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Brief Communication

Serial number classification-based energy-efficient transceiving scheme of warning messages in public warning system

Yang-Ick Joo†

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Abstract: A public warning system (PWS) provides notification to all user equipment (UE) during specific emergency situations such as earthquakes or tsunamis through an earthquake and tsunami warning system or a commercial mobile alert service messages of 3rd generation partnership project (3GPP) evolved-universal terrestrial radio access network (E-UTRAN) systems. During an emergency, 3GPP E-UTRANs broadcast special system information blocks (SIBs) containing warning information and causes UE to decode the SIBs by sending paging message. When a UE decodes the SIBs, it must display the warning information on the screen. In such an emergency situation, energy-efficient operation is strongly required to provide users with public safety services for a sufficiently long time to ensure safety. However, current 3GPP E-UTRANs cannot guarantee the energy-efficient operation of UE to obtain public safety information. Therefore, this paper proposes an energy-efficient transceiving scheme using the serial number type of SIBs. Performance evaluation using computer simulation shows that the proposed scheme improves the energy efficiency of the operation in PWS services.

Keywords: Public Warning System (PWS), Earthquake and Tsunami Warning System (ETWS), Commercial Mobile Alert Service (CMAS)

1. Introduction

A public warning system (PWS) is an emergency warning system that broadcasts early warning information via system information Blocks (SIBs) in 3rd generation partnership project (3GPP) evolved-universal terrestrial radio access network (E-UTRAN) systems. In the current standards of 3GPP E-UTRANs, earthquake and tsunami warning systems (ETWSs) and commercial mobile alert service (CMAS) systems are used to support early warning services through their system information broadcast capability. The E-UTRAN system pages the user equipment (UE) to provide notification that the warning is being broadcast. The “warning message content” received by the E-UTRAN contains an instance of the warning notification. Depending on the size, the E-UTRAN may segment the secondary notification before sending it over to the radio interface **[1]**.

The ETWS is a PWS developed to satisfy regulatory requirements for warning notifications related to earthquake and/or tsunami events. ETWS warning notifications can either be a primary or secondary notification providing detailed information **[1]**. Another PWS is a CMAS developed for the delivery of concurrent warning notifications. CMAS warning notifications are short text messages (CMAS alerts). The E-UTRAN manages the delivery of multiple CMAS warning notifications to the UE and manages any updates of CMAS warning notifications **[1]**.

Because the connectivity of UE is crucial for disseminating the warning messages, their transceiving operation must be energy efficient to guarantee the successful notification of the emergency situation. However, current 3GPP E-UTRAN systems do not provide UE with any reduction method of energy consumption by PWS services **[1]-[3]**. Although Y. Musaka *et al.* **[3]** introduced a delivery sequence for early warning messages, where proximity service (ProSe) is integrated into the ETWS; however, it is not applicable to general 3GPP E-UTRANs without supporting the ProSe. Therefore, this paper proposes an energy-efficient scheme to transceive the warning information by avoiding unnecessary duplicate receptions in UE.

This paper is organized as follows: Section 2 describes the protocol to support PWS services in the 3GPP E-UTRAN

† Corresponding Author (ORCID: http://orcid.org/0000-0003-3125-5316): Professor, Division of Electrical and Electronics Engineering, Korea Maritime & Ocean University, 727, Taejong-ro, Yeongdo-gu, Busan 49112, Korea, E-mail: yijoo@kmou.ac.kr, Tel: 051-410-4419

standard. In Section 3, an energy-efficient transceiving method is proposed for successful warning notifications. In Section 4, the performances of the proposed scheme are demonstrated by computer simulation. Finally, concluding remarks are presented in Section 5.

2. PWS in 3GPP E-UTRA Standard

An evolved NodeB (eNB) sends a *paging* message to ETWS- and/or CMAS-capable UE to inform the presence of ETWS and/or CMAS notifications. If the UE receives a *paging* message including the *etws-Indication* and/or *cmas-Indication* fields, it shall start receiving the ETWS and/or CMAS notifications according to the *schedulingInfoList* contained in SIB1. If the UE receives a *paging* message including *etws-Indication* and/or *cmas-Indication* while it is acquiring ETWS and/or CMAS notification(s), then the UE shall continue acquiring ETWS and/or CMAS notifications based on the previously acquired *schedulingInfoList* until it re-acquires *schedulingInfoList* in SIB1 **[2]**.

The ETWS notifications comprise primary and secondary notifications. The ETWS primary and secondary notifications are contained in SIB10 and SIB11, respectively. The CMAS notification is broadcast via SIB12. Segmentation can be applied for the delivery of the ETWS and/or CMAS notification (only for the secondary notification in the ETWS case). The segmentation size is fixed for the transmission of a specified segment with the same *messageIdentifier*, *serialNumber*, and *warningMessageSegmentNumber* within a cell **[2]**.

3. Proposed method

3.1 Problems of conventional technology

In a warning message transmission system based on the legacy system, because no mechanism exists on which a UE may determine the reception completion of a warning message, the UE cannot recognize message reception even when the UE has received all the warning messages of a specific *messageIdentifier*. Accordingly, the UE continues to receive the SIB to receive a warning message of a different *serialNumber* containing a specific *messageIdentifier* or receive a warning message containing a different *messageIdentifier* while the warning message indication information is set to “True” inside the *paging* message, i.e., until a *paging* message where the warning message indication information set to “False” is received. Therefore, in the warning message transmission system based on conventional technology, a UE repeatedly receives a warning message containing the same *serialNumber* with respect to a specific *messageIdentifier*, thereby increasing the reception energy consumption.

3.2 Prevention from repeated receptions of PWS notifications

According to the proposed scheme, the E-UTRAN provides information if a warning message should be received by the ETWS- or CMAS-capable UE as well as the range information of a relevant warning message when transmitting the warning message, such that the eNB may determine the range at which the UE starts and ends relevant warning message reception to prevent the UE from a duplicate reception of a SIB including the same warning message, thereby minimizing unnecessary energy consumption from the related receiving operation.

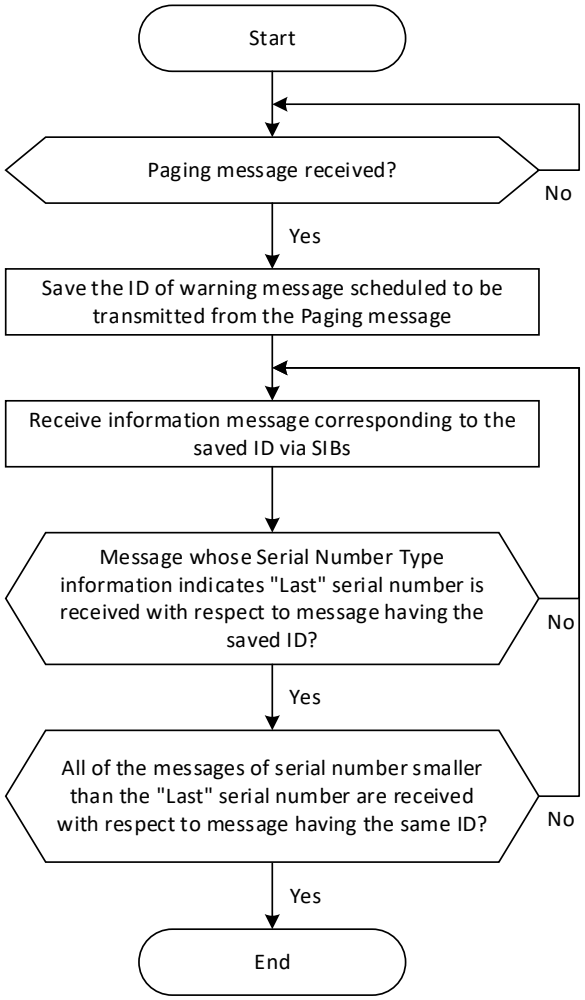

Figure 1: Flowchart of proposed scheme

Figure 1 shows a flowchart of the warning message receiving procedure of a UE in detail. When the *paging* message with an ETWS and/or a CMAS indication is received, the UE saves the ID (*messageIdentifier*) of a warning message scheduled to be transmitted from the received *paging* message, whereas the UE receives warning messages corresponding to the saved ID via a SIB. Subsequently, the UE verifies whether a warning message whose serial number type (*serialNumberType*) information has been set to "Last" is received with respect to the message containing the saved ID. If the warning message with the "Last" indication has not been received, then the UE continues to receive a warning message containing a relevant ID. When it is received, the UE determines whether all messages whose serial number (*serialNumber*) is smaller than the last serial number have been received. If all messages whose serial number is smaller than the last serial number have been received, then the UE considers that the reception of a warning message for a related ID has been completed.

Figure 2 illustrates the proposed SIB fields (ASN.1 format) of SIB10, SIB11, and SIB12 for the ETWS and CMAS. The bold part of the figure displays the additional field in the proposed method. Because this format conforms to the 3GPP E-UTRAN standard, it can be applied easily to commercial systems.

```
SystemInformationBlockType## ::= SEQUENCE
{
    messageIdentifier BIT STRING (SIZE (16)),
    serialNumber      BIT STRING (SIZE (16)),
    serialNumberType  ENUMERATED {Normal, Last},
    …
}
```

Figure 2: Proposed SIB message field (ASN.1 format)

4. Performance Evaluation

To evaluate the energy efficiency of the proposed method, unit energy consumptions were measured for the ETWS or CMAS indication duration.

Figure 3 shows the accumulated unit energy consumption per unit time duration that was used to receive all the required warning messages. In this figure, the energy efficiencies of the legacy 3GPP E-UTRAN standard and the proposed scheme are compared from the time of "indication ON" to "indication OFF." Cases I and II depend on the time at which all the transmissions of the warning message that should be received by the UE have been completed by a serving eNB without considering wireless channel conditions.

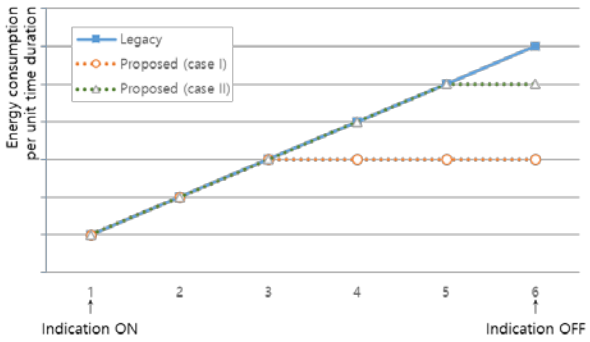

Figure 3: Performance evaluation of energy consumption

As shown in this figure, every UE in the legacy 3GPP E-UTRAN continues to receive the SIB(s) relevant to the PWS services until *etws-Indication* and/or *cmas-Indication* are reset, i.e. the fields do not appear in the *paging* message.

5. Conclusion

The proposed method provides information that enables a UE to determine the time to start and end the reception of the corresponding warning message, thereby preventing duplicate SIB reception. Hence, unnecessary reception power wastage can be minimized.

As the proposed scheme complies with the 3GPP E-UTRAN standard, it can be applied easily to commercial mobile communication services.

Author Contributions

Conceptualization, Y. -I. Joo ; Methodology, Y. -I. Joo; Writing-Original Draft Preparation, Y. -I. Joo; Validation, Y. -I. Joo; Writing-Review & Editing, Y. -I. Joo.

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