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(71) Applicant: **NOKIA SOLUTIONS AND NETWORKS OY** [FI/FI]; Karaportti 3, 02610 Espoo (FI).

(72) Inventor; and

(71) Applicant (for DM, SC only): **ZHANG, Yanji** [CN/CN]; Room 1507, Building 2, No. 20 Shaoyaoju Road, Chaoyang District, Beijing 100029 (CN).(72) Inventors: **ZHENG, Naizheng**; Room 401, Building 2, Taiyangyuan, Dazhongsi, Haidian District, Beijing 100098 (CN). **WU, Chunli**; 12-5-301, Huihuayuan, Huilongguan, Changping District, Beijing 102208 (CN). **HAO, Nan**; No.1 Wang Jing East Road, Chaoyang District, Beijing 100102 (CN).(74) Agent: **KING & WOOD MALLESONS**; 20th Floor, East Tower, World Financial Centre, No.1 Dongsanhuan Zhonglu, Chaoyang District, Beijing 100020 (CN).

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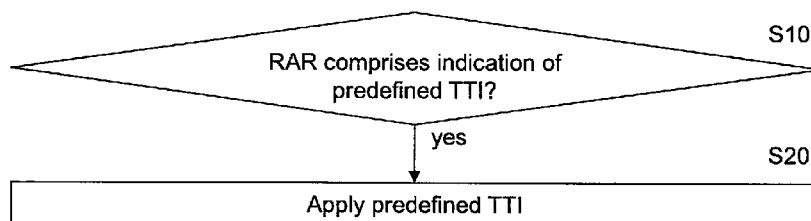


Fig. 2

(57) **Abstract:** It is provided a method, comprising monitoring if a first indication is received indicating that a first predefined transmission time interval is to be applied to a first communication to be transmitted on an uplink shared channel after receiving a random access response of a random access procedure, wherein the first indication is comprised in the random access response to which a default transmission time interval is applied, and the first predefined transmission time interval is different from the default transmission time interval; configuring a communication device to apply the first predefined transmission time interval to the first communication if the random access response comprises the first indication.



RANDOM ACCESS FOR TTI ADAPTATION

Field of the invention

- 5 The present invention relates to an apparatus, a method, and a computer program product related to TTI adaptation. More particularly, the present invention relates to an apparatus, a method, and a computer program product related to random access procedures for TTI adaptation.

10 Abbreviations

	3GPP	3rd Generation Partnership Project
	5G	5 th generation
	ACK	Acknowledgment
15	C-RNTI	Cell RNTI
	CSS	Common Searching Space
	DCI	Downlink Control Information
	DL	Downlink
	eNB	Evolved NodeB
20	E-UTRAN	Evolved UTRAN
	EPDCCH	Enhanced PDCCH
	HARQ	Hybrid Automatic Repeat reQuest
	IP	Internet Protocol
	LTE	Long Term Evolution
25	MAC	Medium Access Control
	msg	message
	MTC	Machine Type Communication
	OFDM	Orthogonal Frequency Division Multiplex
	PDCCH	Physical Downlink Control Channel
30	PDSCH	Physical Downlink Shared Channel
	PHY	Physical (layer)
	PRACH	Physical Random Access Channel
	PUSCH	Physical Uplink Shared Channel
	Rel	Release
35	RRC	Radio Resource Control
	RA	Random Access

	RACH	Random Access Channel
	RAN	Radio Access Network
	RAR	Random Access Response
	RA-RNTI	Random Access RNTI
5	RNTI	Radio Network Temporary Identifier
	RTT	Round Trip Time
	SCH	Shared Channel
	TB	Transport Block
	TCP	Transmission Control Protocol
10	TTI	Transmission Time Interval
	UE	User Equipment
	UL	Uplink
	UMTS	Universal Mobile Telecommunications System
	UTRAN	UMTS Terrestrial Radio Access Network

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Background of the invention

Radio resource management algorithms at layer 1 (PHY) and layer 2 (MAC) such as HARQ management, dynamic packet scheduling, and link adaptation are conducted every TTI.

20 Conventionally, in LTE, a TTI is 1 ms.

The study item "Latency reduction techniques for LTE" [RP-150465] was approved in RAN #67, with the following objective:

- *Study enhancements to the E-UTRAN radio system in order to:*
 - 25 ○ *Significantly reduce the packet data latency over the LTE Uu air interface for an active UE*
 - *Significantly reduce the packet data transport round trip latency for UEs that have been inactive for a longer period (in connected state).*

In addition, the following area should be studied from the PHY-layer

- 30 • *TTI shortening and reduced processing times*
 - *Assess specification impact and study feasibility and performance of TTI lengths between 0.5ms and one OFDM symbol, taking into account impact on reference signals and physical layer control signaling*
 - *backwards compatibility shall be preserved (thus allowing normal operation of*
 - 35 ○ *pre-Rel 13 UEs on the same carrier).*

Currently, it has not been decided (standardized) when the shorter TTI shall be applied. One natural way is to configure shorter TTI via dedicated RRC signalling. When shorter TTI is configured, it may be applied to at least the data channel (PUSCH/PDSCH). If it will be applied on other channels, too, is to be investigated.

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A UE that has been inactive for a longer period may lose the UL synchronization. Then, the RA procedure may be initiated when user data arrive (i.e., if the UE wants to transmit user data on the uplink).

10 Random Access Procedure in LTE

The four steps (messages) of the contention based random access procedures are:

msg1: UE sends Random Access Preamble on RACH in uplink;

msg2: MAC in eNB generates Random Access Response which is transmitted on DL-SCH. The respective resource on the DL-SCH is assigned on PDCCH;

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msg3: The UE performs a first scheduled UL transmission on UL-SCH comprising an identity of the UE;

msg4: Contention Resolution on DL, wherein eNB acknowledges that the identity of the UE was received.

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In addition, there is a non-contention based random access procedure which may be used e.g. during handover or when an RRC connected UE needs to be synchronized for downlink data arrival. The non-contention based RA procedure comprises messages 1 and 2 but does not need messages 3 and 4.

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To ensure good enough coverage and eNB timing estimation accuracy, legacy TTI would likely be applied to at least preamble transmission.

R2-153548 suggests applying legacy 1ms TTI for PRACH preamble transmission, but applying a shorter TTI after preamble transmission to decrease the delay for RA procedure and latency for RRC signaling. The solution proposes to transmit RARs twice, one for legacy UEs, another for UEs capable of a shorter TTI, because the eNB, based on the preamble reception, does not know which TTI is applied by the UE.

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However, this proposal has the following problem: Each UE that generates a preamble during a given RACH opportunity will look for the corresponding RA-RNTI on the PDCCH during the

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associated RA Response Window. In case two separate RARs are transmitted, UE may have confusion on decoding two PDCCH transmissions identified with same RA-RNTI, unless different RA-RNTI or separate PDCCH regions are defined for differentiating two different types of RAR.

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R2-154740 proposes to change the scheduling between short TTI and conventional TTI (i.e. 1ms subframes) either via RRC reconfiguration or dynamically via DCI.

Summary of the invention

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It is an object of the present invention to improve the prior art.

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According to a first aspect of the invention, there is provided an apparatus, comprising response monitoring means adapted to monitor if a first indication is received indicating that a first predefined transmission time interval is to be applied to a first communication to be transmitted on an uplink shared channel after receiving a random access response of a random access procedure, wherein the first indication is comprised in the random access response to which a default transmission time interval is applied, and the first predefined transmission time interval is different from the default transmission time interval; first configuring means adapted to configure a communication device to apply the first predefined transmission time interval to the first communication if the random access response comprises the first indication.

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The random access response may be received in response to a preamble of the random access procedure; and the first communication may comprise an identity of the apparatus in order to resolve a contention of the random access procedure, and the apparatus may further comprise checking means adapted to check if the communication device was configured to communicate applying the first predefined transmission time interval before the random access procedure; selecting means adapted to select the preamble out of a first set of one or more preambles if the communication device was configured to communicate applying the first predefined transmission time interval and to select the preamble out of a second set of one or more preambles if the communication device was configured to communicate applying the default transmission time interval, wherein each of the one or more preambles of the first set is distinct from each of the one or more preambles of the second set.

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The first predefined transmission time interval may be shorter than the default transmission time interval.

5 The apparatus may further comprise control channel monitoring means adapted to monitor if a second indication is received, wherein the second indication indicates that a second predefined transmission time interval will be applied to a contention resolution message of the random access procedure to be received, the second indication is received on a downlink control channel scheduling the contention resolution message, and the default transmission time interval is different from the second predefined transmission time interval; second
10 configuring means adapted to configure the communication device to apply the second predefined transmission time interval to the second communication if the second indication is received.

15 The second predefined transmission time interval may be shorter than the default transmission time interval.

According to a second aspect of the invention, there is provided an apparatus, comprising control channel monitoring means adapted to monitor if an indication is received, wherein the indication indicates that a predefined transmission time interval will be applied to a contention
20 resolution message of a random access procedure to be received on a downlink shared channel, the indication is received on a downlink control channel scheduling the contention resolution message, a default transmission time interval is applied to the messages of the random access procedure before the contention resolution message, and the default transmission time interval is different from the predefined transmission time interval;
25 communication configuring means adapted to configure a communication device to apply the predefined transmission time interval to the receiving of the contention resolution message if the indication is received.

30 The apparatus may further comprise first monitor configuring means adapted to configure the control channel monitoring means to monitor the downlink control channel for the indication based on a received system information.

The apparatus may further comprise second monitor configuring means adapted to configure the control channel monitoring means to monitor the downlink control channel for the
35 indication based on a random access response of the random access procedure.

The predefined transmission time interval may be shorter than the default transmission time interval.

5 The apparatus of any of the first and second aspects may further comprise activating means adapted to configure the communication device to apply the predefined transmission time interval to all transport blocks communicated after the random access procedure.

10 The apparatus of any of the first and second aspects may further comprise communication configuring means adapted to configure the communication device to apply the predetermined transmission time interval to a transport block communicated after the random access procedure if a corresponding instruction is received for the transport block and to apply the default transmission time interval to the transport block if the corresponding instruction is not received for the transport block.

15 According to a third aspect of the invention, there is provided an apparatus, comprising checking means adapted to check if the apparatus is configured to apply a predefined transmission time interval, wherein the apparatus is adapted to apply a default transmission time interval to messages of a random access procedure prior to a contention resolution message of the random access procedure, and the default transmission time interval is
20 different from the predefined transmission time interval; communication configuring means adapted to configure, if the apparatus is configured to apply the predefined transmission time interval, a communication device to apply the default transmission time interval to the messages of the random access procedure prior to the contention resolution message and to apply the predefined transmission time interval to a receiving of the contention resolution
25 message and to all transport blocks communicated after the contention resolution message.

According to a fourth aspect of the invention, there is provided an apparatus, comprising deciding means adapted to decide, upon receipt of a preamble from a terminal in a random access procedure, if a predefined transmission time interval is to be applied to a first
30 communication with the terminal, wherein a default transmission time interval is applied to the preamble and a random access response provided in response to the preamble, and the default transmission time interval is different from the predefined transmission time interval; indicating means adapted to provide an indication to the terminal if it is decided that the predefined transmission time interval is to be applied, wherein the indication indicates that
35 the predefined transmission time interval is to be applied to the communication; configuring means adapted to configure a communication device to apply the predefined transmission

time interval to the first communication if it is decided that the predefined transmission time interval is to be applied.

5 The indicating means may be adapted to provide the indication along with the random access response, and the first communication is a first scheduled transmission on an uplink shared channel after the random access response.

10 The indicating means may be adapted to provide the indication in a downlink control channel, and the first communication is a contention resolution of the random access procedure.

The apparatus may further comprise broadcasting means adapted to broadcast a common configuration information, wherein the common configuration information informs on a configuration of the downlink control channel which contains the indication.

15 The apparatus may further comprise informing means adapted to provide a dedicated configuration information to the terminal along with the random access response, wherein the dedicated configuration information informs on a configuration of downlink control channel that contains the indication.

20 The apparatus may further comprise checking means adapted to check if an information is stored according to which the terminal is configured to apply the predefined transmission time interval; inhibiting means adapted to inhibit the deciding means from deciding that the predefined transmission time interval is to be applied to a communication with the terminal if the information is not stored.

25 The predefined transmission time interval may be shorter than the default transmission time interval.

30 The apparatus may further comprise activating means adapted to configure the communication device to apply the predefined transmission time interval to all transport blocks communicated after the first communication.

35 The apparatus may further comprise communication configuring means adapted to configure the communication device to instruct the terminal to apply the predefined transmission time interval to a transport block communicated after the random access procedure if the communication device applies the predetermined transmission time interval to the transport

block and not to instruct the terminal to apply the predefined transmission time interval to the transport block if the communication device applies the default transmission time interval to the transport block.

5 According to a fifth aspect of the invention, there is provided an apparatus, comprising checking means adapted to check if a configuration parameter is stored indicating that a terminal is configured to apply a predefined transmission time interval, wherein a default transmission time interval is different from the predefined transmission time interval; communication configuring means adapted to configure, if the configuration parameter is
10 stored, a communication device to apply the default transmission time interval to all messages of a random access procedure prior to a contention resolution message of the random access procedure and to apply the predefined transmission time interval to a transmission of the contention resolution message and to all transport blocks communicated after the contention resolution message.

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According to a sixth aspect of the invention, there is provided an apparatus, comprising response monitoring circuitry configured to monitor if a first indication is received indicating that a first predefined transmission time interval is to be applied to a first communication to be transmitted on an uplink shared channel after receiving a random access response of a
20 random access procedure, wherein the first indication is comprised in the random access response to which a default transmission time interval is applied, and the first predefined transmission time interval is different from the default transmission time interval; first configuring circuitry configured to configure a communication device to apply the first predefined transmission time interval to the first communication if the random access
25 response comprises the first indication.

The random access response may be received in response to a preamble of the random access procedure; and the first communication may comprise an identity of the apparatus in order to resolve a contention of the random access procedure, and the apparatus may
30 further comprise checking circuitry configured to check if the communication device was configured to communicate applying the first predefined transmission time interval before the random access procedure; selecting circuitry configured to select the preamble out of a first set of one or more preambles if the communication device was configured to communicate applying the first predefined transmission time interval and to select the preamble out of a
35 second set of one or more preambles if the communication device was configured to communicate applying the default transmission time interval, wherein each of the one or

more preambles of the first set is distinct from each of the one or more preambles of the second set.

5 The first predefined transmission time interval may be shorter than the default transmission time interval.

10 The apparatus may further comprise control channel monitoring circuitry configured to monitor if a second indication is received, wherein the second indication indicates that a second predefined transmission time interval will be applied to a contention resolution message of the random access procedure to be received, the second indication is received on a downlink control channel scheduling the contention resolution message, and the default transmission time interval is different from the second predefined transmission time interval; second configuring circuitry configured to configure the communication device to apply the second predefined transmission time interval to the second communication if the second
15 indication is received.

The second predefined transmission time interval may be shorter than the default transmission time interval.

20 According to a seventh aspect of the invention, there is provided an apparatus, comprising control channel monitoring circuitry configured to monitor if an indication is received, wherein the indication indicates that a predefined transmission time interval will be applied to a contention resolution message of a random access procedure to be received on a downlink shared channel, the indication is received on a downlink control channel scheduling the contention resolution message, a default transmission time interval is applied to the
25 messages of the random access procedure before the contention resolution message, and the default transmission time interval is different from the predefined transmission time interval; communication configuring circuitry configured to configure a communication device to apply the predefined transmission time interval to the receiving of the contention resolution message if the indication is received.
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The apparatus may further comprise first monitor configuring circuitry configured to configure the control channel monitoring circuitry to monitor the downlink control channel for the indication based on a received system information.

The apparatus may further comprise second monitor configuring circuitry configured to configure the control channel monitoring circuitry to monitor the downlink control channel for the indication based on a random access response of the random access procedure.

- 5 The predefined transmission time interval may be shorter than the default transmission time interval.

The apparatus of any of the sixth and seventh aspects may further comprise activating circuitry configured to configure the communication device to apply the predefined
10 transmission time interval to all transport blocks communicated after the random access procedure.

The apparatus of any of the sixth and seventh aspects may further comprise communication configuring circuitry configured to configure the communication device to apply the
15 predetermined transmission time interval to a transport block communicated after the random access procedure if a corresponding instruction is received for the transport block and to apply the default transmission time interval to the transport block if the corresponding instruction is not received for the transport block.

20 According to an eighth aspect of the invention, there is provided an apparatus, comprising checking circuitry configured to check if the apparatus is configured to apply a predefined transmission time interval, wherein the apparatus is configured to apply a default transmission time interval to messages of a random access procedure prior to a contention resolution message of the random access procedure, and the default transmission time
25 interval is different from the predefined transmission time interval; communication configuring circuitry configured to configure, if the apparatus is configured to apply the predefined transmission time interval, a communication device to apply the default transmission time interval to the messages of the random access procedure prior to the contention resolution message and to apply the predefined transmission time interval to a receiving of the
30 contention resolution message and to all transport blocks communicated after the contention resolution message.

According to a ninth aspect of the invention, there is provided an apparatus, comprising deciding circuitry configured to decide, upon receipt of a preamble from a terminal in a
35 random access procedure, if a predefined transmission time interval is to be applied to a first communication with the terminal, wherein a default transmission time interval is applied to

the preamble and a random access response provided in response to the preamble, and the default transmission time interval is different from the predefined transmission time interval; indicating circuitry configured to provide an indication to the terminal if it is decided that the predefined transmission time interval is to be applied, wherein the indication indicates that the predefined transmission time interval is to be applied to the communication; configuring circuitry configured to configure a communication device to apply the predefined transmission time interval to the first communication if it is decided that the predefined transmission time interval is to be applied.

- 10 The indicating circuitry may be configured to provide the indication along with the random access response, and the first communication is a first scheduled transmission on an uplink shared channel after the random access response.

15 The indicating circuitry may be configured to provide the indication in a downlink control channel, and the first communication is a contention resolution of the random access procedure.

20 The apparatus may further comprise broadcasting circuitry configured to broadcast a common configuration information, wherein the common configuration information informs on a configuration of the downlink control channel which contains the indication.

25 The apparatus may further comprise informing circuitry configured to provide a dedicated configuration information to the terminal along with the random access response, wherein the dedicated configuration information informs on a configuration of downlink control channel that contains the indication.

30 The apparatus may further comprise checking circuitry configured to check if an information is stored according to which the terminal is configured to apply the predefined transmission time interval; inhibiting circuitry configured to inhibit the deciding circuitry from deciding that the predefined transmission time interval is to be applied to a communication with the terminal if the information is not stored.

The predefined transmission time interval may be shorter than the default transmission time interval.

The apparatus may further comprise activating circuitry configured to configure the communication device to apply the predefined transmission time interval to all transport blocks communicated after the first communication.

- 5 The apparatus may further comprise communication configuring circuitry configured to configure the communication device to instruct the terminal to apply the predefined transmission time interval to a transport block communicated after the random access procedure if the communication device applies the predetermined transmission time interval to the transport block and not to instruct the terminal to apply the predefined transmission
10 time interval to the transport block if the communication device applies the default transmission time interval to the transport block.

According to a tenth aspect of the invention, there is provided an apparatus, comprising checking circuitry configured to check if a configuration parameter is stored indicating that a
15 terminal is configured to apply a predefined transmission time interval, wherein a default transmission time interval is different from the predefined transmission time interval; communication configuring circuitry configured to configure, if the configuration parameter is stored, a communication device to apply the default transmission time interval to all messages of a random access procedure prior to a contention resolution message of the
20 random access procedure and to apply the predefined transmission time interval to a transmission of the contention resolution message and to all transport blocks communicated after the contention resolution message.

According to an eleventh aspect of the invention, there is provided a method, comprising
25 monitoring if a first indication is received indicating that a first predefined transmission time interval is to be applied to a first communication to be transmitted on an uplink shared channel after receiving a random access response of a random access procedure, wherein the first indication is comprised in the random access response to which a default transmission time interval is applied, and the first predefined transmission time interval is
30 different from the default transmission time interval; configuring a communication device to apply the first predefined transmission time interval to the first communication if the random access response comprises the first indication.

The random access response may be received in response to a preamble of the random
35 access procedure; and the first communication may comprise an identity of an apparatus performing the method in order to resolve a contention of the random access procedure, and

the method may further comprise checking if the communication device was configured to communicate applying the first predefined transmission time interval before the random access procedure; selecting the preamble out of a first set of one or more preambles if the communication device was configured to communicate applying the first predefined transmission time interval and to select the preamble out of a second set of one or more preambles if the communication device was configured to communicate applying the default transmission time interval, wherein each of the one or more preambles of the first set is distinct from each of the one or more preambles of the second set.

- 5
10 The first predefined transmission time interval may be shorter than the default transmission time interval.

- The method may further comprise monitoring if a second indication is received, wherein the second indication indicates that a second predefined transmission time interval will be applied to a contention resolution message of the random access procedure to be received, the second indication is received on a downlink control channel scheduling the contention resolution message, and the default transmission time interval is different from the second predefined transmission time interval; configuring the communication device to apply the second predefined transmission time interval to the second communication if the second indication is received.
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The second predefined transmission time interval may be shorter than the default transmission time interval.

- 25 According to a twelfth aspect of the invention, there is provided a method, comprising monitoring if an indication is received, wherein the indication indicates that a predefined transmission time interval will be applied to a contention resolution message of a random access procedure to be received on a downlink shared channel, the indication is received on a downlink control channel scheduling the contention resolution message, a default transmission time interval is applied to the messages of the random access procedure before the contention resolution message, and the default transmission time interval is different from the predefined transmission time interval; configuring a communication device to apply the predefined transmission time interval to the receiving of the contention resolution message if the indication is received.
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The monitoring of the downlink control channel for the indication may be based on a received system information.

5 The monitoring of the downlink control channel for the indication may be based on a random access response of the random access procedure.

The predefined transmission time interval may be shorter than the default transmission time interval.

10 The method according to any of the eleventh and twelfth aspects may further comprise configuring the communication device to apply the predefined transmission time interval to all transport blocks communicated after the random access procedure.

15 The method according to any of the eleventh and twelfth aspects may further comprise configuring the communication device to apply the predetermined transmission time interval to a transport block communicated after the random access procedure if a corresponding instruction is received for the transport block and to apply the default transmission time interval to the transport block if the corresponding instruction is not received for the transport block.

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According to a thirteenth aspect of the invention, there is provided a method, comprising checking if an apparatus performing the method is configured to apply a predefined transmission time interval, wherein the apparatus is adapted to apply a default transmission time interval to messages of a random access procedure prior to a contention resolution message of the random access procedure, and the default transmission time interval is different from the predefined transmission time interval; configuring, if the apparatus is configured to apply the predefined transmission time interval, a communication device to apply the default transmission time interval to the messages of the random access procedure prior to the contention resolution message and to apply the predefined transmission time interval to a receiving of the contention resolution message and to all transport blocks communicated after the contention resolution message.

35 According to a fourteenth aspect of the invention, there is provided a method, comprising deciding, upon receipt of a preamble from a terminal in a random access procedure, if a predefined transmission time interval is to be applied to a first communication with the terminal, wherein a default transmission time interval is applied to the preamble and a

random access response provided in response to the preamble, and the default transmission time interval is different from the predefined transmission time interval; providing an indication to the terminal if it is decided that the predefined transmission time interval is to be applied, wherein the indication indicates that the predefined transmission time interval is to be applied to the communication; configuring a communication device to apply the predefined transmission time interval to the first communication if it is decided that the predefined transmission time interval is to be applied.

The indication may be provided along with the random access response, and the first communication may be a first scheduled transmission on an uplink shared channel after the random access response.

The indication may be provided in a downlink control channel, and the first communication may be a contention resolution of the random access procedure.

The method may further comprise broadcasting a common configuration information, wherein the common configuration information informs on a configuration of the downlink control channel which contains the indication.

The method may further comprise providing a dedicated configuration information to the terminal along with the random access response, wherein the dedicated configuration information informs on a configuration of downlink control channel that contains the indication.

The method may further comprise checking if an information is stored according to which the terminal is configured to apply the predefined transmission time interval; inhibiting, if the information is not stored, a decision according to which the predefined transmission time interval is to be applied to a communication with the terminal.

The predefined transmission time interval may be shorter than the default transmission time interval.

The method may further comprise configuring the communication device to apply the predefined transmission time interval to all transport blocks communicated after the first communication.

The method may further comprise configuring the communication device to instruct the terminal to apply the predefined transmission time interval to a transport block communicated after the random access procedure if the communication device applies the predetermined transmission time interval to the transport block and not to instruct the terminal to apply the predefined transmission time interval to the transport block if the communication device
5 applies the default transmission time interval to the transport block.

According to a fifteenth aspect of the invention, there is provided a method, comprising checking if a configuration parameter is stored indicating that a terminal is configured to
10 apply a predefined transmission time interval, wherein a default transmission time interval is different from the predefined transmission time interval; configuring, if the configuration parameter is stored, a communication device to apply the default transmission time interval to all messages of a random access procedure prior to a contention resolution message of the random access procedure and to apply the predefined transmission time interval to a
15 transmission of the contention resolution message and to all transport blocks communicated after the contention resolution message.

The method according to any of the eleventh to fifteenth aspects may be a method of transmission time interval adaptation.

According to a sixteenth aspect of the invention, there is provided an apparatus comprising at least one processor, at least one memory including computer program code, and the at least one processor, with the at least one memory and the computer program code, being arranged to cause the apparatus to at least perform at least one of the methods according to
20 the eleventh to fifteenth aspects.

According to a seventeenth aspect of the invention, there is provided a computer program product comprising a set of instructions which, when executed on an apparatus, is configured to cause the apparatus to carry out the method according to at least one of the eleventh to
30 fifteenth aspects. The computer program product may be embodied as a computer-readable medium or directly loadable into a computer.

According to some example embodiments of the invention, at least one of the following technical effects may be provided:

- Delay of RA procedure is reduced;
- Latency is reduced, in particular for transmission of small packets;

- power consumption is reduced.

It is to be understood that any of the above modifications can be applied singly or in combination to the respective aspects to which they refer, unless they are explicitly stated as
5 excluding alternatives.

Brief description of the drawings

Further details, features, objects, and advantages are apparent from the following detailed
10 description of example embodiments of the present invention which is to be taken in conjunction with the appended drawings, wherein

Fig. 1 shows an apparatus according to an example embodiment of the invention;
Fig. 2 shows a method according to an example embodiment of the invention;
15 Fig. 3 shows an apparatus according to an example embodiment of the invention;
Fig. 4 shows a method according to an example embodiment of the invention;
Fig. 5 shows an apparatus according to an example embodiment of the invention;
Fig. 6 shows a method according to an example embodiment of the invention;
Fig. 7 shows an apparatus according to an example embodiment of the invention;
20 Fig. 8 shows a method according to an example embodiment of the invention;
Fig. 9 shows an apparatus according to an example embodiment of the invention;
Fig. 10 shows a method according to an example embodiment of the invention; and
Fig. 11 shows an apparatus according to an example embodiment of the invention.

25 Detailed description of certain example embodiments

Herein below, certain example embodiments of the present invention are described in detail with reference to the accompanying drawings, wherein the features of the example
embodiments can be freely combined with each other unless otherwise described. However,
30 it is to be expressly understood that the description of certain embodiments is given for by way of example only, and that it is by no way intended to be understood as limiting the invention to the disclosed details.

Moreover, it is to be understood that the apparatus is configured to perform the corresponding
35 method, although in some cases only the apparatus or only the method are described.

Some embodiments of the invention address the issue from which step on (msg2, msg3, msg4 of the RA procedure) a shorter TTI may be applied and/or how a shorter TTI may be applied during RA procedure. In addition, some embodiments of the invention provide a solution for a case that the UE is configured with a shorter TTI, but the preamble and/or RAR are transmitted based on legacy 1ms TTI.

For contention based RA procedure, according to some embodiments of the invention, regardless of the TTI applied when UE was synchronized with network, the shorter TTI may be applied from msg3 on and not on msg1 and msg2.

For contention based RA procedure, according to some embodiments of the invention, regardless of the TTI applied when UE was synchronized with network, the shorter TTI may be applied from msg4 on and not on msg1 to msg3 to ensure UL coverage with adequate link budget for msg3 transmission. Msg4 is scheduled with UE's C-RNTI in the same way as for "normal" dedicated data (i.e. user data).

In some embodiments of the invention, for contention based RA procedure, the shorter TTI may be applied from msg3 or msg4 on (and not before the respective message), depending on the way the shorter TTI is implemented by the eNB in the RA procedure.

According to some embodiments of the invention, the default TTI (sometimes also named conventional TTI (1 ms in LTE), which is different from the shorter TTI) is always applied to msg1 and msg2.

On the other hand, in some embodiments of the invention, the shorter TTI is not applied in the contention-free RA procedure. After the contention-free RA procedure, the UE may continue applying the TTI configured before it got out of synchronization or the shorter TTI immediately depending on the indication from eNB during RA procedure.

In some embodiments of the invention, a separate preamble pool or other PRACH resources is defined in order to inform eNB that the UE is configured to apply the shorter TTI. Here, the term "UE is configured to apply the shorter TTI" means that the UE knows the parameter needed to apply the shorter TTI. It does not necessarily imply that the UE indeed applies the shorter TTI. Thus, eNB may distinguish UEs configured with shorter TTI from other UEs not configured to apply the shorter TTI (either because they have not been configured to apply

the shorter TTI although they are capable thereof, or because they are not capable of applying the shorter TTI).

5 The preamble pool (or other PRACH resource) may be predefined or may be defined based on configuration received from eNB, e.g. via system information, which is broadcasted by eNB.

10 The parameters the UE needs to know to apply shorter TTI are those of the radio resource configuration dedicated for shorter TTI. Currently, the radio resource configuration dedicated for shorter TTI has not been fully designed yet. Therefore, the parameters for LTE are not fixed yet. However, conceivable parameters which the UE might have to know are e.g. the frequency/time domain allocation of physical downlink control channel for shorter TTI.

15 In some embodiments of the invention, if a UE is able to support the shorter TTI, eNB may include the necessary parameters into RAR. If eNB includes the parameters into RAR, this may imply that the shorter TTI is to be applied to msg3.

20 A differentiation whether or not the UE is configured to apply the shorter TTI by the preamble, as described above, may be omitted if the shorter TTI is applied from msg4 on only because the eNB could identify UE according to C-RNTI in Msg3. Thus, based on C-RNTI, eNB may check in UE's context stored in eNB if UE is configured to apply the shorter TTI (i.e., if UE knows the parameters needed to apply the shorter TTI). Thus, eNB may distinguish UEs configured to apply the shorter TTI from other UEs not being configured to apply the shorter TTI. Note that UE context is kept in eNB for the UE in connected mode which contains UE configurations/parameters provided by eNB. Thus, eNB may get the parameters needed to apply the shorter TTI configured before RA procedure from UE context, based on C-RNTI.

25 The decision whether or not to apply legacy or shorter TTI for either of msg3 and msg4 may still be met by the eNB, e.g. via explicit indication or via implicit indication as outlined below.

30 The decision may depend on the scheduling strategy and/or data available for transmission, etc., E.g., shorter TTI may be applied when there is a small amount of data to be transmitted.

In some embodiments of the invention, eNB provides an indication (e.g. a flag) in RAR to indicate the application of shorter TTI (or default TTI). Depending on the configuration or implementation, this indication may be interpreted by UE in one of the following ways:

- Activation mechanism: shorter TTI is applied from msg3 on to all TBs;

- per TB indication: shorter TTI is applied on msg3. After msg3, it is indicated per TB, via PDCCH, if the shorter TTI is applied or not;
- For both contention based RA procedure and contention-free RA procedure, the indication may be included in the RAR, e.g. in the UL grant comprised in the RAR.

5

In addition, if shorter TTI was activated before UE performs the RA procedure, in some embodiments of the invention, UE may continue applying the shorter TTI from msg3 on (either according to the activation mechanism or per TB indication) regardless of an indication to apply shorter TTI comprised in RAR. This behaviour may also apply to contention-free RA procedure.

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In some of these embodiments, RAR may comprise an explicit indication to apply the default TTI from msg3 on (which may be an additional indication different from an absence of an indication to apply the shorter TTI). In these embodiments, UE applies the default TTI from msg3 on for all TBs.

15

For contention based RA procedure, the indication to apply shorter TTI may be included in the PDCCH when scheduling msg4. Namely, e.g. DCI (which is transported on PDCCH) may comprise an indication of the TTI to be applied. Since this indication is available at the UE only for msg4, in this case the shorter TTI cannot be applied to msg3. Hence, depending on configuration or implementation, there are the following options if the indication is received that the shorter TTI is to be applied:

20

- Activation mechanism: shorter TTI is applied from msg4 on (and not on msg3); and
- Per TB indication: shorter TTI is applied on msg4 (and not on msg3). After msg4, it is indicated per TB, via PDCCH, if the shorter TTI is applied or not.

25

In addition, if shorter TTI was activated before UE performs the RA procedure, in some embodiments of the invention, UE may continue applying the shorter TTI from msg4 on (either according to the activation mechanism or per TB indication) regardless of an indication to apply shorter TTI comprised in the scheduling message for msg4.

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In some of these embodiments, the scheduling message for msg4 may comprise an explicit indication to apply the default TTI from msg4 on (which may be an additional indication different from an absence of an indication to apply the shorter TTI). In these embodiments, UE applies the default TTI from msg4 on for all TBs.

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In some embodiments of the invention, the way to provide the indication indicates if the shorter TTI is to be applied from msg3 or msg4 on (and not before): If the indication is included in the RAR, the shorter TTI is to be applied on msg 3 and from msg3 on (either for all TBs according to the activation mechanism or for some TBs per per TB indication), and if the indication is provided in the PDCCH, the shorter TTI is to be applied on msg4 or from msg4 on (either for all TBs according to the activation mechanism or for some TBs per TB indication) but not on msg3.

In some embodiments of the invention, only one of the activation mechanism and the “per TB indication” mechanism is implemented. In some of embodiments of the invention, both mechanisms are implemented and eNB may decide which mechanism will be used. E.g., eNB may inform all UEs on the mechanism by broadcasted system information. Alternatively, eNB may inform a particular UE on the mechanism along with the indication to apply the shorter TTI.

In some embodiments of the invention, information on the resource of the physical downlink control channel (e.g. PDCCH/EPDCCH) resource to indicate the shorter TTI required for scheduling the msg3 adaptive retransmission (i.e., the UE applies the scheduling information for HARQ retransmission based on PDCCH DCI indicator) before the contention resolution may be configured via system information which is common for all UEs, in particular those capable of a shorter TTI. Namely, system information is broadcasted to all UEs. Alternatively or in addition, the information on the resource of the physical downlink control channel may be configured via dedicated signalling.

Alternatively or in addition, information on the resource of the physical downlink control channel (e.g. PDCCH/EPDCCH) resource to indicate the shorter TTI may be contained in the RAR message. In this case, the resource is specific for the UE. E.g., the resource may be some common (E)PDCCH region that all the UEs configured with shorter TTI are monitoring.

After contention resolution, the UE may start applying the shorter TTI for subsequent data transmission. That is, if the activation mechanism is configured, the shorter TTI is applied to all transport blocks, while, if “per TB indication” is activated, it is dynamically decided per TB whether or not the shorter TTI is applied.

In some cases, it is predefined in UE and eNB that default TTI is applied to msg1 to msg3, and shorter TTI is applied to msg4 and subsequent data transmission (i.e. to all TBs) if shorter TTI is configured. In these embodiments, an indication to apply shorter TTI is not needed.

5

In some embodiments of the invention, if the contention-free RA procedure is performed, the UE may apply the shorter TTI for subsequent data transmission (either based on activation mechanism or per TB indication) if the indication (e.g. flag) indicates that the shorter TTI is to be applied. Otherwise, the UE may continue applying the TTI configured before out of

10 synchronization, which may be the default TTI (e.g. 1ms in LTE) or the shorter TTI.

In some embodiments of the invention, one or more new parameters (not contained in the present LTE specifications) may be provided in system information message:

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- A resource allocation on PRACH to allow the UE to indicate that it is configured to apply the shorter TTI. The resource allocation may comprise a separate preamble pool, and/or a time/frequency domain allocation.
- A searching space configuration for the physical downlink control channel (or PDCCH/EPDCCH) providing the indication that the shorter TTI is to be applied for Msg3 (and Msg4).

20

In some embodiments of the invention, one or more new parameters (not contained in the present LTE specifications) may be provided in RAR:

25

- An indication in UL grant to indicate whether or not the shorter TTI will be applied after RAR.
- A searching space configuration for the physical downlink control channel (or PDCCH/EPDCCH) providing the indication that the shorter TTI is to be applied for Msg3 (and Msg4).

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Some embodiments of the invention may provide one or more of the following advantages:

Since shorter TTI may be typically used for e.g. TCP ACK, the delay of RA procedure is reduced and therefore, in particular (but not exclusively) the TCP/IP type of traffic transmission benefits from a reduced slow-start period. Besides, it also benefits from the low latency required for small packet transmission, going along with a reduced power consumption. Low latency and/or power efficient transmission of small packet transmissions may be keys for future machine-type-of-communication (MTC) both in 5G and next step

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evolution of LTE networks, where the shorter TTI RA procedure steps according to some embodiments of the invention might well meet the challenging requirements of future MTC applications.

5 Fig. 1 shows an apparatus according to an example embodiment of the invention. The apparatus may be a terminal such as a UE, or an element thereof. Fig. 2 shows a method according to an example embodiment of the invention. The apparatus according to Fig. 1 may perform the method of Fig. 2 but is not limited to this method. The method of Fig. 2 may be performed by the apparatus of Fig. 1 but is not limited to being performed by this
10 apparatus.

The apparatus comprises monitoring means 10, and configuring means 20. The monitoring means 10 and configuring means 20 may be a monitoring circuitry and adjusting circuitry, respectively.

15

The monitoring means 10 monitors if an indication is received (S10). The indication indicates that a predefined transmission time interval is to be applied to a communication to be transmitted on an uplink shared channel after receiving a random access response of a random access procedure. The indication is comprised in the random access response. A
20 default transmission time interval is applied to the random access response. The predefined transmission time interval is different from the default transmission time interval.

The monitoring means 10 may be a response monitoring means.

25 If the random access response comprises the indication (S10 = "yes"), the configuring means 20 configures a communication device to apply the predefined transmission time interval to the communication (S20). The communication device may be a transceiver of the apparatus.

Fig. 3 shows an apparatus according to an example embodiment of the invention. The
30 apparatus may be a terminal such as a UE, or an element thereof. Fig. 4 shows a method according to an example embodiment of the invention. The apparatus according to Fig. 3 may perform the method of Fig. 4 but is not limited to this method. The method of Fig. 4 may be performed by the apparatus of Fig. 3 but is not limited to being performed by this apparatus.

The apparatus comprises monitoring means 110, and configuring means 120. The monitoring means 110 and configuring means 120 may be a monitoring circuitry and configuring circuitry, respectively.

- 5 The monitoring means 110 monitors if an indication is received (S110). The indication indicates that a predefined transmission time interval will be applied to a contention resolution message of a random access procedure to be received on a downlink shared channel. The indication is received on a downlink control channel. A default transmission time interval is applied to the messages of the random access procedure before the
10 contention resolution message, wherein the default transmission time interval is different from the predefined transmission time interval. The downlink shared channel is different from the downlink control channel.

The monitoring means 110 may be a control channel monitoring means.

15

If the indication is received, the configuring means 120 configures a communication device to apply the predefined transmission time interval to the receiving of the contention resolution message (S120). The communication device may be a transceiver of the apparatus.

- 20 The configuring means 120 may be a communication configuring means.

Fig. 5 shows an apparatus according to an example embodiment of the invention. The apparatus may be a terminal such as a UE, or an element thereof. Fig. 6 shows a method according to an example embodiment of the invention. The apparatus according to Fig. 5
25 may perform the method of Fig. 6 but is not limited to this method. The method of Fig. 6 may be performed by the apparatus of Fig. 5 but is not limited to being performed by this apparatus.

- 30 The apparatus comprises checking means 150, and configuring means 160. The checking means 150 and configuring means 160 may be a checking circuitry and adjusting circuitry, respectively.

The checking means 150 checks if the apparatus is configured to apply a predefined transmission time interval (S150). The apparatus is adapted to apply a default transmission
35 time interval to messages of a random access procedure prior to a contention resolution

message of the random access procedure. The default transmission time interval is different from (e.g. longer than) the predefined transmission time interval.

If the apparatus is configured to apply the predefined transmission time interval (S150 = "Yes"), the configuring means 160 configures a communication device

- to apply the default transmission time interval to the messages of the random access procedure prior to the contention resolution message of the random access procedure, and
- to apply the predefined transmission time interval to a receiving of the contention resolution message of the random access procedure and also to all transport blocks communicated after the contention resolution message (S160).

The communication device may be a transceiver of the apparatus. The configuring means 160 may be a communication configuring means.

Fig. 7 shows an apparatus according to an example embodiment of the invention. The apparatus may be a base station such as a NodeB or eNB, or an element thereof. Fig. 8 shows a method according to an example embodiment of the invention. The apparatus according to Fig. 7 may perform the method of Fig. 8 but is not limited to this method. The method of Fig. 8 may be performed by the apparatus of Fig. 7 but is not limited to being performed by this apparatus.

The apparatus comprises deciding means 210, indicating means 220, and configuring means 230. The deciding means 210, indicating means 220, and configuring means 230 may be a deciding circuitry, indicating circuitry, and configuring circuitry, respectively.

The deciding means 210 decides, upon receipt of a preamble from a terminal in a random access procedure, if a predefined transmission time interval is to be applied to a communication with the terminal (S210). A default transmission time interval different from the predefined transmission time interval is applied to the preamble and a random access response provided in response to the preamble.

If it is decided that the predefined transmission time interval is to be applied (S210 = "yes"), the indicating means 220 provides an indication to the terminal (S220). The indication

indicates that the predefined transmission time interval is to be applied to the communication with the terminal.

If it is decided that the predefined transmission time interval is to be applied (S210 = "yes"), the configuring means 230 configures a communication device to apply the predefined transmission time interval to the communication with the terminal (S230). The communication device may be a transceiver of the apparatus.

S220 and S230 may be executed simultaneously or one after the other in an arbitrary sequence.

Fig. 9 shows an apparatus according to an example embodiment of the invention. The apparatus may be a base station such as a NodeB or eNB, or an element thereof. Fig. 10 shows a method according to an example embodiment of the invention. The apparatus according to Fig. 9 may perform the method of Fig. 10 but is not limited to this method. The method of Fig. 10 may be performed by the apparatus of Fig. 9 but is not limited to being performed by this apparatus.

The apparatus comprises checking means 310 and configuring means 320. The checking means 310 and configuring means 320 may be a checking circuitry and configuring circuitry, respectively.

The checking means 310 checks if a configuration parameter is stored (S310). The configuration parameter indicates that a terminal is configured to apply a predefined transmission time interval. A default transmission time interval is different from the predefined transmission time interval. E.g., the configuration parameter may be stored in a UE context.

If the configuration parameter indicating that the terminal is configured to apply the predefined transmission time interval is stored (S310 = "Yes"), the configuring means 320 configures a communication device

- to apply the default transmission time interval to all messages of a random access procedure prior to a contention resolution message of the random access procedure and
- to apply the predefined transmission time interval to a transmission of the contention resolution message and to all transport blocks communicated after the contention resolution message (S320).

The configuring means 320 may be a communication configuring means. The communication device may be a transceiver of the apparatus.

5 Fig. 11 shows an apparatus according to an example embodiment of the invention. The apparatus comprises at least one processor 610, at least one memory 620 including computer program code, and the at least one processor 610, with the at least one memory 620 and the computer program code, being arranged to cause the apparatus to at least perform at least one of the methods according to Figs. 2, 4, 6, 8, and 10 and related
10 description.

Some embodiments of the invention are described wherein the TTI is shorter than a default TTI (e.g. 1 ms in LTE). However, in some embodiments of the invention, the TTI may be longer than the default TTI. This might be useful under rather static conditions in order to
15 save signaling overhead and reduce power consumption.

Some embodiments of the invention are described where a single TTI different from the default TTI is applied. However, in some embodiments of the invention, the eNB may select between plural TTIs different from the default TTI. These plural TTIs may be shorter or longer
20 than the default TTI. In this case, the indication in RAR may not be a flag but e.g. a bitstring.

In some embodiments of the invention, a default TTI does not exist for transmissions after messages 1 and 2 (and message 3 if the indicated TTI is to be applied to message 4 only) of the random access procedure. I.e., in these embodiments, the applicable TTI has to be
25 indicated by the eNB by one of the above described methods.

One piece of information may be transmitted in one or plural messages from one entity to another entity. Each of these messages may comprise further (different) pieces of information.
30

Names of network elements, protocols, and methods are based on current standards. In other versions or other technologies, the names of these network elements and/or protocols and/or methods may be different, as long as they provide a corresponding functionality.

35 If not otherwise stated or otherwise made clear from the context, the statement that two entities are different means that they perform different functions. It does not necessarily

mean that they are based on different hardware. That is, each of the entities described in the present description may be based on a different hardware, or some or all of the entities may be based on the same hardware. It does not necessarily mean that they are based on different software. That is, each of the entities described in the present description may be based on different software, or some or all of the entities may be based on the same software.

Some example embodiments of the invention may be applied to a 3GPP network (e.g. LTE, LTE-A, or a 5G network), as described hereinabove. However, some example embodiments of the invention may be applied to any kind of network wherein different TTIs may be applied.

A terminal may be any kind of terminal which may attach to the respective network. E.g., a terminal may be a UE, a device of a machine-type communication, a laptop, a smartphone, a mobile phone etc.

According to the above description, it should thus be apparent that example embodiments of the present invention provide, for example a terminal such as a UE or a MTC device, or a component thereof, an apparatus embodying the same, a method for controlling and/or operating the same, and computer program(s) controlling and/or operating the same as well as mediums carrying such computer program(s) and forming computer program product(s). According to the above description, it should thus be apparent that example embodiments of the present invention provide, for example a base station such as a NodeB or an eNodeB, or a component thereof, an apparatus embodying the same, a method for controlling and/or operating the same, and computer program(s) controlling and/or operating the same as well as mediums carrying such computer program(s) and forming computer program product(s).

Implementations of any of the above described blocks, apparatuses, systems, techniques, means, entities, units, devices, or methods include, as non-limiting examples, implementations as hardware, software, firmware, special purpose circuits or logic, general purpose hardware or controller or other computing devices, a virtual machine, or some combination thereof.

It should be noted that the description of the embodiments is given by way of example only and that various modifications may be made without departing from the scope of the invention as defined by the appended claims.

WHAT IS CLAIMED IS:

1. Apparatus, comprising

5 response monitoring means adapted to monitor if a first indication is received indicating that a first predefined transmission time interval is to be applied to a first communication to be transmitted on an uplink shared channel after receiving a random access response of a random access procedure, wherein the first indication is comprised in the random access response to which a default transmission time interval is applied, and the first predefined transmission time interval is different from the default transmission time interval;

10 first configuring means adapted to configure a communication device to apply the first predefined transmission time interval to the first communication if the random access response comprises the first indication.

15 2. The apparatus according to claim 1, wherein

the random access response is received in response to a preamble of the random access procedure; and

the first communication comprises an identity of the apparatus in order to resolve a contention of the random access procedure,

20 and the apparatus further comprises

checking means adapted to check if the communication device was configured to communicate applying the first predefined transmission time interval before the random access procedure;

25 selecting means adapted to select the preamble out of a first set of one or more preambles if the communication device was configured to communicate applying the first predefined transmission time interval and to select the preamble out of a second set of one or more preambles if the communication device was configured to communicate applying the default transmission time interval, wherein each of the one or more preambles of the first set is distinct from each of the one or more preambles of the second set.

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3. The apparatus according to any of claims 1 to 2, wherein the first predefined transmission time interval is shorter than the default transmission time interval.

4. The apparatus according to any of claims 1 to 3, further comprising

35 control channel monitoring means adapted to monitor if a second indication is received, wherein the second indication indicates that a second predefined transmission time

interval will be applied to a contention resolution message of the random access procedure to be received, the second indication is received on a downlink control channel scheduling the contention resolution message, and the default transmission time interval is different from the second predefined transmission time interval;

5 second configuring means adapted to configure the communication device to apply the second predefined transmission time interval to the second communication if the second indication is received.

10 5. The apparatus according to claim 4, wherein the second predefined transmission time interval is shorter than the default transmission time interval.

6. Apparatus, comprising

15 control channel monitoring means adapted to monitor if an indication is received, wherein the indication indicates that a predefined transmission time interval will be applied to a contention resolution message of a random access procedure to be received on a downlink shared channel, the indication is received on a downlink control channel scheduling the contention resolution message, a default transmission time interval is applied to the messages of the random access procedure before the contention resolution message, and the default transmission time interval is different from the predefined transmission time interval;

20

 communication configuring means adapted to configure a communication device to apply the predefined transmission time interval to the receiving of the contention resolution message if the indication is received.

25 7. The apparatus according to claim 6, further comprising

 first monitor configuring means adapted to configure the control channel monitoring means to monitor the downlink control channel for the indication based on a received system information.

30 8. The apparatus according to any of claims 6 and 7, further comprising

 second monitor configuring means adapted to configure the control channel monitoring means to monitor the downlink control channel for the indication based on a random access response of the random access procedure.

35 9. The apparatus according to any of claims 6 to 8, wherein the predefined transmission time interval is shorter than the default transmission time interval.

10. The apparatus according to any of claims 1 to 9, further comprising

activating means adapted to configure the communication device to apply the predefined transmission time interval to all transport blocks communicated after the random access procedure.

11. The apparatus according to any of claims 1 to 10, further comprising

communication configuring means adapted to configure the communication device to apply the predetermined transmission time interval to a transport block communicated after the random access procedure if a corresponding instruction is received for the transport block and to apply the default transmission time interval to the transport block if the corresponding instruction is not received for the transport block.

12. Apparatus, comprising

checking means adapted to check if the apparatus is configured to apply a predefined transmission time interval, wherein the apparatus is adapted to apply a default transmission time interval to messages of a random access procedure prior to a contention resolution message of the random access procedure, and the default transmission time interval is different from the predefined transmission time interval;

communication configuring means adapted to configure, if the apparatus is configured to apply the predefined transmission time interval, a communication device to apply the default transmission time interval to the messages of the random access procedure prior to the contention resolution message and to apply the predefined transmission time interval to a receiving of the contention resolution message and to all transport blocks communicated after the contention resolution message.

13. Apparatus, comprising

deciding means adapted to decide, upon receipt of a preamble from a terminal in a random access procedure, if a predefined transmission time interval is to be applied to a first communication with the terminal, wherein a default transmission time interval is applied to the preamble and a random access response provided in response to the preamble, and the default transmission time interval is different from the predefined transmission time interval;

indicating means adapted to provide an indication to the terminal if it is decided that the predefined transmission time interval is to be applied, wherein the indication indicates that the predefined transmission time interval is to be applied to the communication;

configuring means adapted to configure a communication device to apply the predefined transmission time interval to the first communication if it is decided that the predefined transmission time interval is to be applied.

- 5 14. The apparatus according to claim 13, wherein
the indicating means is adapted to provide the indication along with the random access response, and the first communication is a first scheduled transmission on an uplink shared channel after the random access response.
- 10 15. The apparatus according to any of claim 13 to 14, wherein
the indicating means is adapted to provide the indication in a downlink control channel, and the first communication is a contention resolution of the random access procedure.
- 15 16. The apparatus according to claim 15, further comprising
broadcasting means adapted to broadcast a common configuration information, wherein the common configuration information informs on a configuration of the downlink control channel which contains the indication.
- 20 17. The apparatus according to any of claims 15 and 16, further comprising
informing means adapted to provide a dedicated configuration information to the terminal along with the random access response, wherein the dedicated configuration information informs on a configuration of downlink control channel that contains the indication.
- 25 18. The apparatus according to any of claims 13 to 17, further comprising
checking means adapted to check if an information is stored according to which the terminal is configured to apply the predefined transmission time interval;
inhibiting means adapted to inhibit the deciding means from deciding that the predefined transmission time interval is to be applied to a communication with the terminal if
30 the information is not stored.
19. The apparatus according to any of claims 13 to 18, wherein the predefined transmission time interval is shorter than the default transmission time interval.
- 35 20. The apparatus according to any of claims 13 to 19, further comprising

activating means adapted to configure the communication device to apply the predefined transmission time interval to all transport blocks communicated after the first communication.

5 21. The apparatus according to any of claims 13 to 20, further comprising

communication configuring means adapted to configure the communication device to instruct the terminal to apply the predefined transmission time interval to a transport block communicated after the random access procedure if the communication device applies the predetermined transmission time interval to the transport block and not to instruct the
10 terminal to apply the predefined transmission time interval to the transport block if the communication device applies the default transmission time interval to the transport block.

22. Apparatus, comprising

checking means adapted to check if a configuration parameter is stored indicating
15 that a terminal is configured to apply a predefined transmission time interval, wherein a default transmission time interval is different from the predefined transmission time interval;

communication configuring means adapted to configure, if the configuration parameter is stored, a communication device to apply the default transmission time interval to all messages of a random access procedure prior to a contention resolution message of
20 the random access procedure and to apply the predefined transmission time interval to a transmission of the contention resolution message and to all transport blocks communicated after the contention resolution message.

23. Method, comprising

25 monitoring if a first indication is received indicating that a first predefined transmission time interval is to be applied to a first communication to be transmitted on an uplink shared channel after receiving a random access response of a random access procedure, wherein the first indication is comprised in the random access response to which a default transmission time interval is applied, and the first predefined transmission time interval is
30 different from the default transmission time interval;

configuring a communication device to apply the first predefined transmission time interval to the first communication if the random access response comprises the first indication.

35 24. The method according to claim 23, wherein

the random access response is received in response to a preamble of the random access procedure; and

the first communication comprises an identity of an apparatus performing the method in order to resolve a contention of the random access procedure,

5 and the method further comprises

checking if the communication device was configured to communicate applying the first predefined transmission time interval before the random access procedure;

10 selecting the preamble out of a first set of one or more preambles if the communication device was configured to communicate applying the first predefined transmission time interval and to select the preamble out of a second set of one or more preambles if the communication device was configured to communicate applying the default transmission time interval, wherein each of the one or more preambles of the first set is distinct from each of the one or more preambles of the second set.

15 25. The method according to any of claims 23 to 24, wherein the first predefined transmission time interval is shorter than the default transmission time interval.

26. The method according to any of claims 23 to 25, further comprising

20 monitoring if a second indication is received, wherein the second indication indicates that a second predefined transmission time interval will be applied to a contention resolution message of the random access procedure to be received, the second indication is received on a downlink control channel scheduling the contention resolution message, and the default transmission time interval is different from the second predefined transmission time interval;

25 configuring the communication device to apply the second predefined transmission time interval to the second communication if the second indication is received.

27. The method according to claim 26, wherein the second predefined transmission time interval is shorter than the default transmission time interval.

30 28. Method, comprising

monitoring if an indication is received, wherein the indication indicates that a predefined transmission time interval will be applied to a contention resolution message of a random access procedure to be received on a downlink shared channel, the indication is received on a downlink control channel scheduling the contention resolution message, a
35 default transmission time interval is applied to the messages of the random access

procedure before the contention resolution message, and the default transmission time interval is different from the predefined transmission time interval;

configuring a communication device to apply the predefined transmission time interval to the receiving of the contention resolution message if the indication is received.

5

29. The method according to claim 28, wherein

the monitoring of the downlink control channel for the indication is based on a received system information.

10 30. The method according to any of claims 28 and 29, wherein

the monitoring of the downlink control channel for the indication is based on a random access response of the random access procedure.

15 31. The method according to any of claims 28 to 30, wherein the predefined transmission time interval is shorter than the default transmission time interval.

32. The method according to any of claims 23 to 31, further comprising

configuring the communication device to apply the predefined transmission time interval to all transport blocks communicated after the random access procedure.

20

33. The method according to any of claims 1 to 32, further comprising

25 configuring the communication device to apply the predetermined transmission time interval to a transport block communicated after the random access procedure if a corresponding instruction is received for the transport block and to apply the default transmission time interval to the transport block if the corresponding instruction is not received for the transport block.

34. Method, comprising

30 checking if an apparatus performing the method is configured to apply a predefined transmission time interval, wherein the apparatus is adapted to apply a default transmission time interval to messages of a random access procedure prior to a contention resolution message of the random access procedure, and the default transmission time interval is different from the predefined transmission time interval;

35 configuring, if the apparatus is configured to apply the predefined transmission time interval, a communication device to apply the default transmission time interval to the messages of the random access procedure prior to the contention resolution message and to

apply the predefined transmission time interval to a receiving of the contention resolution message and to all transport blocks communicated after the contention resolution message.

35. Method, comprising

- 5 deciding, upon receipt of a preamble from a terminal in a random access procedure, if a predefined transmission time interval is to be applied to a first communication with the terminal, wherein a default transmission time interval is applied to the preamble and a random access response provided in response to the preamble, and the default transmission time interval is different from the predefined transmission time interval;
- 10 providing an indication to the terminal if it is decided that the predefined transmission time interval is to be applied, wherein the indication indicates that the predefined transmission time interval is to be applied to the communication;
- configuring a communication device to apply the predefined transmission time interval to the first communication if it is decided that the predefined transmission time interval is to
- 15 be applied.

36. The method according to claim 35, wherein

- the indication is provided along with the random access response, and the first communication is a first scheduled transmission on an uplink shared channel after the
- 20 random access response.

37. The method according to any of claim 35 to 36, wherein

- the indication is provided in a downlink control channel, and the first communication is a contention resolution of the random access procedure.
- 25

38. The method according to claim 37, further comprising

- broadcasting a common configuration information, wherein the common configuration information informs on a configuration of the downlink control channel which contains the indication.
- 30

39. The method according to any of claims 37 and 38, further comprising

- providing a dedicated configuration information to the terminal along with the random access response, wherein the dedicated configuration information informs on a configuration of downlink control channel that contains the indication.
- 35

40. The method according to any of claims 35 to 39, further comprising

checking if an information is stored according to which the terminal is configured to apply the predefined transmission time interval;

inhibiting, if the information is not stored, a decision according to which the predefined transmission time interval is to be applied to a communication with the terminal.

5

41. The method according to any of claims 35 to 40, wherein the predefined transmission time interval is shorter than the default transmission time interval.

42. The method according to any of claims 35 to 41, further comprising

10 configuring the communication device to apply the predefined transmission time interval to all transport blocks communicated after the first communication.

43. The method according to any of claims 35 to 42, further comprising

15 configuring the communication device to instruct the terminal to apply the predefined transmission time interval to a transport block communicated after the random access procedure if the communication device applies the predetermined transmission time interval to the transport block and not to instruct the terminal to apply the predefined transmission time interval to the transport block if the communication device applies the default transmission time interval to the transport block.

20

44. Method, comprising

checking if a configuration parameter is stored indicating that a terminal is configured to apply a predefined transmission time interval, wherein a default transmission time interval is different from the predefined transmission time interval;

25 configuring, if the configuration parameter is stored, a communication device to apply the default transmission time interval to all messages of a random access procedure prior to a contention resolution message of the random access procedure and to apply the predefined transmission time interval to a transmission of the contention resolution message and to all transport blocks communicated after the contention resolution message.

30

45. A computer program product comprising a set of instructions which, when executed on an apparatus, is configured to cause the apparatus to carry out the method according to any of method claims 23 to 44.

35 46. The computer program product according to claim 45, embodied as a computer-readable medium or directly loadable into a computer.

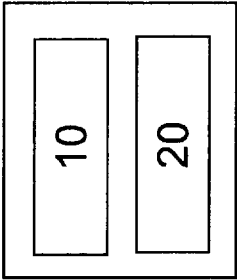


Fig. 1

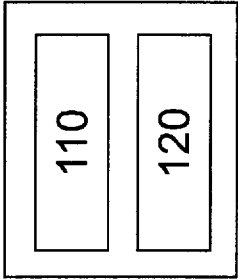


Fig. 3

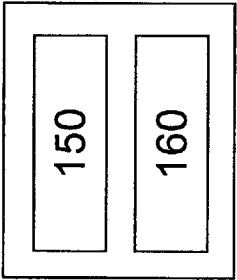


Fig. 5

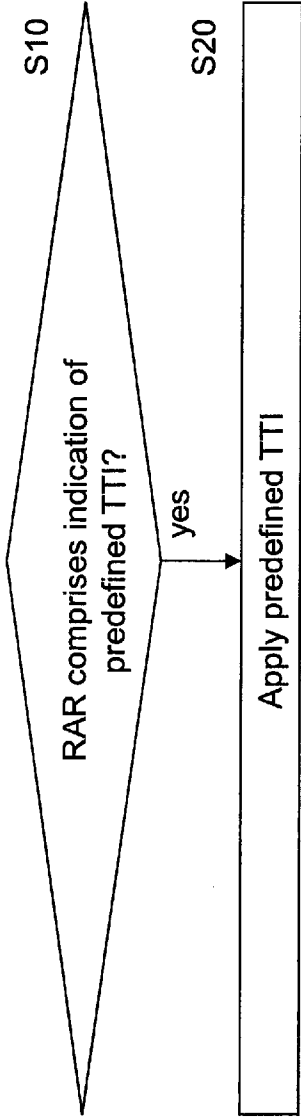


Fig. 2

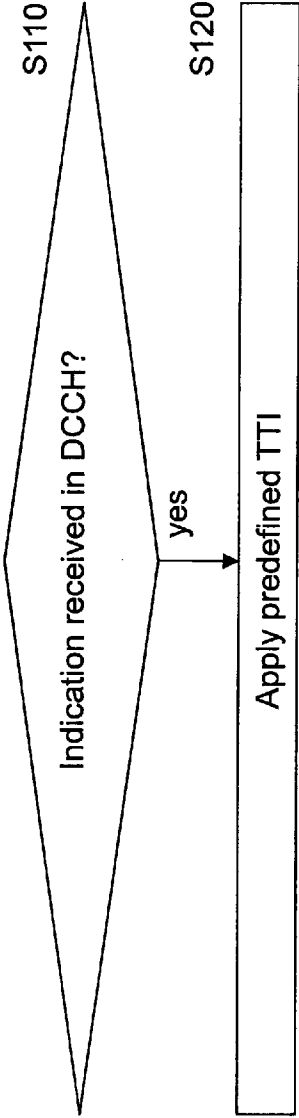


Fig. 4

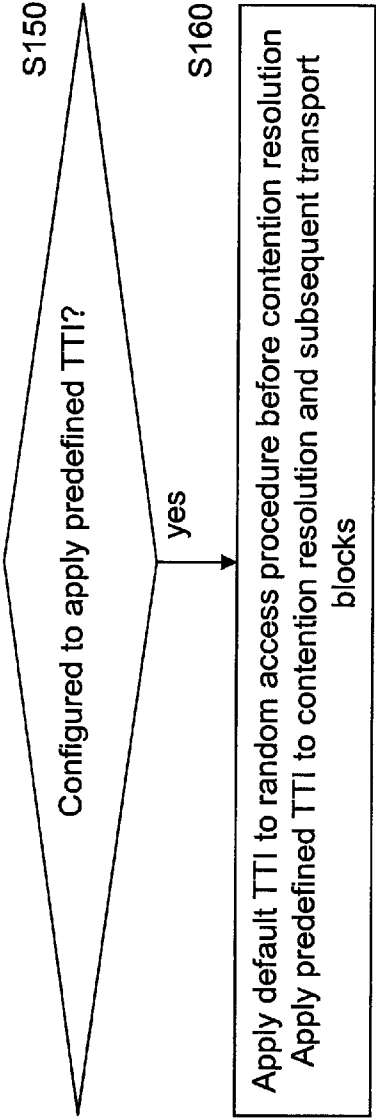


Fig. 6

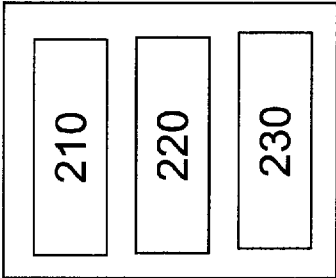


Fig. 7

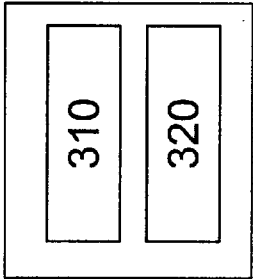


Fig. 9

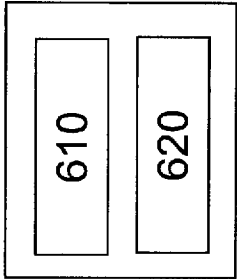


Fig. 11

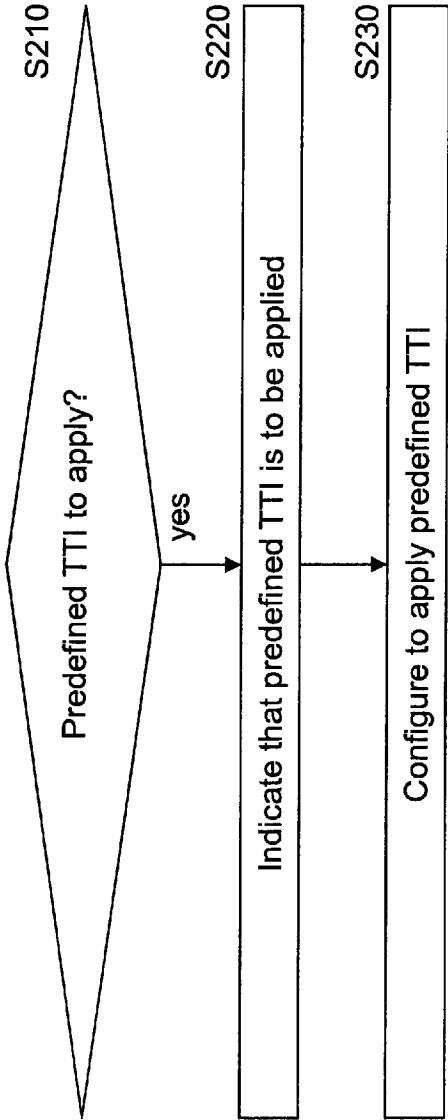


Fig. 8

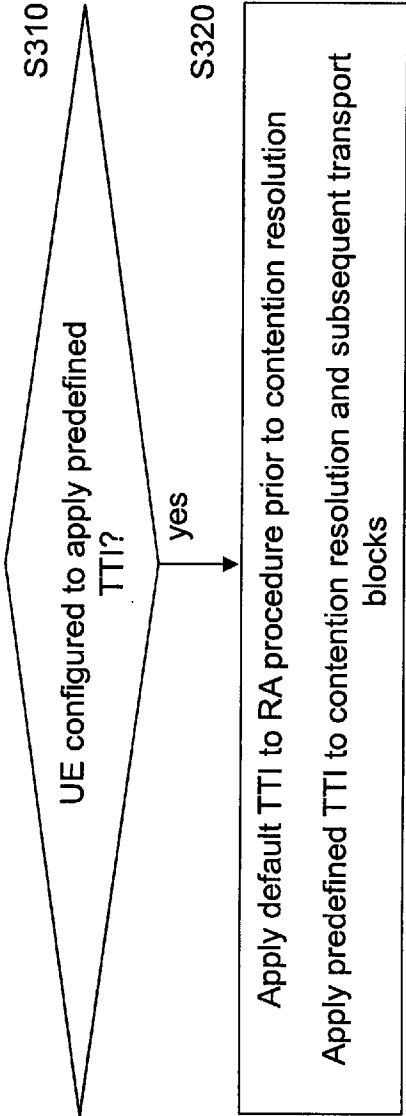


Fig. 10

INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2015/093918

A. CLASSIFICATION OF SUBJECT MATTER

H04W 72/04(2009.01)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 72/-

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:random access,random access reponse,transmission time interval?,RAR,TTI,RA,default,shorter

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2015016431 A1 (NOKIA SOLUTIONS AND NETWORKS OY) 15 January 2015 (2015-01-15) description paragraphs [0074], [0081]-[0084], [0090]-[0101], [0140]	1, 23
A	CN 101803234 A (LG ELECTRONICS INC.) 11 August 2010 (2010-08-11) the whole document	1-46
A	CN 103458528 A (HUAWEI TECHNOLOGIES CO., LTD.) 18 December 2013 (2013-12-18) the whole document	1-46

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

* Special categories of cited documents:

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“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

19 July 2016

Date of mailing of the international search report

28 July 2016

Name and mailing address of the ISA/CN

STATE INTELLECTUAL PROPERTY OFFICE OF THE
P.R.CHINA
6, Xitucheng Rd., Jimen Bridge, Haidian District, Beijing
100088, China

Facsimile No. (86-10)62019451

Authorized officer

WU,Jiangxia

Telephone No. (86-10)62412034

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.

PCT/CN2015/093918

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				IN	5676DEN2014	A	03 April 2015
				WO	2013110683	A1	01 August 2013
				JP	2015508624	A	19 March 2015
				CN	104067683	A	24 September 2014
CN	101803234	A	11 August 2010	KR	101382748	B1	08 April 2014
				KR	20090081728	A	29 July 2009
				CN	101803234	B	27 November 2013
				US	2011032889	A1	10 February 2011
				US	8325755	B2	04 December 2012
				WO	2009038300	A1	26 March 2009
CN	103458528	A	18 December 2013	None			