United States Patent Application Publication	20250266934
Kind Code	A1
Publication Date	August 21, 2025
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HARQ-CAPABLE COMMUNICATION DEVICE AND METHOD THEREOF

Abstract

An operating method of a receiving device may include receiving data from a target transmitting device of at least one transmitting device via a sidelink channel, determining whether to request transmission of replacement data for the data from the target transmitting device according to a performance result of a hybrid automatic repeat request (HARQ) process on the data, and when transmission of the replacement data is requested, transmitting to the target transmitting device a replacement data request signal distinct from an acknowledge (ACK) signal and a negative-ACK (NACK) signal.

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Appl. No.: **19/180831**

Filed: **April 16, 2025**

Foreign Application Priority Data

KR	10-2021-0053164	Apr. 23, 2021
KR	10-2021-0078290	Jun. 16, 2021

Related U.S. Application Data

parent US continuation 17660256 20220422 parent-grant-document US 12301360 child US 19180831

Publication Classification

Int. Cl.: **H04L1/1812** (20230101); **H04L1/08** (20060101); **H04L1/1607** (20230101); **H04L5/00** (20060101); **H04L27/26** (20060101); **H04W72/02** (20090101); **H04W92/18** (20090101)

U.S. Cl.:

CPC **H04L1/1812** (20130101); **H04L1/08** (20130101); **H04L1/1642** (20130101); **H04L5/0053** (20130101); **H04L27/2607** (20130101); **H04W72/02** (20130101); H04W92/18 (20130101)

Background/Summary

CROSS-REFERENCE TO RELATED APPLICATIONS [0001] This application is a Continuation of U.S. patent application Ser. No. 17/660,256, filed on Apr. 22, 2022, which claims priority under 35 U.S.C. § 119 to Korean Patent Application Nos. 10-2021-0053164, filed on Apr. 23, 2021 and 10-2021-0078290, filed on Jun. 16, 2021 in the Korean Intellectual Property Office, the disclosures of which are incorporated by reference herein in their entireties.

TECHNICAL FIELD
[0002] This disclosure relates generally to a communication device, and more particularly, to a hybrid automatic repeat request (HARQ) capable communication device.
DISCUSSION OF THE RELATED ART
[0003] A wireless communication terminal may perform a forward error correction (FEC) process or an automatic repeat request (ARQ) process for securing the reliability of communication by using error detection or error compensation. When the wireless communication terminal operates based on an FEC process, an error in data transmitted from a transmitting device to a receiving device may be self-corrected at the receiving device by using an error correction code, without the need for the transmitting device to retransmit the data.
[0004] On the other hand, in an ARQ process, such an error may be corrected by means of the transmitting device retransmitting the data in response to a request by the receiving device. After each set of data transmissions, the receiving device sends a feedback signal in the form of an Acknowledgement (ACK) signal when the data is successfully decoded, or a negative-ACK (NACK) when the data is not successfully decoded. The retransmission is made in response to the NACK signal.
[0005] Hybrid ARQ (HARQ) is a transmission method that combines an ARQ process with an error correction process. Several different types of HARQ methods have been proposed, where each involves the transmission of ACK and NACK signals in appropriate circumstances. In some cases, a time delay problem of an upper layer is addressed by adding channel coding (e.g., FEC coding) for utilizing an error packet to an existing ARQ. HARQ is used in various mobile communication standards such as high speed packet access (HSPA) and long term evolution (LTE).
SUMMARY
[0006] Embodiments of the inventive concept provide a method of transmitting, by a receiving device to a transmitting device, a feedback signal requesting transmission of “replacement data” with respect to data received by a receiving device from the transmitting device.
[0007] According to an aspect of the inventive concept, there is provided an operating method of a receiving device, the operating method including: receiving data from a transmitting device via a sidelink channel; determining whether to request transmission of replacement data for the received data from the target transmitting device according to a performance result of a hybrid automatic

repeat and request (HARQ) process on the data; and when transmission of the replacement data is requested, transmitting to the target transmitting device a replacement data request signal distinct from an acknowledge (ACK) signal and a negative-ACK (NACK) signal.

[0008] According to another aspect of the inventive concept, there is provided an operating method of a transmitting device, the operating method including: transmitting data to a receiving device via a sidelink channel; receiving, as a feedback signal from the receiving device, any one of an ACK signal, a NACK signal, and a replacement data request signal distinct from the ACK signal and the NACK signal according to a performance result of a HARQ process; determining a type of the feedback signal; and transmitting a replacement data to the receiving device in response to a case where the type of the feedback signal is that of the replacement data request signal.

[0009] According to another aspect of the inventive concept, there is provided a receiving device including: a HARQ buffer storing a performance result of an HARQ process on data received from a target transmitting device via a sidelink channel; an HARQ processor determining whether to request transmission of replacement data for data from the target transmitting device according to the performance result of the HARQ process on the received data, the HARQ processor, when the transmission of the replacement data is requested, determining a feedback signal to be transmitted to the target transmitting device as a replacement data request signal distinct from an ACK signal and a NACK signal; and a radio frequency integrated circuit (RFIC) transmitting the determined replacement data request signal to the target transmitting device.

[0010] According to another aspect of the inventive concept, there is provided a transmitting device including: an RFIC transmitting data to a receiving device via a sidelink channel, and receiving as a feedback signal any one of an ACK signal, a NACK signal, and a replacement data request signal distinct from the ACK signal and the NACK signal according to a performance result of a HARQ process from the receiving device; a buffer temporarily storing the feedback signal; and an HARQ processor determining a type of the feedback signal and generating replacement data to be transmitted to the receiving device in response to a case where the type of the feedback signal is a replacement data request signal.

[0011] In another aspect of the inventive concept, an operating method of a transmitting device includes transmitting first data to a receiving device, where the first data represents original data; receiving, as a feedback signal from the receiving device, an ACK signal, a NACK signal, or a replacement data request signal distinct from the ACK signal and the NACK signal, according to a performance result of a HARQ process with respect to the first data at the receiving device. If the NACK signal is received, second data is transmitted to the receiving device, where the second data represents at least a portion of the original data coded at a first coding rate. If the replacement data request signal is received, replacement data is transmitted to the receiving device, where the replacement data represents at least a portion of the original data coded at a second coding rate lower than the first coding rate.

[0012] The second coding rate produces the replacement data with a higher percentage of original data represented therein as compared to the second data. The likelihood of successful decoding of the replacement data may be higher than that for the second data, resulting in less re-transmissions.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] Embodiments of the inventive concept will be more clearly understood from the following detailed description taken in conjunction with the accompanying drawings in which:

[0014] FIG. **1** is a schematic block diagram of a configuration of a receiving device of the inventive concept;

[0015] FIG. **2** is a flowchart of a method of transmitting any one of an acknowledge ACK signal, a negative-ACK (NACK) signal, and a replacement data request signal to a transmitting device as a feedback signal by a receiving device according to an example embodiment;

[0016] FIG. **3** is a flowchart of a method of transmitting a replacement data request signal to a transmitting device by a receiving device according to an example embodiment;

[0017] FIG. **4** is a complex plane graph illustrating phases of feedback signals cyclically shifted from a base sequence, according to an example embodiment;

[0018] FIG. **5** is a table of a first shift value according to an example embodiment;

[0019] FIG. **6**A is a diagram of an example in which a plurality of communication devices according to an example embodiment transmit data in a second groupcast method;

[0020] FIG. **6**B is a diagram of an example in which receiving devices, which have received data according to an example embodiment of FIG. **6**A, provide feedback signals to a transmitting device;

[0021] FIG. **7**A is a diagram of an example in which a plurality of communication devices according to an example embodiment transmit data in a unicast method;

[0022] FIG. **7**B is a diagram of an example in which the receiving device having received data according to an example embodiment of FIG. **7**A provides feedback signals to a transmitting device;

[0023] FIG. **8** is a table of a second shift value corresponding to the example embodiments of FIGS. **6**A through **7**B;

[0024] FIG. **9**A is a diagram of an example in which a plurality of communication devices according to an example embodiment transmit data in a first groupcast method;

[0025] FIG. **9**B is a diagram of an example in which the receiving devices having received data according to an example embodiment of FIG. **9**A provide feedback signals to a transmitting device;

[0026] FIG. **10** is a table of a second shift value corresponding to the example embodiments of FIGS. **9**A and **9**B;

[0027] FIG. **11** is a table of a first shift value according to another example embodiment;

[0028] FIG. **12** is a table of a second shift value according to another example embodiment;

[0029] FIG. **13** is a block diagram of a schematic configuration of a transmitting device having received a feedback signal, according to an embodiment;

[0030] FIG. **14** is a flowchart of a method of transmitting replacement data by a transmitting device, according to an example embodiment;

[0031] FIG. **15** is a flowchart of a method of transmitting retransmission data or replacement data when a transmitting device receives feedback signals from a plurality of receiving devices, according to an example embodiment; and

[0032] FIG. **16** is a block diagram of a configuration of a wireless communication device, according to an example embodiment.

DETAILED DESCRIPTION OF EMBODIMENTS

[0033] Hereinafter, embodiments of the inventive concept will be described in detail with reference to the accompanying drawings.

[0034] In the following description, a first device that transmits data may be referred to as a transmitting device, and a second device that receives the transmitted data may be a receiving device that performs a HARQ process with respect to the data. The receiving device may transmit a feedback signal, which provides a performance result of the HARQ process, to the transmitting device as feedback.

[0035] In the following description, data transmitted by the transmitting device in a HARQ process may represent “original data”, which may also be referred to as “systematic data” or “user data”. In a given data transmission that represents original data, the transmitted data, which may be referred to herein as “first data”, contains a number of bits exceeding the number of bits of the original data, since the first data is typically prepared with padding bits for both error correction (e.g., FEC padding bits) and error detection (e.g., with CRC padding bits).

[0036] Briefly, in embodiments of the inventive concept to be described in detail hereafter, when a decoding process at the receiving device fails and a NACK feedback message indicating such failure is transmitted by the receiving device back to the transmitting device, the transmitting device may perform a retransmission of data by transmitting "second data" representing at least a portion of the original data that was represented by the first data. On the other hand, when the decoding process fails and the receiving device transmits a "replacement data request signal", which indicates that the decoding process failed for a particular reason (e.g., HARQ buffer saturation), the transmitting device may perform a retransmission of "replacement data" that differs from the second data but also represents at least a portion of the original data. The second data may have been coded at a first coding rate and the replacement data may have been coded at a second coding rate lower than the first coding rate. In other words, the second coding rate produces the replacement data with a higher percentage of original data represented therein as compared to the second data. As a result, the likelihood of successful decoding of the replacement data may be higher than that for the second data, resulting in less re-transmissions in the HARQ process.

[0037] FIG. **1** is a schematic block diagram of a configuration of a receiving device according to an embodiment of the inventive concept. Embodiments will be described hereafter in the context of a sidelink communication, but aspects of the inventive concept may be applicable to other communication environments in other embodiments.

[0038] In a communication environment in which the transmitting device and the receiving device communicate data (i.e., transmit and/or receive data) via a sidelink, the transmitting device may transmit a physical sidelink shared channel (PSSCH) including PSSCH data to the receiving device, and the receiving device may transmit, to the transmitting device, a physical sidelink feedback channel (PSFCH) including feedback signals in response to the PSSCH. According to an embodiment, the feedback signal may include an acknowledge (ACK) signal, a negative-ACK (NACK) signal, and a replacement data request signal. Hereinafter, the replacement data request signal may be also referred to as an initial-ACK (IACK) signal.

[0039] The receiving device may receive data from a plurality of transmitting devices via the PSSCH and the PSFCH, unlike a physical downlink shared channel (PDSCH), and each transmitting device may transmit data to the receiving device by mapping any one of a plurality of HARQ identifications (ID) to the data to be transmitted. In this case, the number of HARQ processes that the receiving device having received data is capable of performing, and a capacity of a buffer temporarily storing the data may be limited.

[0040] Referring to FIG. **1**, the receiving device receiving data may include a reception HARQ processor **10**, an HARQ buffer **11**, and a radio frequency integrated circuit (RFIC) **12**. The reception HARQ processor **10** may include an HARQ controller **110**, a decoder **120**, an HARQ buffer controller **130**, and an HARQ combiner **140**. Various components of the reception HARQ processor **10** illustrated in FIG. **1** may be implemented in hardware, or software, which is performed by a central processing unit (CPU) in the reception HARQ processor **10**. Alternatively, various components of the reception HARQ processor **10** may be also implemented as a combination of hardware and software. In FIG. **1**, it is illustrated that various pieces of information are transmitted between components in the reception HARQ processor **10**, but at least a portion of the various pieces of information may be generated during a software execution process of the CPU, and be also provided to each component.

[0041] The HARQ controller **110** may control the overall operation of components equipped in the reception HARQ processor **10**. The HARQ controller **110** may control an operation of storing received data DATA in the HARQ buffer **11**, or loading buffer data BUF_DATA from the HARQ buffer **11**. According to an example embodiment, the HARQ controller **110** may receive a cyclical redundancy check (CRC) check result CRC_CR from the decoder **120**, and based on the received CRC check result CRC_CR, may control a storing operation of HARQ data. As an example, when the HARQ controller **110** determines that data received as the CRC check result CRC_CR has an error, the HARQ controller **110** may instruct the HARQ buffer controller **130** to store the received data as buffer data BUF_DATA by transmitting a buffer command BUF_CMD thereto.

[0042] The decoder **120** may decode data DATA received via the RFIC **12** of the receiving device, and may provide the decoded result as the CRC check result CRC_CR to the HARQ controller **110**. When the HARQ controller **110** receives the CRC check result CRC_CR of successful decoding, the HARQ controller **110** may control the RFIC **12** to transmit the ACK signal to a transmitting device, by determining a type of the feedback signal FB_Type as the ACK signal.

[0043] According to an embodiment, when the HARQ controller **110** receives the CRC check result CRC_CR of failed decoding, the HARQ controller **110** may control the RFIC **12** to transmit any one of the NACK signal and the replacement data request signal to the transmitting device by determining the type of the feedback signal FB_Type as the NACK signal and the replacement data request signal. The replacement data request signal may be a signal requesting again data that has been initially transmitted to the transmitting device in a state in which the HARQ buffer **11** is not capable of storing the buffer data BUF_DATA. The initially transmitted data may include an initially transmitted transmission block corresponding to each of the plurality of HARQ processes, which are performed in parallel in the receiving device, and as an example, may include the transmission block corresponding to redundancy version (RV) 0.

[0044] When it is determined that, as the CRC check result CRC_CR, decoding has failed, or data may not be stored in the HARQ buffer **11**, or the initially transmitted data is required, the HARQ controller **110** may control the RFIC **12** to transmit the replacement data request signal to the transmitting device. When it is determined that the initially transmitted data is required, as an example, power of a signal received by the RFIC **12** may be instantly increased, and the case of failed de-mapping may be included.

[0045] The HARQ buffer controller **130** may control transmission of data between the HARQ buffer **11** and the reception HARQ processor **10**. The HARQ buffer **11** may be used to temporarily store the received data until an HARQ combination is completed. In addition, in relation with combined data COMB_DATA, the combined data COMB_DATA may be directly provided to an external memory of the reception HARQ processor **10**, or the combined data COMB_DATA may be temporarily stored in the HARQ buffer **11** and then moved to the external memory.

[0046] According to an embodiment, the HARQ buffer controller **130** may designate an address of the HARQ buffer **11** to store the buffer data BUF_DATA, and determine a degree of saturation of the HARQ buffer **11** based on the designated address. As an example, the HARQ buffer controller **130** may determine whether the address mapped to the buffer data BUF_DATA includes an end point address of a predefined address range of the HARQ buffer **11**, and when the end point address is included, may determine that the HARQ buffer **11** is saturated.

[0047] According to an example embodiment, the HARQ buffer controller **130** may provide HARQ buffer availability information BUF_AV to the HARQ controller **110**, and when the HARQ buffer **11** is determined to be saturated, may control the RFIC **12** to transmit the replacement data request signal to the transmitting device. In another scenario, when it is determined that decoding of data has failed but the HARQ buffer **11** is not saturated, the HARQ controller **110** may control the RFIC **12** to transmit the NACK signal to the transmitting device.

[0048] The HARQ combiner **140** may, in response to a combination instruction command COMB_CMD, combine retransmission data RE_DATA with the buffer data BUF_DATA stored in the HARQ buffer **11** and output the combined data COMB_DATA. The HARQ combiner **140** may receive the buffer data BUF_DATA via the HARQ buffer controller **130**, and provide, to the HARQ buffer controller **130**, the combined data COMB_DATA in which the retransmission data RE_DATA is combined with the buffer data BUF_DATA.

[0049] In the related art, the transmitting device, after having received only the ACK signal and the NACK signal as feedback signals with respect to the transmitted data, may be unable to determine whether data is stored in a HARQ buffer of the receiving device. Accordingly, the transmitting device may assume that the data has been stored in the receiving device, and transmit the retransmission data RE_DATA to the receiving device based on an efficient redundancy version index sequence. However, when the receiving device has not stored the data, and the retransmission data RE_DATA is in a high code rate status in which little systematic data is included therein, the receiving device may fail again in decoding regardless of a channel status, and additional retransmission may become necessary.

[0050] As an example, when the redundancy version index sequence used in the data transmission is a sequence of 0-2-3-1, RV0, which has highest self-decodability (that is, a highest decoding success probability before combining), may be used for the initial transmission, and the retransmission may be attempted in a sequence of RV2-RV3-RV1. When the coding rate equals or exceeds a threshold in a process of configuring data in the retransmission, because a systematic data message is not included in the retransmission data RE_DATA (or a smaller percentage of the systematic data message is represented by the total amount of retransmission data), a decoding success probability may be significantly reduced. (Here, a higher coding rate for a given data transmission means that to represent a certain number of original bits, i.e., systematic bits, a higher number of total bits are transmitted. In other words, a lower percentage of original bits is represented by the data transmission.) Accordingly, when the retransmission data RE_DATA has a high coding rate, the need for additional retransmission is more likely. An increase in the number of retransmissions may cause an increase in power consumption of the transmitting and receiving devices, an increase in latency, and a reduction in resource utilization.

[0051] However, in accordance with embodiments of the inventive concept, if the NACK signal is received, second data is transmitted to the receiving device, where the second data represents at least a portion of the original data coded at a first coding rate. If the replacement data request signal is received, replacement data is transmitted to the receiving device, which represents at least a portion of the original data coded at a second coding rate lower than the first coding rate. The second coding rate produces the replacement data with a higher percentage of original data represented therein as compared to the second data. Therefore, the likelihood of successful decoding of the replacement data may be higher than that for the second data, resulting in less re-transmissions in the HARQ process.

[0052] In a vehicle to everything (V2X) communication system, turnover of the HARQ process may be reduced due to the retransmission while an available HARQ process is lacking, which may cause a performance reduction in the entire network. For instance, in a communication environment configured with a plurality of transmitting devices, when data transmission of a high volume between devices with high reliability is required, a continuous transmission failure may affect the entire network of transmitting devices.

[0053] Embodiments of the inventive concept may address this issue by transmitting, from a receiving device under certain conditions, a replacement data request signal distinct from the ACK signal and the NACK signal to the transmitting device. Thereafter, by receiving replacement data of a low code rate, the receiving device may perform the HARQ process again in a more efficient manner.

FIG. **2** is a flowchart of a method of transmitting an ACK signal, a NACK signal, or a replacement data request signal as a feedback signal by a receiving device to a transmitting device, according to an example embodiment. In the method, the receiving device may receive data from at least one transmitting device, and transmit the feedback signal to the transmitting device based on the decoding result for the received data. The receiving device may perform decoding on the received data (S**110**). Data received by the receiving device may include a CRC code, which is a transport block and an error detection block.

[0054] The receiving device may determine whether decoding has succeeded (S**120**). As an example, when the CRC code included in the data is identified as a certain value computed with respect to the remaining data in the data transmission,, the receiving device may determine that decoding has succeeded. When it is determined that decoding has succeeded, the receiving device may transmit to the transmitting device the ACK signal as a signal representing successful decoding of data (S**130**).

[0055] When it is determined that decoding for the data has failed, the receiving device may determine whether replacement data for the receive data should be subsequently transmitted (S**140**). According to an example embodiment, when a replacement data request command is received from an upper layer of a physical layer (PHY) and a medium access control layer (MAC), which are performed by the HARQ process, it may be determined that the replacement data should be transmitted at each time of decoding failure. In addition, the receiving device may determine whether the replacement data should be transmitted based on an available storage space of the HARQ buffer **11**. When it is determined that the replacement data is unnecessary, the receiving device may transmit the NACK signal to the transmitting device (S**150**).

[0056] Otherwise, when it is determined that the replacement data is desired, the receiving device may transmit the replacement data request signal to the transmitting device (S**160**). Accordingly, the receiving device may receive the replacement data from the transmitting device.

[0057] FIG. **3** is a flowchart of a method of transmitting a replacement data request signal to a transmitting device by a receiving device according to an example embodiment.

[0058] Referring to FIG. **3**, the receiving device may determine transmitting of the replacement data request signal based on whether there is the available storage space in the HARQ buffer **11**. When decoding on the received data fails, transmission of data to the HARQ buffer **11** may be attempted (S**141**). The HARQ buffer controller **130** may map an address corresponding to a storage space in the HARQ buffer **11** in an address sequence of the available storage region.

[0059] The receiving device may determine whether there is the available storage space in the HARQ buffer **11** (S**142**). The HARQ buffer controller **130** may determine whether an address mapped to data to be stored in the HARQ buffer **11** includes an end point address in an address range corresponding to a storage space.

[0060] When it is determined that an available storage space is in the HARQ buffer **11**, the receiving device may store data, with an address mapped thereto, in the HARQ buffer **11**, and transmit the NACK signal to the transmitting device (S**150**). When it is determined that the address mapped to the data does not include the end point address, the HARQ buffer controller **130** may transmit the NACK signal to the transmitting device.

[0061] Otherwise, when it is determined that the available storage space is not in the HARQ buffer **11**, the receiving device may transmit the replacement data request signal to the transmitting device (S**160**). Otherwise, when it is determined that the address mapped to the data includes the end point address, the HARQ buffer controller **130** may transmit the replacement data request signal to the transmitting device.

[0062] FIG. **4** is a complex plane graph illustrating phases of feedback signals cyclically shifted from a base sequence BS, according to an example embodiment.

[0063] Referring to FIG. **4**, the feedback signal may have a cyclically shifted phase from the base sequence BS. According to an example embodiment, the base sequence BS may be determined based on a resource pool allocated to the sidelink, and the resource pool may be a combination of frequency and time region resources that may be used in transceiving of a sidelink signal. In other words, because transceiving of a sidelink signal needs to be performed in a predetermined frequency-time resource, and the above resource may be defined as a resource pool.

[0064] The resource pool may be individually defined for transmission and reception, and may be used by being defined commonly for transmission and reception. In addition, the transmitting device and the receiving device may be allocated with one or a plurality of resource pools, and perform a transceiving operation of a sidelink signal. Setting information about the resource pool used for transceiving of a sidelink signal and other setting information about the sidelink may be pre-installed when devices are produced, configured by a current base station, pre-configured by

another base station due to connection transfer from the current base station or by another network unit, or fixed, provisioned by a network, or self-constructed by a terminal.
[0065] To direct a frequency region resource of the resource pool, the receiving device and the transmitting device may direct an initial index and a length of physical resource blocks (PRBs) (for example, the number of PRBs) included in the resource pool, but are not limited thereto, and may configure one resource pool by directing the PRBs by using a bitmap.
[0066] To direct a time region resource of the resource pool, a base station may direct an orthogonal frequency-division multiplexing (OFDM) symbol or indices of a slot, which belongs to the resource pool, in bitmap units. Alternatively, according to another method, a system may be configured so that, by using a formula in a combination of particular slots, the slots satisfying a corresponding formula belong to a corresponding resource pool. In setting the time region resource, for example, the base station may notify devices/users which slots during a particular time period belong to a particular resource pool through use of the bitmap, and in this case, may direct according to the bitmap whether the slots correspond to the resource pool of time resource at each particular time period.
[0067] The receiving device of embodiments of the inventive concept may transmit the feedback signal to the transmitting device based on the PSFCH resource corresponding to the frequency region resource or the time region resource. In addition, even though the same frequency region resource and time region resource are used, the receiving device may perform code division multiplexing (CMD).
[0068] According to an example embodiment, the receiving device may generate a feedback signal having a cyclically shifted code from the base sequence BS based on the Zadoff-Chu sequence. Correlation between codes, which are generated based on the Zadoff-Chu sequence of different indices, may be low. Accordingly, even though the plurality of feedback signals are received from the same frequency region resource and time region resource, the transmitting device may easily differentiate the feedback signals, which are generated based on the Zadoff-Chu sequence of different indices.
[0069] According to FIG. **4**, when the cyclic shift is performed from the base sequence BS in the Zadoff-Chu sequence of different indices, phases of respective cyclically shifted feedback signals may be different from each other. Hereinafter, a method of, by the receiving device, determining a first shift value according to a predefined cyclic shift index, determining the second shift value according to a HARQ process performance result, and determining an index of the Zadoff-Chu sequence based on the first shift value and the second shift value is described.
[0070] FIG. **5** is a table of the first shift value according to an example embodiment.
[0071] Referring to FIG. **5**, the receiving device may determine the number of cyclic shift indices by using an upper layer of the layers performing the HARQ process. The number of cyclic shift indices may be also pre-configured in a process of defining the resource pool between the transmitting device and the receiving device. In the table of FIG. **5**, the number of cyclic shift indices may be determined to be one of 1, 2, 3, and 6, but the number/sequence may differ in other examples.
[0072] When the number of cyclic shift indices is determined to be 1, the receiving device may be in a status in which it has been determined not to perform the CDM, and in this case, the first shift value may be 0. When the number of cyclic shift indices is determined to be 2, the receiving device may determine the shift value 1 as any one of 0 and 3, and when the number of cyclic shift indices is determined to be 3, may determine the first shift value to be any one of 0, 2, and 4. Similarly, when the number of cyclic shift indices is determined to be 6, the receiving device may determine the first shift value as any one of 0 through 5. However, the first shift value determined by the receiving device of the inventive concept is not limited only to the embodiment of FIG. **5**.
[0073] According to an example embodiment, the receiving device may determine any one of candidate cyclic shift indices as the cyclic shift index based on an ID of the receiving device and an

ID of the transmitting device. The candidate cyclic shift index may be determined according to the number of cyclic shift indices, and when the number of cyclic shift index is one, the candidate cyclic shift index may be one. When the number of cyclic shift indices is two, the candidate cyclic shift index may be 1 and 2, when the number of cyclic shift indices is three, the candidate cyclic shift index may be 1 through 3, and when the number of cyclic shift indices is six, the candidate cyclic shift index may be 1 through 6. After the receiving device determines any one of the candidate cyclic shift indices to be the cyclic shift index based on the ID of the receiving device and the ID of the transmitting device, in sidelink communication in which any one of the receiving device and the transmitting device is different, the cyclic shift indices may be determined to be different from each other.

[0074] FIG. **6**A is a diagram of an example in which a plurality of communication devices according to an example embodiment transmit data in a second groupcast method, and FIG. **6**B is a diagram of an example in which receiving devices, which have received data according to an example embodiment of FIG. **6**A, provide the feedback signals to a transmitting device.

[0075] The receiving device of the inventive concept may perform the sidelink communication in a first groupcast communication method, a second groupcast communication method, and the unicast communication method, and a determining method of the second shift value may vary according to each communication method. Descriptions are given for the second groupcast communication method with reference to FIGS. **6**A and **6**B, for the unicast communication method with reference to FIGS. **7**A and **7**B, and for the first groupcast communication method with reference to FIGS. **9**A and **9**B.

[0076] Referring to FIG. **6**A, a transmitting device **610** may transmit common data to a plurality of receiving devices **621** through **624**, that is, may transmit data in the groupcast method. The transmitting device **610** and the plurality of receiving devices **621** through **624** may be devices moving with vehicles. For the groupcast, at least one of separate control information (for example, sidelink control information (SCI)), a physical control channel (for example, a physical sidelink control channel (PSCCH)), and data may be further transmitted. In this case, the transmitting device **610** may transmit a message of performing of a second groupcast to the plurality of receiving devices **621** through **624** by using the SCI.

[0077] Referring to FIG. **6**B, each of the plurality of receiving devices **621** through **624**, which have received the common data by using the second groupcast, may transmit to the transmitting device **610** any one of the ACK signal, the NACK signal, and the replacement data request signal (or the IACK signal) as the feedback signal. When the sidelink communication is performed by using the second groupcast, the transmitting device **610** may differentiate a transmitting device **610**, which has transmitted the feedback signal, via the PSCCH, and may determine a type of following data according to a type of the feedback signal.

[0078] FIG. **7**A is a diagram of an example in which a plurality of communication devices according to an example embodiment transmit data in the unicast method, and FIG. **7**B is a diagram of an example in which receiving devices, which have received data according to an example embodiment of FIG. **7**A, provide the feedback signals to a transmitting device.

[0079] Referring to FIG. **7**A, a transmitting device **710** may transmit data to a receiving device **721**, which is any one of the plurality of receiving devices **721** through **723** except for the transmitting device **710**. The other receiving devices **722** and **723** except for the transmitting device **710** and the receiving device **721** may not receive data transceived in the unicast method between the transmitting device **710** and the receiving device **721**. The transceiving of data between the transmitting device **710** and the receiving device **721** in the unicast method may be performed by mapping in an agreed resource between the transmitting device **710** and the receiving device **721**, or by scrambling by using a mutually agreed value, or by using a preset value in advance. Alternatively, the control information related with the data in the unicast method between the transmitting device **710** and the receiving device **721** may be mapped in a mutually agreed method.

Alternatively, transceiving data between the transmitting device **710** and the receiving device **721** in the unicast method may include an operation of identifying unique IDs therebetween.
[0080] Referring to FIG. **7**B, the receiving device **721** having received data in the unicast method may transmit to the transmitting device **710** any one of the ACK signal, the NACK signal, and the replacement data request signal (or the IACK signal) as the feedback signal. The transmitting device **710** may determine a type of the following data according to a type of the feedback signal.
[0081] FIG. **8** is a table of the second shift value corresponding to the example embodiments of FIGS. **6**A through **7**B.
[0082] Referring to FIG. **8**, when a transmitting device and a receiving device communicate with each other in the second groupcast method and the unicast method, the receiving device may determine the shift value 2 according to a type of the feedback signal, which has been determined as a result of the HARQ process performance. As an example, when it is determined to transmit the NACK signal, the receiving device may determine the second shift value as 0, and when it is determined to transmit the ACK signal, the receiving device may set the second shift value as 6.
[0083] When it is determined to transmit the replacement data request signal, the receiving device may set the second shift value to a different value according to the number of cyclic shift indices. The second shift value may be set so that the cyclic shift value generated according to the second shift value corresponding to the redefined data request signal is set as at least one of remaining cyclic shift values except for a predefined cyclic shift value corresponding to the ACK signal and the NACK signal.
[0084] The receiving device may determine the first shift value and the second shift value, and may determine a sum of the first shift value and the second shift value as the cyclic shift value. According to an example embodiment, the determined cyclic shift value may correspond to the Zadoff-Chu sequence index.
[0085] As an example, referring to FIGS. **5** and **8**, when the candidate cyclic shift indices are 0 through 11, and the number of cyclic shift indices is one, the cyclic shift values generated based on the NACK signal and the ACK signal may be any one of 0 and 6. Accordingly, a second shift value al for the case, where the number of cyclic shift indices is one, may be set as any one of 1 through 5, and 7 through 11, so that the cyclic shift value generated based on the redefined data request signal becomes any one of 1 through 5, and 7 through 11.
[0086] When the number of cyclic shift indices is two, the cyclic shift value generated based on the NACK signal and the ACK signal may be any one of 0, 3, 6, and 9. Accordingly, when the number of cyclic shift indices is two, a second shift value a2 may be set as any one of 1, 2, 4, 5, 7, 8, 10, and 11. In the same method, when the number of cyclic shift indices is three, the cyclic shift value generated based on the NACK signal and the ACK signal may be any one of 0, 2, 4, 6, 8, and 10, and when the number of cyclic shift indices is three, a second shift value a3 may be set as any one of odd numbers less than 11.
[0087] However, when the number of cyclic shift indices is six, because the cyclic shift value generated based on the NACK signal and the ACK signal is any one of 0 through 11, a candidate cyclic shift value corresponding to the replacement data request signal may not be allocated. Accordingly, when the number of cyclic shift indices is allocated as six, it may be understood that the receiving device is not to transmit the replacement data request signal.
[0088] FIG. **9**A is a diagram of an example in which a plurality of communication devices according to an example embodiment transmit data in the first groupcast method, and FIG. **9**B is a diagram of an example in which receiving devices, which have received data according to an example embodiment of FIG. **9**A, feedback the feedback signals to a transmitting device.
[0089] Referring to FIG. **9**A, a transmitting device **910** may transmit common data to first through fourth receiving devices **921** through **924**, that is, may transmit data in the groupcast method. In this case, the transmitting device **910** may be pre-configured to transmit data in the first groupcast method, and in this case, the transmitting device **910** may transmit a message of performing the

first groupcast to the first through fourth receiving devices **921** through **924** via the SCI.
[0090] Referring to FIG. **9**B, each of first through fourth receiving devices **921** through **924**, which have received the common data by using the first groupcast, may transmit to the transmitting device **910** any one of the NACK signal and the replacement data request signal (or the "IACK signal") as the feedback signal. When data is received in the first groupcast method, the first through fourth receiving devices **921** through **924** may determine whether received data may be decoded, and unlike the case of the second groupcast of FIGS. **6**A and **6**B, the first groupcast may provide the feedback signal to the transmitting device **910** only when the data may not be decoded.
[0091] According to an example embodiment, the receiving device, which has succeeded in decoding of the received data, of the first through fourth receiving devices **921** through **924** may not provide any feedback signal to the transmitting device **910**. Referring to FIG. **9**B, the fourth receiving device **924** may not transmit the feedback signal to the transmitting device **910** by succeeding in data decoding. When communication is performed in the first groupcast method, the transmitting device **910** may not determine whether the feedback signal has been transmitted by any receiving device, but may determine the following data to be transmitted to the first through fourth receiving devices **921** through **924** according to a ratio of the number of first through fourth receiving devices **921** through **924** having transmitted the feedback signal over the number of first through fourth receiving devices **921** through **924**.
[0092] According to an embodiment, the transmitting device **910** may determine whether the replacement data needs to be provided to the first through fourth receiving devices **921** through **924** in the groupcast method based on a ratio of the number of receiving devices having transmitted the replacement data request signal over the number of first through fourth receiving devices **921** through **924**. An embodiment, in which whether the replacement data is to be provided to the first through fourth receiving devices **921** through **924** based on the ratio of the receiving devices having transmitted the replacement data request signal is determined, is described in detail below with reference to FIG. **16**.
[0093] FIG. **10** is a table of the second shift value corresponding to the example embodiments of FIGS. **9**A and **9**B.
[0094] Referring to FIG. **10**, when the transmitting device and the receiving device communicate in the first groupcast method, the transmitting device and the receiving device may not generate the ACK signal as the feedback signal even when data decoding is successful, but may generate any one of the NACK signal and the replacement data request signal as the feedback signal only when the data decoding fails.
[0095] When decoding of data fails, the receiving device may determine whether to request the replacement data for data from the transmitting device, and when the replacement data is requested, the receiving device may set the second shift value as 6. Conversely, when the replacement data is not requested, the second shift value may be set as 0.
[0096] The receiving device may determine the cyclic shift value by summing the first shift value with the second shift value. Referring to FIGS. **5** and **10**, when the number of cyclic shift indices is one, the receiving device may generate 0 or 6 as the cyclic shift value according to the type of feedback signal. When the number of cyclic shift indices is two, and the NACK signal is transmitted, the receiving device may generate 0 or 3 as the cyclic shift value according to the cyclic shift index, and when the replacement data request signal is transmitted, the receiving device may generate 6 or 9 as the cyclic shift value according to the cyclic shift index.
[0097] In the same manner, when the number of cyclic shift indices is three, any one of 0, 2, and 4 may be generated as the cyclic shift value corresponding to the NACK signal, and any one of 6, 8, and 10 may be generated as the cyclic shift value corresponding to the replacement data request signal. When the number of cyclic shift indices is six, any one of 0 through 5 may be generated as the cyclic shift value corresponding to the NACK signal, and any one of 6 through 11 may be generated as the cyclic shift value corresponding to the replacement data request signal.

[0098] FIG. **11** is a table of the first shift value according to another example embodiment.
[0099] According to an embodiment, when the receiving device is configured in advance so that the replacement data request signal is provided as the feedback signal to the transmitting device, the receiving device may adjust the number of cyclic shift indices. According to an example embodiment, the candidate cyclic shift index may be set so that a value obtained by dividing the number of candidate cyclic shift values by the number of types of feedback signals including the ACK signal, the NACK signal, and the replacement data request signal is equal to or less than the number of cyclic shift indices. The receiving device may determine the first shift value by selecting any one of the set candidate cyclic shift indices.
[0100] As an example, when the number of candidate cyclic shift values determining the Zadoff-Chu sequence is twelve, and types of the feedback signals are three, the receiving device may determine the maximum number of cyclic shift indices as four, and may set the candidate cyclic shift index corresponding to the number of cyclic shift indices.
[0101] Referring to FIG. **11**, when the number of cyclic shift indices is one, the first shift value may be set as 0, when the number of cyclic shift indices is two, the first shift value may be set as any one of 0 and 3, when the number of cyclic shift indices is three, the first shift value may be set as any one of 0, 2, and 3, and when the number of cyclic shift indices is four, the first shift value may be set as any one of 0, 1, 2, and 3. However, the first shift values corresponding to the cyclic shift indices in FIG. **11** are not limited thereto.
[0102] FIG. **12** is a table of the second shift value according to another example embodiment.
[0103] Referring to FIG. **12**, unlike the second shift value set in FIGS. **8** and **10**, the second shift value corresponding to a type of the feedback signal may be set regardless of the number of cyclic shift indices. As an example, when it is determined to transmit the NACK signal, the receiving device may set 0 as the second shift value, when it is determined to transmit the replacement data request signal, the receiving device may set 4 as the second shift value, and when it is determined to transmit the ACK signal, the receiving device may set 8 as the second shift value.
[0104] Referring to FIGS. **11** and **12**, the receiving device may generate the cyclic shift value by adding the first shift value set according to the embodiment of FIG. **11** and the second shift value set according to the embodiment of FIG. **12**. When the number of cyclic shift indices is one, the cyclic shift value may be determined to be any one of 0, 4, and 8 according to a type of the feedback signal. When the number of cyclic shift indices is two, the cyclic shift value may be determined to be any one of 0, 4, and 8 corresponding to a first cyclic shift index, and to be any one of 3, 7, and 11 corresponding to a second cyclic shift index, according to the type of the feedback signal.
[0105] When the number of cyclic shift indices is three, the cyclic shift value may be determined to be any one of 0, 4, and 8 corresponding to the first cyclic shift index, to be any one of 2, 6, and 10 corresponding to the second cyclic shift index, and to be any one of 3, 7, and 11 corresponding to a third cyclic shift index, according to the type of the feedback signal. When the number of cyclic shift indices is four, the cyclic shift value may be determined to be any one of 0, 4, and 8 corresponding to the first cyclic shift index, to be any one of 1, 5, and 9 corresponding to the second cyclic shift index, to be any one of 2, 6, and 10 corresponding to the third cyclic shift index, and to be any one of 3, 7, and 11 corresponding to a fourth cyclic shift index, according to the type of the feedback signal.
[0106] In example embodiments of FIGS. **5** and **8**, when the number of cyclic shift indices is six, the cyclic shift value corresponding to the replacement data request signal may not be defined, but the cyclic shift value set according to example embodiments of FIGS. **10** and **11** may be defined as a cyclic shift value corresponding to the replacement data request signal for the total number of cyclic shift indices.
[0107] According to an example embodiment, the receiving device and the transmitting device of the inventive concept may include devices capable of providing the replacement data request signal

distinct from the ACK signal and the NACK signal, and may clash with a communication method of a device supporting only transmission of a general ACK signal and a NACK signal. Accordingly, the receiving device and the transmitting device of the inventive concept may also separate and use the PSFCH resource of a device supporting only the ACK signal and the NACK signal. As an example, the PSFCH resource allocated to the transmitting device and the receiving device of the inventive concept may be allocated after at least one of frequency and time region resource is differentiated from the PSFCH resource of a device supporting only the ACK signal and the NACK signal.

[0108] FIG. **13** is a block diagram of a schematic configuration of a transmitting device having received a feedback signal, according to an embodiment.

[0109] Referring to FIG. **13**, the transmitting device of the inventive concept may receive the feedback signal from a receiving device, and may determine the type of feedback signal FB_Type by extracting the cyclic shift value corresponding to the feedback signal. The transmitting device may include a transmission HARQ processor **20** and a buffer **21**. The buffer **21** may temporarily store the feedback signal after receiving the feedback signal via the RFIC of the transmitting device, and may transfer the feedback data FB_Data to the transmission HARQ processor **20** in response to a request of the transmission HARQ processor **20**. The feedback data FB_Data may be a data packet in which the feedback signal received from a receiving device is generated as a series of codes, and may include PSSCH, PSCCH, and PSFCH, which are generated by the receiving device.

[0110] The transmission HARQ processor **20** may include a feedback channel (FCH) extractor **210**, a correlator **220**, a comparator **230**, and a data generator **240**. The FCH extractor **210** may extract the FCH data FCH_Data from the feedback data FB_Data received from the buffer **21**. The FCH data FCH_Data may be data regarding the feedback channel of information included in the Feedback data FB_Data, and the FCH extractor **210** may extract information corresponding to a symbol of a predefined sequence of the Feedback data FB_Data configured with a plurality of symbols, as the FCH data FCH_Data.

[0111] The correlator **220** may extract a correlation value Cor_Val corresponding to any one of the cyclic shift values by performing a correlation computation. As an example, the correlator **220** may perform the correlation computation based on a correlation filter, and may output the cyclic shift value applied when the feedback signal has been generated, as the correlation value Cor_Val.

[0112] The comparator **230** may determine the received type of feedback signal FB_Type by comparing the correlation value Cor_Val output by the correlator **220** to a plurality of reference values. The cyclic shift value according to the number of cyclic shift indices may be pre-configured between the transmitting device and the receiving device for each type of feedback signal FB_Type. Accordingly, the comparator **230** may determine the cyclic shift value corresponding to the feedback signal based on the comparison of the correlation value Cor_Val to the reference values, and may determine the type of feedback signal FB_Type based on the cyclic shift value.

[0113] The data generator **240** may generate following data FL_Data according to the type of feedback signal FB_Type. When the feedback signal is the replacement data request signal, data initially transmitted to the receiving device may be provided. As an example, the transmitting device may retransmit the initially transmitted data to the receiving device by resetting a sequence of a redundancy version or setting as an initial transmission according to a protocol of a network. In other words, when the replacement data request signal is received, the replacement data may be transmitted by resetting the HARQ process. When the transmitting device receives the ACK signal, the HARQ process for new data may be performed, and when the NACK signal is received, the retransmission data may be transmitted to the receiving device by changing the redundancy version.

[0114] FIG. **14** is a flowchart of a method of transmitting the replacement data by a transmitting device, according to an example embodiment.

[0115] Referring to FIG. **14**, the transmitting device may transmit the transport block with the CRC code combined thereto, to at least one receiving device, and when the replacement data request signal is received as the feedback signal corresponding to data from the receiving device, may transmit the replacement data to the at least one receiving device.
[0116] The transmitting device may transmit to the receiving device data including the PSSCH and the PSCCH after mapping the data to the HARQ ID (S**210**).
[0117] The transmitting device may receive any one of the feedback signals from the receiving device (S**220**). As an example, the transmitting device may receive from the receiving device any one of the ACK signal, the NACK signal, and the replacement data request signal as the feedback signal. The ACK signal, the NACK signal, and the replacement data request signal may be signals which have been generated according to cyclically shifted codes from the base sequence to different cyclic shift values from each other.
[0118] The transmitting device may determine the type of the received feedback signal (S**230**). As described with reference to FIG. **13**, the transmitting device may determine the type of the feedback signal based on a correlation value generated according to the correlation computation of the correlator **220**.
[0119] The transmitting device may transmit the replacement data to the receiving device in response to the case in which the type of the feedback signal is the replacement data request signal (S**240**). As an example, when the receiving device having received data determines that a reset of the HARQ process is necessary, the receiving device may provide the replacement data request signal to the transmitting device.
[0120] The case, in which it is determined that the reset of the HARQ process is necessary, may include the case in which it is determined that soft combining by using the received data may be performed even though the receiving device has received data. As an example, the case, in which it is determined that the reset of the HARQ process is necessary, may include a status where the received data may not be stored in the HARQ buffer **11**.
[0121] According to an example embodiment, the transmitting device may transmit the replacement data to the receiving device by setting as the initial transmission according to the protocol of a network, initializing a sequence of the redundancy version, or changing a combining method. The transmitting device may provide the replacement data to the receiving device by setting the redundancy version as 0, or defining the protocol so that a count is set to the initial transmission.
[0122] According to an example embodiment, when the combining method used for performing an existing HARQ process is an incremental redundancy (IR) combining method, the transmitter address having received the replacement data request signal may instruct the receiving device to perform the HARQ process in a chase combining method. Unlike the case in which the IR combining method is performed, when the chase combining method is performed, data configured with the same bit combination as the initially transmitted data may be provided to the receiving device.
[0123] FIG. **15** is a flowchart of a method of transmitting retransmission data or replacement data when a transmitting device receives feedback signals from a plurality of receiving devices, according to an example embodiment.
[0124] Referring to FIG. **15**, when the transmitting device receives data from the plurality of receiving devices in the first groupcast method, the transmitting device may determine whether to transmit the replacement data based on the feedback signals received from the plurality of receiving devices.
[0125] The transmitting device may transmit data to the plurality of receiving devices in the first groupcast method (S**310**). Although the first groupcast method may not specify a receiving device having transmitted the feedback signal, the first groupcast method may be a groupcast method which determines following data according to the type and a ratio of the feedback signal received

by the transmitting device.

[0126] The feedback signals received by the plurality of receiving devices may be collected (S**320**). When the transmitting device and the receiving device communicate in the first groupcast method and the receiving device succeeds in data decoding, because the feedback signal is not transmitted to the transmitting device, the transmitting device may receive the feedback signals only from the receiving devices which have failed in the data decoding.

[0127] The transmitting device may calculate a ratio for the replacement data request signal (S**330**). According to an example embodiment, the ratio for the replacement data request signal may be a ratio of the number of receiving devices having transmitted the replacement data request signals over the number of receiving devices having transmitted the feedback signals. In other words, the transmitting device may calculate a ratio of the number of receiving devices having transmitted the replacement data request signals over the number of receiving devices having transmitted the NACK signals.

[0128] The transmitting device may determine whether a ratio for the replacement data request signal exceeds a threshold ratio (S**340**). The threshold ratio may be a preset ratio when communication is performed in the first groupcast method, but may also be a ratio varying according to the situation.

[0129] When the ratio for the replacement data request signal exceeds the threshold ratio, the transmitting device may transmit the replacement data (S**350**), and when the ratio for the replacement data request signal is equal to or less than the threshold ratio, the transmitting device may transmit the retransmission data (S**360**). The retransmission data may, as an example, be data that is transmitted after the redundancy version is changed from previously transmitted data.

[0130] FIG. **16** illustrates a wireless communication device **1000** according to an example embodiment.

[0131] Referring to FIG. **16**, the wireless communication device **1000** may include an application specific integrated circuit (ASIC) **1010**, an application specific instruction set processor (ASIP) **1030** connected to the ASIC **1010**, a memory **1050** connected to the ASIP **1030**, a main processor **1070** connected to the ASIC **1010** and the ASIP **1020**, and a main memory **1090** connected to the main processor **1070**. The ASIP **1030** and the main processor **1070** may communicate with each other. The ASIP **1030**, the memory **1050**, the main processor **1070**, and the main memory **1090** may be embedded in one chip.

[0132] The ASIP **1030**, which is an integrated circuit customized for a particular purpose, may support an exclusive instruction set for a particular application, and may execute instructions included in an instruction set. The memory **1050** may communicate with the ASIP **1030**, and as a non-transitory storage device, may store a plurality of instructions which are executed by the ASIP **1030**. For example, the memory **1050** may include any type of memory accessible by the ASIP **1030**, such as random-access memory (RAM), read-only memory (ROM), tape, a magnetic disk, an optical disk, a volatile memory, a non-volatile memory, or a combination thereof, as non-limiting examples.

[0133] The main processor **1070** may control the wireless communication device **1000** by executing a plurality of instructions. For example, the main processor **1070** may control the ASIC **1010** and the ASIP **1030**, and may process data received via a communication network or process a user input to the wireless communication device **1000**. The main memory **1090** may communicate with the main processor **1070**, and as a non-transitory storage device, may store a plurality of instructions which are executed by the main processor **1070**. For example, the main memory **1090** may include any type of memory accessible by the main processor **1070**, such as RAM, ROM, tape, a magnetic disk, an optical disk, volatile memory, non-volatile memory, or a combination thereof, as non-limiting examples.

[0134] Communication methods according to one or more of the above-described example embodiments may be performed by at least one of the components included in the wireless

communication device **1000** of FIG. **16**. In some embodiments, at least one operation of operations of a wireless communication method of each of the reception HARQ processor **10** in FIG. **1** and the transmission HARQ processor **20** in FIG. **13** may be implemented as a plurality of instructions stored in the memory **150**. When the ASIP **1030** executes the plurality of instructions stored in the memory **150**, at least a portion of an operation of each of the reception HARQ processor **10** in FIG. **1** and the transmission HARQ processor **20** in FIG. **13** may be performed. In some embodiments, at least one operation of operations of a wireless communication method of each of the reception HARQ processor **10** in FIG. **1** and the transmission HARQ processor **20** in FIG. **13** may be implemented as a hardware block designed by using a logic synthesis or the like and may also be included in the ASIC **1010**. In some embodiments, at least one operation of operations of a wireless communication method of each of the reception HARQ processor **10** in FIG. **1** and the transmission HARQ processor **20** in FIG. **13** may be implemented as a plurality of instructions stored in the main memory **1090**, and when the main processor **1070** executes the plurality of instructions stored in the main memory **1090**, at least one operation of operations of a wireless communication method, that is, at least a portion of an operation of each of the reception HARQ processor **10** in FIG. **1** and the transmission HARQ processor **20** in FIG. **13** may be performed.
[0135] While the inventive concept has been particularly shown and described with reference to embodiments thereof, it will be understood that various changes in form and details may be made therein without departing from the spirit and scope of the following claims.

Claims

1. An operating method of a receiving device comprising: decoding data received from a transmitting device; checking available capacity of a buffer for storing the data based on a decoding failure for the data; and transmitting, to the transmitting device, one of a replacement signal for a first type retransmission data request and a NACK (negative acknowledge) signal for a second type retransmission data request based on a result of checking the available capacity.
2. The operating method of claim 1, wherein the checking available capacity of a buffer comprises, determining whether an address mapped to store the data include an end point address of the buffer.
3. The operating method of claim 1, wherein the transmitting one of a replacement data request signal and an NACK signal comprises, transmitting the replacement signal based on lack of the available capacity of the buffer.
4. The operating method of claim 1, wherein a first coding rate of the first type retransmission data is lower than a second coding rate of the second type retransmission data.
5. The operating method of claim 1, wherein a size of first systematic data of the first type retransmission data is larger than a size of second systematic data of the second type retransmission data.
6. The operating method of claim 1, wherein the first type transmission data corresponds to a sequence of initialized redundancy version or includes initial transmission data from the transmitting device.
7. The operating method of claim 1, wherein a first shift value for generating the replacement signal is different from a second shift value for generating the NACK signal.
8. The operating method of claim 1, wherein the data is received from the transmitting device via PSSCH (physical sidelink feedback channel), and one of the replacement signal and the NACK signal is transmitted to the transmitting device via PSFCH (physical sidelink feedback channel).
9. The operating method of claim 1, wherein the buffer is configured to store data received from other transmitting device.
10. The operating method of claim 1, further comprising: performing the demapping on the data, wherein the transmitting one of a replacement data request signal and an NACK signal comprises, transmitting the replacement signal based on failure of the demapping.

11. The operating method of claim 1, wherein the receiving device and the transmitting device are configured to perform V2X (vehicle to everything) communication.

12. An operating method of a transmitting device, the operating method comprising: transmitting data to a receiving device; receiving, from the receiving device, a replacement signal based on a decoding result for the data and available capacity of a buffer of the receiving device; and retransmitting initial transmission data corresponding to the data to the receiving device.

13. The operating method of claim 12, wherein the receiving a replacement data request signal, comprises, extracting a cyclic shift value corresponding to a Zadoff-Chu sequence of the replacement signal; and identifying the replacement signal based on the cyclic shift value.

14. The operating method of claim 13, wherein the identifying the replacement signal, further comprises, identifying a replacement signal based on a matching of the cyclic shift value with any one of a plurality of first candidate cyclic shift values assigned to the replacement signal.

15. The operating method of claim 14, wherein the plurality of first candidate cyclic shift values are different from a plurality of second candidate cyclic shift values assigned to an acknowledge (ACK) signal or a negative-ACK (NACK) signal.

16. The operating method of claim 12, wherein a first coding rate of the initial transmission data is lower than a second coding rate of retransmission data requested by NACK signal from the receiving device.

17. The operating method of claim 12, wherein the transmitting device is configured to perform unicast-based communication with the receiving device.

18. The operating method of claim 12, wherein the transmitting device is groupcast-based communication with a plurality of receiving devices including the receiving device.

19. An operating method of a receiving device comprising: receiving data from a transmitting device; measuring power of a signal received by a RFIC (radio frequency integrated circuit) of the receiving device, the signal including the data; and transmitting, to the transmitting device, a replacement signal for requesting initial transmission data corresponding to the data based on a measurement result exceeding a threshold.

20. The operating method of claim 19, wherein a first coding rate of the initial transmission data is lower than a second coding rate of retransmission data requested by NACK signal from the receiving device.
