Paging for Mobile-Terminated (MT) Small Data Transmission (SDT)

BACKGROUND

1. Technical Field

The present disclosure relates to transmission and reception of signals in a communication system. In particular, the present disclosure relates to methods and apparatuses for such transmission and reception.

2. Description of the Related Art

The 3rd Generation Partnership Project (3GPP) works at technical specifications for the next generation cellular technology, which is also called fifth generation (5G) including “New Radio” (NR) radio access technology (RAT), which operates in frequency ranges up to 100 GHz. The NR is a follower of the technology represented by Long Term Evolution (LTE) and LTE Advanced (LTE-A).

For systems like LTE and NR, further improvements and options may facilitating efficient operation of the communication system as well as particular devices pertaining to the system.

SUMMARY

One non-limiting and exemplary example facilitates efficient handling of mobile-terminated small data transmission in an inactive state.

In an example, the techniques disclosed here feature an apparatus (e.g. a user equipment, UE). The apparatus comprises a transceiver and circuitry. The circuitry, in operation, receives a paging message, while being in an inactive state. In response to the paging message, the circuitry determines to remain in the inactive state for reception of small data. While remaining in the inactive state, the circuitry transmits a response to the paging message to a network node within a transmission opportunity associated with pre-configured resources.

In another example, the techniques disclosed here feature a network node. The network node comprises a transceiver and circuitry. The circuitry, in operation, transmits a paging message to a user equipment (UE) in an inactive state, and receives a response from the UE in the inactive state. The response indicating that the UE is ready for reception of small data in the inactive state.

In yet another example, the techniques disclosed here feature a method for receiving small data by a user equipment (UE) in an inactive state. The method comprises the steps of receiving a paging message, in response to the paging message, determining to remain in the inactive state for reception of the small data, and, while remaining in the inactive state, transmitting a response to the paging message to a network node within a transmission opportunity associated with pre-configured resources.

In yet another example, the techniques disclosed here feature a method for transmitting small data, by a network node. The method comprises transmitting a paging message to a User Equipment (UE) in an inactive state, and receiving a response from the UE in the inactive state. The response indicating that the UE is ready for reception of the small data in the inactive state.

In yet another example, the techniques disclosed here feature an integrated circuit. In operation, the integrated circuit controls a process of a user equipment. The process comprises the following steps performed by the user equipment: receiving a paging message, in response to the paging message, determining to remain in the inactive state for reception of the small data, and, while remaining in the inactive state, transmitting a response to the paging message to a network node within a transmission opportunity associated with pre-configured resources.

In yet another example, the techniques disclosed here feature an integrated circuit. In operation, the integrated circuit controls a process of a network node. The process comprises the following steps performed by the network node: transmitting a paging message to a User Equipment (UE) in an inactive state, and receiving a response from the UE in the inactive state. The response indicating that the UE is ready for reception of the small data in the inactive state.

In yet another example, the techniques disclosed here feature a program stored on a storage medium and including code instructions. The program, when executed on one or more processors of a user equipment, cause the one or more processors to execute the following steps: receiving a paging message, in response to the paging message, determining to remain in the inactive state for reception of the small data, and, while remaining in the inactive state, transmitting a response to the paging message to a network node within a transmission opportunity associated with pre-configured resources.

In yet another example, the techniques disclosed here feature a program stored on a storage medium and including code instructions. The program, when executed on one or more processors of a network node, cause the one or more processors to execute the following steps: transmitting a paging message to a User Equipment (UE) in an inactive state, and

receiving a response from the UE in the inactive state. The response indicating that the UE is ready for reception of the small data in the inactive state.

In yet another example, the techniques disclosed here feature a user equipment (UE). The UE comprises a transceiver and a circuitry. The circuitry which, in operation, receives an indication to receive small data from a network node, in response to receiving the indication, determines to remain in the inactive state for reception of the small data, and, while remaining in the inactive state, transmits a response on the indication to a network node.

In yet another example, the techniques disclosed here feature a network node. The network node comprises a transceiver and a circuitry. The circuitry which, in operation, transmits an indication to receive small data to a UE in an inactive state. The circuitry, in operation, receives a response from the UE in the inactive state. The response indicating that the UE is ready for reception of the small data in the inactive state.

In yet another example, the techniques disclosed here feature a method for a user equipment (UE) in an inactive state. The method comprises receiving an indication to receive small data from a network node, in response to receiving the indication, determining to remain in the inactive state for reception of the small data, and, while remaining in the inactive state, transmitting a response on the indication to a network node.

In yet another example, the techniques disclosed here feature a method for transmitting small data by a network node. The method comprises transmitting an indication to receive small data to a UE in an inactive state, and receiving a response from the UE in the inactive state. The response indicating that the UE is ready for reception of the small data in the inactive state.

In yet another example, the techniques disclosed here feature an integrated circuit. The integrated circuit which, in operation, controls a process of a user equipment. The process comprises the following steps performed by the user equipment: receiving an indication to receive small data from a network node, in response to receiving the indication, determining to remain in the inactive state for reception of the small data, and, while remaining in the inactive state, transmitting a response on the indication to a network node.

In yet another example, the techniques disclosed here feature an integrated circuit. The integrated circuit which, in operation, controls a process of a network node. The process comprises the following steps performed by the network node: transmitting an indication to receive small data to a UE in an inactive state, and receiving a response from the UE in the inactive state. The response indicating that the UE is ready for reception of the small data in the inactive state.

In yet another example, the techniques disclosed here feature a program stored on a storage medium and including code instructions. The program, when executed on one or more processors of a user equipment, cause the one or more processors to execute the following steps: receiving an indication to receive small data from a network node, in response to receiving the indication, determining to remain in the inactive state for reception of the small data, and while remaining in the inactive state, transmitting a response on the indication to a network node.

In yet another example, the techniques disclosed here feature a program stored on a storage medium and including code instructions. The program, when executed on one or more processors of a network node, cause the one or more processors to execute the following steps: transmitting an indication to receive small data to a UE in an inactive state, and receiving a response from the UE in the inactive state. The response indicating that the UE is ready for reception of the small data in the inactive state.

It should be noted that general or specific examples may be implemented as a system, a method, an integrated circuit, a computer program, a storage medium, or any selective combination thereof. For instance, an integrated circuit can control a process of a UE or network node.

Additional benefits and advantages of the disclosed examples will become apparent from the specification and drawings. The benefits and/or advantages may be individually obtained

by the various examples and features of the specification and drawings, which need not all be provided in order to obtain one or more of such benefits and/or advantages.

BRIEF DESCRIPTION OF THE FIGURES

In the following exemplary embodiments are described in more detail with reference to the attached figures and drawings.

Fig. 1 shows an exemplary architecture for a 3GPP NR system;

Fig. 2 is a schematic drawing that shows a functional split between NG-RAN and 5GC;

Fig. 3 is a sequence diagram for RRC connection setup/reconfiguration procedures;

Fig. 4 is a schematic drawing showing usage scenarios of Enhanced mobile broadband (eMBB), Massive Machine Type Communications (mMTC) and Ultra Reliable and Low Latency Communications (URLLC);

Fig. 5 is a block diagram showing an exemplary 5G system architecture for a non-roaming;

Fig. 6 and 7 illustrate the contention-based and contention-free RACH procedure;

Fig. 8 illustrates the possible RRC state changes;

Fig. 9 illustrates a message exchange for the RRC Resume procedure;

Fig. 10 and 11 illustrate a message exchange for the RRC Release procedure;

Fig. 12 illustrates a message exchange of the prior art for uplink data transmission, including a state change of the UE from Inactive to Connected state;

Fig. 13 and 14 illustrate an exemplary four-step RACH respectively two-step RACH usable for small-data uplink transmissions for an RRC_INACTIVE UE;

Fig. 15 illustrates an exemplary paging procedure for downlink small data transmissions;

Fig. 16 is a block diagram illustrating an exemplary functional structure of a network node and a user equipment;