



(51) International Patent Classification:

H04W 72/04 (2009.01)

(21) International Application Number:

PCT/CN2022/082501

(22) International Filing Date:

23 March 2022 (23.03.2022)

(25) Filing Language:

English

(26) Publication Language:

English

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(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, IT, JM, 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, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, WS, 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, SC, 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: SEGMENTED TRANSMISSION IN NR NTN

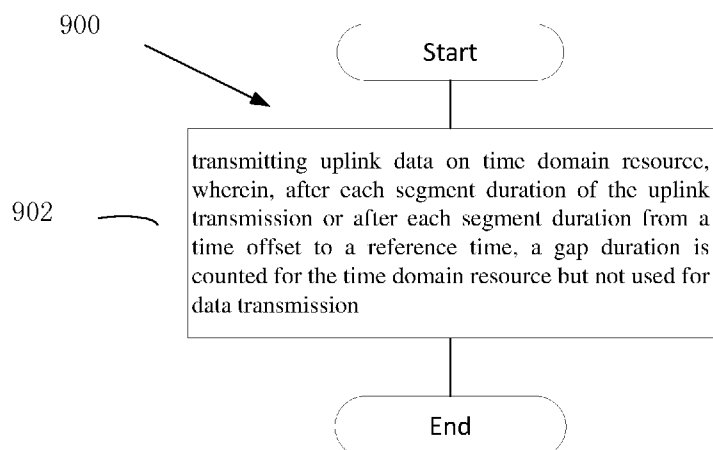


Figure 9

(57) Abstract: Methods and apparatuses for segmented transmission in NR NTN are disclosed. In one embodiment, a UE comprises a processor; and a transceiver coupled to the processor, wherein, the processor is configured to transmit, via the transceiver, uplink data on time domain resource, wherein, after each segment duration of the uplink transmission or after each segment duration from a time offset to a reference time, a gap duration is counted for the time domain resource but not used for data transmission.



SEGMENTED TRANSMISSION IN NR NTN

FIELD

[0001] The subject matter disclosed herein generally relates to wireless communications,
5 and more particularly relates to methods and apparatuses for segmented transmission in NR NTN.

BACKGROUND

[0002] The following abbreviations are herewith defined, at least some of which are referred to within the following description: New Radio (NR), Very Large Scale Integration (VLSI), Random Access Memory (RAM), Read-Only Memory (ROM), Erasable Programmable
10 Read-Only Memory (EPROM or Flash Memory), Compact Disc Read-Only Memory (CD-ROM), Local Area Network (LAN), Wide Area Network (WAN), User Equipment (UE), Evolved Node B (eNB), Next Generation Node B (gNB), Uplink (UL), Downlink (DL), Central Processing Unit (CPU), Graphics Processing Unit (GPU), Field Programmable Gate Array (FPGA), Orthogonal Frequency Division Multiplexing (OFDM), Radio Resource Control (RRC),
15 non-terrestrial networks (NTN), timing advance (TA), Machine-Type Communication (MTC), enhanced MTC (eMTC), Internet-of-Things (IoT), Low Earth Orbit (LEO), Medium earth satellite (MEO), Geostationary earth orbit (GEO), Cyclic Prefix (CP), Physical Uplink Shared Channel (PUSCH), Physical Uplink Control Channel (PUCCH), Transport Block (TB), Time domain resource allocation/assignment (TDRA), time domain window (TDW), Transport Block
20 Size (TBS), Narrowband Internet-of-Things (NB-IoT or NB-IoT).

[0003] For NTN network, the satellite (e.g., LEO, GEO, etc) is moving with high speed, the propagation delay (e.g. timing advance (TA)) and frequency between the satellite and UE are always changing.

[0004] Suppose that the satellite orbital speed is 7.5 km/s at 600km altitude and that a
25 minimum elevation angle on earth is approximately 10 degrees, the maximum delay drift between the satellite and UE will be on the order of $\pm 20 \mu\text{s/s}$.

[0005] UE cannot maintain the original TA during long UL transmission. When the delay exceeds a level (e.g. about 20% percent of Cyclic Prefix (CP)), the OFDM orthogonality would be significantly compromised. This corresponds to a segment duration greater than 8 ms for LEO,
30 32 ms for MEO. It means that, for LEO, if a UL transmission is greater than 8 ms (which can be regarded as a theoretical threshold for segmented transmission), it is necessary that the UL

transmission shall be transmitted in segments. That is, between two segments (or between two segmented transmissions), TA and/or frequency can be updated.

[0006] In NR Release 17 coverage enhancement, PUSCH repetition Type A supports the repetition number up to 32. In NR NTN Release 18, at least repetition number of 32 will still be supported. The total transmission duration for UL transmission with repetition number of 32 will be 32 ms for subcarrier spacing of 15KHz, which is much larger than the theoretical threshold for segmented transmission of 8ms (e.g., for LEO case). So, it is necessary to support segmented UL transmission in NR NTN, especially for LEO.

[0007] This invention proposes different solutions for segmented transmission in NR NTN.

BRIEF SUMMARY

[0008] Methods and apparatuses for segmented transmission in NR NTN are disclosed.

[0009] In one embodiment, a UE comprises a processor; and a transceiver coupled to the processor, wherein, the processor is configured to transmit, via the transceiver, uplink data on time domain resource, wherein, after each segment duration of the uplink transmission or after each segment duration from a time offset to a reference time, a gap duration is counted for the time domain resource but not used for data transmission.

[0010] In some embodiment, the segment duration is determined by a nominal TDW or the number of slots used for TBS determination.

[0011] In some embodiment, the gap duration is an actual gap duration determined by a nominal gap duration (Y0). In particular, the nominal gap duration is the number of symbols that is necessary to perform TA and/or frequency update, that is determined by UE capability, or configured in a higher layer parameter, or is a specified value.

[0012] In some embodiment, data transmission suspending or data transmission termination or data transmission reaching at the boundary of the segments or time advance adjustment in the gap duration is assumed to be an event which cause power consistency and phase continuity not to be maintained across data transmission.

[0013] In some embodiment, the gap duration is determined by data transmission length and position within a slot. For example, the gap duration is determined by the number of unscheduled symbols (M) at the start of the slot for the data transmission. For another example, the gap duration or the position of the gap is determined by the number of unscheduled symbols at the start of the slot and the number of unscheduled symbols at the end of a previous slot. The

gap duration or the position of the gap may be determined by the number of unscheduled symbols before data transmission at the boundary of the segments.

[0014] In another embodiment, a method performed by a UE comprises transmitting uplink data on time domain resource, wherein, after each segment duration of the uplink transmission or after each segment duration from a time offset to a reference time, a gap duration is counted for the time domain resource but not used for data transmission.

[0015] In one embodiment, a base unit comprises a processor; and a transceiver coupled to the processor, wherein, the processor is configured to receive, via the transceiver, uplink data on time domain resource, wherein, after each segment duration of the uplink transmission or after each segment duration from a time offset to a reference time, a gap duration is counted for the time domain resource but not used for data reception..

[0016] In yet another embodiment, a method performed by a base unit comprises receiving uplink data on time domain resource, wherein, after each segment duration of the uplink transmission or after each segment duration from a time offset to a reference time, a gap duration is counted for the time domain resource but not used for data reception.

BRIEF DESCRIPTION OF THE DRAWINGS

[0017] 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:

[0018] Figures 1(a) and 1(b) illustrate two examples of PUSCH transmission with repetition;

[0019] Figures 2(a) to 2(c) illustrate examples of nominal TDW;

[0020] Figures 3(a) and 3(b) illustrate examples of actual TDW;

[0021] Figure 4(a) illustrates an example of segments for unpaired spectrum and available slot counting enabled;

[0022] Figure 4(b) illustrates an example of segments for paired spectrum;

[0023] Figure 5(a) illustrates an example in which PUSCH transmission and PUCCH transmission are multiplexed in time domain and only PUSCH segments are supported;

[0024] Figure 5(b) illustrates an example in which PUSCH transmission and PUCCH transmission are multiplexed in time domain and both PUSCH segments and PUCCH segments are supported;

[0025] Figure 6(a) illustrates an example of different time offsets;

5 [0026] Figure 6(b) illustrates an example in which the start of the X time unit is configured as the start of PUSCH transmission and the X time unit is configured as the same as the nominal TDW of the PUSCH transmission;

[0027] Figure 7(a) illustrates an example that $M > Y_0$;

[0028] Figure 7(b) illustrates an example that $M < Y_0$;

10 [0029] Figure 8(a) illustrates an example that the total unscheduled symbols include both the unscheduled symbols at the start of the slot and the unscheduled symbols at the end of the previous slot;

[0030] Figure 8(b) illustrates an example of the dropped symbols;

[0031] Figure 9 is a schematic flow chart diagram illustrating an embodiment of a
15 method;

[0032] Figure 10 is a schematic flow chart diagram illustrating an embodiment of a method; and

[0033] Figure 11 is a schematic block diagram illustrating apparatuses according to one embodiment.

20 [0034] DETAILED DESCRIPTION

[0035] As will be appreciated by one skilled in the art that certain 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
25 embodiment combining software and hardware aspects that may generally all 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 to hereafter as “code”. The storage devices may be tangible, non-transitory, and/or non-transmission. The storage
30 devices may not embody signals. In a certain embodiment, the storage devices only employ signals for accessing code.

[0036] Certain functional units described in this specification may be labeled as “modules”, in order to more particularly emphasize their independent implementation. 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.

[0037] 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.

[0038] Indeed, a module of code may contain 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. This 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.

[0039] 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 code. The storage device may be, for example, but need not necessarily be, an electronic, magnetic, optical, electromagnetic, infrared, holographic, micromechanical, or semiconductor system, apparatus, or device, or any suitable combination of the foregoing.

[0040] A non-exhaustive list of more specific examples of the storage device would include the following: an electrical connection having one or more wires, a portable computer diskette, a hard disk, random access memory (RAM), read-only memory (ROM), erasable programmable read-only memory (EPROM or Flash Memory), 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.

5 [0041] Code for carrying out operations for embodiments may include 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 be
10 executed 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 very last 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
15 the Internet using an Internet Service Provider).

[0042] 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
20 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 are not limited to", unless otherwise expressly specified. An enumerated listing of items does not imply that any or all of the items are mutually exclusive, otherwise unless expressly specified. The terms "a", "an", and
25 "the" also refer to "one or more" unless otherwise expressly specified.

[0043] Furthermore, described features, structures, or characteristics of various 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,
30 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 any obscuring of aspects of an embodiment.

[0044] Aspects of different 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. This 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 are executed via the processor of the computer or other programmable data processing apparatus, create means for implementing the functions specified in the schematic flowchart diagrams and/or schematic block diagrams for the block or blocks.

[0045] 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 specified in the schematic flowchart diagrams and/or schematic block diagrams block or blocks.

[0046] 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 executed on the computer or other programmable apparatus provides processes for implementing the functions specified in the flowchart and/or block diagram block or blocks.

[0047] 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 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).

[0048] 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 substantially be executed 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, to the illustrated Figures.

[0049] 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.

[0050] 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.

[0051] This disclosure is related to segmented transmission in NR NTN. As mentioned in the background part, the segmented transmission in NR NTN should be supported because UL transmission with repetition is longer than the theoretical threshold for segmented transmission.

[0052] Before describing the embodiments, a summary of the UL transmission (e.g. PUSCH transmission or PUCCH transmission) with repetition is described.

[0053] In NR Release 17 coverage enhancement, PUSCH repetition Type A supports the repetition number up to 32. The UE shall transmit the TB across $N \cdot K$ consecutive slots, where the same symbol allocation is applied in each slot. N is the number of slots for TBS determination. N is equal to or larger than 1. K is the repetition number. When TB processing over multiple slots is supported, N can be larger than 1. That is, the uplink data is scheduled to be transmitted in N slots (e.g. $N = 1$ or 2), and the N slots are repeatedly transmitted K times. N and K are configured by higher layer parameter.

[0054] In each of the $N \cdot K$ consecutive slots, the same symbol allocation is applied. It means that, in each of $N \cdot K$ slots, the same number of symbols and the same position of the symbols within the slot are allocated. For PUSCH mapping type A, the basic time duration of uplink transmission within a slot ranges from 4 to 14 symbols; and for mapping type B, the basic time duration of uplink transmission within a slot ranges from 1 to 14 symbols. It means that

when a slot is scheduled for uplink (e.g., PUSCH) transmission, it is possible that all symbols (i.e. 14 symbols) of the slot or only a part of the symbols are allocated for actual uplink transmission. For example, suppose each slot includes symbols #0 to #13, 7 symbols (e.g. symbols #4 to #10) in each of $N \cdot K$ slots may be allocated.

[0055] Figures 1(a) and 1(b) illustrate two examples of PUSCH transmission with repetition. As shown in Figure 1(a), $N=1$ and $K=8$. In each of $N \cdot K (=8)$ consecutive slots, the same symbol allocation (e.g., symbol#4 to symbol #10) is applied. As shown in Figure 1(b), $N=2$ and $K=4$. In each of $N \cdot K (=8)$ consecutive slots, the same symbol allocation (e.g., symbol#4 to symbol #10) is also applied.

[0056] In NR Release 17 coverage enhancement, available slot counting can be configured by eNB as enabled or disabled. If the UE is configured with available slot counting as enabled, UE shall skip the transmission in the unavailable slot. The total actual transmission duration may be larger than the configured transmission duration due to the unavailable slot within the transmission duration.

[0057] For unpaired spectrum (e.g., TDD band spectrum) and available slot counting enabled, the UE determines the $N \cdot K$ slots for a PUSCH transmission based on *tdd-UL-DL-ConfigurationCommon*, *tdd-UL-DL-ConfigurationDedicated* and *ssb-PositionsInBurst*, and the TDRA information field value in the DCI format 0_1 or 0_2. When the available slot counting is enabled, a slot is not counted in the number of $N \cdot K$ slots for PUSCH transmission if at least one of the symbols indicated in the slot overlaps with a DL symbol indicated by *tdd-UL-DL-ConfigurationCommon* or *tdd-UL-DL-ConfigurationDedicated* if provided, or a symbol of an SS/PBCH block with index provided by *ssb-PositionsInBurst*.

[0058] For unpaired spectrum (e.g., TDD band spectrum) and available slot counting disabled, UE determines $N \cdot K$ consecutive slots for a PUSCH transmission based on the TDRA information field value in the DCI format 0_1 or 0_2 and all slots are counted as the PUSCH transmission slots even some of the slots are not available for PUSCH transmission.

[0059] For paired spectrum (e.g., FDD band spectrum) and SUL band, UE determines $N \cdot K$ consecutive slots for a PUSCH transmission based on the TDRA information field value in the DCI format 0_1 or 0_2, irrespective of whether available slot counting is enabled or not.

[0060] As a whole, the UE shall repeat the TB across the $N \cdot K$ slots determined for the PUSCH transmission, applying the same symbol allocation in each slot.

[0061] In NR Release 17 coverage enhancement, PUCCH repetition supports the repetition number up to 8. Similar to PUSCH repetition, the PUCCH repetition in each of the slots has the same symbol allocation.

[0062] In NR Release 17 coverage enhancement, joint channel estimation over multiple slots is supported. It is based on the conditions to keep power consistency and phase continuity on the multiple slots. In the joint channel estimation, nominal TDW (time domain window) is introduced to specify the channel bundling time duration. The duration of each nominal TDW except the last nominal TDW, in number of consecutive slots, is given by higher layer configuration, or computed as $\min([maxDMRS-BundlingDuration], M)$ where, *maxDMRS-BundlingDuration* is the reported maximum DMRS bundling duration by UE (e.g., a kind of UE capability reporting), and M is the configured higher layer parameter, which can be configured from a parameter set, e.g., {2,4,8...}.

[0063] Figures 2(a) to 2(c) illustrate examples of nominal TDW.

[0064] Figure 2(a) illustrates an example of nominal TDW (which is configured as 4) for unpaired spectrum and available slot counting not enabled. The start of the first nominal TDW is the first slot for the first PUSCH. The end of the last nominal TDW is the last slot for the last PUSCH. The start of any other nominal TDWs (except for the first nominal TDW) is the first slot after the last slot of a previous nominal TDW. Since the available slot counting is not enabled, the start of each nominal TDW (except for the first nominal TDW) is from any slot, which can begin from an uplink slot for uplink transmission or can begin from a slot that cannot be used for uplink transmission (e.g. a slot for downlink transmission).

[0065] Figure 2(b) illustrates an example of nominal TDW (which is configured as 4) for unpaired spectrum and available slot counting enabled. The start of the first nominal TDW is the first slot determined for the first PUSCH transmission. The end of the last nominal TDW is the last slot determined for the last PUSCH transmission. The start of any other nominal TDWs (except for the first nominal TDW) is the first slot determined for PUSCH transmission after the last slot determined for PUSCH transmission of a previous nominal TDW. Since the available slot counting is enabled, the start of each nominal TDW begins from an available slot for uplink (e.g. PUSCH) transmission.

[0066] Figure 2(c) illustrates an example of nominal TDW (which is 4) for paired spectrum. The start of the first nominal TDW is the first slot for the first PUSCH. The end of the last nominal TDW is the last slot for the last PUSCH. The start of any other nominal TDWs

(except for the first nominal TDW) is the first slot after the last slot of a previous nominal TDW. For paired spectrum, uplink transmission can be performed on all of slots.

[0067] To avoid misunderstanding of PUSCH scheduling and PUCCH scheduling, the nominal TDW for PUSCH transmission and the nominal TDW for PUCCH transmission are separately configured.

[0068] A nominal TDW consists of one or multiple actual TDWs. As nominal TDWs are configured separately for PUSCH transmission and PUCCH transmission, the actual TDWs are also separately determined for PUSCH transmission and PUCCH transmission. The UE determines the actual TDWs as follows (by taking PUSCH transmission as example).

[0069] The start of the first actual TDW is the first slot of the first PUSCH transmission within the nominal TDW.

[0070] The end of an actual TDW is the last slot for PUSCH transmission within the nominal TDW, if the actual TDW reaches the end of the last PUSCH transmission within the nominal TDW, and is the last slot of a PUSCH transmission before an event occurs, if the event causes power consistency and phase continuity not to be maintained across PUSCH transmissions of PUSCH repetition within the nominal TDW.

[0071] Events which cause power consistency and phase continuity not to be maintained across PUSCH transmissions within the nominal TDW are:

[0072] (1) A downlink slot or downlink reception or downlink monitoring.

[0073] (2) The gap between any two consecutive PUSCH transmissions that exceeds 13 symbols.

[0074] (3) The gap between any two consecutive PUSCH transmissions that does not exceed 13 symbols but other uplink transmissions (e.g. PUCCH transmission) are scheduled between the two consecutive PUSCH transmissions.

[0075] (4) For PUSCH transmissions, a dropping or cancellation of a PUSCH transmission.

[0076] (5) For any two consecutive PUSCH transmissions due to SRS transmission (i.e. SRS transmission is scheduled or configured between the two consecutive PUSCH transmissions).

[0077] (6) Uplink timing adjustment in response to a timing advance command.

[0078] (7) Frequency hopping.

[0079] The start of any other actual TDWs (except for the first actual TDW) is the first slot determined for PUSCH transmission after the last slot of a previous actual TDW.

[0080] Figures 3(a) and 3(b) illustrate examples of actual TDW.

[0081] Figure 3(a) illustrates an example of actual TDW for unpaired spectrum and
5 available slot counting not enabled, in which:

[0082] actual TDW 1 starts from slot 1 (the start of PUSCH transmission) and ends in slot 4 (e.g., the actual TDW reaches to the end of nominal TDW);

[0083] actual TDW 2 starts from slot 7 (the first slot determined for PUSCH transmission after the last slot of actual TDW 1: slots 5 and 6, which are DL slots, are not for PUSCH
10 transmission) and ends in slot 8 (e.g., the actual TDW reaches to the end of nominal TDW);

[0084] actual TDW 3 starts from slot 9 (the first slot determined for PUSCH transmission after the last slot of actual TDW 2) and ends in slot 9 (slot 10 is DL slot);

[0085] actual TDW 4 starts from slot 11 (the first slot determined for PUSCH transmission after the last slot of actual TDW 3: slot 10 is DL slot) and ends in slot 12 (the end
15 of nominal TDW);

[0086] actual TDW 5 starts from slot 13 (the first slot determined for PUSCH transmission after the last slot of actual TDW 4) and ends in slot 14 (slot 15 is DL slot); and

[0087] actual TDW 6 starts from slot 17 (the first slot determined for PUSCH transmission after the last slot of actual TDW 5: slots 15 and 16 are DL slots) and ends in slot 19
20 (the end of nominal TDW).

[0088] Figure 3(b) illustrates an example of actual TDW for paired spectrum, in which event 1 in slot 5 causes actual TDW 2 starts from slot 6, while event 2 in slot 11 causes actual TDW 3 ends in slot 10 and actual TDW 4 starts from slot 12. Each of event 1 and event 2 may be SRS transmission or PUCCH transmission in the slot, causing PUSCH transmission being
25 interrupted for the consideration of PUSCH transmission power consistency and phase continuity.

[0089] This disclosure proposes that NR NTN uplink supports segmented transmission. That is, UE transmits UL (e.g. PUSCH or PUCCH) data in segments. TA and/or frequency update can be performed in the boundary of the segments.

[0090] According to a first embodiment, the segment is determined per channel (i.e. per
30 PUSCH and per PUCCH). Each UL transmission can be a PUSCH transmission or a PUCCH transmission. So, the segment being determined per channel can be also referred to as determined per transmission.

[0091] After a PUSCH transmission duration of X time unit (i.e. length or duration of a PUSCH segment), a Y time unit shall be dropped or punctured or inserted or counted. In other words, the start of the X time unit is the start of PUSCH transmission.

[0092] In addition, after a PUCCH transmission duration of X time unit (i.e. length or duration of a PUCCH segment), a Y time unit shall be dropped or punctured or inserted or counted. In other words, the start of the X time unit is the start of PUCCH transmission.

[0093] A Y time unit being dropped or punctured means that the uplink transmission during the Y time unit not being transmitted.

[0094] A Y time unit being inserted means that the Y time unit not used for data transmission being inserted between transmissions.

[0095] A Y time unit being counted means the Y time unit being counted for data time domain resource but not used for data transmission.

[0096] In addition, from the gNB's point of view, the Y time unit is also counted for data time domain resource but not used for data reception. That is, at the gNB, after a PUSCH transmission duration of X time unit on time domain resource, a Y time unit is counted for data time domain resource but not used for data reception. In addition, at the gNB, after a PUCCH transmission duration of X time unit on time domain resource, a Y time unit is counted for data time domain resource but not used for data reception.

[0097] For PUSCH transmission, if the number of slots for TBS determination (i.e. N) is larger than 1 (i.e. TB processing over multi-slot is supported), the X time unit can be determined by the number of slots used for TBS determination. This guarantees that that one TB transmission is not across two segments.

[0098] For PUSCH transmission, if channel estimation bundling is supported, the X time unit can be determined by the nominal TDW for PUSCH transmission.

[0099] In particular, X time unit can be determined by a scaling factor and the nominal TDW duration (nominal TDW duration may be referred to as nominal TDW length). Figure 4(a) illustrates an example for unpaired spectrum and available slot counting enabled. In the example of Figure 4(a), the scaling factor is 2. So, each X time unit includes two nominal TDWs. That is, each X time unit ends at the end of the second nominal TDW of the two nominal TDWs.

[00100] If paired spectrum is supported in NR NTN, or for unpaired spectrum and available slot counting disabled, the X time unit can be further determined as the time duration including multiple (=scaling factor) of nominal TDWs, where the unavailable slot, if existing, is

included. Figure 4(b) illustrates an example for paired spectrum. In the example of Figure 4(b), nominal TDW is 4 slots. If the scaling factor is configured as 1, then the X time unit is determined as $1 \times 4 = 4$ slots. If the scaling factor is configured as 2, then the X time unit is determined as $2 \times 4 = 8$ slots.

[00101] Incidentally, the scaling factor, if not configured, may be 1 by default. That is, if the X time unit is not configured, it is equal to nominal TDW by default.

[00102] Similar to PUSCH transmission, for PUCCH transmission, if channel estimation bundling is supported, the X time unit can be determined by the nominal TDW for PUCCH transmission, e.g. by a scaling factor and the nominal TDW duration for PUCCH transmission.

[00103] The PUSCH segments (each with X time unit determined for PUSCH transmission) and the PUCCH segments (each with X time unit determined for PUCCH transmission) are separately configured.

[00104] When only PUSCH segments are present in a time duration (i.e. PUCCH segments are not supported), the TA and/or frequency updates are performed in the following slots: (1) the start of PUSCH transmission; and (2) the boundary of PUSCH segments.

[00105] When only PUCCH segments are present (i.e. PUSCH segments are not supported) in a time duration, the TA and/or frequency updates are performed in the following slots: (1) the start of PUCCH transmission; and (2) the boundary of PUCCH segments.

[00106] When PUSCH transmission and PUCCH transmission are multiplexed in time domain, there can be two situations: only PUSCH segments are supported (i.e. PUCCH segments are not supported), and both PUSCH segments and PUCCH segments are supported.

[00107] When PUSCH transmission and PUCCH transmission are multiplexed in time domain, in the situation that only PUSCH segments are supported, it is proposed that the TA and/or frequency updates are performed in each of the slots including (1) the start of PUSCH transmission, (2) the boundary of PUSCH segments, and (3) the start of PUCCH transmission. Figure 5(a) illustrates an example in which PUSCH transmission and PUCCH transmission are multiplexed in time domain and only PUSCH segments are supported. The nominal TDW is 4 slots. The scaling factor is configured as 1. Paired spectrum (e.g., FDD) is assumed. X time unit (a segment) is 4 slots. In slot 2, PUCCH transmission and PUSCH transmission are time-multiplexed (in the same slot but in different symbols of the slot). PUSCH actual TDW ends in event of PUCCH transmission. So, in the first nominal TDW (slots 1 to 4), there are three

PUSCH actual TDWs (actual TDW 1, actual TDW 2, actual TDW 3). So, the TA and/or frequency updates are performed in slot 1 (the start of PUSCH transmission), slot 2 (the start of PUCCH transmission), slot 5 (the boundary of PUSCH segments), and slot 9 (the boundary of PUSCH segments). In each of the slots where the TA and/or frequency update is performed, the update may be performed in the start of the slot.

[00108] When PUSCH transmission and PUCCH transmission are multiplexed in time domain, in the situation that both PUSCH segments and PUCCH segments are supported, it is proposed that the TA and/or frequency updates are performed in each of the slots including (1) the start of PUSCH transmission, (2) the boundary of PUSCH segments, (3) the start of PUCCH transmission and (4) the boundary of PUCCH segments. Figure 5(b) illustrates an example in which PUSCH transmission and PUCCH transmission are multiplexed in time domain and both PUSCH segments and PUCCH segments are supported. The nominal TDW for PUSCH is 4 slots, and the scaling factor for PUSCH is configured as 1. Paired spectrum is assumed. The segment for PUSCH (X time unit for PUSCH) is 4 slots. The nominal TDW for PUCCH is 2 slots, and the scaling factor for PUCCH is configured as 2. Paired spectrum (e.g FDD) is assumed. The segment for PUCCH (X time unit for PUCCH) is 4 slots. In each of slots 2 to 9, PUCCH transmission and PUSCH transmission are multiplexed (e.g. in different symbols of each slot). PUSCH actual TDW ends in event of PUCCH transmission, while PUCCH actual TDW ends in event of PUSCH transmission. So, slot 1 is PUSCH actual TDW, and each of slots 2 to 9 is PUSCH actual TDW and is also PUCCH actual TDW. So, the TA and/or frequency updates are performed in slot 1 (the start of PUSCH transmission), slot 2 (the start of PUCCH transmission), slot 5 (the boundary of PUSCH segments), slot 6 (the boundary of PUCCH segments), and slot 9 (the boundary of PUSCH segments). In each of the slots where the TA and/or frequency update is performed, the update may be performed in the start of the slot.

[00109] According to the first embodiment, the configuration of the segments is aligned with legacy NR and legacy eMTC and legacy NB-IoT. However, according to the first embodiment, some TA and/or frequency updates are not necessary.

[00110] According to a second embodiment, after X time unit (e.g. each of multiple X time units), if there is any uplink (e.g. PUSCH or PUCCH) transmission, Y time unit shall be dropped or punctured or inserted or counted, where, the start of each X time unit meets the condition $(t - A) \bmod X = T_0$, where the duration or length of the X time unit can be preconfigured. For example, the start of the first X time unit has a time offset T_0 relative to a

reference time point A. An example of the reference time point A is SFN 0 slot 0. Alternatively, the start of the X time unit may be determined by a time offset.

[00111] If the X time unit is configured so that the boundary of two segments is not in the end of the nominal TDW for the uplink (e.g. PUSCH) transmission, the TA and/or frequency update in the Y time unit will cause power consistency and phase continuity not to be maintained across PUSCH transmissions within the nominal TDW. In other words, the TA and/or frequency update in the Y time unit (i.e. uplink timing adjustment in the boundary segmented transmission, or transmission suspending in the boundary segmented transmission, or transmission termination in the boundary segmented transmission, or transmission reaching in the boundary segmented transmission) is also an event that cause power consistency and phase continuity not to be maintained across PUSCH transmissions within the nominal TDW. Accordingly, the events which cause power consistency and phase continuity not to be maintained across PUSCH transmissions within the nominal TDW should also include (8) uplink timing adjustment or transmission suspending or transmission termination or transmission reaching in the boundary segmented transmission.

[00112] According to the second embodiment, the TA and/or frequency updates are performed in each of the slots including (1) the start of each uplink (e.g. PUSCH or PUCCH) transmission and (2) the start of each segment if there is uplink (e.g. PUSCH or PUCCH) transmission at the start of the segment, where the start of segments meets the condition $(t - A) \bmod X = T_0$.

[00113] The time offset T_0 can be UE specifically configured to facilitate UE scheduling. Figure 6(a) illustrates an example of different time offsets. For UE1, the time offset is T_0 relative to the reference time point A; while, for UE2, the time offset is $T_0' = 0$. It is possible that UL transmission starts from the start of a segment (e.g. for UE2) or starts not from the start of a segment (e.g. for UE1).

[00114] If the start of the X time unit is configured as the start of PUSCH transmission and the X time unit is configured as the same as the nominal TDW of the PUSCH transmission, the TA and/or frequency update in the Y time unit would not cause power consistency and phase continuity not to be maintained across PUSCH transmissions within the nominal TDW.

[00115] Figure 6(b) illustrates an example in which the start of the X time unit is configured as the start of PUSCH transmission and the X time unit is configured as the same as

the nominal TDW of the PUSCH transmission (which is configured as 4 slots). The reference time point A is slot 0. The first segment starts from slot 2 ($t=2$ for the first segment) and ends in slot 5; the second segment starts from slot 6 ($t=6$ for the second segment) and ends in slot 9; and the third segment starts from slot 10 ($t=10$ for the third segment) and ends in slot 13. X is equal to 4 (slots). So, the start of the first segment meets the condition $(t - A) \bmod X = (2 - 0) \bmod 4 = 2 = T_0$, the start of the second segment meets the condition $(t - A) \bmod X = (6 - 0) \bmod 4 = 2 = T_0$, the start of the third segment meets the condition $(t - A) \bmod X = (10 - 0) \bmod 4 = 2 = T_0$. As can be seen from Figure 6(b), the TA and/or frequency updates are performed in slot 2 (start of PUSCH transmission, and the start of the first PUSCH segment), in slot 4 (start of PUCCH transmission), in slot 6 (the start of the second segment, i.e. the boundary of the first segment and the second segment), and in slot 10 (the start of the third segment, i.e. the boundary of the second segment and the third segment).

[00116] According to the second embodiment, all uplink transmissions are considered jointly. There is no unnecessary TA and/or frequency update. However, the configuration of the segments is not aligned with legacy NBIoT or legacy eMTC.

[00117] A third embodiment relates determination of the symbols to be dropped or punctured or inserted or counted.

[00118] In the slot determined according to the first embodiment or according to the second embodiment, Y time unit will be dropped or punctured or inserted or counted. Y time unit can be referred to as actual gap duration. The actual gap duration (e.g. in unit of symbols) is determined by a nominal gap duration (Y0) and/or the number of unscheduled symbols (M).

[00119] The nominal gap duration (Y0) can be the number of symbols that is necessary to perform TA and/or frequency update. The number of symbols that is necessary to perform TA and/or frequency update (e.g. Y0) can be determined by at least one of the following manners:

[00120] Manner 1: Y0 is determined by Ymax for performing TA and/or frequency update for the UE reported by the UE. Ymax can be reported for example as a part of UE capability reported by UE.

[00121] Manner 2: Y0 is determined by the gNB, and is configured by a higher layer parameter. For example, the gNB may determine Y0 according to at least one of TA drift rate, the duration length of each segment, and Ymax reported by the UE.

[00122] Manner 3: Y0 is a fixed value, e.g. a specified value.

[00123] NR uplink transmission scheduling is based on symbol level or sub-slot level, instead of based on subframe level. So, depending on NR uplink scheduling length and position, for a slot for uplink (e.g. PUSCH or PUCCH) transmission, some symbols in the slot may not be scheduled for uplink transmission. The symbols at the start and/or at the end of the slot that are not scheduled for uplink transmission can be referred to as unscheduled symbols (M).

[00124] Figure 7(a) illustrates an example that $M > Y_0$, in which M unscheduled symbols are positioned at the start of each slot (depending on scheduling length and position). Since $M > Y_0$, the TA and/or frequency update, that is necessary to be performed in Y_0 symbols, can be completed in the M unscheduled symbols.

[00125] Figure 7(b) illustrates an example that $M < Y_0$. In Figure 7(b), due to PUCCH transmission in slot 5, the unscheduled symbols (M) become less than Y_0 . Since $M < Y_0$, the TA and/or frequency update, that is necessary to be performed in Y_0 symbols, cannot be completed in the M unscheduled symbols. So, extra $Y_0 - M$ symbol(s) are necessary for performing the TA and/or frequency update. In the $Y_0 - M$ symbol(s), which is a gap duration, TA and/or frequency update is also performed. So, the UL (e.g. PUSCH or PUCCH) data transmission is suspended in the gap duration. It can be said that the gap duration is inserted, and is not used for data transmission. It can also be said that the gap duration is counted for data time domain resource but not used for data transmission. In addition, it can be said that the gap duration of data transmission is dropped or punctured, i.e. in the gap duration, the data transmission is not transmitted for the overlapping due to TA and/or frequency update.

[00126] If the actual gap duration is Y symbols, the situation in Figures 7(a) and 7(b) can be described as: in each of the slots which needs TA and/or frequency update, if the first M symbols in the slot are unscheduled by PUSCH and/or PUCCH transmission, $Y = \max(Y_0 - M, 0)$ where Y_0 is the nominal gap duration (e.g. the number of symbols that is necessary to perform TA and/or frequency update). It can be seen that, if the unscheduled symbols (M) is enough for TA and/or frequency update (i.e. $M \geq Y_0$), then $Y = \max(Y_0 - M, 0) = 0$. So, the number of symbols (time units) that shall be dropped or punctured or inserted or counted is 0, i.e. the actual gap duration is 0. On the other hand, if the unscheduled symbols (M) is not enough for TA and/or frequency update (i.e. $M < Y_0$), then $Y = \max(Y_0 - M, 0) = Y_0 - M$. So, the number of symbols (time units) that shall be dropped or punctured or inserted or counted is $Y_0 - M$. Incidentally, if the number of unscheduled symbols (M) is 0, the actual gap duration (Y) is equal to the nominal gap duration (Y_0).

[00127] As a whole, after a PUSCH transmission duration of X time unit, a Y time unit shall be dropped or punctured or inserted or counted. In other words, every a PUSCH transmission duration of X time unit, a Y time unit shall be dropped or punctured or inserted or counted. In addition, after a PUCCH transmission duration of X time unit, a Y time unit shall be
 5 dropped or punctured or inserted or counted. In other words, every a PUCCH transmission duration of X time unit, a Y time unit shall be dropped or punctured or inserted or counted.

[00128] As mentioned above, the unscheduled symbols, in addition to being at the start of the symbol, can also be at the end of the symbol, or at both the start and the end of the symbol. So, if there are unscheduled symbols at both the start and the end of the symbol, the total
 10 number of unscheduled symbols can be extended to the previous slot. Figure 8(a) illustrates an example that the total unscheduled symbols include both the unscheduled symbols at the start of the slot and the unscheduled symbols at the end of the previous slot. In other words, the total unscheduled symbols are the number of unscheduled symbols before data transmission at the boundary of the segments. Compared with Figure 7(b) in which M is less than Y0, in Figure 8(a),
 15 due to the addition of the unscheduled symbols at the end of the previous slot, M becomes more than Y0.

[00129] When the total unscheduled symbols include both the unscheduled symbols at the start of the slot and the unscheduled symbols at the end of the previous slot, if the total unscheduled symbols (M) is less than the number of symbols that is necessary to perform
 20 TA and/or frequency update (Y0) (i.e. $M < Y0$), the number of symbols (time units) shall be dropped is $Y = \max(Y0 - M, 0) = Y0 - M$. The dropped symbols have the following priority:

[00130] 1) first Y PUSCH symbols in the slot for which TA update is performed (the slot may be determined according to the first embodiment or the second embodiment);

[00131] 2) last Y PUSCH symbols in the previous slot;

[00132] 3) first Y PUCCH symbols in the slot for which TA update is performed;
 25 and

[00133] 4) last Y PUCCH symbols in the previous slot.

[00134] That is, the PUCCH transmission is more important than the PUSCH transmission. So, PUSCH symbol(s) have higher priority to be dropped. For the same channel
 30 (PUSCH or PUCCH), the transmission in the slot for which TA update is performed has higher priority to be dropped.

[00135] Figure 8(b) illustrates an example. In Figure 8(b), the dropped symbols are last Y (=Y0-M) PUSCH symbols in the previous slot.

[00136] Figure 9 is a schematic flow chart diagram illustrating an embodiment of a method 900 according to the present application. In some embodiments, the method 900 is performed by an apparatus, such as a remote unit. In certain embodiments, the method 900 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.

[00137] The method 900 may comprise 902 transmitting uplink data on time domain resource, wherein, after each segment duration of the uplink transmission or after each segment duration from a time offset to a reference time, a gap duration is counted for the time domain resource but not used for data transmission.

[00138] In some embodiment, the segment duration is determined by a nominal TDW or the number of slots used for TBS determination.

[00139] In some embodiment, the gap duration is an actual gap duration determined by a nominal gap duration (Y0). In particular, the nominal gap duration is the number of symbols that is necessary to perform TA and/or frequency update, that is determined by UE capability, or configured in a higher layer parameter, or is a specified value.

[00140] In some embodiment, data transmission suspending or data transmission termination or data transmission reaching at the boundary of the segments or time advance adjustment in the gap duration is assumed to be an event which cause power consistency and phase continuity not to be maintained across data transmission.

[00141] In some embodiment, the gap duration is determined by data transmission length and position within a slot. For example, the gap duration is determined by the number of unscheduled symbols (M) at the start of the slot for the data transmission. For another example, the gap duration or the position of the gap is determined by the number of unscheduled symbols at the start of the slot and the number of unscheduled symbols at the end of a previous slot. The gap duration or the position of the gap may be determined by the number of unscheduled symbols before data transmission at the boundary of the segments.

[00142] Figure 10 is a schematic flow chart diagram illustrating an embodiment of a method 1000 according to the present application. In some embodiments, the method 1000 is performed by an apparatus, such as a base unit. 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.

[00143] The method 1000 may comprise 1002 receiving uplink data on time domain resource, wherein, after each segment duration of the uplink transmission or after each segment duration from a time offset to a reference time, a gap duration is counted for the time domain resource but not used for data reception.

[00144] In some embodiment, the segment duration is determined by a nominal TDW or the number of slots used for TBS determination.

[00145] In some embodiment, the gap duration is an actual gap duration determined by a nominal gap duration (Y0). In particular, the nominal gap duration is the number of symbols that is necessary to perform TA and/or frequency update, that is determined by UE capability, or configured in a higher layer parameter, or is a specified value.

[00146] In some embodiment, the gap duration is determined by data transmission length and position within a slot. For example, the gap duration is determined by the number of unscheduled symbols (M) at the start of the slot for the data transmission. For another example, the gap duration or the position of the gap is determined by the number of unscheduled symbols at the start of the slot and the number of unscheduled symbols at the end of a previous slot. The gap duration or the position of the gap may be determined by the number of unscheduled symbols before data transmission at the boundary of the segments.

[00147] Figure 11 is a schematic block diagram illustrating apparatuses according to one embodiment.

[00148] Referring to Figure 11, the UE (i.e. the remote unit) includes a processor, a memory, and a transceiver. The processor implements a function, a process, and/or a method which are proposed in Figure 9.

[00149] The UE comprises a processor; and a transceiver coupled to the processor, wherein, the processor is configured to transmit, via the transceiver, uplink data on time domain resource, wherein, after each segment duration of the uplink transmission or after each segment duration from a time offset to a reference time, a gap duration is counted for the time domain resource but not used for data transmission.

[00150] In some embodiment, the segment duration is determined by a nominal TDW or the number of slots used for TBS determination.

[00151] In some embodiment, the gap duration is an actual gap duration determined by a nominal gap duration (Y0). In particular, the nominal gap duration is the number of symbols that is necessary to perform TA and/or frequency update, that is determined by UE capability, or configured in a higher layer parameter, or is a specified value.

5 [00152] In some embodiment, data transmission suspending or data transmission termination or data transmission reaching at the boundary of the segments or time advance adjustment in the gap duration is assumed to be an event which cause power consistency and phase continuity not to be maintained across data transmission.

[00153] In some embodiment, the gap duration is determined by data transmission
10 length and position within a slot. For example, the gap duration is determined by the number of unscheduled symbols (M) at the start of the slot for the data transmission. For another example, the gap duration or the position of the gap is determined by the number of unscheduled symbols at the start of the slot and the number of unscheduled symbols at the end of a previous slot. The gap duration or the position of the gap may be determined by the number of unscheduled
15 symbols before data transmission at the boundary of the segments.

[00154] The eNB or gNB (i.e. base unit) includes a processor, a memory, and a transceiver. The processor implements a function, a process, and/or a method which are proposed in Figure 10.

[00155] The base unit comprises a processor; and a transceiver coupled to the
20 processor, wherein, the processor is configured to receive, via the transceiver, uplink data on time domain resource, wherein, after each segment duration of the uplink transmission or after each segment duration from a time offset to a reference time, a gap duration is counted for the time domain resource but not used for data reception.

[00156] In some embodiment, the segment duration is determined by a nominal
25 TDW or the number of slots used for TBS determination.

[00157] In some embodiment, the gap duration is an actual gap duration determined by a nominal gap duration (Y0). In particular, the nominal gap duration is the number of symbols that is necessary to perform TA and/or frequency update, that is determined by UE capability, or configured in a higher layer parameter, or is a specified value.

30 [00158] In some embodiment, the gap duration is determined by data transmission length and position within a slot. For example, the gap duration is determined by the number of unscheduled symbols (M) at the start of the slot for the data transmission. For another example,

the gap duration or the position of the gap is determined by the number of unscheduled symbols at the start of the slot and the number of unscheduled symbols at the end of a previous slot. The gap duration or the position of the gap may be determined by the number of unscheduled symbols before data transmission at the boundary of the segments.

5 [00159] Layers of a radio interface protocol may be implemented by the processors. The memories are connected with the processors to store various pieces of information for driving the processors. The transceivers are connected with the processors to transmit and/or receive a radio signal. Needless to say, the transceiver may be implemented as a transmitter to transmit the radio signal and a receiver to receive the radio signal.

10 [00160] The memories may be positioned inside or outside the processors and connected with the processors by various well-known means.

 [00161] In the embodiments described above, the components and the features of the embodiments are combined in a predetermined form. Each component or feature should be considered as an option unless otherwise expressly stated. Each component or feature may be implemented not to be associated with other components or features. Further, the embodiment
15 may be configured by associating some components and/or features. The order of the operations described in the embodiments may be changed. Some components or features of any embodiment may be included in another embodiment or replaced with the component and the feature corresponding to another embodiment. It is apparent that the claims that are not expressly
20 cited in the claims are combined to form an embodiment or be included in a new claim.

 [00162] The embodiments may be implemented by hardware, firmware, software, or combinations thereof. In the case of implementation by hardware, according to hardware implementation, the exemplary embodiment described herein may be implemented by using one or more application-specific integrated circuits (ASICs), digital signal processors (DSPs), digital
25 signal processing devices (DSPDs), programmable logic devices (PLDs), field programmable gate arrays (FPGAs), processors, controllers, micro-controllers, microprocessors, and the like.

 [00163] Embodiments may be practiced in other specific forms. The described embodiments are to be considered in all respects to be only illustrative and not restrictive. The scope of the invention is, therefore, indicated by the appended claims rather than by the
30 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. A user equipment (UE), comprising:
a processor; and
5 a transceiver coupled to the processor, wherein, the processor is configured to transmit, via the transceiver, uplink data on time domain resource, wherein, after each segment duration of the uplink transmission or after each segment duration from a time offset to a reference time, a gap duration is counted for the time domain resource but not used for data transmission.
- 10 2. The UE of claim 1, wherein, the segment duration is determined by a nominal TDW or the number of slots used for TBS determination.
3. The UE of claim 1, wherein, the gap duration is an actual gap duration determined by a nominal gap duration (Y0).
4. The UE of claim 3, wherein, the nominal gap duration is the number of symbols that is
15 necessary to perform TA and/or frequency update, that is determined by UE capability, or configured in a higher layer parameter, or is a specified value.
5. The UE of claim 1, wherein, data transmission suspending or data transmission termination or data transmission reaching at the boundary of the segments or time advance adjustment in the gap duration is assumed to be an event which cause power
20 consistency and phase continuity not to be maintained across data transmission.
6. The UE of claim 1, wherein, the gap duration is determined by data transmission length and position within a slot.
7. The UE of claim 6, wherein, the gap duration is determined by the number of unscheduled symbols (M) at the start of the slot for the data transmission.

8. The UE of claim 6, wherein, the gap duration or the position of the gap is determined by the number of unscheduled symbols at the start of the slot and the number of unscheduled symbols at the end of a previous slot.
9. The UE of claim 6, wherein, the gap duration or the position of the gap is determined by the number of unscheduled symbols before data transmission at the boundary of the segments.
10. A method performed at a user equipment (UE), comprising:
transmitting uplink data on time domain resource, wherein,
after each segment duration of the uplink transmission or after each segment duration from a time offset to a reference time, a gap duration is counted for the time domain resource but not used for data transmission.
11. A base unit, comprising:
a processor; and
a transceiver coupled to the processor, wherein, the processor is configured to receive, via the transceiver, uplink data on time domain resource, wherein,
after each segment duration of the uplink transmission or after each segment duration from a time offset to a reference time, a gap duration is counted for the time domain resource but not used for data reception.
12. The base unit of claim 11, wherein, the segment duration is determined by a nominal TDW or the number of slots used for TBS determination.
13. The base unit of claim 11, wherein, the gap duration is an actual gap duration determined by a nominal gap duration (Y0).
14. The base unit of claim 13, wherein, the nominal gap duration is the number of symbols that is necessary to perform TA and/or frequency update, that is determined by UE capability, or configured in a higher layer parameter, or is a specified value.

15. The base unit of claim 11, wherein, the gap duration is determined by data transmission length and position within a slot.

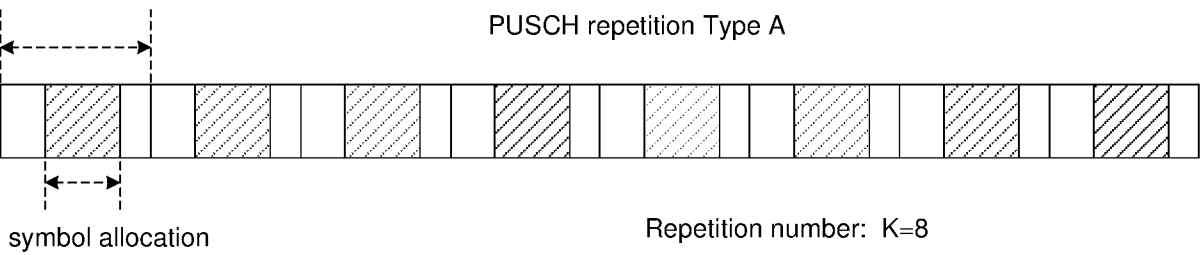


Figure 1(a)

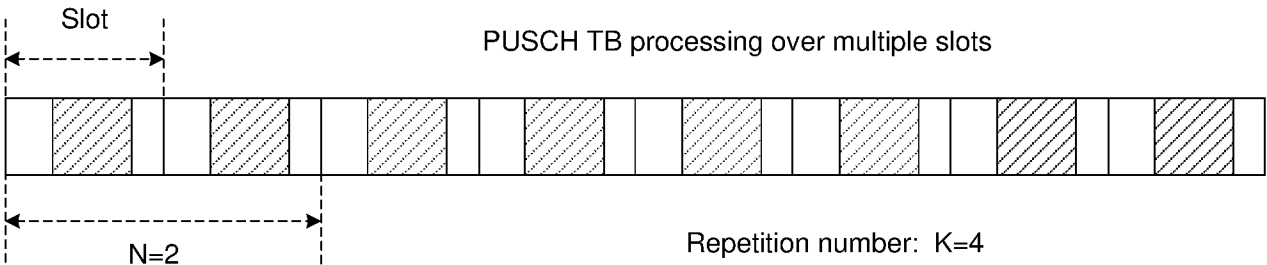


Figure 1(b)

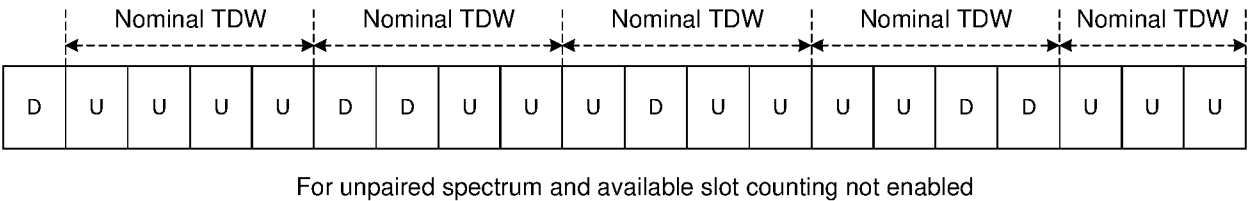


Figure 2(a)

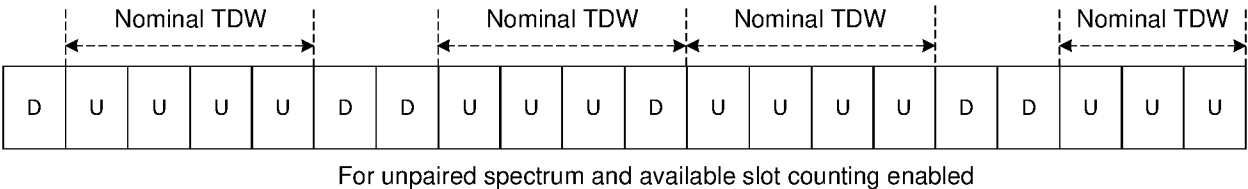


Figure 2(b)

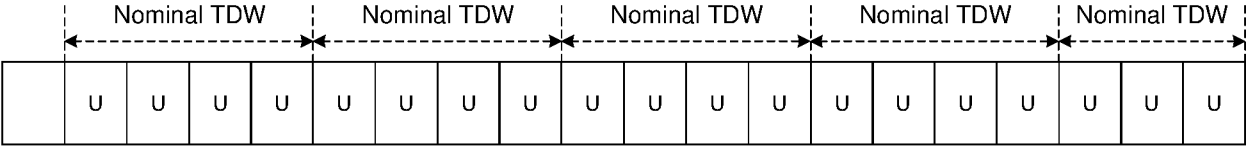


Figure 2(c)

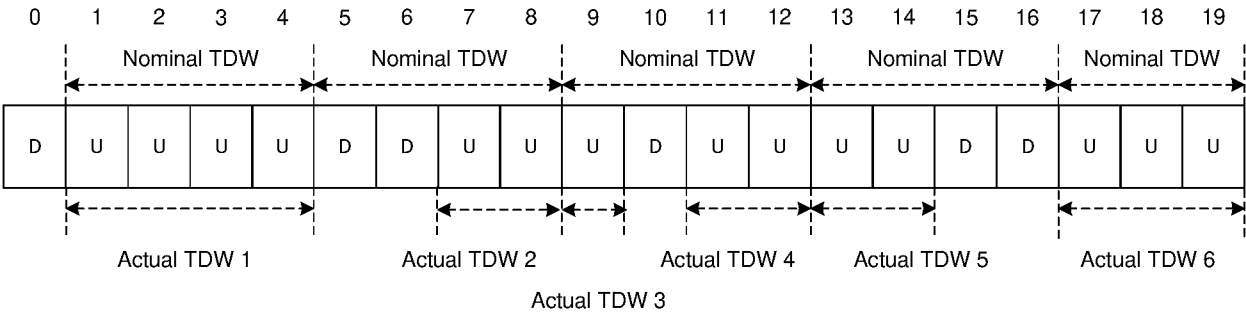


Figure 3(a)

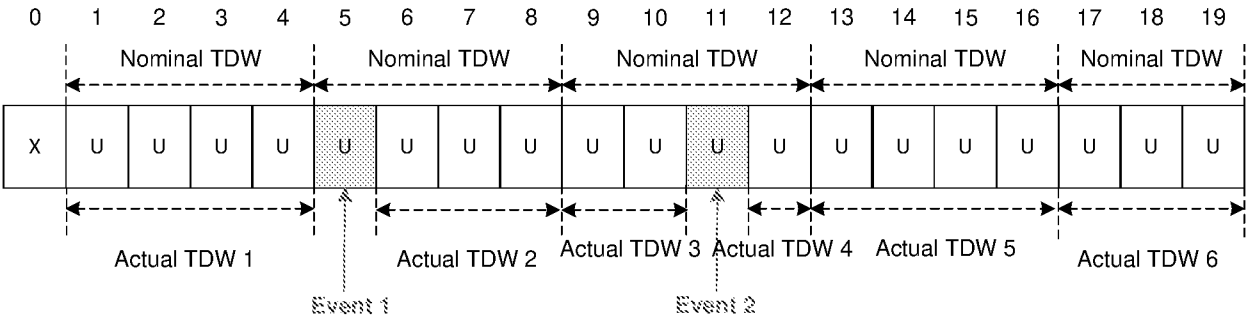


Figure 3(b)

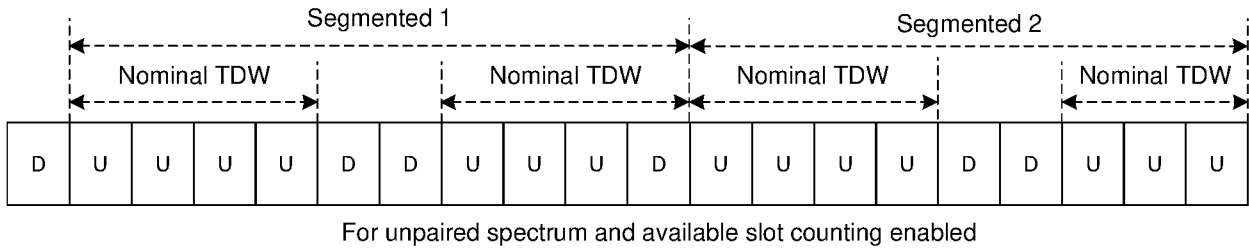


Figure 4(a)

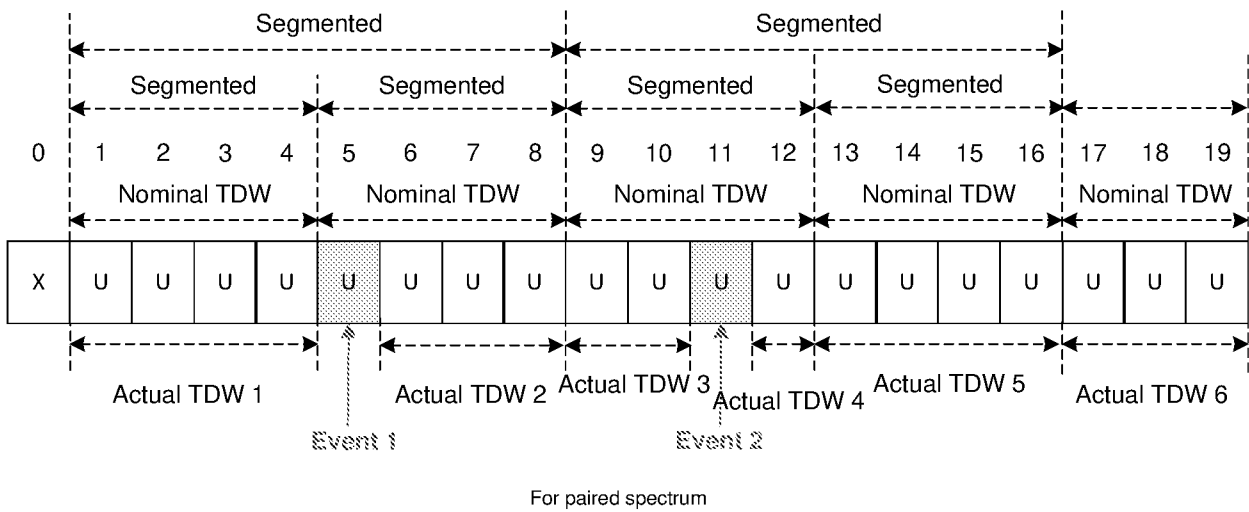


Figure 4(b)

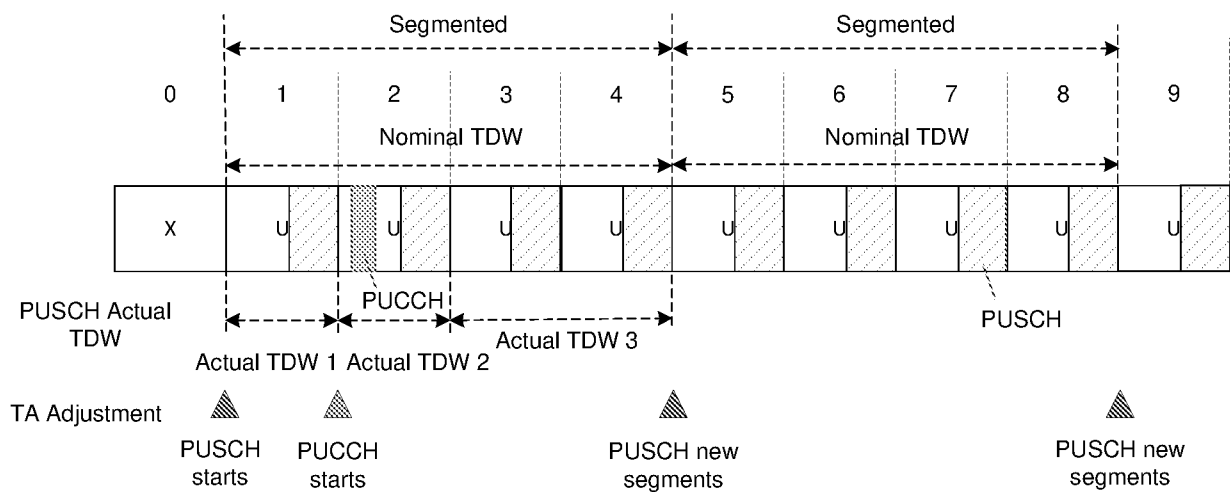


Figure 5(a)

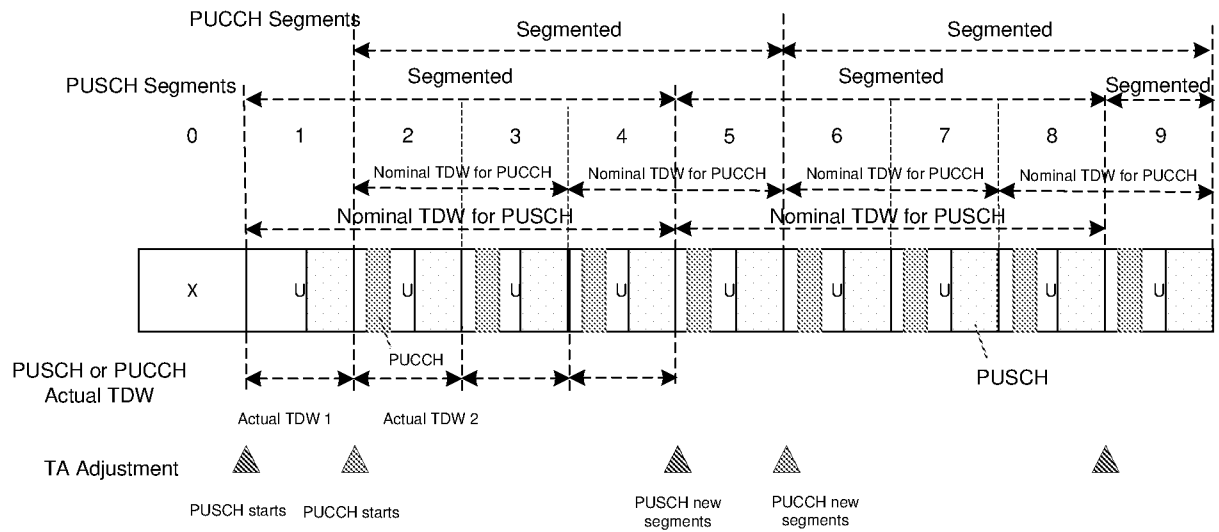


Figure 5(b)

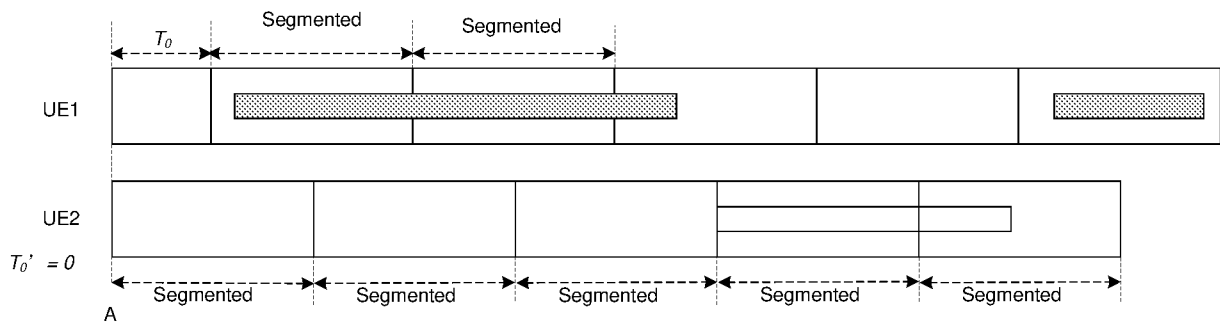


Figure 6(a)

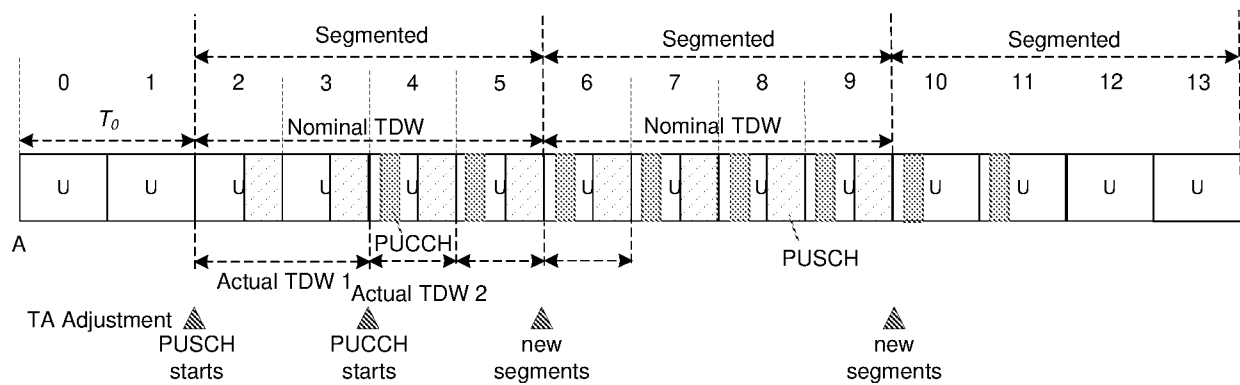


Figure 6(b)

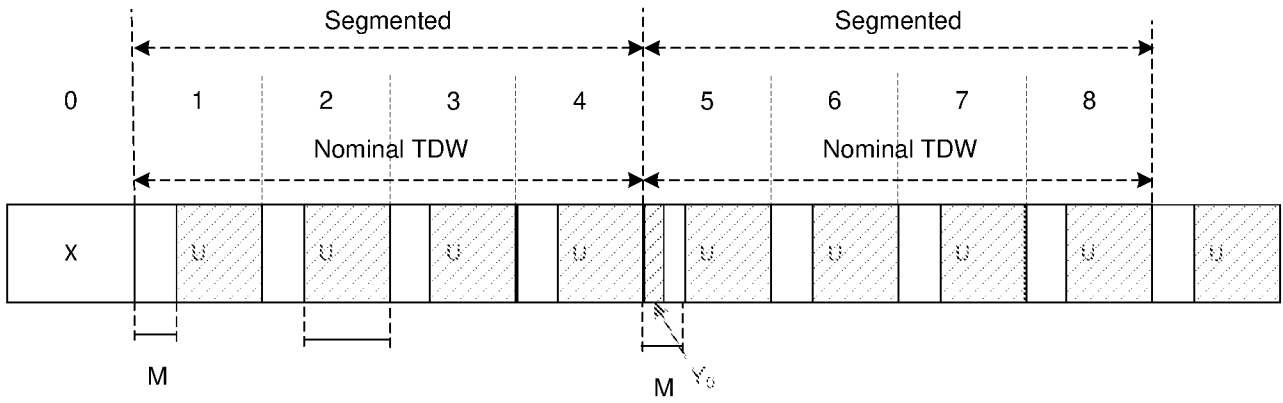
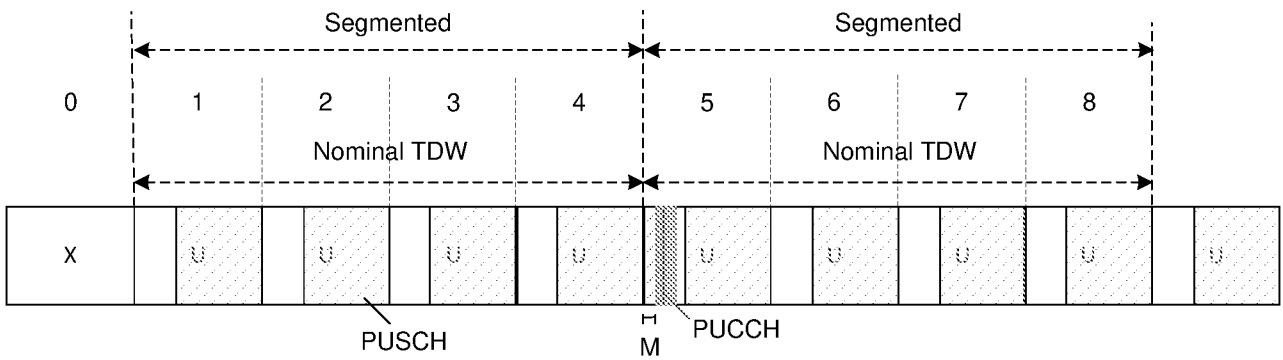


Figure 7(a)



The transmission gap M is not enough for TA/frequency adjustment, $(Y_0 - M)$ symbols of PUCCH is dropped

Figure 7(b)

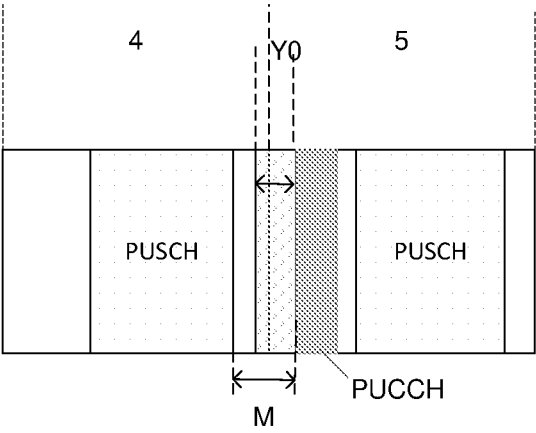


Figure 8(a)

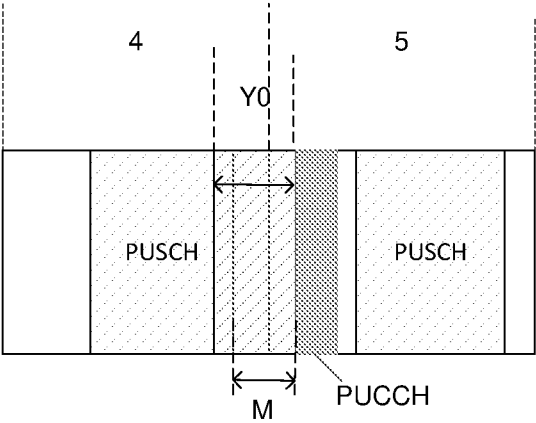


Figure 8(b)

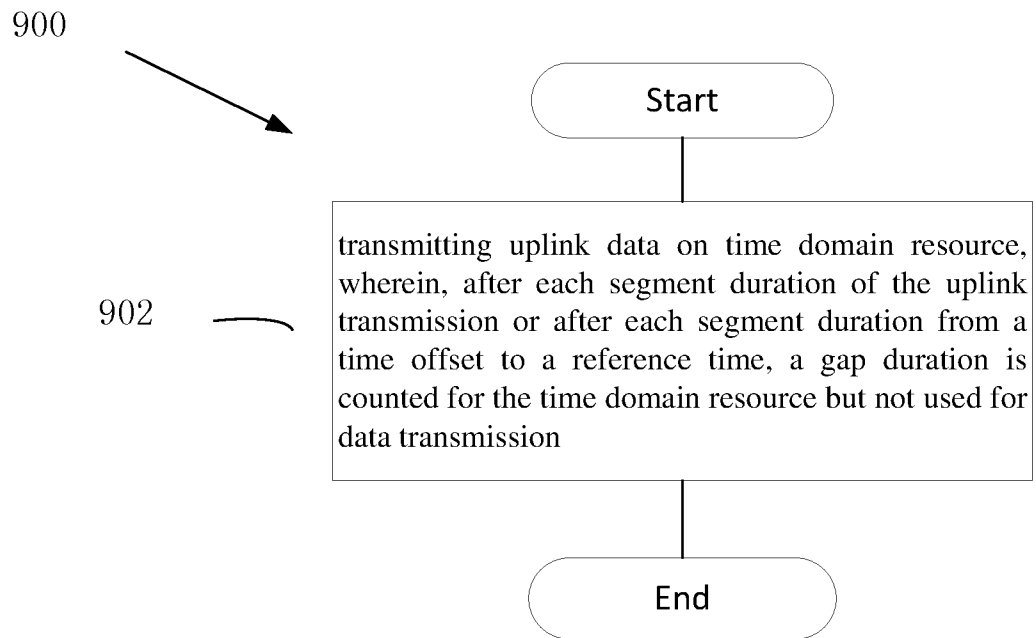


Figure 9

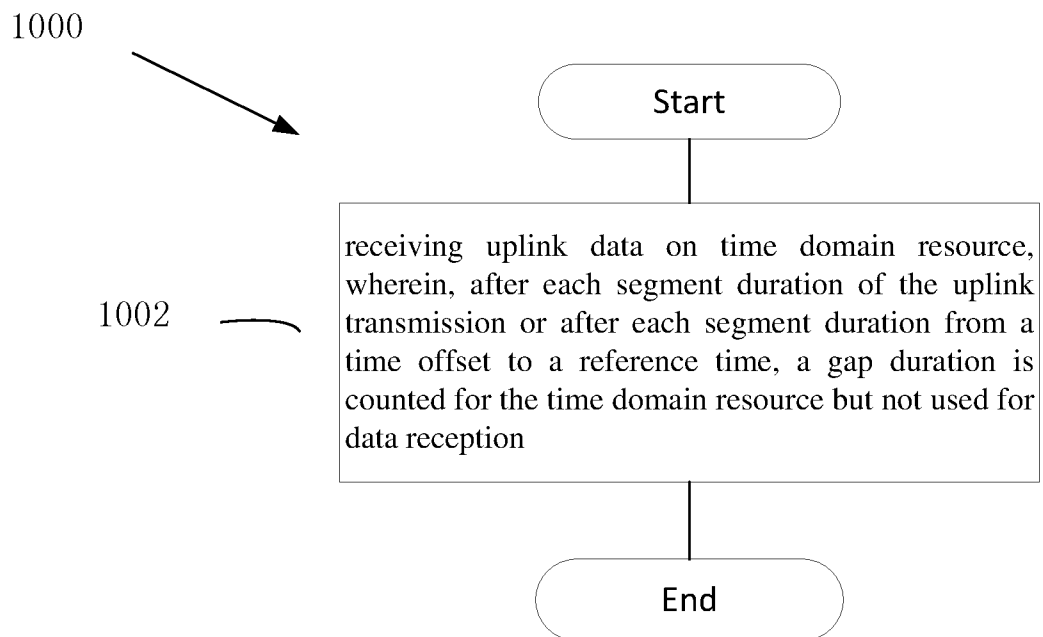


Figure 10

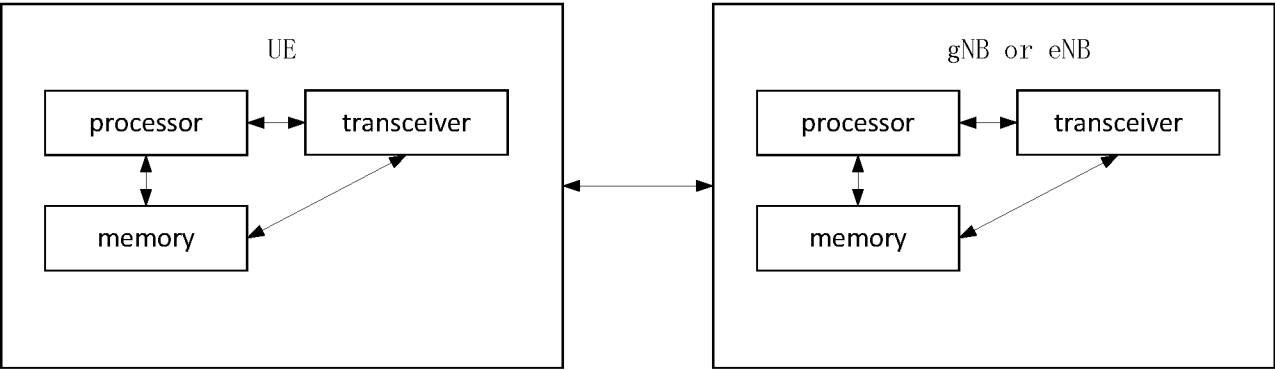


Figure 11

INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2022/082501

A. CLASSIFICATION OF SUBJECT MATTER

H04W 72/04(2009.01)i

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

H04W; 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)

CNKI,CNPAT,WPI,EPODOC,3GPP:NTN,NR, uplink, PUSCH, transmission, segment, duration, gap, time, domain, TA, offset, overlap

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	SPREADTRUM COMMUNICATIONS. "Discussion on enhancements to time and frequency synchronization for IOT NTN" 3GPP TSG RAN WG1 Meeting #106b-e R1-2108931, 19 October 2021 (2021-10-19), section 4	1-15
X	MODERATOR MEDIATEK. "Summary #7 of AI 8.15.1 Enhancements to time and frequency" 3GPP TSG RAN WG1 Meeting #106bis-e R1-2109173, 19 October 2021 (2021-10-19), section 4.2.4	1-15
A	WO 2019013921 A1 (QUALCOMM INCORPORATED) 17 January 2019 (2019-01-17) the whole document	1-15
A	WO 2021198982 A1 (TELEFONAKTIEBOLAGET LM ERICSSONPUBL) 07 October 2021 (2021-10-07) the whole document	1-15



Further documents are listed in the continuation of Box C.



See patent family annex.

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

21 June 2022

Date of mailing of the international search report

27 July 2022

Name and mailing address of the ISA/CN

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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.

PCT/CN2022/082501

Patent document cited in search report			Publication date (day/month/year)	Patent family member(s)			Publication date (day/month/year)
WO	2019013921	A1	17 January 2019	EP	3652988	A1	20 May 2020
				US	2019021017	A1	17 January 2019
				CN	110870349	A	06 March 2020
WO	2021198982	A1	07 October 2021	None			