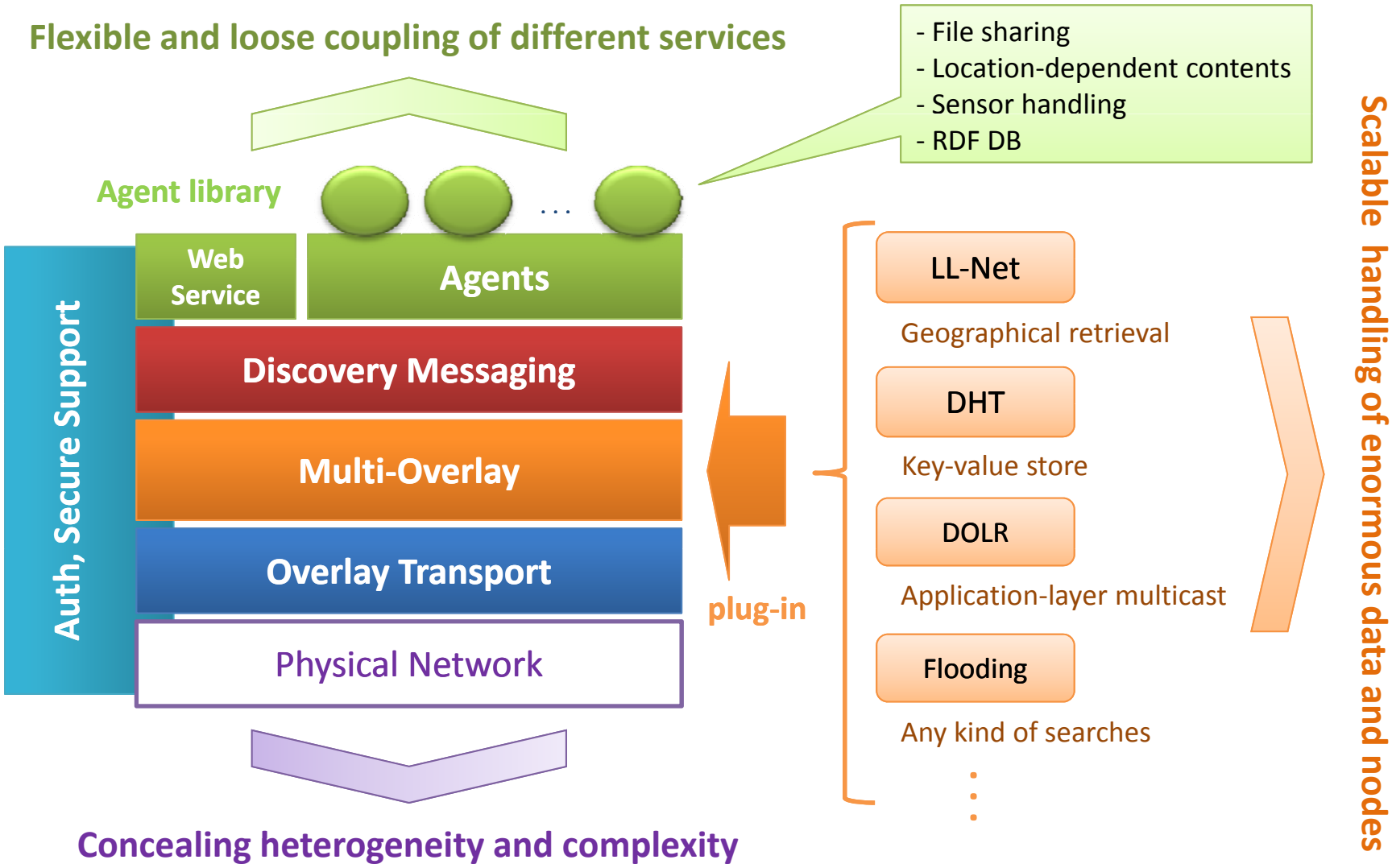
1. Sustainability (maintainability and scalability)
   - Tolerate unstable situations (Churn-Resilient)
2. Scalable data retrieval
   - Handle various kinds of retrieval methods (e.g., location-based retrieval) to the massive sensors
3. Efficient data aggregation
   - Avoid collecting all raw sensing data by aggregating (e.g., max, min, or average value of a certain area)

PIAX: P2P Interactive Agent eXtensions

- Java-based platform that integrates:
  - Multiple P2P overlay discovery functions
  - Mobile agent features



PIAX Structure and Features

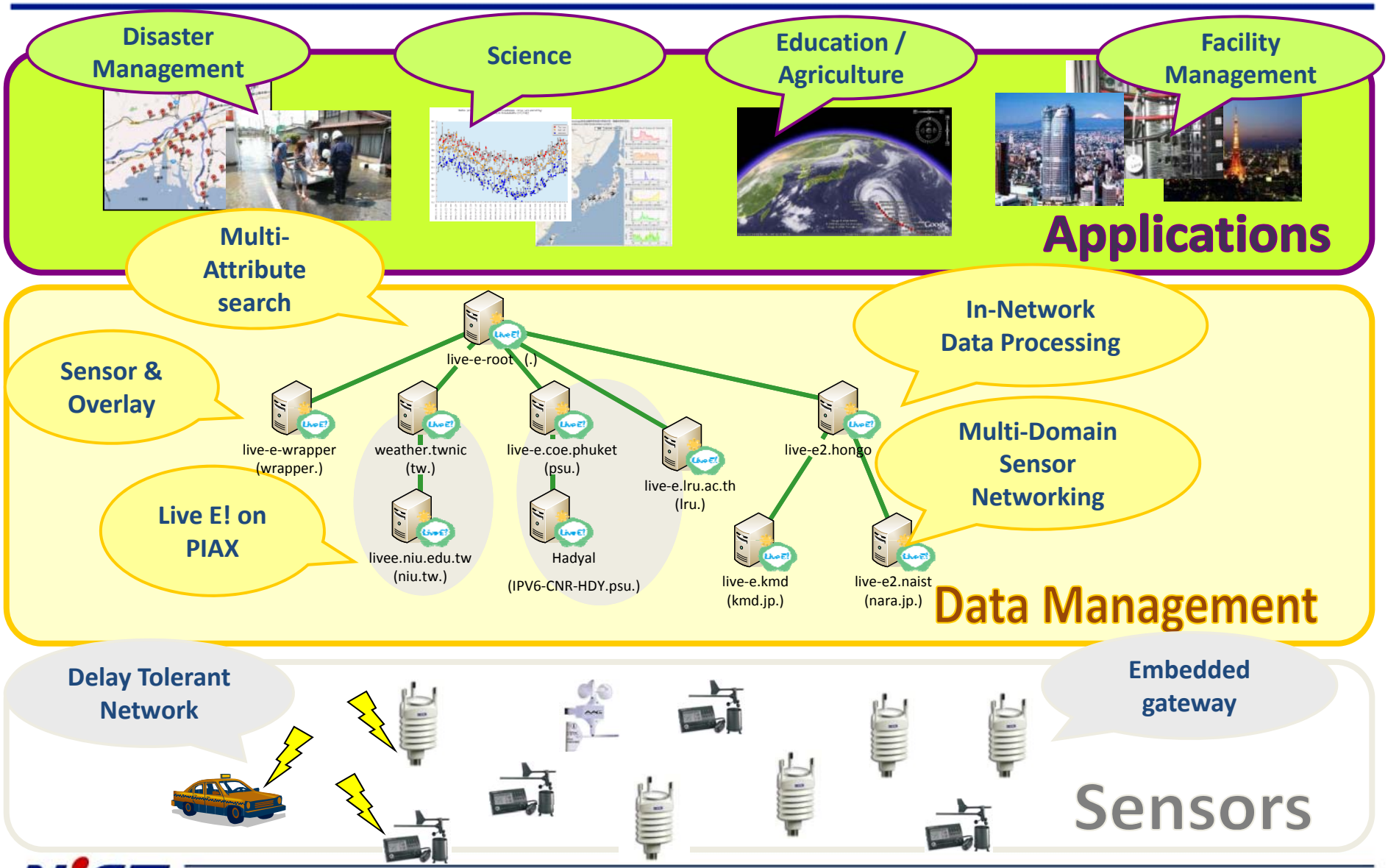


PIAX-based Sensor Overlay Network Platform

- PIAX can support scalable data management on Federated SNs
  1. Sustainability
     - Sensor agent platform and hybrid overlay network will help to tolerate unstable situations
  2. Scalable data retrieval
     - Structured overlays and multiple overlay networks handling will help to handle distributed sensing data efficiently
  3. Efficient data aggregation
     - Distributed data fusion by overlay roaming agents will help to avoid collecting all raw sensing data

Ongoing projects: **Live E! on PIAX, X-Sensor v2**

Live E! Project



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Live E! on PIAX

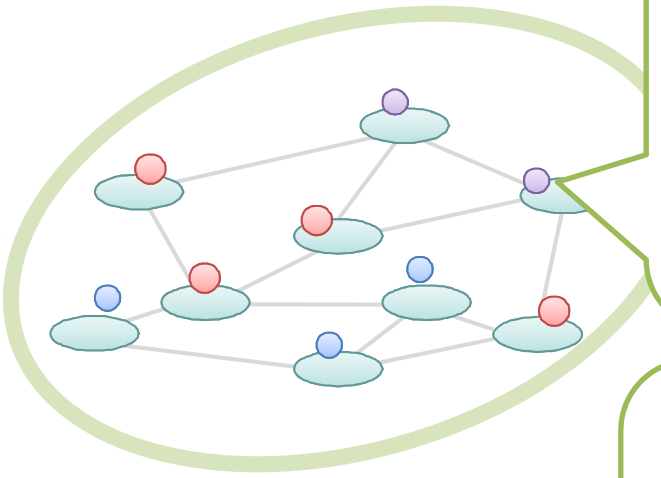
- Developed an agent for enabling other PIAX agents to connect Live E! sensor stations by SOAP protocol

Browse deployed sensors on Web browser

Web I/F

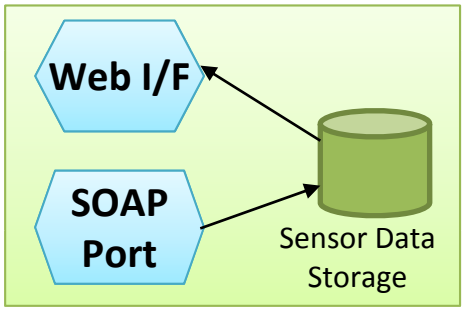
SOAP

PIAX Overlay Network



20 PIAX Peers with Live E! sensors

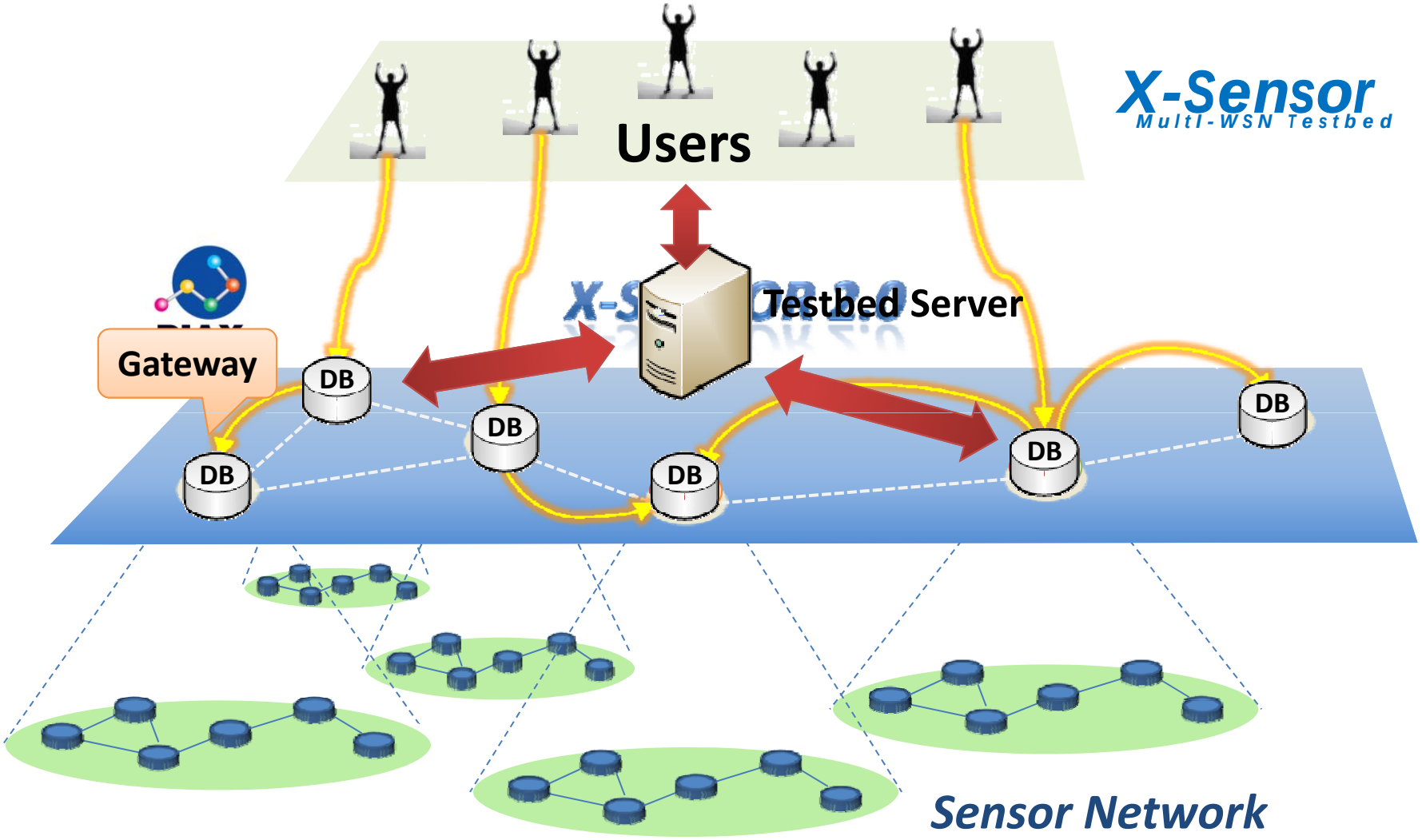
Live E! Agent on PIAX



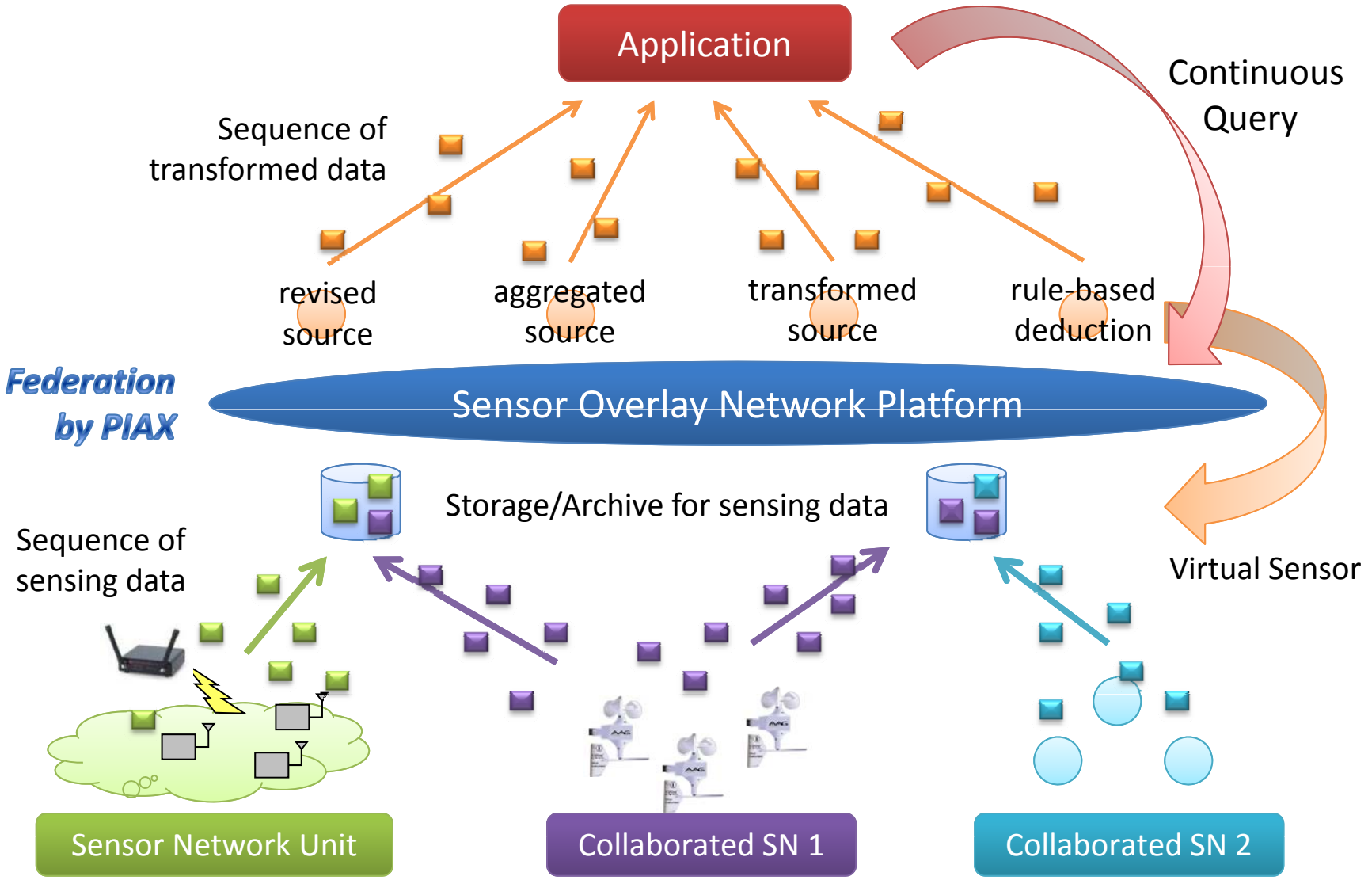
Live E! Weather Sensor Station

SOAP I/F
Sensors:
- Temperature
- Humidity
- Raindrop
- Wind speed etc.

X-Sensor version 2 (based on PIAX)



Towards Sensor Overlay Network Platform



Conclusion

- Sensor Networks
  - Essential infrastructure for ubiquitous or pervasive environment
  - Should be federated for utilizing sensing data
    - Since federation is *unanticipated utilization* of sensing data, loosely-coupled framework will be required
- Sensor Overlay Network Platform
  - Loosely-coupled framework “PIAX” will realize an efficient SON Platform
    - Provide significant deduced data that satisfies versatile needs of high-level applications through federated SNs