Study on Device Based Geo-Fencing and Triggering Services for Enhancing Alert Area Accuracy in Cell Broadcast Service

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Abstract—**This paper is about the enhancement of the alert message service that is the most reliable and swift dissemination method using the cell broadcast function in mobile communication networks. But the cell broadcast area is optimized on the mobility service of UEs. That means the alert messages could be overshot potentially. We studied Geo-fencing to improve alert area accuracy and Geo-Fencing Triggering to enhance reliability of alert messages. We proposed the inter-working algorithm and data definition which is about functions between various devices from public alert systems to mobile network equipment.**

Keywords— alert area, cell broadcast, Device Based Geo-Fencing, Geo-Fencing Triggering, Cell Broadcast Service

I. INTRODUCTION

It is more necessary than ever to build a fast and accurate warning system for adapting to climate change and protecting people's lives and property. The alert message service currently delivers the fastest and most accurate disaster information to the public in South Korea[1].

However, the recent COVID-19 outbreak has led to the use of alert message service for daily living tips, missing person notifications, and local event cancellations. Unrelated alerts and frequent alert messages are causing people to turn off the setting to receive alerts. In addition, the disparity between alert areas, which are distributed by administrative regions, and broadcast areas, which are designed for mobile networks, can lead to overshoot. This means that the structure of the alert service sends alerts to too wide an area, resulting in unrelated or duplicate alerts.

Reducing overshoot can improve the reliability of disaster information and reduce the annoyance of frequent alert messages. To improve the accuracy of warning areas, efforts are underway in many countries to refine the broadcast areas of public alert systems. Instead of setting warning areas based on administrative regions, cell broadcasting is set up by creating geo-fences with polygons or circles [2]. Furthermore, device-based geo-fencing does not unconditionally display the cell broadcast after the device receives it, but checks the location information on the receiver and compares the latitude and longitude of the alert area to display it if it is inside, and does not display it if it is outside, which can improve accuracy [3].

In order to establish a geo-fencing service and Geo-Fencing Triggering service in Korea, this paper defines procedures and equipment internal functions that fit the domestic system environment. It also proposes data definitions and timer definitions to fulfill the functions.

II. BACKGROUND

A. CBS(Cell Broadcast Service) Overall Architecture

The network structure for CBS service in Korea is shown in Figure 1. The integrated alert message system is currently being built and used by the Ministry of the Interior and Safety and the Korea Meteorological Administration. In addition, the National Police Agency is building it to be used for missing person alerts.

The Cell Broadcast Issuance System(CBIS) is connected to the mobile network through a dedicated line, and the LTE network follows the CBIS inter-working document. For 5G networks, the use of CAP (Common Alerting Protocol)[4] is under consideration.

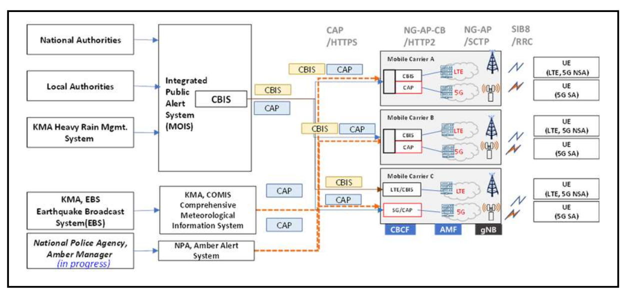

Fig. 1. CBS Service Architecture

As shown in Figure 2, various protocols are used for CBS services. In Korea, at the most end of the mobile network, CBCF receives the alert message from the CBIS and sends NG-AP-CB data to the Access Mobility Function (AMF) in the core network. The base station sends the alert to all UEs in the cell area using the control channel to SIB12 for LTE and SIB8 for 5G.

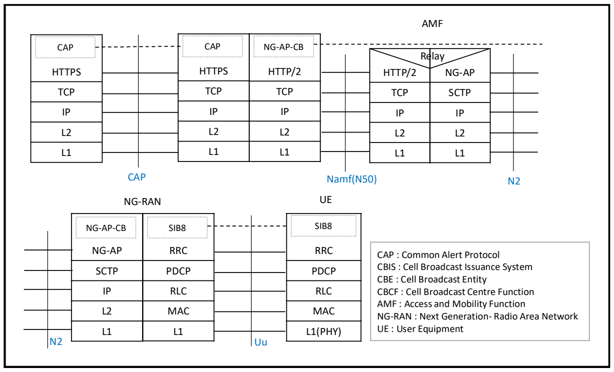

Fig. 2. 5G CBS –Entities and Protocols [5]

B. Problem

The number of alert messages issued in Korea averaged 385 per year from 2012 to 2016, and 880 per year from 2017 to 2019. Especially during the coronavirus pandemic, an average of 52,300 were issued annually from 2020 to 2022[6]. Despite the benefits of alerts to protect people's lives and property, frequent alerts and relatively non-urgent alerts for missing persons, vaccinations, local event advertisements/cancellations, weather information, and daily living tips have led mobile device users to turn off alert settings, which in turn leads them to miss or ignore important alerts such as emergency evacuation notifications, preventing them from being alerted when they really need them.

C. Prevent from turning off CBS alarm

First, legislation and guidelines could be created to ensure that alert messages can only be used to send urgent alerts. Besides, mobile devices could be unsettable with the alert message. However, there already seems to be a social consensus in favor of using the alert message service as a safety alert. [7]

The second is to refine the alert area technically to prevent overshooting. This ensures that alert messages are sent to areas where to be broadcasted and that recipients voluntarily check them. The technical methods for doing this are described in the next chapter.

Even if the reorganization of CBS issuance authority is set aside, we have two technical methods not to turn off the alarm of alert messages. One is to refine the alert area where it is expected to prepare for disaster. The other is to enhance the reliability of alerting people not to turn off the alarm which is always useful to them.

III. Geo-fencing service

The geo-fencing service is a technology that improves the accuracy of warning areas. The main feature is that the alert area is set by drawing a shape on the map to set the alert area, rather than setting the alert area by administrative region and mapping it with the mobile network to cell broadcast. By selecting the exact alert area affected rather than the administrative area, we can reduce overshooting.

A. Broadcast Area vs. Alert Area

The basic unit of cell broadcast is the cell, which is the range covered by a single base station, but mobile networks group base stations together by tracking area code (TAC) for handover. Therefore, alert messages are broadcasted in a larger surrounding area than the desired alert area. The area that is broadcasted the alert message is called the broadcast area. As shown in Figure 3, the TAC-based broadcast area can be reduced to a cell ID-based broadcast area.

Device Based Geo-Fencing ensures that the alert message is only displayed to the receiver in the alert area, which is a smaller area than the broadcast area based on Cell ID. For example, the alert message is presented when the receiver is inside the geometry with the help of location services [8]. Otherwise it is not presented and stored in memory for a certain period of time (timeout<24hr) [8]. The stored alert message is examined from memory and displayed when inside a geometry, again utilizing location-based services through additional services such as Geo-Fencing Triggering.

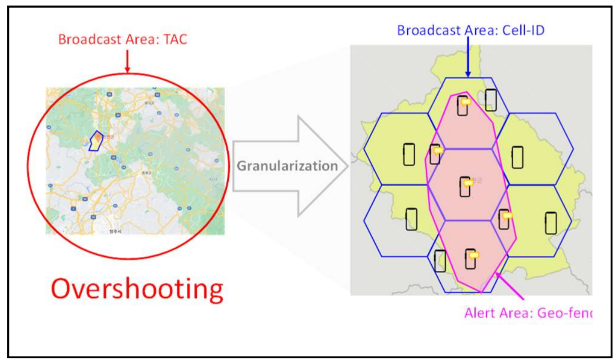

Fig.3. broadcast area vs. alert area

B. Geo-Fencing Triggering : Use Case

Geo-Fencing Triggering can be leveraged for services where a receiver moves and enters the alert area, without duplicate reception to the device that first presented it. However, this is limited to receivers that have previously entered the broadcast area.

Geo-Fencing Triggering is also available to increase the reliability of ensuring that the right mobile device receives the right message. Geo-fencing is used when the alert area is smaller than a province or metropolitan city, and triggering is a double-checking procedure by the UEs that need to present previous alert messages. Geo-Fencing Triggering message is recommended to send a short cycle of 30 seconds and no more than 10 retransmissions.

Also, Geo-Fencing Triggering requires location services, which can cause battery issues if requested frequently. Therefore, limits should be set on an appropriate number of retransmissions with a minimum frequency [8]. And it is also recommended the maximum waiting time for calculating location service. Authority should indicate the limitation to issue an alert message.

IV. Geo-Fencing Triggering

Geo-Fencing Triggering is a way to ensure that the UE receives the alerts it needs to receive without duplication based on its location. When the UE receives a Message ID of 4400(10), it reads the alert message in memory and compares it to its current location. If the UE is within the geometry of the alert message, it displays the alert message if it was not previously displayed.

A. Functional List

For geo-fencing and Geo-Fencing Triggering, issuance systems and mobile network equipment support the features shown in Figure 4. CBIS, a government-managed issuance system, sets a shape drawn on the map to set the alert area and maps the geocode to reduce the time for the CBCF to find the corresponding TAC or Cell-ID. Some triggering parameters are set, encoded in CAP, and sent to the CBCF. It has a triggering cancellation function in case the situation ends early and triggering is not needed anymore.

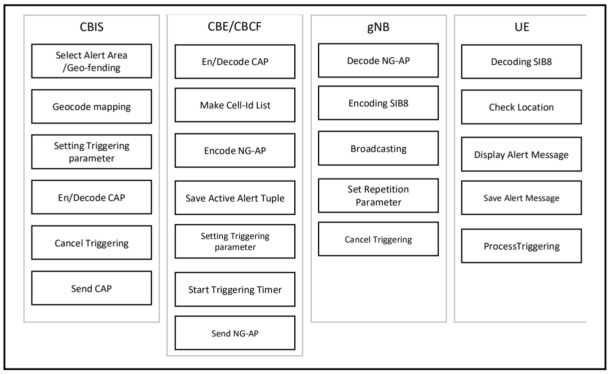

Fig. 4. Function List for Geo-Fencing Triggering

For Geo-Fencing Triggering, the CBCF decodes the CAP, creates an Active Alert Tuple with the Message ID and Serial Number as identifiers, and sets the triggering parameters. It also uses the Triggering Timer to send triggering messages directly, which sends the NG-AP to the AMF when the timer completes.

The AMF is excluded from Figure 4 because it is responsible for forwarding the information received from the CBCF to the gNB. When the gNB receives the triggering message, it performs retransmission based on the retransmission cycle and number of times parameters. When the UE receives the Geo-Fencing Triggering message, it checks the received alert area through location service and executes the display according to the result.

B. Data Definition

The issuer decides whether to perform Device Based Geo-Fencing only or Geo-Fencing Triggering as well. If he or she wants more reliable alert delivery with Geo-Fencing Triggering, set the retransmission period in seconds in cap.alert. CBSTriggerRepeatPeriod as shown in the following Table 1. Also, set how many times to send Geo-Fencing Triggering for the same event.

Table 1. Table Type Styles

System	***Element***	***Data Type***	***Range/ Default***	***Description***
CBIS	cap.alert. CBSTriggerRepeatPeriod	integer	Default: 30 Unit: sec Range: 0 - 2^{17}-1	When alert area is set with geo-fence, **geofencingTriggerRepetitionPeriod** Geo-fencing trigger message (Message ID=4400) repetition period
	cap.alert. CBSTriggerRepeatCount	integer	Default: 3 Unit: count Range: 1 - 65535	When alert area is set with geo-fence, **geofencingTriggerNumberOfBroadcastsRequested** Geo-fencing trigger message (Message ID=4400) the number of broadcast repetition
CBCF	TriggerMsgSendTimer	Integer	Default: 30 Unit: sec Range: 30 – 2^{17}-1	**CBSTriggerRepeatPeriod**= TriggerMsgSendTimer * given 30-second-rule, minimum timer is defined 30 seconds.
	TriggerMsgCompleteTimer	integer	Default: 30 Unit: sec Range: 30 – 86,400	TriggerMsgCompleteTimer is multiplied by **CBSTriggerRepeatPeriod** and **CBSTriggerRepeatCount.** * the maximum time for UE to keep CBS message is 24 hours.

C. Flow Chart

The CBCF and UE need additional behaviors to provide the Device Based Geo-Fencing service and the Geo-Fencing Triggering service. The following is a flowchart of what happens when a message is received from each device.

1) *CBCF : Geo-fencing process*

Figure 5 shows the flowchart for a Device Based Geo-Fencing service in CBCF.

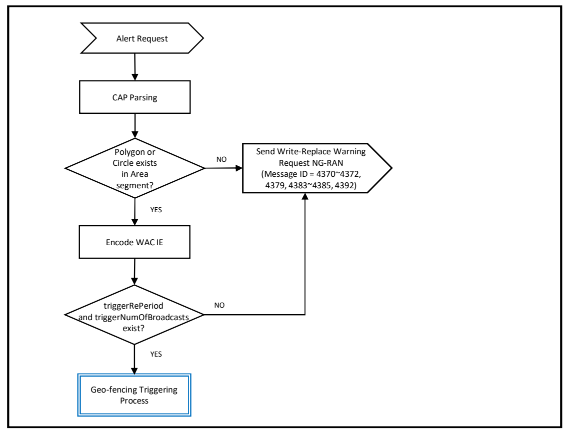

Fig. 5. Device Based Geo-Fencing process in CBCF

2) *CBCF:Geo-Fencing Triggering Process*

Figure 6 shows the flowchart of timers, internal parameter processing, and protocol encoding that CBCF uses for the Geo-Fencing Triggering service.

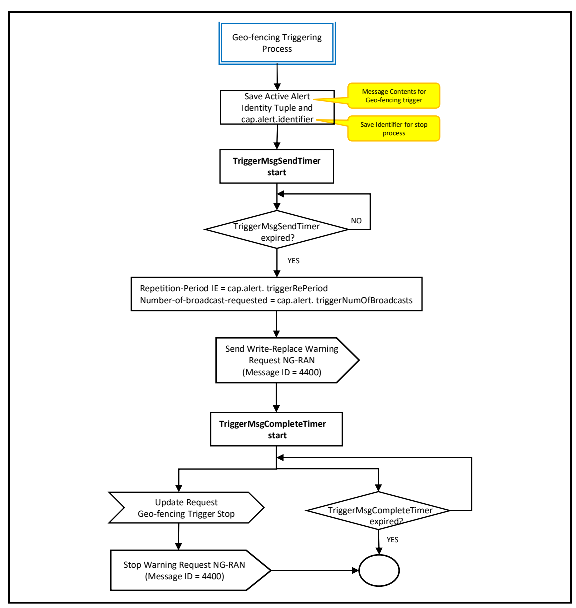

Fig. 6. Geo-Fencing Triggering process in CBCF

3) *UE behavior*

Figure 7 shows the flowchart of operations for the Device Based Geo-Fencing service and the Geo-Fencing Triggering service in the UE. The stored memory is retained for up to 24 hours, after which it is deleted.

When receiving the Geo-fencing trigger message (Message ID = 4400), the UE reads the CBS message stored in memory, compares its current position with the WAC, and displays it if it is inside the shape, otherwise it leaves it alone.

The purpose of Geo-Fencing Triggering is to prevent duplicate reception and ensure reliable delivery to the UEs that need to hear it. This can be useful for large topics to prevent entry into a specific area.

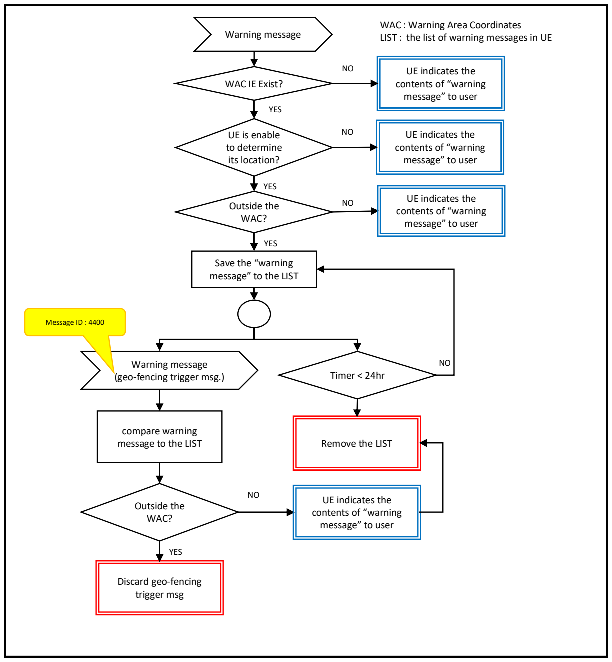

Fig. 7. UE behavior for Geo-Fencing Triggering

CONCLUSIONS

Device Based Geo-Fencing and Geo-Fencing Triggering improve the alert area accuracy and enhance the alert message service reliability, but they are not easy to service in practice. The issuance system is serviced on a nationwide basis, and it is relatively easy to upgrade to 2-3 units. But the mobile equipment is not easy to upgrade because it requires overall integration with mobile network equipment. In addition, legacy mobile devices are also a problem. When receiving information with a new data structure, it is not possible to determine what the mobile device will do. This is because there are many different manufacturers and various device models. Legacy mobile devices might be disconnected, locked, or rebooted because of longer length of alert messages.

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REFERENCES

[1] Hyunji Lee, Yunkwan Byun, Seokjin Jang, Seongjong Choi, Disaster character recognition survey, Korea Broadcasting and Media Engineering Association Fall Conference,2020.11

[2] H.J.Kang, S.L.Ju, S.H.Oh, W.S.Jung, "Service Trends by Country in Geography-based Public Warning Using Commercial Mobile Network", Electronics and Telecommunications Trends, Vol.38 No.3(2023. 6, p066-077,

[3] ATIS-0700041, Wireless Emergency Alerts(WEA) 3.0: Device-Based Geo-Fencing, 2019. 5.

[4] ITU-T X.1303bis CAP 1.2, Common alerting protocol (CAP 1.2), 2014

[5] Hyunjoo Kang, Seung-Hee Oh, Sang-Lim Ju, Woo-Sung Jung, Yong-Tae Lee, "A Proposal of Parameter Extension for Multilanguage in 5G CBS", ICTC 2021, p1437~1440, ISBN: 978-1-6654-2383-0

[6] Seung-Hee Oh, Hyunjoo Kang, Sang-Lim Ju, Woo-Sung Jung, Miryang Kim, "Technical Report of Alert Messages (Version 2.0)", 2023.4.30

[7] Kunho Park, Kyeungsu Pyo, Jihea Jeong, Wusuck Whang, Heejae Kim, "An empirical analysis of the importance and satisfaction of disaster text broadcasting", Journal of the Korean Urban Management Association, Vol.35 No.4(2022. 12) p179-191

[8] 3GPP TS 22.071 Location Service(LCS) Service description

[9] ATIS-0700041, Wireless Emergency Alerts(WEA) 3.0: Device-Based Geo-Fencing, 2019. 5.