



(51) International Patent Classification:
H04L 1/18 (2006.01)

(21) International Application Number:
PCT/CN2016/098682

(22) International Filing Date:
12 September 2016 (12.09.2016)

(25) Filing Language: English

(26) Publication Language: English

(71) Applicant: **LENOVO INNOVATIONS LIMITED (HONG KONG)** [CN/CN]; 23rd Floor, Lincoln House, Taikoo Place, 979 King's Road, Quarry Bay, Hong Kong (CN).

(72) Inventors: **XU, Jing**; WenHua West Street No. 10, Changping District, Beijing 102208 (CN). **SONG, Xinghua**; B2-04L No. 6, Shangdi West Road, Beijing 100085 (CN). **YU, Xiaodong**; No. 452, Building 6, Qinghuayuan, Haidian District, Beijing 100084 (CN). **LOVE, Robert T.**; 817 S. Hough Street, Barrington, Illinois 60010 (US).

(74) Agent: **CHINA SINDA INTELLECTUAL PROPERTY LTD.**; B11th Floor, Focus Place, 19 Financial Street, Xicheng District, Beijing 100033 (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, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, 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: PUSCH TRANSMISSIONS IN A WIRELESS COMMUNICATION SYSTEM

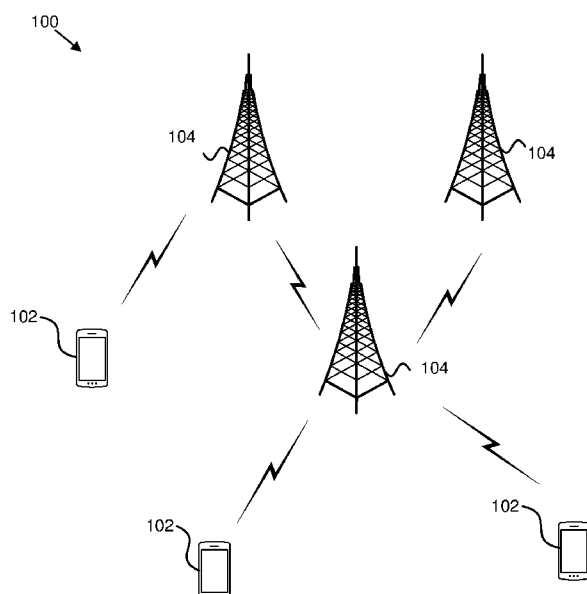


FIG. 1

(57) Abstract: Apparatuses, methods, and systems are disclosed for physical uplink shared channel ("PUSCH") transmissions. One apparatus includes a processor that determines a periodicity integer l corresponding to a hybrid automatic repeat request ("HARQ") round trip time ("RTT"). The apparatus includes a transmitter that transmits a first PUSCH associated with a HARQ process in an uplink pilot time slot ("UpPTS") of a subframe n , and transmits a second PUSCH associated with the HARQ process. The second PUSCH carries information selected from a group including a new transmission and a corresponding retransmission of the first PUSCH in an UpPTS of a subframe $n + k * 1$. k is a positive integer.



PUSCH TRANSMISSIONS IN A WIRELESS COMMUNICATION SYSTEM

FIELD

[0001] The subject matter disclosed herein relates generally to wireless communications and more particularly relates to physical uplink shared channel ("PUSCH") transmissions in a wireless communication system.

BACKGROUND

[0002] The following abbreviations are herewith defined, at least some of which are referred to within the following description: Third Generation Partnership Project ("3GPP"), Positive-Acknowledgment ("ACK"), Binary Phase Shift Keying ("BPSK"), Clear Channel Assessment ("CCA"), Cyclic Prefix ("CP"), Channel State Information ("CSI"), Common Search Space ("CSS"), Downlink Control Information ("DCI"), Downlink ("DL"), Downlink Pilot Time Slot ("DwPTS"), Enhanced Clear Channel Assessment ("eCCA"), Evolved Node B ("eNB"), European Telecommunications Standards Institute ("ETSI"), Frame Based Equipment ("FBE"), Frequency Division Duplex ("FDD"), Frequency Division Multiple Access ("FDMA"), Guard Period ("GP"), Hybrid Automatic Repeat Request ("HARQ"), Licensed Assisted Access ("LAA"), Load Based Equipment ("LBE"), Listen-Before-Talk ("LBT"), Long Term Evolution ("LTE"), Negative-Acknowledgment ("NACK") or ("NAK"), Orthogonal Frequency Division Multiplexing ("OFDM"), Primary Cell ("PCell"), Physical Broadcast Channel ("PBCH"), Physical Downlink Control Channel ("PDCCH"), Physical Downlink Shared Channel ("PDSCH"), Physical Hybrid ARQ Indicator Channel ("PHICH"), Physical Random Access Channel ("PRACH"), Physical Resource Block ("PRB"), Physical Uplink Control Channel ("PUCCH"), Physical Uplink Shared Channel ("PUSCH"), Quality of Service ("QoS"), Quadrature Phase Shift Keying ("QPSK"), Radio Resource Control ("RRC"), Round Trip Time ("RTT"), Receive ("RX"), Single Carrier Frequency Division Multiple Access ("SC-FDMA"), Secondary Cell ("SCell"), Shared Channel ("SCH"), Signal-to-Interference-Plus-Noise Ratio ("SINR"), Transport Block ("TB"), Transport Block Size ("TBS"), Time-Division Duplex ("TDD"), Time Division Multiplex ("TDM"), Transmit ("TX"), Uplink Control Information ("UCI"), User Entity/Equipment (Mobile Terminal) ("UE"), Uplink ("UL"), Universal Mobile Telecommunications System ("UMTS"), Uplink Pilot Time Slot ("UpPTS"), and Worldwide Interoperability for Microwave Access ("WiMAX"). As used herein, "HARQ-ACK" may represent collectively the Positive Acknowledge ("ACK") and the Negative Acknowledge ("NAK"). ACK means that a TB is correctly received while NAK means a TB is erroneously received.

[0003] In wireless communications networks, a radio frame may include two half-frames. Each half-frame may include five subframes. In certain configurations, there are two subframe types in a frame structure for LTE TDD: a normal subframe, and a special subframe. The normal subframe may be defined as two slots that are used for UL or DL transmission. The special subframe may include three fields: DwPTS, GP, and UpPTS. Certain configurations for DwPTS, GP, and UpPTS are listed in Table 1. In some configurations of the special subframe, DwPTS may carry PDSCH; however, UpPTS may not carry PUSCH.

Table 1

Special subframe configuration	Normal cyclic prefix in downlink			Extended cyclic prefix in downlink		
	DwPTS	UpPTS		DwPTS	UpPTS	
		Normal cyclic prefix in uplink	Extended cyclic prefix in uplink		Normal cyclic prefix in uplink	Extended cyclic prefix in uplink
0	$6592 \cdot T_s$	$2192 \cdot T_s$	$2560 \cdot T_s$	$7680 \cdot T_s$	$2192 \cdot T_s$	$2560 \cdot T_s$
1	$19760 \cdot T_s$			$20480 \cdot T_s$		
2	$21952 \cdot T_s$			$23040 \cdot T_s$		
3	$24144 \cdot T_s$			$25600 \cdot T_s$		
4	$26336 \cdot T_s$	$4384 \cdot T_s$	$5120 \cdot T_s$	$7680 \cdot T_s$	$4384 \cdot T_s$	$5120 \cdot T_s$
5	$6592 \cdot T_s$			$20480 \cdot T_s$		
6	$19760 \cdot T_s$			$23040 \cdot T_s$		
7	$21952 \cdot T_s$			$12800 \cdot T_s$		
8	$24144 \cdot T_s$			-	-	-
9	$13168 \cdot T_s$			-	-	-

[0004] The LTE TDD uplink-downlink (“UL/DL”) configurations are shown in Table 2. It should be noted that in Table 2, “D” represents a DL subframe, “U” represents an UL subframe, and “S” represents a special subframe. UL/DL configurations with both 5 millisecond (“ms”) and 10 ms downlink-to-uplink switch-point periodicity are included in the UL/DL configurations. In configurations with 5 ms downlink-to-uplink switch-point periodicity, the

special subframe exists in both half-frames. In configurations with 10 ms downlink-to-uplink switch-point periodicity, the special subframe exists in the first half-frame only.

Table 2

Uplink-downlink configuration	Downlink-to-Uplink Switch-point periodicity	Subframe number									
		0	1	2	3	4	5	6	7	8	9
0	5 ms	D	S	U	U	U	D	S	U	U	U
1	5 ms	D	S	U	U	D	D	S	U	U	D
2	5 ms	D	S	U	D	D	D	S	U	D	D
3	10 ms	D	S	U	U	U	D	D	D	D	D
4	10 ms	D	S	U	U	D	D	D	D	D	D
5	10 ms	D	S	U	D	D	D	D	D	D	D
6	5 ms	D	S	U	U	U	D	S	U	U	D

5

[0005] In certain LTE systems, synchronous HARQ may be applied in UL transmissions. Table 3 shows the timing between PUSCH transmissions in a subframe n and corresponding ACK/NACK feedback in a subframe $n + k_{PHICH}$ for each UL/DL configuration.

Table 3

TDD UL/DL Configuration	subframe index n									
	0	1	2	3	4	5	6	7	8	9
0			4	7	6			4	7	6
1			4	6				4	6	
2			6					6		
3			6	6	6					
4			6	6						
5			6							
6			4	6	6			4	7	

10

[0006] Table 4 shows the timing between an UL grant or a PHICH in a subframe n and corresponding PUSCH transmission in a subframe $n + k$ for each UL/DL configuration, of which UL/DL configuration 0 is a special case. For example, for TDD UL/DL configuration 0, a UE

15

shall upon detection of an UL grant or a PHICH in subframe n intended for the UE, adjust the corresponding PUSCH transmission in the subframe $n + k$, if the MSB of the UL index in the DCI format 0 is set to 1 or if $I_{PHICH} = 0$. A UE shall upon detection of an UL grant or a PHICH in a subframe n intended for the UE, adjust the corresponding PUSCH transmission in subframe $n + 7$, if the LSB of the UL index in the PDCCH/EPDCCH with DCI format 0 is set to 1 in subframe n or if $I_{PHICH} = 1$.

Table 4

TDD UL/DL Configuration	subframe number n									
	0	1	2	3	4	5	6	7	8	9
0	4	6				4	6			
1		6			4		6			4
2				4					4	
3	4								4	4
4									4	4
5									4	
6	7	7				7	7			5

[0007] Although UpPTS may support up to 6 OFDM symbols, it is unclear how the additional OFDM symbols in the UpPTS may be used.

BRIEF SUMMARY

[0008] Apparatuses for physical uplink shared channel (“PUSCH”) transmissions are disclosed. Methods and systems also perform the functions of the apparatus. In one embodiment, the apparatus includes a processor that determines a periodicity integer l corresponding to a hybrid automatic repeat request (“HARQ”) round trip time (“RTT”). In various embodiments, the apparatus includes a transmitter that transmits a first PUSCH associated with a HARQ process in an uplink pilot time slot (“UpPTS”) of a subframe n , and transmits a second PUSCH associated with the HARQ process. The second PUSCH carries information selected from a group including a new transmission and a corresponding retransmission of the first PUSCH in an UpPTS of a subframe $n + k * l$. In such an embodiment, k is a positive integer.

[0009] In one embodiment, the periodicity integer l is selected from a group including 5 and 10. In a further embodiment, the apparatus includes a receiver that receives an uplink (“UL”) grant in a subframe selected from a group including a subframe $n - 5$ and a subframe $n - 6$. In

such an embodiment, the UL grant corresponds to transmitting the first PUSCH in the subframe n . In some embodiments, the apparatus includes a receiver that receives an UL grant in a subframe selected from a group including a subframe $n - 5$ and a subframe $n - 6$, and receives feedback corresponding to the first PUSCH in a physical HARQ indicator channel (“PHICH”) in a subframe selected from a group including a subframe $n + 4$ and a subframe $n + 5$ in response to a configured uplink/downlink (“UL/DL”) configuration being selected from a group including UL/DL configuration 0 and UL/DL configuration 6. In such an embodiment, the UL grant corresponds to transmitting the first PUSCH in the subframe n . In certain embodiments, the apparatus includes a receiver that receives an UL grant in a subframe $n - 5$, and receives feedback corresponding to the first PUSCH in a PHICH in a subframe $n + 5$ in response to a configured UL/DL configuration being UL/DL configuration 1. In such an embodiment, the UL grant corresponds to transmitting the first PUSCH in the subframe n .

[0010] In another embodiment, the apparatus includes a receiver that receives an UL grant in a subframe $n - 3$, and receives feedback corresponding to the first PUSCH in a PHICH in a subframe $n + 7$ in response to a configured UL/DL configuration being selected from a group including UL/DL configuration 2, UL/DL configuration 3, UL/DL configuration 4, and UL/DL configuration 5. In such an embodiment, the UL grant corresponds to transmitting the first PUSCH in the subframe n . In various embodiments, the apparatus includes a receiver that receives an UL grant to trigger transmitting the second PUSCH. In some embodiments, the apparatus includes a receiver that receives feedback in a PHICH corresponding to the first PUSCH in the subframe n . In such embodiments, a PHICH resource functions as a subframe number.

[0011] A method for transmitting PUSCH, in one embodiment, includes determining a periodicity integer l corresponding to a HARQ RTT. In various embodiments, the method includes transmitting a first PUSCH associated with a HARQ process in an UpPTS of a subframe n . In some embodiments, the method includes transmitting a second PUSCH associated with the HARQ process. The second PUSCH carries information selected from a group including a new transmission and a corresponding retransmission of the first PUSCH in an UpPTS of a subframe $n + k * l$. In such an embodiment, k is a positive integer.

[0012] In one embodiment, an apparatus includes a processor that determines a periodicity integer l corresponding to a HARQ RTT. In various embodiments, the apparatus includes a receiver that receives a first PUSCH associated with a HARQ process in an UpPTS of a subframe n . In some embodiments, the receiver receives a second PUSCH associated with the HARQ process. The second PUSCH carries information selected from a group including a new

transmission and a corresponding retransmission of the first PUSCH in an UpPTS of a subframe $n + k * l$. In such an embodiment, k is a positive integer.

[0013] In one embodiment, the periodicity integer l is selected from a group including 5 and 10. In a further embodiment, the apparatus includes a transmitter that transmits an UL grant in a subframe selected from a group including a subframe $n - 5$ and a subframe $n - 6$. In such an embodiment, the UL grant corresponds to receiving the first PUSCH in the subframe n . In some embodiments, the apparatus includes a transmitter that transmits an UL grant in a subframe selected from a group including a subframe $n - 5$ and a subframe $n - 6$, and transmits feedback corresponding to the first PUSCH in a PHICH in a subframe selected from a group including a subframe $n + 4$ and a subframe $n + 5$ in response to a configured UL/DL configuration being selected from a group including UL/DL configuration 0 and UL/DL configuration 6. In such an embodiment, the UL grant corresponds to receiving the first PUSCH in the subframe n . In certain embodiments, the apparatus includes a transmitter that transmits an UL grant in a subframe $n - 5$, and transmits feedback corresponding to the first PUSCH in a PHICH in a subframe $n + 5$ in response to a configured UL/DL configuration being UL/DL configuration 1. In such an embodiment, the UL grant corresponds to receiving the first PUSCH in the subframe n .

[0014] In another embodiment, the apparatus includes a transmitter that transmits an UL grant in a subframe $n - 3$, and transmits feedback corresponding to the first PUSCH in a PHICH in a subframe $n + 7$ in response to a configured UL/DL configuration being selected from a group including UL/DL configuration 2, UL/DL configuration 3, UL/DL configuration 4, and UL/DL configuration 5. In such an embodiment, the UL grant corresponds to receiving the first PUSCH in the subframe n . In various embodiments, the apparatus includes a transmitter that transmits an UL grant to trigger transmission of the second PUSCH. In some embodiments, the apparatus includes a transmitter that transmits feedback in a PHICH corresponding to the first PUSCH in the subframe n . In such embodiments, a PHICH resource functions as a subframe number.

[0015] A method for receiving PUSCH, in one embodiment, includes determining a periodicity integer l corresponding to a HARQ RTT. In various embodiments, the method includes receiving a first PUSCH associated with a HARQ process in an UpPTS of a subframe n . In some embodiments, the method includes receiving a second PUSCH associated with the HARQ process. The second PUSCH carries information selected from a group including a new transmission and a corresponding retransmission of the first PUSCH in an UpPTS of a subframe $n + k * l$. In such an embodiment, k is a positive integer.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016] A more particular description of the embodiments briefly described above will be rendered by reference to specific embodiments that are illustrated in the appended drawings. Understanding that these drawings depict only some embodiments and are not therefore to be considered to be limiting of scope, the embodiments will be described and explained with additional specificity and detail through the use of the accompanying drawings, in which:

[0017] Figure 1 is a schematic block diagram illustrating one embodiment of a wireless communication system for PUSCH transmissions in UpPTS;

[0018] Figure 2 is a schematic block diagram illustrating one embodiment of an apparatus that may be used for transmitting a PUSCH in an UpPTS;

[0019] Figure 3 is a schematic block diagram illustrating one embodiment of an apparatus that may be used for receiving a PUSCH in an UpPTS;

[0020] Figure 4 illustrates one embodiment of HARQ timing for PUSCH transmissions in UpPTS;

[0021] Figure 5 illustrates another embodiment of HARQ timing for PUSCH transmissions in UpPTS;

[0022] Figure 6 illustrates a further embodiment of HARQ timing for PUSCH transmissions in UpPTS;

[0023] Figure 7 illustrates an embodiment of HARQ timing for PUSCH transmissions in UpPTS for UL/DL configurations 0, 1, and 6;

[0024] Figure 8 illustrates an embodiment of HARQ timing for PUSCH transmissions in UpPTS for UL/DL configuration 2;

[0025] Figure 9 illustrates an embodiment of HARQ timing for PUSCH transmissions in UpPTS for UL/DL configurations 3, 4, and 5;

[0026] Figure 10 is a schematic flow chart diagram illustrating one embodiment of a method for transmitting a PUSCH in UpPTS; and

[0027] Figure 11 is a schematic flow chart diagram illustrating one embodiment of a method for receiving a PUSCH in UpPTS.

DETAILED DESCRIPTION

[0028] As will be appreciated by one skilled in the art, aspects of the embodiments may be embodied as a system, apparatus, method, or program product. Accordingly, embodiments may take the form of an entirely hardware embodiment, an entirely software embodiment (including firmware, resident software, micro-code, etc.) or an embodiment combining software and hardware aspects that may all generally be referred to herein as a “circuit,” “module” or

“system.” Furthermore, embodiments may take the form of a program product embodied in one or more computer readable storage devices storing machine readable code, computer readable code, and/or program code, referred hereafter as code. The storage devices may be tangible, non-transitory, and/or non-transmission. The storage devices may not embody signals. In a certain embodiment, the storage devices only employ signals for accessing code.

[0029] Certain of the functional units described in this specification may be labeled as modules, in order to more particularly emphasize their implementation independence. For example, a module may be implemented as a hardware circuit comprising custom very-large-scale integration (“VLSI”) circuits or gate arrays, off-the-shelf semiconductors such as logic chips, transistors, or other discrete components. A module may also be implemented in programmable hardware devices such as field programmable gate arrays, programmable array logic, programmable logic devices or the like.

[0030] Modules may also be implemented in code and/or software for execution by various types of processors. An identified module of code may, for instance, include one or more physical or logical blocks of executable code which may, for instance, be organized as an object, procedure, or function. Nevertheless, the executables of an identified module need not be physically located together, but may include disparate instructions stored in different locations which, when joined logically together, include the module and achieve the stated purpose for the module.

[0031] Indeed, a module of code may be a single instruction, or many instructions, and may even be distributed over several different code segments, among different programs, and across several memory devices. Similarly, operational data may be identified and illustrated herein within modules, and may be embodied in any suitable form and organized within any suitable type of data structure. The operational data may be collected as a single data set, or may be distributed over different locations including over different computer readable storage devices. Where a module or portions of a module are implemented in software, the software portions are stored on one or more computer readable storage devices.

[0032] Any combination of one or more computer readable medium may be utilized. The computer readable medium may be a computer readable storage medium. The computer readable storage medium may be a storage device storing the code. The storage device may be, for example, but not limited to, an electronic, magnetic, optical, electromagnetic, infrared, holographic, micromechanical, or semiconductor system, apparatus, or device, or any suitable combination of the foregoing.

[0033] More specific examples (a non-exhaustive list) of the storage device would include the following: an electrical connection having one or more wires, a portable computer diskette, a hard disk, a random access memory ("RAM"), a read-only memory ("ROM"), an erasable programmable read-only memory ("EPROM" or Flash memory), a portable compact disc read-only memory ("CD-ROM"), an optical storage device, a magnetic storage device, or any suitable combination of the foregoing. In the context of this document, a computer readable storage medium may be any tangible medium that can contain, or store a program for use by or in connection with an instruction execution system, apparatus, or device.

[0034] Code for carrying out operations for embodiments may be any number of lines and may be written in any combination of one or more programming languages including an object oriented programming language such as Python, Ruby, Java, Smalltalk, C++, or the like, and conventional procedural programming languages, such as the "C" programming language, or the like, and/or machine languages such as assembly languages. The code may execute entirely on the user's computer, partly on the user's computer, as a stand-alone software package, partly on the user's computer and partly on a remote computer or entirely on the remote computer or server. In the latter scenario, the remote computer may be connected to the user's computer through any type of network, including a local area network ("LAN") or a wide area network ("WAN"), or the connection may be made to an external computer (for example, through the Internet using an Internet Service Provider).

[0035] Reference throughout this specification to "one embodiment," "an embodiment," or similar language means that a particular feature, structure, or characteristic described in connection with the embodiment is included in at least one embodiment. Thus, appearances of the phrases "in one embodiment," "in an embodiment," and similar language throughout this specification may, but do not necessarily, all refer to the same embodiment, but mean "one or more but not all embodiments" unless expressly specified otherwise. The terms "including," "comprising," "having," and variations thereof mean "including but not limited to," unless expressly specified otherwise. An enumerated listing of items does not imply that any or all of the items are mutually exclusive, unless expressly specified otherwise. The terms "a," "an," and "the" also refer to "one or more" unless expressly specified otherwise.

[0036] Furthermore, the described features, structures, or characteristics of the embodiments may be combined in any suitable manner. In the following description, numerous specific details are provided, such as examples of programming, software modules, user selections, network transactions, database queries, database structures, hardware modules, hardware circuits, hardware chips, etc., to provide a thorough understanding of embodiments.

One skilled in the relevant art will recognize, however, that embodiments may be practiced without one or more of the specific details, or with other methods, components, materials, and so forth. In other instances, well-known structures, materials, or operations are not shown or described in detail to avoid obscuring aspects of an embodiment.

5 [0037] Aspects of the embodiments are described below with reference to schematic flowchart diagrams and/or schematic block diagrams of methods, apparatuses, systems, and program products according to embodiments. It will be understood that each block of the schematic flowchart diagrams and/or schematic block diagrams, and combinations of blocks in the schematic flowchart diagrams and/or schematic block diagrams, can be implemented by code.
10 These code may be provided to a processor of a general purpose computer, special purpose computer, or other programmable data processing apparatus to produce a machine, such that the instructions, which execute via the processor of the computer or other programmable data processing apparatus, create means for implementing the functions/acts specified in the schematic flowchart diagrams and/or schematic block diagrams block or blocks.

15 [0038] The code may also be stored in a storage device that can direct a computer, other programmable data processing apparatus, or other devices to function in a particular manner, such that the instructions stored in the storage device produce an article of manufacture including instructions which implement the function/act specified in the schematic flowchart diagrams and/or schematic block diagrams block or blocks.

20 [0039] The code may also be loaded onto a computer, other programmable data processing apparatus, or other devices to cause a series of operational steps to be performed on the computer, other programmable apparatus or other devices to produce a computer implemented process such that the code which execute on the computer or other programmable apparatus provide processes for implementing the functions/acts specified in the flowchart and/or
25 block diagram block or blocks.

[0040] The schematic flowchart diagrams and/or schematic block diagrams in the Figures illustrate the architecture, functionality, and operation of possible implementations of apparatuses, systems, methods and program products according to various embodiments. In this regard, each block in the schematic flowchart diagrams and/or schematic block diagrams may
30 represent a module, segment, or portion of code, which includes one or more executable instructions of the code for implementing the specified logical function(s).

[0041] It should also be noted that, in some alternative implementations, the functions noted in the block may occur out of the order noted in the Figures. For example, two blocks shown in succession may, in fact, be executed substantially concurrently, or the blocks may

sometimes be executed in the reverse order, depending upon the functionality involved. Other steps and methods may be conceived that are equivalent in function, logic, or effect to one or more blocks, or portions thereof, of the illustrated Figures.

[0042] Although various arrow types and line types may be employed in the flowchart and/or block diagrams, they are understood not to limit the scope of the corresponding embodiments. Indeed, some arrows or other connectors may be used to indicate only the logical flow of the depicted embodiment. For instance, an arrow may indicate a waiting or monitoring period of unspecified duration between enumerated steps of the depicted embodiment. It will also be noted that each block of the block diagrams and/or flowchart diagrams, and combinations of blocks in the block diagrams and/or flowchart diagrams, can be implemented by special purpose hardware-based systems that perform the specified functions or acts, or combinations of special purpose hardware and code.

[0043] The description of elements in each figure may refer to elements of proceeding figures. Like numbers refer to like elements in all figures, including alternate embodiments of like elements.

[0044] Figure 1 depicts an embodiment of a wireless communication system 100 for PUSCH transmissions in UpPTS. In one embodiment, the wireless communication system 100 includes remote units 102 and base units 104. Even though a specific number of remote units 102 and base units 104 are depicted in Figure 1, one of skill in the art will recognize that any number of remote units 102 and base units 104 may be included in the wireless communication system 100.

[0045] In one embodiment, the remote units 102 may include computing devices, such as desktop computers, laptop computers, personal digital assistants (“PDAs”), tablet computers, smart phones, smart televisions (e.g., televisions connected to the Internet), set-top boxes, game consoles, security systems (including security cameras), vehicle on-board computers, network devices (e.g., routers, switches, modems), or the like. In some embodiments, the remote units 102 include wearable devices, such as smart watches, fitness bands, optical head-mounted displays, or the like. Moreover, the remote units 102 may be referred to as subscriber units, mobiles, mobile stations, users, terminals, mobile terminals, fixed terminals, subscriber stations, UE, user terminals, a device, or by other terminology used in the art. The remote units 102 may communicate directly with one or more of the base units 104 via UL communication signals.

[0046] The base units 104 may be distributed over a geographic region. In certain embodiments, a base unit 104 may also be referred to as an access point, an access terminal, a base, a base station, a Node-B, an eNB, a Home Node-B, a relay node, a device, or by any other

terminology used in the art. The base units 104 are generally part of a radio access network that includes one or more controllers communicably coupled to one or more corresponding base units 104. The radio access network is generally communicably coupled to one or more core networks, which may be coupled to other networks, like the Internet and public switched telephone networks, among other networks. These and other elements of radio access and core networks are not illustrated but are well known generally by those having ordinary skill in the art.

[0047] In one implementation, the wireless communication system 100 is compliant with the LTE of the 3GPP protocol, wherein the base unit 104 transmits using an OFDM modulation scheme on the DL and the remote units 102 transmit on the UL using a SC-FDMA scheme. More generally, however, the wireless communication system 100 may implement some other open or proprietary communication protocol, for example, WiMAX, among other protocols. The present disclosure is not intended to be limited to the implementation of any particular wireless communication system architecture or protocol.

[0048] The base units 104 may serve a number of remote units 102 within a serving area, for example, a cell or a cell sector via a wireless communication link. The base units 104 transmit DL communication signals to serve the remote units 102 in the time, frequency, and/or spatial domain.

[0049] In one embodiment, a remote unit 102 may determine a periodicity integer l corresponding to a HARQ RTT. The remote unit 102 may transmit a first PUSCH associated with a HARQ process in an UpPTS of a subframe n . The remote unit 102 may also transmit a second PUSCH associated with the HARQ process. The second PUSCH may carry information selected from a group including a new transmission and a corresponding retransmission of the first PUSCH in an UpPTS of a subframe $n + k * l$. In such an embodiment, k may be a positive integer. Accordingly, a remote unit 102 may transmit PUSCH in an UpPTS.

[0050] In another embodiment, a base unit 104 may determine a periodicity integer l corresponding to a HARQ RTT. In some embodiments, the base unit 104 may receive a first PUSCH associated with a HARQ process in an UpPTS of a subframe n . In certain embodiments, the base unit 104 may receive a second PUSCH associated with the HARQ process. The second PUSCH may carry information selected from a group including a new transmission and a corresponding retransmission of the first PUSCH in an UpPTS of a subframe $n + k * l$. In such an embodiment, k may be a positive integer. Accordingly, a base unit 104 may receive PUSCH in an UpPTS.

[0051] Figure 2 depicts one embodiment of an apparatus 200 that may be used for transmitting a PUSCH in an UpPTS. The apparatus 200 includes one embodiment of the remote

unit 102. Furthermore, the remote unit 102 may include a processor 202, a memory 204, an input device 206, a display 208, a transmitter 210, and a receiver 212. In some embodiments, the input device 206 and the display 208 are combined into a single device, such as a touchscreen. In certain embodiments, the remote unit 102 may not include any input device 206 and/or display 208. In various embodiments, the remote unit 102 may include one or more of the processor 202, the memory 204, the transmitter 210, and the receiver 212, and may not include the input device 206 and/or the display 208.

[0052] The processor 202, in one embodiment, may include any known controller capable of executing computer-readable instructions and/or capable of performing logical operations. For example, the processor 202 may be a microcontroller, a microprocessor, a central processing unit (“CPU”), a graphics processing unit (“GPU”), an auxiliary processing unit, a field programmable gate array (“FPGA”), or similar programmable controller. In some embodiments, the processor 202 executes instructions stored in the memory 204 to perform the methods and routines described herein. The processor 202 is communicatively coupled to the memory 204, the input device 206, the display 208, the transmitter 210, and the receiver 212. In certain embodiments, the processor 202 may determine a periodicity integer l corresponding to a HARQ RTT.

[0053] The memory 204, in one embodiment, is a computer readable storage medium. In some embodiments, the memory 204 includes volatile computer storage media. For example, the memory 204 may include a RAM, including dynamic RAM (“DRAM”), synchronous dynamic RAM (“SDRAM”), and/or static RAM (“SRAM”). In some embodiments, the memory 204 includes non-volatile computer storage media. For example, the memory 204 may include a hard disk drive, a flash memory, or any other suitable non-volatile computer storage device. In some embodiments, the memory 204 includes both volatile and non-volatile computer storage media. In some embodiments, the memory 204 stores data relating to an indication to be provided to another device. In some embodiments, the memory 204 also stores program code and related data, such as an operating system or other controller algorithms operating on the remote unit 102.

[0054] The input device 206, in one embodiment, may include any known computer input device including a touch panel, a button, a keyboard, a stylus, a microphone, or the like. In some embodiments, the input device 206 may be integrated with the display 208, for example, as a touchscreen or similar touch-sensitive display. In some embodiments, the input device 206 includes a touchscreen such that text may be input using a virtual keyboard displayed on the touchscreen and/or by handwriting on the touchscreen. In some embodiments, the input device 206 includes two or more different devices, such as a keyboard and a touch panel.

[0055] The display 208, in one embodiment, may include any known electronically controllable display or display device. The display 208 may be designed to output visual, audible, and/or haptic signals. In some embodiments, the display 208 includes an electronic display capable of outputting visual data to a user. For example, the display 208 may include, but is not limited to, an LCD display, an LED display, an OLED display, a projector, or similar display device capable of outputting images, text, or the like to a user. As another, non-limiting, example, the display 208 may include a wearable display such as a smart watch, smart glasses, a heads-up display, or the like. Further, the display 208 may be a component of a smart phone, a personal digital assistant, a television, a table computer, a notebook (laptop) computer, a personal computer, a vehicle dashboard, or the like.

[0056] In certain embodiments, the display 208 includes one or more speakers for producing sound. For example, the display 208 may produce an audible alert or notification (e.g., a beep or chime). In some embodiments, the display 208 includes one or more haptic devices for producing vibrations, motion, or other haptic feedback. In some embodiments, all or portions of the display 208 may be integrated with the input device 206. For example, the input device 206 and display 208 may form a touchscreen or similar touch-sensitive display. In other embodiments, the display 208 may be located near the input device 206.

[0057] The transmitter 210 is used to provide UL communication signals to the base unit 104 and the receiver 212 is used to receive DL communication signals from the base unit 104. In one embodiment, the transmitter 210 is used to transmit a first PUSCH associated with a HARQ process in an UpPTS of a subframe n , and to transmit a second PUSCH associated with the HARQ process. The second PUSCH may carry information selected from a group including a new transmission and a corresponding retransmission of the first PUSCH in an UpPTS of a subframe $n + k * l$. In such an embodiment, k may be a positive integer. In certain embodiments, the receiver 212 may be used to receive data. In certain embodiments, the receiver 212 is used to receive an UL grant and/or ACK/NACK feedback in PHICH. Although only one transmitter 210 and one receiver 212 are illustrated, the remote unit 102 may have any suitable number of transmitters 210 and receivers 212. The transmitter 210 and the receiver 212 may be any suitable type of transmitters and receivers. In one embodiment, the transmitter 210 and the receiver 212 may be part of a transceiver.

[0058] Figure 3 depicts one embodiment of an apparatus 300 that may be used for receiving a PUSCH in an UpPTS. The apparatus 300 includes one embodiment of the base unit 104. Furthermore, the base unit 104 may include a processor 302, a memory 304, an input device 306, a display 308, a transmitter 310, and a receiver 312. As may be appreciated, the

processor 302, the memory 304, the input device 306, and the display 308 may be substantially similar to the processor 202, the memory 204, the input device 206, and the display 208 of the remote unit 102, respectively. In certain embodiments, the processor 302 may be used determine a periodicity integer l corresponding to a HARQ RTT.

[0059] The transmitter 310 is used to provide DL communication signals to the remote unit 102 and the receiver 312 is used to receive UL communication signals from the remote unit 102. In certain embodiments, the transmitter 310 is used to transmit an UL grant and/or ACK/NACK feedback in PHICH. In one embodiment, the receiver 312 is used to receive a first PUSCH associated with a HARQ process in an UpPTS of a subframe n . In another embodiment, the receiver 312 is used to receive a second PUSCH associated with the HARQ process. The second PUSCH may carry information selected from a group including a new transmission and a corresponding retransmission of the first PUSCH in an UpPTS of a subframe $n + k * l$. In such an embodiment, k may be a positive integer. Although only one transmitter 310 and one receiver 312 are illustrated, the base unit 104 may have any suitable number of transmitters 310 and receivers 312. The transmitter 310 and the receiver 312 may be any suitable type of transmitters and receivers. In one embodiment, the transmitter 310 and the receiver 312 may be part of a transceiver.

[0060] In certain embodiments, synchronous HARQ may be applied in UpPTS. The RTT of a HARQ process in UpPTS may be 5 TTI and/or 10 TTI. Accordingly, the n^{th} transmission and $(n + 1)^{\text{th}}$ transmission (wherein $n > 0$) occurs in UpPTS and such a HARQ process in UpPTS is independent from the normal subframe (e.g., occurs in the special subframes). Therefore, current uplink HARQ timing for the normal subframe may be maintained. As illustrated in Table 2 above, there are 5 ms and 10 ms downlink-to-uplink switch-point periodicities for the various TDD UL/DL configurations. For UL/DL configurations with 5 ms downlink-to-uplink switch-point periodicity, such as UL/DL configurations 0, 1, 2, and 6, both 5 TTI and 10 TTI may be used as a RTT of a HARQ process in UpPTS. For UL/DL configurations with 10 ms downlink-to-uplink switch-point periodicity, such as UL/DL configurations 3, 4, and 5, only 10 TTI may be used as a RTT of a HARQ process in UpPTS. If 5 TTI is used as a RTT of a HARQ process in UpPTS, a shorter time for UL grant demodulation (e.g., 1 ms or less) may be used.

[0061] In certain embodiments, the interval between an UL grant and a corresponding PUSCH transmission may be 5 ms or 6 ms, as illustrated in Figures 4 and 5. In such embodiments, the UL grant is restricted to being in a constant downlink subframe (e.g.,

subframes 0, 1, 5, and 6), therefore, a timing configuration number between an UL grant and a corresponding uplink transmission may be minimized.

[0062] Figure 4 illustrates one embodiment of HARQ timing 400 for PUSCH transmissions in UpPTS. A first radio frame 402 and a second radio frame 404 are illustrated. The first radio frame 402 includes a first special subframe 406 and a second special subframe 408. The second radio frame 404 includes a third special subframe 410 and a fourth special subframe 412. A first HARQ process 414 and a second HARQ process 416 are also illustrated, each having a RTT of 10 TTI.

[0063] The first HARQ process 414 illustrates a first PUSCH transmission 418 during the first special subframe 406, an UL grant 420 during the second special subframe 408, and a second PUSCH transmission 422 during the third special subframe 410. The interval between the UL grant 420 and the second PUSCH transmission 422 (e.g., its corresponding PUSCH transmission) is 5 ms. The first HARQ process 414 may be used for any of the UL/DL configurations 0, 1, 2, 3, 4, 5, or 6.

[0064] The second HARQ process 416 illustrates a first PUSCH transmission 424 during the second special subframe 408, an UL grant 426 during the third special subframe 410, and a second PUSCH transmission 428 during the fourth special subframe 412. The interval between the UL grant 426 and the second PUSCH transmission 428 (e.g., its corresponding PUSCH transmission) is 5 ms. The second HARQ process 416 may be used for any of the UL/DL configurations 3, 4, or 5.

[0065] For the first and second HARQ processes 414 and 416, ACK/NACK for PUSCH transmission in UpPTS may not be feedback, and PUSCH transmission and/or retransmission is triggered by a UL grant. Moreover, non-ACK/NACK feedback may be predefined, configurable, and/or implemented by the base unit 104.

[0066] Figure 5 illustrates another embodiment of HARQ timing 500 for PUSCH transmissions in UpPTS. A first radio frame 502 and a second radio frame 504 are illustrated. The first radio frame 502 includes a first special subframe 506 and a second special subframe 508. The second radio frame 504 includes a third special subframe 510 and a fourth special subframe 512. A first HARQ process 514 and a second HARQ process 516 are also illustrated, each having a RTT of 10 TTI.

[0067] The first HARQ process 514 illustrates a first PUSCH transmission 518 during the first special subframe 506, an UL grant 520 during subframe 5 of the first radio frame 502, and a second PUSCH transmission 522 during the third special subframe 510. The interval between the UL grant 520 and the second PUSCH transmission 522 (e.g., its corresponding

PUSCH transmission) is 6 ms. The first HARQ process 514 may be used for any of the UL/DL configurations 0, 1, 2, 3, 4, 5, or 6.

[0068] The second HARQ process 516 illustrates a first PUSCH transmission 524 during the second special subframe 508, an UL grant 526 during subframe 0 of the second radio frame 504, and a second PUSCH transmission 528 during the fourth special subframe 512. The interval between the UL grant 526 and the second PUSCH transmission 528 (e.g., its corresponding PUSCH transmission) is 6 ms. The second HARQ process 516 may be used for any of the UL/DL configurations 3, 4, or 5.

[0069] For the first and second HARQ processes 514 and 516, ACK/NACK for PUSCH transmission in UpPTS may not be feedback, and PUSCH transmission and/or retransmission is triggered by a UL grant. Moreover, non-ACK/NACK feedback may be predefined, configurable, and/or implemented by the base unit 104.

[0070] Figure 6 illustrates a further embodiment of HARQ timing 600 for PUSCH transmissions in UpPTS. A radio frame 602 is illustrated. The radio frame 602 includes a first special subframe 604 and a second special subframe 606. A HARQ process 608 is illustrated having a RTT of 5 TTI.

[0071] The HARQ process 608 illustrates a first UL grant 610 during subframe 0 of the radio frame 602, a first PUSCH transmission 612 during the first special subframe 604, a second UL grant 614 during subframe 5 of the radio frame 602, and a second PUSCH transmission 616 during the second special subframe 606. The interval between the first UL grant 610 and the first PUSCH transmission 612 (e.g., its corresponding PUSCH transmission) is 1 ms, and the interval between the second UL grant 614 and the second PUSCH transmission 616 (e.g., its corresponding PUSCH transmission) is 1 ms. The HARQ process 608 may be used for any of the UL/DL configurations 0, 1, 2, or 6.

[0072] For the HARQ process 608, ACK/NACK for PUSCH transmission in UpPTS may not be feedback, and PUSCH transmission and/or retransmission is triggered by a UL grant. Moreover, non-ACK/NACK feedback may be predefined, configurable, and/or implemented by the base unit 104.

[0073] In certain embodiments, such as for UL/DL configurations 0 and 6, due to PHICH occurring in subframes 0, 1, 5, and 6, the interval between a PUSCH transmission and a corresponding ACK/NACK feedback may be either 4 ms or 5 ms. Moreover, the interval between an UL grant and a corresponding PUSCH transmission may be either 5 ms or 6 ms.

[0074] In some embodiments, such as for UL/DL configuration 1, due to PHICH occurring in subframes 1 and 6, the interval between a PUSCH transmission and a corresponding

ACK/NACK feedback is 5 ms. Moreover, the interval between an UL grant and a corresponding PUSCH transmission may be 5 ms, as illustrated in Figure 7.

[0075] Figure 7 illustrates an embodiment of HARQ timing 700 for PUSCH transmissions in UpPTS for UL/DL configurations 0, 1, and 6. A first radio frame 702 and a second radio frame 704 are illustrated. The first radio frame 702 includes a first special subframe 706 and a second special subframe 708. The second radio frame 704 includes a third special subframe 710 and a fourth special subframe 712. A first HARQ process 714 and a second HARQ process 716 are also illustrated, each having a RTT of 10 TTIs.

[0076] The first HARQ process 714 illustrates a first PUSCH transmission 718 during the first special subframe 706, an UL grant and/or PHICH 720 during the second special subframe 708, and a second PUSCH transmission 722 during the third special subframe 710. The interval between the UL grant and/or PHICH 720 and the second PUSCH transmission 722 (e.g., its corresponding PUSCH transmission) is 5 ms. The interval between the first PUSCH transmission 718 and the UL grant and/or PHICH 720 (e.g., its corresponding ACK/NACK feedback) is 5 ms. The first HARQ process 714 may be used for any of the UL/DL configurations 0, 1, or 6. In certain embodiments, such as for UL/DL configurations 0 and 6, the interval between the UL grant and/or PHICH 720 and the second PUSCH transmission 722 (e.g., its corresponding PUSCH transmission) may be 6 ms. In such embodiments, the interval between the first PUSCH transmission 718 and the UL grant and/or PHICH 720 (e.g., its corresponding ACK/NACK feedback) may be 4 ms.

[0077] The second HARQ process 716 illustrates a first PUSCH transmission 724 during the second special subframe 708, an UL grant and/or PHICH 726 during the third special subframe 710, and a second PUSCH transmission 728 during the fourth special subframe 712. The interval between the UL grant and/or PHICH 726 and the second PUSCH transmission 728 (e.g., its corresponding PUSCH transmission) is 5 ms. The interval between the first PUSCH transmission 724 and the UL grant and/or PHICH 726 (e.g., its corresponding ACK/NACK feedback) is 5 ms. The second HARQ process 716 may be used for any of the UL/DL configurations 0, 1, or 6. In certain embodiments, such as for UL/DL configurations 0 and 6, the interval between the UL grant and/or PHICH 726 and the second PUSCH transmission 728 (e.g., its corresponding PUSCH transmission) may be 6 ms. In such embodiments, the interval between the first PUSCH transmission 724 and the UL grant and/or PHICH 726 (e.g., its corresponding ACK/NACK feedback) may be 4 ms.

[0078] For the first and second HARQ processes 714 and 716, ACK/NACK for PUSCH transmission in UpPTS may be feedback, and PUSCH transmission and/or retransmission is

triggered by a UL grant. Although the interval between PUSCH transmission and its corresponding ACK/NACK feedback is defined, a base unit 104 may determine whether to send ACK/NACK based on predefined criteria.

[0079] In some embodiments, such as for UL/DL configurations 2, 3, 4, and 5, PHICH occurs in subframes {3, 8}, {0, 8, 9}, {8, 9}, {8} respectively. In embodiments with ACK/NACK for PUSCH transmission in UpPTS being feedback, the interval between a PUSCH transmission and its corresponding ACK/NACK feedback may be 7 ms, as illustrated in Figures 8 and 9. Moreover, the interval between an UL grant and its corresponding PUSCH transmission may be 3 ms. In embodiments in which ACK/NACK for PUSCH transmission in UpPTS is not feedback, the interval between an UL grant and its corresponding PUSCH transmission may be 4 ms or 5 ms.

[0080] Figure 8 illustrates an embodiment of HARQ timing 800 for PUSCH transmissions in UpPTS for UL/DL configuration 2. A first radio frame 802 and a second radio frame 804 are illustrated. The first radio frame 802 includes a first special subframe 806 and a second special subframe 808. The second radio frame 804 includes a third special subframe 810 and a fourth special subframe 812. A first HARQ process 814 and a second HARQ process 816 are also illustrated, each having a RTT of 10 TTI.

[0081] The first HARQ process 814 illustrates a first PUSCH transmission 818 during the first special subframe 806, an UL grant and/or PHICH 820 during subframe 8 of the first radio frame 802, and a second PUSCH transmission 822 during the third special subframe 810. The interval between the UL grant and/or PHICH 820 and the second PUSCH transmission 822 (e.g., its corresponding PUSCH transmission) is 3 ms. The interval between the first PUSCH transmission 818 and the UL grant and/or PHICH 820 (e.g., its corresponding ACK/NACK feedback) is 7 ms.

[0082] The second HARQ process 816 illustrates a first PUSCH transmission 824 during the second special subframe 808, an UL grant and/or PHICH 826 during subframe 3 of the second radio frame 804, and a second PUSCH transmission 828 during the fourth special subframe 812. The interval between the UL grant and/or PHICH 826 and the second PUSCH transmission 828 (e.g., its corresponding PUSCH transmission) is 3 ms. The interval between the first PUSCH transmission 824 and the UL grant and/or PHICH 826 (e.g., its corresponding ACK/NACK feedback) is 7 ms.

[0083] For the first and second HARQ processes 814 and 816, ACK/NACK for PUSCH transmission in UpPTS may be feedback, and PUSCH transmission and/or retransmission is triggered by a UL grant. Although the interval between PUSCH transmission and its

corresponding ACK/NACK feedback is defined, a base unit 104 may determine whether to send ACK/NACK based on predefined criteria.

[0084] Figure 9 illustrates an embodiment of HARQ timing 900 for PUSCH transmissions in UpPTS for UL/DL configurations 3, 4, and 5. A first radio frame 902 and a second radio frame 904 are illustrated. The first radio frame 902 includes a first special subframe 906 and a second special subframe 908. The second radio frame 904 includes a third special subframe 910 and a fourth special subframe 912. A HARQ process 914 has a RTT of 10 TTI.

[0085] The HARQ process 914 illustrates a first PUSCH transmission 916 during the first special subframe 906, an UL grant and/or PHICH 918 during subframe 8 of the first radio frame 902, and a second PUSCH transmission 920 during the third special subframe 910. The interval between the UL grant and/or PHICH 918 and the second PUSCH transmission 920 (e.g., its corresponding PUSCH transmission) is 3 ms. The interval between the first PUSCH transmission 916 and the UL grant and/or PHICH 918 (e.g., its corresponding ACK/NACK feedback) is 7 ms.

[0086] For the HARQ process 914, ACK/NACK for PUSCH transmission in UpPTS may be feedback, and PUSCH transmission and/or retransmission is triggered by a UL grant. Although the interval between PUSCH transmission and its corresponding ACK/NACK feedback is defined, a base unit 104 may determine whether to send ACK/NACK based on predefined criteria.

[0087] In certain embodiments, ACK/NACK for PUSCH transmissions in an UpPTS may not be feedback and an UL grant may be used to trigger initial transmission and/or retransmission. In some embodiments, reserved PHICH resources for an UpPTS may not be used. In one embodiment, schedule complexity may be avoided by avoiding PHICH conflict between a normal uplink subframe and an UpPTS. In various embodiments, it may be predefined and/or configured concerning whether ACK/NACK for PUSCH transmission in an UpPTS is feedback. This may be applied for some and/or all UL/DL configurations. In embodiments with configurable ACK/NACK feedback for PUSCH transmission in UpPTS, the configuration information may be carried by high layer signaling. When a base unit 104 assumes that PHICH conflict between a normal uplink subframe and an UpPTS may be avoided, the base unit 104 may configure a remote unit 102 to receive ACK/NACK feedback for PUSCH transmission in UpPTS. Otherwise, a base unit 104 may configure a remote unit 102 not to receive ACK/NACK feedback for PUSCH transmission in an UpPTS.

[0088] In one embodiment, if ACK/NACK for a PUSCH transmission in an UpPTS is feedback, ACK/NACK for the PUSCH transmission in the UpPTS and a specific uplink subframe are feedback in the same DL subframe and share reserved PHICH resources. In such an embodiment, a subframe indication (e.g., 0 indicates specific uplink subframe, 1 indicates UpPTS) may be included in PHICH resource identification to avoid PHICH resource conflict between UpPTS and an uplink subframe.

[0089] Figure 10 is a schematic flow chart diagram illustrating one embodiment of a method 1000 for transmitting a PUSCH in UpPTS. In some embodiments, the method 1000 is performed by an apparatus, such as the remote unit 102. In certain embodiments, the method 1000 may be performed by a processor executing program code, for example, a microcontroller, a microprocessor, a CPU, a GPU, an auxiliary processing unit, a FPGA, or the like.

[0090] The method 1000 may include determining 1002 a periodicity integer l corresponding to a HARQ RTT. In one embodiment, the periodicity integer l corresponds to a HARQ RTT of either 5 ms or 10 ms based on a configured UL/DL configuration being used. The method 1000 may also include transmitting 1004 a first PUSCH associated with a HARQ process in an UpPTS of a subframe n . The method 1000 may include transmitting 1006 a second PUSCH associated with the HARQ process, and the method 1000 may end. The second PUSCH may carry either a new transmission or a corresponding retransmission of the first PUSCH in an UpPTS of a subframe $n + k * l$. In such an embodiment, k may be a positive integer.

[0091] In one embodiment, the method 1000 includes receiving an UL grant in a subframe $n - 5$ or a subframe $n - 6$. In such an embodiment, the UL grant may correspond to transmitting 1004 the first PUSCH in the subframe n . In some embodiments, the method 1000 includes receiving an UL grant in a subframe $n - 5$ or a subframe $n - 6$, and receiving feedback corresponding to the first PUSCH in a PHICH in a subframe $n + 4$ or a subframe $n + 5$ in response to a configured UL/DL configuration being an UL/DL configuration 0 or an UL/DL configuration 6. In such an embodiment, the UL grant may correspond to transmitting 1004 the first PUSCH in the subframe n . In certain embodiments, the method 1000 includes receiving an UL grant in a subframe $n - 5$, and receiving feedback corresponding to the first PUSCH in a PHICH in a subframe $n + 5$ in response to a configured UL/DL configuration being UL/DL configuration 1. In such an embodiment, the UL grant may correspond to transmitting 1004 the first PUSCH in the subframe n .

[0092] In another embodiment, the method 1000 includes receiving an UL grant in a subframe $n - 3$, and receiving feedback corresponding to the first PUSCH in a PHICH in a subframe $n + 7$ in response to a configured UL/DL configuration being an UL/DL configuration

2, an UL/DL configuration 3, an UL/DL configuration 4, or an UL/DL configuration 5. In such an embodiment, the UL grant may correspond to transmitting 1004 the first PUSCH in the subframe n . In various embodiments, the method 1000 includes receiving an UL grant to trigger transmitting 1006 the second PUSCH. In some embodiments, the method 1000 includes
5 receiving feedback in a PHICH corresponding to the first PUSCH in the subframe n . In such embodiments, a PHICH resource functions as a subframe number.

[0093] Figure 11 is a schematic flow chart diagram illustrating one embodiment of a method 1100 for receiving a PUSCH in UpPTS. In some embodiments, the method 1100 is performed by an apparatus, such as the base unit 104. In certain embodiments, the method 1100
10 may be performed by a processor executing program code, for example, a microcontroller, a microprocessor, a CPU, a GPU, an auxiliary processing unit, a FPGA, or the like.

[0094] The method 1100 may include determining 1102 a periodicity integer l corresponding to a HARQ RTT. In one embodiment, the periodicity integer l corresponds to a HARQ RTT of either 5 ms or 10 ms based on a configured UL/DL configuration being used. In
15 various embodiments, the method 1100 includes receiving 1104 a first PUSCH associated with a HARQ process in an UpPTS of a subframe n . The method 1100 may also include receiving 1106 a second PUSCH associated with the HARQ process, and the method 1100 may end. The second PUSCH may carry a new transmission or a corresponding retransmission of the first PUSCH in an UpPTS of a subframe $n + k * l$. In such an embodiment, k may be a positive
20 integer.

[0095] In one embodiment, the method 1100 includes transmitting an UL grant in a subframe $n - 5$ or a subframe $n - 6$. In such an embodiment, the UL grant may correspond to receiving 1104 the first PUSCH in the subframe n . In some embodiments, the method 1100 includes transmitting an UL grant in a subframe $n - 5$ or a subframe $n - 6$, and transmitting
25 feedback corresponding to the first PUSCH in a PHICH in a subframe $n + 4$ or a subframe $n + 5$ in response to a configured UL/DL configuration being an UL/DL configuration 0 or an UL/DL configuration 6. In such an embodiment, the UL grant may correspond to receiving 1104 the first PUSCH in the subframe n . In certain embodiments, the method 1100 includes transmitting an UL grant in a subframe $n - 5$, and transmitting feedback corresponding to the first PUSCH in
30 a PHICH in a subframe $n + 5$ in response to a configured UL/DL configuration being UL/DL configuration 1. In such an embodiment, the UL grant may correspond to receiving 1104 the first PUSCH in the subframe n .

[0096] In another embodiment, the method 1100 includes transmitting an UL grant in a subframe $n - 3$, and transmitting feedback corresponding to the first PUSCH in a PHICH in a

subframe $n + 7$ in response to a configured UL/DL configuration being an UL/DL configuration 2, an UL/DL configuration 3, an UL/DL configuration 4, or an UL/DL configuration 5. In such an embodiment, the UL grant may correspond to receiving 1104 the first PUSCH in the subframe n . In various embodiments, the method 1100 includes transmitting an UL grant to trigger
5 receiving 1106 the second PUSCH. In some embodiments, the method 1100 includes transmitting feedback in a PHICH corresponding to the first PUSCH in the subframe n . In such embodiments, a PHICH resource functions as a subframe number.

[0097] Embodiments may be practiced in other specific forms. The described
embodiments are to be considered in all respects only as illustrative and not restrictive. The
10 scope of the invention is, therefore, indicated by the appended claims rather than by the
foregoing description. All changes which come within the meaning and range of equivalency of
the claims are to be embraced within their scope.

CLAIMS

1. An apparatus comprising:
a processor that determines a periodicity integer l corresponding to a hybrid automatic
repeat request (“HARQ”) round trip time (“RTT”);
5 a transmitter that:
transmits a first physical uplink shared channel (“PUSCH”) associated with a
HARQ process in an uplink pilot time slot (“UpPTS”) of a subframe n ;
and
transmits a second PUSCH associated with the HARQ process, the second
10 PUSCH carrying information selected from the group consisting of a new
transmission and a corresponding retransmission of the first PUSCH in an
UpPTS of a subframe $n + k * l$, wherein k is a positive integer.
2. The apparatus of claim 1, wherein the periodicity integer l is selected from the group
consisting of 5 and 10.
- 15 3. The apparatus of claim 1, further comprising a receiver that receives an uplink (“UL”)
grant in a subframe selected from the group consisting of a subframe $n - 5$ and a subframe
 $n - 6$, wherein the UL grant corresponds to transmitting the first PUSCH in the subframe
 n .
4. The apparatus of claim 1, further comprising a receiver that receives an UL grant in a
20 subframe selected from the group consisting of a subframe $n - 5$ and a subframe $n - 6$, and
receives feedback corresponding to the first PUSCH in a physical HARQ indicator
channel (“PHICH”) in a subframe selected from the group consisting of a subframe $n + 4$
and a subframe $n + 5$ in response to a configured uplink/downlink (“UL/DL”) configuration
being selected from the group consisting of UL/DL configuration 0 and
25 UL/DL configuration 6, wherein the UL grant corresponds to transmitting the first
PUSCH in the subframe n .
5. The apparatus of claim 1, further comprising a receiver that receives an UL grant in a
subframe $n - 5$, and receives feedback corresponding to the first PUSCH in a PHICH in a

subframe $n + 5$ in response to a configured UL/DL configuration being UL/DL configuration 1, wherein the UL grant corresponds to transmitting the first PUSCH in the subframe n .

- 5 6. The apparatus of claim 1, further comprising a receiver that receives an UL grant in a subframe $n - 3$, and receives feedback corresponding to the first PUSCH in a PHICH in a subframe $n + 7$ in response to a configured UL/DL configuration being selected from the group consisting of UL/DL configuration 2, UL/DL configuration 3, UL/DL configuration 4, and UL/DL configuration 5, wherein the UL grant corresponds to transmitting the first PUSCH in the subframe n .
- 10 7. The apparatus of claim 1, further comprising a receiver that receives an UL grant to trigger transmitting the second PUSCH.
8. The apparatus of claim 1, further comprising a receiver that receives feedback in a PHICH corresponding to the first PUSCH in the subframe n , wherein a PHICH resource functions as a subframe number.
- 15 9. A method comprising:
determining a periodicity integer l corresponding to a hybrid automatic repeat request ("HARQ") round trip time ("RTT"); transmitting a first physical uplink shared channel ("PUSCH") associated with a HARQ process in an uplink pilot time slot ("UpPTS") of a subframe n ; and
20 transmitting a second PUSCH associated with the HARQ process, the second PUSCH carrying information selected from the group consisting of a new transmission and a corresponding retransmission of the first PUSCH in an UpPTS of a subframe $n + k * l$, wherein k is a positive integer.
10. The method of claim 9, wherein the periodicity integer l is selected from the group
25 consisting of 5 and 10.

11. The method of claim 9, further comprising receiving an uplink (“UL”) grant in a subframe selected from the group consisting of a subframe $n - 5$ and a subframe $n - 6$, wherein the UL grant corresponds to transmitting the first PUSCH in the subframe n .
- 5 12. The method of claim 9, further comprising receiving an UL grant in a subframe selected from the group consisting of a subframe $n - 5$ and a subframe $n - 6$, and receiving feedback corresponding to the first PUSCH in a physical HARQ indicator channel (“PHICH”) in a subframe selected from the group consisting of a subframe $n + 4$ and a subframe $n + 5$ in response to a configured uplink/downlink (“UL/DL”) configuration being selected from the group consisting of UL/DL configuration 0 and UL/DL
10 configuration 6, wherein the UL grant corresponds to transmitting the first PUSCH in the subframe n .
13. The method of claim 9, further comprising receiving an UL grant in a subframe $n - 5$, and receiving feedback corresponding to the first PUSCH in a PHICH in a subframe $n + 5$ in response to a configured UL/DL configuration being UL/DL configuration 1, wherein the
15 UL grant corresponds to transmitting the first PUSCH in the subframe n .
14. The method of claim 9, further comprising receiving an UL grant in a subframe $n - 3$, and receiving feedback corresponding to the first PUSCH in a PHICH in a subframe $n + 7$ in response to a configured UL/DL configuration being selected from the group consisting of UL/DL configuration 2, UL/DL configuration 3, UL/DL configuration 4, and UL/DL
20 configuration 5, wherein the UL grant corresponds to transmitting the first PUSCH in the subframe n .
15. The method of claim 9, further comprising receiving an UL grant to trigger transmitting the second PUSCH.
16. The method of claim 9, further comprising receiving feedback in a PHICH corresponding
25 to the first PUSCH in the subframe n , wherein a PHICH resource functions as a subframe number.
17. An apparatus comprising:

a processor that determines a periodicity integer l corresponding to a hybrid automatic repeat request (“HARQ”) round trip time (“RTT”);

a receiver that:

receives a first physical uplink shared channel (“PUSCH”) associated with a

5 HARQ process in an uplink pilot time slot (“UpPTS”) of a subframe n ;

and

receiving a second PUSCH associated with the HARQ process, the second

PUSCH carrying information selected from the group consisting of a new transmission and a corresponding retransmission of the first PUSCH in an

10 UpPTS of a subframe $n + k * l$, wherein k is a positive integer.

18. The apparatus of claim 17, wherein the periodicity integer l is selected from the group consisting of 5 and 10.

19. The apparatus of claim 17, further comprising a transmitter that transmits an uplink (“UL”) grant in a subframe selected from the group consisting of a subframe $n - 5$ and a
15 subframe $n - 6$, wherein the UL grant corresponds to receiving the first PUSCH in the subframe n .

20. The apparatus of claim 17, further comprising a transmitter that transmits an UL grant in a subframe selected from the group consisting of a subframe $n - 5$ and a subframe $n - 6$, and transmits feedback corresponding to the first PUSCH in a physical HARQ indicator channel (“PHICH”) in a subframe selected from the group consisting of a subframe $n + 4$
20 and a subframe $n + 5$ in response to a configured uplink/downlink (“UL/DL”) configuration being selected from the group consisting of UL/DL configuration 0 and UL/DL configuration 6, wherein the UL grant corresponds to receiving the first PUSCH in the subframe n .

25 21. The apparatus of claim 17, further comprising a transmitter that transmits an UL grant in a subframe $n - 5$, and transmits feedback corresponding to the first PUSCH in a PHICH in a subframe $n + 5$ in response to a configured UL/DL configuration being UL/DL configuration 1, wherein the UL grant corresponds to receiving the first PUSCH in the subframe n .

22. The apparatus of claim 17, further comprising a transmitter that transmits an UL grant in a subframe $n - 3$, and transmits feedback corresponding to the first PUSCH in a PHICH in a subframe $n + 7$ in response to a configured UL/DL configuration being selected from the group consisting of UL/DL configuration 2, UL/DL configuration 3, UL/DL configuration 4, and UL/DL configuration 5, wherein the UL grant corresponds to receiving the first PUSCH in the subframe n .
23. The apparatus of claim 17, further comprising a transmitter that transmits an UL grant to trigger transmission of the second PUSCH.
24. The apparatus of claim 17, further comprising a transmitter that transmits feedback in a PHICH corresponding to the first PUSCH in the subframe n , wherein a PHICH resource functions as a subframe number.
25. A method comprising:
determining a periodicity integer l corresponding to a hybrid automatic repeat request (“HARQ”) round trip time (“RTT”);
receiving a first physical uplink shared channel (“PUSCH”) associated with a HARQ process in an uplink pilot time slot (“UpPTS”) of a subframe n ; and
receiving a second PUSCH associated with the HARQ process, the second PUSCH carrying information selected from the group consisting of a new transmission and a corresponding retransmission of the first PUSCH in an UpPTS of a subframe $n + k * l$, wherein k is a positive integer.
26. The method of claim 25, wherein the periodicity integer l is selected from the group consisting of 5 and 10.
27. The method of claim 25, further comprising transmitting an uplink (“UL”) grant in a subframe selected from the group consisting of a subframe $n - 5$ and a subframe $n - 6$, wherein the UL grant corresponds to receiving the first PUSCH in the subframe n .
28. The method of claim 25, further comprising transmitting an UL grant in a subframe selected from the group consisting of a subframe $n - 5$ and a subframe $n - 6$, and

transmitting feedback corresponding to the first PUSCH in a physical HARQ indicator channel (“PHICH”) in a subframe selected from the group consisting of a subframe $n + 4$ and a subframe $n + 5$ in response to a configured uplink/downlink (“UL/DL”) configuration being selected from the group consisting of UL/DL configuration 0 and
5 UL/DL configuration 6, wherein the UL grant corresponds to receiving the first PUSCH in the subframe n .

29. The method of claim 25, further comprising transmitting an UL grant in a subframe $n - 5$, and transmitting feedback corresponding to the first PUSCH in a PHICH in a subframe $n + 5$ in response to a configured UL/DL configuration being UL/DL configuration 1,
10 wherein the UL grant corresponds to receiving the first PUSCH in the subframe n .

30. The method of claim 25, further comprising transmitting an UL grant in a subframe $n - 3$, and transmitting feedback corresponding to the first PUSCH in a PHICH in a subframe $n + 7$ in response to a configured UL/DL configuration being selected from the group consisting of UL/DL configuration 2, UL/DL configuration 3, UL/DL configuration 4,
15 and UL/DL configuration 5, wherein the UL grant corresponds to receiving the first PUSCH in the subframe n .

31. The method of claim 25, further comprising transmitting an UL grant to trigger transmission of the second PUSCH.

32. The method of claim 25, further comprising transmitting feedback in a PHICH
20 corresponding to the first PUSCH in the subframe n , wherein a PHICH resource functions as a subframe number.

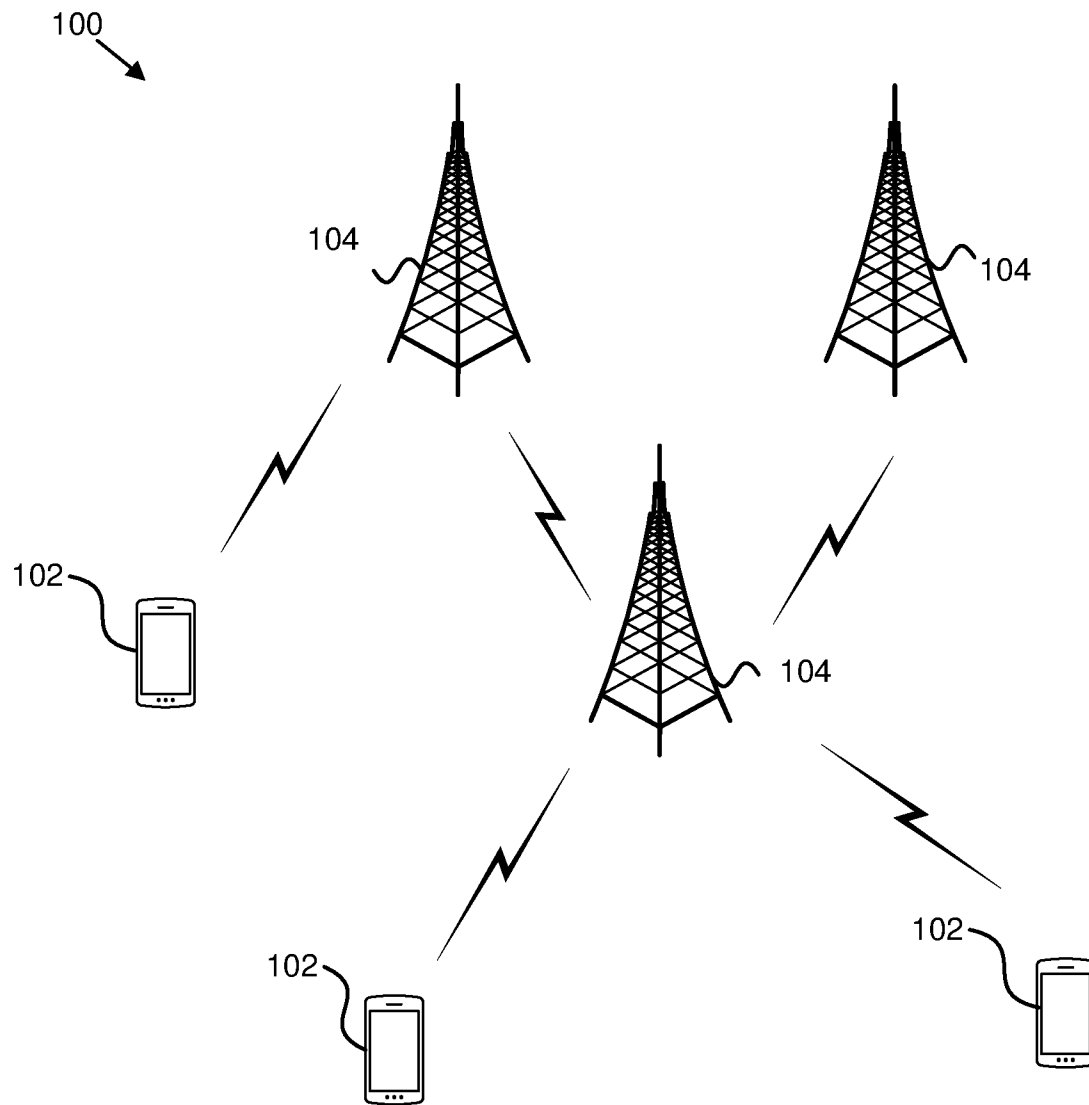


FIG. 1

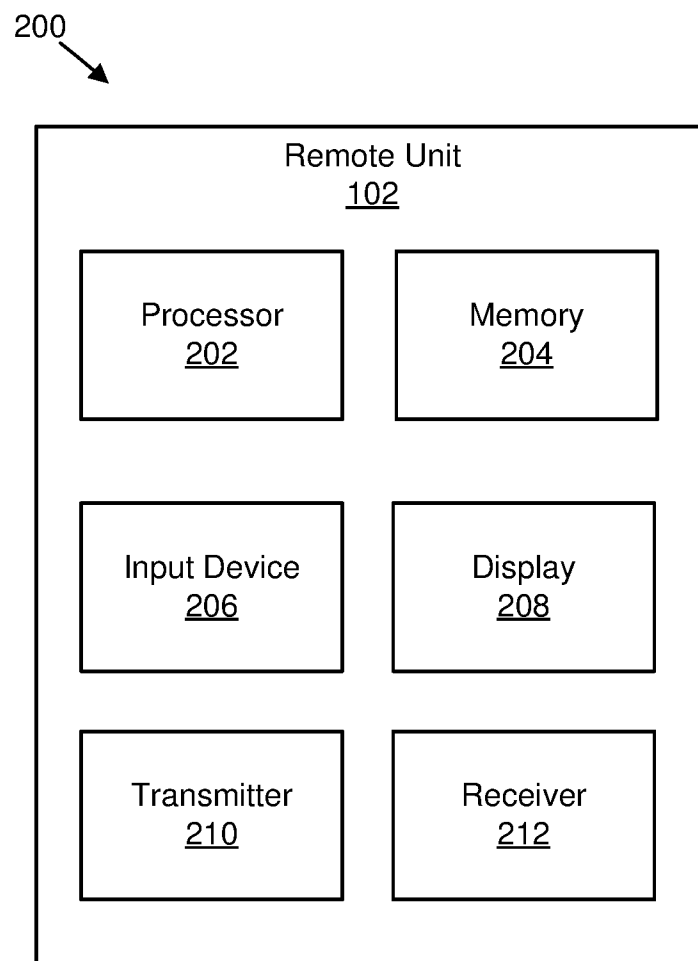


FIG. 2

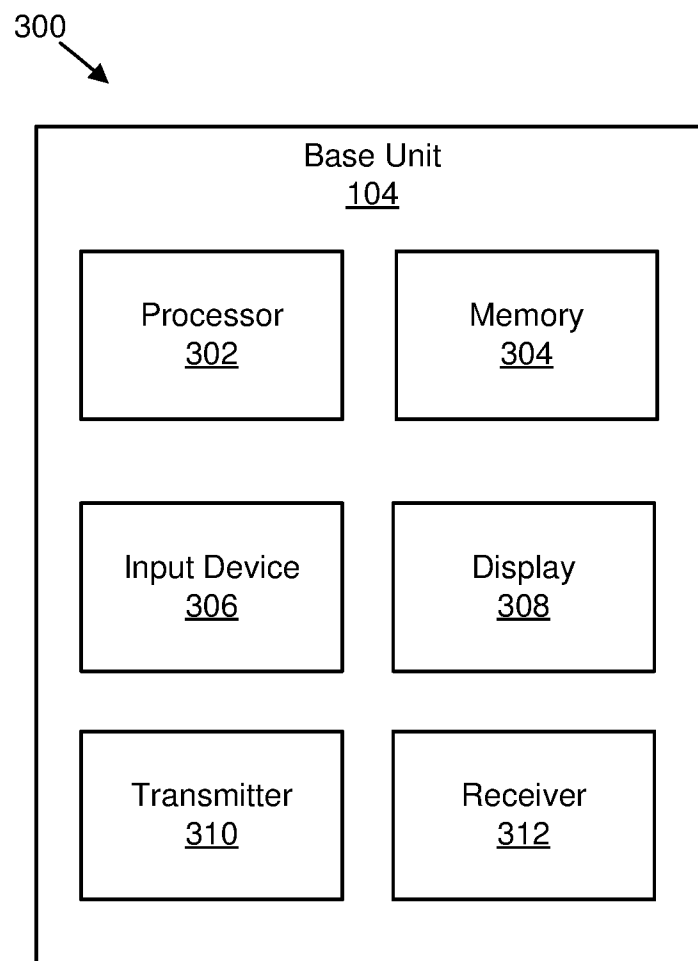


FIG. 3

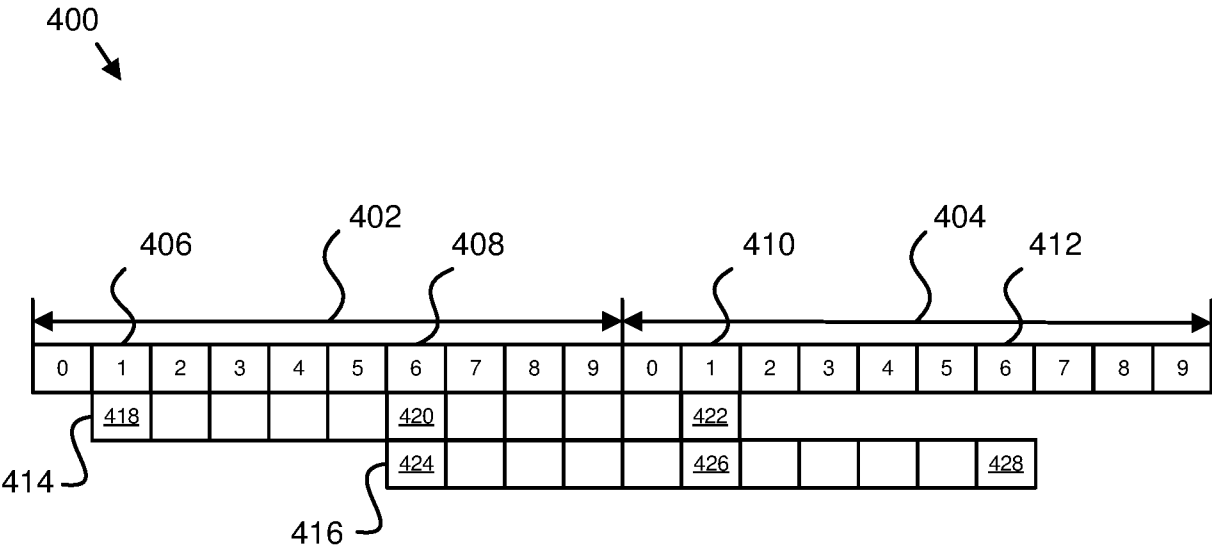


FIG. 4

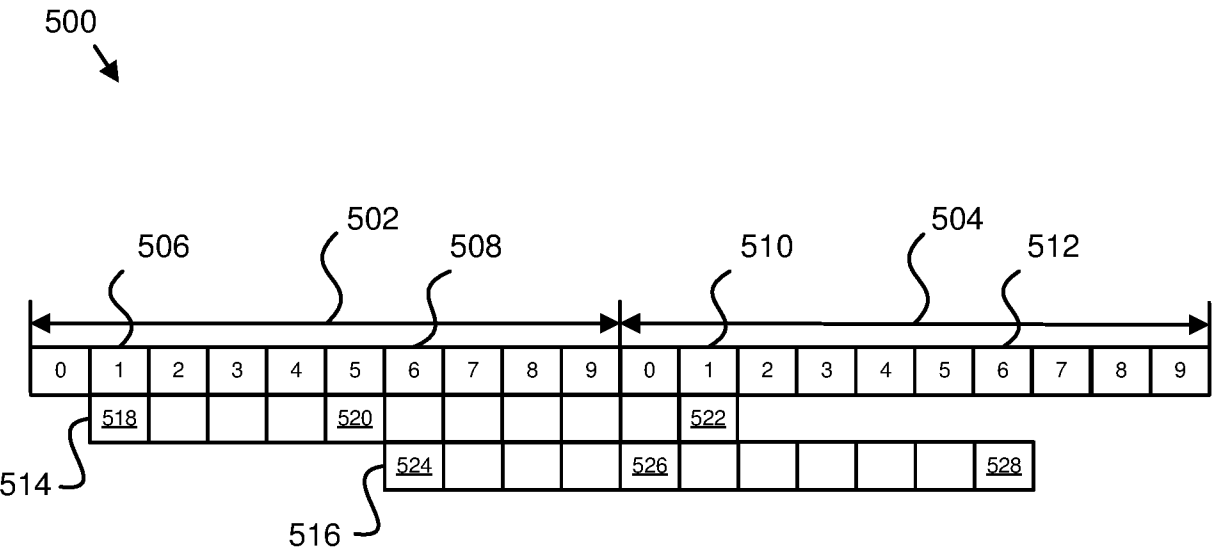


FIG. 5

600
↓

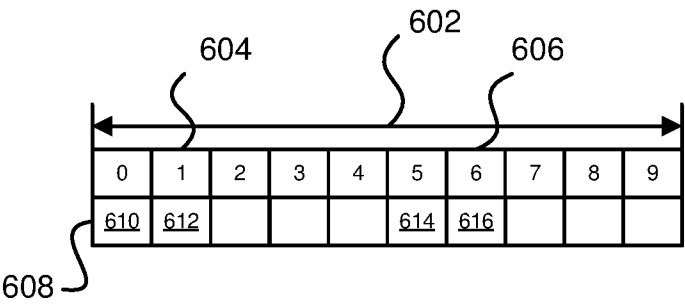


FIG. 6

700
↓

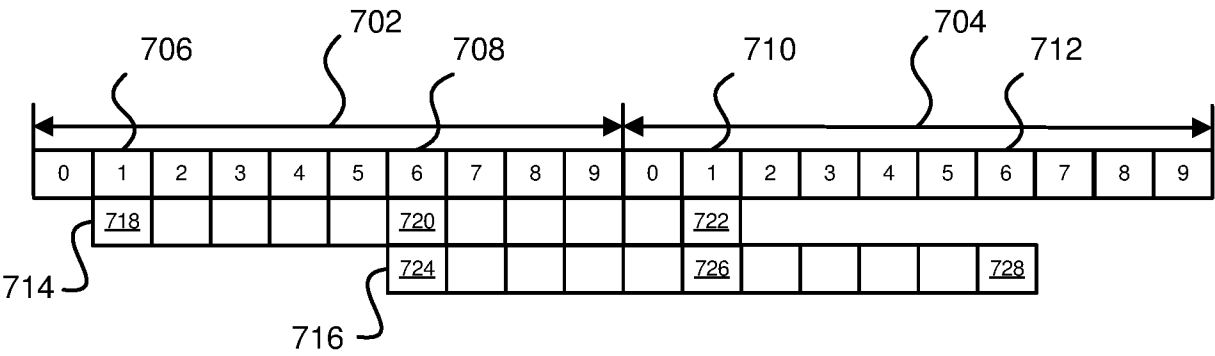


FIG. 7

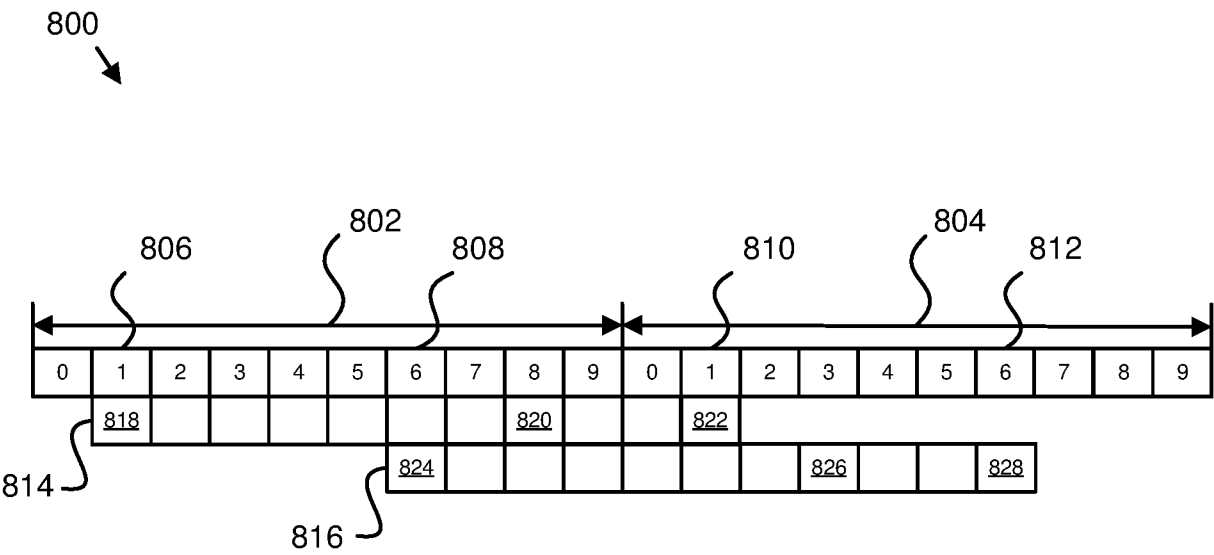


FIG. 8

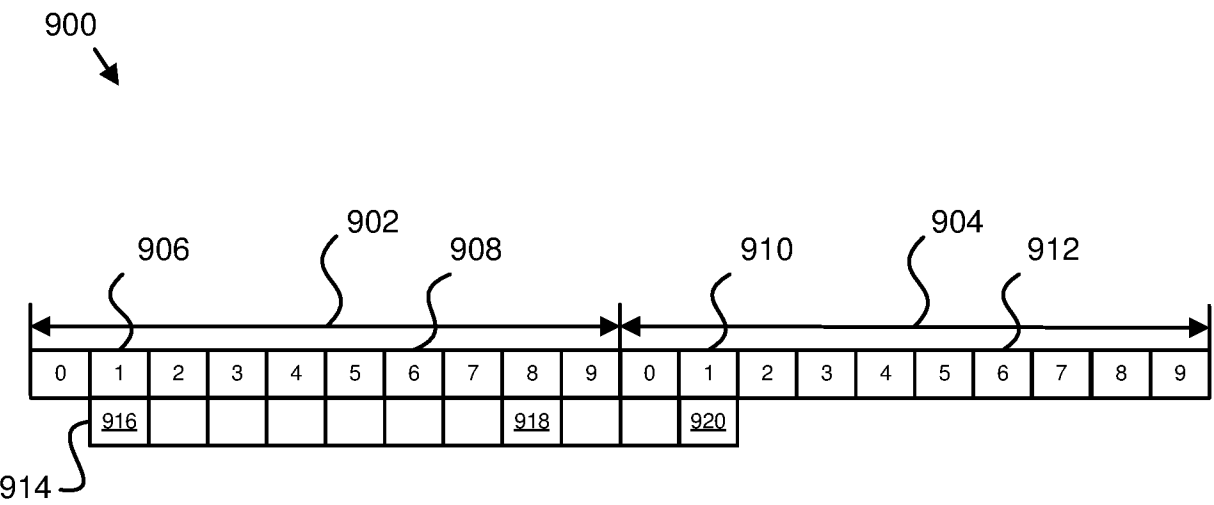


FIG. 9

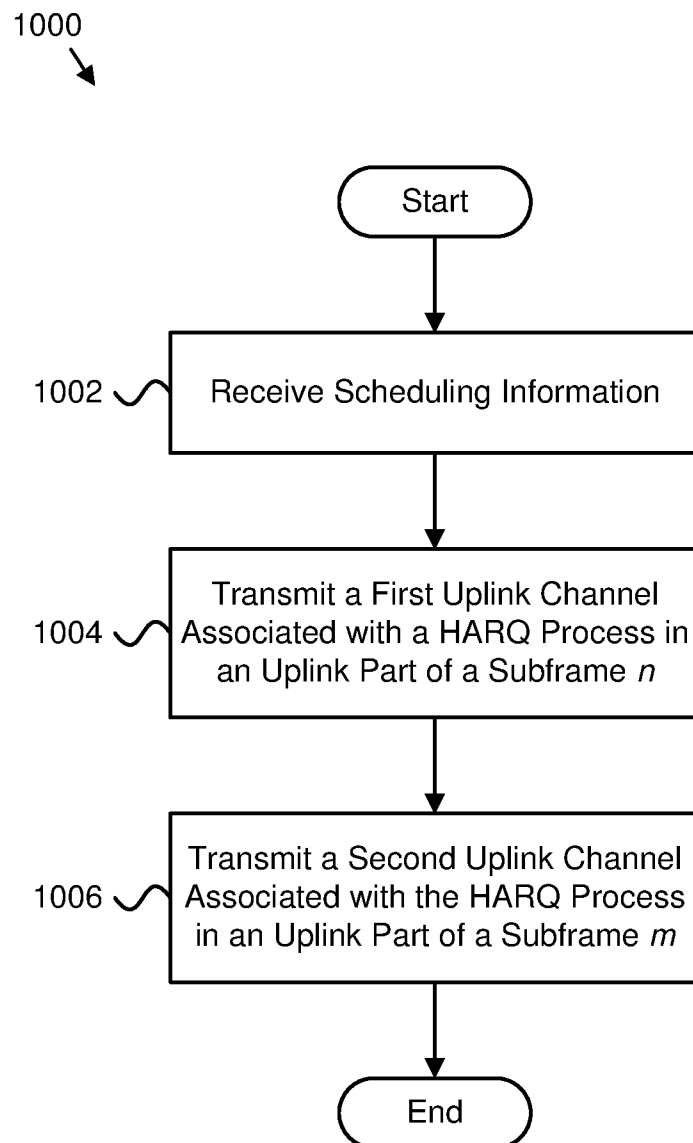


FIG. 10

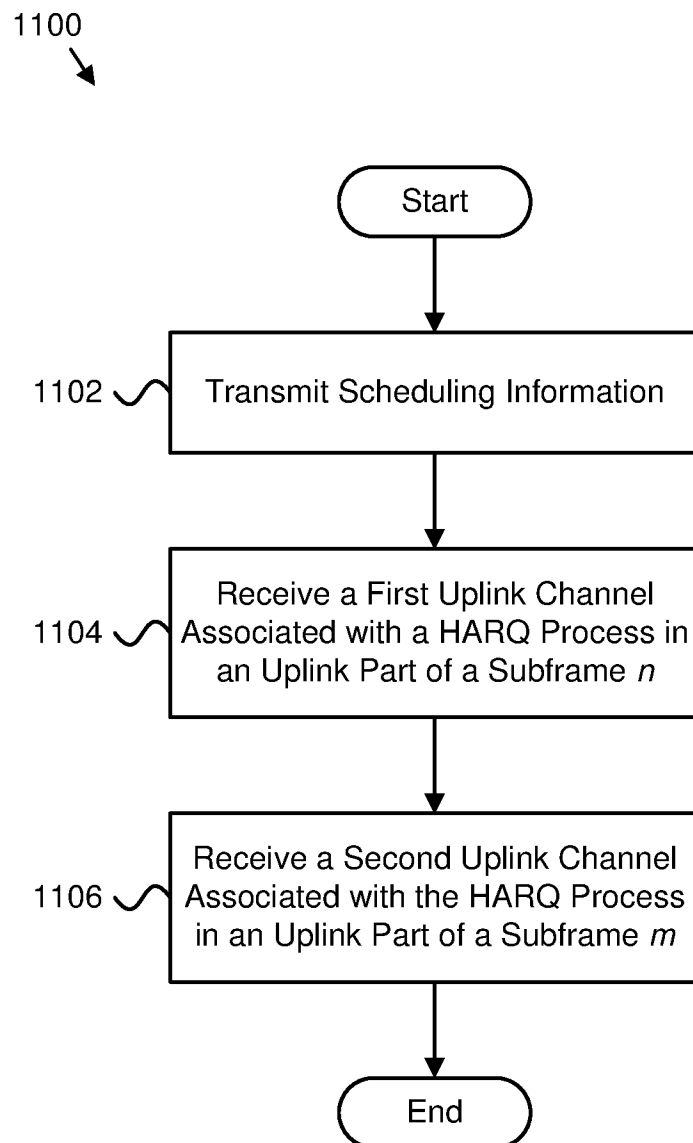


FIG. 11

INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2016/098682

A. CLASSIFICATION OF SUBJECT MATTER

H04L 1/18(2006.01)i

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

H04W H04Q H04L

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,CNKI,WPI,EPODOC,3GPP:RTT, round trip time, PUSCH, UpPTS, HARQ, request+, retransmission, subframe, uplink, UL, grant, downlink, DL, PHICH, configuration, feedback

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	WO 2013191511 A1 (SAMSUNG ELECTRONICS CO., LTD.) 27 December 2013 (2013-12-27) see description, paragraphs [0004]-[0010], [0094]-[0097], [0122]-[0138], [0162]-[0186], Figures 4-7	1-32
Y	Huawei et al. "Scheduling and HARQ timing for PUSCH on UpPTS" 《3GPP TSG RAN WG1 Meeting #86 R1-166144》, 26 August 2016 (2016-08-26), see sections 2-3	1-32
Y	Huawei et al. "Transmission of PUSCH on UpPTS" 《3GPP TSG RAN WG1 Meeting #86 R1-166146》, 26 August 2016 (2016-08-26), see sections 2-3	1-32
A	CN 104104483 A (SAMSUNG ELECTRONICS CO., LTD. ET AL.) 15 October 2014 (2014-10-15) the whole document	1-32
A	CN 102916791 A (SAMSUNG ELECTRONICS CO., LTD. ET AL.) 06 February 2013 (2013-02-06) the whole document	1-32



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

11 May 2017

Date of mailing of the international search report

31 May 2017

Name and mailing address of the ISA/CN

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

Authorized officer

WANG,Jimei

Facsimile No. (86-10)62019451

Telephone No. (86-10)62413363

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.

PCT/CN2016/098682

Patent document cited in search report			Publication date (day/month/year)	Patent family member(s)			Publication date (day/month/year)
WO	2013191511	A1	27 December 2013	KR	20130143531	A	31 December 2013
				EP	2865123	A1	29 April 2015
				CN	103313380	A	18 September 2013
				US	2015327229	A1	12 November 2015
CN	104104483	A	15 October 2014	None			
CN	102916791	A	06 February 2013	None			