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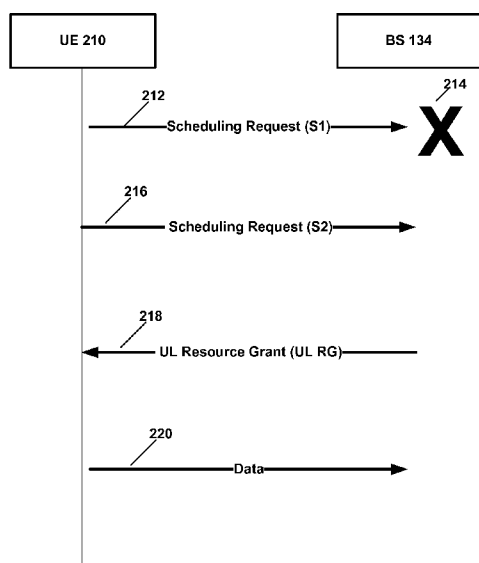


FIG. 2

(57) Abstract: A method may include determining, by a user device, a set of scheduling request resources allocated to the user device for transmitting a scheduling request, with each scheduling request resource of the set of scheduling request resources including a sequence, of a plurality of sequences, and/or a resource block region, wherein each scheduling request resource is associated with different communication requirements; determining a communication requirement for an uplink data transmission; transmitting, by the user device to a base station, a scheduling request via a scheduling request resource that is associated with the determined communication requirement in order to request uplink resources and indicate the associated communication requirement; and receiving, by the user device from the base station, an uplink resource grant that indicates resources allocated to the user device for uplink transmission.



ENHANCED SCHEDULING REQUEST TRANSMISSIONS IN WIRELESS NETWORKS**TECHNICAL FIELD**

[0001] This description relates to wireless communications.

BACKGROUND

[0002] A communication system may be a facility that enables communication between two or more nodes or devices, such as fixed or mobile communication devices. Signals can be carried on wired or wireless carriers.

[0003] An example of a cellular communication system is an architecture that is being standardized by the 3rd Generation Partnership Project (3GPP). A recent development in this field is often referred to as the long-term evolution (LTE) of the Universal Mobile Telecommunications System (UMTS) radio-access technology. E-UTRA (evolved UMTS Terrestrial Radio Access) is the air interface of 3GPP's Long Term Evolution (LTE) upgrade path for mobile networks. In LTE, base stations or access points (APs), which are referred to as evolved NodeBs (eNBs), provide wireless access within a coverage area or cell. In LTE, mobile devices, or mobile stations are referred to as user equipments (UEs). LTE has included a number of improvements or developments.

[0004] 5G New Radio (NR) development is part of a continued mobile broadband evolution process to meet the requirements of 5G, similar to earlier evolution of 3G & 4G wireless networks. In addition, 5G is also targeted at the new emerging use cases in addition to mobile broadband. A goal of 5G is to provide significant improvement in wireless performance, which may include new levels of data rate, latency, reliability, and security. 5G NR may also scale to efficiently connect the massive Internet of Things (IoT), and may offer new types of mission-critical services. Ultra-reliable and low-latency communications (URLLC) devices may require high reliability and very low latency.

SUMMARY

[0005] According to an example implementation, a method includes determining, by a user device, a set of scheduling request resources allocated to the user device for transmitting a scheduling request, with each scheduling request resource of the set of scheduling request resources including a sequence, of a plurality of sequences, and/or a resource block region, wherein each scheduling request resource is associated with a

different communication requirement; determining a communication requirement for an uplink data transmission; transmitting, by the user device to a base station, a scheduling request via a scheduling request resource that is associated with the determined communication requirement in order to request uplink resources and indicate the associated communication requirement; and receiving, by the user device from the base station, an uplink resource grant that indicates resources allocated to the user device for uplink transmission.

[0006] According to an example implementation, an apparatus includes at least one processor and at least one memory including computer instructions, when executed by the at least one processor, cause the apparatus to: determine, by a user device, a set of scheduling request resources allocated to the user device for transmitting a scheduling request, with each scheduling request resource of the set of scheduling request resources including a sequence, of a plurality of sequences, and/or a resource block region, wherein each scheduling request resource is associated with a different communication requirement; determine a communication requirement for an uplink data transmission; transmit, by the user device to a base station, a scheduling request via a scheduling request resource that is associated with the determined communication requirement in order to request uplink resources and indicate the associated communication requirement; and receive, by the user device from the base station, an uplink resource grant that indicates resources allocated to the user device for uplink transmission.

[0007] According to an example implementation, a non-transitory computer-readable storage medium comprising instructions stored thereon that, when executed by at least one processor, are configured to cause a computing system perform a method of determining, by a user device, a set of scheduling request resources allocated to the user device for transmitting a scheduling request, with each scheduling request resource of the set of scheduling request resources including a sequence, of a plurality of sequences, and/or a resource block region, wherein each scheduling request resource is associated with a different communication requirement; determining a communication requirement for an uplink data transmission; transmitting, by the user device to a base station, a scheduling request via a scheduling request resource that is associated with the determined communication requirement in order to request uplink resources and indicate the associated communication requirement; and receiving, by the user device from the base station, an uplink resource grant that indicates resources allocated to the user device for uplink transmission.

[0008] According to an example implementation, a method may include determining, by a base station, a set of scheduling request resources allocated to a user device for

transmitting a scheduling request, with each scheduling request resource of the set of scheduling request resources including a sequence, of a plurality of sequences, and/or a resource block region, wherein each scheduling request resource is associated with a different communication requirement; receiving, by the base station from the user device, a scheduling request via a scheduling request resource associated with a communication requirement; determining, based on the received scheduling request, a communication requirement for the user device; determining, based on the determined communication requirement for the user device, resources to be allocated to the user device; and transmitting, by the base station to the user device, an uplink resource grant that indicates the resources allocated to the user device for uplink transmission.

[0009] According to an example implementation, an apparatus includes at least one processor and at least one memory including computer instructions, when executed by the at least one processor, cause the apparatus to: determine, by a base station, a set of scheduling request resources allocated to a user device for transmitting a scheduling request, with each scheduling request resource of the set of scheduling request resources including a sequence, of a plurality of sequences, and/or a resource block region, wherein each scheduling request resource is associated with a different communication requirement; receive, by the base station from the user device, a scheduling request via a scheduling request resource associated with a communication requirement; determine, based on the received scheduling request, a communication requirement for the user device; determine, based on the determined communication requirement for the user device, resources to be allocated to the user device; and transmit, by the base station to the user device, an uplink resource grant that indicates the resources allocated to the user device for uplink transmission.

[0010] According to an example implementation, a non-transitory computer-readable storage medium comprising instructions stored thereon that, when executed by at least one processor, are configured to cause a computing system to perform a method of determining, by a base station, a set of scheduling request resources allocated to a user device for transmitting a scheduling request, with each scheduling request resource of the set of scheduling request resources including a sequence, of a plurality of sequences, and/or a resource block region, wherein each scheduling request resource is associated with a different communication requirement; receiving, by the base station from the user device, a scheduling request via a scheduling request resource associated with a communication requirement; determining, based on the received scheduling request, a communication

requirement for the user device; determining, based on the determined communication requirement for the user device, resources to be allocated to the user device; and transmitting, by the base station to the user device, an uplink resource grant that indicates the resources allocated to the user device for uplink transmission.

[0011] The details of one or more examples of implementations are set forth in the accompanying drawings and the description below. Other features will be apparent from the description and drawings, and from the claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] FIG. 1 is a block diagram of a wireless network according to an example implementation.

[0013] FIG. 2 is a diagram illustrating operation of a system according to an example embodiment.

[0014] FIG. 3 is a flow chart illustrating operation of a user device according to an example embodiment.

[0015] FIG. 4 is a flow chart illustrating operation of a base station according to an example embodiment.

[0016] FIG. 5 is a block diagram of a node or wireless station (e.g., base station/access point or mobile station/user device/UE) according to an example implementation.

DETAILED DESCRIPTION

[0017] FIG. 1 is a block diagram of a wireless network 130 according to an example implementation. In the wireless network 130 of FIG. 1, user devices 131, 132, 133 and 135, which may also be referred to as mobile stations (MSs) or user equipments (UEs), may be connected (and in communication) with a base station (BS) 134, which may also be referred to as an access point (AP), an evolved NodeB (eNB), next generation NodeB (gNB) or a network node. At least part of the functionalities of an access point (AP), base station (BS), (e)NodeB (eNB) or gNB may also be carried out by any node, server or host which may be operably coupled to a transceiver, such as a remote radio head (RRH). BS (or AP) 134 provides wireless coverage within a cell 136, including to user devices 131, 132, 133 and 135. Although only four user devices are shown as being connected or attached to BS 134, any number of user devices may be provided. BS 134 is also connected to a core network 150 via a S1 interface 151. This is merely one simple example of a wireless network, and

others may be used.

[0018] A user device (user terminal, user equipment (UE)) may refer to a portable computing device that includes wireless mobile communication devices operating with or without a subscriber identification module (SIM), including, but not limited to, the following types of devices: a mobile station (MS), a mobile phone, a cell phone, a smartphone, a personal digital assistant (PDA), a handset, a device using a wireless modem (alarm or measurement device, etc.), a laptop and/or touch screen computer, a tablet, a phablet, a game console, a notebook, and a multimedia device, as examples, or any other wireless device. It should be appreciated that a user device may also be a nearly exclusive uplink only device, of which an example is a camera or video camera loading images or video clips to a network.

[0019] In LTE (as an example), core network 150 may be referred to as Evolved Packet Core (EPC), which may include a mobility management entity (MME) which may handle or assist with mobility/handover of user devices between BSs, one or more gateways that may forward data and control signals between the BSs and packet data networks or the Internet, and other control functions or blocks.

[0020] In addition, by way of illustrative example, the various example implementations or techniques described herein may be applied to various types of user devices or data service types, or may apply to user devices that may have multiple applications running thereon that may be of different data service types. 5G New Radio (NR) development may support a number of different applications or a number of different data service types, such as for example: machine type communications (MTC), enhanced machine type communication (eMTC), Internet of Things (IoT), and/or narrowband IoT user devices, enhanced mobile broadband (eMBB), and ultra-reliable and low-latency communications (URLLC).

[0021] IoT may refer to an ever-growing group of objects that may have Internet or network connectivity, so that these objects may send information to and receive information from other network devices. For example, many sensor type applications or devices may monitor a physical condition or a status, and may send a report to a server or other network device, e.g., when an event occurs. Machine Type Communications (MTC, or Machine to Machine communications) may, for example, be characterized by fully automatic data generation, exchange, processing and actuation among intelligent machines, with or without intervention of humans. Enhanced mobile broadband (eMBB) may support much higher data rates than currently available in LTE.

[0022] Ultra-reliable and low-latency communications (URLLC) is a new data service type, or new usage scenario, which may be supported for 5G New Radio (NR) systems. This enables emerging new applications and services, such as industrial automations, autonomous driving, vehicular safety, e-health services, and so on. 3GPP Rel-15 targets in providing connectivity with reliability corresponding to block error rate (BLER) of 10^{-5} and up to 1 ms U-Plane (user/data plane) latency, by way of illustrative example. Thus, for example, URLLC user devices/UEs may require a significantly lower block error rate than other types of user devices/UEs as well as low latency (with or without requirement for simultaneous high reliability). Thus, for example, a URLLC UE (or URLLC application on a UE) may require much shorter latency, as compared to a eMBB UE (or an eMBB application running on a UE).

[0023] The various example implementations may be applied to a wide variety of wireless technologies or wireless networks, such as LTE, LTE-A, 5G, cmWave, and/or mmWave band networks, IoT, MTC, eMTC, eMBB, URLLC, etc., or any other wireless network or wireless technology. These example networks, technologies or data service types are provided only as illustrative examples.

[0024] Cellular systems, such as LTE and 5G new radio (NR), defines several physical channels to separate different information types. Generally, the channels are categorized as data and control channels. The control channels may be utilized for link establishment, sending a scheduling request (SR), reporting the HARQ (Hybrid Automatic Repeat ReQuest) feedback (ACK/NACK feedback), and performing link adaptation for example. With grant-based UL transmission, a user device (or user equipment (UE)) in RRC (radio resource control) connected state may send a scheduling request (SR) in order to obtain uplink resources to allow the UE to transmit uplink (UL) data to the BS or gNB. For example, in response to a scheduling request (SR), a BS (e.g., eNB/gNB) may send an uplink resource grant to the UE that allocates (and identifies) time-frequency resources to the UE for the uplink transmission of data from the UE to the BS.

[0025] However, some problems may arise with respect to scheduling requests (SRs). First, different service types may have different service requirements or communication requirements. For example, a URLLC application/UE may have much shorter tolerable latency, as compared to an eMBB application or UE, for example. Or, there may be different communication requirements (e.g., different tolerable latencies) for different URLLC applications or UEs. Second, if a UE sends a first (or initial) SR, but does not receive an UL resource grant, the UE may send a subsequent or a second (or retransmitted) SR to the BS. However, the further delay caused by sending the initial or first SR, and waiting to send the

second SR, may create further delay that may reduce the available or remaining latency budget, for example, for such UE or application. There presently is no specified way for a UE to send a SR and indicate different communication (or QoS) requirement, and/or indicate whether a SR is a first (or initial) SR or a second (or retransmitted) SR. Multi-bit SR has been discussed in 3GPP for carrying such information, but the concept was not agreed in 3GPP. Thus, according to the latest specification, the BS presently has no way to be notified of different communication (or Quality of Service (QoS)) requirements of a UE that is transmitting a SR, and/or whether a SR is an initial SR or a retransmitted or subsequent SR (e.g., where a retransmitted or subsequent SR may have a stricter QoS or communication requirement due to time that has elapsed from the first SR transmission). Thus, BS is presently unable to allocate or schedule uplink resources differently for various SRs, due to a lack of information provided to the BS.

[0026] 5G NR employs physical uplink control channel (PUCCH) to carry different control information, such as SR (scheduling request), HARQ (Hybrid ARQ) feedback, and CQI (Channel quality information) report. Each user equipment (UE) is assigned with dedicated resources for PUCCH transmission. The PUCCH resource assignments for SR transmission may be periodical, for example with the configurable periodicity of 2, 7, and $n \cdot 14$ symbols with normal CP (cyclic prefix), where $n \in \{1, 2, 5, 10, 20, 32, 40, 64, 80\}$. In some cases, a UE can be configured with two sets of PUCCH resources, one for URLLC traffic and one for non-URLLC traffic.

[0027] Different UEs can be multiplexed orthogonally over the same PUCCH resource block (RB) region using different phase rotation (or phase rotated) sequences. Thus, for example, a plurality of orthogonal sequences may include phase-rotated sequences that are based on different phase rotations or cyclic shifts of a base (or root) sequence. For example, the base (or root) sequence may be a base (or root) Zadoff-Chu (ZC) sequence. ZC sequences have zero auto correlation property. This means that a plurality of orthogonal sequences may be obtained or generated from different cyclic shifts or phase rotations of a root/base ZC sequence. Thus, different orthogonal sequences may be transmitted by different UEs, e.g., to send a scheduling request (SR) to a BS. For example, a UE may transmit a SR by transmitting a sequence (assigned or allocated to the UE for SR) to a BS. For example, the UE may be allocated a sequence and/or resource block region for transmitting a scheduling request (e.g., for transmitting the phase-rotated sequence assigned to the UE). For example, a resource block region may be a region of one or more resource blocks, where each resource block may include one or more time-frequency resources.

[0028] According to an example embodiment, a UE can be configured to be able to transmit a SR at different periodicities or intervals because the UE can only transmit the SR (phase rotation sequence) only when BS has allocated time-frequency resources for the UE to transmit its SR. The BS may, for example, configure the UE to transmit a SR once per TTI (transmission time interval or subframe), or once every 2 TTIs, or every 7 TTIs, or once every 14 TTIs, or other periodicity. Shorter periodicity requires the BS to allocate more resources for SR transmission (e.g., a URLLC UE or application may be allocated more frequent SR transmission opportunities, e.g., every 2 TTIs).

[0029] However, a problem may arise where a SR may not be received by the BS, and thus, the UE may need to retransmit a SR to the BS. Thus, in such a case, retransmitting the SR causes further delay for the UE (thus, consuming or using a portion of a latency budget for the UE). But a URLLC UE, for example, may typically have strict latency requirements (e.g., 0.5 ms, as an example, between receipt of downlink (DL) data from BS until the BS receives its transmitted UL data). Initially, a URLLC UE may have a latency budget of 0.5 ms (e.g., its UL data should be received by BS within 0.5ms of when UE received DL data), for example, and the UE needs to send a SR first to obtain UL resources for UL data transmission. As noted above, a UE may send a SR by transmitting a sequence (e.g., a phase-rotated or cyclically shifted ZC sequence assigned to the UE for SR) to the BS. 5G NR (New Radio) may have different TTI values. A slot may be 14 symbols, and a mini-slot may be 1-13 symbols, for example. A delay may occur of maybe 1 slot or 1 mini-slot duration (or more) after receiving a SR, before transmitting the UL resource grant to the UE. Thus, for example, depending on how the BS schedules or allocates SR resources, the UE may have to wait until a next/subsequent slot or mini-slot to receive an UL grant. Of course, if no UL grant is received, then the UE may retransmit a SR. However, the latency budget (amount of time remaining for which the UE must deliver UL data to the BS) will then be less (e.g., now only 0.2 ms or 0.25 ms remaining of the original 0.5 ms latency budget), due to time elapsed during initial SR transmission and waiting to retransmit SR. Mini-slot based operation is also known as non-slot based operation.

[0030] For URLLC, the configuration of the number of transmission opportunities (to Transmit a SR) may depend on different parameters, e.g., such as end-to-end latency requirements, transmission time interval (TTI), the queuing delay, delay of sending the SR and receiving allocated resource information. For instance, considering an example 0.5 ms latency target and TTI of 0.125 ms, the UE can be configured with the maximum of two transmission attempts if the SR is decoded successfully in the first attempt. However, the UE

may be scheduled with the maximum of one transmission attempt if the SR is missed (not received by the BS) in the first attempt and the retransmitted SR is detected.

[0031] Currently, a BS (e.g., eNB/gNB) does not know (is unable to determine) if the detected SR is from the initial attempt or the retransmission. It also does not know the delay between the arrival of the data and sending the SR. Hence, it cannot estimate the number of feasible transmission rounds which can meet the latency and reliability targets. The SR in LTE and current 5G NR does not carry any information regarding the communication requirements other than in 5G NR different configurations can be used for low latency services and other services. However, additional information could help to improve URLLC performance, or performance of other UEs, applications or services that may have strict communication requirements. For instance, the UE should be scheduled with shorter delay and higher reliability if the previous SR was missed, or the UE has suffered from a large queuing delay. The lack of such QoS information in the SR may lead to performance degradation for scheduling and also reducing the capability of supporting URLLC in general.

[0032] Thus, BSs (or eNB/gNB) are presently unable differentiate between different communication (or QoS) requirements (e.g., maximum latency, reliability target, message size). Similarly, BSs are also unable to differentiate between an initial or first SR transmission (e.g., where a first communication or QoS requirement may apply) and a second or retransmitted SR (e.g., where a different communication or QoS requirement may apply). As a result, the BS is unable to adapt or adjust its scheduling or allocation of UL resources in response to receiving a SR, under these various conditions.

[0033] To enable adaptation for transmission opportunities, according to an example embodiment, the SR may be adjusted to include additional information (additional bits) regarding the communication requirement with a multi-bit approach, for instance. However, this approach might degrade the performance of SR detection due to including additional bits, thus increasing control overhead and thereby decreasing transmission efficiency. Also, this requires a new design for SR to include additional bits.

[0034] To address this problem, according to an example embodiment, a set of (e.g., multiple) SR resources may be allocated to a UE, wherein each SR resource is associated with a different communication (e.g., QoS) requirement (e.g., a different maximum latency or latency target, a different reliability target, a different message size or a different data throughput target, or any combination, etc.). For example, a plurality of SR resources, such as a plurality of combinations of a sequence (e.g., phase-rotated or phase-rotation sequence) and/or a resource block region, may be assigned to a UE for transmitting a SR, where each

SR resource or each combination of sequence and/or resource block region may be associated with a different communication (e.g., QoS) requirement or target. For example, a sequence for different resource block regions (each different block region indicating a different communication requirement), or multiple (different) phase-rotated sequences (e.g., each different sequence indicating a different communication requirement) for the same resource block region, or a combination thereof, may be allocated to a UE for SR transmission(s) to indicate a different communication (or QoS) requirement of the UE. Furthermore, in another example embodiment, each SR resource (e.g., each sequence and/or resource block region) may be associated with a different set of a plurality of communication requirements (e.g., latency, throughput, message size, ..., or other communication or QoS requirements). Thus, in that situation, as an example, a first sequence may be associated with a first latency requirement, a first throughput or data rate requirement, and a first message size (as examples of a set of communication requirements associated with the first sequence), and a second sequence may be associated with a second latency requirement, a second throughput or data rate requirement, and a second message size (as examples of a set of communication requirements associated with the second sequence).

[0035] In this manner, depending on the situation at the UE (e.g., depending on the communication (or QoS) requirement (such as latency budget or latency target or other communication requirement for the UE), and/or whether a SR is an initial SR transmission or a SR retransmission, ...), a UE may select one of a plurality of SR resources (e.g., select a different sequence and/or resource block region) associated with communication requirement of the UE, and then transmit the SR via the selected SR resource to indicate the communication (or QoS) requirement of the UE for the requested UL resources. For example, a plurality of different sequences may be assigned to a UE for SR transmission, where each sequence may be associated with (and may indicate, when transmitted) different communication (or QoS) requirement of the UE. Thus, in such an illustrative example, the UE may transmit the sequence associated with the selected communication (or QoS) requirement of the UE, in order to communicate such communication (or QoS) requirement of the UE within or as part of the SR transmission, e.g., without requiring the transmission of any additional bits. In this manner, the BS may receive the SR (e.g., the sequence, and/or via a resource block region), and may determine the indicated communication (or QoS) requirement information (e.g., a latency budget) for the UE based on the SR resource (e.g., based on the received sequence, and/or the resource block region used to transmit the SR or

sequence), and may schedule or allocate UL resources to the UE accordingly (or based on the indicated communication/QoS requirement).

[0036] According to an example embodiment, a resource block (RB) region may include one or more resource blocks (RBs), where each RB may include a plurality of time-frequency resources. A RB region may be configured to a UE via, e.g., a RRC (radio resource control) message or other downlink (DL) control message sent to the UE. The resource block region can be one resource block or multiple resource blocks. A RB region may be assigned to one UE only (for example in case the resource block region is used to indicate a UE identifier (or UE ID)), or a RB region may be shared by a group of UEs (in this case the UE can be identified by sequence or the combination of sequence and resource block region). In case there are multiple RBs and only one RB is sufficient to transmit a SR, then a UE may select a RB (one of the RBs) within the RB region that has been assigned to the UE to transmit the SR or sequence. Thus, for example, multiple sequences (e.g., each sequence associated with a different communication requirement for the UE) may be assigned to the UE, and/or different RB regions (or different RBs) may be assigned to the UE (e.g., with each RB region associated with a different communication requirement of the UE), or a combination thereof may be assigned to the UE to allow the UE to send a SR via the SR resource in order to identify the UE and also indicate an associated communication requirement.

[0037] According to an example embodiment, a BS may adjust or adapt the allocation or assignment of UL resources based on the indicated communication (or QoS) requirement associated with the received SR (e.g., based on the received sequence and/or resource block region used to transmit the SR or sequence). For instance, the UE may be scheduled with shorter TTI and/or higher reliability if the previous SR was missed, or if the UE has suffered from a large queuing delay, or if the UE or transmitting application has a high priority QoS or strict communication requirement. According to an example embodiment, some further techniques that a BS may adjust or change its UL resource allocation or assignment to a UE for different indicated communication (or QoS) requirements may include (by way of illustrative examples):

[0038] 1) the BS may schedule the UE resources with a shorter TTI for a higher priority QoS (e.g., shorter latency target), for a second or retransmitted SR (or where an initial SR from the UE was not received or the first UL resource allocation is not received at UE side or with decode failure); and the BS may use a longer TTI to schedule resources to the UE for a lower priority QoS (e.g., for a longer latency target) and/or for an initial or the first

SR. For example, BS may determine or allocate UL resources to the UE based on slot scheduling (e.g., UL resource grant indicates UL resources for the UE have been scheduled during a next slot) for a lower priority QoS (e.g., with longer latency budget) or for an initial SR transmission, while the BS may determine or allocate UL resources for the UE based on mini-slot (also known as non-slot based operation) scheduling (e.g., UL grant indicates UL resources allocated to UE during a next mini-slot, providing quicker resource scheduling to UE) for the higher priority QoS or shorter latency target or for a second or retransmitted SR, for example.

[0039] 2) The BS may adjust the time-frequency resources allocated to the UE, depending on the communication (e.g., QoS) requirement indicated by or associated with the received SR (e.g., associated with the received sequence, and/or the resource block region used by the UE to transmit the SR or sequence). Thus, for example, the BS may allocate or schedule to the UE more time resources and fewer frequency resources (or fewer subcarriers) for a lower priority QoS (e.g., for a longer latency target) and/or for an initial or first SR. On the other hand, the BS may allocate or schedule the UE with fewer time resources across but more frequency resources (e.g., across more subcarriers) for a higher priority QoS (e.g., shorter latency target), for a second or retransmitted SR (or where an initial SR from the UE was not received or the first UL resource allocation is not received at UE side or with decode failure), e.g., in order to decrease the transmission time for the UE to transmit its data. Or, similarly, the BS may allocate a larger number of time resources (e.g., symbols) for transmission of a longer message for a lower priority QoS (such as where SR indicates that data throughput is important, and a higher latency is acceptable), and may schedule a shorter burst (over fewer symbols) of resources for a higher priority QoS or shorter latency communication requirement (e.g., where a short latency budget is indicated by or associated with the received SR or received sequence.). These are just a few examples, and the BS may use other techniques to adjust its scheduling or allocation of UL resources to a UE, depending on the communication (e.g., QoS) requirement indicated or associated with the received SR.

[0040] 3) The BS may adjust or configure other communication parameters or communication configuration for the UE (e.g., for the UL resource grant and/or UL transmission parameters), depending on the communication (e.g., QoS) requirement indicated by or associated with the received SR (e.g., associated with the received sequence, and/or the resource block region used by the UE to transmit the SR or sequence). For example, in some cases (e.g., for some communication or QoS requirements), link adaption

may be performed to improve reliability for subsequent UE UL data transmission, e.g., for a higher priority QoS or communication requirement. Also for example, different MCS (modulation and coding scheme) and/or UE transmission power for the subsequent UL data transmission may be adjusted for different communication (or QoS) requirements. A higher MCS and a lower transmission power may be configured in response to an initial SR transmission and/or in response to a low QoS priority or high latency target. However, for a retransmitted SR, or for a UE transmitting a SR associated with a more demanding communication requirement or higher QoS requirement, the BS may control or instruct the UE to use a more robust (or lower) MCS and/or to use a higher UE transmission power to transmit the data, for example. These adjustments may be performed independently or jointly.

[0041] Thus, according to an example embodiment, a UE (or user device) may perform a method including determining, by a user device, a set of scheduling request resources allocated to the user device for transmitting a scheduling request, with each scheduling request resource of the set of scheduling request resources including a sequence, of a plurality of sequences, and/or a resource block region, wherein each scheduling request resource is associated with a different communication requirement; determining a communication requirement for an uplink data transmission; transmitting, by the user device to a base station, a scheduling request via a scheduling request resource that is associated with the determined communication requirement in order to request uplink resources and indicate the associated communication requirement; and receiving, by the user device from the base station, an uplink resource grant that indicates resources allocated to the user device for uplink transmission and possible updated transmission parameters (e.g., where such transmission parameters for the UE may be set or adjusted by the BS based on the communication (or QoS) requirement associated with the SR resource (e.g., sequence and/or RB region) used by the UE to transmit the SR).

[0042] Thus, according to an example embodiment, a BS may perform a method including determining, by a base station, a set of scheduling request resources allocated to a user device for transmitting a scheduling request, with each scheduling request resource of the set of scheduling request resources including a sequence, of a plurality of sequences, and/or a resource block region, wherein each scheduling request resource is associated with a different communication requirement; receiving, by the base station from the user device, a scheduling request via a scheduling request resource associated with a communication requirement; determining, based on the received scheduling request, a communication

requirement for the user device; determining, based on the determined communication requirement for the user device, resources to be allocated to the user device and possible transmission parameters; and transmitting, by the base station to the user device, an uplink resource grant that indicates the resources allocated to the user device for uplink transmission.

[0043] Therefore, according to an example embodiment, some example techniques may include:

[0044] 1) A BS/gNB configuring a set of SR resources for a UE/user device, which may include a set of phase rotation (or phase-rotated) sequences and/or RB regions for the UE for SR transmission and/or different sequences, where each SR resource of the set of SR resources may be associated with (and may be used to identify) different UE communication (or QoS) requirement. These configured set of SR resources may be communicated to the UE.

[0045] 2) A set of communication requirements (or QoS requirements) may be defined (e.g., in advance, by the network, and/or by the BS), and each communication requirement (or QoS requirement) may be mapped to or associated (e.g., via a mapping table) with a SR resource (e.g., associated with a sequence, and/or a resource block region for transmission of a SR, and/or mapped to a combination of sequence and RB region).

[0046] 3) The BS (or eNB/gNB) may communicate this configuration or assignment of a set of SR resources to the UE (which may include or may indicate the communication requirement/QoS requirement for each SR resource). This may be indicated or communicated by the BS to a UE via a QoS table that indicates a SR resource (e.g., a sequence and/or RB region) for each of one or more communication (or QoS) requirements (e.g., indicating a sequence index for each of a plurality of latency requirements). The mapping table between QoS requirements and the SR resources can be pre-configured or dynamically informed by the BS or other network nodes.

[0047] 4) The UE may determine a communication requirement for its UL data transmission (e.g., maximum latency, or packet size or other communication requirement), and then select the associated SR resource (e.g., select the associated sequence associated with the determined communication requirement /QoS requirement).

[0048] 5) The UE may then transmit a SR to the BS based on or via the associated SR resource (e.g., by transmitting the associated sequence and/or transmit a SR or sequence via an associated RB region)

[0049] 6) The BS may receive the SR and determine the associated

communication (or QoS) requirement of the UE based on the associated (and received SR), e.g., based on the received sequence and/or based on the RB region used to transmit the SR and/or sequence.

[0050] 7) The BS may allocate UL resources based on the indicated communication (or QoS) requirement for the UE (associated with the SR resource used to transmit the received SR).

[0051] 8) The BS may then transmit the UL resource grant to the UE, identifying the UL resources allocated to the UE for UL transmission.

[0052] 9) The UE may then transmit data to the BS via the allocated UL resources.

[0053] Some example technical advantages of this approach may include, for example: allowing a UE to request resources for UL transmission, while indicating a communication (or QoS) requirement of the UE, without requiring additional overhead or bits, and allowing the BS to adjust or change its allocation of UL resources to a UE based on the communication (or QoS) requirement indicated by (or associated with) a received SR. This may allow a BS to vary or adjust (one or more aspects of) its resource allocation and/or UL transmission parameters including for example UL transmission power, modulation/coding schemes (MCS), etc., based on the particular requirements and/or needs of each UE or application that is requesting UL resources, without increasing overhead.

Table 1. An example of QoS set and assigned SR sequences.

QoS index	Latency target (ms)	Sequences
Q1	>0.25	S1
Q2	<0.25 and >.125	S2
Q3	<0.125	S1, S2 (or S3)

[0054] Table 1 is an example of a QoS set (set of QoS requirements) and assigned or associated SR sequences. Thus, as shown in Table 1, in order to support (and communicate) different communication requirements, a Quality of Service (QoS) set is defined for the UE. The set can be formed according to different parameters, such as latency, reliability, or service type, message size, or other communication requirement(s). In this example, a QoS set is shown with different latency targets. Each QoS index corresponds to a specific latency target for delivering the message.

[0055] In the illustrative example shown in Table 1, a different sequence (e.g., sequences S1, S2 and S3) may be transmitted by a UE, and may be used to indicate a

different communication (or QoS) requirement, such as a latency requirement or latency target. Thus, in Table 1, each QoS index identifies an associated latency target. In this example, only three sequences are shown, but any number of sequences may be used or assigned to a UE. As shown, for example, a UE may transmit one (or more) of the sequences in order to communicate or indicate to the BS a specific QoS index, and thus, indicating to the BS an associated latency requirement.

[0056] As shown in Table 1, according to an illustrative example embodiment, QoS index Q1 is associated with (or indicates) a latency target of > 0.25 ms. QoS index Q2 is associated with a latency target of less than or equal to 0.25ms, and longer than or equal to 0.125 ms; and QoS index Q3 is associated with a latency target of shorter than 0.125 ms. Also, as shown in Table 1, a UE may transmit sequence S1 to indicate a QoS index of Q1 (and thus indicate a latency target of longer than or equal to 0.25 ms); a UE may transmit sequence S2 to indicate a QoS index of Q2 (and thus indicate a latency target of between 0.125ms and 0.25ms); and a UE may transmit sequence S3 to indicate a QoS index of Q3 (and thus indicate a latency target of shorter than or equal to 0.125 ms). For example, an initial SR may be transmitted by transmitting sequence S1 when the UE has an initial latency budget of 0.5 ms, but after not receiving an UL resource grant, the UE may retransmit the SR by transmitting sequence S2 (e.g., based on a decreased latency budget of 0.2 ms).

[0057] Alternatively, e.g., if only two sequences are assigned to the UE, sequences S1 and S2 may both be transmitted by the UE (e.g., via consecutive SR opportunities or resources or even on the same resource) to indicate to BS the Q3 QoS index. Also, the UE transmitting both of sequences S1 and S2 (to indicate a request for UL resources, and indicate a QoS index Q3) may also increase a probability of at least one of these sequences being received by the BS. These are merely some examples, and other examples or parameters or values may be used.

[0058] FIG. 2 is a diagram illustrating operation of a system according to an example embodiment. In an example embodiment, a UE 210 is connected with and in communication with BS 134. At 212, UE 210 sends a scheduling request (SR) to BS 134 by transmitting sequence S1 (e.g., see Table 1). In this example, the latency budget may be 0.6 ms for UE 210. At 214, the SR at 212 is not received by BS 134. At 216, UE 210 retransmits its SR to BS 134 by transmitting sequence S2, e.g., based on a decreased latency budget of 0.2ms for the UE 210. Thus, the delay caused by transmitting SR 212, and waiting, has consumed or used up 0.4 ms of the 0.6 ms latency budget for the MS. BS 134 receives the sequence S2 (where sequence S2 was previously assigned to UE 210 to indicate a latency budget of

shorter than or equal to 0.25ms and longer than or equal to 0.125 ms, as shown in Table 1). Based on the mapping shown in Table 1, the BS 134 knows or determined the approximate latency budget (less than or equal to 0.25ms, but greater than or equal to 0.125 ms), the BS 134 allocated UL resources for the UE 210. Thus, because there is only 0.2 ms of latency budget available, the BS 134 may use mini-slot scheduling and may allocate more frequency resources and fewer symbols (less time resources) to speed up or shorten latency for scheduling and transmission of such UL data for the UE. BS 134 may have used different resource scheduling if the SR was transmitted as sequence S1 (which would have indicated a larger latency budget), for example, (e.g., slot-based scheduling may have been used). At 218, the BS transmits to the UE 210 an UL resource grant, which allocates or schedules UL resources to the UE 210. At 220, UE 210 transmits data to the BS 134 via the scheduled UL resources.

[0059] Thus, FIG. 2 illustrates the SR transmission adopting the setting listed in Table 1. The UE sends the initial S1 as the indication for a SR to the gNB. However, the SR (S1) (steps 212/214) is not detected by the BS 134. The UE 210 discovers that the initial SR was not received by the BS, as it does not receive an UL resource grant in response. In the second attempt to transmit a SR, the UE sends S2 as the SR indication. The BS/gNB 134 detects the retransmitted SR and allocates radio resources according to the latency budget, e.g., around 0.20 ms.

[0060] According to an example embodiment, this approach provides a better resource utilization for the URLLC services. In case with larger latency budget, the UE can be scheduled with a moderate BLER (e.g., 10%) for the initial SR transmission round, while a more stringent BLER target is selected for the retransmission of SR if needed. This results in achieving a high spectral efficiency. On the other hand, in case of smaller latency budget, the UE has to be scheduled to achieve a stringent BLER target even for the initial SR transmission round as the retransmission is not envisioned (or may not be viable).

[0061] In addition, the proposed scheme can achieve a better SR detection. In this example, the Q3 results in sending S1 and S2 simultaneously. (In this case, initial SR and second SR were missed, and a 2nd retransmission of SR, and so the UE transmits either S3, or transmits both S1 and S2, e.g., over different resource block regions.

[0062] The proposed enhanced SR can be also used to multiplex different services. For instance, one SR sequence can be assigned for URLLC with a moderate latency requirement, e.g., 1 ms, while the other can be assigned for URLLC with more stringent latency requirement, e.g., 0.5 ms. In case of receiving the former SR, the UE is scheduled

using 0.25ms TTI, and otherwise it is scheduled using short TTI. In MIMO systems, the SR sequences can be configured for each transmit antenna to support more QoS indexes. As another embodiment, different SR sequence can be assigned for URLLC with different packet size.

[0063] Some example embodiments are now described.

[0064] Example 1. FIG. 3 is a flow chart illustrating operation of a user device according to an example embodiment. Operation 310 includes determining, by a user device, a set of scheduling request resources allocated to the user device for transmitting a scheduling request, with each scheduling request resource of the set of scheduling request resources including a sequence, of a plurality of sequences, and/or a resource block region, wherein each scheduling request resource is associated with a different communication requirement. Operation 320 includes determining a communication requirement for an uplink data transmission. Operation 330 includes transmitting, by the user device to a base station, a scheduling request via a scheduling request resource that is associated with the determined communication requirement in order to request uplink resources and indicate the associated communication requirement. And, operation 340 includes receiving, by the user device from the base station, an uplink resource grant that indicates resources allocated to the user device for uplink transmission.

[0065] Example 2. According to an example embodiment of the method of example 1, wherein the transmitting a scheduling request via a scheduling request resource that is associated with the determined communication requirement comprises performing at least one of the following: transmitting, by the user device to the base station, a sequence, which is associated with the determined communication requirement, in order to request uplink resources and indicate the associated communication requirement; transmitting, by the user device to the base station, a scheduling request or sequence via a resource block region, wherein the resource block region is associated with the determined communication requirement, in order to request uplink resources and indicate the associated communication requirement; transmitting, by the user device to the base station, a sequence via a resource block region, wherein a combination of the sequence and the resource block region are associated with the determined communication requirement, in order to request uplink resources and indicate the associated communication requirement; and transmitting, by the user device to the base station, a combination of multiple sequences, wherein the combination of multiple sequences are associated with the determined communication requirement, in order to request uplink resources and indicate the associated communication

requirement.

[0066] Example 3. According to an example embodiment of the method of any of examples 1-2 wherein the determining a set of scheduling request resources comprises: receiving, by the user device from the base station, control information indicating a set of scheduling request resources allocated to the user device for transmitting a scheduling request, with each scheduling request resource of the set of scheduling request resources including an associated combination of a sequence, of a plurality of sequences, and a resource block region, wherein each combination of sequence and resource block region is associated with a different communication requirement.

[0067] Example 4. According to an example embodiment of the method of any of examples 1-3 and further comprising: transmitting, by the user device, data via the resources indicated by the received uplink resource grant.

[0068] Example 5. According to an example embodiment of the method of any of examples 1-4, wherein the set of scheduling request resources allocated to the user device for transmitting a scheduling request comprises at least one of: a plurality of sequences for a first resource block region, with each sequence of the plurality of sequences being associated with a different communication requirement; a first sequence for a plurality of resource block regions, wherein each resource block region is associated with a different communication requirement; and a plurality of any combination of a sequence and a resource block region, wherein each combination of sequence and resource block region is associated with a different communication requirement.

[0069] Example 6. According to an example embodiment of the method of any of examples 1-5, wherein the set of scheduling request resources allocated to the user device for transmitting a scheduling request comprises: a plurality of sequences for a first resource block region, wherein for the first resource block region, each of the plurality of sequences is associated with a different communication requirement.

[0070] Example 7. According to an example embodiment of the method of any of examples 1-6, wherein the different communication requirement comprises at least one of: a different latency target; and a different reliability target; a different message size; and a different user device or a different region or group of user devices.

[0071] Example 8. According to an example embodiment of the method of any of examples 1-7, wherein the transmitting comprises at least one of the following: transmitting, by the user device to a base station, a scheduling request via a first uplink control channel resource that includes a first sequence and a resource block region that are associated with a

first communication requirement, in order to request uplink resources and indicate the first communication requirement; and transmitting, by the user device to a base station, a scheduling request via a second uplink control channel resource that includes a second sequence and a resource block region that are associated with a second communication requirement, in order to request uplink resources and indicate the second communication requirement.

[0072] Example 9. According to an example embodiment of the method of any of examples 1-8 wherein the transmitting a scheduling request comprises: transmitting, by the user device to the base station, a first scheduling request via a first combination of sequence and resource block region that are associated with a first communication requirement in order to request uplink resources and indicate the associated first communication requirement; the method further comprising: determining that an uplink resource grant has not been received in reply to the first scheduling request; determining that a second communication requirement, that is different from the first communication requirement, is applicable for an uplink transmission from the user device based on the determining that the uplink resource grant has not been received; and transmitting, by the user device to the base station, a second scheduling request via the second combination of sequence and resource block region that are associated with the second communication requirement in order to request uplink time-frequency resources and indicate the associated second communication requirement; wherein the receiving an uplink resource grant comprises: receiving, by the user device from the base station, an uplink resource grant, in reply to the second scheduling request, that indicates time-frequency resources allocated to the user device for uplink transmission.

[0073] Example 10. According to an example embodiment of the method of any of examples 1-9 wherein the transmitting comprises: transmitting, by the user device to a base station, a first scheduling request via a first combination of sequence and resource block region that are associated with a first latency requirement; failing to receive an uplink resource grant within a time period after the transmitting the first scheduling request; and transmitting, by the user device to the base station subsequent to the transmitting the first scheduling request, a second scheduling request via a second combination of sequence and resource block region that are associated with a second latency requirement that is stricter or shorter than the first latency requirement.

[0074] Example 11 According to an example embodiment of the method of any of examples 1-10, wherein each sequence is based on at least one of the following: a cyclic shift

of a plurality of different cyclic shifts, that is applied to a base sequence; a cyclic shift that is applied to a base sequence of a plurality of different base sequences; and a cyclic shift of a plurality, of a plurality of different cyclic shifts, that is applied to a base sequence, and the cyclic-shifted sequence is spread with an orthogonal code.

[0075] Example 12. According to an example embodiment of the method of any of examples 1-11 wherein the transmitting comprises: transmitting, by the user device to a base station, a first scheduling request via a first combination of sequence and resource block region that are associated with a first latency requirement; failing to receive an uplink resource grant after the transmitting the first scheduling request; and transmitting, by the user device to the base station subsequent to the transmitting the first scheduling request, a second scheduling request via a second combination of sequence and resource block region that are associated with a second latency requirement that is stricter or shorter than the first latency requirement.

[0076] Example 13. According to an example embodiment of the method of any of examples 1-12, wherein the set of scheduling request resources allocated to the user device for transmitting a scheduling request comprises at least: a first scheduling request resource allocated to the user device for transmitting a first or initial scheduling request; and a second scheduling request resource allocated to the user device for transmitting a second or subsequent scheduling request; wherein each scheduling request resource includes a different sequence and/or resource block region, associated with a different communication requirement of the user device.

[0077] Example 14. According to an example embodiment of the method of any of examples 1-13, wherein the set of scheduling request resources allocated to the user device for transmitting a scheduling request comprises at least: a first scheduling request resource allocated to the user device to indicate a first communication requirement of the user device; and a second scheduling request resource allocated to the user device to indicate a second communication requirement of the user device; wherein each scheduling request resource includes a different sequence and/or resource block region, associated with a different communication requirement of the user device.

[0078] Example 15. An apparatus comprising means for performing a method of any of examples 1-14.

[0079] Example 16. A non-transitory computer-readable storage medium comprising instructions stored thereon that, when executed by at least one processor, are configured to cause a computing system to perform the method of any of examples 1-14.

[0080] Example 17. An apparatus comprising at least one processor and at least one memory including computer instructions, when executed by the at least one processor, cause the apparatus to perform a method of any of examples 1-14.

[0081] Example 18. An apparatus comprising at least one processor and at least one memory including computer instructions, when executed by the at least one processor, cause the apparatus to: determine, by a user device, a set of scheduling request resources allocated to the user device for transmitting a scheduling request, with each scheduling request resource of the set of scheduling request resources including a sequence, of a plurality of sequences, and/or a resource block region, wherein each scheduling request resource is associated with a different communication requirement; determine a communication requirement for an uplink data transmission; transmit, by the user device to a base station, a scheduling request via a scheduling request resource that is associated with the determined communication requirement in order to request uplink resources and indicate the associated communication requirement; and receive, by the user device from the base station, an uplink resource grant that indicates resources allocated to the user device for uplink transmission..

[0082] Example 19. FIG. 4 is a flow chart illustrating operation of a base station according to an example embodiment. Operation 410 includes determining, by a base station, a set of scheduling request resources allocated to a user device for transmitting a scheduling request, with each scheduling request resource of the set of scheduling request resources including a sequence, of a plurality of sequences, and/or a resource block region, wherein each scheduling request resource is associated with a different communication requirement. Operation 420 includes receiving, by the base station from the user device, a scheduling request via a scheduling request resource associated with a communication requirement. Operation 430 includes determining, based on the received scheduling request, a communication requirement for the user device. Operation 440 includes determining, based on the determined communication requirement for the user device, resources to be allocated to the user device. And, operation 450 includes transmitting, by the base station to the user device, an uplink resource grant that indicates the resources allocated to the user device for uplink transmission.

[0083] Example 20. The method of example 19 wherein the receiving a scheduling request comprises: receiving, by the base station from the user device, a sequence, which is associated with a communication requirement; receiving, by the base station from the user device, a scheduling request via a resource block region that is associated with a

communication requirement; receiving, by the base station from the user device, a sequence via a resource block region, wherein the sequence and the resource block region are associated with a communication requirement.

[0084] Example 21. The method of any of examples 19-20 and further comprising: transmitting, by the base station to the user device, control information indicating the set of scheduling request resources allocated to the user device for transmitting a scheduling request, with each scheduling request resource of the set of scheduling request resources including an associated combination of a sequence, of a plurality of sequences, and a resource block region, wherein each combination of sequence and resource block region is associated with a different communication requirement.

[0085] Example 22. The method of any of examples 19-21 and further comprising: receiving, by the base station from the user device, data via the uplink resources indicated by the uplink resource grant.

[0086] Example 23. The method of any of examples 19-22, wherein the set of scheduling request resources allocated to the user device for transmitting a scheduling request comprises at least one of: a plurality of sequences for a first resource block region, with each sequence of the plurality of sequences is associated with a different communication requirement; a first sequence for a plurality of resource block regions, wherein each resource block region is associated with a different communication requirement; and a plurality of any combination of a sequence and a resource block region, wherein each combination of sequence and resource block region is associated with a different communication requirement.

[0087] Example 24. The method of any of examples 19-23, wherein the set of scheduling request resources allocated to the user device for transmitting a scheduling request comprises: a plurality of sequences, wherein each of the plurality of sequences is associated with a different communication requirement.

[0088] Example 25. The method of any of examples 19-24, wherein the different communication requirement comprises at least one of: a different latency target; and a different reliability target; and a different message size; and a different user device or a different region or group of user devices.

[0089] Example 26. The method of any of examples 19-25, wherein the communication requirement comprises a latency requirement, wherein the determining resources comprises at least one of: determining uplink resources to be allocated to the user device based on slot scheduling if the determined communication requirement is a first

latency requirement; and determining uplink resources to be allocated to the user device based on mini-slot scheduling if the determined communication requirement is a second latency requirement that is stricter or shorter than the first latency requirement.

[0090] Example 27. The method of any of examples 19-26, wherein the communication requirement comprises a latency requirement, wherein the determining resources comprises at least one of: determining uplink resources, including resources over a set of resource blocks that is greater than a threshold, to be allocated to the user device if the determined communication requirement is a first latency requirement; and determining resources, including resources over a set of resource blocks that is less than the threshold, to be allocated to the user device if the determined communication requirement is a second latency requirement that is stricter or shorter than the first latency requirement.

[0091] Example 28. An apparatus comprising means for performing a method of any of examples 19-27.

[0092] Example 29. A non-transitory computer-readable storage medium comprising instructions stored thereon that, when executed by at least one processor, are configured to cause a computing system to perform the method of any of examples 19-27.

[0093] Example 30. An apparatus comprising at least one processor and at least one memory including computer instructions, when executed by the at least one processor, cause the apparatus to perform a method of any of examples 19-27.

[0094] Example 31. An apparatus comprising at least one processor and at least one memory including computer instructions, when executed by the at least one processor, cause the apparatus to: determine, by a base station, a set of scheduling request resources allocated to a user device for transmitting a scheduling request, with each scheduling request resource of the set of scheduling request resources including a sequence, of a plurality of sequences, and/or a resource block region, wherein each scheduling request resource is associated with a different communication requirement; receive, by the base station from the user device, a scheduling request via a scheduling request resource associated with a communication requirement; determine, based on the received scheduling request, a communication requirement for the user device; determine, based on the determined communication requirement for the user device, resources to be allocated to the user device; and transmit, by the base station to the user device, an uplink resource grant that indicates the resources allocated to the user device for uplink transmission.

[0095] Example 32. The method of any of examples 1-14 and 19-27, wherein the sequence comprises a phase-rotated sequence that is based on a phase rotation or cyclic

shift of a base sequence.

[0096] Example 33. The method of any of examples 1-14 and 19-27, wherein each scheduling request resource of the set of scheduling request resources is associated with a different set of communication requirements.

[0097] Example 34. The method of any of examples 19-27, 32 and 33 further comprising: setting or configuring, by the base station, one or more updated transmission parameters for the user device (or UE) based on the determined communication (or QoS) requirement; and transmitting, by the base station to the user device, the one or more updated transmission parameters.

[0098] 35. The method of any of examples 1-14, 19-27, and 32-34, wherein the communication requirement is indicated based on at least one of the following: each different sequence indicates or is associated with a different communication requirement for the user device; each different resource block region indicates or is associated with a different communication requirement for the UE; each different combination of sequence and resource block region indicates or is associated with a different communication requirement for the user device; and each different combination of multiple sequences indicates or is associated with a different communication requirement for the user device.

[0099] Example 36. The method of any of examples 1-14, and 32-35 further comprising: receiving, by the user device from the base station, one or more updated transmission parameters for the user device that were set by the base station based on the determined communication (or QoS) requirement that is associated with the scheduling request resource that was used to transmit the scheduling request; and transmitting, by the user device based on the one or more updated transmission parameters, data via the resources indicated by the received uplink resource grant.

[00100] FIG. 5 is a block diagram of a wireless station (e.g., AP or user device) 900 according to an example implementation. The wireless station 900 may include, for example, one or two RF (radio frequency) or wireless transceivers 902A, 902B, where each wireless transceiver includes a transmitter to transmit signals and a receiver to receive signals. The wireless station also includes a processor or control unit/entity (controller) 904 to execute instructions or software and control transmission and receptions of signals, and a memory 906 to store data and/or instructions.

[00101] Processor 904 may also make decisions or determinations, generate frames, packets or messages for transmission, decode received frames or messages for further processing, and other tasks or functions described herein. Processor 904, which may be a

baseband processor, for example, may generate messages, packets, frames or other signals for transmission via wireless transceiver 902 (902A or 902B). Processor 904 may control transmission of signals or messages over a wireless network, and may control the reception of signals or messages, etc., via a wireless network (e.g., after being down-converted by wireless transceiver 902, for example). Processor 904 may be programmable and capable of executing software or other instructions stored in memory or on other computer media to perform the various tasks and functions described above, such as one or more of the tasks or methods described above. Processor 904 may be (or may include), for example, hardware, programmable logic, a programmable processor that executes software or firmware, and/or any combination of these. Using other terminology, processor 904 and transceiver 902 together may be considered as a wireless transmitter/receiver system, for example.

[00102] In addition, referring to FIG. 5, a controller (or processor) 908 may execute software and instructions, and may provide overall control for the station 900, and may provide control for other systems not shown in FIG. 5, such as controlling input/output devices (e.g., display, keypad), and/or may execute software for one or more applications that may be provided on wireless station 900, such as, for example, an email program, audio/video applications, a word processor, a Voice over IP application, or other application or software.

[00103] In addition, a storage medium may be provided that includes stored instructions, which when executed by a controller or processor may result in the processor 904, or other controller or processor, performing one or more of the functions or tasks described above.

[00104] According to another example implementation, RF or wireless transceiver(s) 902A/902B may receive signals or data and/or transmit or send signals or data. Processor 904 (and possibly transceivers 902A/902B) may control the RF or wireless transceiver 902A or 902B to receive, send, broadcast or transmit signals or data.

[00105] The embodiments are not, however, restricted to the system that is given as an example, but a person skilled in the art may apply the solution to other communication systems. Another example of a suitable communications system is the 5G concept. It is assumed that network architecture in 5G will be quite similar to that of the LTE-advanced. 5G is likely to use multiple input – multiple output (MIMO) antennas, many more base stations or nodes than the LTE (a so-called small cell concept), including macro sites operating in co-operation with smaller stations and perhaps also employing a variety of radio technologies for better coverage and enhanced data rates.

[00106] It should be appreciated that future networks will most probably utilise network

functions virtualization (NFV) which is a network architecture concept that proposes virtualizing network node functions into “building blocks” or entities that may be operationally connected or linked together to provide services. A virtualized network function (VNF) may comprise one or more virtual machines running computer program codes using standard or general type servers instead of customized hardware. Cloud computing or data storage may also be utilized. In radio communications this may mean node operations may be carried out, at least partly, in a server, host or node operationally coupled to a remote radio head. It is also possible that node operations will be distributed among a plurality of servers, nodes or hosts. It should also be understood that the distribution of labour between core network operations and base station operations may differ from that of the LTE or even be non-existent.

[00107] Implementations of the various techniques described herein may be implemented in digital electronic circuitry, or in computer hardware, firmware, software, or in combinations of them. Implementations may implemented as a computer program product, i.e., a computer program tangibly embodied in an information carrier, e.g., in a machine-readable storage device or in a propagated signal, for execution by, or to control the operation of, a data processing apparatus, e.g., a programmable processor, a computer, or multiple computers. Implementations may also be provided on a computer readable medium or computer readable storage medium, which may be a non-transitory medium. Implementations of the various techniques may also include implementations provided via transitory signals or media, and/or programs and/or software implementations that are downloadable via the Internet or other network(s), either wired networks and/or wireless networks. In addition, implementations may be provided via machine type communications (MTC), and also via an Internet of Things (IOT).

[00108] The computer program may be in source code form, object code form, or in some intermediate form, and it may be stored in some sort of carrier, distribution medium, or computer readable medium, which may be any entity or device capable of carrying the program. Such carriers include a record medium, computer memory, read-only memory, photoelectrical and/or electrical carrier signal, telecommunications signal, and software distribution package, for example. Depending on the processing power needed, the computer program may be executed in a single electronic digital computer or it may be distributed amongst a number of computers.

[00109] Furthermore, implementations of the various techniques described herein may use a cyber-physical system (CPS) (a system of collaborating computational elements

controlling physical entities). CPS may enable the implementation and exploitation of massive amounts of interconnected ICT devices (sensors, actuators, processors microcontrollers,...) embedded in physical objects at different locations. Mobile cyber physical systems, in which the physical system in question has inherent mobility, are a subcategory of cyber-physical systems. Examples of mobile physical systems include mobile robotics and electronics transported by humans or animals. The rise in popularity of smartphones has increased interest in the area of mobile cyber-physical systems. Therefore, various implementations of techniques described herein may be provided via one or more of these technologies.

[00110] A computer program, such as the computer program(s) described above, can be written in any form of programming language, including compiled or interpreted languages, and can be deployed in any form, including as a stand-alone program or as a module, component, subroutine, or other unit or part of it suitable for use in a computing environment. A computer program can be deployed to be executed on one computer or on multiple computers at one site or distributed across multiple sites and interconnected by a communication network. Method steps may be performed by one or more programmable processors executing a computer program or computer program portions to perform functions by operating on input data and generating output. Method steps also may be performed by, and an apparatus may be implemented as, special purpose logic circuitry, e.g., an FPGA (field programmable gate array) or an ASIC (application-specific integrated circuit).

[00111] Processors suitable for the execution of a computer program include, by way of example, both general and special purpose microprocessors, and any one or more processors of any kind of digital computer, chip or chipset. Generally, a processor will receive instructions and data from a read-only memory or a random access memory or both. Elements of a computer may include at least one processor for executing instructions and one or more memory devices for storing instructions and data. Generally, a computer also may include, or be operatively coupled to receive data from or transfer data to, or both, one or more mass storage devices for storing data, e.g., magnetic, magneto-optical disks, or optical disks. Information carriers suitable for embodying computer program instructions and data include all forms of non-volatile memory, including by way of example semiconductor memory devices, e.g., EPROM, EEPROM, and flash memory devices; magnetic disks, e.g., internal hard disks or removable disks; magneto-optical disks; and CD-ROM and DVD-ROM disks. The processor and the memory may be supplemented by, or incorporated in, special purpose logic circuitry.

[00112] To provide for interaction with a user, implementations may be implemented on a computer having a display device, e.g., a cathode ray tube (CRT) or liquid crystal display (LCD) monitor, for displaying information to the user and a user interface, such as a keyboard and a pointing device, e.g., a mouse or a trackball, by which the user can provide input to the computer. Other kinds of devices can be used to provide for interaction with a user as well; for example, feedback provided to the user can be any form of sensory feedback, e.g., visual feedback, auditory feedback, or tactile feedback; and input from the user can be received in any form, including acoustic, speech, or tactile input.

[00113] Implementations may be implemented in a computing system that includes a back-end component, e.g., as a data server, or that includes a middleware component, e.g., an application server, or that includes a front-end component, e.g., a client computer having a graphical user interface or a Web browser through which a user can interact with an implementation, or any combination of such back-end, middleware, or front-end components. Components may be interconnected by any form or medium of digital data communication, e.g., a communication network. Examples of communication networks include a local area network (LAN) and a wide area network (WAN), e.g., the Internet.

[00114] While certain features of the described implementations have been illustrated as described herein, many modifications, substitutions, changes and equivalents will now occur to those skilled in the art. It is, therefore, to be understood that the appended claims are intended to cover all such modifications and changes as fall within the true spirit of the various embodiments.

[00115] 5G: 5th generation mobile networks

[00116] BLER: Block error rate

[00117] CQI: Channel quality indicator

[00118] LTE: Long-term evolution

[00119] MCS: Modulation and coding scheme

[00120] MLD: Maximum Likelihood Detector

[00121] OLLA: Outer loop link adaptation

[00122] PDCCH: Physical downlink control channel

[00123] PUCCH: Physical uplink control channel

[00124] PDU: Protocol data unit

[00125] RLC: Radio link control

[00126] SR: Scheduling request

[00127] UE: User equipment

[00128] URLLC: Ultra-reliable low-latency communications

WHAT IS CLAIMED IS:

1. A method comprising:

determining, by a user device, a set of scheduling request resources allocated to the user device for transmitting a scheduling request, with each scheduling request resource of the set of scheduling request resources including a sequence, of a plurality of sequences, and/or a resource block region, wherein each scheduling request resource is associated with a different communication requirement;

determining a communication requirement for an uplink data transmission;

transmitting, by the user device to a base station, a scheduling request via a scheduling request resource that is associated with the determined communication requirement in order to request uplink resources and indicate the associated communication requirement; and

receiving, by the user device from the base station, an uplink resource grant that indicates resources allocated to the user device for uplink transmission.

2. The method of claim 1 wherein the transmitting a scheduling request via a scheduling request resource that is associated with the determined communication requirement comprises performing at least one of the following:

transmitting, by the user device to the base station, a sequence, which is associated with the determined communication requirement, in order to request uplink resources and indicate the associated communication requirement;

transmitting, by the user device to the base station, a scheduling request or sequence via a resource block region, wherein the resource block region is associated with the determined communication requirement, in order to request uplink resources and indicate the associated communication requirement;

transmitting, by the user device to the base station, a sequence via a resource block region, wherein a combination of the sequence and the resource block region are associated with the determined communication requirement, in order to request uplink resources and indicate the associated communication requirement; and

transmitting, by the user device to the base station, a combination of multiple sequences, wherein the combination of multiple sequences are associated with the determined communication requirement, in order to request uplink resources and indicate the associated communication requirement.

3. The method of any of claims 1-2 wherein the determining a set of scheduling request resources comprises:

receiving, by the user device from the base station, control information indicating a set of scheduling request resources allocated to the user device for transmitting a scheduling request, with each scheduling request resource of the set of scheduling request resources including an associated combination of a sequence, of a plurality of sequences, and a resource block region, wherein each combination of sequence and/or resource block region is associated with different communication requirement.

4. The method of any of claims 1-3 and further comprising:

transmitting, by the user device, data via the resources indicated by the received uplink resource grant.

5. The method of any of claims 1-4, wherein the set of scheduling request resources allocated to the user device for transmitting a scheduling request comprises at least one of:

a plurality of sequences for a first resource block region, with each sequence of the plurality of sequences being associated with a different communication requirement;

a first sequence for a plurality of resource block regions, wherein each resource block region is associated with a different communication requirement; and

a plurality of any combination of a sequence and a resource block region, wherein each combination of sequence and resource block region is associated with a different communication requirement.

6. The method of any of claims 1-5, wherein the set of scheduling request resources allocated to the user device for transmitting a scheduling request comprises:

a plurality of sequences for a first resource block region, wherein for the first resource block region, each of the plurality of sequences is associated with a different communication requirement.

7. The method of any of claims 1-6, wherein the different communication requirement comprises at least one of:

a different latency target; and

a different reliability target; and

a different message size; and
a different survival time; and
a different user device or a different region or group of user devices.

8. The method of any of claims 1-7, wherein the transmitting comprises at least one of the following:

transmitting, by the user device to a base station, a scheduling request via a first uplink control channel resource that includes a first sequence and/or a resource block region that are associated with a first communication requirement, in order to request uplink resources and indicate the first communication requirement; and

transmitting, by the user device to a base station, a scheduling request via a second uplink control channel resource that includes a second sequence and/or a resource block region that are associated with a second communication requirement, in order to request uplink resources and indicate the second communication requirement.

9. The method of any of claims 1-8 wherein the transmitting a scheduling request comprises:

transmitting, by the user device to the base station, a first scheduling request via a first combination of sequence and resource block region that are associated with a first communication requirement in order to request uplink resources and indicate the associated first communication requirement;

the method further comprising:

determining that an uplink resource grant has not been received in reply to the first scheduling request;

determining that a second communication requirement, that is different from the first communication requirement, is applicable for an uplink transmission from the user device based on the determining that the uplink resource grant has not been received; and

transmitting, by the user device to the base station, a second scheduling request via the second combination of sequence and resource block region that are associated with the second communication requirement in order to request uplink time-frequency resources and indicate the associated second communication requirement;

wherein the receiving an uplink resource grant comprises:

receiving, by the user device from the base station, an uplink resource grant, in reply to the second scheduling request, that indicates time-frequency resources allocated to the user device for uplink transmission.

10. The method of any of claims 1-9 wherein the transmitting comprises:

transmitting, by the user device to a base station, a first scheduling request via a first combination of sequence and resource block region that are associated with a first latency requirement;

failing to receive an uplink resource grant within a time period after the transmitting the first scheduling request; and

transmitting, by the user device to the base station subsequent to the transmitting the first scheduling request, a second scheduling request via a second combination of sequence and resource block region that are associated with a second latency requirement that is stricter or shorter than the first latency requirement.

11. The method of any of claims 1-10, wherein each sequence is based on at least one of the following:

a cyclic shift of a plurality of different cyclic shifts, that is applied to a base sequence;

a cyclic shift that is applied to a base sequence of a plurality of different base sequences; and

a cyclic shift of a plurality of different cyclic shifts, that is applied to a base sequence, and the cyclic-shifted sequence is spread with an orthogonal code.

12. The method of any of claims 1-11 wherein the transmitting comprises:

transmitting, by the user device to a base station, a first scheduling request via a first combination of sequence and resource block region that are associated with a first latency requirement;

failing to receive or decode an uplink resource grant after the transmitting the first scheduling request; and

transmitting, by the user device to the base station subsequent to the transmitting the first scheduling request, a second scheduling request via a second combination of sequence and resource block region that are associated with a second latency requirement that is stricter or shorter than the first latency requirement.

13. The method of any of claims 1-12, wherein the set of scheduling request resources allocated to the user device for transmitting a scheduling request comprises at least:

a first scheduling request resource allocated to the user device for transmitting a first or initial scheduling request; and

a second scheduling request resource allocated to the user device for transmitting a second or subsequent scheduling request;

wherein each scheduling request resource includes a different sequence and/or resource block region, associated with a different communication requirement of the user device.

14. The method of any of claims 1-13, wherein the set of scheduling request resources allocated to the user device for transmitting a scheduling request comprises at least:

a first scheduling request resource allocated to the user device to indicate a first communication requirement of the user device; and

a second scheduling request resource allocated to the user device to indicate a second communication requirement of the user device;

wherein each scheduling request resource includes a different sequence and/or resource block region, associated with a different communication requirement of the user device.

15. An apparatus comprising means for performing a method of any of claims 1-14.

16. A non-transitory computer-readable storage medium comprising instructions stored thereon that, when executed by at least one processor, are configured to cause a computing system to perform the method of any of claims 1-14.

17. An apparatus comprising at least one processor and at least one memory including computer instructions, when executed by the at least one processor, cause the apparatus to perform a method of any of claims 1-14.

18. An apparatus comprising at least one processor and at least one memory including computer instructions, when executed by the at least one processor, cause the apparatus to:

determine, by a user device, a set of scheduling request resources allocated to the user device for transmitting a scheduling request, with each scheduling request resource of the set of scheduling request resources including a sequence, of a plurality of sequences, and/or a resource block region, wherein each scheduling request resource is associated with a different communication requirement;

determine a communication requirement for an uplink data transmission;

transmit, by the user device to a base station, a scheduling request via a scheduling request resource that is associated with the determined communication requirement in order to request uplink resources and indicate the associated communication requirement; and

receive, by the user device from the base station, an uplink resource grant that indicates resources allocated to the user device for uplink transmission.

19. A method comprising:

determining, by a base station, a set of scheduling request resources allocated to a user device for transmitting a scheduling request, with each scheduling request resource of the set of scheduling request resources including a sequence, of a plurality of sequences, and/or a resource block region, wherein each scheduling request resource is associated with a different communication requirement;

receiving, by the base station from the user device, a scheduling request via a scheduling request resource associated with a communication requirement;

determining, based on the received scheduling request, a communication requirement for the user device;

determining, based on the determined communication requirement for the user device, resources to be allocated to the user device; and

transmitting, by the base station to the user device, an uplink resource grant that indicates the resources allocated to the user device for uplink transmission.

20. The method of claim 19 wherein the receiving a scheduling request comprises:

receiving, by the base station from the user device, a sequence, which is associated with a communication requirement;

receiving, by the base station from the user device, a scheduling request via a resource block region that is associated with a communication requirement;

receiving, by the base station from the user device, a sequence via a resource block region, wherein the sequence and the resource block region are associated with a communication requirement.

21. The method of any of claims 19-20 and further comprising:

transmitting, by the base station to the user device, control information indicating the set of scheduling request resources allocated to the user device for transmitting a scheduling request, with each scheduling request resource of the set of scheduling request resources including an associated combination of a sequence, of a plurality of sequences, and a resource block region, wherein each combination of sequence and resource block region is associated with a different communication requirement.

22. The method of any of claims 19-21 and further comprising:

receiving, by the base station from the user device, data via the uplink resources indicated by the uplink resource grant.

23. The method of any of claims 19-22, wherein the set of scheduling request resources allocated to the user device for transmitting a scheduling request comprises at least one of:

a plurality of sequences for a first resource block region, with each sequence of the plurality of sequences is associated with a different communication requirement;

a first sequence for a plurality of resource block regions, wherein each resource block region is associated with a different communication requirement; and

a plurality of any combination of a sequence and a resource block region, wherein each combination of sequence and resource block region is associated with a different communication requirement.

24. The method of any of claims 19-23, wherein the set of scheduling request resources allocated to the user device for transmitting a scheduling request comprises:

a plurality of sequences, wherein each of the plurality of sequences is associated with a different communication requirement.

25. The method of any of claims 19-24, wherein the different communication requirement comprises at least one of:

- a different latency target; and
- a different reliability target; and
- a different message size; and
- a different survival time; and
- a different user device or a different region or group of user devices.

26. The method of any of claims 19-25, wherein the communication requirement comprises a latency requirement, wherein the determining resources comprises at least one of:

- determining uplink resources to be allocated to the user device based on slot scheduling if the determined communication requirement is a first latency requirement; and
- determining uplink resources to be allocated to the user device based on mini-slot scheduling if the determined communication requirement is a second latency requirement that is stricter or shorter than the first latency requirement.

27. The method of any of claims 19-26, wherein the communication requirement comprises a latency requirement, wherein the determining resources comprises at least one of:

- determining uplink resources, including resources over a set of resource blocks that is greater than a threshold, to be allocated to the user device if the determined communication requirement is a first latency requirement; and
- determining resources, including resources over a set of resource blocks that is less than the threshold, to be allocated to the user device if the determined communication requirement is a second latency requirement that is stricter or shorter than the first latency requirement.

28. An apparatus comprising means for performing a method of any of claims 19-27.

29. A non-transitory computer-readable storage medium comprising instructions stored thereon that, when executed by at least one processor, are configured to cause a computing system to perform the method of any of claims 19-27.

30. An apparatus comprising at least one processor and at least one memory including computer instructions, when executed by the at least one processor, cause the apparatus to perform a method of any of claims 19-27.

31. An apparatus comprising at least one processor and at least one memory including computer instructions, when executed by the at least one processor, cause the apparatus to:

determine, by a base station, a set of scheduling request resources allocated to a user device for transmitting a scheduling request, with each scheduling request resource of the set of scheduling request resources including a sequence, of a plurality of sequences, and/or a resource block region, wherein each scheduling request resource is associated with a different communication requirement;

receive, by the base station from the user device, a scheduling request via a scheduling request resource associated with a communication requirement;

determine, based on the received scheduling request, a communication requirement for the user device;

determine, based on the determined communication requirement for the user device, resources to be allocated to the user device; and

transmit, by the base station to the user device, an uplink resource grant that indicates the resources allocated to the user device for uplink transmission.

32. The method of any of claims 1-14 and 19-27, wherein the sequence comprises a phase-rotated sequence that is based on a phase rotation or cyclic shift of a base sequence.

33. The method of any of claims 1-14, 19-27 and 32, wherein each scheduling request resource of the set of scheduling request resources is associated with a different set of communication requirements.

34. The method of any of examples 19-27, 32 and 33, further comprising:
setting or configuring, by the base station, one or more updated transmission parameters for the user device (or UE) based on the determined communication (or QoS) requirement; and

transmitting, by the base station to the user device, the one or more updated transmission parameters.

35. The method of any of claims 1-14, 19-27 and 32-34, wherein the communication requirement is indicated based on at least one of the following:

each different sequence indicates or is associated with a different communication requirement for the user device;

each different resource block region indicates or is associated with a different communication requirement for the UE;

each different combination of sequence and resource block region indicates or is associated with a different communication requirement for the user device; and

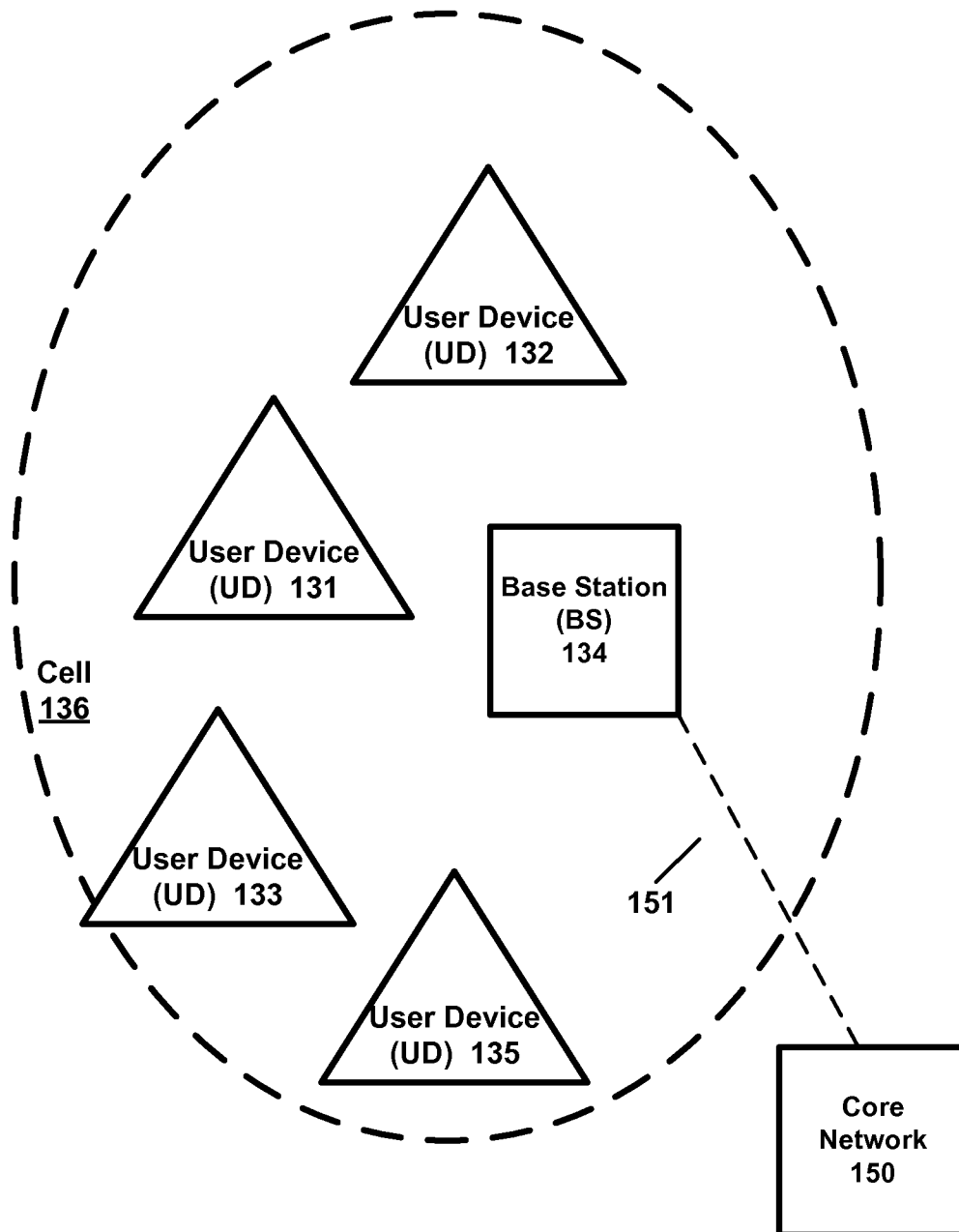
each different combination of multiple sequences indicates or is associated with a different communication requirement for the user device.

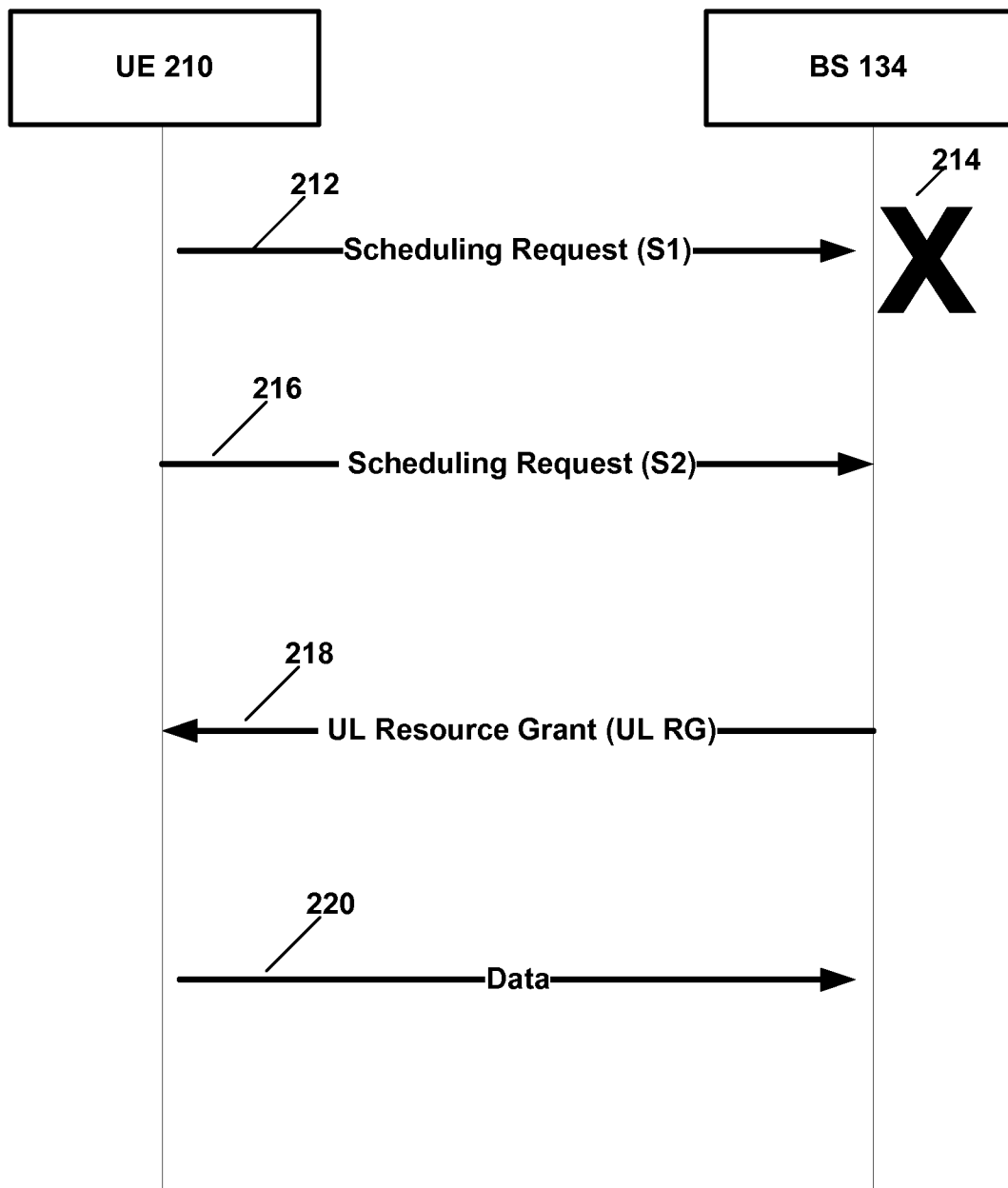
36. The method of any of claims 1-14, and 32-35 further comprising:

receiving, by the user device from the base station, one or more updated transmission parameters for the user device that were set by the base station based on the determined communication (or QoS) requirement that is associated with the scheduling request resource that was used to transmit the scheduling request; and

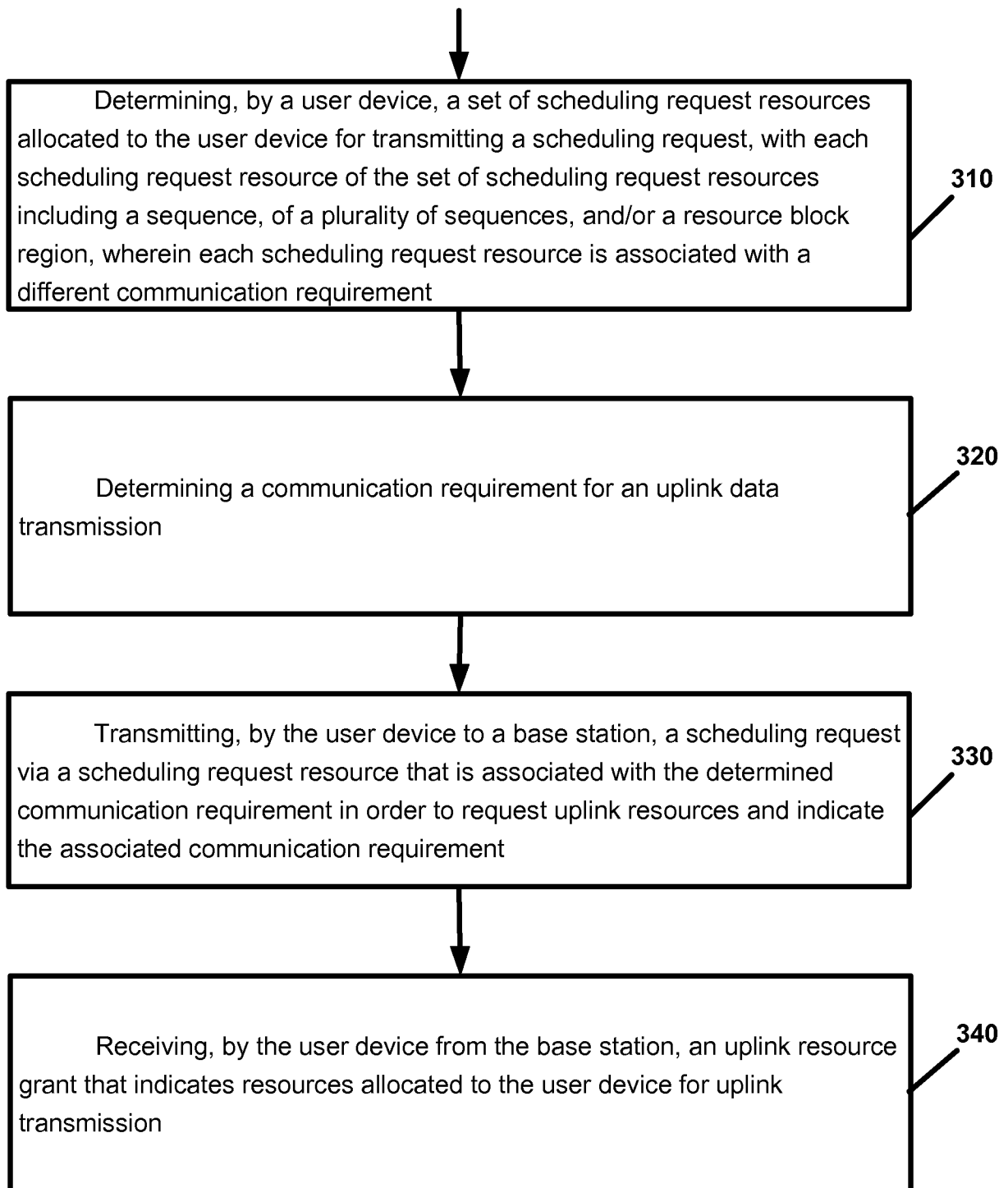
transmitting, by the user device based on the one or more updated transmission parameters, data via the resources indicated by the received uplink resource grant.

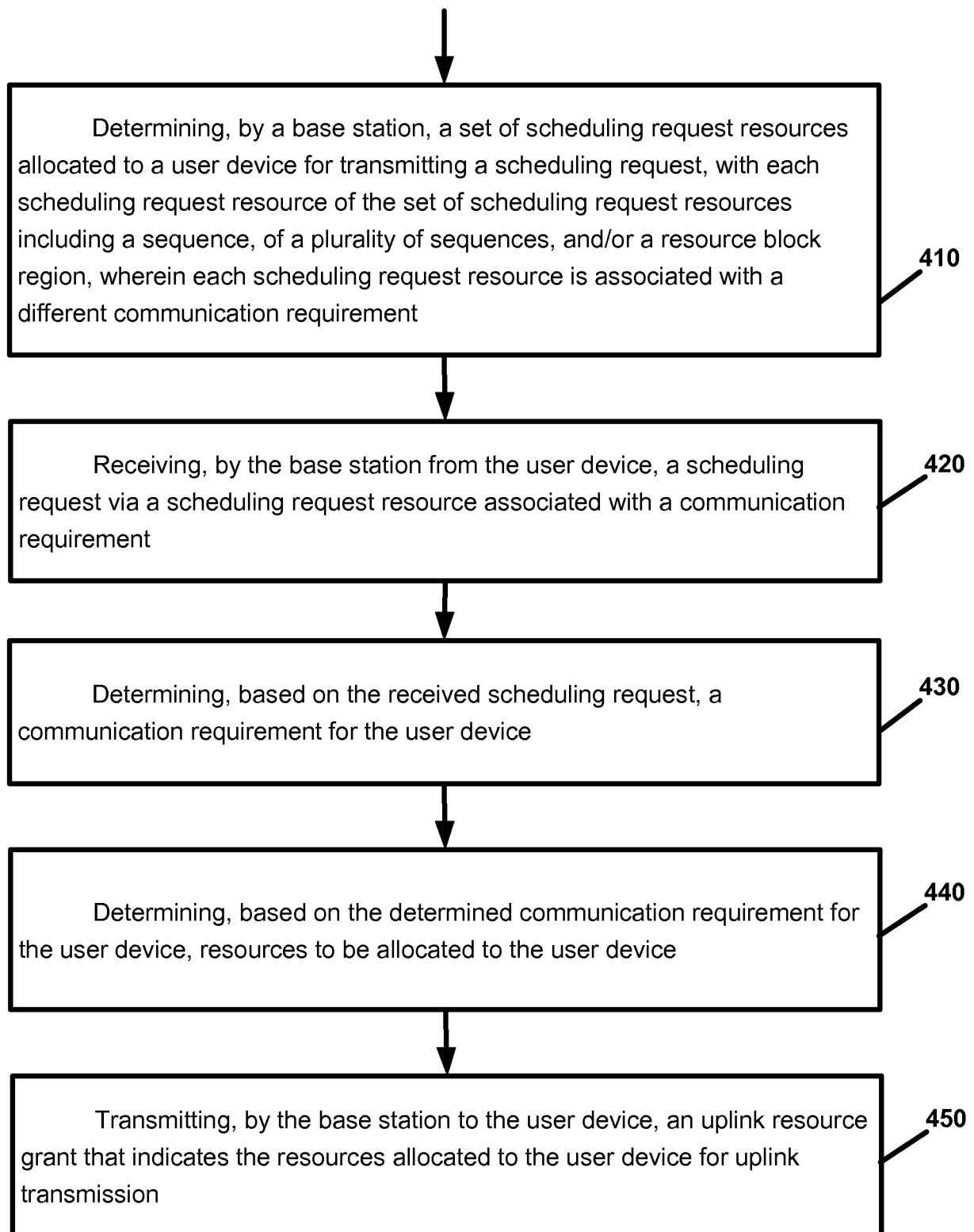
Example Wireless Network 130

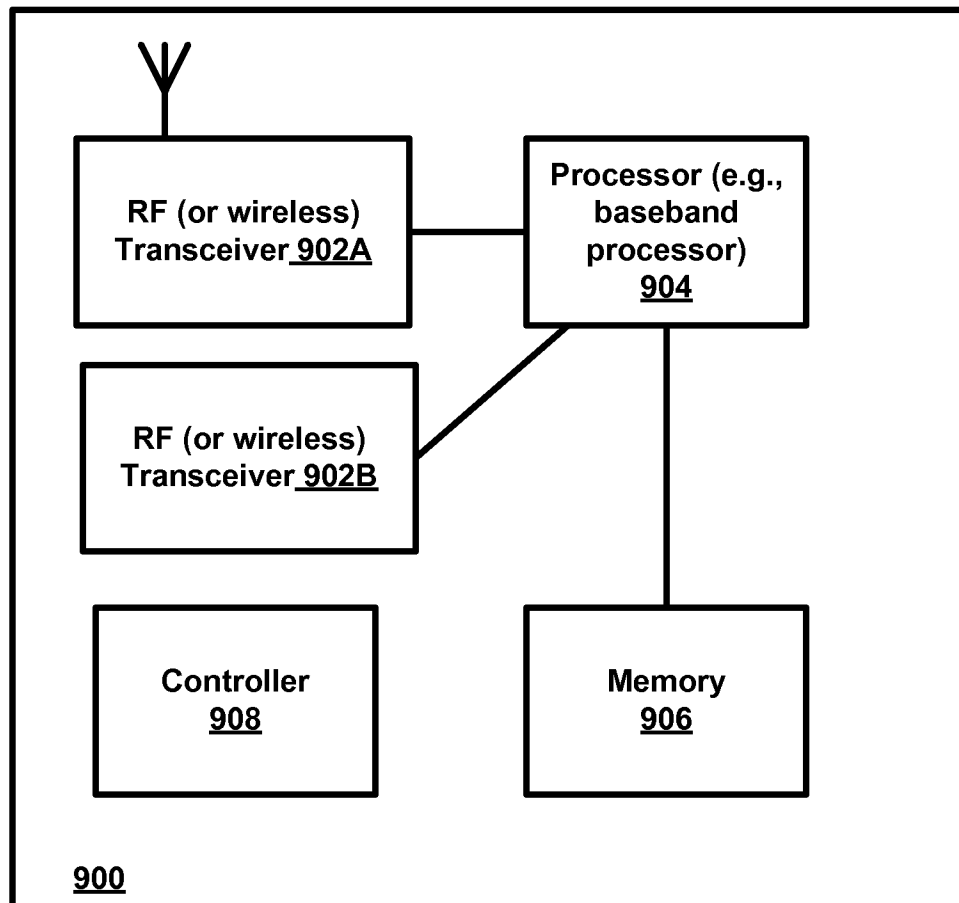
**FIG. 1**

**FIG. 2**

3/5

**FIG. 3**

**FIG. 4**

**FIG. 5**

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2018/077489

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04W72/12 H04L5/00 H04J13/00
ADD.

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 H04L H04J

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)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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Y	paragraphs [0008], [0015], [0298] - [0308], [0338] - [0342], [0399] - [0405]	9,10,12
Y	US 2018/279324 A1 (WANG XIAO FENG [US] ET AL) 27 September 2018 (2018-09-27) paragraphs [0127], [0128] ----- -/-	9,10,12



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

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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

10 May 2019

Date of mailing of the international search report

17/05/2019

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INTERNATIONAL SEARCH REPORT

International application No

PCT/EP2018/077489

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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Information on patent family members

International application No

PCT/EP2018/077489

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