Research on Applicability of Positioning System for Access Control in NPP

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1. Introduction

Recently, the importance of cyber security is growing in NPP. But, the level of physical protection such as access control is the same level as before. This paper investigated the indoor location tracking technology to trace the location of the passengers in real time and control access to the restricted area. Ultimately, it evaluated the applicability of the system to the nuclear power plant.

2. Positioning Systems

Indoor positioning system(IPS) is a system to track objects or people inside a closed environments using radio waves, magnetic fields or acoustic signals. From now on, there is no standard for an IPS.

In this paper, we depict six different positioning techniques, which efficiently applicate infrastructure: Infrared, Ultrasound, WLAN, UWB, RFID and BLE.

2.1 Infrared

Active Badges is major method of indoor positioning system using infrared. It is based on fixed infrared detectors located throughout an indoor space [1]. The system could consist of one detector or additional AoA capabilities. Infrared signal can't penetrate through the wall and ceiling, so photo detectors should clarify the division of the sector to be implemented with a metric error.

Active Badge system emits IR pulse with unique codes per 15 seconds. Central server receives data from fixed photo detectors, location of passengers thus can be determined. Because of positional rate, it is not suitable for real time application.

2.2 Ultrasound

The distance can be determined from Time of Arrival(ToA) method of Ultrasound pulses which send from an emitter to a receiver. In contrast to radio frequency systems, the ultrasound's operating range is 50 meter or less.

A general example of the ultrasound positioning method is Active Bats [2], Dolphin and Crickets. In case of Active Bats, users are tagged with ultrasound tags called BAT. These bats periodically transmit the ultrasound signal to the receiver on the ceiling. Transmitter's position is determined by using ToA multilateration.

The disadvantage is that many receivers should be installed and arranged tightly.

2.3 WLAN

WLAN indoor positioning system is based on the signal strength generated from AP(Access Point). The distance between AP and the terminal is estimated to determine the location. Distance data from a transmitter is included in the amplitudes of the received waveforms and the arrival times. Therefore, distance determination using WLAN is possible from ToA, TDoA(Time Difference of Arrival), RTT(Round Trip Time) and RSSI(Received Signal Strength Indicator).

AP can be an attractive approach because it is readily available in a variety of indoor environments. Generally, it is possible to cover from 50m to 100m. The most popular IPS method of WLAN is RSSI-based estimation. In general, RSSI-based technology can be applied with positioning techniques such as propagation modeling, Cell of Origin(CoO), Fingerprinting(FP) [3] and multilateration.

2.4 UWB

UWB(Ultra Wide Band) is accurate technology that operates without modulation and demodulation. A major advantage of UWB is that large bandwidth translates into a high resolution in time. It estimates ToA of received pulse signal to determine the position. This system consists of stimulus radio wave generators and receivers for receiving reflected wave. Because of occupying large frequency bandwidth, it can transmit data under NLoS conditions.

On the other hands, reflected signal include various returns, so partial signal penetration is not useful under certain conditions. The disadvantages are that signal output power allowed by regulation is very small. It can also limit the coverage.

2.5 RFID

RFID is a technology to transmit data by recognizing tags using electromagnetic field in non-contact methods. RFID IPS consists of tags and readers. When the reader sends an RF signal, it can determine receiving the assigned unique ID whether the tag is located around it. The accuracy of these systems depends on the number and location of the reader. The advantage of RFID technology is that it works fast and the RF tag can be read in any environment. Examples of popular RFID

location finding systems are SPOT ON[4] and LAND-MARK[5].

2.6 BLE(Bluetooth Low Energy)

On behalf of Wi-Fi, Bluetooth-based positioning has emerged. Since BLE consumes very low power, it has the advantage of constantly transmitting and receiving signals. BLE-based technology is similar to Wi-Fi in principle. Generally, the position is calculated with a triangulation method. In other words, the beacon at a specific location sends signals to the receiver to determine its position. For instance, iBeacon uses the BLE signal instead of GPS to track the position of the workers and calculate the distance between the beacon and iPhone. A major advantage is high security, low power, mesh-based topology and small size.

3. Regulation

3.1 Electromagnetic radiation and immunity test

EPRI TR-102323 and REG. Guide 1.180 standard are related to electromagnetic radiation and immunity test. Because I&C facilities may be vulnerable to electromagnetic waves, the electromagnetic radiation and immunity tests related to the use of wireless equipment are managed to maintain or lower the radiation limit.

Table I: Standard for radiated electric field

Standard	RE102		RS103	
	Freq. (MHz)	Limit (dBuV/m)	Freq. (MHz)	Immunit y Level
EPRI TR-102323	2-100	44	0.01-10000	140
	100-10000	44-83.9		
REG.Guide 1.180(Rev.1)	2-25	59	30-10000	140
	25-10000	59-72		

3.2 Usage guideline for Wireless equipment

According to USNRC REG. Guide 1.180, when wireless equipment is used in NPP, separation distances should be defined from sensitive I&C facilities as below.

$$d = \frac{\sqrt{30 P_t G_t}}{E}$$

Where:

P_t=the effective radiated power of the EMI emitter(in Watts);
G_t=the gain of the EMI emitter(dimensionless);ands,
E=the allowable radiated electric field strength(Volts/meter)

4. Applicability

In this paper, diversity of different methods for indoor positioning system shows any solutions may apply to NPP. If the accuracy is the most important factor, the ultrasound-based system will be ideal solution. If the cost is important parameter, infrared system can be proper choice.

Considering EMI and RFI, it is essential to introduce minimum IPS in NPP. Other than that, it needs also low power for reducing EMI risks. That in its turn means the most important factor will be area per node.

On the other hands, the integrated systems can be optimal solution for NPP.

5. Conclusion

It goes without saying that importance of offline security. As discussed, there are many solutions for IPS. Considering regulation, the most important parameters, integrated system(BLE/RFID) will be strategic attempt for IPS. BLE is mesh-based topology. That means we can install minimum nodes for IPS in NPP. Plus, interference with I&C facilities can be also minimized due to low power.

Active transmitter tags are strategically place in closed room scale environment. The receiver tags get transmissions and calculate their positions [6]. The calculated object positions were transmitted to server to be monitored in real time.

By using integrated system, it can be powerful solution for access control in NPP.

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