# Implementation of Context-Aware Services Platform Supporting Mobile Agents

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***Abstract*** - A context-aware services platform supporting mobile agents consists of sensor nodes and a sensor coordinator. Sensor nodes collect environmental information and transmit the collected information to the sensor coordinator through wireless sensor networks. The sensor coordinator passes the information to the context-aware service module, and the mobile agent. The context-aware service module or the mobile agent performs services suitable for a user's situation based on the environmental information and a service actuation message is delivered to an actuation node through the sensor coordinator. In this paper, we present a context-aware services platform structure employed in our project, and describe context-aware services platform interfaces with a context-aware service module and mobile agents.

**Keywords:** Sensor platform, sensor coordinator, sensor node, mobile agent, context-aware services.

## 1 Introduction

Wireless sensor networking is an emerging technology that has a wide range of potential applications including environment monitoring, smart spaces, medical systems and robotic exploration [1]. Wireless sensor networks are designed to handle very low data throughput (as low as a few bits/day), exchanging data with high message latency for long node battery life and low cost [2]. Target applications for these networks are inventory management, industrial control and monitoring, security, intelligent agriculture, and consumer products such as wireless keyboards and personal computer (PC) enhanced toys.

The networks often have stringent cost and battery life goals; nodes in an Institute of Electrical and Electronics Engineers (IEEE) 802.15.4 Low-Rate Wireless Personal Area Network (LR-WPAN), for example, must have multiyear operation from a 750mAh AAA cell while being considerably simpler (having fewer logic gates, smaller analog circuitry, and less memory) than a comparable Bluetooth device In addition, the system must be capable of universal (worldwide) unlicensed operation, which greatly limits possible frequency band, modulation, and other physical layer alternatives.

A context-aware services platform supporting mobile agents consists of one or more sensor/actuation nodes and a sensor coordinator. A sensor node, which may have various environmental sensors, collects environmental information and transmits the collected information to the sensor coordinator through the wireless sensor network. Environmental information can be temperature, light, sound, humidity, motion.

The sensor coordinator manages sensor network topology, receives message from sensor nodes and passes it to the context-aware service agent over Ethernet or wireless LAN. The sensor coordinator also interfaces with mobile agents to alarm a state of environmental emergency and transmits collected environment information only when it is requested.

A service actuation message from the context-aware service module or a mobile agent is delivered to an appliance through the sensor coordinator. A mobile agent provides home view services, home monitoring services, and remote home appliance control services. The context-aware service agent may run in a home server, and initiates services suitable for the situation based on environmental information collected by sensor nodes.

In this paper, we present system architecture of a context-aware services platform employed in our project and describe context-aware services platform interfaces with a context-aware service module and mobile agents.

## 2 Technical issues

The situation with wireless sensor networks is quite different. Because no infrastructure is associated with the ad hoc networks they employ, the economics of wireless sensor networks only consider the cost of the individual network node [3]. The design of wireless sensor network nodes has a larger effect on the economic potential of the resulting network than does the design of nodes for networks containing infrastructure, such as a cellular telephone network. The value of a wireless sensor network is determined solely by the nodes themselves. Node implementation is, therefore, of primary importance in the design of a successful wireless sensor network.

One important but often overlooked factor in the design of wireless sensor network nodes is the effect finite stability of the node time base has on the minimum attainable duty cycle, and, therefore, the minimum attainable average power consumption, of the network node. The resulting trade-off between the cost of the node time base and the attainable life of the battery (or other power source) must be made properly to achieve the desired market success [4].

## 3 System architecture of context-aware services platform

We have designed and implemented a context-aware services platform supporting mobile agents. The context-aware services platform consists of several ZigBee sensor nodes and a sensor coordinator, and interfaces with a context-aware service module and mobile agents. The system architecture of the context-aware services platform is shown in Figure 1.

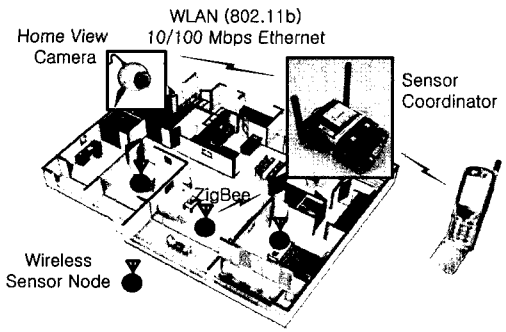


Figure 1. Context-aware services platform architecture

The cost for an individual network node is the major aspect of economics in wireless sensor networks. Thus, the cost effectiveness of an individual senor node has to be thoroughly examined during the design and implementation stages.

### 3.1 Sensor coordinator

A sensor coordinator combines wireless sensor networks and IP networks. A ZigBee gateway shown in Figure 2 is used as a sensor coordinator in our context-aware services platform. As a ZigBee gateway provides an interface between ZigBee and IP devices [5], the sensor coordinator acts as a bridge between sensor networks and a context-aware service module in IP networks. In our architecture, the connection between the sensor coordinator and a mobile agent is established through the Internet.

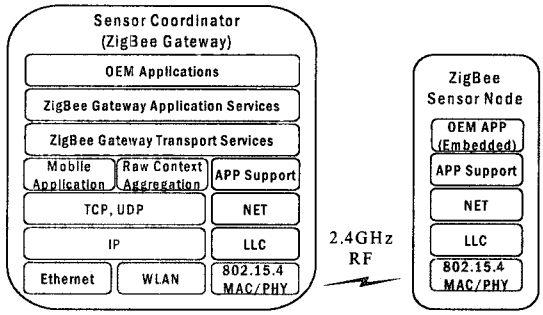


Figure 2. Block diagram of sensor coordinator

The sensor coordinator that we made is a high-performance processing module designed for sensor, signal processing, control, and wireless sensor networking applications based on IBM's PPC-405GPr processor. It uses embedded Linux operating system and provides a variety of additional interfaces including two UART channels, 10/100 ethernet, I2C, GPIO, and IEEE 802.11b wireless LAN of mini-PCI type [6]. Figure 3 shows a picture of the sensor coordinator used in our project.

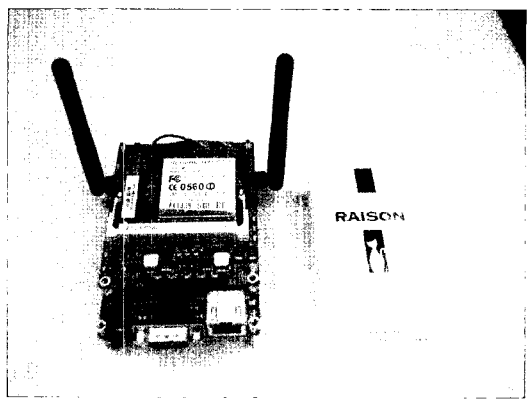


Figure 3. A picture of the sensor coordinator

### 3.2 Sensor node

The utilization of sensor nodes in a real network is critical to the success of the network [7]. In our project,

we use only light and temperature information to activate context-aware services, but all other sensed data such as humidity, acceleration of a moving object are bypassed to the context-aware service module for further implementation. A sensor node uses TinyOS operating system which is an efficient modular embedded software platform for building wireless mesh networks [8].

### 3.3 Context-aware services platform interface

A sensor node gathers environmental information and transmits it to the sensor coordinator over IEEE 802.15.4 (2.4GHz). The sensor coordinator dispatches the sensor data field and makes a new packet for delivering to the context-aware service module using UDP socket. We implemented context-aware services platform interfaces which run in the sensor coordinator to communicate with sensor nodes and the context-aware service module as shown in Figure 4.

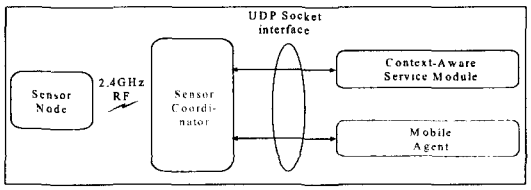


Figure 4. Block diagram of sensor platform interface

The context-aware service module makes a decision to provide a service based on the received data and the predetermined threshold value for each service actuation. Once a service actuation message is delivered to an appliance through the sensor coordinator and the service is automatically actuated without user's intervention. The interface between the sensor coordinator and a mobile agent is shown in Figure 5.

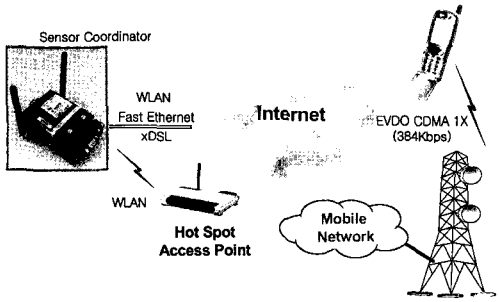


Figure 5. Interface between sensor coordinator and mobile agent

In the case of mobile agents, when a connection to a mobile agent is established through the Internet, the sensor coordinator provides a still image to the mobile agent periodically and transmits home environmental information if requested. A service actuation message can be initiated by the mobile agent user. The service actuation message is delivered to the appliance through the sensor coordinator over the internet. The user interface of the mobile agent is shown in figure 6.

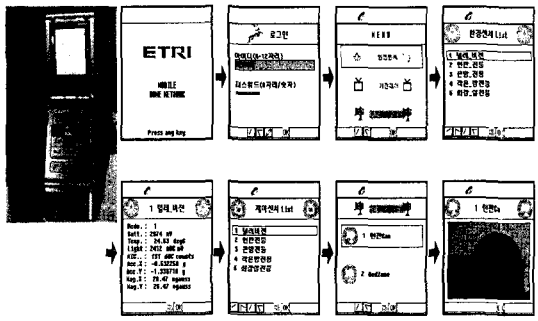


Figure 6. The user interface of the mobile agent

### 3.4 Context-aware service scenarios

A number of scenarios are applied to verify the sensor platform functionality such as collecting sensed information, service actuation, and communication between the sensor platform and the context-aware service module/mobile agents. For example, a man in a hot room is considered. Based on the received temperature information from the sensor node in the room, the context-aware service module makes a decision to turn on an electric fan in the room and send a service actuation message to turn on the electric fan.

Another example is a context-aware based intelligent home care system [9]. A context-aware framework interfaces with a context-aware services platform and an intelligent agent, and arbitrates between them for intelligent and automatic services according to the contexts. Sensor nodes, such as pressure sensor, temperature sensor, humidity sensor, etc., collect data of home environment and users' situations, and send them to a sensor coordinator, which manages several kinds of sensors and interfaces with a context-aware framework. A sensor networking/topology sub-block adds, deletes and updates the information of sensor nodes and a sensor coordinator. The sensor coordinator sends and receives messages to and from context-aware framework in home server.

A context-aware framework consists of semantic analyzer, context integration, standard schema, context manager and a context-aware interface agent. When a context-aware framework receives sensing data, namely raw context, from a context-aware services platform agent, semantic analyzer performs analysis of the received data's

meaning. Then a context is organized by integrating several sensing information, and standard schema is registered and used for Integrating Context Information that is sent to intelligent agent. Lastly, context MIB (Management Information Base) is configured by context manager. In an intelligent agent, standard services are modeled by users or manufacturers, and customized automatic behaviors (services) are formed as the residents' preferences. A service interaction sub-block mediates the operation of intelligent and automatic services as the predefined priority scheme. Figure 7 shows the architecture of context-aware based intelligent home care system. In our system, a context-aware framework and an intelligent agent are in a home server. Figure 8 shows the flow of the proposed system.

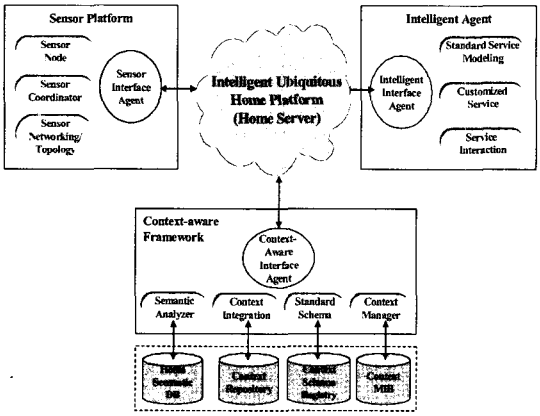


Figure 7. Architecture of context-aware based intelligent home care system

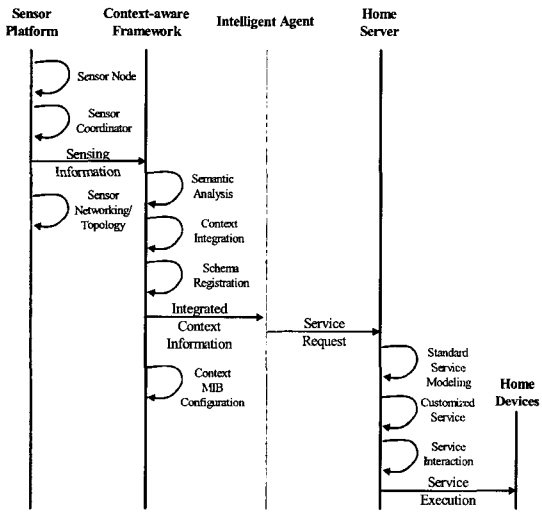


Figure 8. Flows of context-aware based intelligent home care system

# 4 Conclusions

In this paper, we present system architecture of a context-aware services platform supporting mobile agents which consists of sensor nodes and a sensor coordinator. We also describe context-aware services platform interfaces with a context-aware service module and mobile agents. The context-aware services platform presented in this paper is an earlier version of a prototype. Thus, there are many aspects to be improved, and many functionalities to be added for providing reliable, low-power, low-cost, worldwide available services.

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