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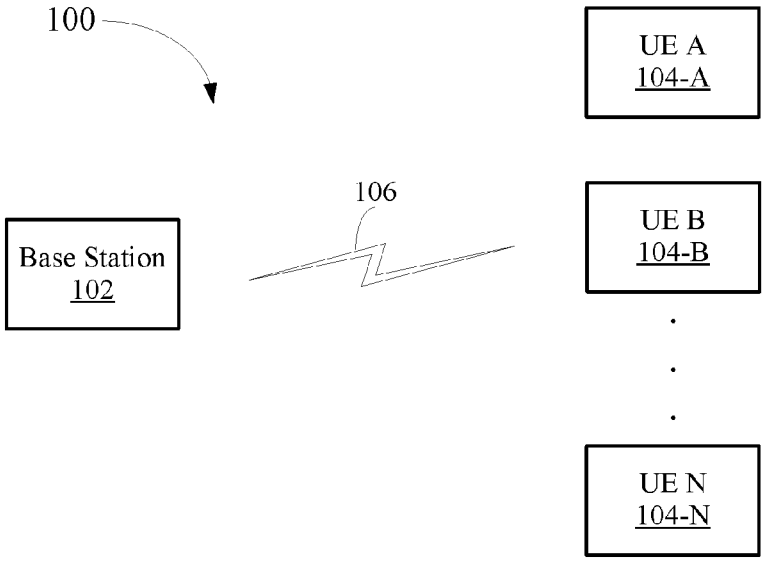
(54) Title: METHODS OF TRANSMITTING MISSION CRITICAL SMALL DATA USING RANDOM ACCESS CHANNEL

FIG. 1A



(57) Abstract: A method for a user equipment to transmit a short message to a base station includes the following operations: generating a short message; choosing, among a plurality of codebooks, a codebook corresponding to the short message; identifying, in the codebook, a code word corresponding to a radio network temporary identity (RNTI) of the user equipment; dividing the code word into one or more binary sequences; mapping the one or more binary sequences to one or more random access channel (RACH) preambles; and transmitting the one or more RACH preambles to the base station using a random access channel.

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METHODS OF TRANSMITTING MISSION CRITICAL SMALL DATA USING RANDOM ACCESS CHANNEL

TECHNICAL FIELD

[0001] This application generally relates to wireless telecommunication and particularly relates to methods of transmitting mission critical small data in a wireless network using a random access channel.

BACKGROUND

[0002] In a typical wireless communications environment (e.g., Long Term Evolution (LTE)), a user equipment (UE) communicates voice and/or data signals with one or more service networks via base stations (also referred to as "evolved Node-Bs" (eNBs)). In such wireless communication system, a UE may initiate a random access procedure to communicate with a base station for many events. The random access procedure can be performed in a contention-based or non-contention-based manner depending on whether a Random Access Channel (RACH) resource used by the UE is randomly selected by the UE itself or assigned by the network.

[0003] Recently, an emerging technology (e.g., the Internet of Things) has received a lot of attention because it empowers full mechanical automation of operating many devices by enabling them to communicate with each other. Such communications among those machine-type communications (MTC) devices are known as machine-to-machine (M2M) communications. MTC communication has some different features than current human-to-human (H2H) communications. For example, a MTC device such as a smart meter may generate a very small data transmission during its report time interval and then go to sleep for a long time interval. In another example, a MTC device (e.g., a fire alarm) may only transmit a small-size but mission-critical alarm message.

[0004] Currently, the aforementioned random access procedure has to be performed to enable the data transmission regardless of the size and importance of the data to be transmitted each time, resulting significant overhead. In addition, it is difficult to transmit the mission-critical but small-size data over any uplink channel other than the scheduled PUSCH in the current LTE specification. But the limited number of PUSCH resource block (RB) may

not be able to support a large number of MTC devices within a specific area, resulting in unpredictable transmission delays.

SUMMARY

[0005] An object of the present application is to provide a method for transmitting mission-critical small data between UE and base station using a random access channel with reduced overhead and time delay.

[0006] According to a first aspect of the present application, a method for a user equipment to transmit a short message to a base station includes the following operations: generating a short message; choosing, among a plurality of codebooks, a codebook corresponding to the short message; identifying, in the codebook, a code word corresponding to a radio network temporary identity (RNTI) of the user equipment; dividing the code word into one or more binary sequences; mapping the one or more binary sequences to one or more random access channel (RACH) preambles; and transmitting the one or more RACH preambles to the base station using a random access channel.

[0007] According to a second aspect of the present application, a method for a base station to decode a short message transmitted from a user equipment within coverage of the base station includes the following operations: receiving one or more random access channel (RACH) preambles from the user equipment via a random access channel; determining one or more binary sequences by decoding the one or more RACH preambles; combining the one or more binary sequences into a code word; determining a short message by decoding the code word; choosing, among a plurality of codebooks, a codebook corresponding to the short message; and identify, in the chosen codebook, an RNTI of the user equipment, wherein the RNTI corresponds to the code word..

[0008] According to a third aspect of the present application, a base station includes one or more processors, memory and a plurality of instructions stored in the memory that, when executed by the one or more processors, perform a plurality of operations as described above in connection with the base station.

BRIEF DESCRIPTION OF DRAWINGS

[0009] The accompanying drawings, which are included to provide a further understanding of the embodiments and are incorporated herein and constitute a part of the specification,

illustrate the described embodiments and together with the description serve to explain the underlying principles. Like reference numerals refer to corresponding parts.

[0010] FIG. 1A is a block diagram of an exemplary wireless communication system in which embodiments of the present application may be practiced.

[0011] FIG. 1B is a block diagram illustrating a contention-based random access procedure that includes multiple steps.

[0012] FIG. 2A is a block diagram illustrating the UE-side operations for transmitting a short, mission-critical message to a base station according to some embodiments of the present application.

[0013] FIG. 2B is a block diagram illustrating the base station-side operations for receiving a short, mission-critical message from a UE according to some embodiments of the present application.

[0014] FIG. 3 is a flowchart illustrating one embodiment of a method for transmitting a short, mission-critical message from a UE to a base station according to some embodiments of the present application.

[0015] FIG. 4 is a flowchart illustrating one embodiment of a method for receiving a short, mission-critical message from a UE according to some embodiments of the present application.

DETAIL DESCRIPTIONS

[0016] Reference will now be made in detail to embodiments, examples of which are illustrated in the accompanying drawings. In the following detailed description, numerous non-limiting specific details are set forth in order to assist in understanding the subject matter presented herein. But it will be apparent to one of ordinary skill in the art that various alternatives may be used without departing from the scope of claims and the subject matter may be practiced without these specific details. With reference now to the figures, exemplary block diagrams of data processing environments are provided in which illustrative embodiments may be implemented. It should be appreciated that these figures are only exemplary and are not intended to assert or imply any limitation with regard to the

environments in which different embodiments may be implemented. Many modifications to the depicted environments may be made.

[0017] FIG. 1A is a block diagram of an exemplary wireless communication system 100 in which embodiments of the present application may be practiced. A base station 102 is in wireless communication with a plurality of user equipments 104 (which may also be referred to as user devices, mobile stations, subscriber units, access terminals, etc.). A first user equipment (UE) 104-A, a second user equipment (UE) 104-B, and an n-th user equipment 104-N are shown in FIG. 1A. The base station 102 transmits data to and receives data from the UEs 104 over a radio frequency (RF) communication channel 106.

[0018] As used herein, the term "transmitter" refers to any component or device that transmits signals. A transmitter may be implemented in a base station 102 that transmits signals to one or more user equipments 104. Alternatively, a transmitter may be implemented in a user equipment 104 that transmits signals to one or more base stations 102. The term "receiver" refers to any component or device that receives signals. A receiver may be implemented in a user equipment 104 that receives signals from one or more base stations 102. Alternatively, a receiver may be implemented in a base station 102 that receives signals from one or more user equipments 104. The communications system 100 may comply with various wireless communication technologies, such as the Global System for Mobile communications (GSM) technology, Wideband Code Division Multiple Access (WCDMA) technology, Time Division-Synchronous Code Division Multiple Access (TD-SCDMA) technology, Long Term Evolution (LTE) technology, and others.

[0019] FIG. 1B is a block diagram illustrating a contention-based random access procedure that includes the following four steps: (1) random access preamble step on Physical Random Access Channel (PRACH); (2) random access response step on Physical Downlink Shared Channel (PDSCH) with UE addressing using Random Access Radio Network Temporary Identity (RA-RNTI) on Physical Downlink Control Channel (PDCCH); (3) scheduled transmission step on Physical Uplink Shared Channel (PUSCH); and (4) contention resolution step on Physical Downlink Shared Channel (PDSCH).

[0020] In the random access preamble step, UE 104 selects one of the 64 available RACH preambles. In other words, only 6-bit random access preamble ID information is conveyed in the random access preamble step. The random access response message replied from the base

station 102 includes the following information: (i) the 6-bit random access preamble ID, (ii) a timing alignment value for the UE 104 to change its timing, (iii) an initial uplink grant resource so that the UE 104 can use the PUSCH in the subsequent step and (iv) Cell Radio Network Temporary Identity (C_RNTI) for further communication. After receiving the valid random access response message from the base station 102, the UE 104 allocates the resources according to the initial uplink grant resource and transmits a scheduled transmission with C_RNTI on PUSCH. Note that, in the current LTE specification, the size of the transport blocks is at least 80 bits. Finally, the base station 102 uses this optional contention resolution step to end the random access procedure.

[0021] As noted above, the aforementioned random access procedure has to be completed to enable data transmission between an UE and a base station regardless of the size of the data to be transmitted whenever a data transmission is to be performed in the current LTE wireless communication system. This requires a large amount of signaling overhead and may result in an unpredictable transmission delay. There are at least two problems for this approach to be adopted for the machine-to-machine communications: (i) the unpredictable transmission delay makes it unfit for those mission-critical applications (e.g., a firm alarm); and (ii) the allocated PUSCH resource may not be efficiently utilized because messages from a MTC device are much smaller than the allocated PUSCH resource.

[0022] The present application proposes a solution to the aforementioned problem by embedding small-size but mission-critical data (e.g., an alarm message of multiple bits long and generated by a fire alarm sensor) in the initial random access preamble transmission step from the UE to the base station. In addition to the small-size but mission-critical data, the other information required by the base station is the originator of the data, i.e., the UE ID. In other words, the base station needs to know at least the alarm message itself and the fire alarm sensor that generates the alarm message before taking any further actions, e.g., sending a report message to a remote device (e.g., a server or a mobile terminal such as a smartphone).

[0023] For illustrative purposes, it is assumed in the following example that there are less than or equal to 65536 UEs (e.g., MTC devices) within a base station's coverage and a mission-critical message generated by one of the UEs is a 2-bit long alarm message with four possible values. Thus, the current 16-bit RNTI is long enough as an UE ID to differentiate these MTC devices within a base station's coverage. Note that when the number of UEs

within a base station's coverage exceeds 65536, a new UE ID whose length is longer than 16 bits is required to uniquely identify individual UEs with the base station's coverage. In order for a UE to transmit a mission-critical message, the UE's 16-bit RNTI is encoded into one of a plurality of code words that is 24-bit or longer within a codebook. The codebook is uniquely associated with the mission-critical message such that each code word within the codebook corresponds to the same mission-critical message from a particular UE. The code word is then divided into one or more 6-bit binary sequences, which are then mapped to one or more random access preambles and transmitted to the base station in the initial random access preamble transmission step.

[0024] FIG. 2A is a block diagram illustrating the UE-side operations for transmitting a 2-bit, mission-critical alarm message to a base station according to some embodiments of the present application. As shown in FIG. 2A, the UE first selects, among multiple RNTI codebooks 200, a particular one 201 corresponding to the 2-bit alarm message. Given the UE's RNTI, a particular code word X within the selected codebook 201 is then identified as being mapped to the RNTI. For ease of description, every 2 bits of the codeword X are grouped together as a binary sequence having a sequential order. For example, '00' are label as 'A' symbol, '01' as 'B' symbol, '11' as 'C' symbol and '10' as 'D' symbol, respectively.

[0025] For example, if the alarm message is "00", the output code word X of the corresponding RNTI is configured to contain more 'A' symbols than any other symbols. In one embodiment, the output codeword X has 6 'A' symbols, 2 'B' symbols, '2' C symbols and '2' D symbols. Thus the total number of possible code words within a codebook corresponding to a particular alarm message with a predefined symbol distribution is determined by the different orderings of A, B, C and D symbols. In this example, the total number is C(12, 6)*C(6, 2)*C(4, 2)*C(2, 2)=83160, which is larger than 65536, i.e., the total number of all possible 16-bit RNTI information sequences. Consequently, we can randomly choose 65536 code words among the possible 83160 code words to populate an RNTI codebook for a corresponding alarm message. Table 1 shows an exemplary RNTI codebook when the alarm message is "00".

Table 1. Exemplary RNTI codebook when the alarm message is "00"

RNTI	**Code Word X**	**Code Word X represented in 2-bit sequences of symbols**
0000000000000000	00000000000000010111111010	AAAAAABBCCDD
.....	.....	.....
1111111111111111	10000000000000010111111000	DAAAAABBCCDA

[0026] Similarly, an RNTI codebook can be generated when the alarm message is "01", "11" or "10", respectively, by having more 'B', 'C' or 'D' symbols in a code word X. In other words, the RNTI of the same UE is mapped to different code words within different codebooks for different alarm messages. But for a particular codebook, the RNTI corresponds to one and only one code word (e.g., code word X shown in FIG. 2A).

[0027] Table 2 shows exemplary symbol distributions of a code word X for different alarm message.

Table 2. Exemplary symbol distribution of the code word X for different alarm messages

Alarm	**Symbol distribution of X represented in 2-bit sequences of symbols**
00	**6A**, 2B, 2C, 2D
01	2A, **6B**, 2C, 2D
11	2A, 2B, **6C**, 2D
10	2A, 2B, 2C, **6D**

[0028] Note that other distributions of symbols in the code word X is also feasible as long as the occurrence of 'A', 'B', 'C' and 'D' symbols are not equal within a code word and the number of different orderings of that symbol distribution is larger than the number of all possible RNTIs assuming that RNTI is used as the UE ID for the MTC devices within a base station's coverage. For example, having 5A, 2B, 3C and 2D in the code word X is another possible symbol distribution because the total number of possible code words for the RNTI

codebook C(12, 5)*C(7, 2)*C(5, 3)*C(2, 2)=166320, which is greater than 65536. The symbol distribution can be chosen to meet different error quality targets for the RNTI and the alarm message. Also note that the length of the code word X can be chosen to meet different error quality targets for the RNTI and the alarm message. For example, a 30-bit codeword of X can be chosen to have 9 A symbols, 2 B symbols, 2 C symbols and 2 D symbols for the alarm message of "00" for a much larger possible code word space for the RNTI codebook. In this example, C(15,9)*C(6,2)*C(4,2)*C(2,2)=450450.

[0029] After identifying the code word X, the UE converts the code word X into one or more RACH preambles so that they can be transmitted by the PRACH procedure. In this step, the code word X is divided into one or more groups of 6-bit sequences, which are then mapped to one or more RACH preambles to be transmitted by the UE. As shown in FIG. 2A, let xk denotes the k-th bit of the code word X where k is from {1, …, 24}, the value of the binary sequence of {x1, x2, x3, x4, x5, x6} defines a first RACH preamble configuration index P1; the value of the binary sequence of {x7, x8, x9, x10, x11, x12} defines the second RACH preamble configuration index P2; the value of the binary sequence of {x13, x14, x15, x16, x17, x18} defines the third RACH preamble configuration index P3; the value of the binary sequence of {x19, x20, x21, x22, x23, x24} defines the fourth RACH preamble configuration index P4.

[0030] Next, the UE transmits the above-determined RACH preambles in an order of P1, P2, P3 and P4. In some embodiments, there is a time interval between each RACH preamble transmission. Such time interval can be pre-defined or configured by the system/network/eNB and broadcast to UEs using high-layer signaling.

[0031] FIG. 2B is a block diagram illustrating the base station-side operations for recovering a short, mission-critical message from a UE according to some embodiments of the present application. As shown in the figure, after the base station receives these random access preamble messages from the UE, the base station first re-generates the code word X and then decodes the alarm message by checking the distribution of the received symbols within the re-generated code word X. Let N_A, N_B, N_C and N_D denote the corresponding number of A, B, C and D symbols in the reconstructed code word X. Table 3 shows an exemplary predefined rule of decoding the alarm message.

Table 3. Exemplary rule of decoding the alarm message

Condition	**Alarm message decision**
N_A is the largest among N_A, N_B, N_C and N_D	00
N_B is the largest among N_A, N_B, N_C and N_D	01
N_C is the largest among N_A, N_B, N_C and N_D	11
N_D is the largest among N_A, N_B, N_C and N_D	10

[0032] Using the alarm message, the base station selects the same RNTI codebook 201 that has been used by the UE as described above. In other words, both the base station and the UE have the same set of RNTI codebooks 200 in order for the UE to transmit the short mission-critical message to the base station. Within the RNTI codebook 201, the code word X is found and the corresponding RNTI is identified accordingly as the UE ID.

[0033] FIG. 3 is a flowchart illustrating one embodiment of a method for transmitting a short, mission-critical message from a UE to a base station according to some embodiments of the present application. First, the UE generates (310) a short alarm message. In some embodiments, the UE is communicatively coupled to a third-party device adjacent to the user equipment (e.g., a firm alarm sensor or a smart meter) and the UE generates a short alarm message in response to an alarm signal from the firm alarm sensor. In some other embodiments, the other device is a smart meter and the UE receives a parameter (e.g., power usage) provided by the smart meter on a regular basis and then generates one or more short messages including the value of the parameter. Next, the UE chooses (320) a codebook corresponding to the alarm message. As noted above, the codebook is configured such that it corresponds to a unique short message generated by the user equipment. The UE then identifies (330) a code word within the codebook corresponding to the UE's identifier (e.g., RNTI). In other words, each entry within a codebook defines a unique mapping relationship between a code word and an RNTI of a user equipment within coverage of the base station. By doing so, the base station can recover the RNTI when it receives the code word. Next, the UE divides (340) the code word into one or more binary sequences and maps (350) the one or more binary sequences to one or more RACH preambles. For example, each binary sequence is mapped to one RACH preamble as described above in connection with FIG. 2A. Finally,

the UE transmits (360) the one or more RACH preambles to a base station using a corresponding random access channel between the UE and the base station.

[0034] FIG. 4 is a flowchart illustrating one embodiment of a method for receiving a short, mission-critical message from a UE according to some embodiments of the present application. First, the base station receives (410) one or more random access preambles from a UE via a random access channel (e.g., PRACH). As described above, the base station decodes (420) the random access preambles to determine one or more binary sequences. Next, the base station combines (430) the binary sequences to re-generate the code word as described above in connection with FIG. 2B, which then is used to determine (440) a short message corresponding to the code word. Next, the base station chooses (450), among a plurality of codebooks, a codebook that corresponds to the short message. Finally, the base station identifies (460), in the chosen code book, an RNTI of the user equipment based on, e.g., a mapping relationship between the RNTI and the corresponding to the code word.

[0035] In some embodiments, the plurality of codebooks are generated by a server and then given to the base station, which then shares them with a plurality of user equipments within coverage of the base station. Whenever there is any update to the codebooks, the base station transmits updated codebooks to the plurality of user equipments within coverage of the base station.

[0036] The description of the present application has been presented for purposes of illustration and description, and is not intended to be exhaustive or limited to the invention in the form disclosed. Many modifications and variations will be apparent to those of ordinary skill in the art. The embodiment was chosen and described in order to best explain the principles of the invention, the practical application, and to enable others of ordinary skill in the art to understand the invention for various embodiments with various modifications as are suited to the particular use contemplated.

[0037] The terminology used in the description of the embodiments herein is for the purpose of describing particular embodiments only and is not intended to limit the scope of claims. As used in the description of the embodiments and the appended claims, the singular forms “a,” “an,” and “the” are intended to include the plural forms as well, unless the context clearly indicates otherwise. It will also be understood that the term “and/or” as used herein refers to and encompasses any and all possible combinations of one or more of the associated

listed items. It will be further understood that the terms "comprises" and/or "comprising," when used in this specification, specify the presence of stated features, integers, steps, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, integers, steps, operations, elements, components, and/or groups thereof.

[0038] It will also be understood that, although the terms first, second, etc. may be used herein to describe various elements, these elements should not be limited by these terms. These terms are only used to distinguish one element from another. For example, a first port could be termed a second port, and, similarly, a second port could be termed a first port, without departing from the scope of the embodiments. The first port and the second port are both ports, but they are not the same port.

[0039] Many modifications and alternative embodiments of the embodiments described herein will come to mind to one skilled in the art having the benefit of the teachings presented in the foregoing descriptions and the associated drawings. Therefore, it is to be understood that the scope of claims are not to be limited to the specific examples of the embodiments disclosed and that modifications and other embodiments are intended to be included within the scope of the appended claims. Although specific terms are employed herein, they are used in a generic and descriptive sense only and not for purposes of limitation.

[0040] The embodiments were chosen and described in order to best explain the underlying principles and their practical applications, to thereby enable others skilled in the art to best utilize the underlying principles and various embodiments with various modifications as are suited to the particular use contemplated.

WHAT IS CLAIMED IS:

1. A method for a user equipment to transmit a short message to a base station, comprising:

generating a short message;

choosing, among a plurality of codebooks, a codebook corresponding to the short message;

identifying, in the codebook, a code word corresponding to a radio network temporary identity (RNTI) of the user equipment;

dividing the code word into one or more binary sequences;

mapping the one or more binary sequences to one or more random access channel (RACH) preambles; and

transmitting the one or more RACH preambles to the base station using a random access channel.

2. The method of claim 1, wherein the user equipment is communicatively coupled to a third-party device adjacent to the user equipment and the short message is related to the third-party device.

3. The method of claim 2, wherein the user equipment is configured to automatically generate the short message according to a predefined schedule, the short message including a parameter provided by the third-party device.

4. The method of claim 2, wherein the user equipment is configured to automatically generate the short message in response to an alarm signal provided by the third-party device.

5. The method of claim 1, wherein each of the plurality of codebooks corresponds to a unique short message generated by the user equipment.

6. The method of claim 1, wherein each entry within a codebook defines a unique mapping relationship between a code word and an RNTI of a user equipment within coverage of the base station.

7. The method of claim 1, wherein the base station is configured to:

receive the one or more RACH preambles from the user equipment;

determine the one or more binary sequences by decoding the one or more RACH preambles;

combining the one or more determined binary sequences into a code word;

determine the short message by decoding the code word;

choose, among a plurality of codebooks, a codebook corresponding to the determined short message;

identify, in the chosen codebook, the RNTI corresponding to the code word; and

submitting a report message to a remote server, the report message including the determined short message and the RNTI.

8. The method of claim 1, wherein the base station is configured to share the plurality of codebooks with a plurality of user equipments within coverage of the base station.

9. The method of claim 8, wherein the base station is configured to update the plurality of codebooks according to a predefined schedule and transmit the updated codebooks to the plurality of user equipments within coverage of the base station.

10. The method of claim 1, wherein a total number of code words within a respective codebook is no less than a total number of user equipments within coverage of the base station.

11. A method for a base station to decode a short message transmitted from a user equipment within coverage of the base station, comprising:

receiving one or more random access channel (RACH) preambles from the user equipment via a random access channel;

determining one or more binary sequences by decoding the one or more RACH preambles;

combining the one or more binary sequences into a code word;

determining a short message by decoding the code word;

choosing, among a plurality of codebooks, a codebook corresponding to the short message; and

identify, in the chosen codebook, an RNTI of the user equipment, wherein the RNTI corresponds to the code word.

12. The method of claim 11, wherein the user equipment is communicatively coupled to a third-party device adjacent to the user equipment.

13. The method of claim 11, wherein each of the plurality of codebooks corresponds to a unique short message generated by the user equipment.

14. The method of claim 11, wherein each entry within a codebook defines a unique mapping relationship between a code word and an RNTI of a use equipment within coverage of the base station.

15. The method of claim 11, wherein the user equipment is configured to:

generate a short message;

choose, among a plurality of codebooks, a codebook corresponding to the generated short message;

identify, in the chosen codebook, a code word corresponding to the RNTI of the user equipment;

dividing the code word into the one or more binary sequences;

mapping the one or more binary sequences into the one or more RACH preambles; and

transmitting the one or more RACH preambles to the base station using the random access channel.

16. The method of claim 11, wherein the base station is configured to share the plurality of codebooks with a plurality of user equipments within coverage of the base station.

17. The method of claim 16, wherein the base station is configured to update the plurality of codebooks according to a predefined schedule and transmit the updated codebooks to the plurality of user equipments within coverage of the base station.

18. The method of claim 11, wherein a total number of code words within a respective codebook is no less than a total number of user equipments within coverage of the base station.

19. A base station configured to decode a short message transmitted from a user equipment within coverage of the base station, comprising:

one or more processors;

memory in electronic communication with the one or more processors; and

a plurality of instructions stored in the memory and to be executed by the one or more processors, the plurality of instructions further including:

receiving one or more random access channel (RACH) preambles from the user equipment via a random access channel;

determining one or more binary sequences by decoding the one or more RACH preambles accordingly;

combining the one or more binary sequences into a code word;

determining a short message by decoding the code word;

choosing, among a plurality of codebooks, a codebook corresponding to the short message;

identifying, in the chosen codebook, an RNTI of the user equipment, wherein the RNTI corresponds to the code word.

20. The base station of claim 19, wherein each of the plurality of codebooks corresponds to a unique short message generated by the user equipment.

21. The base station of claim 19, wherein each entry within a codebook defines a unique mapping relationship between a code word and an RNTI of a use equipment within coverage of the base station.

22. The base station of claim 19, wherein a total number of code words within a respective codebook is no less than a total number of user equipments within coverage of the base station.

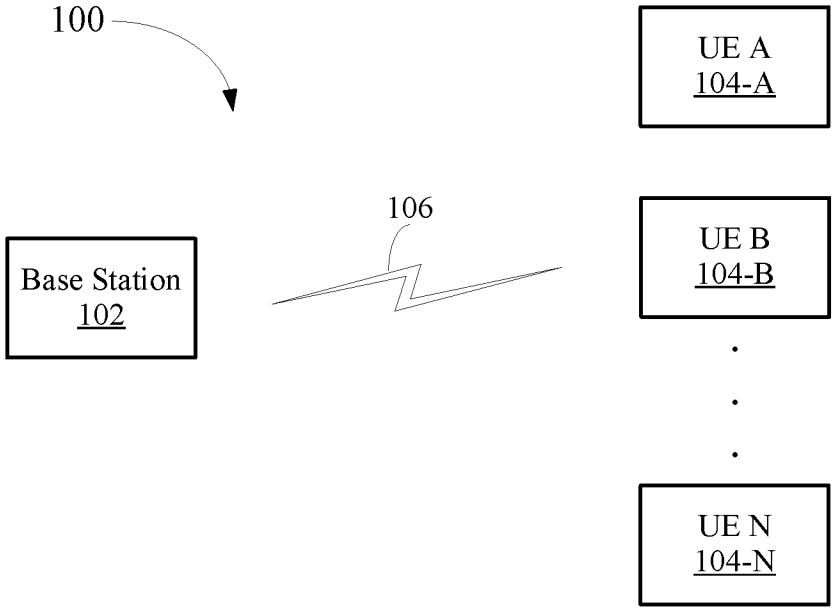
100
UE A
104-A
106
Base Station
102
UE B
104-B
UE N
104-N

FIG. 1A

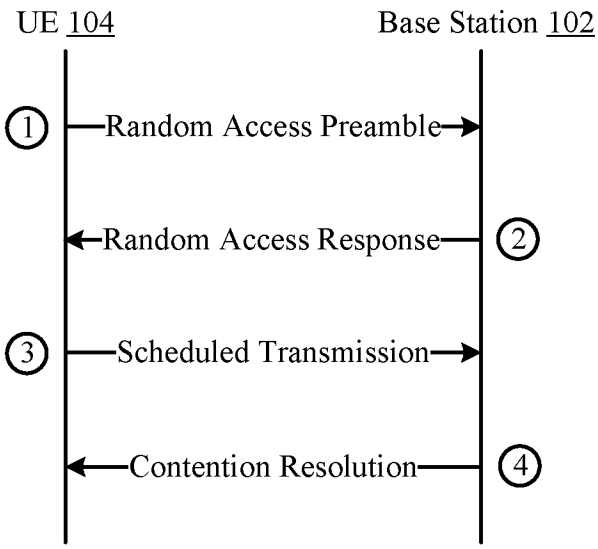
UE 104
Base Station 102
1
Random Access Preamble
Random Access Response
2
3
Scheduled Transmission
Contention Resolution
4

FIG. 1B

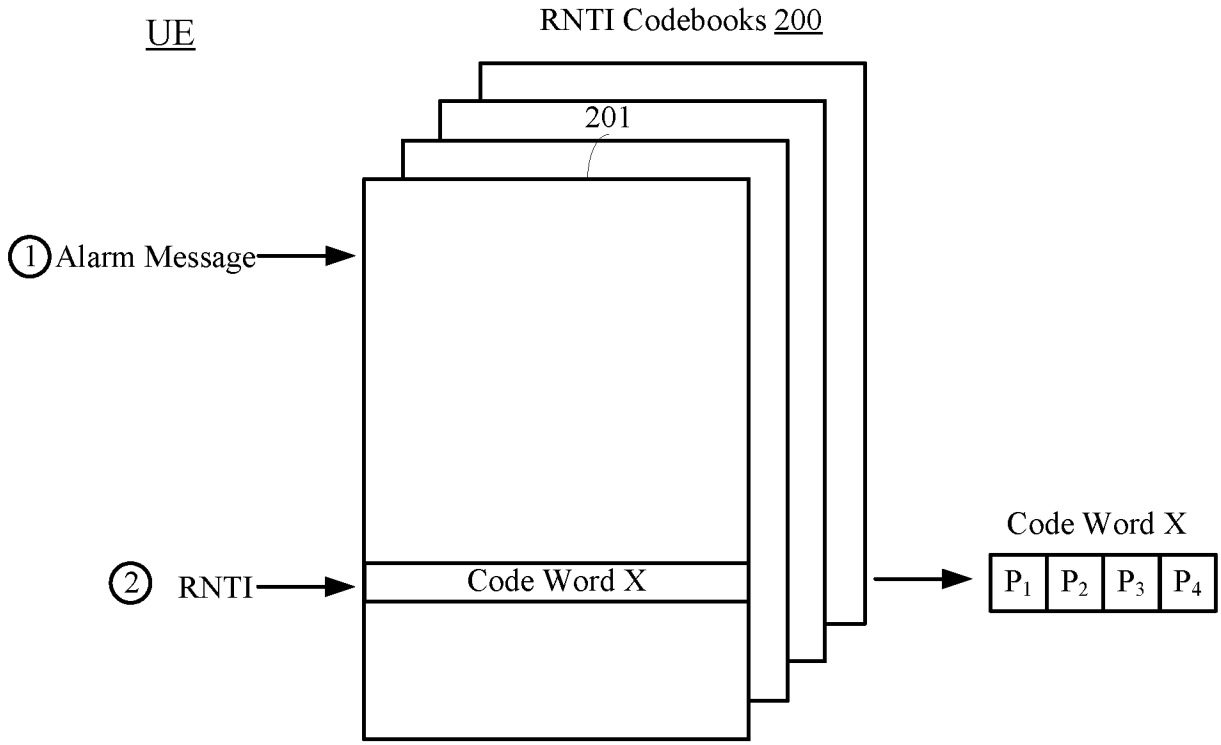
UE
RNTI Codebooks 200
201
1 Alarm Message
2 RNTI
Code Word X
Code Word X
P1 P2 P3 P4

FIG. 2A

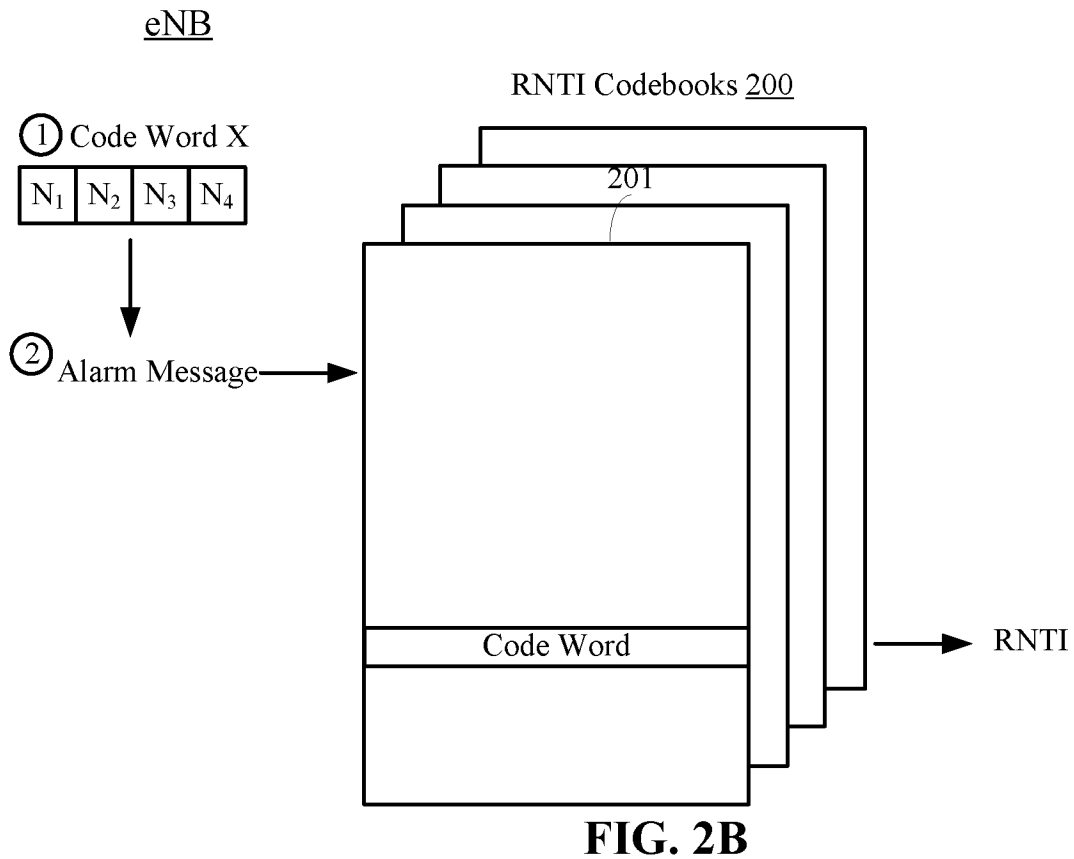
eNB
RNTI Codebooks 200
1 Code Word X
N1 N2 N3 N4
201
2 Alarm Message
Code Word
RNTI

FIG. 2B

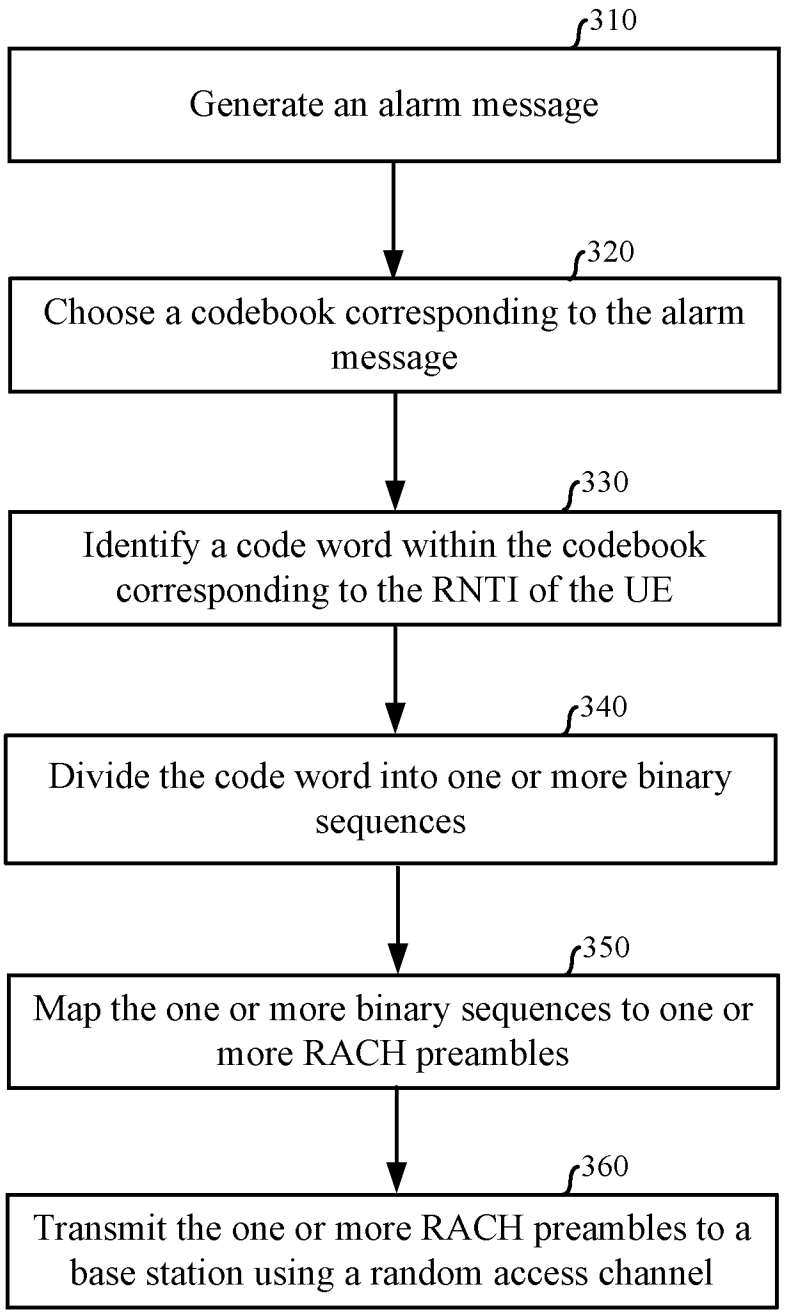
310
Generate an alarm message
320
Choose a codebook corresponding to the alarm message
330
Identify a code word within the codebook corresponding to the RNTI of the UE
340
Divide the code word into one or more binary sequences
350
Map the one or more binary sequences to one or more RACH preambles
360
Transmit the one or more RACH preambles to a base station using a random access channel

FIG. 3

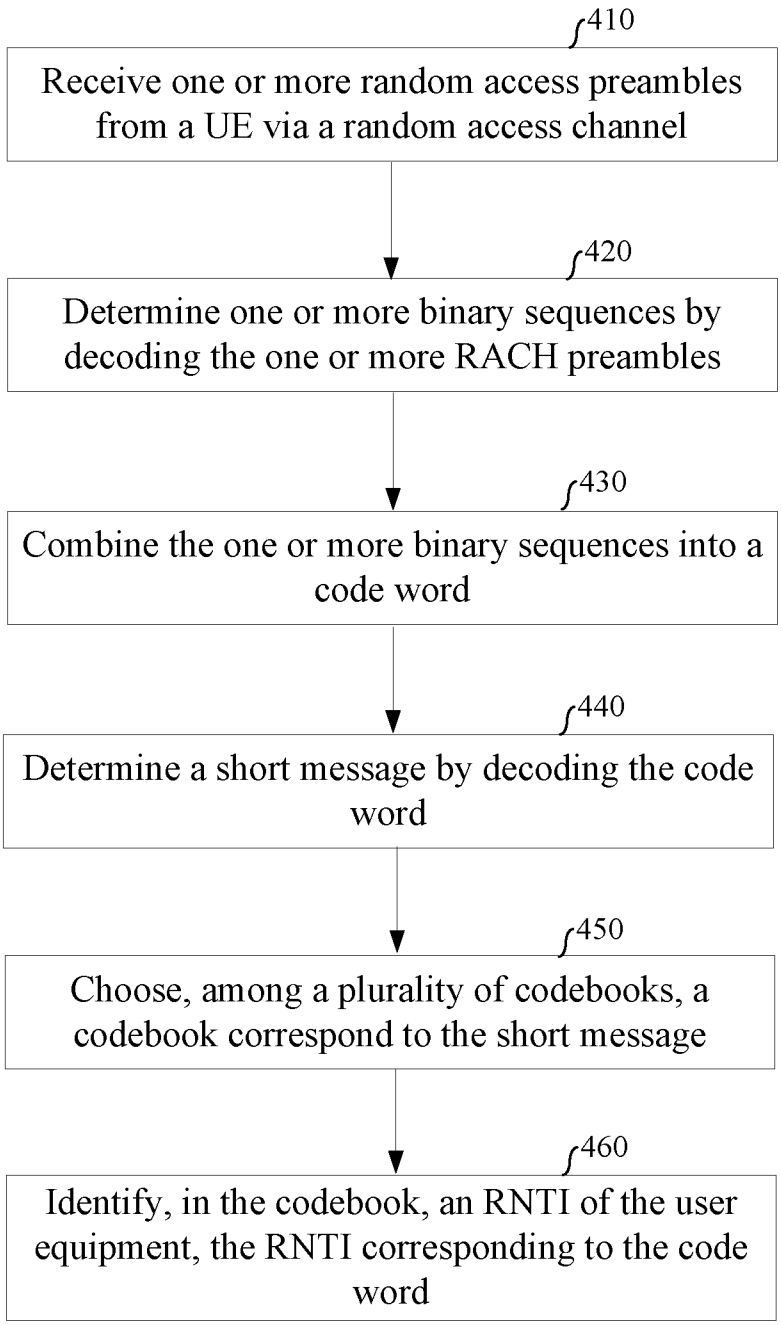
410
Receive one or more random access preambles from a UE via a random access channel
420
Determine one or more binary sequences by decoding the one or more RACH preambles
430
Combine the one or more binary sequences into a code word
440
Determine a short message by decoding the code word
450
Choose, among a plurality of codebooks, a codebook correspond to the short message
460
Identify, in the codebook, an RNTI of the user equipment, the RNTI corresponding to the code word

FIG. 4