An evolvable Network of Tiny Sensors (ANTS)

for Public and EPC Sensor Network

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Contents

- What is Ubiquitous Sensor Network?
- ANTS and Public Sensor Network
- Auto-ID Labs and EPC Sensor Network
- Conclusion
EPC RFID Network Architecture

1. Reader scans and read the EPC
2. Send Data to a computer running middleware
3. Filter Data
4. Query ONS (Object Naming Service)
5. ONS database maps the EPC to a URL
6. URL points to the location where information is stored using PML
Active Tags

- Battery assisted Long-range Active Tag (eg. Savi)
  - 433.92MHz, 27.8 kbps, 0.6mW, 100m (UHF transceiver)
  - 123KHz, 3.65m, Wake-up LF receiver
  - Lifetime 5years, active twice per day
  - 128KB memory, -30 ~ 70 degrees operating environment
SAL (Smart Active Labels)

- SAL: Thin and Flexible Labels having an IC and power sources
- Started from early 2002, now has 17 companies
  - Power Paper, Graphic Solutions, KSW microtec, etc
  - 4 sub-working groups: Standard, Technology, User, Demonstration
- Targeting SAL with temperature tracking first

**Semi-SAL**

- **Label surface substrate and overlay protection**
- **RFID inlet (Antenna, chip, etc)**
- **Power Source (Thin and flexible battery)**
- **Backing substrate and adhesive layer**

**SAL**

- **Antenna & Matching network**
- **Logic & Power Management**
- **Memory**
- **Tx**
- **Rx**
- **PA**
- **LNA**
- **MOD**
- **DEMOE**
- **PLL**
- **Controller**
- **Chip**
- **Antenna**
- **Chip**
- **Battery**
- **Semi-Passive Label (PowerID™)**
Sensor Networks

- Network of sensor nodes with computation & sensing & wireless communication capabilities

- What we can do with Sensor Networks?
  - Sensing(Actuation) : Motion->Image->Classifier
  - Collaboration : Estimate moving direction & speed
  - Mobile Sensors : Tracking
RFID meets Sensor Network

RFID Research

Sensor Network Research

History
(Read/Write)
Automatic Identification
(Read)

Battery
(Long range)

Sensors
(Sensing)

Smart Sensors
(Ad-hoc network)

Passive RFID
Active RFID
Smart Active Label
Sensor Network
Ubiquitous Sensor Network

- Everywhere, everything with RFID tags
- Sensing ID and environmental information
- Providing services via network

Read Only RFID → Read/Write RFID → Sensing USN → Networking USN

Service and application

Wireless Sensor Network

- DMB DTV
- Celluar PCS
- IMT-2000 4G
- WLAN type
- Wire-line xDSL

New radio interface

Ubiquitous Sensor Network

- Chipless tags
- Smart Active Labels

RFID + Sensing

Animal tracking

Hospital

Logistics, SCM

Telematics, ITS

Home network

RFID

USN

Ubiquitous

Sensor

Network
Vision of Korean IT839 Strategy

A master plan for the IT industry, in an effort to gain more growth momentum from the IT sector in Korea.

- 2.3 GHz mobile Internet (WiBro)
- DMB service
- Home network service
- Telematics service
- RFID-based service
- W-CDMA service
- DTV service
- VoIP service

Introducing and promoting 8 Services

- BcN (Broadband Convergence Network)
- USN (Ubiquitous Sensor Network)
- IPv6

Building 3 infrastructures

- NG Mobile Phone
- Digital TV
- Home Network
- IT SoC
- Post PC
- Embedded S/W
- Digital Contents
- Telematics
- Intelligent Robot

Developing 9 IT New Growth Engine
Evolvability in Sensor Networks

- Sensor networks will populate the world as the present Internet does
- Facing a deeply dynamic Future. We need **evolvability**: 
  - Adapt to new environments and applications
  - Support of present tendencies and able to evolve according to market innovations, anticipating the future

<table>
<thead>
<tr>
<th>ANTS Functionality</th>
<th>Evolvability Relation</th>
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<tbody>
<tr>
<td><strong>Hardware</strong></td>
<td>Adaptability (different nodes for different requirements), Modularity &amp; scalability (component based), Upgradability &amp; dependability (fault-tolerant dynamic upgrades), adaptability (by allowing HW and SW updates)</td>
</tr>
<tr>
<td><strong>Operating system</strong></td>
<td>Adaptability (different nodes for different requirements), Modularity &amp; scalability (component based), Upgradability &amp; dependability (fault-tolerant dynamic upgrades), adaptability (by allowing HW and SW updates)</td>
</tr>
<tr>
<td><strong>Network Architecture</strong></td>
<td>Scalability (with number of micro or macro nodes), Interoperability (providing easy access to gateways)</td>
</tr>
<tr>
<td><strong>Communication Protocols</strong></td>
<td>Scalability (with number of nodes), adaptability &amp; dependability (to new or dead nodes and moving nodes or sub-networks)</td>
</tr>
<tr>
<td><strong>Localization</strong></td>
<td>Scalability and adaptability (for new generations of nodes) dependability (dead nodes, whichever reason)</td>
</tr>
<tr>
<td><strong>Security</strong></td>
<td>Adaptability (new trust values dependent on incoming traffic) scalability &amp; modularity (new security option at applications level), adaptability (activity values for dead nodes)</td>
</tr>
<tr>
<td><strong>Synchronization</strong></td>
<td>Scalability &amp; adaptability (for new HPLs or LPNs)</td>
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<tr>
<td><strong>Context Awareness</strong></td>
<td>Interoperability (to other networks through BOSS), adaptability &amp; dependability (delivering context data through a secondary context overly network), scalability (not dependent on size of network)</td>
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ANTS Pilot Project - Haroobang
ANTS Pilot Project – Haroobang for Disaster management & U-tourism

Field Test in Halla Mountain (1950m high) – Jeju Island
ANTS Pilot Project – Haroobang for Disaster management & U-tourism

Test Site in Cheju University in Jeju Island (Jan. 5, 2006)
Auto-ID Labs Research Focus

- **Business, Application, Privacy & Security**
  - Fundamentally New Business Processes
    - (Payment, Leasing, Quality Mgmt, Factory Design, Brand Protection, Grey Markets, Counterfeiting, etc)

- **Networking & Software**
  - System Architecture vs. Infrastructure
    - (EPC Sensor Network, NFC, Apps- versus Event-Servers)

- **RF & Chip Design**
  - From Class 1 to Class 5
    - (Memory, Semi-active, Active, Sensors, Wireless)

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Basic Research  Deployment
## EPC Tag Classification

<table>
<thead>
<tr>
<th>EPC Tag Class</th>
<th>Tag Class Capabilities</th>
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<tbody>
<tr>
<td>Class 0</td>
<td>Read only, (I.e., the EPC number is encoded onto the tag during manufacture and can be read by a reader, not written to)</td>
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<tr>
<td>Class 1</td>
<td>Read, write once (I.e., tags are manufactured without the EPC number which can be encoded onto the tag later in the field)</td>
</tr>
<tr>
<td>Class 2</td>
<td>Read / write / Higher functionality</td>
</tr>
<tr>
<td>Class 3</td>
<td>Class 2 capabilities plus a power source to provide increased range and/or advanced functionality, e.g., sensors</td>
</tr>
<tr>
<td>Class 4</td>
<td>Class 3 capabilities plus active communication and the ability to communicate with other tags</td>
</tr>
<tr>
<td>Class 5</td>
<td>Class 4 capabilities plus the ability to communication with passive tags as well</td>
</tr>
</tbody>
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EPC Sensor Network Components

- **EPCglobal Core Services**
  - Subscriber Authentication (TBD)
  - EPCIS Discovery (TBD)
  - ONS Root
  - Manager Number Assignment (offline service)

- **EPCglobal Subscriber**
  - EPCIS Accessing Application
  - EPCIS Query Interface
  - EPCIS Repository
  - Filtering & Collection (ALE) Interface
  - Filtering & Collection ("RFID Middleware")
  - EPCIS Capturing Application

- **Partner EPCglobal Subscriber**
  - EPCIS Accessing Application
  - Optional bypass for real-time "push"

- **Link sensor data with corresponding master data to change it to valuable information**
- **Store and maintain updated sensor data with the help of EPCIS repository**
- **EPCIS provides decision point to react sensor data**
- **Give commands to Sensor Tag actuator throughout backward communication channel**

- **Sensor data filtering & aggregation according to type, effective distance, periods, threshold, unit**
- **Sensor data accumulating (average, reliability)**

- **Sensor Event manipulation, Sensor Tag Selection**
- **Sensor data Smoothing**
- **Translate complex sensor data query from IS to Sensor Tag specific query/operation to inject into BS**

- **Sensor Identification Memory for Sensor data reading and sensor operation air interface**

- **Sensor Tag, Active Sensor Tag, Active Sensor Tag Network**

- **Sensor Network Discovery service provides linkage to specific servers which have sensor network information**
- **Sensor data translator Enables heterogeneous sensors to be interoperable**
- **Reader management Provides sensor network management using other network protocols (SNMP, UPnP, OSGi)**
Conclusion

- RFID & Sensor Network is a key enabling technology for Ubiquitous Computing

- Emerging of new generation of Sensor Networks
  - Will change the paradigm of Ubiquitous Sensor Networks
  - New requirement: evolvability

- ANTS building a:
  - Complete architecture
  - Flexible and adaptable
  - Prepared for the future
    - for Public and EPC Sensor Networks