U-FIPI: Ubiquitous Sensor Network Service Infra Supporting Bidirectional Location-Awareness between Mobile Nodes and Fixture Nodes

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Abstract- We introduce a ubiquitous sensor network system, called U-FIPI, to monitor the early symptom of fire and intruder in indoor environment. Especially, this system adapts a novel approach to provide bidirectional location-awareness service between various mobile nodes and U-FIPI fixture nodes making it suitable for total service as a new concept of building management system.

I. INTRODUCTION[1]

The emergence of sensor network makes it possible to monitor target environments in remote places. The network consists of hundreds of fixture nodes which cumulate a variety of sensor data, and each fixture node forwards local data to the server. Especially, we have been developing U-FIPI (Ubiquitous-Fire and Intruder Prevention Infra) to provide not only monitoring service for fire and intruder, but also location-awareness service for various localization service potentially occurred inside a building. Many target environments have been chosen based on vulnerability from fire and intruder, and U-FIPI has been successfully installed to these areas.

Recently, buildings are equipped with various systems to monitor or control current environmental condition, such as smoke sensor to detect fire, movement detection sensor to observe intruder, HVAC system to adjust temperature for a room in the building, and location tracking system. Even though these systems operate in a similar way, installation or maintenance of each system had to be performed independently with large amount of cost and effort. In this sense, U-FIPI can be the best alternative to these independent subsystems since it focuses on providing "All-In-One" service using sensor network. Placing various services in a single sensor node, it reduces installation cost dramatically, and facilitates system administrator to maintain the integrated system with less effort. Moreover, to give geographical sense to each U-FIPI fixture node, target environment is divided into multiple subareas, called Pico-Cell(means a unit space in a building such as room or floor), to localize each area. Every data received from sensor network can be matched with the geographical information to find its originator.

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Figure 1 shows services provided by U-FIPI. The real-time detection of the early symptom of fire and intruder is the basic service provided by U-FIPI. Every U-FIPI sensor node (fixture node) is equipped with multi-sensors for smoke, flame, temperature and movement detection to recognize situations surrounding each location-cell with various views. Apart from this monitoring service, there is also a need to distinguish authorized security guards from intruders. U-FIPI uses movement detection sensor to detect intruder. Every person can be detected by the system as intruder. This fact may lead to lots of false alarms whenever authorized guards, such as policemen or firefighter, walk around the building to patrol the target environment in their needs. It causes the system administrator to confuse to find whether the alarm was sent by intruder or by authority.

Therefore, the new mechanism to recognize both types of person is required for U-FIPI to be more competitive. In other words, if person who is located in a certain area is authorized, the system must avoid generating alarms, rather provide useful services to them, such as current environmental data. Furthermore, system administrator who monitors the target environment in a remote place should track authorities' positions as well as intruder's one. That means, U-FIPI has to adapt location-awareness service [1]. Even though many sorts of location-awareness technologies have been suggested, none of them consider the constraint in which we are facing [2,3,4]. That is, it is difficult to adapt additional hardware or complex software logic to the existing infrastructure. And the existing service, such as environmental monitoring, must not be affected from the newly added service. We designed U-FIPI system to support location-awareness service under these constrains.

The detailed constraints are like follow.

- *Sustainability of the existing service*:
  U-FIPI has been providing environmental monitoring service, such as the early symptom of the fire and intruder. Although location-awareness service is newly added to the system, it must not cause side-effect to the existing service.
- *Supporting a variety of mobile node*:
  Recently, many sorts of mobile nodes are being released to the market. Not only develops a new type of mobile node for this service, but also those mobile nodes in the market need to use the added service as well supporting compatibility.
- *Designing the add-on type protocol for location-awareness service*:

Modification of the existing protocol brings about large change of overall system's software. Therefore, add-on type's protocol is necessary for the location-awareness service rather than redesigning the existing protocol.

Next section will describe the technical issues under these constrains and the solution we adapted.

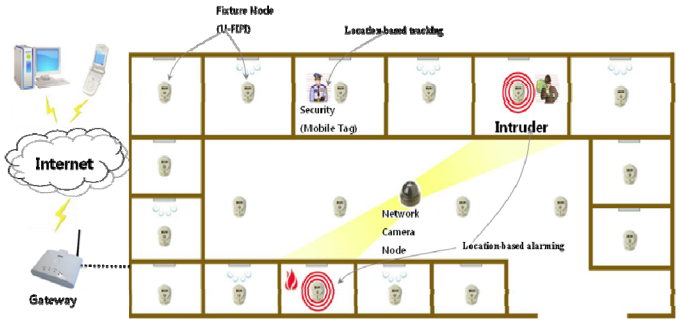

Figure 1 Various services supported by U-FIPI

II. Technical Issues and Solution

Turning to the technical consideration, there is a primary issue based on constrains stated last section. In fact, it is quite challenging to implement the prerequisite technology in sensor network, bidirectional localization technology. Mobile node needs to interact with fixture node to locate itself, and the fixture node has a responsibility to forward mobile nodes' information to the server for post-processing to provide advanced services, such as location tracking or message delivery among mobile nodes. In this sense, routing function is essential in that it helps data generated by mobile nodes to travel across the sensor network. However, most ad-hoc routing algorithms of sensor network are designed under the precondition that every sensor node is stationary [5]. When mobile node participates in the network and requests data forward to remote places, it may bring about critical problems to the network condition [6,7]. Frequent handover of multiple mobile nodes may cause fixture node to fail to update its routing table properly, which may lead to abnormal routing information, such as missing or duplicated routes to certain nodes. This can be the primary reason to diminish the sustainability of the existing service. Considering these problems, the previous method has a difficulty to provide existing service as well as other location-awareness services, so another approach for fixture and mobile nodes communication is needed to assure a stable network condition as well as mobility.

The need for the new approach makes us propose ID-exchange protocol under a new network topology to provide localization service. Recognizing current routing functions of sensor network lack of support for mobility, the proposed ID-exchange protocol partly relies on routing function to locate mobile nodes and forward data to remote places. That means, the new network topology makes both mobile and fixture nodes exchange their IDs in a different way to build a session between two nodes compared to the general procedure of sensor network. The detailed explanation can be found in our technical report.

III. Demonstration

We installed U-FIPI to demonstrate three scenarios, 1) The location-awared real-time detection of the early symptom of fire and intruder, 2) distinguishing between authorized security guards and intruders, 3) location identification and concurrent tracking using bi-directional mobile-tag devices as shown in Figure 2. Figure 2 shows system components which consist of U-FIPI system. Fixture node uses four sensors to detect smoke, flame, temperature, and movement, and CC2430 RF transceiver for sensor networking. U-Tag is also equipped with the same RF transceiver with fixture node for location-awareness service. Gateway connects between sensor network and internet to forward sensor data to the remote server. Server is placed in the head office of the building to monitor target environment with GUI program.

Figure 2. U-FIPI Devices for Demonstration

The first scenario is to identify the early symptom of fire or intruder. The U-FIPI fixture node can identify the so small scale fire symptom even though the light of a gas lighter or match with exact location information. Then the nearest fixture node which is charge of the pico-cell area detects it in real-time, and sends fire-alarm signal to whom have concern through the sensor network. When intruder walks in to the certain cell, the fixture node also detects it, and sends intruder-alarm signal to the patrol guards.

The second scenario is to distinguish authorized patrol guards from intruder in a building. Two U-Tags are assigned to two people to entitle authority to access areas in building. Another person is given nothing as intruder. Compared to the first scenario, when people who possess U-Tag walk around the areas, fixture node sends authorized access signal to the server. Moreover, they can receive environmental information from the fixture node through U-Tag. In contrast to the authorities, intruder still causes alarm signals without receiving any services from the fixture node.

The last scenario is location tracking. Server keeps the geographical information matching with the real environment. Every data received from sensor network can be displayed in

various ways according to its location, and arrival-time. This makes it possible to provide location tracking services which track not only intruder, but also authorities with their real-time positions.

It is noted that these scenarios can be achieved just adapting U-FIPI system, which integrates various sensor network services.

IV. Conclusion

U-FIPI system was introduced to provide not only environmental monitoring, but also location-identification and tracking service. Especially, We expect that when U-FIPI cooperates with U-Tag to distinguish authorities from intruder has a potential to be a competitive building management system in the market.

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