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The Development of Target-Oriented Real-Time Smart Tracking System to Distinguish Objects

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Abstract

Recently, with the development of the systems that support tracking of various objects and the component technology of Internet of Things (IoT), the use of tracking system is increasing in social infrastructures and various industrial sectors. With the application of the IT technology that can manage the movement of objects in real time in industrial sites, the sectors where the technology of tracking system can be applied are expanding. However, to satisfy the various demands of industrial sites, the existing tracking system has many technological problems. For example, due to the technological problems in solving spatial errors and errors related to time, there are limitations in introducing object-based tracking system in the medical industry or industrial sites with high risks, and these errors, when involved in service sectors, can seriously hurt customers' reliability. Also, even in sectors where error range is not important, there are many problems such as high power consumption, high utilization of data, and the trouble of object tracking in some locations. Analyzing problems such as errors of tracking, power consumption, data use, and situations where object-tracking is not supported, this study tried to reduce error range and design and develop an intelligent smart tracking system that minimizes data use with low-power base.

Keywords*: Tracking System, Middleware, Intelligent System, IoT, ICT*

1. Introduction

Among the recent ICT (Information and Communications Technologies), the technology that attracted the most attention as a new growth engine is Internet of Things (IoT) [1-2]. IoT is an intelligent technology and service that connects all the things based on the internet and enables transmission of information between human and things, things and things, and things and the system without human intervention [3].

The tracking system, one of the applications of IoT technology, tracks and manages the location information of objects including various things and humans, and is essentially used in various fields such as medicine, construction sites, logistics, e-commerce, military but there are still many tasks to be handled [4-7].

The errors of tracking system due to technological problems and environmental factors are a big issue to apply the system to various industrial fields and in the industrial field that requires sophisticated and accurate tracking, it is especially hard to apply this technology. Due to high consumption of power, long-term tracking is difficult and there is maintenance problem such as changing batteries. So for the simultaneous tracking of moving objects or devices, the battery problem should be solved.

Also, continuous tracking requires heavy use of network so the amount of data consumption is huge. For long-term use of tracking system, considerable data use is another important task to tackle. Due to the characteristics of GPS system, there is the problem that tracking is not possible in some locations. The errors that occur in non-GPS areas can be a problem that may cause a big error or mistake in the analysis result of all the objects tracked.

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So this paper analyzed problems and vulnerabilities of the tracking systems, searched a way to solve the problems, and designed and developed a smart tracking system with an improved algorithm that reduces errors of tracking and can manage tracked object effectively.

2. Related Works

This paper developed an intelligent middleware monitoring system that can effectively manage tracked objects and an algorithm to improve the range of error in tracking data. To develop the system, a development plan was made and data research was conducted. Through this process the problems and vulnerabilities of the existing systems were analyzed and solved.

2.1. Company Vehicle Tracking Device

In November, 2014, Auto Information Communications released 'Moto Safe 2', the location-based service terminal and an MTM device that applies vehicle operation management system, which can effectively manage the vehicles that are operated by companies or enterprises [8-9]. These vehicles are based on this tracking system.

2.2. LBS Location Tracking Device for Theft Prevention in Lorries

'Sorem S location tracking device', a device to control the location of cars, was released to be used exclusively for lorries, and unlike theft prevention devices that only have loud alarms, it used tracking system that can track the stolen vehicle [10-11].

2.3. Cargo Location Tracking System

It is a system that can systematically manage the amount of loaded goods, product information, shipping status, and whether the products are missing through radio frequency recognition, receive location information from satellite positioning system when the car is moving, connect with Google Map regarding the information including real-time location of the goods loaded on the vehicle, distribution channel, and area of production, and manage the distribution process of products [12-13].

It was proposed to use location tracking method and wireless data communication method using satellite positioning system and find the location of vehicles through interface module on map for the effective management of containers in the container yard at ports [14].

Also, there was a study that measured the location of transportation vehicle using satellite positioning system, complemented the problem of errors, and improved accuracy of location tracking. It studied a way to combine DGPS and mark the moving object on digital map [15].

2.4. Vehicle Space Management System

The previous studies and existing systems for the management of vehicle operation space focus on the effective management of entering and leaving vehicles. The purpose of the existing studies—studies on the controlling system using extensible markup language, the controlling system of vehicle operation management using ultrahigh frequency card and the way to position RF card readers, wireless controlling system using code division multiple access communication network-is the effective management of vehicle operation space [16-17].

There was a study that researched the integrated controlling system of vehicle operation space using finger prints instead of radio frequency recognition. This study was conducted to solve the problem of tag copy of the existing controlling system using radio frequency recognition system and the problem of checking the use of real users, but the

original purpose is the vehicle access management. So until now, the controlling system of vehicle operation space through radio frequency recognition was mostly cases that applied the simple recognition function, the feature of radio frequency recognition devices [18].

3. Smart Multiple Object Tracking System Capable of Real-Time Target-Oriented Object Tracking

This paper developed a smart multiple object tracking system with low power, low data consumption, minimized errors, and sophisticated tracking using IoT-based real-time location service and RFID recognition technology. The basic structure of this object tracking system is shown in Figure 1.

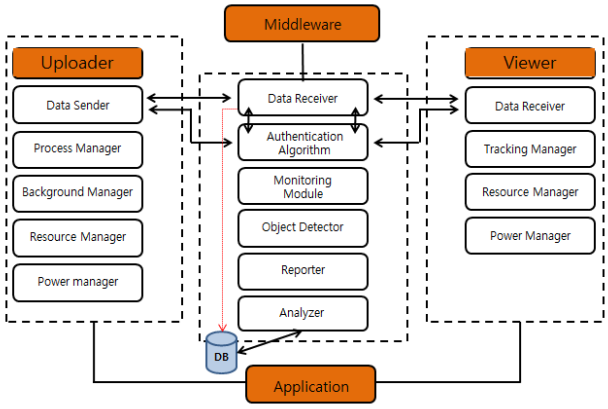

Figure 1. The Composition of the Multiple Object Tracking System

The object tracking system is composed of Middleware and Application. Middleware is made up of Data Receiver, Authentication Algorithm, Data Analyzer, Object Detector, Reporter, and Monitoring Manager, and Application comprises of Uploader, Viewer, Process Manager, Background Manager, Resource Manager, Power Manager, Data Sender, and Tracking Manager.

When connected to the Client Middleware, Data Receiver gets location data from Uploader system, goes through the certification process through certification algorithm, and conducts the role of saving it in Middleware, while the Data Analyzer analyzes the received data to process it to valuable data and utilize it. Object Detector does not use the data transmitted from applications but it uses a separate system, installed in fixed places such as parking lot, and used for detecting and tracking surrounding objects. It conducts an algorithm to detect objects effectively. Reporter is a system that reports the data detected in a system installed in fixed places to Middleware. It intelligently detects various events that occur in fixed places and reports them. Monitoring Manager can monitor the information sent from Reporter and can monitor the location data transmitted from Application at the same time.

Uploader is used by users to send tracking data to Middleware by constantly detecting one's location data, and Viewer is a system that can monitor the tracking information of Uploader users using Application. For users' convenience, Uploader system should be able to continue tracking even when the users are not aware. So by using Background Manager, just with the initial implementation of Application, it can be used without implementing the Application afterwards. Also, using the Process Manager, even when the application is abnormally shut down for reasons such as memory problems, automatic rerun is supported, and when the system is rebooted, Application is rerun. In addition,

with the use of Resource Manager, Application can be used for a long time by minimizing the battery and data use.

3.1. The Composition of Middleware

A. Data Receiver

It is used to receive the tracking data from Uploader and the data detected at the Object Detector of the Middleware. Uploader data is received through Socket and JDBC communications and is made up of Multi-Thread to be able to receive data from multiple Uploaders at the same time. Data Receiver is composed of Network Manager that enables communications and Process Manager and Resource Manager that collect data stably. The composition of Middleware Data Receiver is shown in Figure 2.

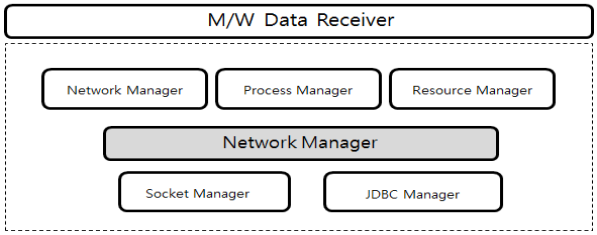

Figure 2. Construction of Middleware Data Receiver

B. Authentication Procedure

When the data transmitted to Data Receiver from Uploader –personal identification, group identification, location data, and time about the connected client— is certified through Authentication Algorithm, it is retransmitted to Data Receiver.

This algorithm is implemented only once when Middleware is run for the first time, waits at Listen mode, and when data enters through Data Receiver, it conducts Accept. If there are no problems in communications, in case of Uploader, it checks up Protocol and saves the transmitted data in Database of Middleware and in case of Viewer, it checks the group ID and selects data and sends to Viewer based on the ID. The implementation process of Authentication Algorithm is as Figure 3.

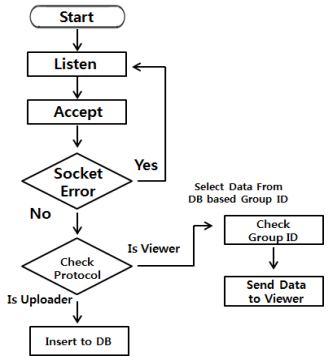

Figure 3. The Implementation Process of Authentication Algorithm

C. Data Analyzer

Data Analyzer analyzes data so that the transmitted data can be processed to be valuable data and utilized, and while doing it, data analysis can be conducted to be appropriate for the purpose of tracking. For example, in case of operation vehicle monitoring tracking, frequent tracking is not necessary, so by reducing the tracking data

interval and conducting analysis, the time for analysis can be minimized. When it is used for medical purposes, it can analyze patients' movement pattern and recognize emergency situation of patients. In case of tracking the nationwide movement of lorries, analysis can be conducted depending on location and time so movement rate and distribution rate can be found. So Data Analyzer is used to deduce various results according to various purposes using simple tracking data.

D. Object Detector

Object Detector is used not for the tracking using mobile devices but for the tracking of moving objects in fixed places such as parking lot or inside vehicles. Object Detector detects the movement of cars in parking space and find out illegal parking or the movement rate of vehicles. This system detects cars based on Image Processing using cameras, and for more accurate detection, it uses radio frequency recognition tag and radio frequency recognition reader, and accurately finds out the movement and parking status of vehicles. This system is made up of Image Detector, radio frequency recognition reader, radio frequency recognition tag, and Gateway. The operating environment of Object Detector is shown in Figure 4.

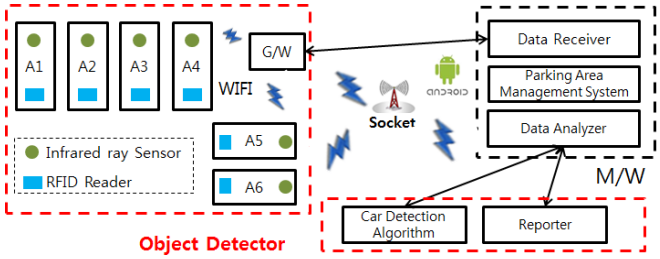

Figure 4. The Operating Environment of Object Detector

E. Reporter

Reporter conducts the role of reporting the data detected in a system installed in fixed places such as car operating space to the data analyzing system of Middleware and intelligently detects and reports various events that occur in fixed places. The low-power, minimal data use algorithm of Reporter enables convenient maintenance and long-term use of Object Detector. The block diagram of Reporter is shown in Figure 5.

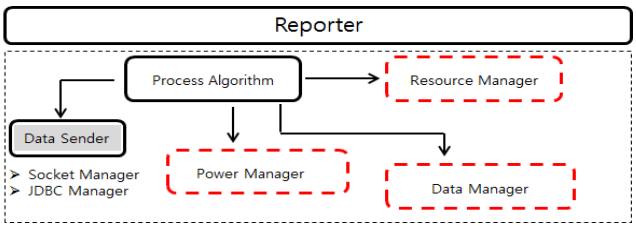

Figure 5. Reporter

F. Monitoring Manager

Monitoring Manager is a system for integrated monitoring and controlling of the information sent from Reporter and the information of satellite positioning system transmitted from Application. The composition of Monitoring Manager is shown in Figure 6.

Figure 6. The Composition of Monitoring Manager

3.2. The Composition of Application

A. Uploader

Uploader is used to detect the location information of the user through satellite positioning system and upload the tracking data to Middleware and it materializes the optimal algorithm for long-term operation and maintenance. When a user logs in for the system to recognize him/her and runs the application, this system sends individual ID, group ID, the coordinates of the satellite positioning system, and time to Middleware Server according to the time unit that the user set. Middleware Server, when clients are connected, goes through certification process, saves the data that each user sent through Uploader in the database. The composition of the user interface of Uploader system is shown in Figure 7.

Figure 7. The User Interface of Uploader System

Uploader is largely made up of Platform Manager and Network Manager. Platform Manager is composed of Background Service that maintains the Application in running mode even when the user is not aware, Battery Manager that manages battery, and Resource Manager that always keeps Application in stable state through the resource management of the system. It conducts communication with Middleware through Network Manager, maintains stable network environment, and minimizes data use. The structure of Uploader system is as Figure 8.

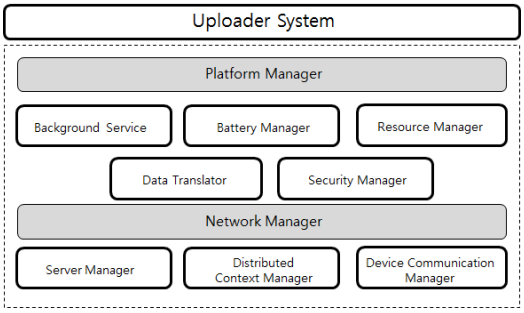

Figure 8. The Block Structure of Uploader System

B. Viewer

Viewer is a mobile monitoring system to find the location information of satellite positioning system for users saved in Middleware. Through Viewer, the moving route of all the users can be found through Google Map format, and the setting including moving route according to users or moving route according to users of different regions can be customized and tracking information is managed. As for the way to use Viewer system, one can use Drop Down menu, select location and the name of the user, and set up location, user, whole location, and whole users. Then by clicking Show button, user's location can be found through Marker, and when Marker is clicked, information on the given marker is displayed. The composition of Viewer user interface is as Figure 9.

Figure 9. The Composition of Viewer User Interface

C. Process Management

Process Management supports the function to rerun Uploader application automatically when it is abnormally shut down due to reasons such as memory problems and rerun the application when the system is rebooted. So the user can keep the Uploader in running mode.

When the system is shut down, Activity of Application is run to restart the service, and when onCreate Method is called, if there is existing alarm, removes it, and when onDestroy Method is called, runs the alarm.

When a certain amount of time passes, an alarm that notifies Pending Intent is run and Broadcast Receiver receives the Intent. Here, Restart Service Receiver is materialized and made to receive the Intent and when the process is finished, restarts Persistent Service.

In order to run Uploader when booting the system, Service At Boot Receiver was materialized and was registered as a start program when smart phone system is booted. The block structure of Process Manager is shown in Figure 10.

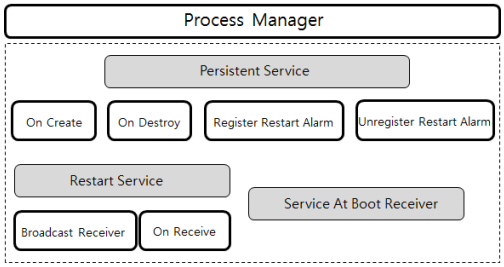

Figure 10. The Block Structure of Process Manager

D. Background Manager

Background Manager is connected to Process Manager and is used as Background Service of Uploader system, and runs the program without running Application. Uploader system should be able to keep extracting satellite positioning system information with a single initial setting, so in order to make Application always running, it hides Uploader inside the system.

E. Resource Manager

Resource Manager has the function to efficiently use the data and electricity consumed in the communication process that Uploader detects the information of satellite positioning system and sends it to Middleware and reduces the consumption of data and electricity, and for this, an improved algorithm was developed. This algorithm was made to automatically convert the means of communication such as network, Wi-Fi, and satellite positioning system appropriately to the situation so that it can use data and electricity efficiently.

F. Tracking Manager

Tracking Manager reduces errors and mistakes of satellite positioning system and complements the problem of tracking not working under unexpected or expected circumstances. To solve the problem of satellite positioning system, in places where satellite positioning system does not work such as inside a building or a tunnel, it is automatically converted to data network and starts tracking, and considering the characteristics of satellite positioning system, in preparation of errors, an algorithm to measure the moving speed compared to distance was developed and solved the problem. For example, in case of a distance that seems impossible considering the moving speed and passing time, the tracking data is deleted.

4. System Integration and Performance Evaluation

4.1. Materialization of the System

The object tracking system suggested in this paper was developed with Delphi-based Middleware and Android OS -based application. Depending on the movement of each object, tracking module is created, according to which, application is composed for the operation of system. Server management module is combined with tracking module and the server manages the operation of Middleware. The tracking data that occurred in Uploader is transmitted to Middleware through communication module and is saved in

database through certification process. Viewer access Middleware, brings the saved data, and visualizes the tracking data. The structure of the whole materialization system and connection system is Figure 11.

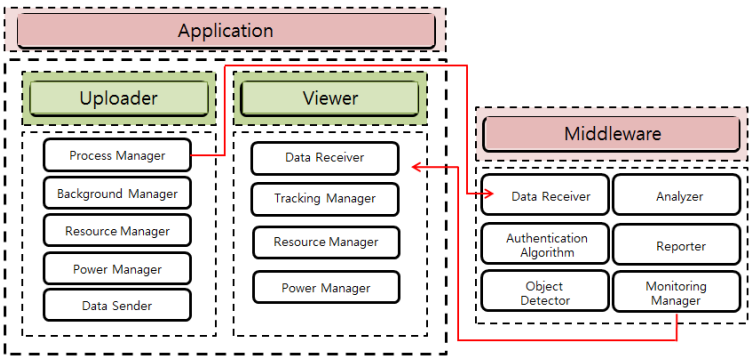

Figure 11. The Structure of Materialization System and Connection System

A. Smart multi-object Tracking

1) Network Manager

Network Manager exists both in tracking module and server management module and to perform the role of communicating with Middleware about the information of tracked object, Socket communication-based data transmitter was developed using TCP/IP-based exclusive protocol. In order to regularly track their location and send the data to Middleware, when the users of Uploader complete the process of log-in and setting server IP and port, and enter their own device ID, the data is automatically transmitted to Middleware. The user interface for Uploader setting is shown in Figure 12.

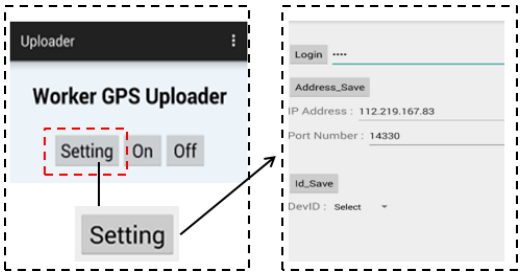

Figure 12. The User Interface for Uploader Setting

2) Resource Manager

Resource Manager is a module for the system to use resource efficiently. It uses an algorithm that optimizes the system and automatically convertS the means of communication such as network, Wi-Fi, and satellite positioning system appropriately to the situation. Also, it was made to be able to convert any time according to the user's setting, so that resources such as data and electricity will be managed efficiently.

3) Background Manager

When Uploader users run the system, for the convenience of users, Background Manager maintains the system in operation mode even when the users do not recognize and when the system is unexpectedly shut down for reasons such as lack of resources

including memory or when the user reboots smart phone, Uploader system will rerun automatically. When a user completes setting in Uploader, and presses 'Run to BackGround' button, the system keeps running without the user having to run it again.

B. Smart Multi-Object Server Management

1) Server Network Manager

Server Network Manager plays the role of transmitting and receiving data between Uploader and Viewer. Using protocol, it distinguishes Upload and Viewer, and through certification process, it receives tracking data in case of Uploader, and sends the requested data in case of Viewer.

2) Monitoring Manager

Monitoring Manager is a module for monitoring manager system that conducts integrated monitoring of the information sent by Reporter and the information of satellite positioning system transmitted by mobile application.

3) Data Analysis Manager

Data Analysis Manager was developed to analyze the tracking data saved in the database within Middleware and to utilize data based on the new analysis result. Using the analyzed data through Monitoring Manager, various visualized analysis results can be found. By setting time, the moving route of a certain period of time can be checked and it was made to show moving routes according to different setting—by location, user, and date.

4.2. Performance Evaluation of the System

In order to evaluate the performance of this system, it was compared to the existing tracking system. To measure the efficiency of each battery, GSam Battery Monitor system was used, and to measure data, My Data Manager system of Mobidia Technology was used and an experiment was conducted. This system operates in Background Service environment and does not need to maintain apps in running mode, so the efficiency of battery and data is high. Considering the result of experiment that found the apps running in Background Service has 10% less battery and 5 % less data, it is expected that the battery efficiency of this system will be about 110% higher on average compared to existing systems and data consumption efficiency will be about 105% higher on average.

5. Conclusion

This paper analyzed the problems and vulnerabilities of existing tracking system, searched solutions, and designed and materialized an improved system. The problems that made it hard to apply the existing systems to various fields due to the range of error were resolved by developing network scheduling algorithm and could satisfy various requirements appropriate for the diverse characteristics of industrial sites. Also, by developing an algorithm that can tackle the limitation in long-term use due to high energy consumption and limited data capacity and that can reduce battery consumption to solve maintenance problem, it increased the efficiency of real-time object-tracking and the range of using the system.

So this paper analyzed the above-mentioned problems and vulnerabilities of existing systems and developed low-power, high-efficiency based smart real-time multi-object tracking system so it can be used in various fields of tracking.

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