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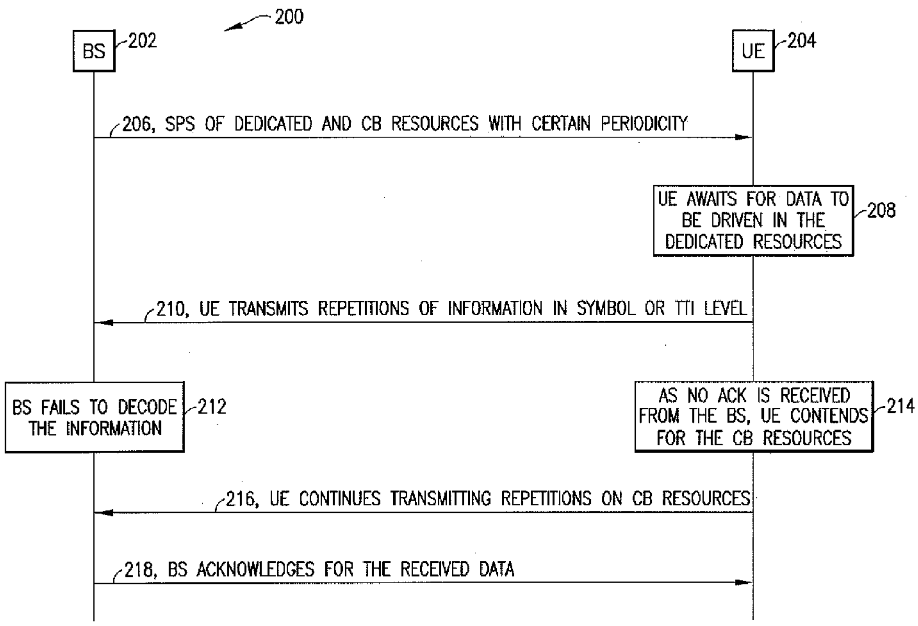

FIG.2

(57) Abstract: Embodiments are with regard to user equipment comprising one or more memories and a computer program code configured to, with one or more processors, to cause the user equipment to: receive a configuration of dedicated resources and contention-based resources; if there is available data to transmit, transmit the data or any repetitions thereof on the dedicated resources; if an acknowledgement is not received, continue to transmit the repetitions on the contention-based resources, and if an acknowledgement is not received, either drop data or continue to transmit the repetitions on the dedicated resources.

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Semi-Persistent Scheduling of Contention Based Channel for Transmission Repetitions

TECHNICAL FIELD

This embodiments relate generally to wireless communication systems and, more specifically, to employing a pre-scheduling scheme for contention based channels to be used for necessary transmission repetitions.

BACKGROUND

This section is intended to provide a background or context to the embodiments disclosed below. The description herein may include concepts that could be pursued, but are not necessarily ones that have been previously conceived, implemented or described. Therefore, unless otherwise explicitly indicated herein, what is described in this section is not prior art to the description in this application and is not admitted to be prior art by inclusion in this section.

In the pre-scheduling scheme defined by the current 3GPP standard, for instance, semi-persistent scheduling (SPS), the base station (or eNB), assigns separate resources with a certain periodicity for each UE. These SPS resources are UE specific and, if there is available data during the pre-scheduled interval, they may be reserved to the UE for a longer period of time for transmission/reception. The scheme reduces signaling overhead and helps to avoid the limitation of the control channel capacity, enabling a higher number of users both in downlink and uplink.

For downlink (DL), only initial transmissions use SPS resources. When it fails, the UE sends a negative acknowledgement (NACK) and awaits a subsequent HARQ retransmission. Retransmissions are explicitly scheduled by a base station through a control channel assignment.

For uplink (UL), when the initial transmission fails the base station sends a NACK and the retransmissions can either be explicitly scheduled or follow the SPS pattern.

Going forward, wireless communications will support countless emerging use cases and applications with a high variability of their performance attributes. While system capacity may not be the critical point, stringent latency and/or reliability requirements might be. Discussions of future activity envisage expanding and supporting diverse families of usage scenarios and applications, including Ultra-Reliable and Low-Latency Communications (URLLC).

The process of acknowledgments and retransmission granting can cause extended delays, which would be undesirable for URLLC use cases. Moreover, errors can occur either on acknowledge decoding or in retransmission signaling, affecting the reliability of system.

The current embodiments move beyond these techniques and materials.

Abbreviations that may be found in the specification and/or the drawing figures are defined below, after the detailed description section.

BRIEF SUMMARY

This section is intended to include examples and is not intended to be limiting. As discussed in detail below, the current embodiments combine transmissions on pre-configured dedicated resources with automatic retransmissions on a set of shared contention-based resources.

This embodiments include autonomous methods for deciding at which radio resources to transmit repetitions. The embodiments also include the corresponding UE- and BS-behaviors, as well as the corresponding air interface signaling between those entities.

BRIEF DESCRIPTION OF THE DRAWINGS

In the attached Drawing Figures:

FIG. 1 is a block diagram of one possible and non-limiting exemplary system in which the exemplary embodiments may be practiced;

FIG. 2 is an illustration of an embodiment of the proposed embodiments for the uplink;

FIG. 3 is a logic flow diagram for semi-persistent scheduling of contention based channel for transmission repetitions, and illustrates the operation of an exemplary method, a result of execution of computer program instructions embodied on a computer readable memory, functions performed by logic implemented in hardware, and/or interconnected means for performing functions in accordance with exemplary embodiments;

FIG. 4 illustrates an embodiment the embodiments with repetitions and contention; and

FIG. 5A and FIG. 5B illustrate SPS transmission without the concept of the current embodiments and SPS transmission with the contention based (CB) for repetitions concept of the current embodiments, respectively.

DETAILED DESCRIPTION OF THE DRAWINGS

This embodiments relate to a fifth generation (5G) concept design, focusing on a new scheme with improved resource utilization and latency reduction, to be applied for Machine Type Communication (MTC). The 5G radio access technology is expected to enable a wide range of MTC services, including the support of ultra-reliable and low latency communication (URLLC) to be used in many novel applications. The 3GPP group, in the technical report TR 38.913, defines stringent targets for reliability, for example $1\text{-}10^{-5}$ within 1ms, and average user plane latency of 0.5ms. Meeting such requirements in an efficient way demands new solutions to come in the future mobile wireless technologies.

In 5G systems it is expected that MTC exploits the use of transmission repetitions in a proactive way, in order to increase the success probability of transmitting a message. Nevertheless, for URLLC use cases, the application of such schemes is very restricted due to the tight latency requirement.

In order to overcome some of the disadvantages of the current state of affairs, exemplary embodiments of the current embodiments look to use a new concept that employs a pre-scheduling scheme for CB channels to be used in case of necessary transmission repetitions, in a low latency and resource efficient way.

Embodiments of the present embodiments may provide enhanced latency by pre-scheduling resources to be used on necessity of further transmission repetitions for a reliable communication. The suggested scheme has improved radio resource utilization, since it proposes occasional use of shared pre-scheduled resources by a group of users.

The retransmissions procedure specified by 3GPP for NB-IoT [3GPP TR 45.820] has the amount of time-frequency resources, for instance, the number of repetitions and the number of tones, set individually per UE depending on the coverage condition. The UEs are dynamically scheduled with up to 2048 repetitions onto a 1ms TTI. This technique can lead to high latency and resource consumption when the number of necessary repetitions is overestimated.

In addition, there is the SPS scheme under the LTE standard, together with the contention based PUSCH (CB-PUSCH) transmission. In the 3GPP technical report [3GPP TR 36.881], it is proposed that in order to reduce the waste of resources when a UE has no available data to transmit in its pre-scheduled interval, that multiple UEs share the same PUSCH resource (either dynamically granted or configured). If more than one UE transmits at the same time in the resource, then a collision happens and the base station may not be able to decode the data. Thus, the collision should be detected in order to arrange a retransmission of the data of each UE. This can result in an extended latency and compromise the applicability of the technique in URLLC use cases. In addition, such retransmission is not supported by CB-PUSCH resources.

Some of the existing concepts and possible 5G solutions available in the literature are described in the following references, none of them coincide with the current embodiments: Ratasuk, R.; Prasad, A.; Zexian Li; Ghosh, A.; Uusitalo, M., "Recent advancements in M2M communications in 4G networks and evolution towards 5G", Intelligence in Next Generation Networks (ICIN), vol. 52, no. 57, pp. 17-19, February 2015; R2-154191, Contention based uplink transmission, Huawei, HiSilicon, 3GPP RAN2#91bis, October 2015; R2-154122, Analysis on resource efficiency of uplink access solutions, CATT, CATR, 3GPP RAN2#91bis, October 2015; and K. Zhou et al., "Adaptive transmission and multiple-access for sparse-traffic sources", Proceedings of the 20th EUSIPCO, 2012.

Concerning the current embodiments, the word "exemplary" as used herein means "serving as an example, instance, or illustration." Any embodiment described herein as "exemplary" is not necessarily to be construed as preferred or advantageous over other embodiments. All of the embodiments described in this Detailed Description are exemplary embodiments provided to enable persons skilled in the art to make or use the embodiments and not to limit the scope of the embodiments which is defined by the claims.

Therefore, the exemplary embodiments herein describe techniques for semi-persistent scheduling of contention based channel for transmission repetitions.

According to embodiments of the current embodiments, the base station (BS) configures the UE to use a pre-scheduled (SPS) dedicated time-frequency resource pattern with a certain periodicity. Besides that, the BS also configures the UE with CB resources (shared by a group of UEs, in order to optimize resources utilization) located among its periodic dedicated resources. The later should be used by the UE only if it needs to perform further retransmissions.

In both uplink and downlink cases, the BS should reconcile the amount of dedicated and CB resources in order to avoid waste and, at the same time, reduce the probability of collision. This reconciliation can be done by proper allocation of necessary dedicated resources and by grouping the number of users per CB channel according to the target success probability and expected error rate.

The BS can reconfigure the UEs in order to increase or reduce the number of users sharing a CB resource depending on the conditions and target reliability.

The BS can configure the decision rules to use the dedicated and the CB channels for continuing retransmissions or for a drop in the information. This can be defined according to the QoS constraints or to a maximum number of allowed repetitions per UE.

The BS may or may not assign orthogonal reference signals to the UEs sharing the same CB channel so as to be able to differentiate them by their transmitted signal.

In the uplink case, if the UE has available data to transmit, it uses its dedicated SPS resources to transmit repetitions of the information (for example, in symbol or TTI level) in order to increase the probability of success.

If the UE does not receive an ACK from the BS, then it continues transmitting the repetitions in the pre-scheduled CB resources. Note, however, that there is the possibility that there may be no repetitions on the dedicated resources, but merely a single transmission per piece of data, which may occur if the reliability on the dedicated resources is adequately high.

In the downlink case, if there is available data for the UE, the dedicated SPS resources are used by the BS to transmit the information and may be used by the BS to transmit repetitions of the information (for example, in symbol or TTI level) in order to increase the probability of success.

If the BS does not receive an ACK from the UE, then it continues transmitting the repetitions in the pre-scheduled CB resources. For example, if the BS receives a NACK from the UE, then it continues transmitting the repetitions in the pre-scheduled CB resources.

In the downlink case, if BS does not receive an ACK from more than one UE, then it has to choose to which UE it will continue transmitting to on the CB channel (randomly or based on QoS requirements). As such, a UE sending a NACK, or a UE not sending an ACK, for data received from the BS in its dedicated SPS resources should monitor its allocated resources on the CB channel and detect whether it is the intended recipient for any data received on these allocated resources on the CB channel. On the other hand, a UE which sent an ACK for data received on the dedicated resources may skip the monitoring of its allocated resources on the CB channel.

In case the transport block is still not decoded (for instance, due to a collision in CB channel or poor channel condition), an ACK will not be issued and the information should be retransmitted in the next resource opportunity or dropped (where this decision can also be based on QoS constraints). This concept could also be referred to as existing due to unrecoverable collisions, where the application of advanced receiver structures can permit the decoding of the information even in colliding situations.

Transmitting repetitions or retransmissions could also be implemented in such a manner as to transmit one single repetition or many repetitions of the same information, or different redundant versions of the same information (or portions of it). Regarding semi-persistent scheduling (SPS), it could also be implemented as a persistent scheduling (e.g., pre-scheduling of a sequence of resource chunks valid until the UE is active or receives another allocation) or as a single pre-scheduling (e.g. without a periodicity, not necessarily persistent). In general, the embodiments may be practiced with any form of pre-scheduling, even though (semi-)persistent scheduling implementation may be more applicable for URLLC cases.

Additional description of these techniques is presented after a system into which the exemplary embodiments may be used is described.

FIG. 1 is a block diagram of one possible and non-limiting exemplary system in which the exemplary embodiments may be practiced. In FIG. 1, a user equipment (UE) 110 is in wireless communication with a wireless network 100. A UE is a wireless, typically mobile device that can access a wireless network. The UE 110 includes one or more processors 120, one or more memories 125, and one or more transceivers 130 interconnected through one or more buses 127. Each of the one or more transceivers 130 includes a receiver, Rx, 132 and a transmitter, Tx, 133. The one or more buses 127 may be address, data, or control buses, and may include any interconnection mechanism, such as a series of lines on a motherboard or integrated circuit, fiber optics or other optical communication equipment, and the like. The one or more transceivers 130 are connected to one or more antennas 128. The one or more memories 125 include computer program code 123. Note that the YYY module allows functionality for the semi-persistent scheduling of contention based channel for transmission repetitions where any method or examples of such embodiments discussed herein can be practiced. The UE 110 includes a YYY module 140, comprising one of or both parts 140-1 and/or 140-2, which may be implemented in a number of ways. The YYY module 140 may be implemented in hardware as YYY module 140-1, such as being implemented as part of the one or more processors 120. The YYY module 140-1 may be implemented also as an integrated circuit or through other hardware such as a programmable gate array. In another example, the YYY module 140 may be implemented as YYY module 140-2, which is implemented as computer program code 123 and is executed by the one or more processors 120. For instance, the one or more memories 125 and the computer program code 123 may be configured to, with the one or more processors 120, to cause the user equipment 110 to perform one or more of the operations as described herein. The UE 110 communicates with base station 170 via a wireless link 111.

The base station (for instance, an evolved NodeB) 170 is a base station (e.g., for LTE, long term evolution) that provides access by wireless devices such as the UE 110 to the wireless network 100. The base station 170 includes one or more processors 152, one or more memories 155, one or more network interfaces (N/W I/F(s)) 161, and one or more transceivers 160 interconnected through one or more buses 157. Each of the one or more transceivers 160 includes a receiver, Rx, 162 and a transmitter, Tx, 163. The one or more transceivers 160 are connected to one or more antennas 158. The one or more memories 155 include computer program code 153. Note that the ZZZ module allows functionality for the semi-persistent scheduling of contention based channel for transmission repetitions where any method or examples of such embodiments discussed herein can be practiced. The base station 170 includes a ZZZ module 150, comprising one of or both parts 150-1 and/or 150-2, which may be implemented in a number of ways. The ZZZ module 150 may be implemented in hardware as ZZZ module 150-1, such as being implemented as part of the one or more processors 152. The ZZZ module 150-1 may be implemented also as an integrated circuit or through other hardware such as a programmable gate array. In another example, the ZZZ module 150 may be implemented as ZZZ module 150-2, which is implemented as computer program code 153 and is executed by the one or more processors 152. For instance, the one or more memories 155 and the computer program code 153 are configured to, with the one or more processors 152, to cause the base station 170 to perform one or more of the operations as described herein. The one or more network interfaces 161 communicate over a network such as via the links 176 and 131. Two or more base stations 170 communicate using, e.g., link 176. The link 176 may be wired or wireless or both and may implement, e.g., an X2 interface.

The one or more buses 157 may be address, data, or control buses, and may include any interconnection mechanism, such as a series of lines on a motherboard or integrated circuit, fiber optics or other optical communication equipment, wireless channels, and the like. For example, the one or more transceivers 160 may be implemented as a remote radio head (RRH) 195, with the other elements of the base station 170 being physically in a different location from the RRH, and the one or more buses 157 could be implemented in part as fiber optic cable to connect the other elements of the base station 170 to the RRH 195.

It is noted that description herein indicates that “cells” perform functions, but it should be clear that the base station that forms the cell would perform the functions. The cell makes up part of a base station. That is, there can be multiple cells per base station. For instance, there could be three cells for a single base station carrier frequency and associated bandwidth, each cell covering one-third of a 360-degree area so that the single base station's coverage area covers an approximate oval or circle. Furthermore, each cell can correspond to a single carrier and a base station may use multiple carriers. So if there are three 120-degree cells per carrier and two carriers, then the base station has a total of 6 cells.

The wireless network 100 may include a network control element (NCE) 190 that may include MME (Mobility Management Entity)/SGW (Serving Gateway) functionality, and which provides connectivity with a further network, such as a telephone network and/or a data communications network (e.g., the Internet). The base station 170 is coupled via a link 131 to the NCE 190. The link 131 may be implemented as, e.g., an S1 interface. The NCE 190 includes one or more processors 175, one or more memories 171, and one or more network interfaces (N/W I/F(s)) 180, interconnected through one or more buses 185. The one or more memories 171 include computer program code 173. The one or more memories 171 and the computer program code 173 are configured to, with the one or more processors 175, cause the NCE 190 to perform one or more operations.

The wireless network 100 may implement network virtualization, which is the process of combining hardware and software network resources and network functionality into a single, software-based administrative entity, a virtual network. Network virtualization involves platform virtualization, often combined with resource virtualization. Network virtualization is categorized as either external, combining many networks, or parts of networks, into a virtual unit, or internal, providing network-like functionality to software containers on a single system. Note that the virtualized entities that result from the network virtualization may still be implemented, at some level, using hardware such as processors 152 or 175 and memories 155 and 171, and also such virtualized entities create technical effects.

The computer readable memories 125, 155, and 171 may be of any type suitable to the local technical environment and may be implemented using any suitable data storage technology, such as semiconductor based memory devices, flash memory, magnetic memory devices and systems, optical memory devices and systems, fixed memory and removable memory. The computer readable memories 125, 155, and 171 may be means for performing storage functions. The processors 120, 152, and 175 may be of any type suitable to the local technical environment, and may include one or more of general purpose computers, special purpose computers, microprocessors, digital signal processors (DSPs) and processors based on a multi-core processor architecture, as non-limiting examples. The processors 120, 152, and 175 may be means for performing functions, such as controlling the UE 110, base station 170, and other functions as described herein.

In general, the various embodiments of the user equipment 110 can include, but are not limited to, cellular phones such as smart devices, tablets, personal digital assistants (PDAs) having wireless communication capabilities, portable computers having wireless communication capabilities, image capture devices such as digital cameras having wireless communication capabilities, gaming devices having wireless communication capabilities, music storage and playback appliances having wireless communication capabilities, internet appliances permitting wireless Internet access and browsing, tablets with wireless communication capabilities, as well as portable units or terminals that incorporate combinations of such functions. In addition, various embodiments of the user equipment include machines, communicators and categories of equipment, which are not primarily or not at all in use by human interaction.

FIG. 2 is an illustration of the proposed embodiments for the uplink 200. The BS 202 first configures the UE 204 with the semi-persistent scheduling information of its dedicated channels and the contention based channels, where this information can include time-frequency location and periodicity of the resources, as shown in action 206. This is an example, but consider also that, instead SPS with certain periodicity, it could simply be a pre-scheduling of dedicated and CB resources. Thereafter, in the uplink case, the UE awaits for data to be driven in the dedicated resources, shown on the diagram as block 208. The UE 204 will be able to regularly use its pre-scheduled resources whenever it has data available for transmission, reducing signaling overhead, latency and error probability on scheduling request and granting messages.

As seen from action 210, the UE transmits repetitions of information in symbol or TTI level. The UE transmits its available data using repetitions in a proactive way in order to increase the probability of success of reception. Thus, this action could be merely once or many repetitions.

As seen from block 212, the BS may fail to decode the information. Thus, as seen in block 214, the UE will not receive an ACK from the BS, so that the UE will have to contend for the CB resources. Thus, in case the UE does not get an ACK during its transmission, then it contends for the CB channel and continues its repetitions on it as seen in the figure as action 216. A soft combining of the received data will substantially increase the probability of success, resulting in an acknowledgment from the BS, as can be seen from action 218.

The same type of procedure can basically be implemented in the other direction for the downlink transmission (except for the initial configuration setting that is typically transmitted from the BS to the UE side).

FIG. 3 depicts a representation of the information and the decision flow of an embodiment of the embodiments. It shows that the information is initially transmitted on the pre-scheduled dedicated resources. A decision to continue retransmitting on the CB resources is taken if an ACK is not received. If there is still no acknowledgement after the transmissions on the CB channel, then a decision should be taken to either continue retransmitting that information or drop it. This decision rule can initially be configured by the BS taking into account the QoS requirement and the maximum number of allowed repetitions per user.

Block 302 represents the BS configuring SPS of dedicated and CB resources to UEs.

Block 304 represents checking if there is available data to transmit. If there is, then the method proceeds to block 306 which requires a decision as to whether there is data to transmit. If yes, then the process, as shown in block 308 transmits data or any repetitions thereof on dedicated resources. If no, then the process returns to block 304.

After transmitting at least a portion of the available data and possible repetitions thereof on dedicated resources, as shown in block 308, another decision point is reached as to whether an ACK is received. If yes, then the process returns to block 304 to determine if there is still available data to transmit. If no, then the technique calls for continuing to transmit repetitions on CB resources as shown in block 312.

Once again, a decision point is reached in block 314 to determine if an ACK has been received. If yes, then he process returns to block 304 to determine if there is still available data to transmit. If no, then the technique calls for deciding whether or not to drop the data, as shown in block 316.

If the data is to be dropped, then the process returns to block 304 to determine once again if there is still available data to transmit. If the data is not to be dropped, then the process returns to block 308 to again transmit repetitions on dedicated resources.

Exemplary embodiments of the current embodiments employ an optimized scheduling algorithm in the base station to allocate the amount of dedicated and contention based resources for the users in a way that prevents wasting by providing the necessary resources estimated to meet targeted latency and reliability. In some embodiments, the scheduler may determine which users, and as such how many users, to allocate to specific resources on the CB channel in order to achieve a certain maximum probability of collision on these resources in view of reliability of the dedicated resources of the users. In other embodiments, all users of the BS may allocated the same resources on the CB channel, which is advantageously possible when the probability of failure on the dedicated resources is adequately low to produce a low probability of collision on the CB resources, as users would rarely have to resort to the use of the CB resources. The scheduler may set the periodicity of CB resources to be the same or different from the periodicity of dedicated SPS resources of a UE.

Note that the concept can be implemented with a NACK message but there is also the possibility of implementing with an implicit NACK (that is, “no ACK”), which should be a preferable approach for the URLLC cases. In that case, it may be preferable to have the risk of a pointless transmission (which may not be energy efficient), than have the risk of not getting a retransmission when it is really needed (which could reduce the reliability and increase latency). Note that when using an explicit NACK, the node could also misunderstand an NACK as an ACK and not retransmit when is needed. As such, both approaches are shown herein. Thus, the embodiments include an enablement for a solution to prevent wasting.

FIG. 4 illustrates a situation in which different UEs transmit their repetitions in symbol or TTI level. Some UEs might not get an ACK and will contend for continuing their repetitions on the

CB channel. The probability of more than one UE needing to use the CB channel should be reduced by the pre-scheduling strategy.

The embodiments may improve the probability of successful reception combined with reduced delays, which would be caused by negative acknowledgment and retransmissions re-scheduling. In addition, it allows for allocation of large numbers of users to the same CB resource while maintaining, under typical operation, low probability of collision on these resources. The embodiments may avoid the signaling caused by the retransmission grants and, consequently, reduces the delays caused by re-scheduling of non-acknowledged blocks and the probability of errors on control signals.

FIG. 5A illustrates SPS transmission without use of the embodiments, while FIG. 5B illustrates SPS transmission with the CB for repetitions concept of the embodiments. Together these figures show the improvement on delay and reduced signaling using the embodiments, compared to a usual retransmission procedure. If information is not decoded from the dedicated SPS transmissions, the node does not need to wait for a NACK and a rescheduling grant. It uses the CB resources to continue transmitting, and increase success probability with lower delay and signaling. Note, continuing the discussion of the embodiment involved in preventing wasting, the NACK which should occur at the same time in Fig. 5A and Fig. 5B could also be labeled as “no ACK” instead for this “no wasting” embodiment.

Embodiments herein may be implemented in software (executed by one or more processors), hardware (e.g., an application specific integrated circuit), or a combination of software and hardware. In an example of an embodiment, the software (e.g., application logic, an instruction set) is maintained on any one of various conventional computer-readable media. In the context of this document, a “computer-readable medium” may be any media or means that can contain, store, communicate, propagate or transport the instructions for use by or in connection with an instruction execution system, apparatus, or device, such as a computer, with one example of a computer described and depicted, e.g., in FIG. 1. A computer-readable medium may comprise a computer-readable storage medium (e.g., 104, 134, or other device) that may be any media or means that can contain, store, and/or transport the instructions for use by or in connection with an instruction execution system, apparatus, or device, such as a computer. A computer-readable storage medium does not comprise merely propagating signals.

If desired, the different functions discussed herein may be performed in a different order and/or concurrently with each other. Furthermore, if desired, one or more of the above-described functions may be optional or may be combined.

Although various aspects of the embodiments are set out in the independent claims, other aspects of the embodiments comprise other combinations of features from the described embodiments and/or the dependent claims with the features of the independent claims, and not solely the combinations explicitly set out in the claims.

Without in any way limiting the scope, interpretation, or application of the claims appearing below, a technical effect or advantage of one or more of the example embodiments disclosed herein is, in URLLC use cases where capacity is not a main requirement, a certain flexibility to sacrifice some extra resources in order to meet the targets of latency and reliability. Another technical effect or advantage of one or more of the example embodiments disclosed herein is that the concept of transmitting repetitions using a CB channel brings a new degree of freedom optimize resources. Yet a further technical effect or advantage of one or more of the example embodiments disclosed herein is to optimize the use of radio resources.

It is also noted herein that while the above describes examples of embodiments of the embodiments, these descriptions should not be viewed in a limiting sense. Rather, there are several variations and modifications which may be made without departing from the scope of the present embodiments as defined in the appended claims.

List of abbreviations used herein:

3GPP	3rd generation partnership project
5G	Fifth generation
ACK	Acknowledgement
NACK	Negative-acknowledgement
BS	Base station
CB	Contention based
DL	Downlink
UL	Uplink

eNB	Evolved Node B, base station node in LTE
HARQ	Hybrid automatic repeat request
LTE	Long term evolution
MTC	Mission type communication
PUSCH	Physical uplink shared channel
QoS	Quality of Service
ReTx	Retransmission or retransmitting
Rx	Reception or receiving
SPS	Semi-persistent scheduling
TTI	Transmission time interval
Tx	Transmission or transmitting
UE	User equipment
URLLC	Ultra-reliable and low latency communication

CLAIMS

1. User equipment comprising one or more memories and a computer program code configured to, with one or more processors, to cause the user equipment to:
receive a configuration of dedicated resources and contention-based resources;
if there is available data to transmit, transmit the data or any repetitions thereof on the dedicated resources;
if an acknowledgement is not received, continue to transmit the repetitions on the contention-based resources, and
if an acknowledgement is not received, either drop data or continue to transmit the repetitions on the dedicated resources.

2. The user equipment as claimed in claim 1, wherein the dedicated resources are dedicated time-frequency resources and the user equipment is configured to use a dedicated time-frequency resource pattern with a certain periodicity.

3. The user equipment of claim 2, the configuration further comprising contention-based resources shared by a group of user devices, the contention-based resources located among the dedicated resources with the certain periodicity.

4. The user equipment of any of the preceding claims, wherein a decision to drop the data is made based on quality of service constraints or to a maximum number of allowed repetitions per user equipment.

5. A method, comprising:
receiving a configuration of dedicated resources and contention-based resources;
if there is available data to transmit, transmitting the data or any repetitions thereof on the dedicated resources;
if an acknowledgement is not received, continuing to transmit the repetitions on the contention-based resources, and
if an acknowledgement is not received, either dropping data or continuing to transmit the repetitions on the dedicated resources.

6. The method of claim 5, wherein the dedicated resources are dedicated time-frequency resources and the user equipment is configured to use a dedicated time-frequency resource pattern with a certain periodicity.

7. The method of claim 6, the configuration further comprising contention-based resources shared by a group of user devices, the contention-based resources located among the dedicated resources with the certain periodicity.

8. The method of any of the preceding claims 5 to 7 wherein a decision to drop the data is made based on quality of service constraints or to a maximum number of allowed repetitions per user equipment.

9. A non-transitory computer readable medium storing a program causing a computer to execute a process, the process comprising: if there is available data to transmit, causing transmitting the data or any repetitions thereof on configured dedicated resources;
if an acknowledgement is not received, causing continuing to transmit the repetitions on configured contention-based resources, and
if an acknowledgement is not received, causing either dropping data or continuing to transmit the repetitions on the dedicated resources.

10. A computer program comprising instructions which, when the program is executed by a computer, cause a base station to carry out the method of any of claims 5 to 8.

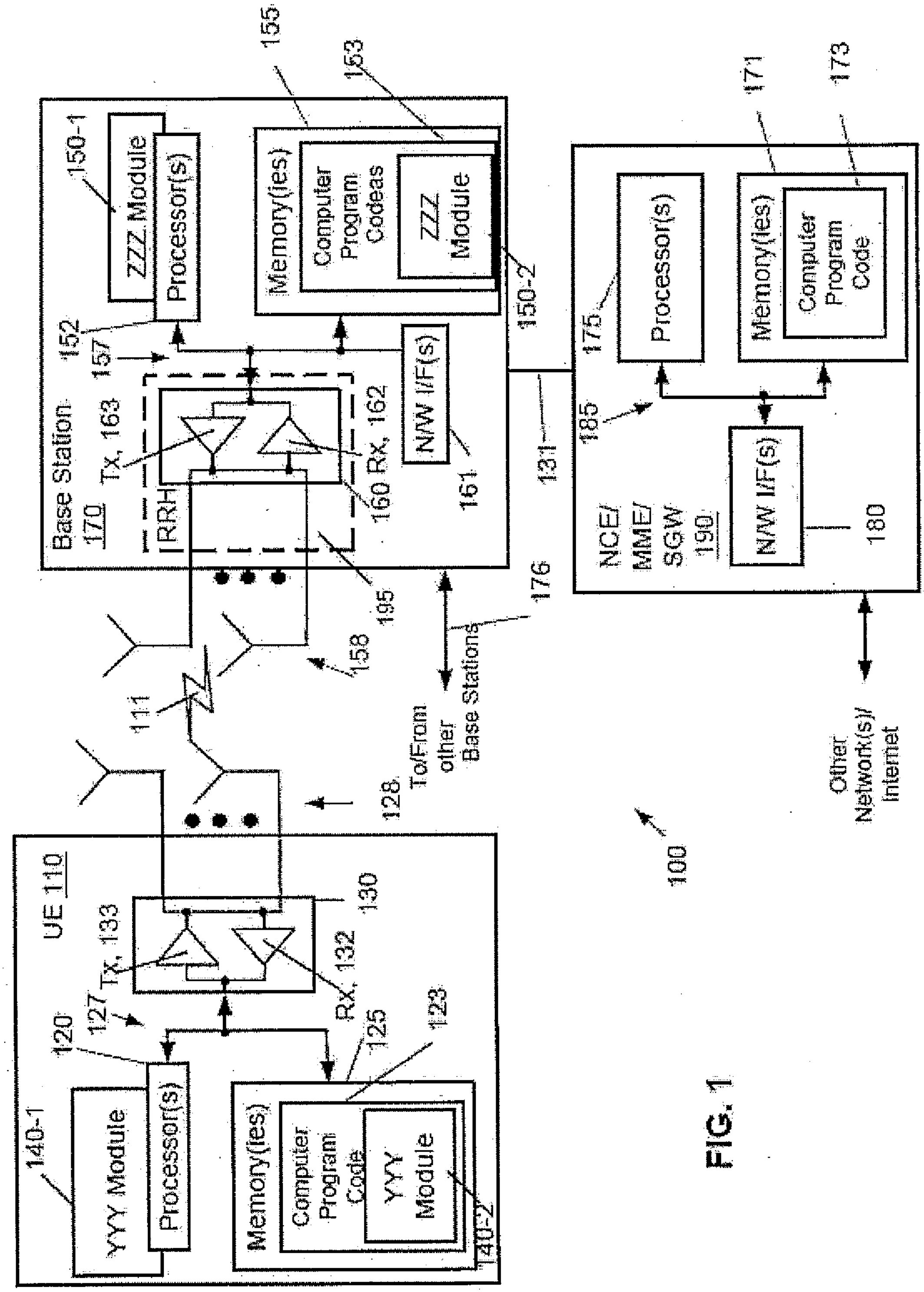
Base Station
170
ZZZ Module
150-1
Processor(s)
152
157
Memory(ies)
155
Computer Program Codeas
153
ZZZ Module
150-2
N/W I/F(s)
161
RRH
Tx, 163
Rx, 162
160
195
158
111
176
To/From other Base Stations
131
NCE/ MME/ SGW
190
175
Processor(s)
Memory(ies)
171
Computer Program Code
173
185
N/W I/F(s)
180
Other Network(s)/ Internet
100
UE 110
Tx, 133
Rx, 132
130
128
127
120
Processor(s)
YYY Module
140-1
Memory(ies)
125
Computer Program Code
123
YYY Module
140-2

FIG. 1

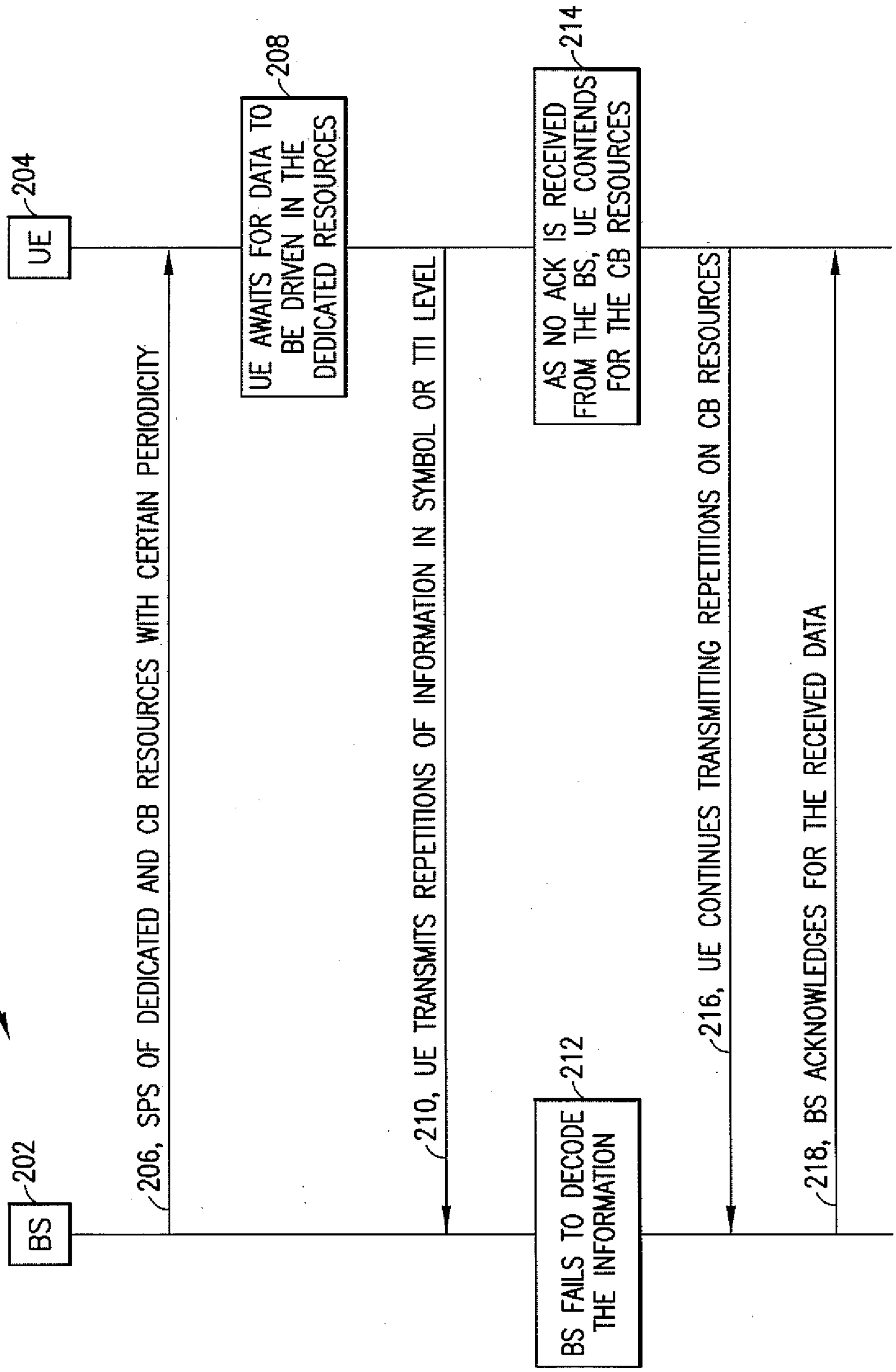
200
BS
202
UE
204
206, SPS OF DEDICATED AND CB RESOURCES WITH CERTAIN PERIODICITY
UE AWAITS FOR DATA TO BE DRIVEN IN THE DEDICATED RESOURCES
208
210, UE TRANSMITS REPETITIONS OF INFORMATION IN SYMBOL OR TTI LEVEL
BS FAILS TO DECODE THE INFORMATION
212
AS NO ACK IS RECEIVED FROM THE BS, UE CONTENDS FOR THE CB RESOURCES
214
216, UE CONTINUES TRANSMITTING REPETITIONS ON CB RESOURCES
218, BS ACKNOWLEDGES FOR THE RECEIVED DATA

FIG.2

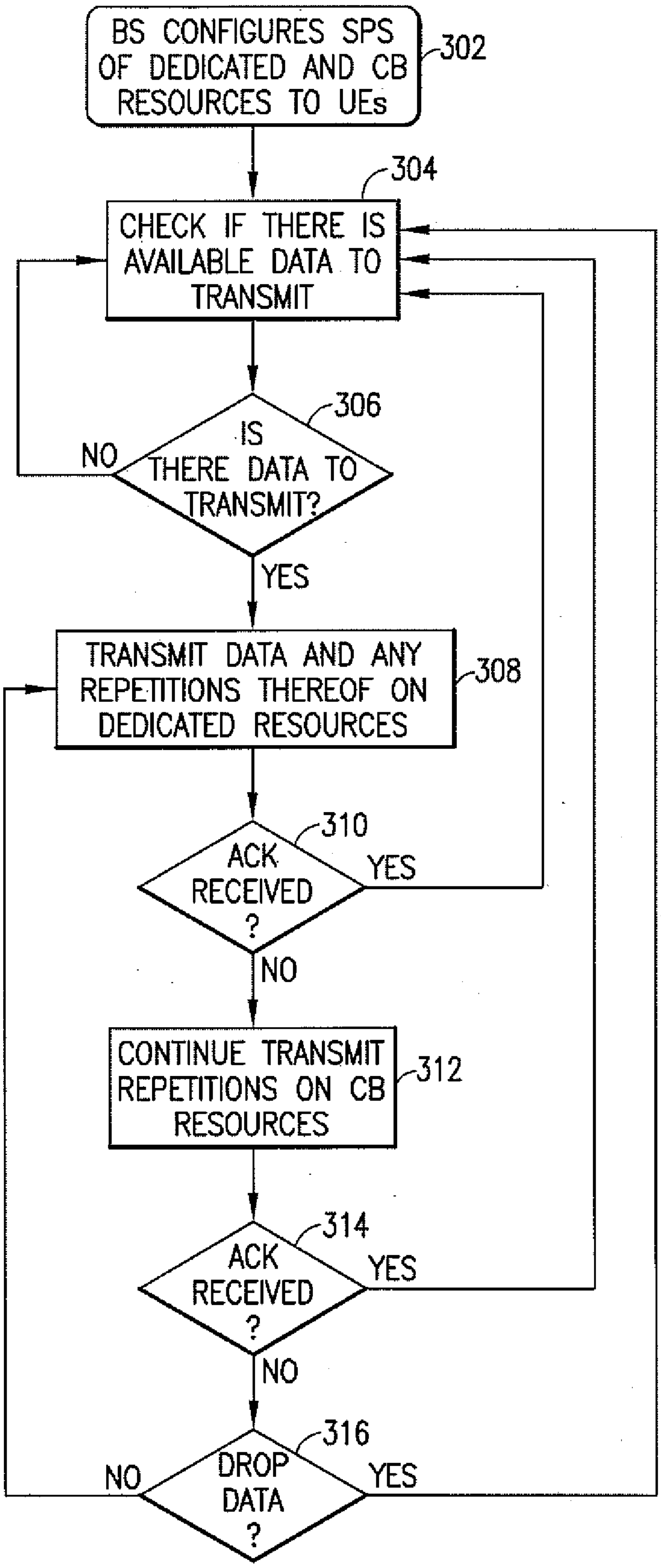
BS CONFIGURES SPS OF DEDICATED AND CB RESOURCES TO UEs
302
304
CHECK IF THERE IS AVAILABLE DATA TO TRANSMIT
306
IS THERE DATA TO TRANSMIT?
NO
YES
TRANSMIT DATA AND ANY REPETITIONS THEREOF ON DEDICATED RESOURCES
308
310
ACK RECEIVED ?
YES
NO
CONTINUE TRANSMIT REPETITIONS ON CB RESOURCES
312
314
ACK RECEIVED ?
YES
NO
316
DROP DATA ?
NO
YES

FIG.3

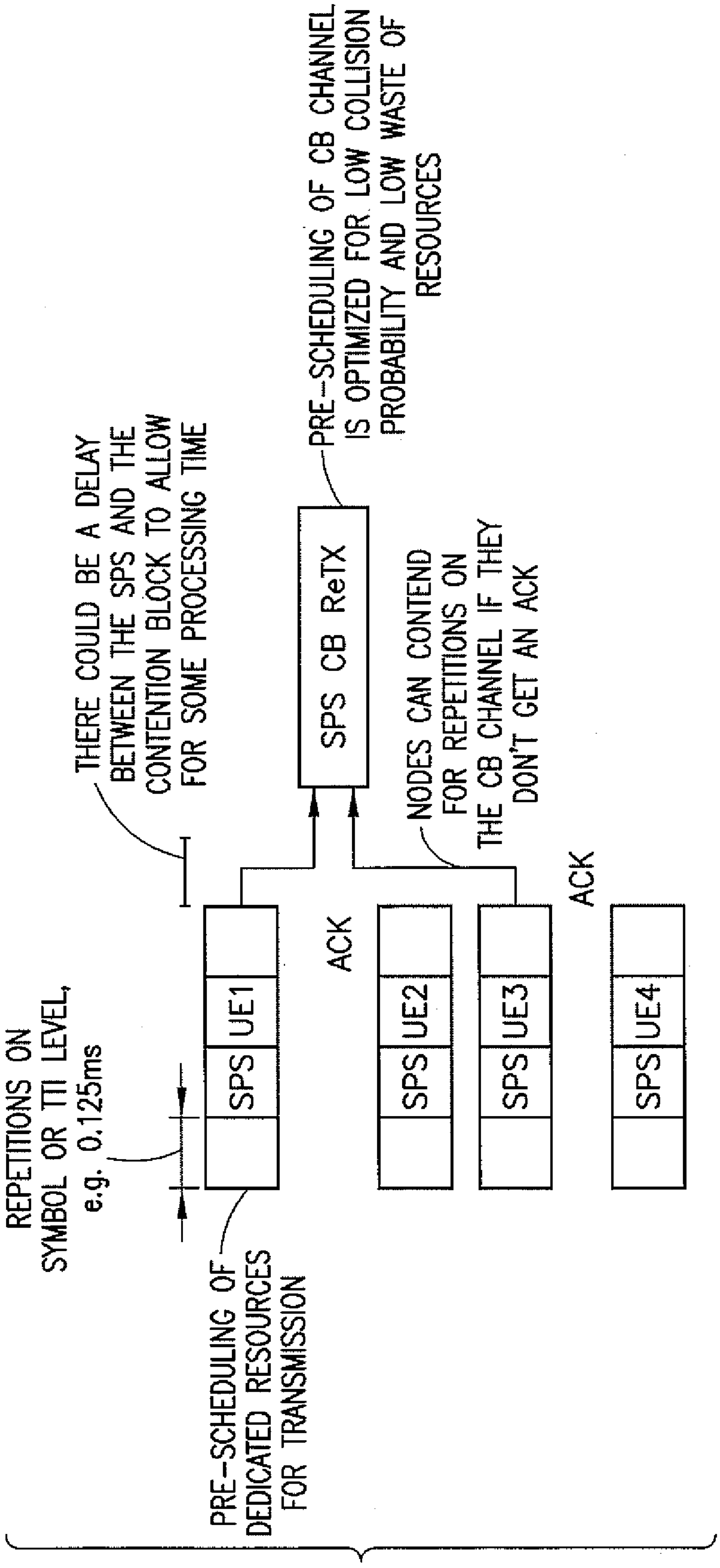
PRE-SCHEDULING OF CB CHANNEL IS OPTIMIZED FOR LOW COLLISION PROBABILITY AND LOW WASTE OF RESOURCES
THERE COULD BE A DELAY BETWEEN THE SPS AND THE CONTENTION BLOCK TO ALLOW FOR SOME PROCESSING TIME
SPS CB ReTX
NODES CAN CONTEND FOR REPETITIONS ON THE CB CHANNEL IF THEY DON'T GET AN ACK
REPETITIONS ON SYMBOL OR TTI LEVEL, e.g. 0.125ms
SPS
UE1
ACK
SPS
UE2
SPS
UE3
ACK
SPS
UE4
PRE-SCHEDULING OF DEDICATED RESOURCES FOR TRANSMISSION

FIG.4

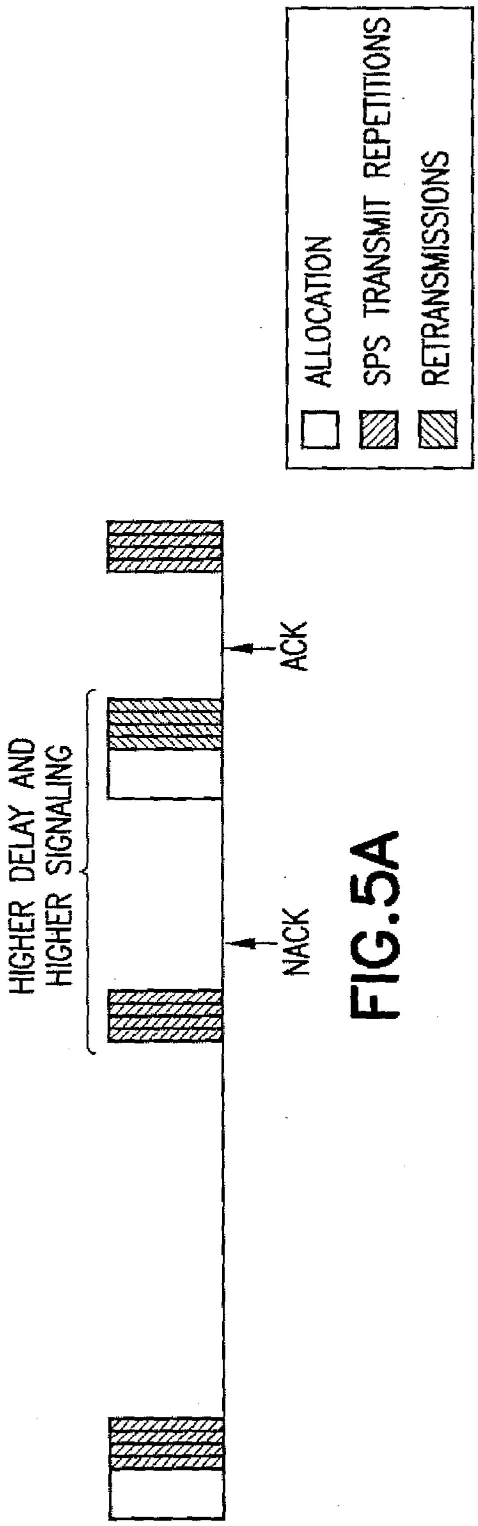
ALLOCATION
SPS TRANSMIT REPETITIONS
RETRANSMISSIONS
HIGHER DELAY AND HIGHER SIGNALING
NACK
ACK

FIG.5A

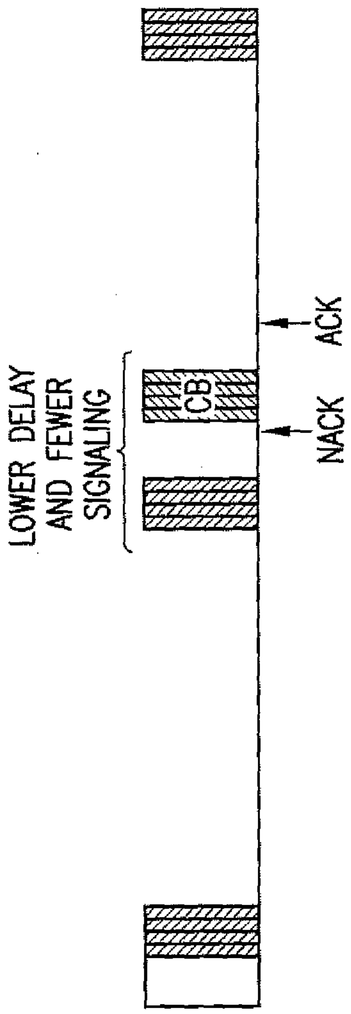
LOWER DELAY AND FEWER SIGNALING
CB
NACK
ACK

FIG.5B

INTERNATIONAL SEARCH REPORT

International application No.
PCT/FI2017/050552

A. **CLASSIFICATION OF SUBJECT MATTER**

See extra sheet

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)

IPC: H04W

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

FI, SE, NO, DK

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

EPODOC, EPO-Internal full-text databases, WPIAP, XP3GPP, XPAIP, XPESP, XPETSI, XPI3E, XPIEE, XPIETF, XPIOP, XPIPCOM, XPJPEG, XPMISC, XPOAC, XPRD, XPTK, COMPDX, INSPEC, NPL, Internet, ESPACENET

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2016105570 A1 (INTERDIGITAL PATENT HOLDINGS [US]) 30 June 2016 (30.06.2016) Abstract, paragraphs [0044], [0059], [0064]-[0067], [0072], [0076], [0079], [0129], [0160]-[0168], [0175]-[0184], [0205], [0213], [0241], [0256], [0258], [0261]-[0262], [0285], [0294], [0303], figures 4-6	1-10
A	WO 2013096555 A1 (RESEARCH IN MOTION LTD [CA]) 27 June 2013 (27.06.2013) The whole document.	1-10
A	US 2013034071 A1 (LEE HYUN WOO [KR] et al.) 07 February 2013 (07.02.2013) The whole document.	1-10
A	US 2016050667 A1 (PAPASAKELLARIOU ARIS [US] et al.) 18 February 2016 (18.02.2016) The whole document.	1-10

☒ 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

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"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	Date of mailing of the international search report
09 October 2017 (09.10.2017)	10 October 2017 (10.10.2017)

Name and mailing address of the ISA/FI	Authorized officer
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Facsimile No. +358 29 509 5328	Telephone No. +358 29 509 5000

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 2530992 A1 (SHARP KK [JP]) 05 December 2012 (05.12.2012) The whole document.	1-10

Patent document cited in search report	Publication date	Patent family members(s)	Publication date
WO 2016105570 A1	30/06/2016	None	
WO 2013096555 A1	27/06/2013	CA 2859961 A1	27/06/2013
		CA 2859961 C	16/05/2017
		CN 104160772 A	19/11/2014
		CN 104160772 B	17/08/2016
		EP 2795983 A1	29/10/2014
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		KR 101616220 B1	11/05/2016
		TW 201334612 A	16/08/2013
		TW I571163 B	11/02/2017
		TW 201334613 A	16/08/2013
		TW I586199 B	01/06/2017
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		US 2013163532 A1	27/06/2013
		US 8964678 B2	24/02/2015
		US 2013163533 A1	27/06/2013
		US 8964679 B2	24/02/2015
US 2013034071 A1	07/02/2013	US 8917686 B2	23/12/2014
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		WO 2011136586 A2	03/11/2011
US 2016050667 A1	18/02/2016	CN 106576302 A	19/04/2017
		EP 3195680 A1	26/07/2017
		KR 20170043539 A	21/04/2017
		WO 2016028060 A1	25/02/2016
EP 2530992 A1	05/12/2012	CN 102726112 A	10/10/2012
		JP 2011155335 A	11/08/2011
		US 2012294269 A1	22/11/2012
		WO 2011093270 A1	04/08/2011

CLASSIFICATION OF SUBJECT MATTER

IPC
H04W 72/12 (2009.01)
H04W 72/14 (2009.01)
H04W 72/04 (2009.01)
H04W 74/08 (2009.01)