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Brief Communication

Energy-efficient transceiving scheme using last serial number notification of warning messages in public warning system

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Abstract: A public warning system (PWS) notifies all the user equipment (UE) in a specific area about a disaster, such as an earthquake or a tsunami, through the earthquake and tsunami warning system (ETWS) or the commercial mobile alert service (CMAS) messages of 3rd generation partnership project (3GPP) evolved-universal terrestrial radio access network (E-UTRAN) systems. In an emergency situation such as a natural disaster, special system information blocks (SIBs) that contain warning information are broadcasted by 3GPP E-UTRANs. The E-UTRAN sends paging messages to notify about the warning information and to enable UE in the area to decode the SIBs and display the warning information on the screen. In such situations, public safety services should be provided for a sufficient time to ensure safety in an energy-efficient manner. However, conventional commercial networks do not support the energy-efficient operation of UE during an emergency. Therefore, in this paper, an energy-efficient transceiving scheme that uses the last serial number notification of warning messages is proposed. The performance of the scheme is evaluated using a computer simulation. The simulation results demonstrate that the proposed scheme improves the energy efficiency of the operation.

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

1. Introduction

Public warning systems (PWSs) effectively transmit messages to warn people about serious emergencies in a timely manner. Commercial PWSs, the 3rd generation partnership project (3GPP) evolved-universal terrestrial radio access network (E-UTRAN) systems, broadcast system information blocks (SIBs) that contain early warning information. According to the present standards of 3GPP E-UTRANs, the earthquake and tsunami warning system (ETWS) and commercial mobile alert service (CMAS) are designed for the transmission of warning information using the capability of system information broadcast **[1]**. The E-UTRAN system pages the user equipment (UE) to provide an indication that an early warning information is being broadcasted **[2]**.

ETWS is a PWS developed to fulfill regulatory requirements for warning notifications related to natural disasters such as earthquake and/or tsunami events. An ETWS notification can be a primary or a secondary notification that provides detailed information **[2]**. Furthermore, CMAS is a type of PWS developed for the delivery of concurrent warning notifications. E-UTRAN manages the delivery of multiple CMAS warning notifications to the UE and the updates of CMAS warning notifications **[2]**.

Since the connectivity of UE is crucial for the dissemination of warning messages, the energy-efficient transceiving of warning messages is required for the successful notification of an emergency situation for a sufficient time and to ensure safety. However, conventional 3GPP E-UTRAN systems do not consider the energy-efficient operation of UE during an emergency situation **[2]-[4]**. Y. Musaka *et al.* **[4]** introduced a delivery sequence for early warning messages, in which the proximity service (ProSe) was integrated into the ETWS. However, it was not applicable to conventional 3GPP E-UTRANs without supporting the ProSe. Y. –I. Joo **[1]** designed a transceiving scheme for warning messages. However, it consumed resources to indicate the serial number type and its related processing power. Therefore, this paper proposes an energy-efficient scheme to transceive warning information via paging messages.

This paper is organized as follows: Section 2 explains the message exchanging protocol for the PWS services defined in the 3GPP E-UTRAN standard. In Section 3, the proposed method for energy-efficient warning notifications is described. In Section 4, the performances of the proposed scheme are demonstrated by computer simulation. Finally, concluding remarks are presented in Section 5.

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2. PWS in 3GPP E-UTRA Standard

The *paging* message is sent by an evolved NodeB (eNB) to inform ETWS- and/or CMAS-capable UE about the presence of ETWS and/or CMAS notifications. When the ETWS- and/or CMAS-capable UE receives a *paging* message with the indication(s) (the *etws-Indication* and/or *cmas-Indication* fields) that are/is set to TRUE, the UE starts 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 it shall continue acquiring ETWS and/or CMAS notifications based on the previously acquired *schedulingInfoList* until it re-acquires *schedulingInfoList* in SIB1 **[3]**.

ETWS notifications include primary and secondary notifications. The SIB10 and SIB11 are broadcast containing primary and secondary ETWS notifications, respectively. SIB12 is used to broadcast CMAS notifications. Segmentation can be applied for the delivery of ETWS and/or CMAS notification (only for the secondary notification in the ETWS case) **[3]**.

3. Proposed method

3.1 Problem of conventional technology

In the case of PWS message broadcasting based on the legacy system, since a mechanism for which a UE might determine the completion of a warning message reception is absent, the UE cannot finish the reception of the message even when it has received all the warning messages of a specific *messageIdentifier*. Therefore, the UE continuously receives the corresponding SIBs to obtain a warning message with a different *serialNumber* of a specific *messageIdentifier*. Therefore, in the warning message transmission system based on the 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 **[1]**.

To solve the problem, an energy-efficient message transceiving scheme was proposed in **[1]**. It prevented unnecessary duplicate reception by indicating the serial number type. However, it required additional resources to indicate the serial number type and consumed the related processing power. Therefore, this paper proposes an enhanced energy-efficient scheme to transceive the warning information via paging messages.

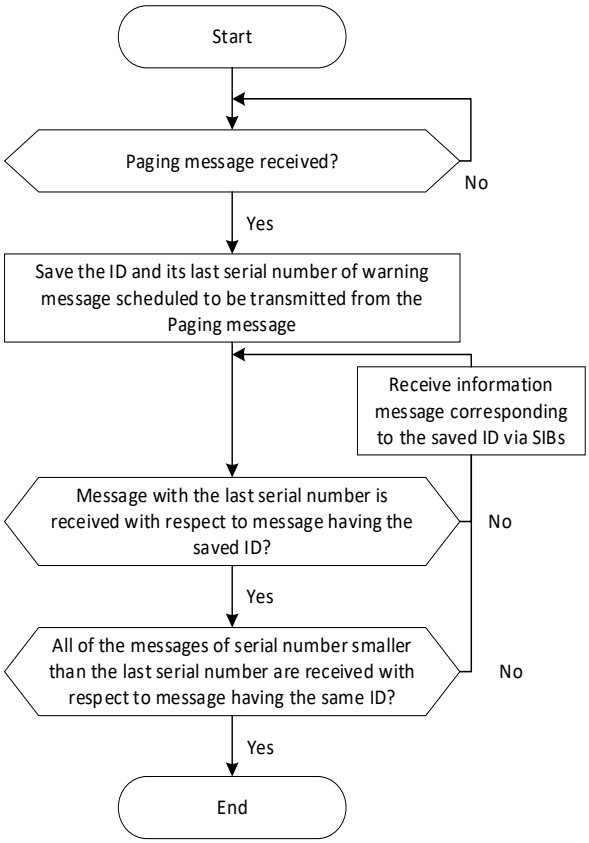

Figure 1: Flowchart of the proposed scheme

3.2 Energy-efficient message transceiving scheme for PWS services

According to the proposed scheme, E-UTRAN provides information about the existence of a warning message in the relevant SIBs as well as the information of the range at which the UE terminates the reception of relevant messages to prevent the UE from a duplicate reception of a SIB including the same warning information. Therefore, unnecessary energy consumption from the related receiving operation of the UE and the transmitting operation of the eNB is minimized.

Figure 1 shows the receiving procedure of a warning message of a UE in detail. When a *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 and its last serial number (*lastSerialNumber*) from the received *paging* message and starts acquiring the warning information corresponding to the saved ID via SIBs. Subsequently, the UE verifies whether a warning message with the saved last serial number is received. If the warning message with the last serial number has not been received, then the UE continues to receive a warning message with the same ID. When it is received, the UE

checks whether all of the messages of serial number smaller than the last serial number have been received. If all these messages have been received, then the UE recognizes that the reception of a warning message for a related ID has been completed.

Figure 2 illustrates the proposed *paging* message fields (ASN.1 format) in case of ETWS service. The CMAS service can also be designed similarly. The additional field in the proposed method is highlighted in bold.

```
Paging ::= SEQUENCE {
…
etwsInfoList   EtwsInfoList,      // sequence of EtwsInfo
…
}
EtwsInfo ::= SEQUENCE {
    messageIdentifier   BIT STRING,
    lastSerialNumber   BIT STRING,
…
}
```

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

Therefore, the UE can save the processing power of receiving SIB procedure compared with that of the scheme in **[1],** since the method in **[1]** has to parse the additional field by the number of *serialNumber*. From the perspective of eNB, the wireless channel resources can be saved because the eNB does not have to carry the fields of serial number type in each relevant SIB, which is different from that of **[1]**.

4. Performance Evaluation

To evaluate the performance of the proposed method, the accumulated unit energy consumption per unit time duration was used to receive all the required warning messages.

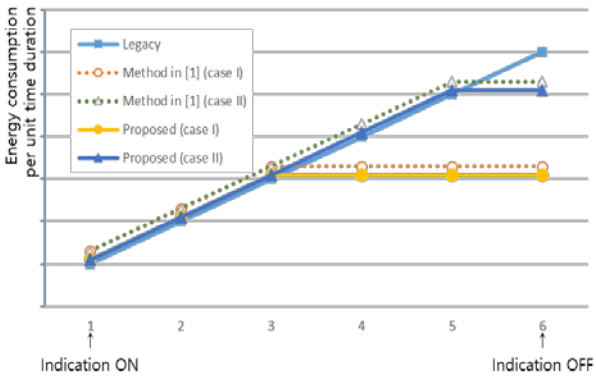

Figure 3: Performance evaluation of energy consumption

Figure 3 shows the results. In this figure, the energy efficiencies of the legacy 3GPP E-UTRAN standard, the method proposed in **[1]**, and the proposed scheme from the time of "indication ON" to "indication OFF" are compared. Cases I and II depend on the time at which the transmissions of the warning message that should be received by the UE were completed by a serving eNB without considering wireless channel conditions.

As shown in this figure, the UEs in the legacy system continue 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. The methods in **[1]** and this paper show a slightly greater energy consumption thana that of other methods till the completion time of warning messages since they have additional fields. However, these schemes demonstrate a better performance with respect to the overall energy efficiency. The proposed method is comparatively energy-efficient because it reduces the additional field in **[1]**.

5. Conclusion

The proposed method reduces unnecessary reception power wastage with minimum additional field of message. As the proposed scheme complies with the commercial standard, it can be easily applied to legacy 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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