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# How to utilize various Bluetooth devices when receiving Korean Public Alert System

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### *Abstract*

*In severe disaster situations, Emergency alert provide information for people to survive. However, the only device that can receive the Cell Broadcasting Service (CBS) of the Korean Public Alert System (KPAS), the Public Warning System (PWS), is Smart Phone and Receiving the disaster information is very limited. Therefore, this paper proposes a solution to the problem. First, we discover problems through the analysis of KPAS, and second, we propose Smart Watch and Navigation as devices to receive Emergency alert. The devices can receive disaster information through Bluetooth communication from Smart Phone and provide content such as disaster-related images and videos. Based on the proposed items, the application was developed, and as a result of the test, Smart Phone provided more disaster information like images and videos than current emergency alert, and the method of notification of emergency alert was varied. And Smart Watch and Navigation received disaster information successfully through Smart Phone, which also provided various disaster information like images and videos. The developed application has expanded functionally than the existing emergency alert and can benefit many people in emergency situations.*

***Keywords:*** *Cell Broadcasting Service, Public Warning System, Korean Public Alert System, Emergency alert, Bluetooth, Application.*

## 1. Introduction

In 2021, when COVID-19 is going global, we are keenly aware of the need for emergency alert [1]. For example, When a person infected with COVID-19 appears, the path of the confirmed person should be traced, and the contact person should be screened and contacted to be isolated from others. However, in situations where the contact person cannot be specified, it is necessary to voluntarily conduct an infection test for COVID-19 through an emergency alert [2]. In addition, in the event of a sudden heavy snowfall, heavy rain, earthquake, typhoon, or other disaster situation, it is possible to deliver effective information so that the public can respond quickly. For these reasons, emergency alert is importantly used as disaster information transmission method [3].

Currently, two services are being implemented in Korea to send and receive emergency alert. The first of these services is the Cell Broadcasting Service (CBS). This refers to a broadcasting service that allows a mobile phone to receive data information (text) transmitted from a base station by inputting specific receiving ID (channel) into a mobile phone. The second service is Digital Multimedia Broadcasting (DMB). This is a service applied with a mobile communication system to receive data information (text or voice)

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transmitted using a channel of a broadcaster.[4] emergency alert are being sent and received through these two services, but in a situation where emergency alert cannot be confirmed, the benefits of emergency alert that allow people under the influence of disasters to obtain information that can respond quickly are all disappears. To compensate for this, devices that are convenient and simple to check information on warning messages, and can be received other than Smart Phones, should be developed so that warning messages can be checked.

In this paper, we suggest methods to establish an emergency alert system through analysis of the emergency alert system in South Korea. Presented items include a method of receiving emergency alert using Smart Watch and Navigation, and Content Development for various emergency alert. By utilizing suggested methods, we develop an application that can perform the functions.

## 2. Analysis of Disaster Information Delivery System in Korea

Before establishing a new disaster information transmission system, we will analyze Korean Public Alert System.

### 2.1 Analysis of Korean Public Alert System

#### 2.1.1 What is KPAS?

Each county operates a Public Warning System (PWS) to announce natural disasters or various emergency information using mobile communication systems. PWS uses the Cell Broadcast Service (CBS) to deliver warning messages. And CBS is a technology that sends unauthorized messages to all terminals within the area from the base station by inputting a specific receiving ID into the terminal.

Among the various PWS, the Korean Public Alert System (KPAS) was proposed by the Telecommunications Technology Association (TTA), a South Korean disaster information delivery system, and KPAS's requirements are defined in "3GPP TS 22.268" [5]-[7].

#### 2.1.2 KPAS in 3GPP PWS standard

The Republic of Korea promoted 3GPP PWS standardization for the fourth time in 3GPP. The following Table 1 is requirements for standardization.

**Table 1. Requirements of 1$^{st}$ KPAS for PWS standardization**

| Number | Requirements |
|---|---|
| 1 | Two classes of Warning Notification shall be supported; class 0 & class1. |
| 2 | The classes are differentiated per opt-out function. Class 0 shall have no opt-out and class 1 shall allow opt-out by the user. |
| 3 | The current implementation requirement is for the message of up to 180bytes (90 Korean Characters) text. |

#### 2.1.3 How does KPAS work?

The network architecture of KPAS is as shown in figure 1, which is configured to provide emergency alert services in 3GPP-based mobile networks. In the event of an emergency, the Emergency Operations Center of the Government collects relevant disaster information into the Alert aggregator and sends warning messages to the PLMN Gateway of the Mobile network operator via the Alert gateway. Messages are then sent to the users' Mobile Devices via PLMN Infrastructure [5]-[6].

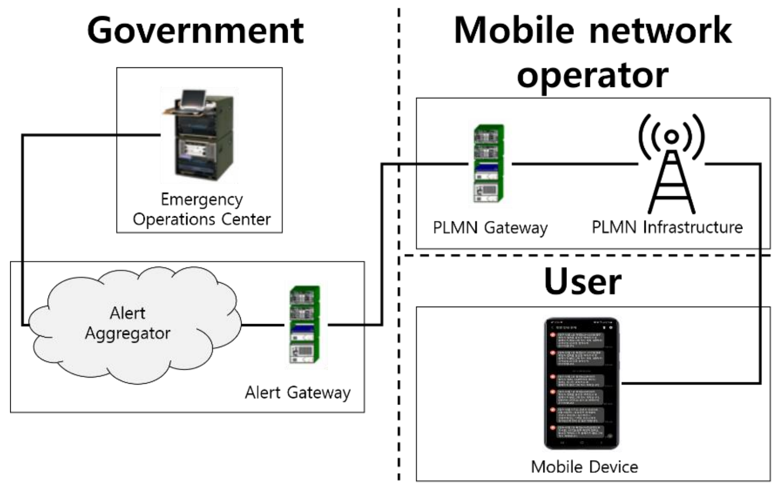


**Figure 1. KPAS Reference Architecture**

## 2.2 Standardization on KPAS

### 2.2.1 Analysis of TTA's standard history of KPAS

Looking at the standard history of TTA in Korea, it can be seen that from the start of KPAS standardization in September 2011 and until June 2017, the standard name is "Korean Public Alert System over LTE Network". Since then, in June 2019, the term LTE has been deleted from the standard name and standard document for the provision of CBS using 5G. So the current standard document is called "Requirements and message format for Korean Public Alert System over mobile network" [7]-[10].

With the introduction of 5G, it is expected that disaster information will be delivered using a terminal that has a user interface different from that of existing mobile devices.

For example, IoT devices and wearable devices can be used to provide emergency alert services tailored to the characteristics of the device.

### 2.2.2 Additional requirements in South Korea due to changes in PWS standardization

To develop and standardize PWS using 5G, the term "enhances of Public Warning System (ePWS)" was coined. By standardizing the technical standards of ePWS, it is expected that the language barrier issue of the existing text-based emergency alert service will be resolved, and be easier to obtain emergency alert from the information vulnerable groups through the use of various mobile devices. As ePWS is standardized, 3GPP's PWS requirements in South Korea have also been added, which can be seen by looking at Table. 2 [5]-[6].

**Table 2. Requirements of 2$^{nd}$ KPAS for PWS standardization**

| Number | Requirements |
|---|---|
| 1 | In addition, Warning Notification shall support up to 315 Bytes (up to 157 Korean Characters) from LTE onwards. |
| 2 | KPAS shall support Warning Notifications in various languages. A PWS-UE shall display Warning Notifications whose first texts are dedicated words when a PWS-UE receives Warning Notifications in other languages than Korean. |
| 3 | A PWS-UE in KPAS shall support two dedicated alerting indication (audio attention signals). |

### 2.3 Analysis of the transmission and reception process of Emergency alert

The EPS (LTE)'s message transfer structure of KPAS is as shown in Fig.2. The message delivery structure in EPS (LTE) will go through a total of four stages, from which a mobile operator receives a message from the government and delivers it to the user. The CBE recognizes that disaster information is to be delivered to the CBC. Afterwards, messages will be sent to the base station, which is eNodeB (evolved Node B), via MME.

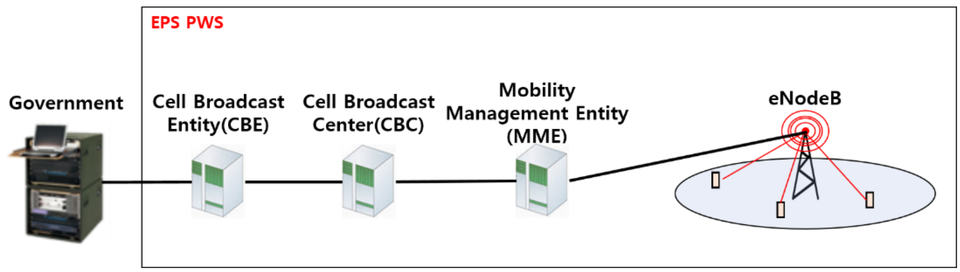


**Figure 2. EPS (LTE) Message Transfer Structure**

The 5GS (5G)'s message transfer structure of KPAS can be found in Fig.3. It has two message delivery structures as a feature. Structure 1 passes the CBC and Structure 2 passes the CBCF.

After the CBE recognizes the message transmission, it forwards the message to the CBC. CBC sends a message to the CBC, and CBC sends a message to the PWS-IWF. PWS-IWF delivers signals to AMF to suit the service-based interfaces provided by AMF. It is finally transferred from AMF to (R)AN ((Radio) Access Network).

Structure 2 carries a message from the CBE to the CBCF, which carries the channel and properties of the message from the CBCF, and passes the signal to the AMF in line with the service-based interface provided by the CMF. This is also finally transmitted from AMF to (R)AN.

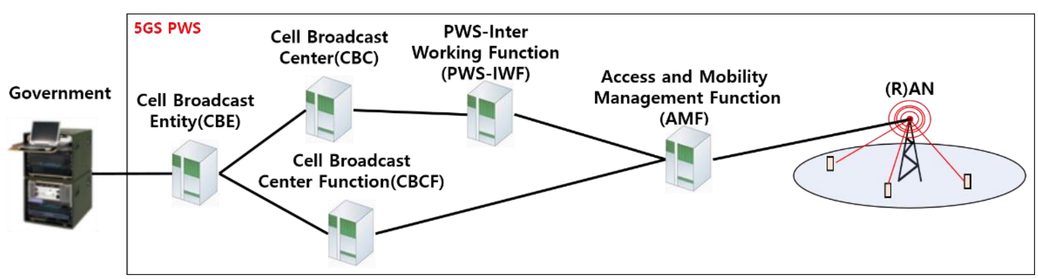


**Figure 3. 5GS (5G) Message Transfer Structure**

Finally, Smart Phone users will be able to receive warning message via eNodeB to CBS on EPS (LTE) PWS, and 5GS (5G) PWS to CBS via (R)AN [11].

## 3. Construction Method of Energency Alert System

According to a survey on the disaster information delivery system in South Korea, 5G, an advanced mobile network, was standardized to be introduced into the disaster information delivery system, and there are many additional requirements for KPAS, but no other devices have been developed that will be used as interfaces other than Smart Phones. And now, KPAS only sends textual information, so there is a need to develop additional emergency alert contents.

To solve these problems, we propose a variety of terminals other than Smart Phones and new emergency alert content, not just text information.

### 3.1 Propose a terminal for receiving disaster information other than a smart phone

In 2021, there are devices that use a variety of communications around us. To make a proposal as a warning message receiving device other than a Smart Phone among many devices, the existing emergency alert system should not be affected. To do this, it would be ideal to use the disaster information received by the smart phone and transmit it to a new receiver. As the wearable market and IoT market gradually grow, there are various devices that can communicate with smart phones. Among them, Smart Watch and Navigation using Bluetooth communication are proposed as new warning message receiving devices as shown in Fig.4.

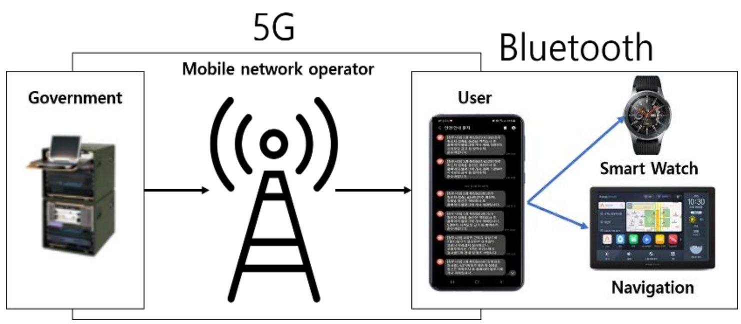


**Figure 4. Proposed Emergency alert transmission method**

#### 3.1.1 Smart Watch

Smart Watch is expected to be able to easily check disaster information. Because it is located on the wrist, user can easily recognize notifications.

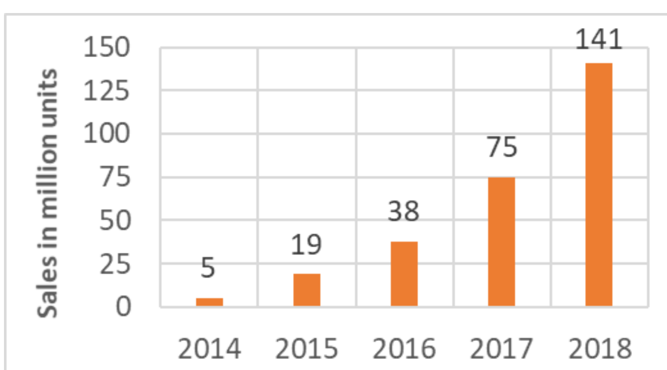


**Figure 5. 2014~2018 Smart Watch Sales Trend**

In Fig.5, we can be seen that the usage of Smart Watch continues to increase. If the Smart Watch can receive disaster information, more people will be able to receive disaster information in a variety of ways [12]. For this reason, the Smart Watch is the first to be proposed as a device for receiving disaster information through Bluetooth. Specific methods will be to develop emergency alert receiving application exclusive of Smart Watch to receive disaster information through Bluetooth communication from Smart Phone.

Next, we propose methods to utilize Smart Watch's disaster information delivery. Considering the characteristics that Smart Watch is located on the wrist, the proposed method provides primary notification service through vibration and provides secondary warning message when Smart Watch is confirmed. And disaster-related videos or images can be provided for users.

### 3.1.2 Navigation

With the current system, if a emergency message is received while driving, the driver cannot check it. To solve this problem, we propose Navigation as a second device for receiving disaster information using Bluetooth. Navigation will also develop a disaster information receiving application dedicated to Navigation like smart watch.

And it can be confirmed through Fig.6 that the number of navigation users for smart phone increases due to the universal use of smart phone. For this purpose, the disaster information receiving application dedicated for navigation will be developed so that it can be executed on the smart phone. [13]

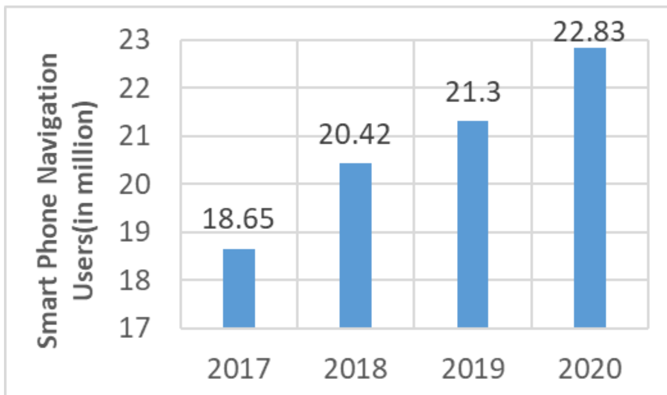


**Figure 6. Smart Phone Navigation User Trends**

### 3.2 Propose various disaster information delivery methods from Smart Phone

Currently, Smart Phone only provides emergency alert to users in text format and only provides notification sounds when received. These notifications can simply grasp the severity of a disaster, but are not sufficient to communicate more accurately information about the disaster. Therefore, we will develop various disaster information delivery functions. The developed functions are as follows. The first provides notification sounds and vibrations according to the severity of the disaster. And provide TTS (Text-To-Speech) as the second method, the corresponding emergency alert will be read through TTS. This function makes it easier for people to obtain emergency alert without having to check directly. The third method is the animation effect. It is provided in three colors depending on the severity of the disaster on the screen. As the last 4th method, disaster information will be provided through contents. Contents can be informed of the location of the earthquake, the website of the Korea Meteorological Administration, or the news can be provided by video.

## 4. Application Development for Delivery of Disaster Information

We proceeded with the application development that will be used for the previously proposed Bluetooth devices and Smart Phone.

### 4.1 Smart Phone – Smart Watch

The implementation plan is to develop an application dedicated for Smart Phone and an application dedicated for Smart Watch as shown in Fig. 7. The application dedicated of smart phone shows a disaster alert when it detects a disaster alert, and shows content such as images and videos related to the disaster. And it uses Bluetooth communication to deliver disaster information to Smart Watch. The smartwatch notifies users when it receives disaster information sent by the smartphone and provides content such as disaster-related images and videos, just like the smartphone-only app.

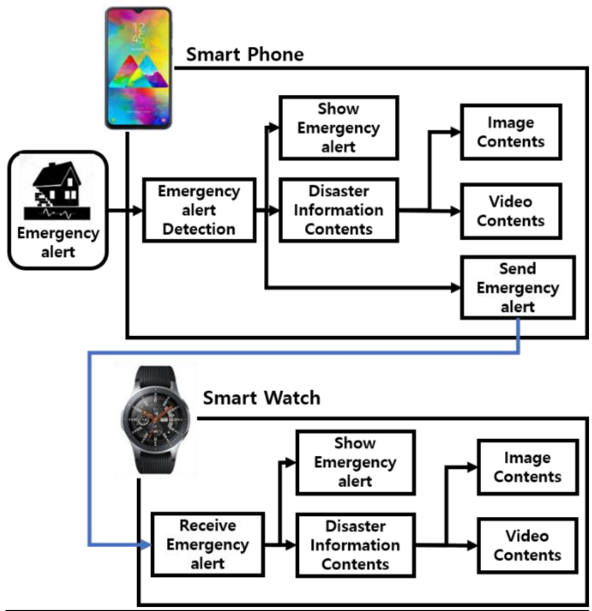


**Figure 7. Smart Phone and Smart Watch Flowchart**

Because CBS could not be used directly to proceed with the development, the development was carried out with SMS instead.

### 4.1.1 Smart Phone

First, we develop the detection function of warning messages. To this end, we developed a warning message detection function by analyzing the keywords in KPAS message format of the Ministry of the Interior and Safety [7].

Second, we develop warning message display to the user and disaster content provision. The warning message display was developed to display at the top of the screen when the user runs the application, and the content provision was developed so that users can select the content they want to receive by creating a button at the bottom of the screen.


**Figure 8. Configure Smart Phone Screen**

As the last function of the smart phone, it has developed the function of delivering emergency messages to the smart watch. For Bluetooth communication between two devices, development was conducted using

Samsung Accessory Protocol (SAP). SAP is a protocol provided for Bluetooth communication between the Android Smart Phone and Galaxy Watch selected for testing.

### 4.1.2 Smart Watch

SAP was used to send emergency alert from smart phones to smart watches. After developing the function to receive warning message in Smart Watch, it is confirmed that warning message is received normally. Since then, warning message display and content display functions have been developed. As a result, Fig.9 has been completed.


**Figure 9. Configure Smart Watch Screen**

At the top of the screen, disaster icons and text were displayed, and the middle, warning message was displayed. At the bottom, the button to switch to the content screen is positioned. The content screen was developed in the form of scrolling up and down.

### 4.2 Smart Phone – Navigation

Smart Phone and Navigation will also develop a dedicated application in which two devices are paired. The development of an application dedicated to Smart Phone is almost identical to that of Smart Phone and Smart Watch Fair. The difference is that it does not use SAP and uses the basic Bluetooth communication connection method of Android devices. The difference is that it does not use SAP and uses the basic Bluetooth communication connection method of Android devices. In addition, we developed a notification method and a pop-up window method when receiving warning message so that the application can operate normally during smart phone navigation is operating. Navigation's development content is almost the same as Smart Watch and the development part, but the difference is that the receiving screen is displayed in the form of Floating Window for normal operation of navigation functions when receiving warning message messages.

The development was also carried out with SMS on behalf of CBS because CBS could not be used directly to proceed with the development.

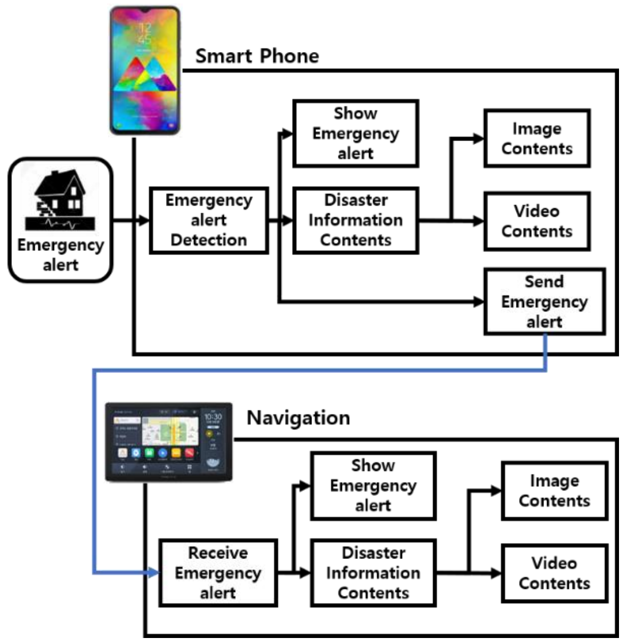


**Figure 10. Smart Phone and Navigation Flowchart**

### 4.2.1 Smart Phone

There are a total of three characteristics when developing Bluetooth communication between Smart Phone and Navigation Pair. The first was to call up Navigation's name for the correct connection between Smart Phone and Navigation. Second, to eliminate the problem that Bluetooth communication is also terminated when the application is terminated, the communication function was developed as a foreground service. Finally, because Smart Phone Navigation needs to operate normally when running, we developed to receive a notification method and a pop-up window method. In both methods, a notification screen is created at the top of the smart phone screen when a emergency message is received, and if the notification is selected, it has been developed so that disaster information can be provided through the main UI of the application normally.

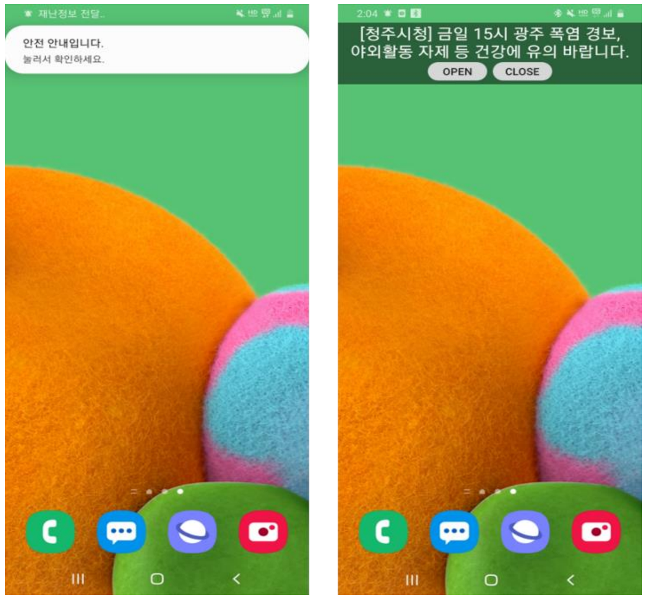


**Figure 11. Notification format and Pop-up Window format When warning message is received**

The main UI is shown in Fig. 12, and the warning message is displayed at the top of the screen, and content buttons are located at the bottom.


**Figure 12. Smart Phone Main Screen**

### 4.2.2 Navigation

It was developed as a Foreground service, the same as the Smart Phone Application, and it was developed to receive warning message through Bluetooth communication. The received warning message was developed to be displayed in the floating window format so that it does not affect the operation of Navigation. As a result, you can see the same screen as Fig.13.


**Figure 13. Floating Window Format When Receiving Emergency messages**

Fig. 14 is the main screen of the navigation, which can be viewed by selecting the notification.


**Figure 14. Navigation Main Screen**

## 5. Application Test Result

Two pairs of applications were developed and tested to verify that the application was functioning normally. The test consists of three types of messages. The three types of messages are divided into the risk steps defined in KPAS, and we will refer to them as KPAS 1, KPAS 2, and KPAS 3, in order from the high to low risk.

We can't use CBS so we created a Disaster Center application that uses SMS to send test warning messages.

### 5.1 Development of Application for Disaster Center

The main screen of the Application in the Disaster Center is Fig.15. It was developed to send warning message in SMS format when the Test message button is selected.

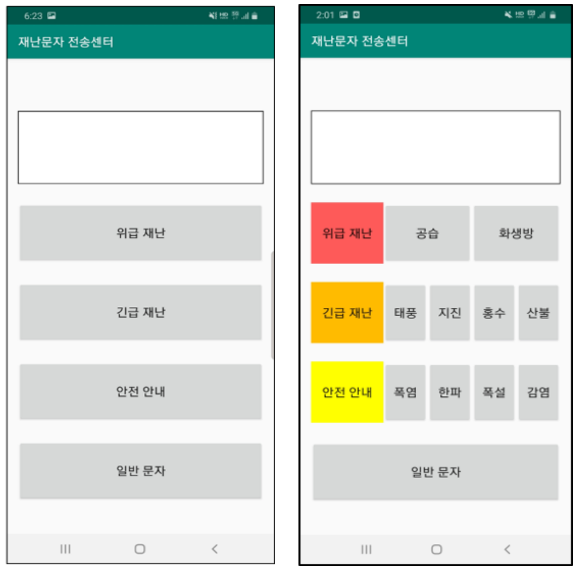


**Figure 15. Disaster Center Main Screen**

### 5.2 Application Test of Smart Phone and Smart Watch

We install the developed application on both devices and conduct the test using the transmission center application. KPAS 3 types of warning messages were sent as test texts and the results were confirmed.

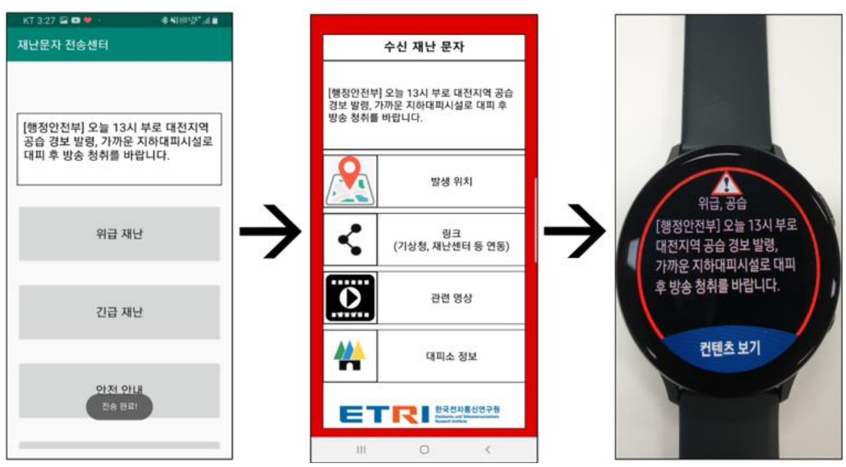


**Figure 16. Test the application on KPAS 1 transfer**

As shown in 16, when sending KPAS 1 messages, the Smart Phone generates a red flashing signal and simultaneously produces a siren of more than 60 dB and vibration. If you look at the screen, you can see that the warning message sent at the top is output normally, and you can check the content buttons at the bottom. In addition, the Smart Watch vibrates, and you can see that a red UI and a emergency message are displayed on the screen.

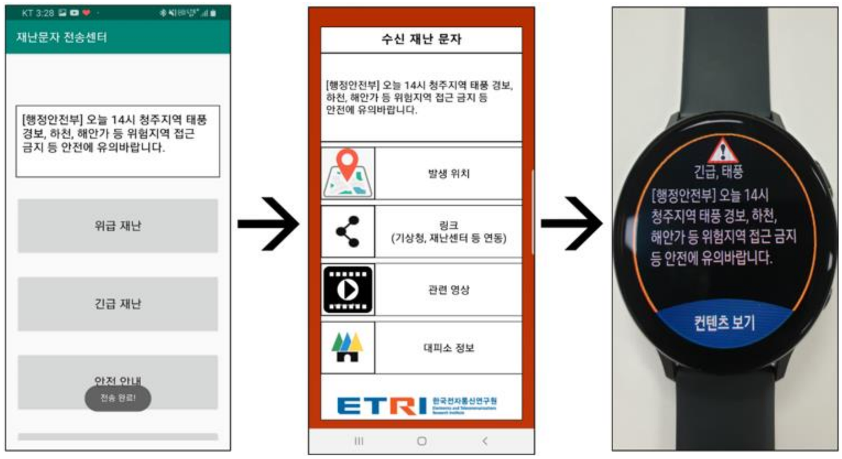


**Figure 17. Test the application on KPAS 2 transfer**

As shown in Fig.17, When sending KPAS 2 messages, the smart phone has an orange flashing signal, and simultaneously produces a siren of 40dB of more than 60 dB and a vibration. On the Smart Watch, you can see that the orange UI, the type of disaster, and the contents of the warning message are displayed normally.

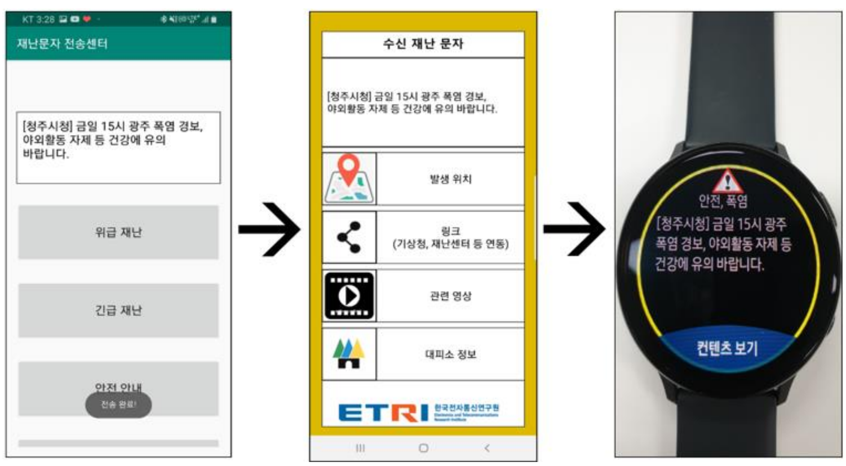


**Figure 18. Test the application on KPAS 3 transfer**

As shown in Fig.18, when sending KPAS 3 messages, the smart phone has an yellow flashing signal, and simultaneously basic vibration occurs, a emergency message is displayed, and the content screen is displayed normally. On the Smart Watch, you can see that the yellow UI, the type of disaster, and the contents of the warning message are displayed normally.

### 5.3 Smart Phone and Navigation Application Test

In this test, two types of test will be conducted: Smart Phone and Navigation's positive sending and receiving of warning message and Smart Phone Navigation's positive operation. Install the application developed in Smart Phone and Navigation and test it using the transport center application. In addition, KPAS 1 messages, KPAS 2 messages, and KPAS 3 messages are sent and the results are checked. Smart Phone's application was tested by Notification.

Fig.19 is the results of the Smart Phone and Navigation warning message test. Smart Phone generated sirens and vibrations of more than 60 dB when receiving KPAS 1 messages. We also confirmed that a notification in Notification format was received at the top of the screen and selecting the notification would run the default UI, where red flashing animation is enabled. Navigation could confirm that the same siren as the Smart Phone is generated and a floating window type notification is executed at the top of the screen. It can also be confirmed that the warning message is normally displayed in the alert.

The following is the result of the KPAS 2 message. As shown in Fig. 20, on the top of the smart phone, the notification of KPAS 2 messages is displayed, and it can be seen that sirens of more than 40 dB and vibrations occur. In addition, the main UI, where orange flashing animation is executed, was output normally when notification is selected. Navigation can see orange bell icons and warning message displayed, and a siren of the same size as a Smart Phone has occurred.

When receiving KPAS 3 messages, only vibrations occur. If Smart Phone is not silence mode, sirens occur according to the sound size value. On the screen, Notification format were executed, and yellow flashing animation was executed when the notification was selected. The navigation was marked with yellow bell icons and warning message.

The Smart Phone Navigation's application test was conducted in Pop-up Window format. As shown in Fig.22, You can see that Navigation is operating positive and that notifications in Pop-up Window format have been received.


**Figure 19. Test the application KPAS 1 transfer**


**Figure 20. Test the application KPAS 2 transfer**


**Figure 21. Test the application KPAS 3 transfer**


**Figure 22. Smart Phone Navigation Test Screen**

## 6. Conclusion

In this study, we conducted a study to receive warning message from Smart Phone, Smart Watch and Navigation.

The contents developed in the Smart Phone are to distinguish disaster characters by applying a string classification method to determine whether the character is a disaster character when a smart phone receives a text. In addition, when information such as a disaster-related occurrence location, related link, related video, and surrounding shelter location is received, the application was implemented by developing disaster information content so that the information can be displayed to the user along with the warning message. Smart Watch and Navigation implemented an app that can be displayed on Smart Watch and Navigation by receiving text messages in the form of emergency messages from Smart Phone, and developed the app to show disaster-related information in addition to warning message.

Based on the results of this study, many people will be able to safely cope with disaster situations if additional development is carried out to receive disaster information related to warning messages through more diverse terminals.

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