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(54) Title: BASE STATION, USER EQUIPMENT AND METHOD FOR SMALL DATA TRANSMISSION BASED ON RANDOM ACCESS

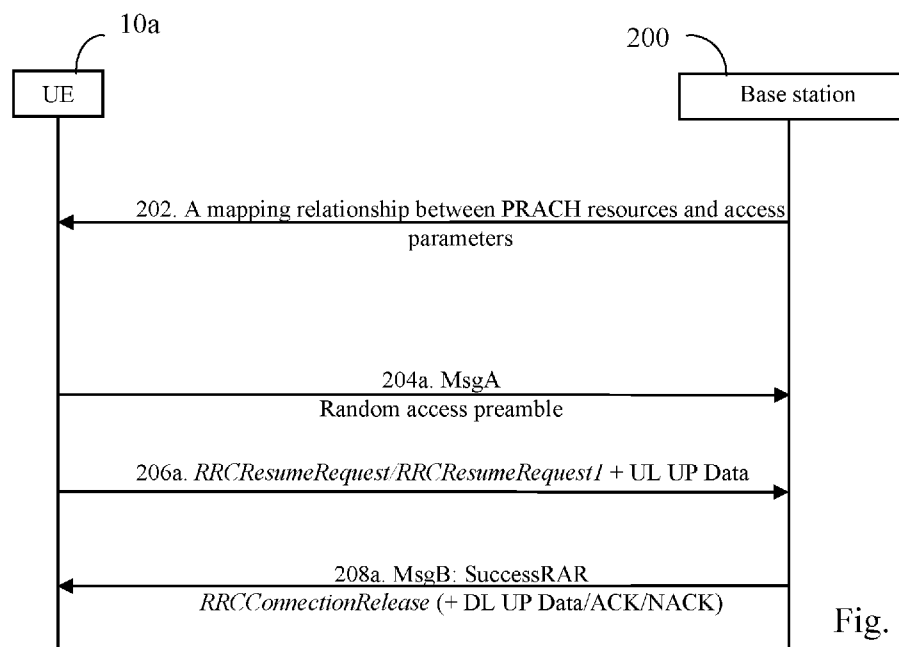


Fig. 2A

(57) Abstract: A method for small data transmission (SDT) based on random access executable in a user equipment includes: receiving a configuration indicating a mapping relationship between a plurality of physical random access channel (PRACH) resources and a plurality of access parameters from a base station, selecting one of the PRACH resources corresponding to an access parameter of the user equipment according to the mapping relationship, transmitting to the base station a random access preamble over the selected PRACH resource, transmitting a radio resource control (RRC) connection resume request to the base station, and receiving an RRC connection release request from the base station.

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Base Station, User Equipment and Method for Small Data Transmission Based on Random Access

Technical Field

[0001] The present disclosure relates to the field of communication systems, and more particularly, to a base station, a user equipment and a method for small data transmission based on random access.

Background Art

[0002] Wireless communication systems and networks have developed towards being a broadband and mobile system. In cellular wireless communication systems, user equipment (UE) is connected by a wireless link to a radio access network (RAN). The RAN comprises a set of base stations (BSs) which provide wireless links to the UEs located in cells covered by the base station, and an interface to a core network (CN) which provides overall network control. As will be appreciated the RAN and CN each conduct respective functions in relation to the overall network. The 3rd Generation Partnership Project (3GPP) has developed the so-called Long Term Evolution (LTE) system, namely, an Evolved Universal Mobile Telecommunication System Territorial Radio Access Network, (E-UTRAN), for a mobile access network where one or more macro-cells are supported by a base station known as an eNodeB or eNB (evolved NodeB). More recently, LTE is evolving further towards the so-called 5G or NR (New Radio) systems where one or more cells are supported by a base station known as a gNB.

[0003] Ultra-reliable low-latency communication (URLLC), is one of several different types of use cases supported by the 5G NR standard, as stipulated by 3GPP Release 15. URLLC is a communication service for successfully delivering packets with stringent requirements, particularly in terms of availability, latency, and reliability. URLLC is developed to support the emerging applications and services, such as wireless control and automation in industrial factory environments, inter-vehicular communications for improved safety and efficiency, and the tactile internet. Thus, URLLC is important for 5G as it supports verticals bringing new business to the whole telecommunication industry.

[0004] One of the key features of URLLC is low latency. Low latency allows a network to be optimized for processing incredibly large amounts of data with minimal delay or latency. URLLC requires a quality of service (QoS) totally different from mobile broadband services. In addition, small and infrequent data traffic is one of the important scenarios for the URLLC. For example, smart phone applications require traffic from Instant Messaging services (whatsapp, QQ, wechat, etc), heart-beat/keep-alive traffic from IM/email clients, and pushing notifications from various applications. Furthermore, wearable devices require periodic positioning information, industrial wireless sensor networks require transmitting temperature, pressure readings periodically or in an event triggered manner, smart meters and smart meter networks require sending periodic meter readings. NR supports RRC_INACTIVE state and UEs with infrequent (periodic and/or non-periodic) data transmission are generally maintained by the network in the RRC_INACTIVE state. Until Rel-16, the RRC_INACTIVE state does not support data transmission. Hence, the UE has to resume the connection (i.e. return to RRC_CONNECTED state) for any downlink (DL) and uplink (UL) data. Connection setup and subsequently release to RRC_INACTIVE state happens for each data transmission. However, transmitting small and infrequent data packets results in unnecessary power consumption and signaling overhead. For UEs in RRC_INACTIVE state, contentions happen while small data transmission is performed. Thus, reducing collision and controlling the network congestion is a necessary work to be done.

Technical Problem

[0005] The collisions between the RACH-based Small Data Transmissions (SDTs) initiated by different UEs shall lead to SDT failure and network congestion resulting in resources waste and poor QoS guarantee and is a problem need to be resolved.

Technical Solution

[0006] An object of the present disclosure is to propose a base station, a user equipment and a method for small data transmission based on random access.

[0007] A first aspect of the disclosure provides a method for small data transmission (SDT) based on random access executable in a user equipment comprises: receiving a configuration indicating the mapping relationship between a plurality of physical random access channel (PRACH) resources and a plurality of access parameters from a base station; selecting one of the PRACH resources corresponding to an access parameter of the user equipment according to the mapping relationship; transmitting to the base station a random access preamble over the selected PRACH resource; transmitting a radio resource control (RRC) connection resume request to the base station; and receiving an RRC connection release request from the base station.

[0008] In an embodiment of the present disclosure, the transmitting to the base station the random access preamble over the selected PRACH resource comprises: transmitting to the base station a first message carrying uplink (UL) user plane (UP) data and/or the random access preamble over the selected PRACH resource; and wherein the receiving the RRC connection release request from the user equipment comprises: receiving a second message carrying the RRC connection release request and/or downlink (DL) user plane (UP) data or Acknowledgment (ACK) signal or Negative-Acknowledgment (NACK) signal from the base station.

[0009] In an embodiment of the present disclosure, the transmitting the radio resource control (RRC) connection resume request to the base station comprises: transmitting the RRC connection resume request and/or uplink (UL) user plane (UP) data to the user equipment; and wherein the receiving the RRC connection release request from the user equipment comprises: receiving a second message carrying the RRC connection release request and/or downlink (DL) user plane (UP) data or Acknowledgment (ACK) signal or Negative-Acknowledgment (NACK) signal from the base station.

[0010] In an embodiment of the present disclosure, the method further comprises: receiving a second message carrying a random access response (RAR) from the base station, after the transmitting to the base station the random access preamble; wherein the transmitting the radio resource control (RRC) connection resume request to the base station comprises: transmitting a third message carrying the radio resource control (RRC) connection resume request and/or UL UP data to the base station; and wherein the receiving the RRC connection release request from the base station comprises: receiving a fourth message carrying the RRC connection release request and/or downlink (DL) user plane (UP) data or Acknowledgment (ACK) signal or Negative-Acknowledgment (NACK) signal from the base station.

[0011] In an embodiment of the present disclosure, the transmitting to the base station the random access preamble over the selected PRACH resource comprises: transmitting to the base station a first message carrying the random access preamble and/or uplink (UL) user plane (UP) grant request or a scheduling report (SR) or a buffer status report (BSR) over the selected PRACH resource; wherein after transmitting to the base station the first message carrying uplink (UL) user plane (UP) data and/or the random access preamble over the selected PRACH resource, the method further comprises: receiving a second message carrying a random access response (RAR)

and/or UL grant signal from the base station, after the transmitting to the base station the first message carrying the random access preamble and/or uplink (UL) user plane (UP) grant request or the scheduling report (SR) or the buffer status report (BSR) over the selected PRACH resource; wherein the transmitting the radio resource control (RRC) connection resume request to the base station comprises: transmitting a third message carrying the radio resource control (RRC) connection resume request and/or UL UP data to the base station; and wherein the receiving the RRC connection release request from the base station comprises: receiving a fourth message carrying the RRC connection release request and/or downlink (DL) user plane (UP) data or Acknowledgment (ACK) signal or Negative-Acknowledgment (NACK) signal from the base station.

[0012] In an embodiment of the present disclosure, the transmitting to the base station the random access preamble over the selected PRACH resource comprises: transmitting to the base station a first message carrying uplink (UL) user plane (UP) data and/or the random access preamble over the selected PRACH resource; wherein after transmitting to the base station the first message carrying uplink (UL) user plane (UP) data and/or the random access preamble over the selected PRACH resource, the method further comprises: receiving a second message carrying a random access response (RAR) and/or Acknowledgment (ACK) signal or Negative-Acknowledgment (NACK) signal from the base station, after the transmitting to the base station the first message carrying uplink (UL) user plane (UP) data and/or the random access preamble; wherein the transmitting the radio resource control (RRC) connection resume request to the base station comprises: transmitting a third message carrying the radio resource control (RRC) connection resume request and/or subsequent UL UP data to the base station; and wherein the receiving the RRC connection release request from the base station comprises: receiving a fourth message carrying the RRC connection release request and/or downlink (DL) user plane (UP) data or Acknowledgment (ACK) signal or Negative-Acknowledgment (NACK) signal from the base station.

[0013] In an embodiment of the present disclosure, the selecting one of the PRACH resources corresponding to the access parameter of the user equipment according to the mapping relationship comprises: measuring strengths of signals received on the PRACH resources to obtain measurement results of the PRACH resources; determining a PRACH pool having available PRACH resources that the measurement results are less than (or equal to) a configured threshold transmitted by the base station; and selecting one of the PRACH resources from the PRACH pool.

[0014] In an embodiment of the present disclosure, the strengths of signals indicate Reference Signal Received Power (RSRP), Reference Signal Received Quality (RSRQ), Received Signal Strength Indicator (RSSI), and/or Signal to Interference plus Noise Ratio (SINR).

[0015] In an embodiment of the present disclosure, the measuring strengths of signals received on the PRACH resources to obtain the measurement results comprises: measuring the strengths of signals received on the PRACH resources to obtain the measurement results during a monitoring time duration beginning from a starting time of a PRACH occasion or from a configured time point.

[0016] In an embodiment of the present disclosure, a length of the PRACH occasion equals to a length of the monitoring time duration plus the PRACH resource.

[0017] In an embodiment of the present disclosure, a measurement result of the PRACH occasion within a measurement cycle is defined as an average against an active duration of the measurement results during the active duration.

[0018] In an embodiment of the present disclosure, a measurement result of the PRACH occasion within the

measurement cycle is defined as an average against the measurement cycle duration of the measurement results during the active duration.

[0019] In an embodiment of the present disclosure, each of the measurement results is an average of the strengths of signals received on each of the PRACH resources against the monitoring time duration.

[0020] In an embodiment of the present disclosure, a length of the monitoring time duration is adjustable or configurable depending on different user equipments or different SDT services.

[0021] In an embodiment of the present disclosure, the measuring strengths of signals received on the PRACH resources to obtain the measurement results is performed when a SDT service happens.

[0022] In an embodiment of the present disclosure, the method further comprises: if the measurement result is less than (or equals to) the configured threshold, selecting the measuring PRACH occasion or the next PRACH occasion to perform the SDT service.

[0023] In an embodiment of the present disclosure, the method further comprises: if the measurement result is less than (or equals to) the configured threshold, selecting the measuring PRACH occasion or the next PRACH occasion to perform the SDT service after waiting a back off time duration.

[0024] In an embodiment of the present disclosure, the method further comprises: if no available PRACH resource is detected for a configured number of measurement times, adjusting/raising the configured threshold.

[0025] In an embodiment of the present disclosure, the PRACH pool having the available PRACH resources is maintained by the user equipment in real time.

[0026] In an embodiment of the present disclosure, a PRACH resource that is occupied as indicated by the base station is excluded to the available PRACH resources.

[0027] A second aspect of the disclosure provides a user equipment. The base station comprises a transceiver and a processor connected with the transceiver and configured to execute the following operations comprising: receiving a configuration indicating the mapping relationship between a plurality of physical random access channel (PRACH) resources and a plurality of access parameters from a base station; selecting one of the PRACH resources corresponding to an access parameter of the user equipment according to the mapping relationship; transmitting to the base station a random access preamble over the selected PRACH resource; transmitting a radio resource control (RRC) connection resume request to the base station; and receiving an RRC connection release request from the base station.

[0028] In an embodiment of the present disclosure, the transmitting to the base station the random access preamble over the selected PRACH resource comprises: transmitting to the base station a first message carrying uplink (UL) user plane (UP) data and/or the random access preamble over the selected PRACH resource; and wherein the receiving the RRC connection release request from the user equipment comprises: receiving a second message carrying the RRC connection release request and/or downlink (DL) user plane (UP) data or Acknowledgment (ACK) signal or Negative-Acknowledgment (NACK) signal from the base station.

[0029] In an embodiment of the present disclosure, the transmitting the radio resource control (RRC) connection resume request to the base station comprises: transmitting the RRC connection resume request and/or uplink (UL) user plane (UP) data to the user equipment; and wherein the receiving the RRC connection release request from the user equipment comprises: receiving a second message carrying the RRC connection release request and/or downlink (DL) user plane (UP) data or Acknowledgment (ACK) signal or Negative-Acknowledgment (NACK) signal from the base station.

[0030] In an embodiment of the present disclosure, the method further comprises: receiving a second message carrying a random access response (RAR) from the base station, after the transmitting to the base station the random access preamble; wherein the transmitting the radio resource control (RRC) connection resume request to the base station comprises: transmitting a third message carrying the radio resource control (RRC) connection resume request and/or UL UP data to the base station; and wherein the receiving the RRC connection release request from the base station comprises: receiving a fourth message carrying the RRC connection release request and/or downlink (DL) user plane (UP) data or Acknowledgment (ACK) signal or Negative-Acknowledgment (NACK) signal from the base station.

[0031] In an embodiment of the present disclosure, the transmitting to the base station the random access preamble over the selected PRACH resource comprises: transmitting to the base station a first message carrying the random access preamble and/or uplink (UL) user plane (UP) grant request or a scheduling report (SR) or a buffer status report (BSR) over the selected PRACH resource; wherein after transmitting to the base station the first message carrying uplink (UL) user plane (UP) data and/or the random access preamble over the selected PRACH resource, the method further comprises: receiving a second message carrying a random access response (RAR) and/or UL grant signal from the base station, after the transmitting to the base station the first message carrying the random access preamble and/or uplink (UL) user plane (UP) grant request or the scheduling report (SR) or the buffer status report (BSR) over the selected PRACH resource; wherein the transmitting the radio resource control (RRC) connection resume request to the base station comprises: transmitting a third message carrying the radio resource control (RRC) connection resume request and/or UL UP data to the base station; and wherein the receiving the RRC connection release request from the base station comprises: receiving a fourth message carrying the RRC connection release request and/or downlink (DL) user plane (UP) data or Acknowledgment (ACK) signal or Negative-Acknowledgment (NACK) signal from the base station.

[0032] In an embodiment of the present disclosure, the transmitting to the base station the random access preamble over the selected PRACH resource comprises: transmitting to the base station a first message carrying uplink (UL) user plane (UP) data and/or the random access preamble over the selected PRACH resource; wherein after transmitting to the base station the first message carrying uplink (UL) user plane (UP) data and/or the random access preamble over the selected PRACH resource, the method further comprises: receiving a second message carrying a random access response (RAR) and/or Acknowledgment (ACK) signal or Negative-Acknowledgment (NACK) signal from the base station, after the transmitting to the base station the first message carrying uplink (UL) user plane (UP) data and/or the random access preamble; wherein the transmitting the radio resource control (RRC) connection resume request to the base station comprises: transmitting a third message carrying the radio resource control (RRC) connection resume request and/or subsequent UL UP data to the base station; and wherein the receiving the RRC connection release request from the base station comprises: receiving a fourth message carrying the RRC connection release request and/or downlink (DL) user plane (UP) data or Acknowledgment (ACK) signal or Negative-Acknowledgment (NACK) signal from the base station.

[0033] In an embodiment of the present disclosure, the selecting one of the PRACH resources corresponding to the access parameter of the user equipment according to the mapping relationship comprises: measuring strengths of signals received on the PRACH resources to obtain measurement results of the PRACH resources; determining a PRACH pool having available PRACH resources that the measurement results are less than (or equal to) a configured threshold transmitted by the base station; and selecting one of the PRACH resources from the PRACH

pool.

[0034] In an embodiment of the present disclosure, the strengths of signals indicate Reference Signal Received Power (RSRP), Reference Signal Received Quality (RSRQ), Received Signal Strength Indicator (RSSI), and/or Signal to Interference plus Noise Ratio (SINR).

[0035] In an embodiment of the present disclosure, the measuring strengths of signals received on the PRACH resources to obtain the measurement results comprises: measuring the strengths of signals received on the PRACH resources to obtain the measurement results during a monitoring time duration beginning from a starting time of a PRACH occasion or from a configured time point.

[0036] In an embodiment of the present disclosure, a length of the PRACH occasion equals to a length of the monitoring time duration plus the PRACH resource.

[0037] In an embodiment of the present disclosure, a measurement result of the PRACH occasion within a measurement cycle is defined as an average against an active duration of the measurement results during the active duration.

[0038] In an embodiment of the present disclosure, a measurement result of the PRACH occasion within the measurement cycle is defined as an average against the measurement cycle duration of the measurement results during the active duration.

[0039] In an embodiment of the present disclosure, each of the measurement results is an average of the strengths of signals received on each of the PRACH resources against the monitoring time duration

[0040] In an embodiment of the present disclosure, a length of the monitoring time duration is adjustable or configurable depending on different user equipments or different SDT services.

[0041] In an embodiment of the present disclosure, the measuring strengths of signals received on the PRACH resources to obtain the measurement results is performed when a SDT service happens.

[0042] In an embodiment of the present disclosure, the operations further comprises: if the measurement result is less than or equals to the configured threshold, selecting the measuring PRACH occasion or the next PRACH occasion to perform the SDT service.

[0043] In an embodiment of the present disclosure, the operations further comprises: if the measurement result is less than or equals to the configured threshold, selecting the measuring PRACH occasion or the next PRACH occasion to perform the SDT service after waiting a back off time duration.

[0044] In an embodiment of the present disclosure, the method further comprises: if no available PRACH resource is detected for a configured number of measurement times, adjusting/raising the configured threshold.

[0045] In an embodiment of the present disclosure, the PRACH pool having the available PRACH resources is maintained by the user equipment in real time.

[0046] In an embodiment of the present disclosure, a PRACH resource that is occupied as indicated by the base station is excluded to the available PRACH resources.

[0047] A third aspect of the disclosure provides a method for small data transmission (SDT) based on random access executable in a base station. The method comprises: transmitting a configuration indicating the mapping relationship between a plurality of physical random access channel (PRACH) resources and a plurality of access parameters to a user equipment; receiving, from the user equipment, a random access preamble over a selected PRACH resource, wherein the selected PRACH resource is selected from one of the PRACH resources

corresponding to an access parameter of the user equipment according to the mapping relationship; receiving a radio resource control (RRC) connection resume request from the user equipment; and transmitting an RRC connection release request to the user equipment.

[0048] In an embodiment of the present disclosure, the access parameters are user equipment identities (IDs).

[0049] In an embodiment of the present disclosure, the access parameters are access IDs.

[0050] In an embodiment of the present disclosure, the access parameters are access categories.

[0051] In an embodiment of the present disclosure, the access parameters are Quality-of-Service (QoS) profiles.

[0052] In an embodiment of the present disclosure, the access parameters indicate priorities of the plurality of physical random access channel (PRACH) resources.

[0053] In an embodiment of the present disclosure, the access parameters indicate various SDT service types.

[0054] In an embodiment of the present disclosure, the transmitting the mapping relationship between the plurality of physical random access channel (PRACH) resources and the plurality of access parameters to the user equipment mapping relationship comprises: periodically broadcasting the configuration message indicating the mapping relationship between the plurality of PRACH resources and the plurality of access parameters to the user equipment.

[0055] In an embodiment of the present disclosure, the transmitting the mapping relationship between the plurality of physical random access channel (PRACH) resources and the plurality of access parameters to the user equipment mapping relationship comprises: periodically unicasting the configuration message indicating the mapping relationship between the plurality of PRACH resources and the plurality of access parameters to the user equipment.

[0056] In an embodiment of the present disclosure, the mapping relationship is modified or generated according a network load.

[0057] In an embodiment of the present disclosure, the mapping relationship is transmitted from a 5G core network.

[0058] In an embodiment of the present disclosure, the receiving, from the user equipment, the random access preamble over the selected PRACH resource comprises: receiving, from the user equipment, a first message carrying uplink (UL) user plane (UP) data and/or the random access preamble over the selected PRACH resource; and wherein the transmitting the RRC connection release request to the user equipment comprises: transmitting a second message carrying the RRC connection release request and/or downlink (DL) user plane (UP) data or Acknowledgment (ACK) signal or Negative-Acknowledgment (NACK) signal to the user equipment.

[0059] In an embodiment of the present disclosure, the receiving the radio resource control (RRC) connection resume request from the user equipment comprises: receiving the RRC connection resume request and/or uplink (UL) user plane (UP) data from the user equipment; and wherein the transmitting the RRC connection release request to the user equipment comprises: transmitting a second message carrying the RRC connection release request and/or downlink (DL) user plane (UP) data or Acknowledgment (ACK) signal or Negative-Acknowledgment (NACK) signal to the user equipment.

[0060] In an embodiment of the present disclosure, the method further comprises: transmitting a second message carrying a random access response (RAR) to the user equipment, after the receiving, from the user equipment, the random access preamble; wherein the receiving the radio resource control (RRC) connection resume request from

the user equipment comprises: receiving a third message carrying the radio resource control (RRC) connection resume request and/or UL UP data from the user equipment; and wherein the transmitting the RRC connection release request to the user equipment comprises: transmitting a fourth message carrying the RRC connection release request and/or downlink (DL) user plane (UP) data or Acknowledgment (ACK) signal or Negative-Acknowledgment (NACK) signal to the user equipment.

[0061] In an embodiment of the present disclosure, the receiving, from the user equipment, the random access preamble over the selected PRACH resource comprises: receiving, from the user equipment, a first message carrying the random access preamble and/or uplink (UL) user plane (UP) grant request or a scheduling report (SR) or a buffer status report (BSR) over the selected PRACH resource; wherein after receiving, from the user equipment, the first message carrying uplink (UL) user plane (UP) data and/or the random access preamble over the selected PRACH resource, the method further comprises: transmitting a second message carrying a random access response (RAR) and/or UL grant signal to the user equipment, after the receiving, from the user equipment, the first message carrying the random access preamble and/or uplink (UL) user plane (UP) grant request or the scheduling report (SR) or the buffer status report (BSR) over the selected PRACH resource; wherein the receiving the radio resource control (RRC) connection resume request from the user equipment comprises: receiving a third message carrying the radio resource control (RRC) connection resume request and/or UL UP data from the user equipment; and wherein the transmitting the RRC connection release request to the user equipment comprises: transmitting a fourth message carrying the RRC connection release request and/or downlink (DL) user plane (UP) data or Acknowledgment (ACK) signal or Negative-Acknowledgment (NACK) signal to the user equipment.

[0062] In an embodiment of the present disclosure, the receiving, from the user equipment, the random access preamble over the selected PRACH resource comprises: receiving, from the user equipment, a first message carrying uplink (UL) user plane (UP) data and/or the random access preamble over the selected PRACH resource; wherein after receiving, from the user equipment, the first message carrying uplink (UL) user plane (UP) data and/or the random access preamble over the selected PRACH resource, the method further comprises: transmitting a second message carrying a random access response (RAR) and/or Acknowledgment (ACK) signal or Negative-Acknowledgment (NACK) signal to the user equipment, after the receiving, from the user equipment, the first message carrying uplink (UL) user plane (UP) data and/or the random access preamble; wherein the receiving the radio resource control (RRC) connection resume request from the user equipment comprises: receiving a third message carrying the radio resource control (RRC) connection resume request and/or subsequent UL UP data from the user equipment; and wherein the transmitting the RRC connection release request to the user equipment comprises: transmitting a fourth message carrying the RRC connection release request and/or downlink (DL) user plane (UP) data or Acknowledgment (ACK) signal or Negative-Acknowledgment (NACK) signal to the user equipment.

[0063] In an embodiment of the present disclosure, the method further comprises: transmitting a configured threshold and/or a measuring configuration to the user equipment, wherein the user equipment is used for measuring strengths of signals received on the PRACH resources to obtain measurement results of the PRACH resources, for determining a PRACH pool having available PRACH resources that measurement results are less than (or equal to) the configured threshold, and for selecting one of the PRACH resources from the PRACH pool.

[0064] A fourth aspect of the disclosure provides a base station. The base station comprises a transceiver and a processor connected with the transceiver and configured to execute the following operations comprising:

transmitting a configuration indicating the mapping relationship between a plurality of physical random access channel (PRACH) resources and a plurality of access parameters to a user equipment; receiving, from the user equipment, a random access preamble over a selected PRACH resource, wherein the selected PRACH resource is selected from one of the PRACH resources corresponding to an access parameter of the user equipment according to the mapping relationship; receiving a radio resource control (RRC) connection resume request from the user equipment; and transmitting an RRC connection release request to the user equipment.

[0065] In an embodiment of the present disclosure, the access parameters are user equipment identities (IDs).

[0066] In an embodiment of the present disclosure, the access parameters are access IDs.

[0067] In an embodiment of the present disclosure, the access parameters are access categories.

[0068] In an embodiment of the present disclosure, the access parameters are Quality-of-Service (QoS) profiles.

[0069] In an embodiment of the present disclosure, the access parameters indicate priorities of the plurality of physical random access channel (PRACH) resources.

[0070] In an embodiment of the present disclosure, the access parameters indicate various SDT service types.

[0071] In an embodiment of the present disclosure, the transmitting the configuration indicating the mapping relationship between the plurality of physical random access channel (PRACH) resources and the plurality of access parameters to the user equipment mapping relationship comprises: periodically broadcasting the mapping relationship between the plurality of PRACH resources and the plurality of access parameters to the user equipment.

[0072] In an embodiment of the present disclosure, the transmitting the configuration indicating the mapping relationship between the plurality of physical random access channel (PRACH) resources and the plurality of access parameters to the user equipment mapping relationship comprises: periodically unicasting the mapping relationship between the plurality of PRACH resources and the plurality of access parameters to the user equipment.

[0073] In an embodiment of the present disclosure, the mapping relationship is modified or generated according a network load.

[0074] In an embodiment of the present disclosure, the mapping relationship is transmitted from a 5G core network.

[0075] In an embodiment of the present disclosure, the receiving, from the user equipment, the random access preamble over the selected PRACH resource comprises: receiving, from the user equipment, a first message carrying uplink (UL) user plane (UP) data and/or the random access preamble over the selected PRACH resource; and wherein the transmitting the RRC connection release request to the user equipment comprises: transmitting a second message carrying the RRC connection release request and/or downlink (DL) user plane (UP) data or Acknowledgment (ACK) signal or Negative-Acknowledgment (NACK) signal to the user equipment.

[0076] In an embodiment of the present disclosure, the receiving the radio resource control (RRC) connection resume request from the user equipment comprises: receiving the RRC connection resume request and/or uplink (UL) user plane (UP) data from the user equipment; and wherein the transmitting the RRC connection release request to the user equipment comprises: transmitting a second message carrying the RRC connection release request and/or downlink (DL) user plane (UP) data or Acknowledgment (ACK) signal or Negative-Acknowledgment (NACK) signal to the user equipment.

[0077] In an embodiment of the present disclosure, the method further comprises: transmitting a second message carrying a random access response (RAR) to the user equipment, after the receiving, from the user equipment, the

random access preamble; wherein the receiving the radio resource control (RRC) connection resume request from the user equipment comprises: receiving a third message carrying the radio resource control (RRC) connection resume request and/or UL UP data from the user equipment; and wherein the transmitting the RRC connection release request to the user equipment comprises: transmitting a fourth message carrying the RRC connection release request and/or downlink (DL) user plane (UP) data or Acknowledgment (ACK) signal or Negative-Acknowledgment (NACK) signal to the user equipment.

[0078] In an embodiment of the present disclosure, the receiving, from the user equipment, the random access preamble over the selected PRACH resource comprises: receiving, from the user equipment, a first message carrying the random access preamble and/or uplink (UL) user plane (UP) grant request or a scheduling report (SR) or a buffer status report (BSR) over the selected PRACH resource; wherein after receiving, from the user equipment, the first message carrying uplink (UL) user plane (UP) data and/or the random access preamble over the selected PRACH resource, the method further comprises: transmitting a second message carrying a random access response (RAR) and/or UL grant signal to the user equipment, after the receiving, from the user equipment, the first message carrying the random access preamble and/or uplink (UL) user plane (UP) grant request or the scheduling report (SR) or the buffer status report (BSR) over the selected PRACH resource; wherein the receiving the radio resource control (RRC) connection resume request from the user equipment comprises: receiving a third message carrying the radio resource control (RRC) connection resume request and/or UL UP data from the user equipment; and wherein the transmitting the RRC connection release request to the user equipment comprises: transmitting a fourth message carrying the RRC connection release request and/or downlink (DL) user plane (UP) data or Acknowledgment (ACK) signal or Negative-Acknowledgment (NACK) signal to the user equipment.

[0079] In an embodiment of the present disclosure, the receiving, from the user equipment, the random access preamble over the selected PRACH resource comprises: receiving, from the user equipment, a first message carrying uplink (UL) user plane (UP) data and/or the random access preamble over the selected PRACH resource; wherein after receiving, from the user equipment, the first message carrying uplink (UL) user plane (UP) data and/or the random access preamble over the selected PRACH resource, the method further comprises: transmitting a second message carrying a random access response (RAR) and/or Acknowledgment (ACK) signal or Negative-Acknowledgment (NACK) signal to the user equipment, after the receiving, from the user equipment, the first message carrying uplink (UL) user plane (UP) data and/or the random access preamble; wherein the receiving the radio resource control (RRC) connection resume request from the user equipment comprises: receiving a third message carrying the radio resource control (RRC) connection resume request and/or subsequent UL UP data from the user equipment; and wherein the transmitting the RRC connection release request to the user equipment comprises: transmitting a fourth message carrying the RRC connection release request and/or downlink (DL) user plane (UP) data or Acknowledgment (ACK) signal or Negative-Acknowledgment (NACK) signal to the user equipment.

[0080] In an embodiment of the present disclosure, the method further comprises: transmitting a configured threshold and/or a measuring configuration to the user equipment, wherein the user equipment is used for measuring strengths of signals received on the PRACH resources to obtain measurement results of the PRACH resources, for determining a PRACH pool having available PRACH resources that measurement results are less than (or equal to) the configured threshold, and for selecting one of the PRACH resources from the PRACH pool.

[0081] A fifth aspect of the disclosure provides a method for small data transmission (SDT) based on random

access executable in a base station. The method comprises: establishing a mapping relationship between type parameters and lengths of back off durations; detecting data volume or random access channel (RACH) type (2-step RACH and 4-step RACH) or SDT type (RACH based SDT and Configured Grant based SDT) during a RACH-based SDT performed by a first user equipment with a PRACH resource; selecting one of the back off durations from the mapping relationship according to the detected data volume or the detected RACH type or the detected SDT type; and transmitting information of the selected back off duration to a second user equipment in a coverage of a cell controlled by the base station, so that the second user equipment does not perform RACH-based SDT with the PRACH resource selected by the first user equipment during the selected back off duration.

[0082] In an embodiment of the present disclosure, the transmitting information of the selected back off duration to a second user equipment in a coverage of a cell controlled by the base station comprises: broadcasting or unicasting information of the selected back off duration to the second user equipment.

[0083] In an embodiment of the present disclosure, the type parameters are selected from a group comprising data volume, service type, random access channel (RACH) type, and SDT type.

[0084] In an embodiment of the present disclosure, the data volume is represented in a scheduling report (SR) or a buffer status report (BSR).

[0085] In an embodiment of the present disclosure, the service type is represented by access identity (ID), category ID, QoS related parameters.

[0086] In an embodiment of the present disclosure, the RACH type comprises 2-step RACH and 4-step RACH.

[0087] In an embodiment of the present disclosure, the SDT type comprises pre-configured grant-based SDT and RACH-based SDT, or pre-configured grant-based SDT, 2-step RACH-based SDT and 4-step RACH-based SDT.

[0088] A sixth aspect of the disclosure provides a base station. The base station comprises a transceiver and a processor connected with the transceiver and configured to execute the following operations comprising: establishing a mapping relationship between type parameters and lengths of back off durations; detecting data volume or random access channel (RACH) type or SDT type during a RACH-based SDT performed by a first user equipment with a PRACH resource; selecting one of the back off durations from the mapping relationship according to the detected data volume or the detected RACH type or the detected SDT type; and transmitting information of the selected back off duration to a second user equipment in a coverage of a cell controlled by the base station, so that the second user equipment does not perform RACH-based SDT with the PRACH resource during the selected back off duration.

[0089] In an embodiment of the present disclosure, the transmitting information of the selected back off duration to a second user equipment in a coverage of a cell controlled by the base station comprises: broadcasting or unicasting information of the selected back off duration to the second user equipment.

[0090] In an embodiment of the present disclosure, the type parameters are selected from a group comprising data volume, service type, random access channel (RACH) type, and SDT type.

[0091] In an embodiment of the present disclosure, the data volume is represented in a scheduling report (SR) or a buffer status report (BSR).

[0092] In an embodiment of the present disclosure, the service type is represented by access identity (ID), category ID, QoS related parameters.

[0093] In an embodiment of the present disclosure, the RACH type comprises 2-step RACH and 4-step RACH.

[0094] In an embodiment of the present disclosure, the SDT type comprises pre-configured grant-based SDT and RACH-based SDT, or pre-configured grant-based SDT, 2-step RACH-based SDT and 4-step RACH-based SDT.

[0095] A seventh aspect of the disclosure provides a method for small data transmission (SDT) based on random access executable in a base station. The method comprises: establishing a mapping relationship between SDT service types and access identities (IDs) or access categories; determining, from the mapping relationship, an access control configuration that sets which access identities (IDs) or access categories are allowed to perform SDT services according to network load; and transmitting the access control configuration to a user equipment that is allowed perform SDT services, so that the user equipment performs RACH-based SDT.

[0096] In an embodiment of the present disclosure, the transmitting the access control configuration to a user equipment that is allowed perform SDT services comprises: broadcasting the access control configuration to the user equipment that is allowed perform SDT services.

[0097] In an embodiment of the present disclosure, the network load indicates counts of successful/failed random accesses, count of attempts of random access, and the amount of data transmitted within a specified time duration.

[0098] An eighth aspect of the disclosure provides a base station. The base station comprises a transceiver and a processor connected with the transceiver and configured to execute the following operations comprising: establishing a mapping relationship between SDT service types and access identities (IDs) or access categories; determining, from the mapping relationship, an access control configuration that sets which access identities (IDs) or access categories are allowed to perform SDT services according to network load; and transmitting the access control configuration to a user equipment that is allowed perform SDT services, so that the user equipment performs RACH-based SDT.

[0099] In an embodiment of the present disclosure, the transmitting the access control configuration to a user equipment that is allowed perform SDT services comprises: broadcasting the access control configuration to the user equipment that is allowed perform SDT services.

[0100] In an embodiment of the present disclosure, the network load indicates counts of successful/failed random accesses, count of attempts of random access, and the amount of data transmitted within a specified time duration.

[0101] The disclosed method may be implemented in a chip. The chip may include a processor, configured to call and run a computer program stored in a memory, to cause a device in which the chip is installed to execute the disclosed method.

[0102] The disclosed method may be programmed as computer executable instructions stored in non-transitory computer readable medium. The non-transitory computer readable medium, when loaded to a computer, directs a processor of the computer to execute the disclosed method.

[0103] The non-transitory computer readable medium may comprise at least one from a group consisting of: a hard disk, a CD-ROM, an optical storage device, a magnetic storage device, a Read Only Memory, a Programmable Read Only Memory, an Erasable Programmable Read Only Memory, EPROM, an Electrically Erasable Programmable Read Only Memory and a Flash memory.

[0104] The disclosed method may be programmed as computer program product, that causes a computer to execute the disclosed method.

[0105] The disclosed method may be programmed as computer program, that causes a computer to execute the disclosed method.

Advantageous Effects

[0106] Embodiments of the disclosure are provided to a base station, a user equipment and a method for small data transmission based on random access. This present disclosure proposes several methods to reduce collision among UEs performing RACH-based small data transmission, and to mitigate the network congestion. Restriction between UEs/SDT services and the PRACH resources is introduced so that the RACH-based SDT occurrences are decentralized in the configured PRACH resources. Collisions of random access initiated by different UEs on the same PRACH resource are reduced. The restriction can be mapping between UE IDs/access IDs/access categories/QoS profiles and PRACH resources.

[0107] The selection of PRACH resource may be based on the measurement of the PRACH resources. The UE shall monitor the configured PRACH resources. If the measurement result is less than or equal to the configured threshold, it is considered to be available for the UE to perform RACH-based small data transmission. The measurement quantity is the strength of the signals received by the UE on the configured PRACH resources. Small data transmission based on the LBT mechanism shall effectively reduce the collisions among UEs.

[0108] UE may continuously monitor the PRACH resource and record/report the PRACH resource status information, or take power saving into account to perform measurement based on the Discontinuous Reception (DRX) mechanism. Additionally, the UE may perform monitoring since receiving the PRACH resources configuration or entering the RRC_INACTIVE state. Or the measurement may be triggered by the small data transmission, namely the UE shall start monitoring only when there is small data transmission to be performed, after available PRACH resources is detected and/or the small data transmission is performed successfully, then the UE shall stop the measurement. However, the UE can be configured to perform monitoring in any of the measurement modes mentioned above.

[0109] In addition, the present disclosure also proposes performing back off when the UE is failed to perform small data transmission based on random access. When contention of random access occurs among UEs performing small data transmission, the base station shall send back off information to the UEs failed to perform RACH-based small data transmission or/and UEs in the coverage of the cell through unicast and/or broadcast. The time length of back off may be obtained by the data volume and/or SDT type (RACH-based SDT or preconfigured grant-based SDT) and/or random access type (2-step random access or 4-step random access).

[0110] In addition, the present disclosure also proposes a mechanism based on access control is introduced for the base station to forbid or allow some UEs to perform RACH-based small data transmission so that the network load can be controlled. The small data transmission services are categorized into several access categories, and/or several access IDs are assigned to the small data transmission services. Then base station shall control the base station network load through forbidding/allowing small data services with specific access IDs or belong to specific access categories to be performed. The configuration shall be adjusted dynamically based on the network load by the base station so that the radio resources can be utilized efficiently. The access control configuration can be transmitted to the UEs through broadcast or unicast. Or in another way, random access procedure for the small data transmission can be accepted/rejected by the base station based on the access control configuration.

Description of Drawings

[0111] In order to more clearly illustrate the embodiments of the present disclosure or related art, the following figures will be described in the embodiments are briefly introduced. It is obvious that the drawings are merely some embodiments of the present disclosure, a person having ordinary skill in this field can obtain other figures according

to these figures without paying the premise.

[0112] Fig. 1 depicts a telecommunication system including UEs, a base station, and a network entity device.

[0113] Fig. 2A and 2B illustrate flowcharts of a 2-step RACH-based SDT performed by the user equipment and the base station according to embodiments of the present disclosure.

[0114] Figs. 3A, 3B, and 3C illustrate flowcharts of a 4-step RACH-based SDT performed by the user equipment 10a and the base station 200 according to embodiments of the present disclosure.

[0115] Fig. 4 illustrates a flowchart of a measurement-based PRACH resource selection in SDT performed by the user equipment and the base station according to an embodiment of the present disclosure.

[0116] Fig. 5 illustrates PRACH resource pattern.

[0117] Fig. 6 illustrates a DRX measurement cycle.

[0118] Fig. 7 illustrates a flowchart of determining back-off based on assistance information performed by the user equipment and the base station according to an embodiment of the present disclosure.

[0119] Fig. 8 illustrates a flowchart of access control based network (NW) Congestion performed by the user equipment 10a and the base station according to an embodiment of the present disclosure.

[0120] Fig. 9 is a block diagram of an example system for wireless communication according to an embodiment of the present disclosure.

DETAILED DESCRIPTION OF EMBODIMENTS

[0121] Embodiments of the disclosure are described in detail with the technical matters, structural features, achieved objects, and effects with reference to the accompanying drawings as follows. Specifically, the terminologies in the embodiments of the present disclosure are merely for describing the purpose of the certain embodiment, but not to limit the disclosure.

[0122] As noted in 3GPP TS 22.891, the NR system shall:

- be efficient and flexible for low throughput short data bursts
- support efficient signaling mechanisms (e.g. signaling is less than payload)
- reduce signaling overhead in general.

[0123] Signaling overhead from RRC_INACTIVE state UEs for small data packets is a general problem and will become a critical issue with more UEs in NR not only for network performance and efficiency but also for the UE battery performance. In general, any device that has intermittent small data packets in RRC_INACTIVE state will benefit from enabling small data transmission in INACTIVE.

[0124] The key enablers for small data transmission in NR, namely the RRC_INACTIVE state, 2-step, 4-step RACH and configured grant type-1 have already been specified as part of Rel-15 and Rel-16. So, this work builds on these building blocks to enable small data transmission in RRC_INACTIVE state for NR.

[0125] In the revised WID of Small Data Transmission RP-201305, the following scope relating to Small Data Transmission has been identified:

[0126] This work item enables small data transmission in RRC_INACTIVE state as follows:

- For the RRC_INACTIVE state:

- UL small data transmissions for RACH-based schemes (i.e. 2-step and 4-step RACH):
 - General procedure to enable UP data transmission for small data packets from INACTIVE state (e.g. using MSGA or MSG3) [RAN2]
 - Enable flexible payload sizes larger than the Rel-16 CCCH message size that is possible currently for INACTIVE state for MSGA and MSG3 to support UP data transmission in UL (actual payload size can be up to network configuration) [RAN2]
 - Context fetch and data forwarding (with and without anchor relocation) in INACTIVE state for RACH-based solutions [RAN2, RAN3]

Note 1: The security aspects of the above solutions should be checked with SA3

- Transmission of UL data on pre-configured PUSCH resources (i.e. reusing the configured grant type 1) – when TA is valid
 - General procedure for small data transmission over configured grant type 1 resources from INACTIVE state [RAN2]
 - Configuration of the configured grant type1 resources for small data transmission in UL for INACTIVE state [RAN2]
- Specify RRM core requirements for small data transmission in RRC_INACTIVE, if needed [RAN4]

No new RRC state should be introduced in this WID. Transmission of small data in UL, subsequent transmission of small data in UL and DL and the state transition decisions should be under network control.

Focus of the WID should be on licensed carriers and the solutions can be reused for NR-U if applicable.

[0127] For direct data transmission in RRC_INACTIVE state, in case of collision and network congestion occurring, mechanisms to mitigate the network congestion should be considered in the design.

[0128] Related agreements on Small Data Transmission (SDT)

[0129] 3GPP RAN2#111-e Agreements

[0130] 1 Small data transmission with RRC message is supported as baseline for RA-based and CG based schemes.

[0131] 2. RRC-less can be studied for limited use cases (e.g. same serving cell and/or for CG) with lower priority.

[0132] 3. Context fetch and data forwarding with anchor re-location and without anchor re-location will be considered. FFS if there are problems with the scenario “without anchor relocation”.

[0133] 4. From RAN2 perspective, stored “configuration” in the UE Context is used for the RLC bearer configuration for any SDT mechanism (RACH and CG).

[0134] 5. The 2-step RACH or 4-step RACH should be applied to RACH based uplink small data transmission in RRC_INACTIVE.

[0135] 6. The uplink small data can be sent in MSGA of 2-step RACH or msg3 of 4-step RACH.

[0136] 7. Small data transmission is configured by the network on a per DRB basis.

[0137] 8. Data volume threshold is used for the UE to decide whether to do SDT or not. FFS how we calculate data volume. FFS if an “additional SDT specific” RSRP threshold is further used to determine whether the UE should do SDT.

[0138] 9. UL/DL transmission following UL SDT without transitioning to RRC_CONNECTED is supported.

[0139] 10. When UE is in RRC_INACTIVE, it should be possible to send multiple UL and DL packets as part of the same SDT mechanism and without transitioning to RRC_CONNECTED on dedicated grant. FFS on details and whether any indication to network is needed.

[0140] With reference to Fig. 1, a telecommunication system including UEs 10a, 10b, a base station 200, and a network entity device 30. Connections between devices and device components are shown as lines and arrows in the Figs. The UE 10a may include a processor 11a, a memory 12a, and a transceiver 13a. The UE 10b may include a processor 11b, a memory 12b, and a transceiver 13b. The base station 200 may include a processor 201, a memory 202, and a transceiver 203. The network entity device 300 may include a processor 301, a memory 302, and a transceiver 303. Each of the processors 11a, 11b, 201, and 301 may be configured to implement proposed functions, procedures and/or methods described in the description. Layers of radio interface protocol may be implemented in the processors 11a, 11b, 201, and 301. Each of the memory 12a, 12b, 202, and 302 operatively stores a variety of program and information to operate a connected processor. Each of the transceiver 13a, 13b, 203, and 303 is operatively coupled with a connected processor, transmits and/or receives radio signals or wireline signals. The first base station 200 may be an eNB, a gNB, or one of other types of radio nodes, and may configure radio resources for the UEs 10a and 10b.

[0141] Each of the processor 11a, 11b, 201, and 301 may include an application-specific integrated circuits (ASICs), other chipsets, logic circuits and/or data processing devices. Each of the memory 12a, 12b, 202, and 302 may include a read-only memory (ROM), a random access memory (RAM), a flash memory, a memory card, a storage medium and/or other storage devices. Each of the transceiver 13a, 13b, 203, and 303 may include baseband circuitry and radio frequency (RF) circuitry to process radio frequency signals. When the embodiments are implemented in software, the techniques described herein can be implemented with modules, procedures, functions, entities and so on, that perform the functions described herein. The modules can be stored in a memory and executed by the processors. The memory can be implemented within a processor or external to the processor, in which those can be communicatively coupled to the processor via various means are known in the art.

[0142] The network entity device 300 may be a node in a CN. CN may include LTE CN or 5G core (5GC) which includes user plane function (UPF), session management function (SMF), mobility management function (AMF), unified data management (UDM), policy control function (PCF), control plane (CP)/user plane (UP) separation (CUPS), authentication server (AUSF), network slice selection function (NSSF), and the network exposure function (NEF).

[0143] Embodiment 1

[0144] Referring to Fig. 1 and Fig. 2A and 2B illustrating flowcharts of a 2-step RACH-based SDT performed

by the user equipment 10a and the base station 200 according to embodiments of the present disclosure, the main idea of this embodiment is to introduce a restriction between UEs or SDT services and the PRACH resources so that the RACH-based SDT occurrences are distributed in the configured PRACH resources with equal probability as far as possible.

[0145] The base station 200 transmits a mapping relationship between a plurality of physical random access channel (PRACH) resources and a plurality of access parameters to the user equipment 10a (Step 202). The access parameters includes but are not limited to UE IDs/access ID/access category/QoS related parameters (e.g., delay requirement, etc.) of the SDT services. The mapping relationship is between UE IDs/access ID/access category/QoS related parameters (e.g., delay requirement, etc.) of the services and the PRACH resources, etc. The RACH-based SDTs in the coverage of a cell controlled by the base station 200 occur among non-overlapping PRACH resources.

[0146] In another way, the SDT dedicated PRACH resources may be designed into several non-overlapping subsets of the PRACH resources. Each PRACH resource subset is configured to one or several UEs, i.e. the UE 10a is restricted to select PRACH resource (randomly with equal possibility or based on the measurement result) from the subset of PRACH resources that configured for it. Or the mapping relationship is between the PRACH resource subsets and the service types/access ids/access categories/QoS related parameters (e.g., delay requirement, etc.)/priorities or other service related profiles. UEs supporting services with the same value or with the value within a range of one or several of the above mentioned profiles are restricted to select PRACH resources (randomly with equal possibility or based on the measurement result) from the subset of PRACH resources configured for the services to perform SDT.

[0147] The restriction may be defined in the technical specification or configured by the base station 200. The base station 200 may get the related configuration from the 5GC and then forward it to the UEs, or the base station 200 may modify/generate the restriction information according to the network load and then transmit it to the UEs 10a, 10b in the coverage of the cell controlled by the base station 200. The restriction related configuration information may be transmitted by the base station 200 to the UE 10a through unicast or broadcast periodically or be triggered.

[0148] As illustrated in Fig. 2A, in one embodiment, the UE 10a selects one of the PRACH resources corresponding to an access parameter of the user equipment 10a according to the mapping relationship and transmits to the base station 200 a message MsgA carrying a random access preamble over the selected PRACH resource (Step 204a). Then, the UE 10a transmits a message carrying the RRC connection resume request *RRCResumeRequest* and uplink (UL) user plane (UP) data or Acknowledgment (ACK) signal or Negative-Acknowledgment (NACK) signal to the base station 200 as illustrated in Step 206a. The base station 200 transmits a second message MsgB carrying the RRC connection release request *RRCconnectionreleaserequest* and downlink (DL) user plane (UP) data or Acknowledgment (ACK) signal or Negative-Acknowledgment (NACK) signal to the user equipment 10a (Step 208a).

[0149] As illustrated in Fig. 2B, in another embodiment, the UE 10a selects one of the PRACH resources corresponding to an access parameter of the user equipment 10a according to the mapping relationship and transmits to the base station 200 a first message MsgA carrying uplink (UL) user plane (UP) data and/or the random access preamble over the selected PRACH resource (Step 204b). The base station 200 transmits a second message MsgB carrying the RRC connection release request *RRCconnectionreleaserequest* and downlink (DL) user plane (UP) data or Acknowledgment (ACK) signal or Negative-Acknowledgment (NACK) signal to the user equipment 10a (Step

208b).

[0150] Refer to Fig. 1 and Figs. 3A, 3B, and 3C illustrating flowcharts of a 4-step RACH-based SDT performed by the user equipment 10a and the base station 200 according to embodiments of the present disclosure. As illustrated in Fig. 3A, the base station 200 transmits a mapping relationship between a plurality of physical random access channel (PRACH) resources and a plurality of access parameters to the user equipment 10a (Step 302). In another embodiment, the UE 10a selects one of the PRACH resources corresponding to an access parameter of the user equipment 10a according to the mapping relationship and transmits to the base station 200 a first message Msg1 carrying a random access preamble over the selected PRACH resource (Step 304a). The base station 200 transmits a second message Msg2 carrying a random access response (RAR) to the user equipment 10a (Step 306a), after receiving the random access preamble. The UE 10a transmits a third message Msg3 carrying the radio resource control (RRC) connection resume request and/or UL UP data to the base station 200 (Step 308a). The base station 200 transmits a fourth message Msg4 carrying the RRC connection release request and/or downlink (DL) user plane (UP) data or Acknowledgment (ACK) signal or Negative-Acknowledgment (NACK) signal to the user equipment 10a (Step 310a).

[0151] In another embodiment of the present disclosure as illustrated in Fig. 3B, the base station 200 transmits a mapping relationship between a plurality of physical random access channel (PRACH) resources and a plurality of access parameters to the user equipment 10a (Step 302). The UE 10a selects one of the PRACH resources corresponding to an access parameter of the user equipment 10a according to the mapping relationship and transmits to the base station 200 a first message Msg1 carrying the random access preamble and/or uplink (UL) user plane (UP) grant request or a scheduling report (SR) or a buffer status report (BSR) over the selected PRACH resource (Step 304b). The base station 200 transmits a second message Msg2 carrying a random access response (RAR) and/or UL grant signal to the user equipment 10a (Step 306b), after receiving the random access preamble. The UE 10a transmits a third message Msg3 carrying the radio resource control (RRC) connection resume request and/or UL UP data to the base station 200 (Step 308b). The base station 200 transmits a fourth message Msg4 carrying the RRC connection release request and/or downlink (DL) user plane (UP) data or Acknowledgment (ACK) signal or Negative-Acknowledgment (NACK) signal to the user equipment 10a (Step 310b).

[0152] In still another embodiment of the present disclosure as illustrated in Fig. 3C, the base station 200 transmits a mapping relationship between a plurality of physical random access channel (PRACH) resources and a plurality of access parameters to the user equipment 10a (Step 302). The UE 10a selects one of the PRACH resources corresponding to an access parameter of the user equipment 10a according to the mapping relationship and transmits to the base station 200 a first message Msg1 carrying uplink (UL) user plane (UP) data and/or the random access preamble over the selected PRACH resource (Step 304c). The base station 200 transmits a second message Msg2 carrying a random access response (RAR) and Acknowledgment (ACK) signal or Negative-Acknowledgment (NACK) signal to the user equipment 10a (Step 306c), after receiving the random access preamble. The UE 10a transmits a third message Msg3 carrying the radio resource control (RRC) connection resume request and/or subsequent UL UP data to the base station 200 (Step 308c). The base station 200 transmits a fourth message Msg4 carrying the RRC connection release request and/or downlink (DL) user plane (UP) data or Acknowledgment (ACK) signal or Negative-Acknowledgment (NACK) signal to the user equipment 10a (Step 310c).

[0153] This disclosure reduces collision among UEs performing RACH-based small data transmission, and to mitigate the network congestion. Restriction between UEs/SDT services and the PRACH resources is introduced so

that the RACH-based SDT occurrences are decentralized in the configured PRACH resources. Collisions of random access initiated by different UEs on the same PRACH resource are reduced.

[0154] Embodiment 2

[0155] Refer to Fig. 1 and Fig. 4. Fig. 4 illustrates a flowchart of a measurement-based PRACH resource selection in SDT performed by the user equipment 10a and the base station 200 according to an embodiment of the present disclosure. This embodiment intends to bring a new way for PRACH resource selection based on measurement for small data transmission. After receiving the PRACH resource configuration (Step 402), the UE 10a performs measurement on the configured PRACH resources (Step 404). According to the configured threshold and the measurement result, UE 10a determines on which PRACH resources to perform RACH-based SDT. The UE 10a selects the PRACH resources that the measurement result is less than or equal to the configured threshold to perform 2/4 step RACH-based SDT (Step 410) as introduced in Figs. 2A, 2B, 3A, 3B and 3C. Then, the base station 200 transmits RRC connection release request to the UE 10a as introduced in Step 208a in Fig. 2A, or in Step 208b in Fig. 2B, in Step 310a in Fig. 3A, in Step 310b in Fig. 3B, or in Step 310c in Fig. 3C.

[0156] In some embodiment, the operation of selecting one of the PRACH resources corresponding to the access parameter of the user equipment according to the mapping relationship comprises the following operations. The UE 10a measures strengths of signals received on the PRACH resources to obtain measurement results of the PRACH resources. Then the UE 10a determines a PRACH pool having available PRACH resources that the measurement results are less than or equal to a configured threshold transmitted by the base station 200. Then the UE 10a selects one of the PRACH resources from the PRACH pool.

[0157] The measurement quantity shall be the strength of signals received on the configured PRACH resources. The strengths of signals indicate Reference Signal Received Power (RSRP), Reference Signal Received Quality (RSRQ), Received Signal Strength Indicator (RSSI), and Signal to Interference plus Noise Ratio (SINR), and so on. PRACH resources on which strong signal can be detected means that the resources are occupied by UE 10a performing random access or data transmission. Not performing SDT on these resources can reduce random access contentions among UEs 10a and 10b. And using the PRACH resources with low measurement results to perform SDT makes it more likely to be succeed in performing RACH-based SDT.

[0158] The minimum PRACH resource for UE 10a to perform monitoring and measurement may be specified by the PRACH resource configuration information. It can be part of a PRACH occasion as shown in Fig. 5 illustrating PRACH resource pattern. UE 10a monitors the PRACH resource during the T_{monitor} and determines whether the PRACH occasion is occupied. If the measurement result is less than or equal to the configured threshold, the PRACH occasion is available, otherwise it is occupied.

[0159] In some embodiments, UE 10a continuously performs monitoring and measurement on the PRACH resources configured. If the PRACH resource is available, i.e. the measurement is less than or equal to the configured threshold, it is recorded or reported to upper layer. If there is small data to be transmitted, the UE 10a selects one available PRACH occasion and perform SDT with it.

[0160] The UE 10a may behave like that, it performs monitoring continuously, record/report the available PRACH resources or record the available/occupied status of the PRACH resource with the result of T_{monitor} duration's measurement, without suspend/abort the measurement. In another embodiment, the UE 10a may performs measurement at the start time of the coming PRACH occasions, determines whether the PRACH occasions are available after measurement of T_{monitor} duration, then the UE 10a stops monitoring and wait for another coming

PRACH occasion to perform measurement.

[0161] In some embodiments, taking power saving into account, the measurement of the PRACH resources can be designed to be based on the Discontinuous Reception (DRX) mechanism. UE 10a does not continuously monitor the configured PRACH resources. As is shown in Fig. 6 illustrating a DRX measurement cycle, UE 10a monitors the configured PRACH resources during the “active duration” and perform continuous reception. For the left duration of the measurement cycle, i.e. “inactive duration”, UE 10a goes back to sleep and does not perform reception. The measurement result of the PRACH occasion within the measurement cycle can be defined as the average against the active duration of the measurement results during the active duration. In another embodiment, the measurement result of the PRACH occasion within the measurement cycle can be defined as the average against the measurement cycle duration of the measurement results during the active duration. When SDT service is about to happen, the UE 10a selects one available PRACH occasion that meet the preconfigured condition and perform SDT.

[0162] In some embodiment, the UE 10a does not monitor the PRACH resources until the SDT service happens. When SDT service happens, the UE 10a performs measurement on the configured PRACH resources. If there is PRACH resource available detected, i.e. the measurement result is less than or equal to the configured threshold, the UE 10a selects the next PRACH occasion and perform SDT with it. Or the UE 10a backs off (Step 408), i.e. wait for a time of configured duration, and then perform SDT with the next PRACH occasion. Otherwise, if the measurement result shows that there is no PRACH resource available, the UE 10a may go on performing measurement until available PRACH resource is detected, or the UE 10a wait for a time duration and then perform measurement again, until available PRACH resource is detected. The length of the time duration can be fixed/configured or a random value in a given range.

[0163] If there is no available PRACH resource detected for a long time duration or number of measurement times, the configured threshold can be adjusted.

[0164] Optionally, a PRACH resource pool including the available PRACH resources is maintained by the UE 10a. The PRACH resource pool is updated in real time according to the measurement results.

[0165] The available PRACH resources need to exclude the PRACH resources that are occupied as indicated by the broadcast information from the base station 200.

[0166] The length of monitor time duration T_{monitor} can be configured, it can be UE specific or services specific, namely different UEs/services can be configured with different length of monitor time duration. The measurement result can be the average of the measurement results against the time duration T_{monitor} .

[0167] The selection of PRACH resource may be based on the measurement of the PRACH resources. The UE shall monitor the configured PRACH resources. If the measurement result is less than or equal to the configured threshold, it is considered to be available for the UE to perform RACH-based small data transmission. The measurement quantity is the strength of the signals received by the UE on the configured PRACH resources. Small data transmission based on the LBT mechanism shall effectively reduce the collisions among UEs.

[0168] Embodiment 3

[0169] Refer to Fig. 1 and Fig. 7. Fig. 7 illustrates a flowchart of determining back-off based on assistance information performed by the user equipment 10a, 10b and the base station 200 according to an embodiment of the present disclosure. This embodiment discloses that association between lengths of back off duration and the data volume/service type or RACH type (2-step RACH and 4-step RACH)/SDT type is introduced. The base station 200 establishes a mapping relationship between type parameters and lengths of back off durations (Step 702). Preferably,

the mapping relationship between data volume or RACH type/SDT type and lengths of back off durations is established. The base station 200 can detect the data volume and/or RACH type/SDT type information during the RACH-based SDT performed by the UE 10a using a PRACH resource. The base station 200 selects one of the back off durations from the mapping relationship according to the detected data volume or the detected RACH type or the detected SDT type, and broadcasts or unicasts the selected back off duration information to other UE 10b (Step 710) in the coverage of the cell controlled by the base station 200. A back off indication is defined to indicate the back off duration information, name it as BI-2. The UE 10b received the BI-2 from the base station 200 shall not perform RACH-based SDT with the same PRACH resource (in frequency domain perspective) during the duration indicated by the back off indication BI-2. That is, the user equipment 10b does not perform RACH-based SDT with the PRACH resource during the selected back off duration.

[0170] The embodiment of the present disclosure proposes performing back off when the UE is failed to perform small data transmission based on random access. When contention of random access occurs among UEs 10a and 10b performing small data transmission, the base station 200 sends back off information to the UE 10b failed to perform RACH-based small data transmission or/and UE 10b in the coverage of the cell controlled by the base station 200 through unicast and/or broadcast. The time length of back off may be obtained by the data volume and/or SDT type (RACH-based SDT or preconfigured grant-based SDT) and/or random access type (2-step random access or 4-step random access).

[0171] The data volume information can be represented in any form, such as BSR, SR, or any other variables. It can be a continuous value within a range, or a fixed value of several discrete values.

[0172] The service type may include smartphone applications and non-smartphone applications. The smartphone applications contain Instant Messaging services, heart-beat/alive traffic, push notifications, etc. The non-smartphone applications include traffic from wearables, sensors, smart meters, etc. It can be represented by access ID, category ID, QoS related parameters, etc.

[0173] The RACH type may include 2-step RACH and 4-step RACH. The value of SDT type may be pre-configured grant-based SDT and RACH-based SDT, or pre-configured grant-based SDT, 2-step RACH-based SDT and 4-step RACH-based SDT.

[0174] The value of the back off indication can be a continuous value within a range, or a fixed value of several discrete values. Or it can be represented as several levels, such as low, middle and high, or level₀, level₂, level₃ ... level_n.

[0175] One data volume value or a range of volume values can be mapped to one back off value. Or more than one data volume values can be mapped to one back off value. And vice versa.

[0176] One RACH-type/SDT type can be mapped to one back off value. Or more than one RACH type/SDT type can be mapped to one back off value. And vice versa.

[0177] The service type and the value of back off indication may be one-to-one mapping, many-to-one mapping, one-to-many mapping or many-to-many mapping. No specific restriction is specified here.

[0178] The back off indication may be broadcasted to UEs in the system information. Or it may be transmitted to the UEs through unicast, e.g., RAR message.

[0179] Embodiment 4

[0180] Refer to Fig. 1 and Fig. 8. Fig. 8 illustrates a flowchart of access control based network (NW) Congestion performed by the user equipment 10a and the base station 200 according to an embodiment of the present disclosure.

This embodiment discloses that services, e.g., heart-beat service, one shot service, etc. of the small data transmission services can be mapped to the access IDs and/or access categories. That is to say different access IDs can be assigned to the small data services. The base station 200 establishes a mapping relationship between Small data transmission (SDT) service types and access identities (IDs) or access categories. Small data transmission services can be mapped to different access categories. The assignment and mapping can be based on the service type, traffic pattern, QoS (e.g., priority, delay requirement, etc.) or other related profiles. The base station 200 determines, from the mapping relationship, an access control configuration that sets which access identities (IDs) or access categories are allowed to perform SDT services according to network (NW) load. The base station 200 transmits the access control configuration to a user equipment 10a that is allowed perform SDT services, so that the user equipment 10a performs RACH-based SDT.

[0181] The base station 200 dynamically forbid or allow UE 10a supporting services with one or several specific access IDs/access categories to perform SDT based on the network load or according to the configuration. The configuration that which access ids/access categories is forbidden or allowed to perform SDT can be transmitted to UEs through the system information broadcasted by the base station 200. Or in another way, the base station 200 accepts or rejects the random access for SDT services with one or several specified access IDs/access categories according to the configuration.

[0182] The association between the access IDs/access categories and the services or related QoS profiles can be specified by the technical specifications or the configurations can be received by the base station 200 from the network entity device 300, e.g. 5GC, or base station 200 may specify or dynamically adjust it.

[0183] The network load may be the count of successful/failed random accesses, the count attempt of random access, the amount of data transmitted, etc. within a specified time duration. The base station 200/ network entity device 300 may dynamically adjust the access control configuration according the network load.

[0184] Fig. 9 is a block diagram of an example system 700 for wireless communication according to an embodiment of the present disclosure. Embodiments described herein may be implemented into the system using any suitably configured hardware and/or software. Fig. 10 illustrates the system 700 including a radio frequency (RF) circuitry 710, a baseband circuitry 720, a processing unit 730, a memory/storage 740, a display 750, a camera 760, a sensor 770, and an input/output (I/O) interface 780, coupled with each other as illustrated.

[0185] The processing unit 730 may include a circuitry, such as, but not limited to, one or more single-core or multi-core processors. The processors may include any combinations of general-purpose processors and dedicated processors, such as graphics processors and application processors. The processors may be coupled with the memory/storage and configured to execute instructions stored in the memory/storage to enable various applications and/or operating systems running on the system.

[0186] The baseband circuitry 720 may include a circuitry, such as, but not limited to, one or more single-core or multi-core processors. The processors may include a baseband processor. The baseband circuitry may handle various radio control functions that enable communication with one or more radio networks via the RF circuitry. The radio control functions may include, but are not limited to, signal modulation, encoding, decoding, radio frequency shifting, etc. In some embodiments, the baseband circuitry may provide for communication compatible with one or more radio technologies. For example, in some embodiments, the baseband circuitry may support communication with 5G NR, LTE, an evolved universal terrestrial radio access network (EUTRAN) and/or other wireless metropolitan area networks (WMAN), a wireless local area network (WLAN), a wireless personal area network

(WPAN). Embodiments in which the baseband circuitry is configured to support radio communications of more than one wireless protocol may be referred to as multi-mode baseband circuitry. In various embodiments, the baseband circuitry 720 may include circuitry to operate with signals that are not strictly considered as being in a baseband frequency. For example, in some embodiments, baseband circuitry may include circuitry to operate with signals having an intermediate frequency, which is between a baseband frequency and a radio frequency.

[0187] The RF circuitry 710 may enable communication with wireless networks using modulated electromagnetic radiation through a non-solid medium. In various embodiments, the RF circuitry may include switches, filters, amplifiers, etc. to facilitate the communication with the wireless network. In various embodiments, the RF circuitry 710 may include circuitry to operate with signals that are not strictly considered as being in a radio frequency. For example, in some embodiments, RF circuitry may include circuitry to operate with signals having an intermediate frequency, which is between a baseband frequency and a radio frequency.

[0188] In various embodiments, the transmitter circuitry, control circuitry, or receiver circuitry discussed above with respect to the UE, eNB, or gNB may be embodied in whole or in part in one or more of the RF circuitries, the baseband circuitry, and/or the processing unit. As used herein, “circuitry” may refer to, be part of, or include an Application Specific Integrated Circuit (ASIC), an electronic circuit, a processor (shared, dedicated, or group), and/or a memory (shared, dedicated, or group) that execute one or more software or firmware programs, a combinational logic circuit, and/or other suitable hardware components that provide the described functionality. In some embodiments, the electronic device circuitry may be implemented in, or functions associated with the circuitry may be implemented by, one or more software or firmware modules. In some embodiments, some or all of the constituent components of the baseband circuitry, the processing unit, and/or the memory/storage may be implemented together on a system on a chip (SOC).

[0189] The memory/storage 740 may be used to load and store data and/or instructions, for example, for system. The memory/storage for one embodiment may include any combination of suitable volatile memory, such as dynamic random access memory (DRAM)), and/or non-volatile memory, such as flash memory. In various embodiments, the I/O interface 780 may include one or more user interfaces designed to enable user interaction with the system and/or peripheral component interfaces designed to enable peripheral component interaction with the system. User interfaces may include, but are not limited to a physical keyboard or keypad, a touchpad, a speaker, a microphone, etc. Peripheral component interfaces may include, but are not limited to, a non-volatile memory port, a universal serial bus (USB) port, an audio jack, and a power supply interface.

[0190] In various embodiments, the sensor 770 may include one or more sensing devices to determine environmental conditions and/or location information related to the system. In some embodiments, the sensors may include, but are not limited to, a gyro sensor, an accelerometer, a proximity sensor, an ambient light sensor, and a positioning unit. The positioning unit may also be part of, or interact with, the baseband circuitry and/or RF circuitry to communicate with components of a positioning network, e.g., a global positioning system (GPS) satellite. In various embodiments, the display 750 may include a display, such as a liquid crystal display and a touch screen display. In various embodiments, the system 700 may be a mobile computing device such as, but not limited to, a laptop computing device, a tablet computing device, a netbook, an ultrabook, a smartphone, etc. In various embodiments, system may have more or less components, and/or different architectures. Where appropriate, methods described herein may be implemented as a computer program. The computer program may be stored on a storage medium, such as a non-transitory storage medium.

[0191] The embodiment of the present disclosure is a combination of techniques/processes that can be adopted in 3GPP specification to create an end product.

[0192] A person having ordinary skill in the art understands that each of the units, algorithm, and steps described and disclosed in the embodiments of the present disclosure are realized using electronic hardware or combinations of software for computers and electronic hardware. Whether the functions run in hardware or software depends on the condition of application and design requirement for a technical plan. A person having ordinary skill in the art can use different ways to realize the function for each specific application while such realizations should not go beyond the scope of the present disclosure. It is understood by a person having ordinary skill in the art that he/she can refer to the working processes of the system, device, and unit in the above-mentioned embodiment since the working processes of the above-mentioned system, device, and unit are basically the same. For easy description and simplicity, these working processes will not be detailed.

[0193] It is understood that the disclosed system, device, and method in the embodiments of the present disclosure can be realized with other ways. The above-mentioned embodiments are exemplary only. The division of the units is merely based on logical functions while other divisions exist in realization. It is possible that a plurality of units or components are combined or integrated in another system. It is also possible that some characteristics are omitted or skipped. On the other hand, the displayed or discussed mutual coupling, direct coupling, or communicative coupling operate through some ports, devices, or units whether indirectly or communicatively by ways of electrical, mechanical, or other kinds of forms.

[0194] The units as separating components for explanation are or are not physically separated. The units for display are or are not physical units, that is, located in one place or distributed on a plurality of network units. Some or all of the units are used according to the purposes of the embodiments. Moreover, each of the functional units in each of the embodiments can be integrated in one processing unit, physically independent, or integrated in one processing unit with two or more than two units.

[0195] If the software function unit is realized and used and sold as a product, it can be stored in a readable storage medium in a computer. Based on this understanding, the technical plan proposed by the present disclosure can be essentially or partially realized as the form of a software product. Or, one part of the technical plan beneficial to the conventional technology can be realized as the form of a software product. The software product in the computer is stored in a storage medium, including a plurality of commands for a computational device (such as a personal computer, a server, or a network device) to run all or some of the steps disclosed by the embodiments of the present disclosure. The storage medium includes a USB disk, a mobile hard disk, a read-only memory (ROM), a random access memory (RAM), a floppy disk, or other kinds of media capable of storing program codes.

[0196] Embodiments of the disclosure are provided to a base station, a user equipment and a method for small data transmission based on random access. In a first aspect of the present disclosure, mapping relationship between UE IDs/service types/QoS profiles/access ids/access categories/etc. and PRACH resources/PRACH occasion is introduced. In a second aspect of the present disclosure, measurement based PRACH resources selection mechanism is introduced so that the UE shall perform RACH-based small data transmission with the available PRACH resources. In a third aspect of the present disclosure, mapping relationship between data volume/SDT type/RACH type/etc. and back off time duration is introduced. The base station determines back off time duration based on the data volume/SDT type/RACH type/etc. of the UE that performs random access successfully and transmitted the back off configuration to the UEs through unicast and/or broadcast. Then the UEs attempt to perform RACH-based

SDT with the same PRACH resource (in frequency domain perspective) back off according to the configuration. In a fourth aspect of the present disclosure, access IDs are assigned for the small data services, and/or the small data transmission services are categorized into several categories. Enhancement on access control mechanism is introduced based on the access ID/access category/etc. to allow/forbid specific UEs/services to perform RACH-based SDT according to the configuration. The adjustment can be depend on the network load to alleviate the network congestion.

[0197] While the present disclosure has been described in connection with what is considered the most practical and preferred embodiments, it is understood that the present disclosure is not limited to the disclosed embodiments but is intended to cover various arrangements made without departing from the scope of the broadest interpretation of the appended claims.

Claims

What is claimed is:

1. A method for small data transmission (SDT) based on random access executable in a user equipment comprising:

receiving a configuration indicating a mapping relationship between a plurality of physical random access channel (PRACH) resources and a plurality of access parameters from a base station;

selecting one of the PRACH resources corresponding to an access parameter of the user equipment according to the mapping relationship;

transmitting to the base station a random access preamble over the selected PRACH resource;

transmitting a radio resource control (RRC) connection resume request to the base station; and

receiving an RRC connection release request from the base station.

2. The method of claim 1, wherein the transmitting to the base station the random access preamble over the selected PRACH resource comprises:

transmitting to the base station a first message carrying uplink (UL) user plane (UP) data and/or the random access preamble over the selected PRACH resource; and

wherein the receiving the RRC connection release request from the user equipment comprises:

receiving a second message carrying the RRC connection release request and/or downlink (DL) user plane (UP) data or Acknowledgment (ACK) signal or Negative-Acknowledgment (NACK) signal from the base station.

3. The method of claim 1, wherein the transmitting the radio resource control (RRC) connection resume request to the base station comprises:

transmitting the RRC connection resume request and/or uplink (UL) user plane (UP) data to the user equipment; and

wherein the receiving the RRC connection release request from the user equipment comprises:

receiving a second message carrying the RRC connection release request and/or downlink (DL) user plane (UP) data or Acknowledgment (ACK) signal or Negative-Acknowledgment (NACK) signal from the base station.

4. The method of claim 1, wherein the method further comprises:

receiving a second message carrying a random access response (RAR) from the base station, after the transmitting to the base station the random access preamble;

wherein the transmitting the radio resource control (RRC) connection resume request to the base station comprises:

transmitting a third message carrying the radio resource control (RRC) connection resume request and/or UL UP data to the base station; and

wherein the receiving the RRC connection release request from the base station comprises:

receiving a fourth message carrying the RRC connection release request and/or downlink (DL) user plane (UP) data or Acknowledgment (ACK) signal or Negative-Acknowledgment (NACK) signal from the base station.

5. The method of claim 1, wherein the transmitting to the base station the random access preamble over the selected PRACH resource comprises:

transmitting to the base station a first message carrying the random access preamble and/or uplink (UL) user plane (UP) grant request or a scheduling report (SR) or a buffer status report (BSR) over the selected PRACH resource;

wherein after transmitting to the base station the first message carrying uplink (UL) user plane (UP) data

and/or the random access preamble over the selected PRACH resource,

the method further comprises:

receiving a second message carrying a random access response (RAR) and/or UL grant signal from the base station, after the transmitting to the base station the first message carrying the random access preamble and/or uplink (UL) user plane (UP) grant request or the scheduling report (SR) or the buffer status report (BSR) over the selected PRACH resource;

wherein the transmitting the radio resource control (RRC) connection resume request to the base station comprises:

transmitting a third message carrying the radio resource control (RRC) connection resume request and/or UL UP data to the base station; and

wherein the receiving the RRC connection release request from the base station comprises:

receiving a fourth message carrying the RRC connection release request and/or downlink (DL) user plane (UP) data or Acknowledgment (ACK) signal or Negative-Acknowledgment (NACK) signal from the base station.

6. The method of claim 1, wherein the transmitting to the base station the random access preamble over the selected PRACH resource comprises:

transmitting to the base station a first message carrying uplink (UL) user plane (UP) data and/or the random access preamble over the selected PRACH resource;

wherein after transmitting to the base station the first message carrying uplink (UL) user plane (UP) data and/or the random access preamble over the selected PRACH resource, the method further comprises:

receiving a second message carrying a random access response (RAR) and Acknowledgment (ACK) signal or Negative-Acknowledgment (NACK) signal from the base station, after the transmitting to the base station the first message carrying uplink (UL) user plane (UP) data and/or the random access preamble;

wherein the transmitting the radio resource control (RRC) connection resume request to the base station comprises:

transmitting a third message carrying the radio resource control (RRC) connection resume request and/or subsequent UL UP data to the base station; and

wherein the receiving the RRC connection release request from the base station comprises:

receiving a fourth message carrying the RRC connection release request and/or downlink (DL) user plane (UP) data or Acknowledgment (ACK) signal or Negative-Acknowledgment (NACK) signal from the base station.

7. The method of claim 1, wherein the selecting one of the PRACH resources corresponding to the access parameter of the user equipment according to the mapping relationship comprises:

measuring strengths of signals received on the PRACH resources to obtain measurement results of the PRACH resources;

determining a PRACH pool having available PRACH resources that the measurement results are less than or equal to a configured threshold transmitted by the base station; and

selecting one of the PRACH resources from the PRACH pool.

8. The method of claim 7, wherein the strengths of signals indicate Reference Signal Received Power (RSRP), Reference Signal Received Quality (RSRQ), Received Signal Strength Indicator (RSSI), and/or Signal to Interference plus Noise Ratio (SINR).

9. The method of claim 7, wherein the measuring strengths of signals received on the PRACH resources to obtain the measurement results comprises:

measuring the strengths of signals received on the PRACH resources to obtain the measurement results during a monitoring time duration beginning from a starting time of a PRACH occasion or from a configured time point.

10. The method of claim 9, wherein a length of the PRACH occasion equals to a length of the monitoring time duration plus the PRACH resource.

11. The method of claim 9, wherein a measurement result of the PRACH occasion within a measurement cycle is defined as an average against an active duration of the measurement results during the active duration.

12. The method of claim 9, wherein a measurement result of the PRACH occasion within the measurement cycle is defined as an average against the measurement cycle duration of the measurement results during the active duration.

13. The method of claim 9, wherein each of the measurement results is an average of the strengths of signals received on each of the PRACH resources against the monitoring time duration

14. The method of claim 9, wherein a length of the monitoring time duration is adjustable or configurable depending on different user equipments or different SDT services.

15. The method of claim 9, wherein the measuring strengths of signals received on the PRACH resources to obtain the measurement results is performed when a SDT service happens.

16. The method of claim 15, further comprising:

if the measurement result is less than or equals to the configured threshold, selecting a next the measuring PRACH occasion or the next PRACH occasion to perform the SDT service.

17. The method of claim 15, further comprising:

if the measurement result is less than or equals to the configured threshold, selecting a next the measuring PRACH occasion or the next PRACH occasion to perform the SDT service after waiting a back off time duration.

18. The method of claim 7, further comprising:

if no available PRACH resource is detected for a configured number of measurement times, adjusting/raising the configured threshold.

19. The method of claim 7, wherein the PRACH pool having the available PRACH resources is maintained by the user equipment in real time.

20. The method of claim 16, wherein a PRACH resource that is occupied as indicated by the base station is excluded to the available PRACH resources.

21. A user equipment comprising:

a transceiver; and

a processor connected with the transceiver and configured to execute the following operations comprising:

receiving a configuration indicating a mapping relationship between a plurality of physical random access channel (PRACH) resources and a plurality of access parameters from a base station;

selecting one of the PRACH resources corresponding to an access parameter of the user equipment according to the mapping relationship;

transmitting to the base station a random access preamble over the selected PRACH resource;

transmitting a radio resource control (RRC) connection resume request to the base station; and

receiving an RRC connection release request from the base station.

22. The user equipment of claim 21, wherein the transmitting to the base station the random access preamble over the selected PRACH resource comprises:

transmitting to the base station a first message carrying uplink (UL) user plane (UP) data and/or the random

access preamble over the selected PRACH resource; and

wherein the receiving the RRC connection release request from the user equipment comprises:

receiving a second message carrying the RRC connection release request and/or downlink (DL) user plane (UP) data or Acknowledgment (ACK) signal or Negative-Acknowledgment (NACK) signal from the base station.

23. The user equipment of claim 21, wherein the transmitting the radio resource control (RRC) connection resume request to the base station comprises:

transmitting the RRC connection resume request and/or uplink (UL) user plane (UP) data to the user equipment; and

wherein the receiving the RRC connection release request from the user equipment comprises:

receiving a second message carrying the RRC connection release request and/or downlink (DL) user plane (UP) data or Acknowledgment (ACK) signal or Negative-Acknowledgment (NACK) signal from the base station.

24. The user equipment of claim 21, wherein the operations further comprise:

receiving a second message carrying a random access response (RAR) from the base station, after the transmitting to the base station the random access preamble;

wherein the transmitting the radio resource control (RRC) connection resume request to the base station comprises:

transmitting a third message carrying the radio resource control (RRC) connection resume request and/or UL UP data to the base station; and

wherein the receiving the RRC connection release request from the base station comprises:

receiving a fourth message carrying the RRC connection release request and/or downlink (DL) user plane (UP) data or Acknowledgment (ACK) signal or Negative-Acknowledgment (NACK) signal from the base station.

25. The user equipment of claim 21, wherein the transmitting to the base station the random access preamble over the selected PRACH resource comprises:

transmitting to the base station a first message carrying the random access preamble and/or uplink (UL) user plane (UP) grant request or a scheduling report (SR) or a buffer status report (BSR) over the selected PRACH resource;

wherein after transmitting to the base station the first message carrying uplink (UL) user plane (UP) data and/or the random access preamble over the selected PRACH resource

the operations further comprise:

receiving a second message carrying a random access response (RAR) and/or UL grant signal from the base station, after the transmitting to the base station the first message carrying the random access preamble and/or uplink (UL) user plane (UP) grant request or the scheduling report (SR) or the buffer status report (BSR) over the selected PRACH resource;

wherein the transmitting the radio resource control (RRC) connection resume request to the base station comprises:

transmitting a third message carrying the radio resource control (RRC) connection resume request and/or UL UP data to the base station; and

wherein the receiving the RRC connection release request from the base station comprises:

receiving a fourth message carrying the RRC connection release request and/or downlink (DL) user plane (UP) data or Acknowledgment (ACK) signal or Negative-Acknowledgment (NACK) signal from the base station.

26. The user equipment of claim 21, wherein the transmitting to the base station the random access preamble

over the selected PRACH resource comprises:

transmitting to the base station a first message carrying uplink (UL) user plane (UP) data and/or the random access preamble over the selected PRACH resource;

wherein after transmitting to the base station the first message carrying uplink (UL) user plane (UP) data and/or the random access preamble over the selected PRACH resource, the operations further comprise:

receiving a second message carrying a random access response (RAR) and Acknowledgment (ACK) signal or Negative-Acknowledgment (NACK) signal from the base station, after the transmitting to the base station the first message carrying uplink (UL) user plane (UP) data and/or the random access preamble;

wherein the transmitting the radio resource control (RRC) connection resume request to the base station comprises:

transmitting a third message carrying the radio resource control (RRC) connection resume request and/or subsequent UL UP data to the base station; and

wherein the receiving the RRC connection release request from the base station comprises:

receiving a fourth message carrying the RRC connection release request and/or downlink (DL) user plane (UP) data or Acknowledgment (ACK) signal or Negative-Acknowledgment (NACK) signal from the base station.

27. The user equipment of claim 21, wherein the selecting one of the PRACH resources corresponding to the access parameter of the user equipment according to the mapping relationship comprises:

measuring strengths of signals received on the PRACH resources to obtain measurement results of the PRACH resources;

determining a PRACH pool having available PRACH resources that the measurement results are less than or equal to a configured threshold transmitted by the base station; and

selecting one of the PRACH resources from the PRACH pool.

28. The user equipment of claim 27, wherein the strengths of signals indicate Reference Signal Received Power (RSRP), Reference Signal Received Quality (RSRQ), Received Signal Strength Indicator (RSSI), and/or Signal to Interference plus Noise Ratio (SINR).

29. The user equipment of claim 27, wherein the measuring strengths of signals received on the PRACH resources to obtain the measurement results comprises:

measuring the strengths of signals received on the PRACH resources to obtain the measurement results during a monitoring time duration beginning from a starting time of a PRACH occasion or from a configured time point.

30. The user equipment of claim 29, wherein a length of the PRACH occasion equals to a length of the monitoring time duration plus the PRACH resource.

31. The user equipment of claim 29, wherein a measurement result of the PRACH occasion within a measurement cycle is defined as an average against an active duration of the measurement results during the active duration.

32. The user equipment of claim 29, wherein a measurement result of the PRACH occasion within the measurement cycle is defined as an average against the measurement cycle duration of the measurement results during the active duration.

33. The user equipment of claim 29, wherein each of the measurement results is an average of the strengths of signals received on each of the PRACH resources against the monitoring time duration.

34. The user equipment of claim 29, wherein a length of the monitoring time duration is adjustable or configurable depending on different user equipments or different SDT services.

35. The user equipment of claim 29, wherein the measuring strengths of signals received on the PRACH resources to obtain the measurement results is performed when a SDT service happens.

36. The user equipment of claim 35, wherein the operations further comprise:

if the measurement result is less than or equals to the configured threshold, selecting a next the measuring PRACH occasion or the next PRACH occasion to perform the SDT service.

37. The user equipment of claim 35, wherein the operations further comprise:

if the measurement result is less than or equals to the configured threshold, selecting a next the measuring PRACH occasion or the next PRACH occasion to perform the SDT service after waiting a back off time duration.

38. The user equipment of claim 27, wherein the operations further comprise:

if no available PRACH resource is detected for a configured number of measurement times, adjusting/raising the configured threshold.

39. The user equipment of claim 27, wherein the PRACH pool having the available PRACH resources is maintained by the user equipment in real time.

40. The user equipment of claim 36, wherein a PRACH resource that is occupied as indicated by the base station is excluded to the available PRACH resources.

41. A method for small data transmission (SDT) based on random access executable in a base station, comprising:

transmitting a mapping relationship between a plurality of physical random access channel (PRACH) resources and a plurality of access parameters to a user equipment;

receiving, from the user equipment, a random access preamble over a selected PRACH resource, wherein the selected PRACH resource is selected from one of the PRACH resources corresponding to an access parameter of the user equipment according to the mapping relationship;

receiving a radio resource control (RRC) connection resume request from the user equipment; and

transmitting an RRC connection release request to the user equipment.

42. The method of claim 21, wherein the access parameters are user equipment identities (IDs).

43. The method of claim 41, wherein the access parameters are access IDs.

44. The method of claim 41, wherein the access parameters are access categories.

45. The method of claim 41, wherein the access parameters are Quality-of-Service (QoS) profiles.

46. The method of claim 41, wherein the access parameters indicate priorities of the plurality of physical random access channel (PRACH) resources.

47. The method of claim 41, wherein the access parameters indicate various SDT service types.

48. The method of claim 41, wherein the transmitting the mapping relationship between the plurality of physical random access channel (PRACH) resources and the plurality of access parameters to the user equipment mapping relationship comprises:

periodically broadcasting the mapping relationship between the plurality of PRACH resources and the plurality of access parameters to the user equipment.

49. The method of claim 41, wherein the transmitting the mapping relationship between the plurality of physical random access channel (PRACH) resources and the plurality of access parameters to the user equipment mapping relationship comprises:

periodically unicasting the mapping relationship between the plurality of PRACH resources and the plurality of

access parameters to the user equipment.

50. The method of claim 41, wherein the mapping relationship is modified or generated according a network load.

51. The method of claim 41, wherein the mapping relationship is transmitted from a 5G core network.

52. The method of claim 41, wherein the receiving, from the user equipment, the random access preamble over the selected PRACH resource comprises:

receiving, from the user equipment, a first message carrying uplink (UL) user plane (UP) data and/or the random access preamble over the selected PRACH resource; and

wherein the transmitting the RRC connection release request to the user equipment comprises:

transmitting a second message carrying the RRC connection release request and/or downlink (DL) user plane (UP) data or Acknowledgment (ACK) signal or Negative-Acknowledgment (NACK) signal to the user equipment.

53. The method of claim 41, wherein the receiving the radio resource control (RRC) connection resume request from the user equipment comprises:

receiving the RRC connection resume request and/or uplink (UL) user plane (UP) data from the user equipment; and

wherein the transmitting the RRC connection release request to the user equipment comprises:

transmitting a second message carrying the RRC connection release request and/or downlink (DL) user plane (UP) data or Acknowledgment (ACK) signal or Negative-Acknowledgment (NACK) signal to the user equipment.

54. The method of claim 41, wherein the method further comprises:

transmitting a second message carrying a random access response (RAR) to the user equipment, after the receiving, from the user equipment, the random access preamble;

wherein the receiving the radio resource control (RRC) connection resume request from the user equipment comprises:

receiving a third message carrying the radio resource control (RRC) connection resume request and/or UL UP data from the user equipment; and

wherein the transmitting the RRC connection release request to the user equipment comprises:

transmitting a fourth message carrying the RRC connection release request and/or downlink (DL) user plane (UP) data or Acknowledgment (ACK) signal or Negative-Acknowledgment (NACK) signal to the user equipment.

55. The method of claim 41, wherein the receiving, from the user equipment, the random access preamble over the selected PRACH resource comprises:

receiving, from the user equipment, a first message carrying the random access preamble and/or uplink (UL) user plane (UP) grant request or a scheduling report (SR) or a buffer status report (BSR) over the selected PRACH resource;

wherein after receiving, from the user equipment, the first message carrying uplink (UL) user plane (UP) data and/or the random access preamble over the selected PRACH resource

the method further comprises:

transmitting a second message carrying a random access response (RAR) and/or UL grant signal to the user equipment, after the receiving, from the user equipment, the first message carrying the random access preamble and/or uplink (UL) user plane (UP) grant request or the scheduling report (SR) or the buffer status report (BSR) over

the selected PRACH resource;

wherein the receiving the radio resource control (RRC) connection resume request from the user equipment comprises:

receiving a third message carrying the radio resource control (RRC) connection resume request and/or UL UP data from the user equipment; and

wherein the transmitting the RRC connection release request to the user equipment comprises:

transmitting a fourth message carrying the RRC connection release request and/or downlink (DL) user plane (UP) data or Acknowledgment (ACK) signal or Negative-Acknowledgment (NACK) signal to the user equipment.

56. The method of claim 41, wherein the receiving, from the user equipment, the random access preamble over the selected PRACH resource comprises:

receiving, from the user equipment, a first message carrying uplink (UL) user plane (UP) data and/or the random access preamble over the selected PRACH resource;

wherein after receiving, from the user equipment, the first message carrying uplink (UL) user plane (UP) data and/or the random access preamble over the selected PRACH resource, the method further comprises:

transmitting a second message carrying a random access response (RAR) and Acknowledgment (ACK) signal or Negative-Acknowledgment (NACK) signal to the user equipment, after the receiving, from the user equipment, the first message carrying uplink (UL) user plane (UP) data and/or the random access preamble;

wherein the receiving the radio resource control (RRC) connection resume request from the user equipment comprises:

receiving a third message carrying the radio resource control (RRC) connection resume request and/or subsequent UL UP data from the user equipment; and

wherein the transmitting the RRC connection release request to the user equipment comprises:

transmitting a fourth message carrying the RRC connection release request and/or downlink (DL) user plane (UP) data or Acknowledgment (ACK) signal or Negative-Acknowledgment (NACK) signal to the user equipment.

57. The method of claim 41, further comprising:

transmitting a configured threshold and a measuring configuration to the user equipment, wherein the user equipment is used for measuring strengths of signals received on the PRACH resources to obtain measurement results of the PRACH resources, for determining a PRACH pool having available PRACH resources that measurement results are less than or equal to the configured threshold, and for selecting one of the PRACH resources from the PRACH pool.

58. A base station comprising:

a transceiver; and

a processor connected with the transceiver and configured to execute the following operations comprising:

transmitting a mapping relationship between a plurality of physical random access channel (PRACH) resources and a plurality of access parameters to a user equipment;

receiving, from the user equipment, a random access preamble over a selected PRACH resource, wherein the selected PRACH resource is selected from one of the PRACH resources corresponding to an access parameter of the user equipment according to the mapping relationship;

receiving a radio resource control (RRC) connection resume request from the user equipment; and

transmitting an RRC connection release request to the user equipment.

59. The base station of claim 58, wherein the access parameters are user equipment identities (IDs).

60. The base station of claim 58, wherein the access parameters are access IDs.
61. The base station of claim 58, wherein the access parameters are access categories.
62. The base station of claim 58, wherein the access parameters are Quality-of-Service (QoS) profiles.
63. The base station of claim 58, wherein the access parameters indicate priorities of the plurality of physical random access channel (PRACH) resources.
64. The base station of claim 58, wherein the access parameters indicate various SDT service types.
65. The base station of claim 58, wherein the transmitting the mapping relationship between the plurality of physical random access channel (PRACH) resources and the plurality of access parameters to the user equipment mapping relationship comprises:
- periodically broadcasting the mapping relationship between the plurality of PRACH resources and the plurality of access parameters to the user equipment.
66. The base station of claim 58, wherein the transmitting the mapping relationship between the plurality of physical random access channel (PRACH) resources and the plurality of access parameters to the user equipment mapping relationship comprises:
- periodically unicasting the mapping relationship between the plurality of PRACH resources and the plurality of access parameters to the user equipment.
67. The base station of claim 58, wherein the mapping relationship is modified or generated according a network load.
68. The base station of claim 58, wherein the mapping relationship is transmitted from a 5G core network.
69. The base station of claim 58, wherein the receiving, from the user equipment, the random access preamble over the selected PRACH resource comprises:
- receiving, from the user equipment, a first message carrying uplink (UL) user plane (UP) data and/or the random access preamble over the selected PRACH resource; and
 - wherein the transmitting the RRC connection release request to the user equipment comprises:
 - transmitting a second message carrying the RRC connection release request and/or downlink (DL) user plane (UP) data or Acknowledgment (ACK) signal or Negative-Acknowledgment (NACK) signal to the user equipment.
70. The base station of claim 58, wherein the receiving the radio resource control (RRC) connection resume request from the user equipment comprises:
- receiving the RRC connection resume request and/or uplink (UL) user plane (UP) data from the user equipment; and
 - wherein the transmitting the RRC connection release request to the user equipment comprises:
 - transmitting a second message carrying the RRC connection release request and/or downlink (DL) user plane (UP) data or Acknowledgment (ACK) signal or Negative-Acknowledgment (NACK) signal to the user equipment.
71. The base station of claim 58, wherein the method further comprises:
- transmitting a second message carrying a random access response (RAR) to the user equipment, after the receiving, from the user equipment, the random access preamble;
 - wherein the receiving the radio resource control (RRC) connection resume request from the user equipment comprises:
 - receiving a third message carrying the radio resource control (RRC) connection resume request and/or UL UP data from the user equipment; and

wherein the transmitting the RRC connection release request to the user equipment comprises:

transmitting a fourth message carrying the RRC connection release request and/or downlink (DL) user plane (UP) data or Acknowledgment (ACK) signal or Negative-Acknowledgment (NACK) signal to the user equipment.

72. The base station of claim 58, wherein the receiving, from the user equipment, the random access preamble over the selected PRACH resource comprises:

receiving, from the user equipment, a first message carrying the random access preamble and/or uplink (UL) user plane (UP) grant request or a scheduling report (SR) or a buffer status report (BSR) over the selected PRACH resource;

wherein after receiving, from the user equipment, the first message carrying uplink (UL) user plane (UP) data and/or the random access preamble over the selected PRACH resource

the operations further comprise:

transmitting a second message carrying a random access response (RAR) and/or UL grant signal to the user equipment, after the receiving, from the user equipment, the first message carrying the random access preamble and/or uplink (UL) user plane (UP) grant request or the scheduling report (SR) or the buffer status report (BSR) over the selected PRACH resource;

wherein the receiving the radio resource control (RRC) connection resume request from the user equipment comprises:

receiving a third message carrying the radio resource control (RRC) connection resume request and/or UL UP data from the user equipment; and

wherein the transmitting the RRC connection release request to the user equipment comprises:

transmitting a fourth message carrying the RRC connection release request and/or downlink (DL) user plane (UP) data or Acknowledgment (ACK) signal or Negative-Acknowledgment (NACK) signal to the user equipment.

73. The base station of claim 58, wherein the receiving, from the user equipment, the random access preamble over the selected PRACH resource comprises:

receiving, from the user equipment, a first message carrying uplink (UL) user plane (UP) data and/or the random access preamble over the selected PRACH resource;

wherein after receiving, from the user equipment, the first message carrying uplink (UL) user plane (UP) data and/or the random access preamble over the selected PRACH resource, the method further comprises:

transmitting a second message carrying a random access response (RAR) and Acknowledgment (ACK) signal or Negative-Acknowledgment (NACK) signal to the user equipment, after the receiving, from the user equipment, the first message carrying uplink (UL) user plane (UP) data and/or the random access preamble;

wherein the receiving the radio resource control (RRC) connection resume request from the user equipment comprises:

receiving a third message carrying the radio resource control (RRC) connection resume request and/or subsequent UL UP data from the user equipment; and

wherein the transmitting the RRC connection release request to the user equipment comprises:

transmitting a fourth message carrying the RRC connection release request and/or downlink (DL) user plane (UP) data or Acknowledgment (ACK) signal or Negative-Acknowledgment (NACK) signal to the user equipment.

74. The base station of claim 58, further comprising:

transmitting a configured threshold and a measuring configuration to the user equipment, wherein the user equipment is used for measuring strengths of signals received on the PRACH resources to obtain measurement

results of the PRACH resources, for determining a PRACH pool having available PRACH resources that measurement results are less than or equal to the configured threshold, and for selecting one of the PRACH resources from the PRACH pool.

75. A method for small data transmission (SDT) based on random access executable in a base station, comprising:

establishing a mapping relationship between type parameters and lengths of back off durations;

detecting data volume or random access channel (RACH) type or SDT type during a RACH-based SDT performed by a first user equipment with a PRACH resource;

selecting one of the back off durations from the mapping relationship according to the detected data volume or the detected RACH type or the detected SDT type; and

transmitting information of the selected back off duration to a second user equipment in a coverage of a cell controlled by the base station, so that the second user equipment does not perform RACH-based SDT with the PRACH resource during the selected back off duration.

76. The method of claim 75, wherein the transmitting information of the selected back off duration to a second user equipment in a coverage of a cell controlled by the base station comprises:

broadcasting or unicasting information of the selected back off duration to the second user equipment.

77. The method of claim 75, wherein the type parameters are selected from a group comprising data volume, service type, random access channel (RACH) type, and SDT type.

78. The method of claim 77, wherein the data volume is represented in a scheduling report (SR) or a buffer status report (BSR).

79. The method of claim 77, wherein the service type is represented by access identity (ID), category ID, QoS related parameters.

80. The method of claim 77, wherein the RACH type comprises 2-step RACH and 4-step RACH.

81. The method of claim 77, wherein the SDT type comprises pre-configured grant-based SDT and RACH-based SDT, or pre-configured grant-based SDT, 2-step RACH-based SDT and 4-step RACH-based SDT.

82. A base station comprising:

a transceiver; and

a processor connected with the transceiver and configured to execute the following operations comprising:

establishing a mapping relationship between type parameters and lengths of back off durations;

detecting data volume or random access channel (RACH) type or SDT type during a RACH-based SDT performed by a first user equipment with a PRACH resource;

selecting one of the back off durations from the mapping relationship according to the detected data volume or the detected RACH type or the detected SDT type; and

transmitting information of the selected back off duration to a second user equipment in a coverage of a cell controlled by the base station, so that the second user equipment does not perform RACH-based SDT with the PRACH resource during the selected back off duration.

83. The base station of claim 82, wherein the transmitting information of the selected back off duration to a second user equipment in a coverage of a cell controlled by the base station comprises:

broadcasting or unicasting information of the selected back off duration to the second user equipment.

84. The base station of claim 82, wherein the type parameters are selected from a group comprising data volume, service type, random access channel (RACH) type, and SDT type.

85. The base station of claim 84, wherein the data volume is represented in a scheduling report (SR) or a buffer status report (BSR).

86. The base station of claim 84, wherein the service type is represented by access identity (ID), category ID, QoS related parameters.

87. The base station of claim 84, wherein the RACH type comprises 2-step RACH and 4-step RACH.

88. The base station of claim 84, wherein the SDT type comprises pre-configured grant-based SDT and RACH-based SDT, or pre-configured grant-based SDT, 2-step RACH-based SDT and 4-step RACH-based SDT.

89. A method for small data transmission (SDT) based on random access executable in a base station, comprising:

establishing a mapping relationship between SDT service types and access identities (IDs) or access categories; determining, from the mapping relationship, an access control configuration that sets which access identities (IDs) or access categories are allowed to perform SDT services according to network load; and

transmitting the access control configuration to a user equipment that is allowed perform SDT services, so that the user equipment performs RACH-based SDT.

90. The method of claim 89, wherein the transmitting the access control configuration to a user equipment that is allowed perform SDT services comprises:

broadcasting the access control configuration to the user equipment that is allowed perform SDT services.

91. The method of claim 89, wherein the network load indicates counts of successful/failed random accesses, count of attempts of random access, and the amount of data transmitted within a specified time duration.

92. A base station comprising:

a transceiver; and

a processor connected with the transceiver and configured to execute the following operations comprising:

establishing a mapping relationship between SDT service types and access identities (IDs) or access categories; determining, from the mapping relationship, an access control configuration that sets which access identities (IDs) or access categories are allowed to perform SDT services according to network load; and

transmitting the access control configuration to a user equipment that is allowed perform SDT services, so that the user equipment performs RACH-based SDT.

93. The base station of claim 92, wherein the transmitting the access control configuration to a user equipment that is allowed perform SDT services comprises:

broadcasting the access control configuration to the user equipment that is allowed perform SDT services.

94. The base station of claim 92, wherein the network load indicates counts of successful/failed random accesses, count of attempts of random access, and the amount of data transmitted within a specified time duration.

95. A chip, comprising:

a processor, configured to call and run a computer program stored in a memory, to cause a device in which the chip is installed to execute any of the methods of claims 1 to 20.

96. A chip, comprising:

a processor, configured to call and run a computer program stored in a memory, to cause a device in which the chip is installed to execute any of the methods of claims 41 to 57.

97. A chip, comprising:

a processor, configured to call and run a computer program stored in a memory, to cause a device in which the

chip is installed to execute any of the methods of claims 75 to 81.

98. A chip, comprising:

a processor, configured to call and run a computer program stored in a memory, to cause a device in which the chip is installed to execute any of the methods of claims 89 to 91.

99. A computer readable storage medium, in which a computer program is stored, wherein the computer program causes a computer to execute any of the methods of claims 1 to 20.

100. A computer readable storage medium, in which a computer program is stored, wherein the computer program causes a computer to execute any of the methods of claims 41 to 57.

101. A computer readable storage medium, in which a computer program is stored, wherein the computer program causes a computer to execute any of the methods of claims 75 to 81.

102. A computer readable storage medium, in which a computer program is stored, wherein the computer program causes a computer to execute any of the methods of claims 89 to 91.

103. A computer program product, comprising a computer program, wherein the computer program causes a computer to execute any of the methods of claims 1 to 20.

104. A computer program product, comprising a computer program, wherein the computer program causes a computer to execute any of the methods of claims 41 to 57.

105. A computer program product, comprising a computer program, wherein the computer program causes a computer to execute any of the methods of claims 75 to 81.

106. A computer program product, comprising a computer program, wherein the computer program causes a computer to execute any of the methods of claims 89 to 91.

107. A computer program, wherein the computer program causes a computer to execute any of the methods of claims 1 to 20.

108. A computer program, wherein the computer program causes a computer to execute any of the methods of claims 41 to 57.

109. A computer program, wherein the computer program causes a computer to execute any of the methods of claims 75 to 81.

110. A computer program, wherein the computer program causes a computer to execute any of the methods of claims 89 to 91.

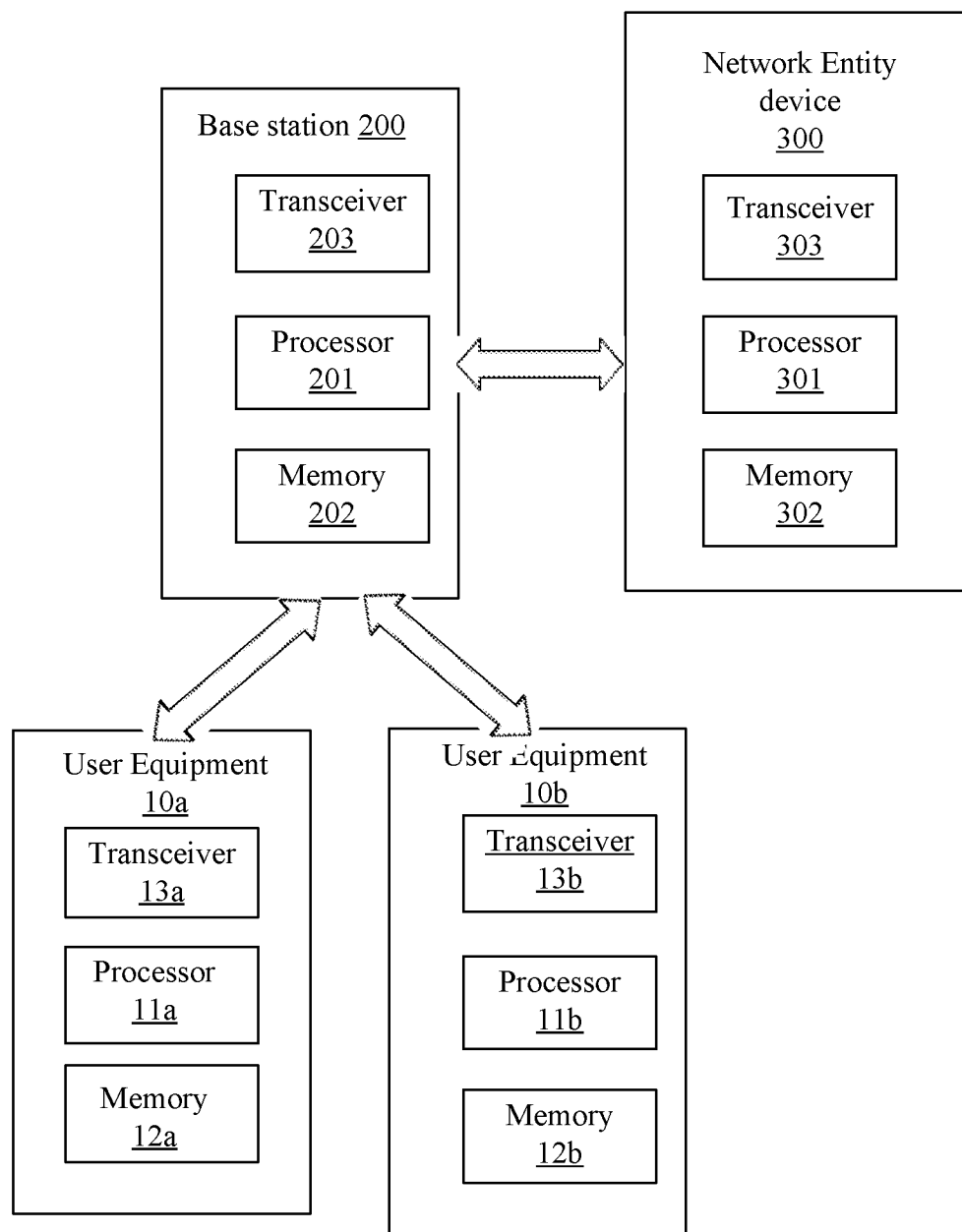


Fig. 1

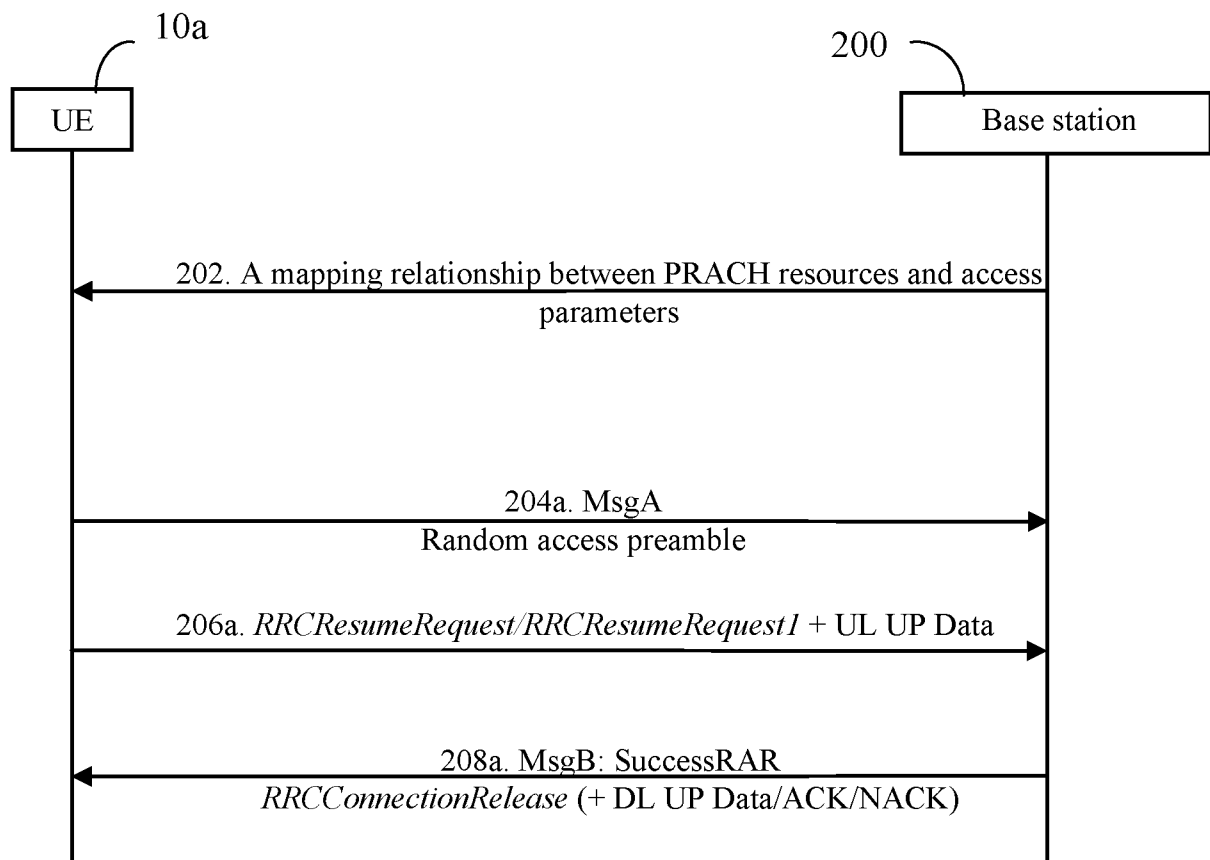


Fig. 2A

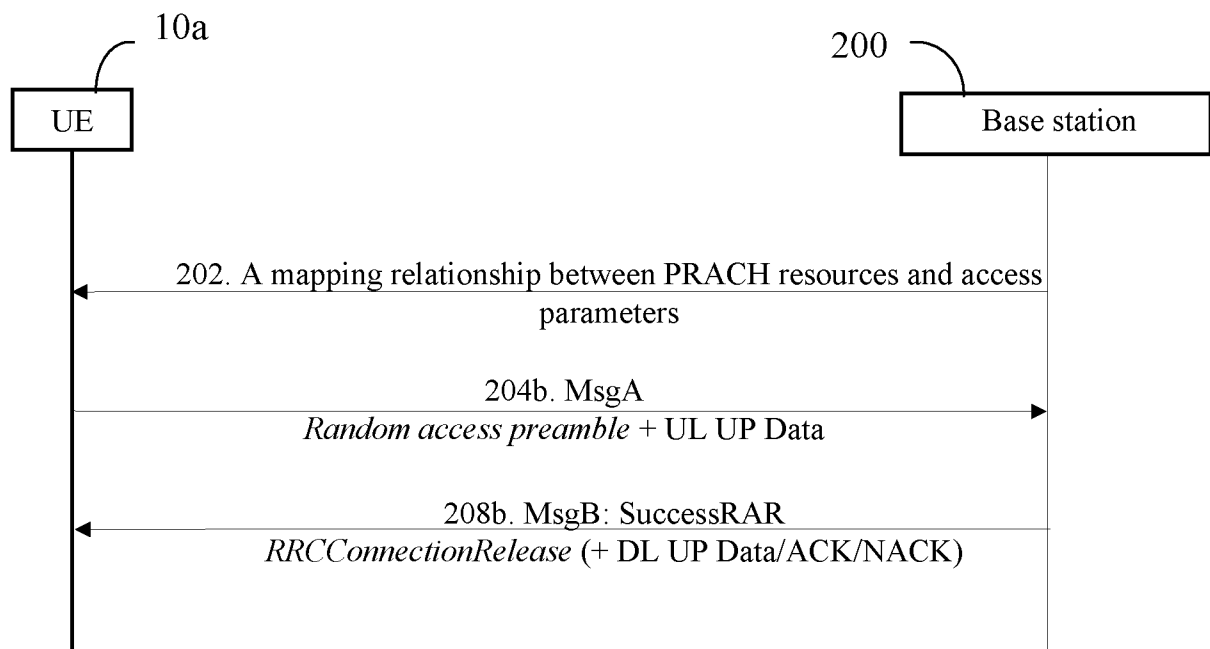


Fig. 2B

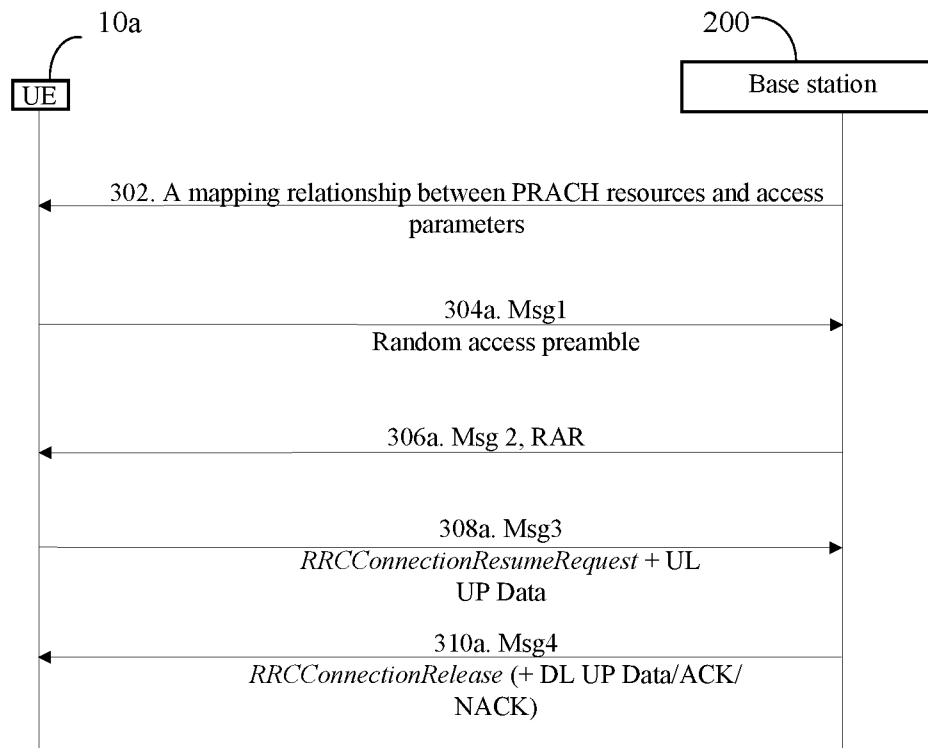


Fig. 3A

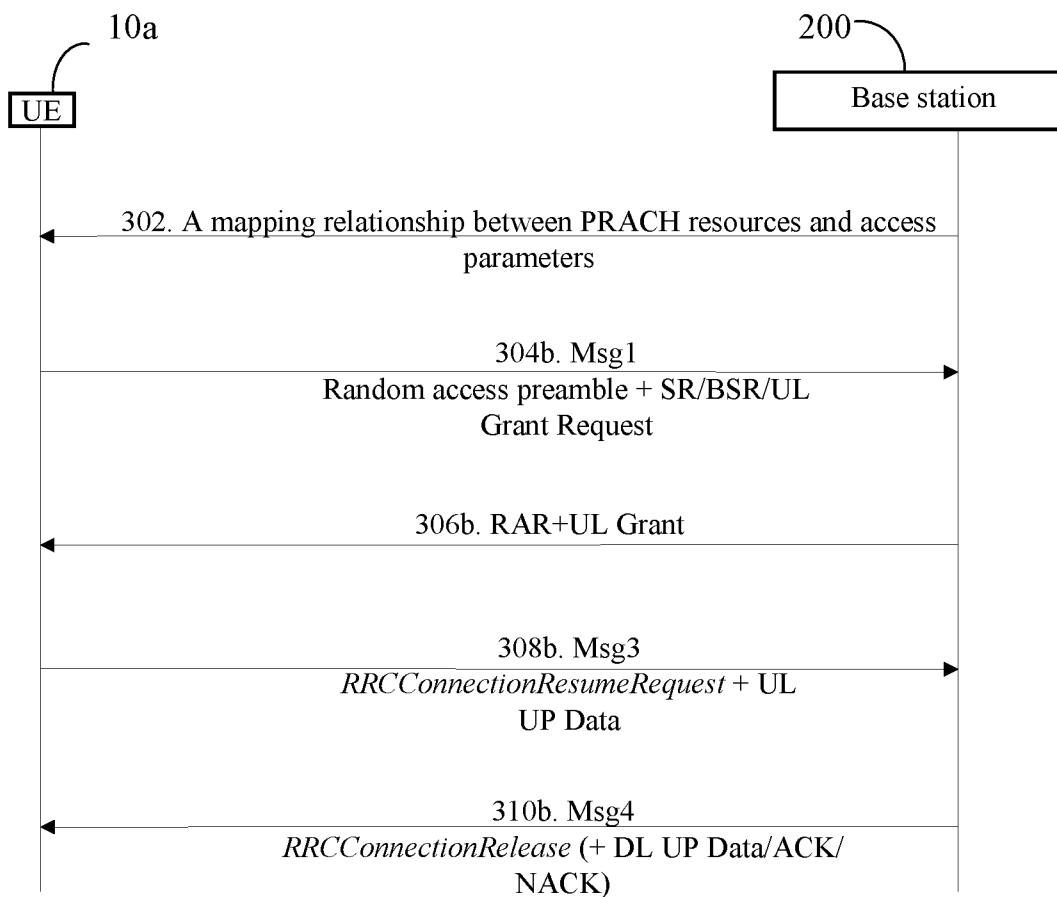


Fig. 3B

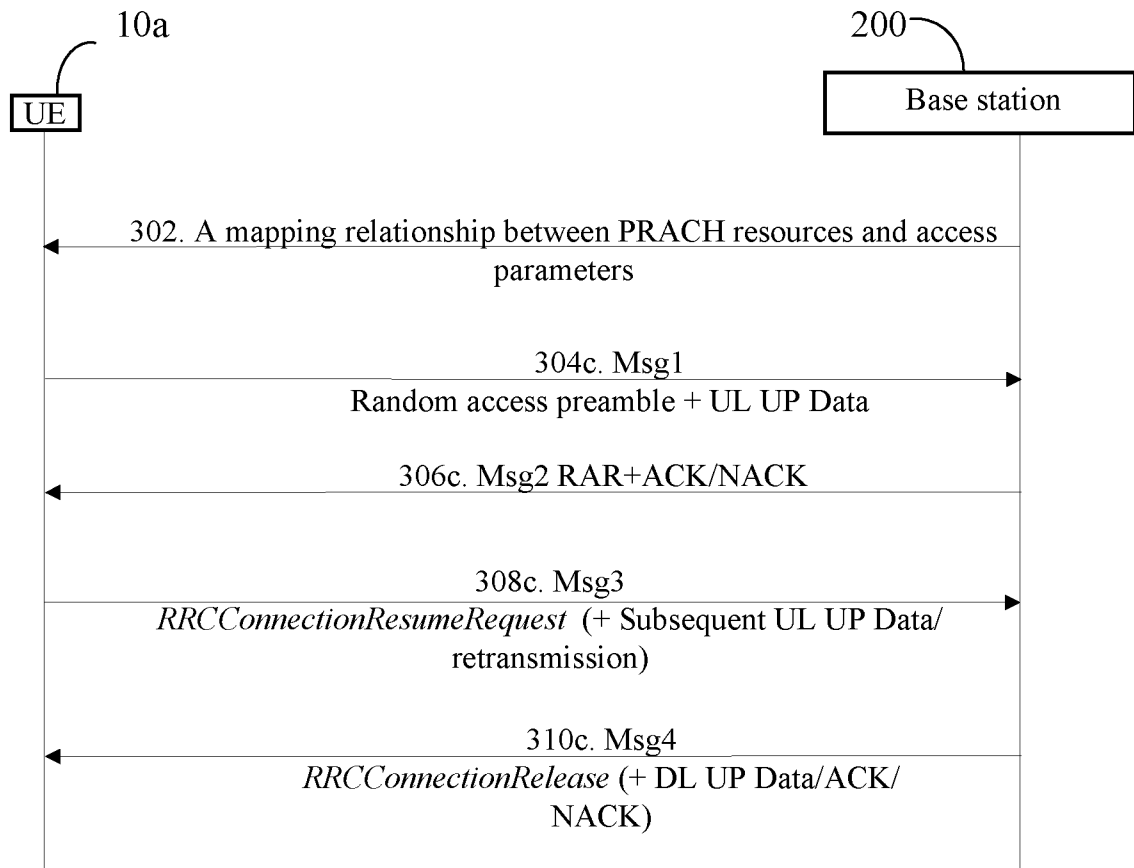


Fig. 3C

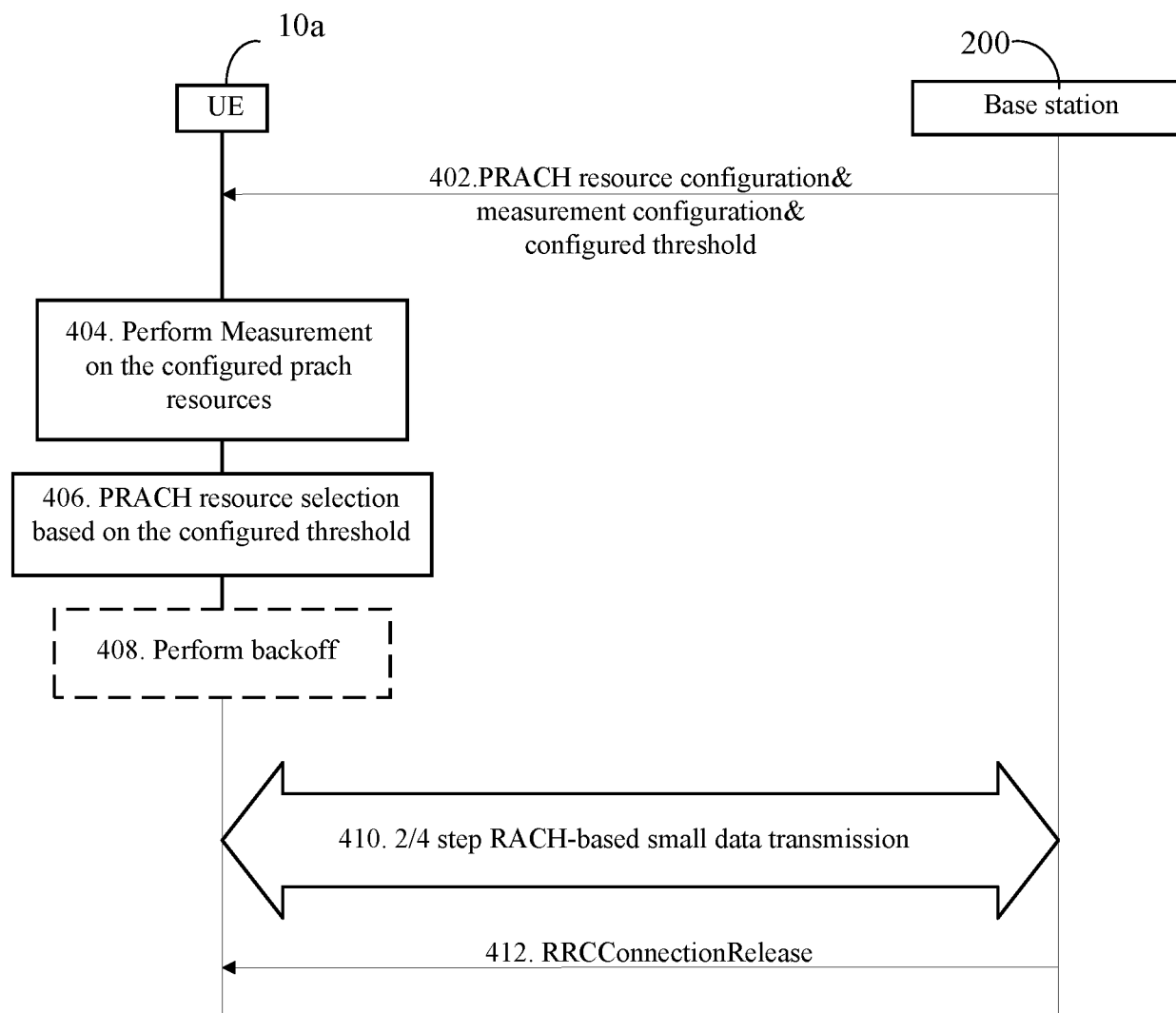


Fig. 4

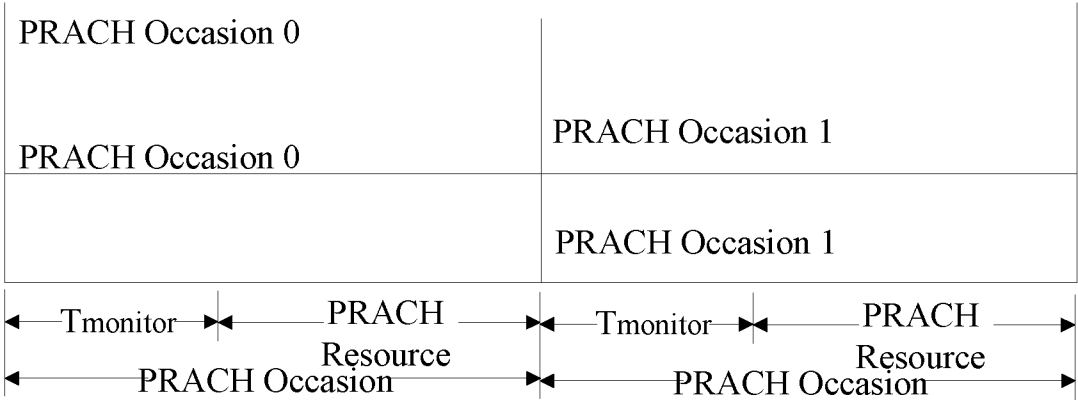


Fig. 5

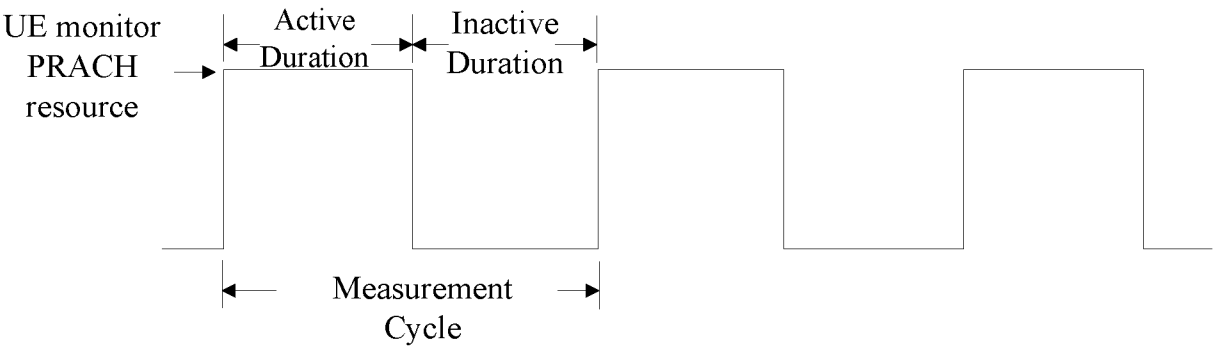


Fig. 6

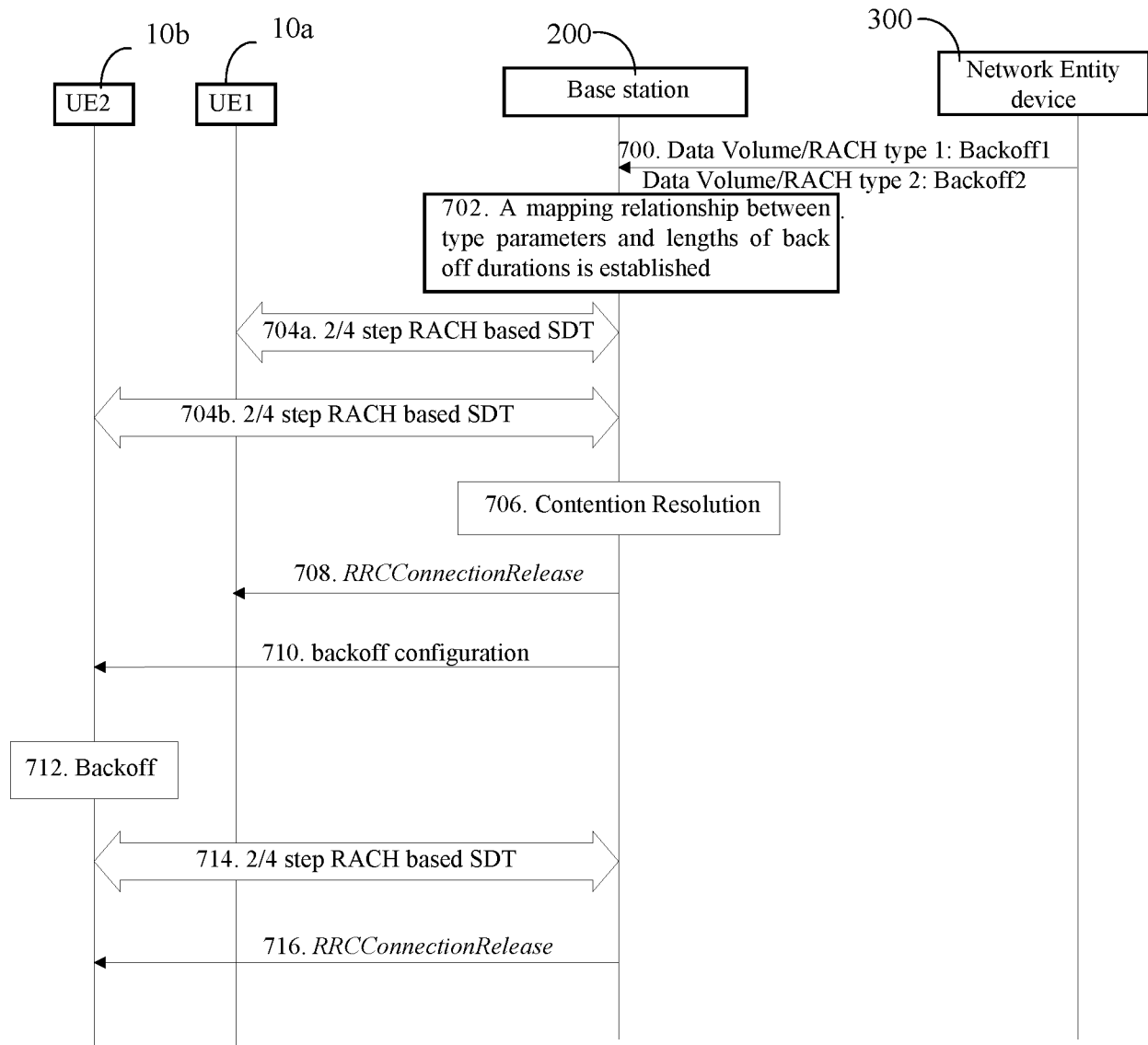


Fig. 7

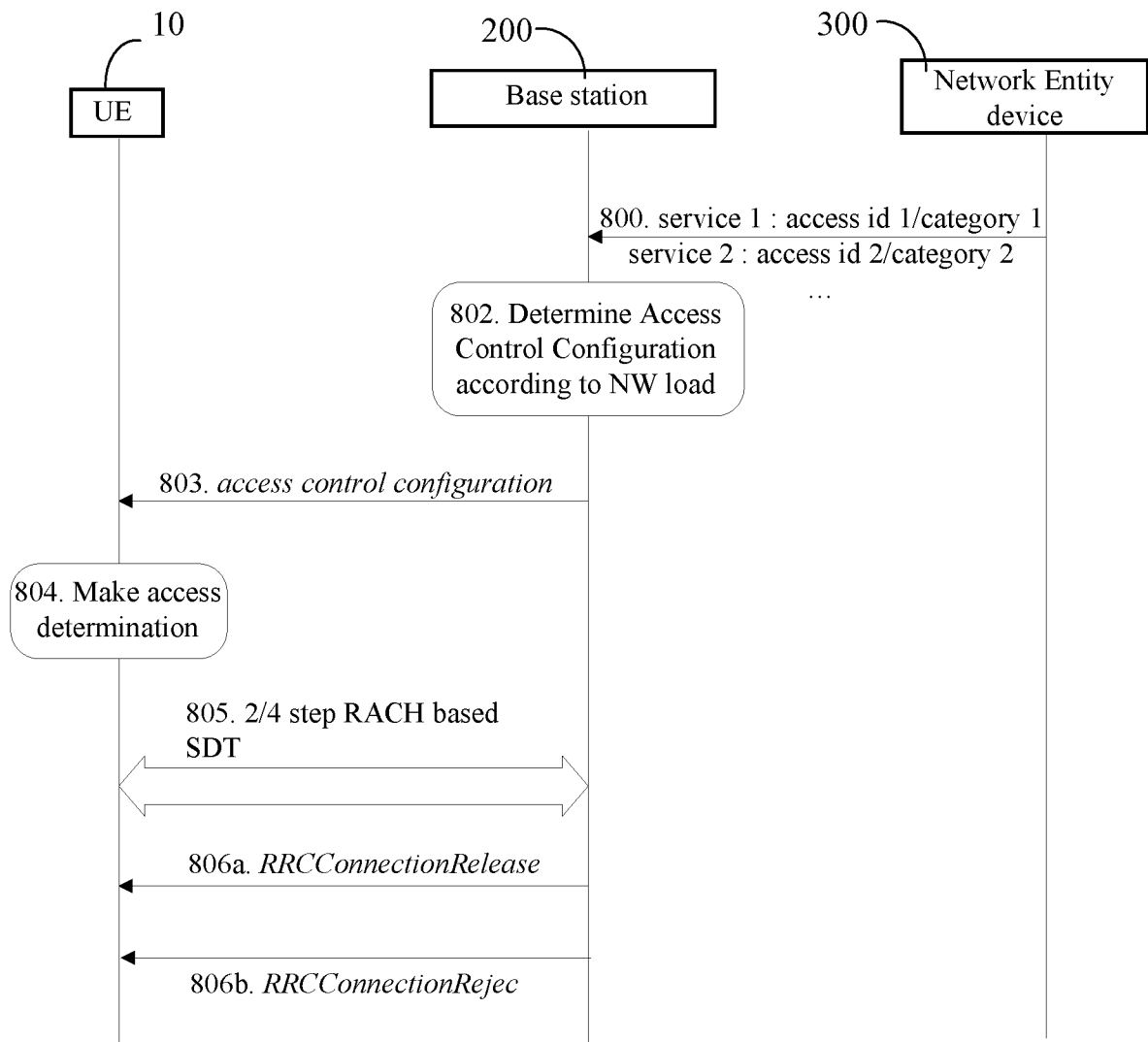


Fig. 8

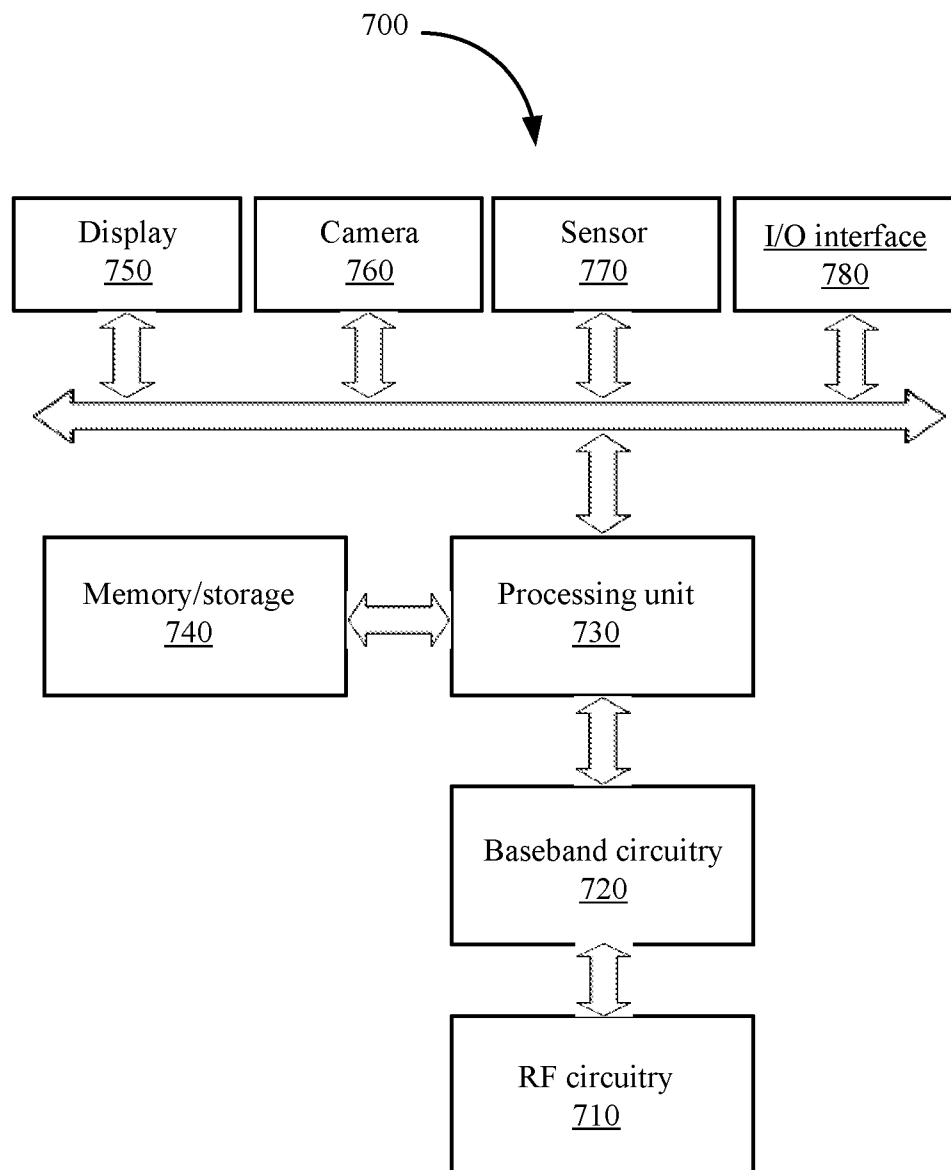


Fig. 9

INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2020/120954

A. CLASSIFICATION OF SUBJECT MATTER

H04W 74/08(2009.01)i; H04W 76/00(2018.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

H04W

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

CNABS;CNTXT;CNKI;VEN;WOTXT;EPTXT;USTXT;3GPP: (small or early) 3d data 3d transmi+, sdt, edt, random access, rach, prach, rrc 5d inactiv+, type, back 2d off

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 2020088097 A1 (QUALCOMM INC et al.) 07 May 2020 (2020-05-07) description, paragraphs [0031]-[0093], figures 2-10	1-110
A	CN 109952747 A (TELEFONAKTIEBOLAGET ERICSSON L M) 28 June 2019 (2019-06-28) the whole document	1-110
A	vivo. "General Considerations on Small Data Transmission" 3GPP TSG RAN WG2 Meeting #111-electronic R2-2006550, 07 August 2020 (2020-08-07), the whole document	1-110
A	Intel Corporation. "SDT mechanism on RRC/non-RRC based approaches and RACH requirements" 3GPP TSG RAN WG2 Meeting #111-e R2-2006713, 07 August 2020 (2020-08-07), the whole document	1-110
A	Nokia et al. "Small Data Transmission over pre-configured PUSCH resources" 3GPP TSG-RAN WG2 Meeting #111e R2-2007489, 07 August 2020 (2020-08-07), the whole document	1-110

☐ Further documents are listed in the continuation of Box C.☒ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

29 June 2021

Date of mailing of the international search report

09 July 2021

Name and mailing address of the ISA/CN

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Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

- [1] There are three inventions covered by the claims indicated as follows:
- [2] I: Claims 1-74, 95, 96, 99, 100, 103, 104, 107 and 108 direct to a method, UE, base station for small data transmission (SDT) based on random access, wherein PRACH resources over which a random access preamble is transmitted are selected on the basis of a mapping relationship between a plurality of PRACH resources and a plurality of access parameters;
- [3] II: Claims 75-88, 97, 101, 105 and 109 direct to a method and base station for small data transmission based on random access, wherein the base station establishes a mapping relationship between type parameters and lengths of back off durations and selects one of the back off durations from the mapping relationship according to detected data volume or RACH type or SDT type; and
- [4] III: Claims 89-94, 98, 102, 106 and 110 direct to a method and base station for small data transmission based on random access, wherein the base station establishes a mapping relationship between SDT service types and access identities or access categories and determines, from the mapping relationship, an access control configuration according to network load.
- [5] The same or corresponding technical features among the inventions above are as follows: SDT based on random access is performed; and the base station transmits SDT-related configuration to the UE.
- [6] The prior art has been identified as D1 (WO2020088097A1), and discloses the same or corresponding technical features (see description, paragraphs [0031]-[0093], figures 2-10). Therefore, the same or corresponding technical features of claims above do not make a contribution over the prior art and cannot be considered as special technical features within the meaning of PCT Rule 13.2. The application, hence does not meet the requirements of unity of invention as defined in PCT Rule 13.1.

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☒ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- ☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- ☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.

PCT/CN2020/120954

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