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Research paper

Construction of Transmission Control System for Digital Signage Services based on Wi-Fi

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Abstract

Background/Objectives: In this paper, we have studied digital signage service operation technology based on Wi-Fi for smart tourism service.

Methods/Statistical analysis: We constructed a system based on hybrid positioning technology using GPS, Wi-Fi and Beacon. Then, Wi-Fi transmission control algorithm was developed and applied to the system.

Findings: Through the system performance analysis, we obtained the performance evaluation result that the proposed system has low data transmission failure rate and high service utilization rate.

Improvements/Applications: We provide service scheduling functions by classifying digital signage service types in real time and non-real time. We have developed a system that enables services withoutinterruption even if a communication failure occurs.

Keywords: *Digital Signage, GPS, Wi-Fi, Beacon, Mixed Positioning*

1. Introduction

Recently, due to the influence of Korean Culture, a lot of foreign tourists are visiting and are continuously increasing. In the past, tourism has been a sightseeing-oriented tour, but recently it has evolved into hybrid tourism such as food, shopping, and experience. Currently, tourist information service is provided by cultural commentator, entrance board, voice guidance device, kiosk terminal, and app. Recently smart tourism that can provide various types of contents to tourists is becoming a main stream[1, 2].

Smart culture tourism guide is a typical application field of location based service. However, it is a burden for location service providers due to the service charge policy of location information providers (telecommunication companies, Google, Naver etc.)[3, 4]. In addition, location-based services are developing as map-based services, while cultural tourism services should be provided simultaneously with map and location-based content providing services. However, GPS-based location services have problems such as time and accuracy of positioning. Wi-Fi adapter of digital signage uses internal or external (USB) and judges the network quality according to the strength of the received signal. Thus, the digital signage manager is connected to an unwanted AP, and a failure frequently occurs[5].

To solve this problem, we need an algorithm that can determine the Wi-Fi AP that the digital signage can access, and change the AP that can be accessed according to the network environment. In this paper, we have studied hybrid positioning technology using spatial information technology that can provide location - based smart tour guide service and implemented the system. GPS, Wi-Fi and Beacon technology were used as positioning infrastructure. Based on this infrastructure, hybrid positioning algorithm and beacon positioning algorithm have been developed and applied. The transmission control system developed by our team consists of Wi-Fi Transmission Controller (WTC) and Content Viewer (CV). WTC also includes Wi-Fi AP List management algorithm, transmission algorithm, and CV service monitoring technology.

2. Mixed Positioning Technology

In this paper, we tried to improve positioning accuracy and response speed by using various outdoor positioning infrastructures such as GPS, Wi-Fi, and beacon. GPS uses satellite communications and can find locate a user if it can receive satellite signals. However, the GPS technology has an error range, and the location information cannot be known accurately. In order to minimize the error range, a receiver based on satellite communication is required[6]. To solve this problem, we used positioning technology that can be used in existing handsets.

Wi-Fi must be installed to overlap the wireless network because the range of radio waves is not constant. In addition, Wi-Fi cannot detect collisions for two nodes transmitting simultaneously. In addition, since the operating system automatically changes the Wi-Fi AP according to the strength of the received signal, there is a high possibility that the Internet connection is disconnected. When the WLAN transmission error is overlapped, there is a problem that a network error is reported to the upper protocol[7, 8]. Therefore, if a specific AP fails, it must be able to manage the Wi-Fi state that can access the other AP using the WLAN card.

Beacon sends BLE (Bluetooth low energy) as a short distance communication technology. It can be transmitted 1 to 10 times per second, and the battery can be used for 2 years or more. Beacons can be transmitted from a minimum of 5m to a maximum of

70m[9]. Once the beacon is activated, it can be linked to wearable devices such as smart phones, smart glasses, and smart watches, and it can be spread over IoT (Internet of Things) to connect various objects. Therefore, the mobile payment market and location-based mobile ad market are also expected to grow. Beacons have a variety of functions and high accuracy, but they do not have enough infra-structure and need to be newly installed[10].

The concept of mixed positioning applied to the system developed in this paper is shown in [Figure 1]. First, if the GPS signal is available, it transmits the position value to the GPS coordinates and then collects the Wi-Fi SSID, RSSI or Beacon ID and RSSI value. When the collected Wi-Fi or beacon information is transmitted to the Location Server, the Location Server provides basic content based on the received information.

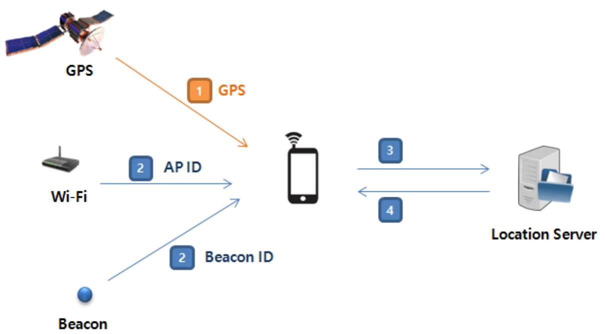


Figure 1:.Concept of mixed positioning

3. System Configuration

3.1. Structure of the Complete System

Digital signage system based on Wi-Fi consists of an operating server and a client (digital signage). Operational servers perform tasks such as content management, Wi-Fi transmission management, and remote power management required for digital signage operations. The client (digital signage) performs the corresponding inter-working functions.

The structure of the proposed system is shown in [Figure 2]. The contents viewer of DS (Digital Signage) performs display contents on the screen. The Wi-Fi Transmission Controller is responsible for the contents and Wi-Fi transmission tasks, as well as for checking and executing the Contents Viewer. In this way, the data processing function and the UI are separated. The power controller manages the power of the DS HW according to the schedule.

The contents schedule management of the server manages contents to be displayed on the screen. Control Message IF receives the JSON / HTTP interface, and Data IF receives the JSOOP / HTTP interface. DS Service Schedule Management is responsible for managing DS's service schedules. Control Message IF communicates JSON / HTTP interface, but does not send or receive Bearer Data in Data IF.

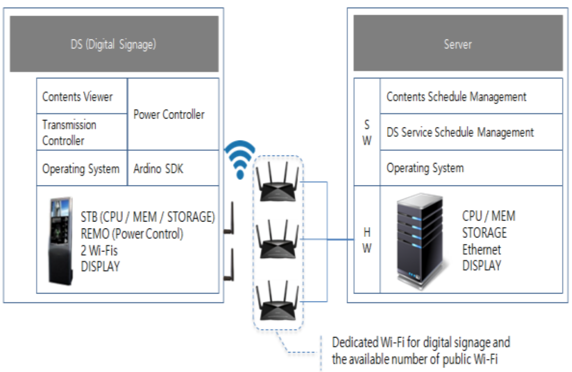


Figure 2:.Configuration diagram of the complete system

3.2. *Algorithm Configuration*

The scheduling algorithm should be designed so that real-time data is transmitted during service operating hours, and non-real-time data is transmitted after the service operating hours or there is no real-time data to be transmitted. The process flow of the proposed system is shown in [Figure 3]. As shown in [Figure 3], data is transmitted through a data transmission scheduler, a Wi-Fi transmission controller, and a Wi-Fi receiver agent. In other words, real-time data and non-real-time data are received in Queue format and transmitted through the transmission queue according to the data transmission schedule.

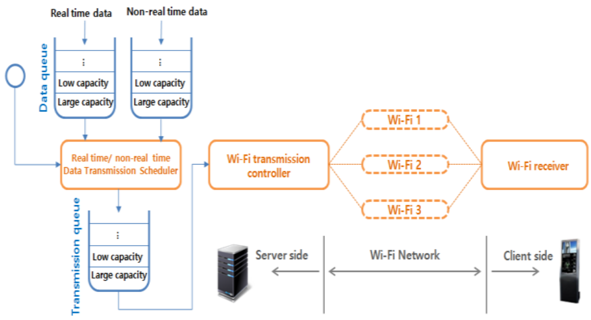


Figure 3.:Diagram for data transmission

Currently, the communication functions implemented on the DS are transmitted without considering the importance of application data. Therefore, it is necessary to classify the service data distributed on the DS and utilize it as a judgment criterion of real time. In this paper, we deal with DS and data queue to be transmitted by dividing basic DS service into streaming, web, file transfer and control message. In addition, a transmission algorithm has been developed to enable stable data transmission and reception on Wi-Fi (see [Figure 4]).

After applying [Figure 4], if there is another data request during data transmission / reception by scheduling according to the priority order of data, Wi-Fi transmission data request message is received in Queue. Then, the Wi-Fi AP List is managed according to the Contents Viewer control algorithm as shown in [Figure 5].

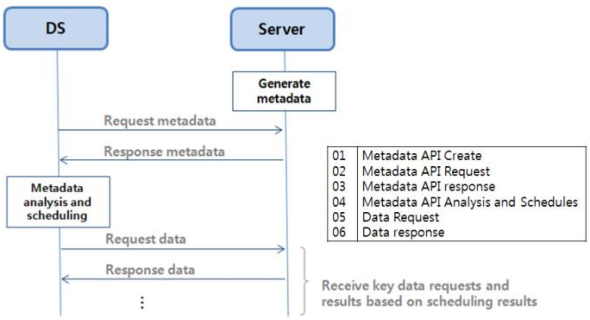


Figure 4:.Data flow between DS and server on WTC and Wi-Fi

```
Create and save of ap_list managed by system (OS)
    Create ap_list(memory)
    Register ap to the ap_list managed by system(OS)
    Store ap_list to a file(ap_list.log)

Create, connect and store net_available_ap_list, which can be connected
via Wi_Fi
    Create net_available_ap_list that can connect to Wi_Fi
    Create internet_available_ap_list with internet connection with Wi_Fi
    Sequential access to ap registered in net_available_ap_list
    If the connection is successful
        Registering the ap in net_available_ap_list (memory)
            - Equipment name, ap name, signal strength, check time
        Store the ap in a file (net_available_ap_list.log)
            - Equipment name, ap name, signal strength, check time
    If the internet connection is successful through the AP
        Registering the AP in internet_available_ap_list
            - Equipment name, ap name, signal strength, delay, check
```

time
Save the ap in a file (internet_available_ap_list.log)
- Equipment name, ap name, signal strength, delay, check time
Return to 2.2 if a connection or Internet connection fails via the AP

Report various AP information to DB server
Connect to ap with strongest signal strength in internet_available_list
If the connection is successful
Connecting to DB server
If the connection is successful
Save net_available_list and internet_available_list to DB respectively
If the connection fails
Remove the ap from internet_available_ap_list
Modify the internet_available_ap_list.log file (remove the ap) then go to 3.1
If the connection fails
Remove the ap from net_available_ap_list
Modify the net_available_ap_list.log file (remove the ap) then go to 3.1

Figure 5. Algorithm for Wi-Fi AP List Management and Contents Viewer Control

4. System Implementation and Performance Evaluation

4.1System Implementation

In this paper, we implemented the system according to the detailed configuration of digital signage software. [Figure 6] is the display screen of Contents Viewer.

Figure 6:.Display screen of Contents Viewer

In this paper, we implemented a program to manage Wi-Fi network APs. The development system creates a list of APs managed by the system and a list of APs connectable via Wi-Fi.

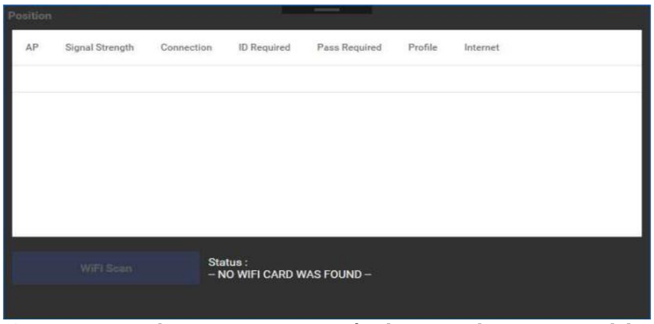


Figure 7:.Screen that cannot scan Wi-Fi for devices without Wi-Fi module

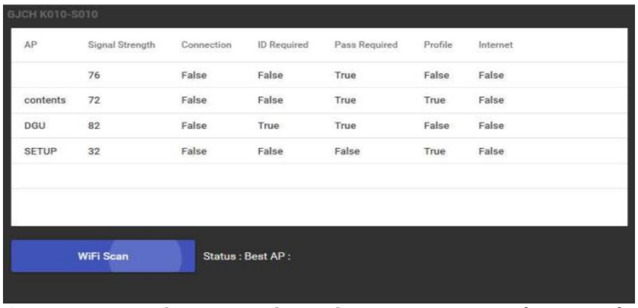
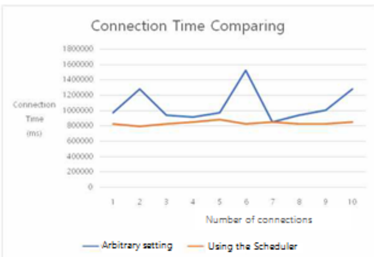


Figure 8:.Screen showing AP list and acquiring access information for each AP

Then, after sequential access to each AP, confirm the signal strength and connection time and store the log. Also, after informing the DB server about log information for each AP, the network is managed by connecting to the AP having the highest signal strength. As shown in [Figure 7], Wi-Fi scanning cannot be performed for devices without a Wi-Fi module. [Figure 8] is a process screen that confirms the AP list and acquires access information for each AP. This is done every 10 minutes on each Wi-Fi Agent for a seamless network connection.

4.2. Performance Evaluation of the System

In this paper, we conducted a performance test to compare the wireless Internet access time using the Wi-Fi AP access algorithm in the Android system. The experiment was conducted in two open wireless access point environments with different signal strengths. For this purpose, we set the AP with a relatively low signal to SoftAP-2A and installed it at a distance of 5m from the test location. The AP with relatively high signal strength was set to SoftAP-85 and installed at the test location. We performed tests by dividing the Wi-Fi scheduler when not in use and the one using the Wi-Fi scheduler. The test results were compared for 10 cases considering the case of 10 cases. We performed tests by dividing the Wi-Fi scheduler when not in use and the one using the Wi-Fi scheduler. We performed the test with 10 test data. As shown in [Figure 9], we confirmed that test results using the Wi-Fi scheduler are more stable and faster.



Arbitrary setting (SoftAP-2A)	Using the Schedular (SoftAP-85)
976562	823975
1281739	793457
946045	823974
915527	854493
976562	885010
1525878	823975
854492	854493
946045	823975
1007080	823974
1281738	854492

Figure 9:.Connection time result according to task case

In this paper, we experiment the data transfer rate for the real - use data of the developed digital signage service smart organization system. As a result, we found that the data loss rate is as follows - 13.3% (4 times out of 30 times) of 1623 ea low-capacity image data, 36.7% (11 times) of one image data (60MB), 6.7% (2 times) of 5 a regular image data (about 1MB), and 0% of text data (522KB).

The average service rate of operation of the digital signage service, which was based on Windows OS in the existing small PC, was about 70%. In this paper, we changed the operating system based on Android OS and developed the system which upgraded the mainboard specification to increase the system operation rate. In addition, we re-implemented the existing Web-based application as a Java application and we confirmed that the rate of operation increased by more than 90% over 24 hours and if no action is taken, the service can be maintained for up to 120 hours(5 days).

As a result of 100 times measurements of the service response speed of the developed system, the average response speed was 1.023 seconds. And as a result of the graph analysis, when the experiment is continuously continued, the service response rate is slowed down to 0.1 ~ 0.3 sec as shown in [Figure 10].

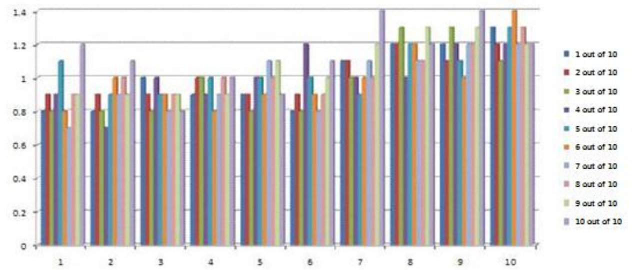


Figure 10:. Service response speed 100 times measurement result data graph

5. Conclusion

In this paper, we have studied digital signage service operation technology based on Wi-Fi for smart tourism service. To do this, we constructed a system based on hybrid positioning technology using GPS, Wi-Fi and Beacon. Then, Wi-Fi transmission control algorithm was developed and applied to the system.

Content Viewer and data transmission control algorithms were applied to display information efficiently. In addition, we implemented a Wi-Fi Transmission Controller that continuously monitors the Content Viewer and restarts it when service interruption occurs.

We also evaluated the performance of the system. As a result of the performance evaluation of the development system, excellent results were obtained with a data transmission failure rate of 14.175% (preferably less than 40%), a service utilization rate of 95% (more than 90% is good) and a service response speed of 1.023 seconds (less than 1.5 seconds).

The Wi-Fi network-based digital signage system developed in this paper has increased the degree of freedom of digital signage installed in the existing wired network. And it can facilitate installation, operation, and maintenance based on the efficiency of the Wi-Fi network in various environments.

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