(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) **World Intellectual Property Organization**
International Bureau

(43) **International Publication Date**
18 July 2019 (18.07.2019)

WIPO | PCT

(10) **International Publication Number**
WO 2019/136706 A1

(51) **International Patent Classification:**
H04L 1/18 (2006.01) ***H04W 24/10*** (2009.01)

(21) **International Application Number:**
PCT/CN2018/072442

(22) **International Filing Date:**
12 January 2018 (12.01.2018)

(25) **Filing Language:** English

(26) **Publication Language:** English

(71) **Applicant: ZTE CORPORATION** [CN/CN]; ZTE Plaza, Keji Road South, Hi-Tech Industrial Park, Nanshan, Shenzhen, Guangdong 518057 (CN).

(72) **Inventors: HAN, Xianghui**; ZTE Plaza, Keji Road South, Hi-Tech Industrial Park, Nanshan, Shenzhen, Guangdong 518057 (CN). **XIA, Shuqiang**; ZTE Plaza, Keji Road South, Hi-Tech Industrial Park, Nanshan, Shenzhen, Guangdong 518057 (CN). **GOU, Wei**; ZTE Plaza, Keji Road South, Hi-Tech Industrial Park, Nanshan, Shenzhen, Guangdong 518057 (CN). **LIANG, Chunli**; ZTE Plaza, Keji Road South, Hi-Tech Industrial Park, Nanshan, Shenzhen, Guangdong 518057 (CN). **SHI, Jing**; ZTE Plaza, Keji Road South, Hi-Tech Industrial Park, Nanshan, Shenzhen, Guangdong 518057 (CN). **REN, Min**; ZTE Plaza, Keji Road South, Hi-Tech Industrial Park, Nanshan, Shenzhen, Guangdong 518057 (CN).

(74) **Agent: BEYOND ATTORNEYS AT LAW**; F6, Xijin Centre, 39 Lianhuachi East Rd., Haidian District, Beijing 100036 (CN).

(81) **Designated States** *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) **Designated States** *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report (Art. 21(3))*

(54) **Title:** METHODS AND SYSTEMS FOR UPLINK CONTROL CHANNEL TRANSMISSION

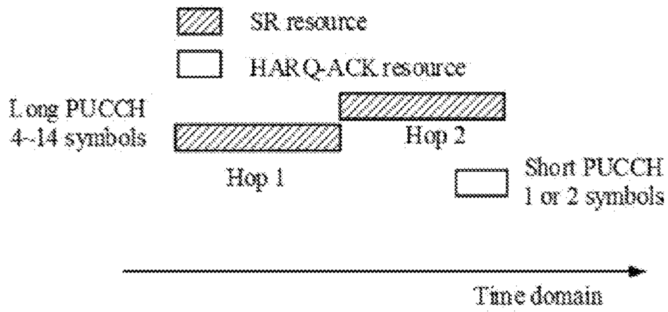

FIG. 3

(57) **Abstract:** Described are methods, systems and devices for improved uplink control channel transmissions. In some embodiments, the disclosed technology provides rules for selectively transmitting at least a portion of a scheduling request (SR) or at least a portion of a hybrid automatic repeat request (HARQ) acknowledgement (ACK) message when their time resources overlap. In an example, the selective transmission is based on the lengths of their time resources, starting positions of their time resources, or their traffic types. In other embodiments, rules are provided for increasing transmission diversity, and for selecting a physical uplink control channel (PUCCH) format when at least three PUCCH formats are available and a minimum number of physical resource blocks (PRBs) for at least two physical uplink control channel (PUCCH) formats are the same.

WO 2019/136706 A1

METHODS AND SYSTEMS FOR UPLINK CONTROL CHANNEL TRANSMISSION

TECHNICAL FIELD

This document generally relates to systems, devices, and techniques for wireless communications.

BACKGROUND

Wireless communication technologies are moving the world toward an increasingly connected and networked society. The rapid growth of wireless communications and advances in technology has led to greater demand for capacity and connectivity. Other aspects, such as energy consumption, device cost, spectral efficiency, and latency are also important to meeting the needs of various communication scenarios. In comparison with the existing wireless networks, next generation systems and wireless communication techniques need to support much deeper coverage and huge number of connections.

SUMMARY

This document relates to methods, systems, and devices for uplink control channel transmissions. Embodiments of the disclosed technology solve several issues related to the transmission of a scheduling request (SR) and a hybrid automatic repeat request (HARQ) acknowledgement (ACK) message. This is achieved by providing a set of rules that establish priorities between existing parameters and procedures in a variety of situations to improve system performance. For example, this patent document discloses rules for the transmission of the SR and the HARQ-ACK message when their resources either partially or completely overlap, for increasing transmission diversity, and for selecting an appropriate transmission format.

In one exemplary aspect, a wireless communication method is disclosed. The method includes determining that a first set of time resources overlaps with a second set of time resources, wherein a first set of resources for a first type of communication comprises the first set of time resources, and wherein a second set of resources for a second type of communication comprises the second set of time resources, and transmitting a signal, wherein the signal excludes at least a portion of the first type of communication based on lengths of the first and second sets of time resources, starting positions of the first and second sets of time resources, or traffic types of the first and second types of communication.

In another exemplary aspect, a wireless communication method is disclosed. The method includes determining that a first set of time resources overlaps with a second set of time resources, wherein a first set of resources for a scheduling request (SR) comprises the first set of time resources, and wherein a second set of resources for a hybrid automatic repeat request (HARQ) acknowledgement (ACK) message comprises the second set of time resources, and transmitting a signal comprising at least a portion of the SR or at least a portion of the HARQ-ACK based on a format used on the first and second set of time resources or a type of the SR.

In yet another exemplary aspect, a wireless communication method is disclosed. The method includes determining that a first set of time resources for a scheduling request (SR) overlaps with a second set of time resources for a hybrid automatic repeat request (HARQ) acknowledgement (ACK) message, determining an initial cyclic shift for a transmission of only the HARQ-ACK message, and transmitting the SR and the HARQ-ACK message over a set of transmission resources, wherein the set of transmission resources are based on the initial cyclic shift or a type of the SR.

In yet another exemplary aspect, a wireless communication method is disclosed. The method includes determining that a minimum number of physical resource blocks (PRBs) for at least two physical uplink control channel (PUCCH) formats are the same, wherein at least three PUCCH formats are available, and selecting one of the at least three PUCCH formats based on a rule, wherein the rule is based on a number of symbols, a code rate, or a multiplexing capacity associated with each of the at least three PUCCH formats.

In yet another exemplary aspect, the above-described methods are embodied in the form of processor-executable code and stored in a computer-readable program medium.

In yet another exemplary embodiment, a device that is configured or operable to perform the above-described methods is disclosed.

The above and other aspects and their implementations are described in greater detail in the drawings, the descriptions, and the claims.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 shows an example of a base station (BS) and user equipment (UE) in wireless communication, in accordance with some embodiments of the presently disclosed technology.

FIG. 2 shows examples of cases where resources for the SR and the HARQ-ACK message partially overlap.

FIG. 3 shows another example of a case where resources for the SR and the HARQ-ACK message partially overlap.

FIG. 4 shows yet another example of a case where multiple resources for SRs and HARQ-ACK messages partially overlap.

FIG. 5 shows an example of a wireless communication method for uplink control channel transmissions.

FIG. 6 shows another example of a wireless communication method for uplink control channel transmissions.

FIG. 7 shows yet another example of a wireless communication method for uplink control channel transmissions.

FIG. 8 shows yet another example of a wireless communication method for uplink control channel transmissions.

FIG. 9 is a block diagram representation of a portion of an apparatus that may implement a method or technique described in this patent document.

DETAILED DESCRIPTION

Among the signaling from the UE to the network, scheduling request (SR) and hybrid ARQ (HARQ) feedback are among the most important ones. SR is used by the UE to request resource allocation in the UL so it can send data. HARQ feedback is necessary for the HARQ operation. The feedback is an ACK if the UE recognized data intended for it on the physical downlink shared channel (PDSCH) and the UE did not detect any transmission error on the PDSCH data. It is a NACK if the UE recognized data intended for it on the PDSCH but the UE detected some transmission error on the PDSCH data.

Existing communication systems face a variety of challenges with regard to uplink control channel transmissions. In an example, the UE behavior when the physical uplink control channel (PUCCH) carrying an SR partially overlaps with the PUCCH transmission of the HARQ-ACK or the periodic channel state information (P-CSI) is ill-defined. In another example, simultaneous transmission of the SR and the HARQ-ARQ message in severe channel fading conditions results in seriously degraded performance. In yet another example, the use of PUCCH format 0 in New Radio (NR) does not support transmission diversity. In yet another example, the selection of the appropriate PUCCH format is ill-defined. In yet another example, an implicit mapping that selects between two possible PUCCH resources, when a large number of PUCCH resources are available, is not well defined. The technology disclosed in this patent document address these issues related to uplink control channel transmissions.

FIG. 1 shows an example of a wireless communication system that includes a base station (BS) 120 and one or more user equipment (UE) 111, 112 and 113. In some embodiments, each of the UEs may transmit uplink control information (UCI) (131, 132, 133). For example, the UCI may comprise an SR or a HARQ-ACK message. In response to requests or feedback, the base station may then transmit control information or data (141, 142, 143) back to the UEs.

SR Transmission Partially Overlaps With HARQ-ACK/P-CSI Transmission

Embodiment 1. As shown in FIG. 2, four cases are shown in which PUCCH carrying SR partial overlaps with PUCCH transmission of HARQ-ACK in the time domain. In Cases 1 and 2, the PUCCH symbols for SR transmission fully or partially includes PUCCH symbols for HARQ-ACK transmission, and the starting symbol of PUCCH symbols for HARQ-ACK transmission is later than that of SR transmission. In Cases 3 and 4, PUCCH symbols for HARQ-ACK transmission fully or partially includes PUCCH symbols for SR transmission, and the starting symbol of PUCCH symbols for SR transmission is later than that of HARQ-ACK transmission.

In some embodiments, the UE may have the capability and may be configured to transmit both channels, and the UE would transmit both SR and HARQ-ACK using the corresponding configured resources. In other embodiments, the UE may not have this ability and its behavior may be defined in the context of the cases shown in FIG. 2.

In some embodiments, the transmission with the longer length is dropped, or not transmitted. For example, in Case 2, the HARQ-ACK transmission may be entirely dropped, such that both the HARQ-ACK transmission is not resumed even for the non-overlapping symbols of the HARQ-ACK transmission. If the length of time-domain resources for SR and HARQ-ACK are the same, the one first transmitted has high priority.

In some embodiments, the UE may drop the one used for enhanced Mobile Broadband (eMBB) transmission if the other transmission is for Ultra-Reliable and Low Latency Communication (URLLC). For example, if the transmission of SR is for eMBB traffic and HARQ-ACK message is for the feedback of a downlink URLLC transmission, the UE would drop SR transmission.

In some embodiments, the priority rules for when the SR transmission partially overlaps with the HARQ-ACK/P-CSI transmission include (1) dropping the transmission with the longer length (if the transmissions have identical lengths, the one transmitted first has a higher priority and will be transmitted), and (2) dropping the transmission based on the traffic type. In an example, URLLC traffic is prioritized over eMBB traffic.

In some embodiments, the following set of rules may be adopted when dropping the transmission with the lower priority:

(1) The UE drops all the symbols of the lower priority transmission.

(2) The UE only drops the hop containing overlapping symbols, and the hop without a collision (the non-overlapping symbols) would still be transmitted. In an example, one PUCCH transmission may have more than 1 hops if frequency hopping is enabled.

(3) The UE only drops the overlapping symbols, and the non-overlapping symbols would still be transmitted.

(4) The rule may depend on the UE implementation. For example, the UE shall attempt to drop all the symbols once it notices the collision.

In the example shown in FIG. 3, the configured PUCCH for the SR transmission is a long PUCCH with frequency hopping is enabled, while the HARQ-ACK message is indicated to be transmitted in a short PUCCH. In this case, UE can only transmit positive SR in the first hop (Hop 1) using the corresponding SR resources configured, and drop SR transmission in the second hop (Hop 2). Furthermore, the UE transmits short PUCCH using the resources configured for HARQ-ACK. In some embodiments, the example of FIG. 3 may be implemented using any available PUCCH format.

Embodiment 2. In some embodiments, when PUCCH symbols for SR transmission partially overlap with HARQ-ACK transmission which is expected to be transmitted using PUCCH format 0, at least one of the rules described in Table 1 may be implemented.

Table 1: Procedures for partial overlap using PUCCH Format 0

- In case of negative SR, HARQ-ACK is transmitted using HARQ-ACK-only resources
- In case of positive SR,
  - On the overlapping symbols,
    - HARQ-ACK and SR are transmitted using resources configured for HARQ-ACK+SR.
    - Or, HARQ-ACK is transmitted using the configured SR resources. Here the SR resources includes resources both in frequency and code domain. HARQ-ACK is BPSK or QPSK modulated for one or two bits HARQ-ACK respectively.
  - On the non-overlapping SR symbols (if any),
    - SR is transmitted using the configured SR resources,
    - Or SR is dropped. Or in the hop without overlapping symbols, SR is transmitted using the configured SR resources, but in the hop with overlapping symbols, SR is dropped.
  - On the non-overlapping HARQ-ACK symbols (if any), HARQ-ACK is transmitted using the configured HARQ-ACK resources.

In an example, PUCCH format 0 is a short PUCCH format based on sequence selection for 1~2 bits HARQ-ACK transmission, i.e., different HARQ-ACK states are carried by different cyclic shift sequences. The cyclic shift sequences configured for HARQ-ACK+SR may be in the same physical resource block (PRB) with the cyclic shift sequences configured for HARQ-ACK only. In some embodiments, the configured PUCCH for SR is a PUCCH format 1 (long PUCCH format for 1~2 bits UCI).

In some embodiments, when the configured PUCCH symbols for SR transmission partially overlaps with the HARQ-ACK message transmission, and is expected to be transmitted using PUCCH format 1. In an example, PUCCH format 1 is a long PUCCH format based on sequence modulation for 1~2 bits HARQ-ACK transmission. In this scenario, at least one of the rules described in Table 2 may be implemented.

Table 2: Procedures for partial overlap using PUCCH Format 1

- On the overlapping HARQ-ACK symbols,
  - UE shall transmit HARQ-ACK using the configured SR resources,
  - Or, UE shall transmit HARQ-ACK using the configured cyclic shifts for SR and the configured frequency resources for HARQ-ACK.
- On the non-overlapping SR symbols (if any), SR is dropped, or SR is transmitted using the configured SR resources.
- On the non-overlapping HARQ-ACK symbols (if any), HARQ-ACK is transmitted using the configured HARQ-ACK resources including both time/frequency/code domain

In some embodiments, the configured PUCCH for SR is a PUCCH format 0.

Embodiment 3. In some embodiments, when the configured PUCCH symbols for a SR transmission partially overlaps with HARQ-ACK transmission, and is expected to be transmitted using short PUCCH format 2 carrying more than 2 bits. For example, the SR is used for triggering eMBB traffic and the short PUCCH is used for the feedback of one or multiple downlink (DL) URLLC transmissions. The following rule is used:

- A single SR bit is jointly coded with HARQ-ACK bits and to be transmitted using HARQ-ACK resources.

In some embodiments, when the configured PUCCH symbols for a SR transmission partially overlaps with HARQ-ACK transmission, and is expected to be transmitted using long PUCCH format 3/4 carrying more than 2 bits, the following rule is used:

- A single SR bit is jointly coded with HARQ-ACK bits and to be transmitted using HARQ-ACK resources. Or HARQ-ACK transmission is dropped, and SR is transmitted on the configured SR resources.

Embodiment 4. As shown in Case 1-2 in FIG. 4, PUCCH symbols for SR transmission overlaps with multiple HARQ-ACK transmission. In some embodiments, the UE may use the rules defined in the context of Embodiment 1 and/or Embodiment 2.

In some embodiments, if HARQ-ACK is expected to transmitted in PUCCH format with more than 2 bits, a single SR bit is jointly coded with HARQ-ACK bits in each HARQ-ACK transmission occasions that having collision with SR transmission, or a single SR bit is jointly coded with HARQ-ACK bits only in the first HARQ-ACK transmission occasion that having collision with SR transmission.

In some embodiments, if HARQ-ACK is expected to be transmitted in PUCCH format 0 , each HARQ-ACK in each HARQ-ACK transmission occasion is transmitted on its overlapping symbols using SR resources. Here the SR resources includes resources both in the time, frequency and code domain. HARQ-ACK is BPSK or QPSK modulated for one or two bits HARQ-ACK respectively. Or, HARQ-ACK and SR are transmitted using resources configured for HARQ-ACK+SR.

As shown in Case 3-2 in FIG. 4, PUCCH symbols for HARQ-ACK transmission overlaps with multiple SR transmission occasions. In some embodiments, the UE may use the rules defined in the context of Embodiment 1 and/or Embodiment 2.

In some embodiments, if HARQ-ACK is expected to be transmitted in PUCCH format with more than 2 bits, a single SR bit corresponding to the first SR occasion is jointly coded with HARQ-ACK bits, or all SR bits corresponding to each SR occasion are jointly coded with HARQ-ACK bits, or only the SR occasion corresponding to high priority is regarded as one bit and jointly coded with HARQ-ACK bits. The priority here could be a URLLC traffic. The coded bits are transmitted using HARQ-ACK resources.

In some embodiments, if HARQ-ACK is expected to be transmitted in PUCCH format 0 , each HARQ-ACK in each HARQ-ACK transmission occasion is transmitted on its overlapping symbols using SR resources. Here the SR resources includes resources both in the time, frequency and code domain. HARQ-ACK is BPSK or QPSK modulated for one or two bits HARQ-ACK respectively. Or, HARQ-ACK and SR are transmitted using resources configured for HARQ-ACK+SR.

Embodiment 5. In some embodiments, the HARQ-ACK message may also be a periodic CSI (P-CSI) message. For example, the disclosed embodiments also apply to partially overlapped transmission of SR and periodic/semi-static CSI in PUCCH. Note, periodic/semi-static CSI can only be carried in PUCCH formats for more than 2 bits UCI, e.g., PUCCH format 2, or, PUCCH format 3 or PUCCH format 4.

In some embodiments, the SR may also be a periodic CSI (P-CSI) message. For example, the disclosed embodiments also apply to partially overlapped transmission of HARQ-ACK and periodic/ semi-static in PUCCH. In some cases, UE is not configured the simultaneous transmission of HARQ-ACK and periodic/ semi-static. In some embodiments, HARQ-ACK and

P-CSI are jointly coded and transmitted using the configured HARQ-ACK resources or periodic/ semi-static resources.

The disclosed embodiments also apply to the partial overlap of PUCCH and physical uplink shared channel (PUSCH).

In some embodiments, UE is not expected to transmit a SR partially overlaps with a HARQ-ACK transmission in the time domain. In other words, a SR transmission from a UE is not expected to have a partial overlap time resource with a HARQ-ACK transmission from the UE. That is, the time resource of a SR transmission and a HARQ-ACK transmission are either exactly the same or time-division multiplexed (TDMed).

In some embodiments, UE is not expected to transmit a SR partially overlaps with a HARQ-ACK transmission in time domain, wherein the HARQ-ACK is carried on some of PUCCH formats, e.g., PUCCH Formats for more than 2 bits, or PUCCH format 1 and PUCCH Formats for more than 2 bits.

In some embodiments, UE is not expected to transmit a SR partially overlaps with a periodic CSI transmission in PUCCH, or aperiodic CSI transmission in PUCCH, or aperiodic CSI transmission in PUSCH.

In some embodiments, UE is not expected to transmit HARQ-ACK partially overlaps with a periodic/ semi-static CSI transmission in PUCCH, or aperiodic CSI transmission in PUCCH, or aperiodic CSI transmission in PUSCH.

In some embodiments, UE is not expected to transmit a SR partially overlaps with a HARQ-ACK transmission in time domain, wherein, the time resources of SR transmission and HARQ-ACK transmission both contain more than 4 symbols (long duration) or both contain no more than 2 symbols (short duration).

In some embodiments, UE is not expected to transmit a SR partially overlaps with a HARQ-ACK transmission in time domain, wherein, the time resource of SR transmission contains more than 4 symbols (long duration) and the time resource of HARQ-ACK transmission contains no more than 2 symbols (short duration); Or the time resource of HARQ-ACK transmission contains more than 4 symbols (long duration) and the time resource of SR transmission contains no more than 2 symbols (short duration).

Simultaneous Transmission of SR and HARQ-ACK

In some embodiments, and for the simultaneous transmission of 1 or 2 bits HARQ-ACK and SR using PUCCH format 0, the following two cases are considered:

(1) In case of negative SR, the same PUCCH resources as for HARQ-ACK only transmission are used.

(2) In case of positive SR, HARQ-ACK are transmitted on the PRB for HARQ-ACK only transmission. In an example, the mapping of ACK and NACK to cyclic shifts is based on the index of initial cyclic shift of the HARQ-ACK only ($CS_{initial}$) and a fixed mapping pattern as given in Table 3 and Table 4 below corresponding to 1- and 2-bit HARQ-ACK, respectively.

Table 3: Mapping pattern for 1-bit HARQ-ACK and positive SR

HARQ-ACK	NACK	ACK
Cyclic shift	($CS_{intitial}$+3) mod 12	($CS_{intitial}$+9) mod 12

Table 4: Mapping pattern for 2-bit HARQ-ACK and positive SR

HARQ-ACK	NACK, NACK	NACK, ACK	ACK, ACK	ACK, NACK
Cyclic shift	($CS_{intitial}$+1) mod 12	($CS_{intitial}$+4) mod 12	($CS_{intitial}$+7) mod 12	($CS_{intitial}$+10) mod 12

In some embodiments, a maximum of 12 SR per PRB can be configured with semi-static SR simultaneously. In other embodiments, one PRB can support simultaneous transmission of 2-bit HARQ-ACK with SR only for one UE, and the four remaining resources can be used for other purposes (e.g., 1-bit A/N with SR or 2-bit A/N only).

Based on the above embodiment, totally 8 cyclic shifts in one PRB are used for transmission of positive SR and 2 bits HARQ-ACK in PUCCH format 0. The minimum cyclic shift distance is 1, which would be detrimental to the performance, especially when the delay spread of the channel is large. A complementary scheme is to also allow positive SR and 1/2 bits HARQ-ACK could be transmitted in different resource blocks (RBs).

In some embodiments, the cyclic shifts used for transmission of positive SR and HARQ-ACK using PUCCH format 0 could be in *N* PRBs, where *N*, for example, is 2. In some embodiments, one PRB is used for HARQ-ACK only transmission, and one PRB is used for transmission of HARQ-ACK and positive SR.

In some embodiments, two PRBs are used for the combination of SR and HARQ-ACK. For instance, the cyclic shifts for the transmission of ‘NACK, NACK’ and negative SR, or ‘NACK, ACK’ and negative SR, or ‘NACK, NACK’ and positive SR, or ‘NACK, ACK’ and positive SR are allocated in one PRB, and the cyclic shifts for the transmission of ‘ACK, ACK’ and negative SR, or ‘ACK, NACK’ and negative SR, or ‘ACK, ACK’ and positive SR, or ‘ACK, NACK’ and positive SR are allocated in another PRB. Table 5 and Table 6 give two options as a detailed example for 2-bit HARQ-ACK and SR transmission.

In some embodiments, the cyclic shifts used for transmission of positive SR and 1-bit HARQ-ACK using PUCCH format 0 are in one PRB, and the cyclic shifts used for transmission of positive SR and 2-bit HARQ-ACK using PUCCH format 0 are in more than 1 PRB.

In an example, denote the PRB used for HARQ-ACK only transmission indicated by network as RB#i. In some embodiments, the other PRB denoting as RB#j used for transmission of HARQ-ACK and positive SR is implicitly indicated by RB#i. For instance, j=i + offset_value. The offset value could be a default value such as offset_value=1. Or j =N-1-i, where N is the number of PRBs in the bandwidth part. Or offset_value is a function of $CS_{intitial}$, which is the initial cyclic shift configured for HARQ-ACK only.

In some embodiments, the PRB denoting as RB#j used for transmission of HARQ-ACK and positive SR is the same RB configured for SR-only transmission (denoting as RB#k), or is implicitly indicated by RB#k. For example, j = k + $CS_{intitial}$ + offset_value2, where $CS_{intitial}$ is the initial cyclic shift configured for HARQ-ACK only.

In some embodiments, the PRB denoting as RB#j used for transmission of HARQ-ACK and positive SR is configured by RRC signaling.

The cyclic shifts for HARQ-ACK and positive SR in RB#j could be the same as the cyclic shifts configured for HARQ-ACK only, or are implicitly indicated by the initial cyclic shift configured for HARQ-ACK only, or the initial cyclic shift in RB#j is configured by RRC signaling, or are implicitly indicated by the cyclic shift configured for SR only.

A triggering condition of allowing positive SR and 1/2 bits HARQ-ACK to be transmitted in more than one RBs, could be determined by the index of one or more resources in a configured PUCCH resource set. For example, the resource here includes $CS_{intitial}$, the initial cyclic shift configured for HARQ-ACK only. For instance, when the configured $CS_{intitial}$ is a value ranging 0~M, only one PRB is used for HARQ-ACK only and HARQ-ACK + SR, while when the configured $CS_{intitial}$ is a value ranging M+1~N, more than one PRBs are used for HARQ-ACK only and HARQ-ACK + SR, transmission respectively. Assuming the length of sequence is K, M=K/2-1 and N=K-1. In another example, the triggering condition between using one or more than one PRB depends on whether the value of $CS_{initial}$ is odd or even. In yet another example, the triggering condition between using one or more than one PRB depends on whether the initial PRB index or the starting symbol index is odd or even.

Table 5: Mapping pattern for 2-bit HARQ-ACK and SR in PRB#i

HARQ-ACK	NACK, NACK+ negative SR	NACK, ACK + negative SR	NACK, NACK+ positive SR	NACK, ACK + positive SR
Cyclic shift Option 1	$CS_{intitial}$	$(CS_{intitial}+6)$ mod 12	$(CS_{intitial}+3)$ mod 12	$(CS_{intitial}+9)$ mod 12
Cyclic shift Option 2	$CS_{intitial}$	$(CS_{intitial}+3)$ mod 12	$(CS_{intitial}+6)$ mod 12	$(CS_{intitial}+9)$ mod 12

Table 6: Mapping pattern for 2-bit HARQ-ACK and SR in PRB#j

HARQ-ACK	ACK, ACK+ negative SR	ACK, NACK+ negative SR	ACK, ACK+ positive SR	ACK, NACK+ positive SR
Cyclic shift Option 1	$CS_{intitial}$	$(CS_{intitial}+6)$ mod 12	$(CS_{intitial}+3)$ mod 12	$(CS_{intitial}+9)$ mod 12
Cyclic shift Option 2	$CS_{intitial}$	$(CS_{intitial}+3)$ mod 12	$(CS_{intitial}+6)$ mod 12	$(CS_{intitial}+9)$ mod 12

In some embodiments, for 1-bit HARQ-ACK and SR transmission, the cyclic shift for ACK and positive SR, is implicitly indicated by the initial cyclic shift for HARQ-ACK only. The resource for NACK and positive SR is the same as the resource configured for SR-only.

In some embodiments, for 2-bit HARQ-ACK and SR transmission, the cyclic shifts for 'NACK, ACK' and positive SR,'ACK, NACK' and positive SR, and'ACK, ACK' and positive SR are implicitly indicated by the initial cyclic shift for HARQ-ACK only. The resource for 'NACK,

NACK' and positive SR is the same as the resource configured for SR-only.

Supporting Transmission Diversity in PUCCH Format 0 for NR

In some embodiments, PUCCH format 0 is a format based on sequence selection. For 1-bit HARQ-ACK transmission, 2 cyclic shifts are needed, while 4 cyclic shifts are required for 2-bit HARQ-ACK transmission. When the number of transmitter ports increases, the number of resources would be exponentially increased if using orthogonal resources for different ports.

In the following examples, the sequence length is assumed to be *N=12*, and the CS configurations for these examples are disclosed.

Embodiments with 1-bit HARQ-ACK. If a UE transmits HARQ-ACK using PUCCH format 0, the UE determines a value m_{CS} for computing a value of cyclic shift α as $m_{CS} = m + m_0$ where m_0 is provided by higher layer parameter *PUCCH-F0-F1-initial-cyclic-shift* of *PUCCH-F0-resource-config*, and m is determined by Table 3 for different antenna ports for 1-bit HARQ-ACK transmission.

Table 7: Cyclic shift configuration for 1-bit HARQ-ACK transmission using 2 ports

HARQ-ACK	NACK		ACK	
Antenna port	0	1	0	1
Cyclic shift Option 1	0	3	6	9
Cyclic shift Option 2	0	6	3	9
Cyclic shift Option 3	0	1	6	7
Cyclic shift Option 4	0	0	6	6

For Option 1, the cyclic shift distance between ACK and NACK is the largest, i.e., N/2 on each antenna port. For Option 2, the cyclic shift distance for a specific HARQ-ACK state is the largest i.e., N/2 between different antenna ports. But for both Option 1 and Option 2, the cyclic shift between ACK and NACK is 3 among two ports.

For Option 3, the cyclic shift between ACK and NACK is 5 among two ports. Option 3 may have a better performance in large delay spread channel.

For Option 4, the cyclic shift between ACK and NACK is 6 among two ports. But the transmission diversity is lost.

Table 8: Cyclic shift configuration for 1-bit HARQ-ACK transmission using 4 ports

HARQ-ACK	NACK				ACK			
Antenna port	0	1	2	3	0	1	2	3
Cyclic shift Option 1	0	3	7	10	6	9	1	4
Cyclic shift Option 2	0	3	6	9	7	10	1	4
Cyclic shift Option 3	0	1	2	3	6	7	8	9
Cyclic shift Option 4	0	0	1	1	6	6	7	7

For Option 1, the cyclic shift distance between ACK and NACK is the largest, i.e., N/2 on each antenna port. For Option 2, the cyclic shift distance for a specific HARQ-ACK state is the largest i.e., N/4 among different antenna ports. But for both Option 1 and Option 2, the cyclic shift between ACK and NACK is 1 among four ports.

For Option 3, the cyclic shift between ACK and NACK is 3 among four ports. Option 3 may have a better performance in large delay spread channel.

For Option 4, the cyclic shift between ACK and NACK is 5 among two ports. But partial transmission diversity is lost.

In other embodiments, another alternative is the cyclic shift m is indicated by RRC.

In some embodiments, the network configures P groups, each group contains Q cyclic shifts, where P is the number of HARQ-ACK states (P=2 for 1 bit and P=4 for two bits), Q is the number of transmission ports for PUCCH. For Option 3, the minimum CS distance in each group is 1, while the minimum CS distance is 6 for a specific antenna port among different groups.

In some embodiments, the network configures P groups, each group contains Q cyclic shifts, where P is the number of transmission ports for PUCCH, Q is the number of HARQ-ACK states (Q=2 for 1 bit and Q=4 for two bits). For Option 3, the minimum CS distance in each group is 6, while the minimum CS distance 1 among different groups.

In some embodiments, the cyclic shift in each group is in the same PRB, if the number of cyclic shifts in each group is no more than X. X is 4 or 8. Otherwise, the cyclic shift in each group could be distributed in different PRBs.

For a specific option, the value in each entry can be shifted by a same offset. For example, assuming the value in an entry is a, it can be shifted by mod(a+offset, 12). In some embodiments, divide a sequence into N parts, where N is the number of antenna ports. UE transmits one unique part out of the N parts on each antenna ports. For example, if N=2, one part is the even points of the sequence, and another part is the odd points of the sequence, or one part is the points of the sequence indexing from 0~5, and another part is the odd points of the sequence, indexing from 6~11.

Embodiments with 2-bit HARQ-ACK.

Table 9: Cyclic shift configuration for 2-bit HARQ-ACK transmission using 2 ports

HARQ-ACK	00		01		11		10	
Antenna port	0	1	0	1	0	1	0	1
Option 1	0	3	6	9	1	4	7	10
Option 2-1	0	6	3	9	1	4	7	10
Option 2-2	0	6	1	4	3	9	7	10
Option 3	0	1	3	4	6	7	9	10
Option 4	0	0	3	3	6	6	9	9

Another alternative is the cyclic shift m is indicated by RRC.

In some embodiments, the network configures P groups, each group contains Q cyclic shifts, where P is the number of transmission ports for PUCCH, Q is the number of HARQ-ACK states (Q=2 for 1 bit and Q=4 for two bits). For Option 3, the minimum CS distance in each group is N/Q=3, while the minimum CS distance 1 among different groups.

Table 10: Cyclic shift configuration for 2-bit HARQ-ACK transmission using 4 ports

HARQ-ACK	00				01				11				10			
Antenna port	0	1	2	3	0	1	2	3	0	1	2	3	0	1	2	3
Option 1	0	1	2	3	6	7	8	9	0	1	2	3	6	7	8	9
Option 2	0	1	0	1	2	3	2	3	6	7	6	7	8	9	8	9
Option 3	0	1	2	3	4	5	10	11	6	7	8	9	0	1	2	3

Another alternative is the cyclic shift m is indicated by RRC.

In some embodiments, the network configures P groups, each group contains Q cyclic shifts, where P is the number of HARQ-ACK states (P=2 for 1 bit and P=4 for two bits), Q is the number of transmission ports for PUCCH. For Option 1, the CS in the first two groups are in the first PRB, the CS in the last two groups are in the second PRB.

In some embodiments, the network configures P groups, each group contains Q cyclic shifts, where P is the number of transmission ports for PUCCH, Q is the number of HARQ-ACK states (Q=2 for 1 bit and Q=4 for two bits). For Option 2, the CS in the first two groups are in the first PRB, the CS in the last two groups are in the second PRB. For Option 3, the CS in the first three groups are in the first PRB, the CS in the last groups are in the second PRB.

In some embodiments, for 2-bit HARQ-ACK transmission with 2 or 4 transmitting antenna ports, the two HARQ-ACK is bundled to one bit. In other embodiments, for 2-bit HARQ-ACK transmission with 2 or 4 transmitting antenna ports, the bundled one bit HARQ-ACK is transmitted using the same CS configuration for 1-bit HARQ-ACK transmission with 2 or 4 transmitting antenna ports respectively, as shown in Table 7 and Table 8.

Embodiments with 1-bit HARQ-ACK + SR.

Table 11: Cyclic shift configuration for 1-bit HARQ-ACK+SR transmission using 2 ports

HARQ-ACK+SR	00		01		11		10	
Antenna port	0	1	0	1	0	1	0	1
Option 1	0	1	3	4	6	7	9	10

In Table 11, the two bits '00','01', '11', or '10' corresponds to 'NACK, negative SR', 'NACK, positive SR', 'ACK, positive SR', or 'ACK, negative SR' respectively.

In some embodiments, one of the options shown in Table 9 can also be used for 1-bit HARQ-ACK and SR transmission using two ports, by re-interpreting the two bits HARQ-ACK to 1-bit HARQ-ACK and SR transmission.

In some embodiments, the options shown in Table 11 can also be used for 2-bit HARQ-ACK transmission using two ports, by re-interpreting the 1-bit HARQ-ACK and SR transmission to two bits HARQ-ACK.

Table 12: Cyclic shift configuration for 1-bit HARQ-ACK+SR transmission using 4 ports

HARQ-ACK+SR	00				01				11				10			
Antenna port	0	1	2	3	0	1	2	3	0	1	2	3	0	1	2	3
Option 1	0	1	2	0	3	4	5	3	6	7	8	6	9	10	11	9

In Table 12, the two bits '00','01', '11', or '10' corresponds to 'NACK, negative SR', 'NACK, positive SR', 'ACK, positive SR', or 'ACK, negative SR' respectively.

In some embodiments, one of the options shown in Table 10 can also be used for 1-bit HARQ-ACK and SR transmission using 4 ports, by re-interpreting the two bits HARQ-ACK to 1-bit HARQ-ACK and SR transmission.

In some embodiments, the options shown in Table 12 can also be used for 2-bit HARQ-ACK transmission using four ports, by re-interpreting the 1-bit HARQ-ACK and SR transmission to two bits HARQ-ACK.

Embodiments with 2-bit HARQ-ACK + SR. For negative SR and 2-bit HARQ-ACK transmission with 2 transmitting antenna ports, HARQ-ACK is transmitted using the same CS configuration for 2-bit HARQ-ACK only transmission with 2 transmitting antenna ports in one PRB. For positive SR and 2-bit HARQ-ACK transmission with 2 transmitting antenna ports, HARQ-ACK is transmitted using the same CS configuration for 2-bit HARQ-ACK only transmission with 2 transmitting antenna ports in another PRB.

In some embodiments, the 2-bit HARQ-ACK is bundled to one bit. Then, for SR and

2-bit HARQ-ACK transmission with 2 transmitting antenna ports, the bundled 1-bit HARQ-ACK is transmitted using the same CS configuration for 1-bit HARQ-ACK and SR only transmission with 2 transmitting antenna ports.

For SR and 2-bit HARQ-ACK transmission with 4 transmitting antenna ports, the two HARQ-ACK is bundled to one bit. Then, for negative SR and 2-bit HARQ-ACK transmission with 4 transmitting antenna ports, the bundled one bit HARQ-ACK is transmitted using the same CS configuration for 1-bit HARQ-ACK only transmission with 4 transmitting antenna ports in one PRB. For positive SR and 2-bit HARQ-ACK transmission with 4 transmitting antenna ports, the bundled one bit HARQ-ACK is transmitted using the same CS configuration for 1-bit HARQ-ACK only transmission with 4 transmitting antenna ports in another PRB. Or, for SR and 2-bit HARQ-ACK transmission with 4 transmitting antenna ports, the bundled one bit HARQ-ACK is transmitted using the same CS configuration for 1-bit HARQ-ACK and SR only transmission with 4 transmitting antenna ports.

PUCCH Format Selection for UCI

In some embodiments, if the UE cannot determine a PUCCH format 2 or 3 or 4 to transmit UCI, rules should be specified for UE to pick up one PUCCH format. For example, if a UE has periodic/semi-persistent CSI reports and HARQ-ACK/SR to transmit in a PUCCH and the UE does not determine a PUCCH format 2 or 3 or 4 to transmit HARQ-ACK/SR and the UE is configured to transmit periodic/semi-persistent CSI report(s) in a PUCCH using PUCCH format 2 or PUCCH format 3 or PUCCH format 4, respectively, and *PUCCH-F2-simultaneous-HARQ-ACK-CSI = TRUE*, or *PUCCH-F3-simultaneous-HARQ-ACK-CSI = TRUE*, or *PUCCH-F4-simultaneous-HARQ-ACK-CSI*, respectively.

In some embodiments, the rule/procedure disclosed in Table 13 may be implemented.

Table 13: Procedures for selecting a PUCCH format

• If the UE is configured with $J \geq 1$ PUCCH format 2 resources, or with $J \geq 1$ PUCCH format 3 resources, or with $J \geq 1$ PUCCH format 4 resources, where the resources are indexed according to an ascending order for a number of corresponding Res

- if $\left(O_{\text{ACK}}+O_{\text{SR}}+O_{\text{CSI}}+O_{\text{CRC}}\right)\leq M_{\text{RB},0}^{\text{PUCCH}}\cdot N_{\text{sc,ctrl}}^{\text{RB}}\cdot N_{\text{symb},0}^{\text{PUCCH}}\cdot Q_m\cdot r$, the PUCCH uses PUCCH format 2 resource 0, or the PUCCH format 3 resource 0, or the PUCCH format 4 resource 0 by selecting the minimum number $M_{\text{RB},0,\min}^{\text{PUCCH}}$ of PRBs from the $M_{\text{RB},0}^{\text{PUCCH}}$ PRBs satisfying $\left(O_{\text{ACK}}+O_{\text{SR}}+O_{\text{CSI}}+O_{\text{CRC}}\right)\leq M_{\text{RB},0,\min}^{\text{PUCCH}}\cdot N_{\text{sc,ctrl}}^{\text{RB}}\cdot N_{\text{symb},0}^{\text{PUCCH}}\cdot Q_m\cdot r$ as described in Subclauses 9.2.3 and 9.2.5.1;
- else if $\left(O_{\text{ACK}}+O_{\text{SR}}+O_{\text{CSI}}+O_{\text{CRC}}\right)> M_{\text{RB},j}^{\text{PUCCH}}\cdot N_{\text{sc,ctrl}}^{\text{RB}}\cdot N_{\text{symb},j}^{\text{PUCCH}}\cdot Q_m\cdot r$ and $\left(O_{\text{ACK}}+O_{\text{SR}}+O_{\text{CSI}}+O_{\text{CRC}}\right)\leq M_{\text{RB},j+1}^{\text{PUCCH}}\cdot N_{\text{sc,ctrl}}^{\text{RB}}\cdot N_{\text{symb},j+1}^{\text{PUCCH}}\cdot Q_m\cdot r$, $0\leq j< J-1$, the UE transmits a PUCCH conveying HARQ-ACK/SR and periodic/semi-persistent CSI report(s) in a respective PUCCH where the PUCCH uses PUCCH format 2 resource $j+1$, or the PUCCH format 3 resource $j+1$, or the PUCCH format 4 resource $j+1$ by selecting the minimum number $M_{\text{RB},j+1,\min}^{\text{PUCCH}}$ of PRBs from the $M_{\text{RB},j+1}^{\text{PUCCH}}$ PRBs satisfying $\left(O_{\text{ACK}}+O_{\text{SR}}+O_{\text{CSI}}+O_{\text{CRC}}\right)\leq M_{\text{RB},j+1,\min}^{\text{PUCCH}}\cdot N_{\text{sc,ctrl}}^{\text{RB}}\cdot N_{\text{symb},0}^{\text{PUCCH}}\cdot Q_m\cdot r$
- else the PUCCH uses PUCCH format 2 resource $J-1$, or the PUCCH format 3 resource $J-1$, or the PUCCH format 4 resource $J-1$ by selecting the minimum number $M_{\text{RB},J-1,\min}^{\text{PUCCH}}$ of PRBs from the $M_{\text{RB},J-1}^{\text{PUCCH}}$ PRBs satisfying $\left(O_{\text{ACK}}+O_{\text{SR}}+O_{\text{CSI}}+O_{\text{CRC}}\right)\leq M_{\text{RB},J-1,\min}^{\text{PUCCH}}\cdot N_{\text{sc,ctrl}}^{\text{RB}}\cdot N_{\text{symb},0}^{\text{PUCCH}}\cdot Q_m\cdot r$

  where
  - O_{ACK} is the total number of HARQ-ACK bits;
  - $O_{\text{SR}}=0$ if there is no scheduling request bit; otherwise, $O_{\text{SR}}=1$;
  - O_{CSI} is the total number of CSI reports bits;
  - O_{CRC} is the total number of CRC bits, if any;
  - r is the code rate given by higher layer parameter *PUCCH-F2-maximum-coderate* for PUCCH format 2, or *PUCCH-F3-maximum-coderate* for PUCCH format 3, or *PUCCH-F4-maximum-coderate* for PUCCH format 4, respectively.
  - $M_{\text{RB}}^{\text{PUCCH}}$ is the number of PRBs for PUCCH format 2, or PUCCH format 3, or PUCCH format 4, respectively, where $M_{\text{RB}}^{\text{PUCCH}}$ is provided by higher layer parameter *PUCCH-F2-number-of-PRBs* for PUCCH format 2 or by higher layer parameter *PUCCH-F3-number-of-*PRBs for PUCCH format 3, and $M_{\text{RB}}^{\text{PUCCH}}=1$ for PUCCH format 4;
  - $N_{\text{sc,ctrl}}^{\text{RB}}=N_{\text{sc}}^{\text{RB}}-4$ for PUCCH format 2 and $N_{\text{sc,ctrl}}^{\text{RB}}=N_{\text{sc}}^{\text{RB}}$ for PUCCH format 3 and PUCCH format 4;
  - $N_{\text{symb}}^{\text{PUCCH}}$ is the number of symbols for PUCCH format 2 ($N_{\text{symb}}^{\text{PUCCH,}}$), or PUCCH format 3 ($N_{\text{symb}}^{\text{PUCCH,}}$), or PUCCH format 4 ($N_{\text{symb}}^{\text{PUCCH,}}$), respectively, where $N_{\text{symb}}^{\text{PUCCH}}$ is provided by higher layer parameter *PUCCH-F0-F2-number-of-symbols* for PUCCH format 2, and is

determined by higher layer parameter *PUCCH-F1-F3-F4-number-of-symbols* for PUCCH format 3 or for PUCCH format 4 after excluding a number of symbols used for DM-RS transmission for PUCCH format 3 or for PUCCH format 4, respectively ▪ $Q_m = 1$ if pi/2-BPSK is the modulation scheme and $Q_m = 2$ if QPSK is the modulation scheme as indicated by higher layer parameter *PUCCH-PF3-PF4-pi/2BPSK* for PUCCH format 3 or PUCCH format 4. For PUCCH format 2, $Q_m = 2$.

However, in some embodiments, if the minimum number $M_{\mathrm{RB},j,\min}^{\mathrm{PUCCH}}$ of PRBs for at least two PUCCH formats is the same, an additional rule may be defined.

In some some embodiments, UE uses the following priority rule to select a PUCCH format: Format 4> Format 3> Format 2 if at least two of the three formats has a same minimum number $M_{\mathrm{RB},j,\min}^{\mathrm{PUCCH}}$ of PRBs. The reason is PUCCH format 4 is a format with long duration which may satisfy the coverage and have multiplexing capacity. PUCCH format 3 is a long PUCCH format without multiplexing capacity. PUCCH format 2 is short PUCCH.

In some embodiments, considering PUCCH format 3 without multiplexing capacity may have the best performance, therefore the priority rule could be Format 3> Format 4> Format 2, or Format 3> Format 2> Format 4.

In some embodiments, UE uses the following priority rule to select the PUCCH format: Format 2> Format 4> Format 3 if at least two of the three formats has a same minimum number $M_{\mathrm{RB},j,\min}^{\mathrm{PUCCH}}$ of PRBs. This is to save more resources.

In some embodiments, UE uses a PUCCH format has the largest or smallest number of symbols in the time domain. In some embodiments, if the number of symbols of PUCCH format 3 and format 4 are the same, UE uses PUCCH format 4 for the transmission. In some embodiments, if the number of symbols of PUCCH format 3 and format 4 are the same, UE uses PUCCH format 3 for the transmission.

In some embodiments, UE uses a PUCCH format has the lowest code rate. If at least two PUCCH formats still has the same code rate, UE selects a PUCCH format by an order of: Format 4> Format 3> Format 2, or Format 2> Format 4> Format 3.

In some embodiments, the priority is based on PUCCH format index, i.e., Format 4> Format 3> Format 2 or Format 2> Format 3> Format 4. In some embodiments, the priority is based on one or more physical resource, where at least includes one or more of the following: a smallest or largest RB index, a smallest or largest starting index, the number of symbols in time domain.

Mapping when Increased Number of PUCCH Resources are Available

The *PUCCH-resource-set-size* may be defined as the number of resources in a resource set configured to a UE. The network uses an 2-bit PUCCH resource indicator field to further indicate at least one PUCCH resource to the UE.

If the *PUCCH-resource-set-size* is larger than four and the PUCCH resource indicator field indicates N PUCCH resources, N>=2, the UE determines a PUCCH resource from the two PUCCH resources through a mapping function.

One feature of introducing implicit mapping is to enable more alternatives within a resource set while not increasing the ARI overhead. However, the selection within a subset would not be always fully controlled by gNB. Therefore, the N resources within a subset better to have a same format. Otherwise, mismatch of required PUCCH format and actual transmitted format would occur. For example, the N resources are not allowed to be configured as one for PUCCH Format 0 and another for PUCCH Format 3.

In some embodiments, the N resources within a subset correspond to a same PUCCH format. In some embodiments, the N resources within a subset correspond to a same PUCCH format with the same duration in the time domain. In some embodiments, the N resources within a subset all correspond to a long PUCCH or all correspond to a short PUCCH. In some embodiments, the N resources within a subset all correspond to a PUCCH for up to 2 bits UCI or all correspond to a PUCCH for more than 2 bits UCI.

Another feature of implicit mapping is to reduce the possibility of collision among UEs, though cannot be avoided. In LTE, the lowest CCE index of the DL assignment is used to avoid collision among UEs scheduled in one subframe. In NR, it seems also necessary to introduce a parameter depending on the slot index in which the assignment is transmitted. Because, the HARQ-ACK corresponding to multiple PDSCH from different slots may be transmitted in one PUCCH. So, it is better to also reduce collision possibility incurred by different slots. For example, the mapping function is given as,

$$i = \left(\frac{n_{CCE}}{L} + c(n_s)\right) modN$$

where n_{CCE} and L is the lowest CCE index and aggregation level of the DL assignment in slot n_s, respectively. $c(i)$ is a pseudo-random function and initialized by a configured ID.

In some embodiments, the mapping function depends on at least one or more following parameters: CCE index control channel element (CCE) index, control resource set (CORESET) index, aggregation level (AL), a pseudo-random function which initialized by a configured ID and the number of N.

In some embodiments, the mapping function could be one or more following equations.

$$i = \left(n_{CORESET} + \frac{n_{CCE}}{L} + c(n_s)\right) modN$$

$$i = \left(\frac{n_{CCE}}{L} + n_{cs}(n_s, l)\right) modN$$

$$i = \left(n_{CORESET} + \frac{n_{CCE}}{L}\right) modN$$

$$i = \left(n_{CORESET} + \frac{n_{CCE}}{L} + n_{cs}(n_s, l)\right) modN$$

$$i = (n_{cs}(n_s, l)) modN$$

where, $n_{CORESET}$ is the index of the corresponding DL control resource set. n_{CCE} is the lowest CCE index of corresponding DL control channel, L is the aggregation level of DL control channel. $n_{cs}(n_s, l)$ is a function of slot index n_s and symbol index l.

In some embodiments, the mapping function is different for different PUCCH formats. For example, for PUCCH formats with multiplexing capacity, the mapping function could at least be determined one of the following factors, control channel element (CCE) index, control resource set (CORESET) index, aggregation level (AL), and the number of N. For PUCCH formats without multiplexing capacity, the mapping function could at least be determined one of the following factors, slot index and starting symbol index.

In some embodiments, the mapping function is different for different PUCCH formats. For example, the mapping function of PUCCH formats with less than 2 bits is different from formats with more than 2 bits. For example, UE determines a PUCCH resource from the two PUCCH resources depending on the state of the first bit for PUCCH formats with less than 2 bits. This may be beneficial to the HARQ-ACK state randomization.

In some embodiments, the mapping function is different for different PUCCH formats. For example, the mapping function of PUCCH formats with different duration is different. For example, UE determines a PUCCH resource from the two PUCCH resources depending on the state of the number of symbols. In some embodiments, UE would use the first resource if the number of PUCCH length is even, and use the second resource if the number of PUCCH length is odd. This may be beneficial to UE multiplexing.

FIG. 5 shows an example of a wireless communication method for uplink control channel transmissions. The method 500 includes, at step 510, determining that a first set of time resources overlaps with a second set of time resources, wherein a first set of resources for a first type of communication comprises the first set of time resources, and wherein a second set of resources for a second type of communication comprises the second set of time resources.

The method includes, at step 520, transmitting a signal, wherein the signal excludes at least a portion of the first type of communication based on lengths of the first and second sets of time resources, starting positions of the first and second sets of time resources, or traffic types of the first and second types of communication.

In some embodiments, and as described in the context of the "SR Transmission Partially Overlaps With HARQ ACK/P-CSI Transmission" section described in this patent document wherein the time resources of a first and second type of communication overlap, the selective transmission of at least a portion of a first type of communication or at least a portion of a second type of communication may be based on lengths of the first and second sets of time resources, starting positions of the first and second sets of time resources, or traffic types of the first and second types of communication.

In some embodiments, the method 500 may be implemented in scenarios described in the context of FIGS. 2, 3 and 4, and in the "SR Transmission Partially Overlaps With HARQ ACK/P-CSI Transmission" section described in this patent document.

FIG. 6 shows an example of a wireless communication method carried out on a wireless communication apparatus (or user equipment), in accordance with some embodiments of the presently disclosed technology. This example may include some features and/or steps that are similar to those shown in FIG. 5, and described in this document. At least some of these features and/or components may not be separately described in this section.

The method 600 includes, at step 610, determining that a first set of time resources overlaps with a second set of time resources, wherein a first set of resources for a scheduling request (SR) comprises the first set of time resources, and wherein a second set of resources for a hybrid automatic repeat request (HARQ) acknowledgement (ACK) message comprises the second set of time resources.

The method 600 includes, at step 620, transmitting a signal comprising at least a portion of the SR or at least a portion of the HARQ-ACK based on a format used on the first and second set of time resources or a type of the SR.

In some embodiments, the method 600 may be implemented in scenarios disclosed in the context of FIGS. 2, 3 and 4, and in the "SR Transmission Partially Overlaps With HARQ ACK/P-CSI Transmission" section described in this patent document.

FIG. 7 shows an example of a wireless communication method carried out on a wireless communication apparatus (or user equipment), in accordance with some embodiments of the presently disclosed technology. This example may include some features and/or steps that are similar to those shown in FIGS. 5 and 6, and described in this document. At least some of these features and/or components may not be separately described in this section.

The method 700 includes, at step 710, determining that a first set of time resources for a scheduling request (SR) overlaps with a second set of time resources for a hybrid automatic repeat request (HARQ) acknowledgement (ACK) message.

The method 700 includes, at step 720, determining an initial cyclic shift for a transmission of only the HARQ-ACK message.

The method 700 includes, at step 730, transmitting the SR and the HARQ-ACK message over a set of transmission resources, wherein the set of transmission resources are based on the initial cyclic shift or a type of the SR.

In some embodiments, the method 700 may be implemented in scenarios disclosed in the "Simultaneous Transmission of SR and HARQ ACK" section described in this patent document.

FIG. 8 shows an example of a wireless communication method carried out on a wireless communication apparatus (or user equipment), in accordance with some embodiments of the presently disclosed technology. This example may include some features and/or steps that are similar to those shown in FIGS. 5, 6 and 7, and described in this document. At least some of these features and/or components may not be separately described in this section.

The method 800 includes, at step 810, determining that a minimum number of physical resource blocks (PRBs) for at least two physical uplink control channel (PUCCH) formats are the same, wherein at least three PUCCH formats are available.

The method 800 includes, at step 820, selecting one of the at least three PUCCH formats based on a rule, wherein the rule is based on a number of symbols, a code rate, or a multiplexing capacity associated with each of the at least three PUCCH formats.

In some embodiments, the method 800 may be implemented in scenarios disclosed in the "PUCCH Format Selection for UCI" section described in this patent document.

FIG. 9 is a block diagram of an example apparatus that may implement a method or technique described in this documents (e.g., methods 500, 600, 700 or 800). A apparatus 905, such as a base station or a wireless device (or UE), can include processor electronics 910 such as a microprocessor that implements one or more of the techniques presented in this document. The apparatus 905 can include transceiver electronics 915 to send and/or receive wireless signals over one or more communication interfaces such as antenna(s) 920. The apparatus 905 can include other communication interfaces for transmitting and receiving data. Apparatus 905 can include one or more memories (not explicitly shown) configured to store information such as data and/or instructions. In some implementations, the processor electronics 910 can include at least a portion of the transceiver electronics 915. In some embodiments, at least some of the disclosed techniques, modules or functions are implemented using the apparatus 905.

It is intended that the specification, together with the drawings, be considered exemplary only, where exemplary means an example and, unless otherwise stated, does not imply an ideal or a preferred embodiment. As used herein, the singular forms "a", "an" and "the" are intended to include the plural forms as well, unless the context clearly indicates otherwise. Additionally, the use of "or" is intended to include "and/or", unless the context clearly indicates otherwise.

Some of the embodiments described herein are described in the general context of methods or processes, which may be implemented in one embodiment by a computer program product, embodied in a computer-readable medium, including computer-executable instructions, such as program code, executed by computers in networked environments. A computer-readable medium may include removable and non-removable storage devices including, but not limited to, Read Only Memory (ROM), Random Access Memory (RAM), compact discs (CDs), digital versatile discs (DVD), etc. Therefore, the computer-readable media can include a non-transitory storage media. Generally, program modules may include routines, programs, objects, components, data structures, etc., that perform particular tasks or implement particular abstract data types. Computer- or processor-executable instructions, associated data structures, and program modules represent examples of program code for executing steps of the methods disclosed herein. The particular sequence of such executable instructions or associated data structures represents examples of corresponding acts for implementing the functions described in such steps or processes.

Some of the disclosed embodiments can be implemented as devices or modules using hardware circuits, software, or combinations thereof. For example, a hardware circuit implementation can include discrete analog and/or digital components that are, for example, integrated as part of a printed circuit board. Alternatively, or additionally, the disclosed components or modules can be implemented as an Application Specific Integrated Circuit (ASIC) and/or as a Field Programmable Gate Array (FPGA) device. Some implementations may additionally or alternatively include a digital signal processor (DSP) that is a specialized microprocessor with an architecture optimized for the operational needs of digital signal processing associated with the disclosed functionalities of this application. Similarly, the various components or sub-components within each module may be implemented in software, hardware or firmware. The connectivity between the modules and/or components within the modules may be provided using any one of the connectivity methods and media that is known in the art, including, but not limited to, communications over the Internet, wired, or wireless networks using the appropriate protocols.

While this document contains many specifics, these should not be construed as limitations on the scope of an invention that is claimed or of what may be claimed, but rather as descriptions of features specific to particular embodiments. Certain features that are described in this document in the context of separate embodiments can also be implemented in combination in a single embodiment. Conversely, various features that are described in the context of a single embodiment can also be implemented in multiple embodiments separately or in any suitable sub-combination. Moreover, although features may be described above as acting in certain combinations and even initially claimed as such, one or more features from a claimed combination can in some cases be excised from the combination, and the claimed combination may be directed to a sub-combination or a variation of a sub-combination. Similarly, while operations are depicted in the drawings in a particular order, this should not be understood as requiring that such operations be performed in the particular order shown or in sequential order, or that all illustrated operations be performed, to achieve desirable results.

Only a few implementations and examples are described and other implementations, enhancements and variations can be made based on what is described and illustrated in this disclosure.

CLAIMS

1. A method for wireless communication, comprising:

determining that a first set of time resources overlaps with a second set of time resources, wherein a first set of resources for a first type of communication comprises the first set of time resources, and wherein a second set of resources for a second type of communication comprises the second set of time resources; and

transmitting a signal, wherein the signal excludes at least a portion of the first type of communication based on lengths of the first and second sets of time resources, starting positions of the first and second sets of time resources, or traffic types of the first and second types of communication.

2. The method of claim 1, wherein the first type of communication comprises a request for resources to enable subsequent data transmissions, and wherein the second type of communication comprises a feedback message that acknowledges successful or unsuccessful reception of a previously received signal.

3. The method of claim 1, wherein a length of the first set of time resources is longer than a length of the second set of time resources.

4. The method of claim 1, wherein the lengths of the first and second set of time resources are equal, and wherein the second set of time resources starts earlier in time than the first set of time resources.

5. The method of claim 1, wherein the traffic type of the first type of communication comprises enhanced Mobile Broadband (eMBB) traffic and the traffic type of the second type of communication comprises Ultra-Reliable and Low Latency Communication (URLLC).

6. The method of any of claims 1 to 5, wherein the first and second set of time resources comprise symbols, and wherein the signal excludes all symbols of the first type of communication.

7. The method of any of claims 1 to 5, wherein the first and second set of time resources comprise symbols, and wherein the signal excludes symbols of the first type of communication that overlap with symbols of the second type of communication.

8. The method of claim 1, wherein the first type of communication comprises a scheduling request (SR) or a hybrid automatic repeat request (HARQ) acknowledgement (ACK) message, and wherein the second type of communication comprises a periodic or semi-static channel state information (CSI) message.

9. A method for wireless communication, comprising:

determining that a first set of time resources overlaps with a second set of time resources, wherein a first set of resources for a scheduling request (SR) comprises the first set of time resources, and wherein a second set of resources for a hybrid automatic repeat request (HARQ) acknowledgement (ACK) message comprises the second set of time resources; and

transmitting a signal comprising at least a portion of the SR or at least a portion of the HARQ-ACK based on a format used on the first and second set of time resources or a type of the SR.

10. The method of claim 9, wherein the format for the second type of communication is physical uplink control channel format 0.

11. The method of claim 9 or 10, wherein the SR comprises a negative SR, and wherein the HARQ-ACK message is transmitted on the second set of resources.

12. The method of claim 10, wherein the SR comprises a positive SR.

13. The method of claim 12, wherein the first and the second set of time resources comprise symbols, wherein the signal comprises overlapping symbols of the positive SR and the HARQ-ACK message, and wherein the signal is transmitted on resources configured for simultaneous transmission of the SR and the HARQ-ACK message.

14. The method of claim 12, wherein the first and the second set of time resources comprise symbols, wherein the signal comprises overlapping symbols of the HARQ-ACK message, wherein the signal is transmitted on the first set of resources, and wherein the HARQ-ACK message is modulated using BPSK and QPSK for one-bit and two-bit HARQ-ACK messages, respectively.

15. The method of claim 12, wherein the first and the second set of time resources comprise symbols, wherein the signal comprises non-overlapping symbols of the positive SR, and wherein the signal is transmitted on the first set of resources.

16. The method of claim 12, wherein the first and the second set of time resources comprise symbols, wherein the signal comprises non-overlapping symbols of the HARQ-ACK message, and wherein the signal is transmitted on the second set of resources.

17. The method of claim 9, wherein the format for the second type of communication is physical uplink control channel format 1.

18. The method of claim 17, wherein the first and the second set of time resources comprise symbols, and wherein the signal comprises overlapping symbols of the HARQ-ACK message, and wherein the signal is transmitted on the first set of resources.

19. The method of claim 17, wherein the first and the second set of time resources comprise symbols, and wherein the signal comprises overlapping symbols of the HARQ-ACK, and wherein the signal is transmitted using cyclic shifts configured for the SR and using frequency resources configured for the HARQ-ACK message.

20. The method of claim 17, wherein the first and the second set of time resources comprise symbols, and wherein the signal excludes non-overlapping symbols of the SR.

21. The method of claim 17, wherein the first and the second set of time resources comprise

symbols, wherein the signal comprises non-overlapping symbols of the SR, and wherein the signal is transmitted on the first set of resources.

22. The method of claim 17, wherein the first and the second set of time resources comprise symbols, wherein the signal comprises non-overlapping symbols of the HARQ-ACK message, and wherein the signal is transmitted on the second set of resources.

23. A method for wireless communication, comprising:

determining that a first set of time resources for a scheduling request (SR) overlaps with a second set of time resources for a hybrid automatic repeat request (HARQ) acknowledgement (ACK) message;

determining an initial cyclic shift for a transmission of only the HARQ-ACK message; and

transmitting the SR and the HARQ-ACK message over a set of transmission resources, wherein the set of transmission resources are based on the initial cyclic shift or a type of the SR.

24. The method of claim 23, wherein the type of the SR is a positive SR or a negative SR.

25. The method of any of claim 23, further comprising:

determining an index of the initial cyclic shift;

in response to determining that the index is between *0* and *M*, allocating one physical resource block (PRB) to the set of transmission resources; and

in response to determining that the index is between *M+1* and *N*, allocating more than one PRB to the set of transmission resources.

26. A method for wireless communication, comprising:

determining that a minimum number of physical resource blocks (PRBs) for at least two physical uplink control channel (PUCCH) formats are the same, wherein at least three PUCCH formats are available; and selecting one of the at least three PUCCH formats based on a rule, wherein the rule is based on a number of symbols, a code rate, or a multiplexing capacity associated with each of the at least three PUCCH formats.

27. The method of claim 26, wherein the at least three PUCCH formats comprise PUCCH format 2, PUCCH format 3 and PUCCH format 4.

28. The method of any of claims 26 to 27, wherein in the rule is PUCCH format 4 > PUCCH format 3 > PUCCH format 2.

29. The method of any of claims 26 to 27, wherein in the rule is PUCCH format 2 > PUCCH format 4 > PUCCH format 3.

30. The method of any of claims 26 to 27, wherein the selecting is based on a largest number of symbols in each of the at least three PUCCH formats.

31. The method of any of claims 26 to 27, wherein the selecting is based on a smallest number of symbols in each of the at least three PUCCH formats.

32. The method of any of claims 26 to 27, wherein the selecting is based on a lowest code rate of each of the at least three PUCCH formats.

33. The method of claim 26, wherein a number of symbols in PUCCH format 3 and PUCCH format 4 are equal, and wherein PUCCH format 4 is selected.

34. The method of claim 26, wherein code rates of at least two of the at least three PUCCH formats are equal, and wherein the rule is PUCCH format 4 > PUCCH format 3 > PUCCH format 2.

35. The method of claim 26, wherein code rates of at least two of the at least three PUCCH

formats are equal, and wherein the rule is PUCCH format 2 > PUCCH format 4 > PUCCH format 3.

36. A wireless communications apparatus comprising a processor, wherein the processor is configured to implement a method recited in any of claims 1 to 8.

37. A wireless communications apparatus comprising a processor, wherein the processor is configured to implement a method recited in any of claims 9 to 22.

38. A wireless communications apparatus comprising a processor, wherein the processor is configured to implement a method recited in any of claims 23 to 25.

39. A wireless communications apparatus comprising a processor, wherein the processor is configured to implement a method recited in any of claims 26 to 35.

40. A computer program product comprising a computer-readable program medium code stored thereupon, the code, when executed by a processor, causing the processor to implement a method recited in any of claims 1 to 8.

41. A computer program product comprising a computer-readable program medium code stored thereupon, the code, when executed by a processor, causing the processor to implement a method recited in any of claims 9 to 22.

42. A computer program product comprising a computer-readable program medium code stored thereupon, the code, when executed by a processor, causing the processor to implement a method recited in any of claims 23 to 25.

43. A computer program product comprising a computer-readable program medium code stored thereupon, the code, when executed by a processor, causing the processor to implement a method recited in any of claims 26 to 35.

44. A method for wireless communication, comprising:

selectively transmitting at least a portion of a first type of communication or at least a portion of a second type of communication, wherein the first type of communication is different from the second type of communication,

wherein a first set of resources for the first type of communication comprises a first set of time resources, wherein a second set of resources for the second type of communication comprises a second set of time resources, wherein the first set of time resources partially overlaps the second set of time resources, and

wherein the selectively transmitting is based on lengths of the first and second sets of time resources, starting positions of the first and second sets of time resources, or traffic types of the first and second types of communication.

45. The method of claim 44, wherein the first type of communication comprises a request for resources to enable subsequent data transmissions, and wherein the second type of communication comprises a feedback message that acknowledges successful reception of a previously received signal.

46. The method of claim 44, wherein the at least a portion of the first type of communication is selectively transmitted, and wherein a length of the first set of time resources is shorter than a length of the second set of time resources.

47. The method of claim 44, wherein the at least a portion of the first type of communication is selectively transmitted, wherein the lengths of the first and second set of time resources are equal, and wherein the first set of time resources starts earlier in time than the second set of time resources.

48. The method of claim 44, wherein the first type of communication comprises a scheduling request (SR) or a hybrid automatic repeat request (HARQ) acknowledgement (ACK) message, and wherein the second type of communication comprises a periodic or semi-static channel state information (CSI) message.

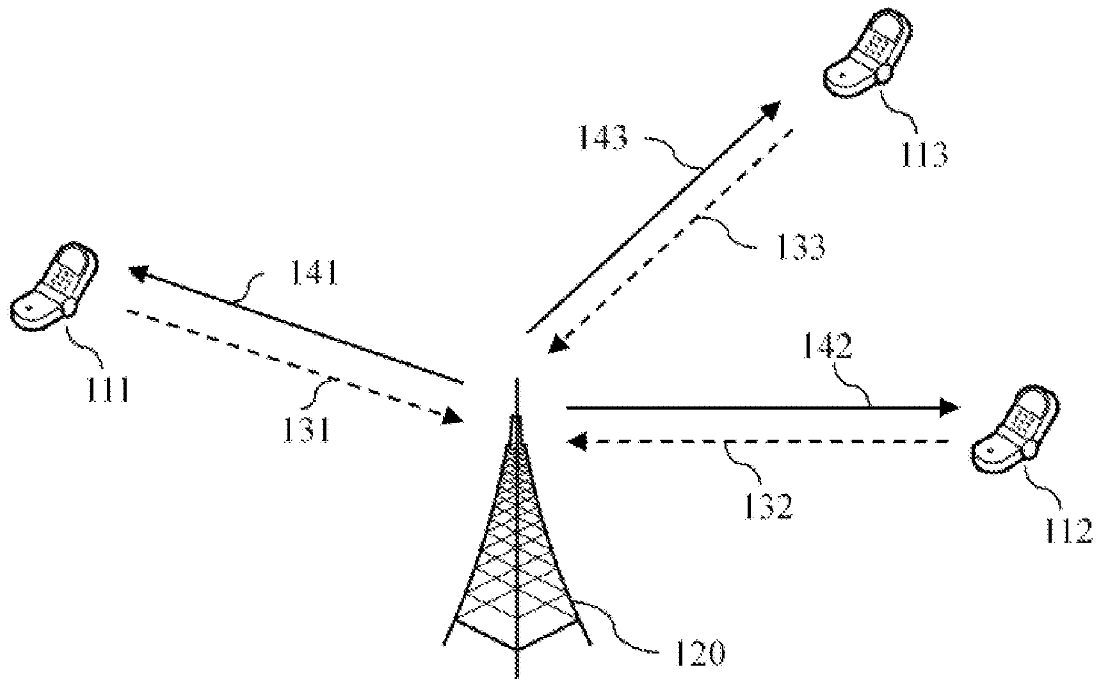

FIG. 1

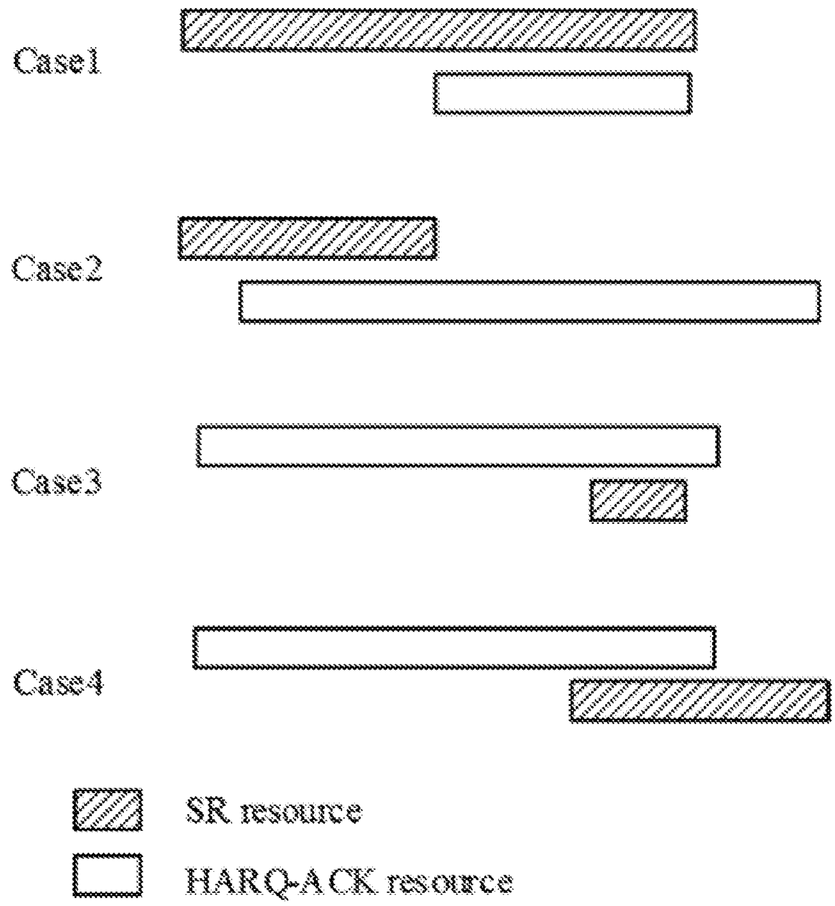

FIG. 2

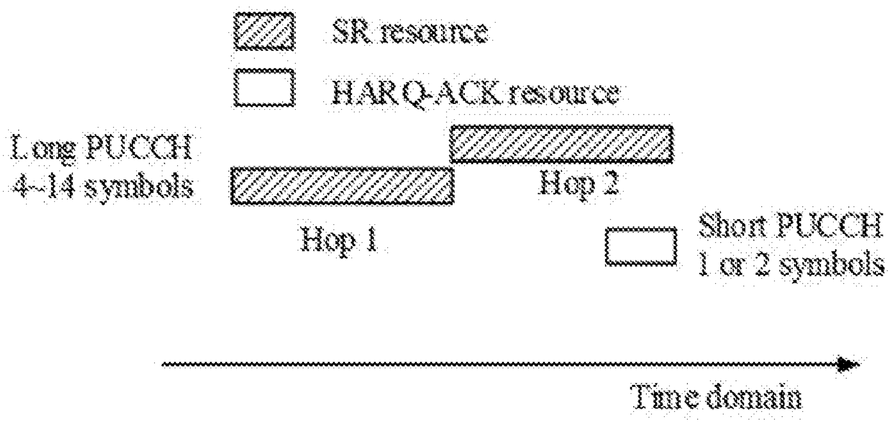
SR resource
HARQ-ACK resource
Long PUCCH
4~14 symbols
Hop 1
Hop 2
Short PUCCH
1 or 2 symbols
Time domain

FIG. 3

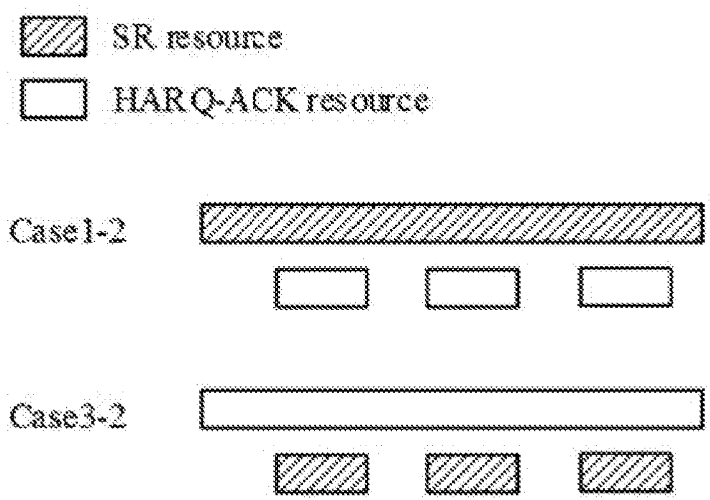
SR resource
HARQ-ACK resource
Case1-2
Case3-2

FIG. 4

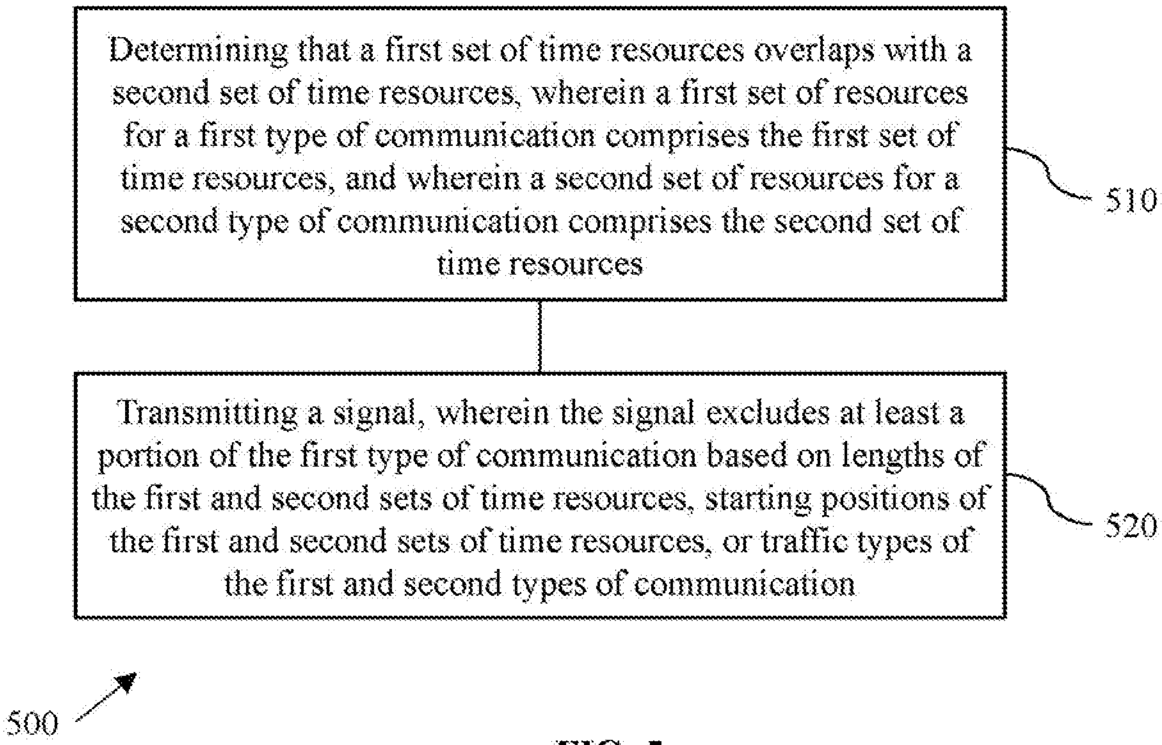
Determining that a first set of time resources overlaps with a second set of time resources, wherein a first set of resources for a first type of communication comprises the first set of time resources, and wherein a second set of resources for a second type of communication comprises the second set of time resources
510
Transmitting a signal, wherein the signal excludes at least a portion of the first type of communication based on lengths of the first and second sets of time resources, starting positions of the first and second sets of time resources, or traffic types of the first and second types of communication
520
500

FIG. 5

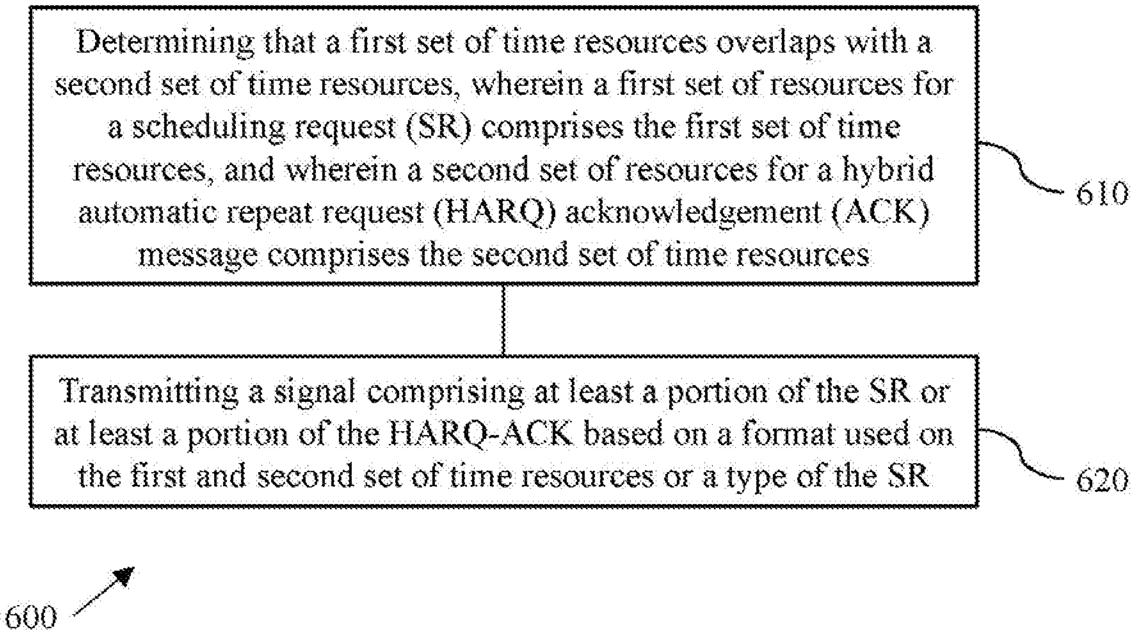
Determining that a first set of time resources overlaps with a second set of time resources, wherein a first set of resources for a scheduling request (SR) comprises the first set of time resources, and wherein a second set of resources for a hybrid automatic repeat request (HARQ) acknowledgement (ACK) message comprises the second set of time resources
610
Transmitting a signal comprising at least a portion of the SR or at least a portion of the HARQ-ACK based on a format used on the first and second set of time resources or a type of the SR
620
600

FIG. 6

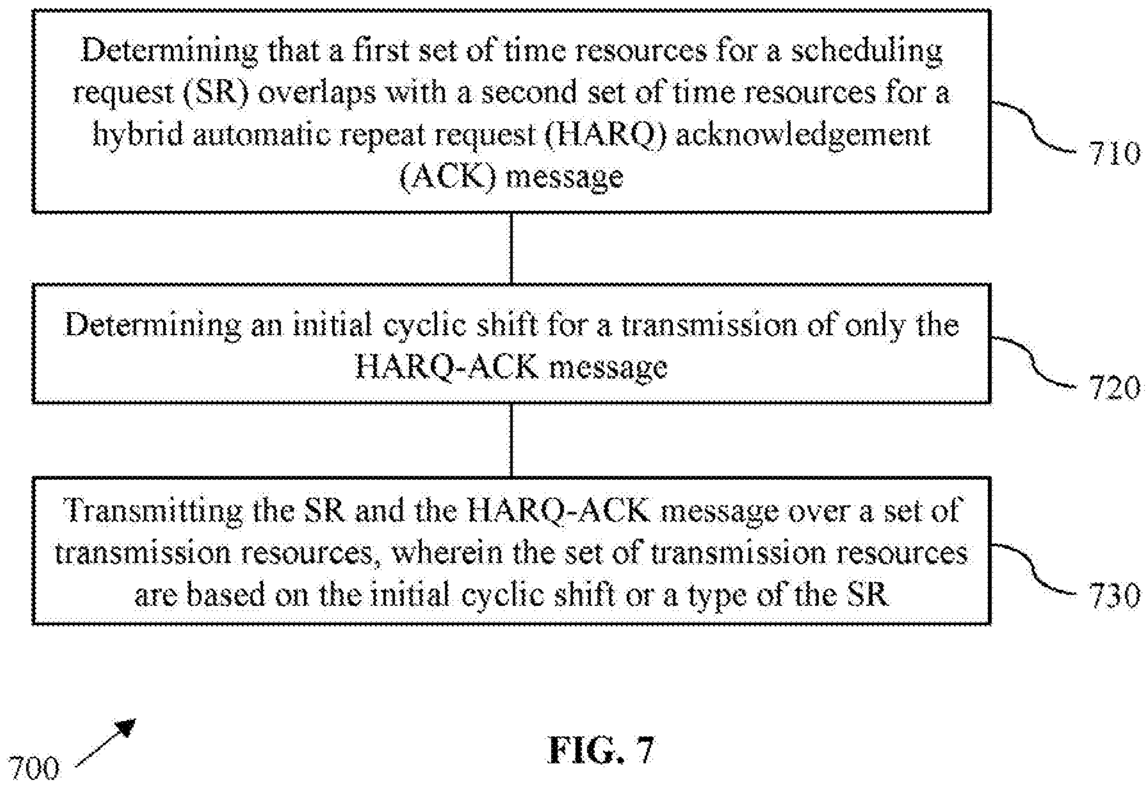
Determining that a first set of time resources for a scheduling request (SR) overlaps with a second set of time resources for a hybrid automatic repeat request (HARQ) acknowledgement (ACK) message
710
Determining an initial cyclic shift for a transmission of only the HARQ-ACK message
720
Transmitting the SR and the HARQ-ACK message over a set of transmission resources, wherein the set of transmission resources are based on the initial cyclic shift or a type of the SR
730
700

FIG. 7

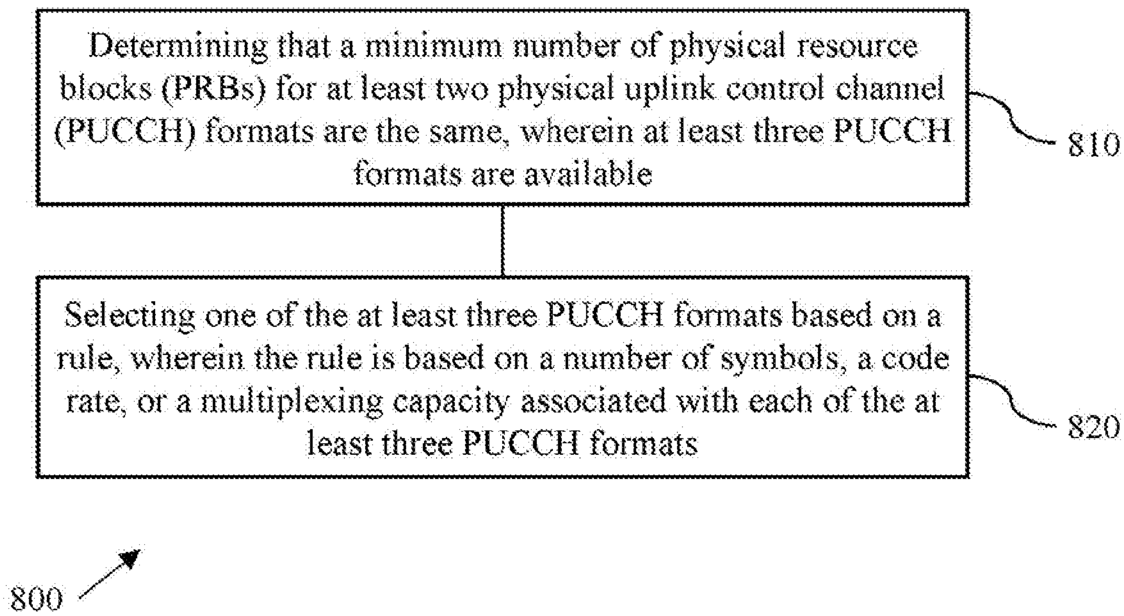
Determining that a minimum number of physical resource blocks (PRBs) for at least two physical uplink control channel (PUCCH) formats are the same, wherein at least three PUCCH formats are available
810
Selecting one of the at least three PUCCH formats based on a rule, wherein the rule is based on a number of symbols, a code rate, or a multiplexing capacity associated with each of the at least three PUCCH formats
820
800

FIG. 8

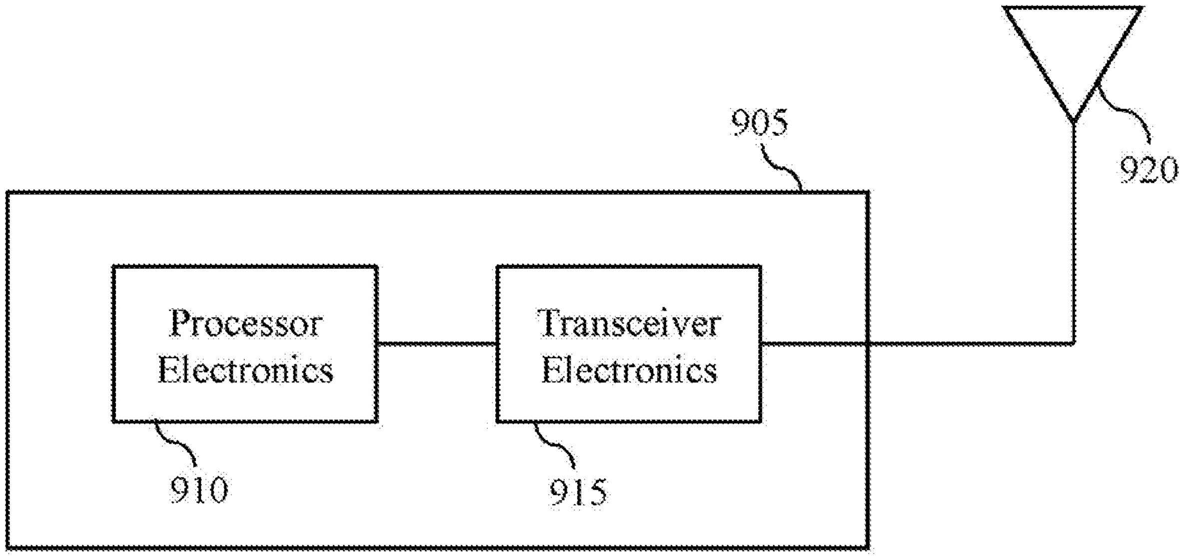
905
920
Processor
Electronics
Transceiver
Electronics
910
915

FIG. 9

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2018/072442

A. CLASSIFICATION OF SUBJECT MATTER

H04L 1/18(2006.01)i； H04W 24/10(2009.01)i

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

H04L; H04W; H04Q

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)

CNPAT, WPI, EPODOC, 3GPP, CNKI:time resource, resource, overlap, type, HARQ-ACK,ACK , NACK, SR, scheduling request, select, collocate, configure, deploy, PRB, minimum, format, PUCCH, multiplex

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	3GPP TS 38.213 V15.0.0,. "Physical layer procedures for control(Release 15)," 31 December 2017 (2017-12-31), section 9.2	26-35，39，43
A	3GPP TS 38.213 V15.0.0,. "Physical layer procedures for control(Release 15)," 31 December 2017 (2017-12-31), section 9.2	1-25，36-38，40-42，44-48
A	ZTE et. al,. "On short PUCCH for up to 2 bits UCI, R1-1719672," *3GPP TSG RAN WG1 Meeting 91,* 01 December 2017 (2017-12-01), the whole document	1-48
A	INTERDIGITAL INC.,. "On HARQ-ACK and SR multiplexing on Short-PUCCH, R1-1720638," *3GPP TSG RAN WG1 Meeting 91,* 01 December 2017 (2017-12-01), the whole document	1-48
A	WO 2017023146 A1 (INNOVATIVE TECHNOLOGY LAB CO., LTD.) 09 February 2017 (2017-02-09) the whole document	1-48

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

* Special categories of cited documents:
- "A" document defining the general state of the art which is not considered to be of particular relevance
- "E" earlier application or patent but published on or after the international filing date
- "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- "O" document referring to an oral disclosure, use, exhibition or other means
- "P" document published prior to the international filing date but later than the priority date claimed
- "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
- "&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
14 September 2018	**25 September 2018**

Name and mailing address of the ISA/CN	Authorized officer
STATE INTELLECTUAL PROPERTY OFFICE OF THE P.R.CHINA **6, Xitucheng Rd., Jimen Bridge, Haidian District, Beijing 100088** **China**	**LI,Xiaoli**
Facsimile No. **(86-10)62019451**	Telephone No. **86-(10)-53961772**

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	CN 103828318 A (LG ELECTRONICS INC.) 28 May 2014 (2014-05-28) the whole document	1-48

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2018/072442

Patent document cited in search report			Publication date (day/month/year)	Patent family member(s)			Publication date (day/month/year)
WO	2017023146	A1	09 February 2017	US	2017041923	A1	09 February 2017
CN	103828318	A	28 May 2014	US	2014233517	A1	21 August 2014
				CN	107196743	A	22 September 2017
				US	2018103467	A1	12 April 2018
				CN	107222301	A	29 September 2017
				KR	20140078694	A	25 June 2014
				EP	3346658	A1	11 July 2018
				US	2017135094	A1	11 May 2017
				EP	2760171	A2	30 July 2014
				WO	2013043018	A2	28 March 2013
				US	2016073396	A1	10 March 2016
				EP	2760172	A2	30 July 2014
				US	2018124779	A1	03 May 2018
				WO	2013043017	A2	28 March 2013
				US	2014226608	A1	14 August 2014
				CN	103828319	A	28 May 2014
				KR	20140089352	A	14 July 2014
				JP	2014531825	A	27 November 2014