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(54) **COMMUNICATION METHOD, COMMUNICATION APPARATUS, AND COMMUNICATION SYSTEM**

(71) Applicant: **HUAWEI TECHNOLOGIES CO., LTD.**, Shenzhen (CN)

(72) Inventors: **Jiajie TONG**, Hangzhou (CN); **Huazi ZHANG**, Hangzhou (CN); **Xianbin WANG**, Hangzhou (CN); **Jun WANG**, Hangzhou (CN)

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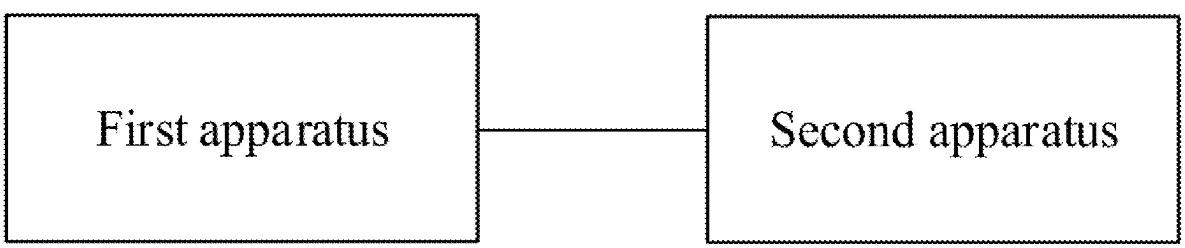
(57) **ABSTRACT**

A method includes: respectively encoding m first codewords to obtain m second codewords, where the second codeword is obtained by repeating the first codeword, and m is a positive integer; separately coupling additional information with the m second codewords to obtain m coupled codes; and sending the m coupled codes. In this solution, the additional information is coupled with the m second codewords to obtain the m coupled codes, and the m coupled codes are transmitted. After the additional information in the m coupled codes is decoupled, transmission effect that is the same as or similar to that of merely transmitting the m second codewords may be obtained. In this way, more information can be sent additionally without changing a decoding rate of the second codeword, and channel throughput performance is improved.



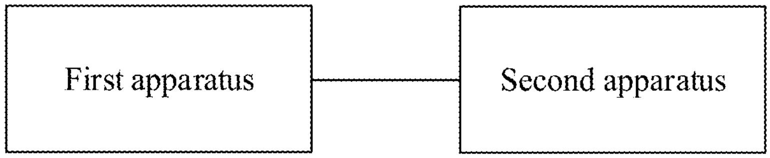


FIG. 1

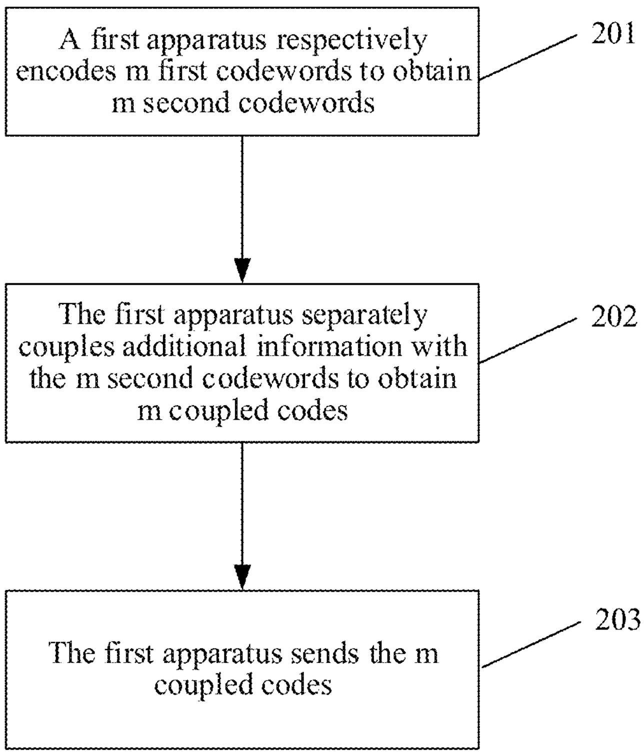


FIG. 2

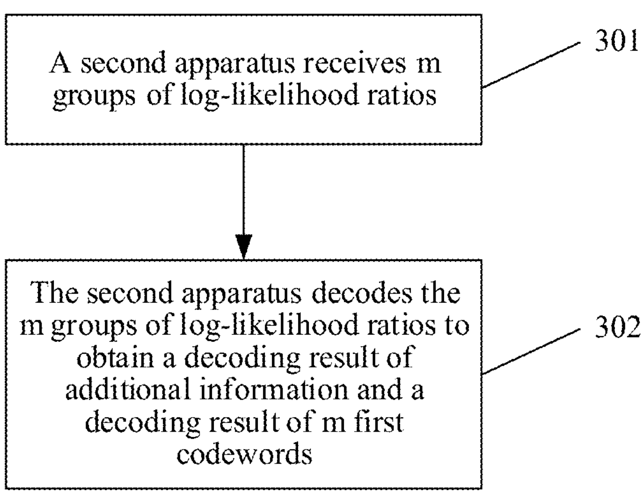


FIG. 3

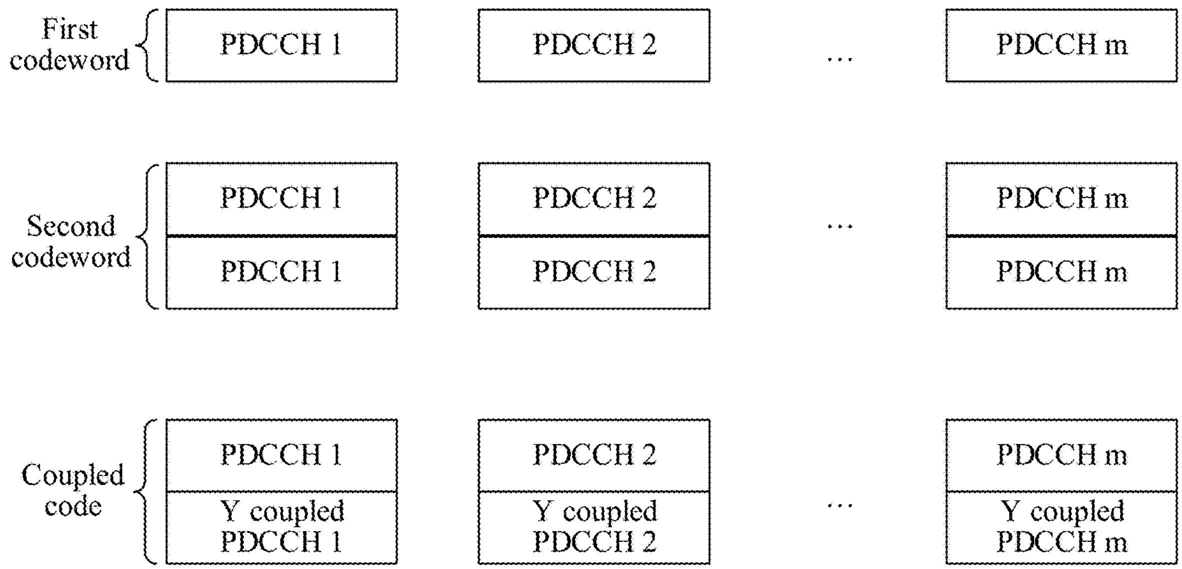


FIG. 4

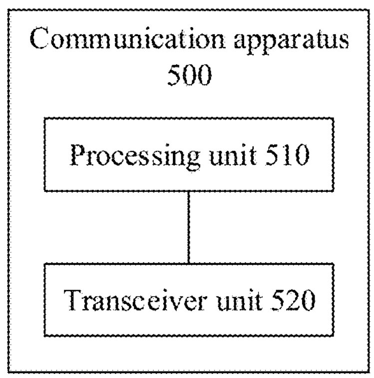


FIG. 5

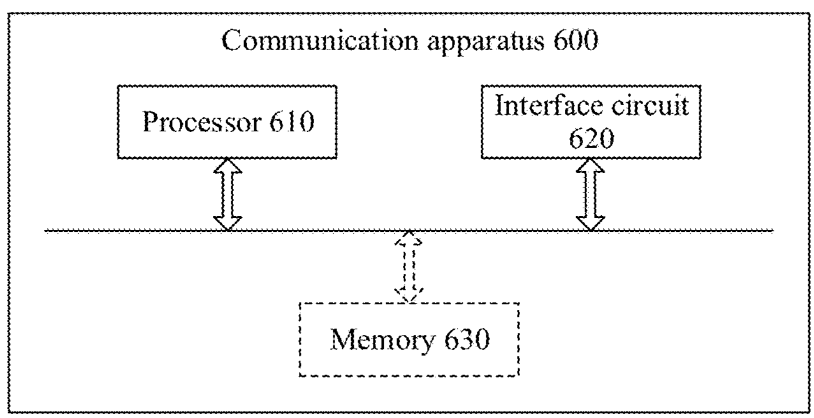


FIG. 6

COMMUNICATION METHOD, COMMUNICATION APPARATUS, AND COMMUNICATION SYSTEM

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is a continuation of International Application No. PCT/CN2022/130828, filed on Nov. 9, 2022, the disclosure of which is hereby incorporated by reference in its entirety.

TECHNICAL FIELD

[0002] Embodiments of this application relate to the field of wireless communication technologies, and in particular, to a communication method, a communication apparatus, and a communication system.

BACKGROUND

[0003] A polar code is a channel coding scheme that can be strictly proved to reach a Shannon channel capacity, and has features such as good performance and low complexity. A mother code length of the polar code is an integer power of 2. For example, the mother code length is 256 bits, 512 bits, or the like.

[0004] When a code length required for actual communication is different from the mother code length, matching between the code length and the mother code length needs to be implemented in a manner such as puncturing or retransmission. Puncturing or retransmission means that several positions in a mother code obtained through encoding are removed or retransmitted, so that the mother code meets a code length requirement. For example, in 5th generation (5G) communication, a maximum mother code length of a downlink polar code is 512 bits, and a maximum code length of a downlink sent codeword may reach 1728 bits. Therefore, the mother code whose length is 512 bits may be repeatedly sent, so that a code length of an actually sent codeword reaches 1728 bits. Each coded bit in the mother code is repeatedly sent three or four times.

[0005] In this solution, because the coded bit needs to be repeatedly sent, channel utilization decreases. Therefore, how to further improve channel throughput performance while ensuring effect of repeatedly sending the coded bit needs to be resolved.

SUMMARY

[0006] Embodiments of this application provide a communication method, a communication apparatus, and a communication system, to improve channel performance.

[0007] According to a first aspect, an embodiment of this application provides a communication method. The method may be performed by a first apparatus. The method includes: respectively encoding m first codewords to obtain m second codewords, where the second codeword is obtained by repeating the first codeword, and m is a positive integer; separately coupling additional information with the m second codewords to obtain m coupled codes, where the coupled code includes a first part and a second part, the first part is the same as a first codeword that is in the m first codewords and that corresponds to the coupled code, and the second part is obtained by coupling the additional information with a second codeword that is in the m second codewords and that corresponds to the coupled code; and sending the m coupled codes.

[0008] In the foregoing solution, the additional information is coupled with the m second codewords to obtain the m coupled codes, and the m coupled codes are transmitted. After the additional information in the m coupled codes is decoupled, transmission effect that is the same as or similar to that of merely transmitting the m second codewords may be obtained. In this way, more information can be sent additionally without changing a decoding rate of the second codeword, and channel throughput performance is improved.

[0009] In an embodiment, each element value of the second part is obtained by performing an exclusive OR operation on each element value in the additional information and each element value in the second codeword except the first codeword.

[0010] In the foregoing solution, the additional information may be coupled to each second codeword to obtain a corresponding coupled code, thereby improving channel throughput performance.

[0011] In an embodiment, an $(i+1)^{th}$ first codeword in the m first codewords is X^i and $X^i=\{x_0{}^i, x_1{}^i, x_2{}^i, \ldots, x_{N^i-1}{}^i\}$, an $(i+1)^{th}$ coupled code in the m coupled codes is E^i and $E^i=\{e_0{}^i, e_1{}^i, e_2{}^i, \ldots, e_{M^i-1}{}^i\}$, the additional information is Y and $Y=\{y_0, y_1, y_2, \ldots, y_{N'-1}\}$, $i=0, 1, 2, \ldots, m-1$, N^i represents a quantity of element values of X^i, M^i represents a quantity of element values of E^i, and N' represents a quantity of element values of Y;

a first part of E^i is $\{e_0{}^i, e_1{}^i, e_2{}^i, \ldots e_{N^i-1}{}^i\}$, and the first part is generated by using the following method:

for(j=0; j<N^i; j=j+1)

$e_j{}^i = x_j{}^i$; and

a second part of E^i is $\{e_{N^i}{}^i, e_{N^i+1}{}^i, e_{N^i+2}{}^i, \ldots e_{M^i-1}{}^i\}$, and the second part is generated by using the following method:

for(j=N^i; j<M^i; j=j+1)

$e_j{}^i = x_{mod(j,N^i)}{}^i \hat{} y_{mod(j-N^i+\Delta^i,N')}$, where

mod represents a modulo operation, ^ represents an exclusive OR operation, and Δ^i represents a coupling sequence number offset value of the additional information.

[0012] In an embodiment, $\Delta^i=i*mod(\Sigma_{i=0}{}^{m-1}(M^i-N^i), N')$, where Σ represents a summation operation. In the foregoing solution, a manner of coupling the additional information with the second codeword may be flexibly set, and for example, a mapping relationship between the element value of the additional information and the element value of the second codeword for performing an exclusive OR operation may be flexibly selected.

[0013] In an embodiment, additional information coupled in the m coupled codes is the same.

[0014] In the foregoing solution, the same additional information is coupled to the m second codewords to obtain the m coupled codes, so that enhanced sending of the additional information can be implemented, and a receive end can accurately decode the additional information.

[0015] In an embodiment, the first codeword is a polar code.

[0016] According to a second aspect, an embodiment of this application provides a communication method. The method may be performed by a first apparatus. The method includes: receiving m groups of log-likelihood ratios, where the m groups of log-likelihood ratios one-to-one correspond to m coupled codes, the m coupled codes one-to-one correspond to m second codewords, the m second codewords are obtained by repeatedly encoding m first codewords, and m is a positive integer respectively; and decoding the m groups of log-likelihood ratios to obtain a decoding result of additional information and a decoding result of the m first codewords, where the coupled code includes a first part and a second part, the first part is the same as a first codeword that is in the m first codewords and that corresponds to the coupled code, and the second part is obtained by coupling the additional information with a second codeword that is in the m second codewords and that corresponds to the coupled code.

[0017] In the foregoing solution, the additional information is coupled with the m second codewords to obtain the m coupled codes, and the m coupled codes are transmitted. After the additional information in the m coupled codes is decoupled, transmission effect that is the same as or similar to that of merely transmitting the m second codewords may be obtained. In this way, more information can be sent additionally without changing a decoding rate of the second codeword, and channel throughput performance is improved.

[0018] In an embodiment, the decoding the m groups of log-likelihood ratios to obtain a decoding result of additional information and a decoding result of the m first codewords includes: for one group of log-likelihood ratios in the m groups of log-likelihood ratios, decoupling a second part of the group of log-likelihood ratios based on a first part of the group of log-likelihood ratios, to obtain a log-likelihood ratio of the additional information, where a quantity of element values in the first part of the group of log-likelihood ratios is equal to a quantity of element values in a first part of a coupled code that is in the m coupled codes and that corresponds to the group of log-likelihood ratios, and a quantity of element values in the second part of the group of log-likelihood ratios is equal to a quantity of element values in a second part of the coupled code that is in the m coupled codes and that corresponds to the group of log-likelihood ratios; determining the decoding result of the additional information based on log-likelihood ratios that are of the additional information and that respectively correspond to the m groups of log-likelihood ratios; and decoupling the group of log-likelihood ratios based on the decoding result of the additional information, to obtain a decoding result of a first codeword corresponding to the group of log-likelihood ratios.

[0019] In the foregoing solution, the decoding result of the additional information is first obtained through decoding, and then each group of log-likelihood ratios is decoupled based on the additional information, to obtain a decoding result of a corresponding first codeword, so that fast and accurate decoding can be implemented.

[0020] In an embodiment, the determining the decoding result of the additional information based on log-likelihood ratios that are of the additional information and that respectively correspond to the m groups of log-likelihood ratios includes: determining a sum value of the log-likelihood ratios that are of the additional information and that respectively correspond to the m groups of log-likelihood ratios; and decoding the sum value to obtain the decoding result of the additional information.

[0021] In the foregoing solution, m log-likelihood ratios of the additional information are first obtained through decoding, and then the m log-likelihood ratios are summed up and decoded to obtain the decoding result of the additional information. This helps improve decoding accuracy of the additional information.

[0022] In an embodiment, the decoupling the group of log-likelihood ratios based on the decoding result of the additional information, to obtain a decoding result of a first codeword corresponding to the group of log-likelihood ratios includes: decoupling the second part of the group of log-likelihood ratios based on the decoding result of the additional information and the first part of the group of log-likelihood ratios, to obtain decoupling information of the group of log-likelihood ratios; and decoding the decoupling information of the group of log-likelihood ratios to obtain the decoding result of the first codeword corresponding to the group of log-likelihood ratios.

[0023] In the foregoing solution, the second part of the group of likelihood ratios is first decoupled based on the decoding result of the additional information, to obtain the decoupling information of the group of log-likelihood ratios, and then the decoupling information of the group of log-likelihood ratios is decoded to obtain the decoding result of the first codeword corresponding to the group of log-likelihood ratios, thereby improving decoding accuracy of the first codeword.

[0024] In an embodiment, the group of log-likelihood ratios is L^i and $L^i=\{l_0^i, l_1^i, l_2^i, \ldots, l_{M^i-1}^i\}$, the decoupling information of the group of log-likelihood ratios is Q^i and $Q^i=\{q_0^i, q_1^i, q_2^i, \ldots, q_{M^i-1}^i\}$, the decoding result of the additional information is $\acute{Y}$ and $\acute{Y}=\{\acute{y}_0, \acute{y}_1, \ldots \acute{y}_{N'-1}\}$, $i=0, 1, 2, \ldots, m-1$, M^i represents a quantity of element values of L^i and a quantity of element values of Q^i, N^i represents a quantity of element values of a first part of Q^i, and N' represents a quantity of element values of $\acute{Y}$;

the first part of Q^i is generated by using the following method:

for($j=0$; $j<N^i$; $j=j+1$)

$q_j^i = l_j^i$; and

a second part of Q^i is generated by using the following method:

for($j=N^i$; $j<M^i$; $j=j+1$)

$q_{mod(j,N^i)}^i = G(l_{mod(j-N^i+\Delta^i,N')}^i, q_{mod(j,N^i)}^i, \acute{y}_{mod(j-N^i+\Delta^i,N')})$, where

mod represents a modulo operation, Δ^i represents a coupling sequence number offset

-continued

value of the additional information, and the function G represents a feedback decoupling log-likelihood ratio combination operation function.

[0025] In an embodiment, the group of log-likelihood ratios is L^i and $L^i=\{l_0^{\,i}, l_1^{\,i}, l_2^{\,i}, \ldots, l_{M^i-1}^{\,i}\}$, the log-likelihood ratio of the additional information is Z^i and $Z^i=\{z_0^{\,i}, z_1^{\,i}, z_2^{\,i}, \ldots, z_{N'-1}^{\,i}\}$, i=0, 1, 2, . . . , m−1, N' represents a quantity of element values of Z^i, and M^i represents a quantity of element values of the group of log-likelihood ratios;

[0026] the log-likelihood ratio of the additional information is generated by using the following method:

$$\text{for } \left(j = N^i;\ j < M^i;\ j = j+1\right) z^i_{mod(j-N^i+\Delta^i,N')} = z^i_{mod(j-N^i+\Delta^i,N')} + F\left(l^i_j, l^i_{mod(j,N^i)}\right),$$

where

[0027] mod represents a modulo operation, F represents a log-likelihood ratio decoupling operation function, and Δ^i represents a coupling sequence number offset value of the additional information.

[0028] In an embodiment, $\Delta_i=i*\mathrm{mod}(\Sigma_{i=0}^{m-1}(E^i-N^i), N')$, where Σ represents a summation operation.

[0029] In the foregoing solution, a manner of coupling the additional information with the second codeword may be flexibly set, and for example, a mapping relationship between the element value of the additional information and the element value of the second codeword for performing an exclusive OR operation may be flexibly selected.

[0030] In an embodiment, the sum value of the log-likelihood ratios that are of the additional information and that respectively correspond to the m groups of log-likelihood ratios is Z and $Z=\Sigma_{i=0}^{m-1} Z^i$. Z^i represents a log-likelihood ratio that is of the additional information and that corresponds to an i^{th} group of log-likelihood ratios.

[0031] In an embodiment, the first codeword is a polar code.

[0032] According to a third aspect, an embodiment of this application provides a communication apparatus. The apparatus has a function of implementing any implementation method of the first aspect and the second aspect. The function may be implemented by hardware, or may be implemented by hardware executing corresponding software. The hardware or the software includes one or more modules corresponding to the function.

[0033] According to a fourth aspect, an embodiment of this application provides a communication apparatus, including a processor coupled to a memory. The processor is configured to invoke a program stored in the memory, to perform any implementation method of the first aspect and the second aspect. The memory may be located inside or outside the apparatus. In addition, there may be one or more processors.

[0034] According to a fifth aspect, an embodiment of this application provides a communication apparatus, including a processor and a memory. The memory is configured to store computer instructions. When the apparatus runs, the processor executes the computer instructions stored in the memory, to enable the apparatus to perform any implementation method of the first aspect and the second aspect.

[0035] According to a sixth aspect, an embodiment of this application provides a communication apparatus, including a unit or means configured to perform operations of any implementation method of the first aspect and the second aspect.

[0036] According to a seventh aspect, an embodiment of this application provides a communication apparatus, including a processor and an interface circuit. The processor is configured to: communicate with another apparatus through the interface circuit, and perform any implementation method of the first aspect and the second aspect. There are one or more processors.

[0037] According to an eighth aspect, an embodiment of this application further provides a computer-readable storage medium. The computer-readable storage medium stores instructions, and when the instructions are run on a communication apparatus, any implementation method of the first aspect and the second aspect is performed.

[0038] According to a ninth aspect, an embodiment of this application further provides a computer program product. The computer program product includes a computer program or instructions. When the computer program or the instructions are run by a communication apparatus, any implementation method of the first aspect and the second aspect is performed.

[0039] According to a tenth aspect, an embodiment of this application further provides a chip system, including a processor, configured to perform any implementation method of the first aspect and the second aspect.

[0040] According to an eleventh aspect, an embodiment of this application further provides a communication system. The communication system includes a first apparatus configured to perform any implementation method of the first aspect and a second apparatus configured to perform any implementation method of the first aspect.

BRIEF DESCRIPTION OF DRAWINGS

[0041] FIG. **1** is a diagram of a communication system to which an embodiment of this application is applicable;

[0042] FIG. **2** is a schematic flowchart of a communication method according to an embodiment of this application;

[0043] FIG. **3** is a schematic flowchart of a communication method according to an embodiment of this application;

[0044] FIG. **4** is an example diagram of coupling additional information to a PDCCH according to an embodiment of this application;

[0045] FIG. **5** is a diagram of a communication apparatus according to an embodiment of this application; and

[0046] FIG. **6** is a diagram of a communication apparatus according to an embodiment of this application.

DESCRIPTION OF EMBODIMENTS

[0047] FIG. **1** is a diagram of a communication system to which an embodiment of this application is applicable. The communication system includes a first apparatus and a second apparatus. When the first apparatus is used as a sending device, the second apparatus is used as a receiving device. When the second apparatus is used as a sending device, the first apparatus is used as a receiving device. Embodiments of the first apparatus and the second apparatus are not limited in embodiments of this application.

[0048] For ease of description, in this application, an example in which the first apparatus is a sending device and the second apparatus is a receiving device is used for description.

[0049] For example, the first apparatus is a terminal device or a chip in the terminal device, and the second apparatus is also a terminal device or a chip in the terminal device. For another example, the first apparatus is a terminal device or a chip in the terminal device, and the second apparatus is a network device or a chip in the network device. For another example, the first apparatus is a network device or a chip in the network device, and the second apparatus is also a network device or a chip in the network device.

[0050] In embodiments of this application, the terminal device may be a device having a wireless transceiver function, and may be user equipment (UE), an access terminal, a subscriber unit, a subscriber station, a mobile station, a remote station, a remote terminal, a mobile device, a user terminal, a wireless communication device, a user agent, or a user apparatus. The terminal device may be deployed on land, and includes an indoor device, an outdoor device, a handheld device, or a vehicle-mounted device; may be deployed on water (for example, on a ship); or may be deployed in air (for example, on a plane, a balloon, or a satellite). The terminal device may be a cellular phone, a mobile phone, a tablet computer (pad), a wireless data card, a wireless modem, a satellite terminal, a vehicle-mounted device, a wearable device, an unmanned aerial vehicle, a robot, a smart point of sale (POS) machine, a customer-premises equipment (CPE), a computer having a wireless transceiver function, a virtual reality (VR) terminal device, an augmented reality (AR) terminal device, a terminal device in industrial control, a terminal device in self driving, a terminal device in remote medical, a terminal device in a smart grid, a terminal in transportation safety, a terminal device in a smart city, and a terminal in smart home.

[0051] In embodiments of this application, the network device is a device having a wireless transceiver function, and is configured to communicate with the terminal device; or may be a device that can connect the terminal device to a wireless network, for example, a radio access network (RAN) device or a node. In embodiments of this application, the network device may include various forms of base stations, for example, a macro base station, a micro base station (also referred to as a small cell), a relay station, an access point, a device that implements a base station function in a communication system evolved after a 5G communication system, an access point (AP) in a wireless fidelity (Wi-Fi) system, an integrated access and backhaul (IAB) node, a transmission and reception point (TRP), a transmission point (TP), a mobile switching center, a device that undertakes a base station function in device-to-device (D2D), vehicle-to-everything (V2X), and machine-to-machine (M2M) communication; may further include a central unit (CU) and a distributed unit (DU) in a cloud radio access network (C-RAN) system, and a network device in a non-terrestrial communication network (NTN) communication system, that is, may be deployed on a high-altitude platform or a satellite; or may be various devices that constitute an access node, such as an active antenna processing unit (AAU) and a baseband unit (BBU). This is not limited in embodiments of this application.

[0052] FIG. **2** is a schematic flowchart of a communication method according to an embodiment of this application. The method is executed by a first apparatus, and the method describes an encoding process of the first apparatus. The method includes the following operations.

[0053] Operation **201**: The first apparatus respectively encodes m first codewords to obtain m second codewords, where m is a positive integer.

[0054] The first codeword herein may be a polar code or a code of another type. This is not limited in this application.

[0055] The second codeword is obtained by repeating the first codeword, that is, the first codeword is used as a mother code, and the mother code is repeatedly encoded to obtain the second codeword.

[0056] It is assumed that the m first codewords are X^0, X^1, . . . , and X^{m-1}, and quantities of elements in X^0, X^1, . . . , and X^{m-1} are respectively N^0, N^1, . . . , and N^{m-1}. An $(i+1)^{th}$ first codeword is $X^i=\{x_0^i, x_1^i, x_2^i, \ldots, x_{N^i-1}^i\}$, and i=0, 1, 2, . . . , m−1. N^i indicates a quantity of element values of X^i.

[0057] The $(i+1)^{th}$ first codeword X^i is used as an example. The element value in X^i is repeated, to obtain a second codeword corresponding to X^i. For example, a second codeword corresponding to X^i is $\{x_0^i, x_1^i, x_2^i, \ldots, x_{N^i-1}^i, x_0^i, x_1^i, x_2^i, \ldots, x_{N^i-1}^i\}$. For another example, a second codeword corresponding to X^i is $\{x_0^i, x_1^i, x_2^i, \ldots, x_{N^i-1}^i, x_0^i, x_1^i, x_2^i, \ldots, x_{N^i-1}^i, x_0^i, x_1^i, x_2^i, \ldots, x_{N^i-1}^i\}$. For another example, a second codeword corresponding to X^i is $\{x_0^i, x_1^i, x_2^i, \ldots, x_{N^i-1}^i, x_0^i, x_1^i, x_2^i, \ldots, x_{N^i-1}^i, x_0^i, x_1^i, x_2^i\}$. For another example, a second codeword corresponding to X^i is $\{x_0^i, x_1^i, x_2^i, \ldots, x_{N^i-1}^i, x_0^i, x_1^i, x_2^i, \ldots, x_{N^i-1}^i, x_0^i, x_1^i, x_2^i, x_3^i, x_4^i, x_6^i\}$, and the like. In an embodiment, each element value in X^i is repeated once or more times to obtain a corresponding second codeword.

[0058] A corresponding second codeword may be obtained for each first codeword in the m first codewords, and second codewords corresponding to different first codewords may have a same length or may have different lengths. Therefore, the m first codewords correspond to the m second codewords.

[0059] Operation **202**: The first apparatus separately couples additional information with the m second codewords to obtain m coupled codes.

[0060] The additional information in an embodiment of the application is information that needs to be additionally sent in addition to information that is of the m second codewords and that is sent by the first apparatus to a second apparatus. The additional information is coupled with the m second codewords for sending, so that channel throughput performance can be improved. Content of the additional information is not limited in embodiments of this application, and may be any type of information. The additional information and the first codeword may be codewords of a same type, for example, both are polar codes, or may be codewords of different types. This is not limited herein.

[0061] In an embodiment, the additional information is divided into m pieces of sub-information, and then each piece of sub-information is coupled with one second codeword in the m second codewords, to obtain the m coupled codes. For example, a 1^{st} piece of sub-information is coupled with a 1^{st} second codeword to obtain a 1^{st} coupled code, a 2^{nd} piece of sub-information is coupled with a 2^{nd} second codeword to obtain a 2^{nd} coupled code, . . . , and by analogy. The m coupled codes are obtained in total.

[0062] In an embodiment, same additional information is coupled to m second codewords to obtain the m coupled codes, that is, the additional information coupled in the m coupled codes is the same.

[0063] For ease of description, an embodiment of the application is described by using an example in which the same additional information is coupled in the m coupled codes.

[0064] It is assumed that the m coupled codes corresponding to the m second codewords are $E^0, E^1, \ldots,$ and E^{m-1}, and quantities of element values in $E^0, E^1, \ldots,$ and E^{m-1} are respectively $M^0, M^1, \ldots,$ and M^{m-1}. E^0 corresponds to X^0, E^1 corresponds to $X^1, \ldots,$ and E^{m-1} corresponds to X^{m-1}. $M^0>N^0$, $M^1>N^1, \ldots,$ and $M^{m-1}>N^{m-1}$. An $(i+1)^{th}$ coupled code is $E^i=\{e_0^i, e_1^i, e_2^i, \ldots, e_{M^i-1}^i\}$, and $i=0, 1, \ldots, m-1$.

[0065] Each coupled code includes two parts: a first part and a second part, where the first part is the same as a first codeword that is in the m first codewords and that corresponds to the coupled code, and the second part is obtained by coupling the additional information with a second codeword that is in the m second codewords and that corresponds to the coupled code. For example, each element value of the second part is obtained by performing an exclusive OR operation on each element value in the additional information and each element value in a corresponding second codeword except the first codeword.

[0066] It is assumed that the additional information is Y and $Y=\{y_0, y_1, y_2, \ldots, y_{N'-1}\}$, and N' indicates a quantity of element values in Y.

[0067] In an embodiment, a relationship between E^i, X^i, and Y is as follows:

a first part of E^i is $\{e_0^i, e_1^i, e_2^i, \ldots e_{N^i-1}^i\}$, and the first part is generated by using the following method:
for(j=0; j<N^i; j=j+1)
$e_j^i = x_j^i$; and
a second part of E^i is $\{e_{N^i}^i, e_{N^i+1}^i, e_{N^i+2}^i, \ldots e_{M^i-1}^i\}$, and the second part is generated by
using the following method:
for(j=N^i; j<M^i; j=j+1)
$e_j^i = x_{mod(j,N^i)}^i$ ^ $y_{mod(j-N^i+\Delta^i,N')}$, where
mod represents a modulo operation, ^ represents an exclusive OR operation, and Δ^i represents a coupling sequence number offset value of the additional information.

[0068] For example, $\Delta^i=i*mod(\Sigma_{i=0}^{m-1}(M^i-N^i), N')$, where Σ represents a summation operation.

[0069] Certainly, the foregoing merely provides an example of an implementation method for coupling the additional information Y to each second codeword. In actual application, the foregoing coupling method is not limited.

[0070] Operation **203**: The first apparatus sends the m coupled codes.

[0071] In an embodiment, the first apparatus sends the m coupled codes to the second apparatus.

[0072] It should be noted that, the first apparatus may send a coupled code each time the coupled code is generated, and does not need to uniformly send the m coupled codes after all the m coupled codes are generated. Certainly, the m coupled codes may alternatively be uniformly sent after all the m coupled codes are generated. A method for sending the m coupled codes is not limited in embodiments of this application.

[0073] In the foregoing solution, the additional information is coupled with the m second codewords to obtain the m coupled codes, and the m coupled codes are transmitted. After the additional information in the m coupled codes is decoupled, transmission effect that is the same as or similar to that of merely transmitting the m second codewords may be obtained. In this way, more information can be sent additionally without changing a decoding rate of the second codeword, and channel performance is improved.

[0074] FIG. **3** is a schematic flowchart of a communication method according to an embodiment of this application. The method is executed by a second apparatus, and the method describes a decoding process of the second apparatus. The method includes the following operations.

[0075] Operation **301**: The second apparatus receives m groups of log-likelihood ratios (LLR).

[0076] After the first apparatus sends the m coupled codes by using the method in the embodiment in FIG. **2**, the second apparatus may receive the m groups of log-likelihood ratios, where the m groups of log-likelihood ratios one-to-one correspond to the m coupled codes. For example, a 1^{st} group of log-likelihood ratios corresponds to a 1^{st} coupled code, a 2^{nd} group of log-likelihood ratios corresponds to a 2^{nd} coupled code, and by analogy.

[0077] A quantity of element values in each group of log-likelihood ratios is the same as a quantity of element values in a coupled code corresponding to the group of log-likelihood ratios.

[0078] One group of log-likelihood ratios is also referred to as one group of received soft values.

[0079] Operation **302**: The second apparatus decodes the m groups of log-likelihood ratios to obtain a decoding result of additional information and a decoding result of m first codewords.

[0080] In an embodiment, for one group of log-likelihood ratios in the m groups of log-likelihood ratios, the second apparatus decouples a second part of the group of log-likelihood ratios based on a first part of the group of log-likelihood ratios, to obtain a log-likelihood ratio of the additional information, where a quantity of element values in the first part of the group of log-likelihood ratios is equal to a quantity of element values in a first part of a coupled code that is in the m coupled codes and that corresponds to the group of log-likelihood ratios, and a quantity of element values in the second part of the group of log-likelihood ratios is equal to a quantity of element values in a second part of the coupled code that is in the m coupled codes and that corresponds to the group of log-likelihood ratios; then determines the decoding result of the additional information based on log-likelihood ratios that are of the additional information and that respectively correspond to the m groups of log-likelihood ratios; and decouples the group of log-likelihood ratios based on the decoding result of the additional information, to obtain a decoding result of a first codeword corresponding to the group of log-likelihood ratios.

[0081] In an embodiment, that the second apparatus determines the decoding result of the additional information based on log-likelihood ratios that are of the additional information and that respectively correspond to the m groups of log-likelihood ratios may be, for example, that the second apparatus first determines a sum value of the log-likelihood ratios that are of the additional information and that respectively correspond to the m groups of log-likelihood ratios, and then decodes the sum value to obtain the decoding result of the additional information. In this method, m log-likelihood ratios of the additional information are first obtained through decoding, and then the m log-likelihood ratios are summed up and decoded to obtain the decoding result of the additional information. This helps improve decoding accuracy of the additional information.

[0082] In an embodiment, that the second apparatus decouples the group of log-likelihood ratios based on the decoding result of the additional information, to obtain a decoding result of a first codeword corresponding to the group of log-likelihood ratios may be, for example, that the second apparatus decouples the second part of the group of log-likelihood ratios based on the decoding result of the additional information and the first part of the group of log-likelihood ratios, to obtain decoupling information of the group of log-likelihood ratios, and decodes the decoupling information of the group of log-likelihood ratios to obtain the decoding result of the first codeword corresponding to the group of log-likelihood ratios. In this method, the second part of the group of likelihood ratios is first decoupled based on the decoding result of the additional information, to obtain the decoupling information of the group of log-likelihood ratios, and then the decoupling information of the group of log-likelihood ratios is decoded to obtain the decoding result of the first codeword corresponding to the group of log-likelihood ratios, thereby improving decoding accuracy of the first codeword.

[0083] It is assumed that the m groups of log-likelihood ratios are $L^0, L^1, \ldots,$ and L^{m-1}, where $L^i=\{l_0{}^i, l_1{}^i, l_2{}^i, \ldots, l_{M^i-1}{}^i\}$ represents an $(i+1)^{th}$ group of log-likelihood ratios in the m groups of log-likelihood ratios, and $i=0, 1, 2, \ldots, m-1$. M^i indicates a quantity of element values of L^i. L^i corresponds to X^i and E^i.

[0084] In an embodiment, it is assumed that a log-likelihood ratio that is of the additional information and that corresponds to the $(i+1)^{th}$ group of log-likelihood ratios L^i is Z^i and $Z^i=\{z_0{}^i, z_1{}^i, z_2{}^i, \ldots, z_{N'-1}{}^i\}$, $i=0, 1, 2, \ldots, m-1$, and N' represents a quantity of element values of Z^i. In this case, the following method may be used to generate Z^i:

$$\text{for } (j=N^i;\ j<M^i;\ j=j+1)\ z^i_{mod(j-N^i+\Delta^i,N')} = z^i_{mod(j-N^i+\Delta^i,N')} + F\left(l^i_j,\ l^i_{mod(j,N^i)}\right),$$

where

[0085] mod represents a modulo operation, and A represents a coupling sequence number offset value of the additional information. An initial value of each element in Z^i is set to 0. F represents a log-likelihood ratio decoupling operation function. In an embodiment, F(L0,L1)–(sig(L0)^sig(L1)?−1:1)*(abs(L0)>abs(L1) ?abs(L1):abs(L0)), where L0 and L1 are input values of the function F. sig is a sign obtaining operation. If L0 is greater than 0, sig(L0) is equal to 0; otherwise, sig(L0) is equal to 1. If L1 is greater than 0, sig(L1) is equal to 0; otherwise, sig(L1) is equal to 1. If a result of sig(L0)^sig(L1) is 0, a value of (sig(L0)^sig(L1)?−1:1) is −1. If the result of sig(L0)^sig(L1) is 1, the value of (sig(L0)^sig(L1)?−1:1) is 1. abs is a function for obtaining an absolute value. ^indicates an exclusive OR operation.

[0086] After the m groups of log-likelihood ratios of the additional information are obtained, the m groups of log-likelihood ratios may be summed up to obtain a sum value Z and $Z=\Sigma_{i=0}^{m-1} Z^i$, and then the sum value Z is decoded to obtain decoded information Ý of the additional information Y and $\acute{Y}=\{\acute{y}_0, \acute{y}_1, \ldots \acute{y}_{N'-1}\}$.

[0087] After the decoding information Ý of the additional information Y is obtained, each group of log-likelihood ratios is decoupled based on Ý, to obtain decoupling information of each group of log-likelihood ratios. It is assumed that decoupling information of the $(i+1)^{th}$ group of log-likelihood ratios is Q^i and $Q^i=\{q_0{}^i, q_1{}^i, q_2{}^i, \ldots, q_{M^i-}{}^i\}$, and the decoding result of the additional information is Ý, $i=0, 1, 2, \ldots, m-1$, M^i represents a quantity of element values of Q^i, N^i represents a quantity of element values of a first part of Q^i, and N' represents a quantity of element values of Ý.

The first part of Q^i is $\{q_0{}^i, q_1{}^i, q_2{}^i, \ldots, q_{N^i-1}{}^i\}$, and is generated by using the following method:

for(j=0; j<N^i; j=j+1)

$q_j{}^i = l_j{}^i$; and

a second part of Q^i is $\{q_{N^i}{}^i, q_1{}^i, q_2{}^i, \ldots, q_{M^i-1}{}^i\}$, and is generated by using the following method:

for(j=N^i; j<M^i; j=j+1)

$q_{mod(j,N^i)}{}^i = G(l_{mod(j-N^i+\Delta^i,N')}{}^i, q_{mod(j,N^i)}{}^i, \acute{y}_{mod(j-N^i+\Delta^i,N')})$, where

mod represents a modulo operation, and Δ^i represents a coupling sequence number offset value of the additional information. For a meaning of Δ^i, refer to the description of the embodiment in FIG. 3. Details are not described again. The function G represents a feedback decoupling log-likelihood ratio combination operation function. In an embodiment, G (L0,L1,B)=(B==0)?(L1+L0):(L1−L0), where L0, L1, and B are input values of the function G. If B is equal to 0, a value of the function G is L1+L0. If B is not equal to 0, the value of the G function is L1−L0.

[0088] After the decoupling information of each group of log-likelihood ratios is obtained, the decoupling information of each group of log-likelihood ratios may be decoded to obtain decoding information of each coupled code. For example, if $\acute{X}^i$ represents decoding information of X^i, decoding information $\acute{X}^0$, $\acute{X}^1$, and $\acute{X}^{m-1}$ of X^0, X^1, . . . , and X^{m-1} may be obtained.

[0089] It should be noted that, during decoding, the second apparatus may perform a decoupling operation before receiving a group of log-likelihood ratios, and decouple the group of log-likelihood ratios to obtain a log-likelihood ratio of the additional information, instead of performing a decoupling operation after receiving the m groups of log-likelihood ratios. Certainly, the second apparatus may alternatively uniformly perform the decoupling operation after receiving the m groups of log-likelihood ratios. This is not limited in embodiments of this application.

[0090] In the foregoing solution, the additional information is coupled with the m second codewords to obtain the m coupled codes, and the m coupled codes are transmitted. After the additional information in the m coupled codes is decoupled, transmission effect that is the same as or similar to that of merely transmitting the m second codewords may be obtained. In this way, more information can be sent additionally without changing a decoding rate of the second codeword, and channel throughput performance is improved.

[0091] For example, the following provides an application of an embodiment. FIG. **4** is an example diagram of coupling additional information to a PDCCH according to an embodiment of this application. It is assumed that there is coding information of m segments of physical downlink control channels (PDCCH), which are a PDCCH **1**, a PDCCH **2**, . . . , and a PDCCH m, and lengths of the m segments of PDCCHs are all N. The coding information of the m segments of PDCCHs is m first codewords. The coding information of the segments of PDCCHs is repeated once to obtain m second codewords. Then, additional information Y is separately coupled to second parts of the second codewords to obtain m coupled codes. The additional information Y includes one or more of the following information: an aggregation level, a user ID corresponding to each PDCCH, and an information length of each PDCCH. A base station sends the m coupled codes through broadcast, and all a plurality of UEs can receive the m coupled codes.

[0092] If the additional information Y includes the user ID corresponding to each PDCCH, for UE, after receiving the m coupled codes, the UE first decodes the m coupled codes to obtain additional information A. If it is found that an ID of the UE does not appear in the additional information A, subsequent decoding may be abandoned; otherwise, coding information of a corresponding segment of the PDCCH continues to be decoded. The method can reduce a quantity of decoding times, that is, reduce a quantity of blind detection times.

[0093] If the additional information Y includes the information length of each PDCCH, for UE, after receiving the m coupled codes, the UE first decodes the m coupled codes to obtain additional information A, so as to obtain the information length of each PDCCH. Subsequently, the PDCCH may be decoded once based on the information length of each PDCCH, and there is no need to attempt to decode the PDCCH based on a plurality of information lengths, so that a quantity of blind detection times can be reduced.

[0094] If the additional information Y includes the aggregation level, for UE, after receiving the m coupled codes, the UE first decodes the m coupled codes to obtain the additional information A, so as to obtain the aggregation level. Subsequently, the PDCCH may be decoded based on the aggregation level, and there is no need to attempt to decode the PDCCH at a plurality of aggregation levels, so that a quantity of blind detection times can be reduced.

[0095] It may be understood that, to implement the functions in the foregoing embodiments, the first apparatus or the second apparatus includes corresponding hardware structures and/or software modules for performing the functions. One of ordinary skilled in the art should be easily aware that, in this application, the units and method operations in the examples described with reference to embodiments disclosed in this application can be implemented by hardware or a combination of hardware and computer software. Whether a function is performed by hardware or hardware driven by computer software depends on particular application scenarios and design constraints of the technical solutions.

[0096] FIG. **5** and FIG. **6** are diagrams of structures of possible communication apparatuses according to embodiments of this application. These communication apparatuses may be configured to implement the function of the first apparatus or the second apparatus in the foregoing method embodiments, and therefore may also implement beneficial effect of the foregoing method embodiments. In an embodiment of the application, the communication apparatus may be the first apparatus or the second apparatus shown in FIG. **1**.

[0097] A communication apparatus **500** shown in FIG. **5** includes a processing unit **510** and a transceiver unit **520**. The communication apparatus **500** is configured to implement the function of the first apparatus or the second apparatus in the foregoing method embodiments.

[0098] When the communication apparatus **500** is configured to implement the function of the first apparatus in the foregoing method embodiments, the processing unit **510** is configured to: respectively encode m first codewords to obtain m second codewords, where the second codeword is obtained by repeating the first codeword, and m is a positive integer; and separately couple additional information with the m second codewords to obtain m coupled codes, where the coupled code includes a first part and a second part, the first part is the same as a first codeword that is in the m first codewords and that corresponds to the coupled code, and the second part is obtained by coupling the additional information with a second codeword that is in the m second codewords and that corresponds to the coupled code; and the transceiver unit **520** is configured to send the m coupled codes.

[0099] In an embodiment, each element value of the second part is obtained by performing an exclusive OR operation on each element value in the additional information and each element value in the second codeword except the first codeword.

[0100] In an embodiment, an $(i+1)^{th}$ first codeword in the m first codewords is X^i and $X^i=\{x_0{}^i, x_1{}^i, x_2{}^i, \ldots, x_{N^i-1}{}^i\}$, an $(i+1)^{th}$ coupled code in the m coupled codes is E^i and $E^i=\{e_0{}^i, e_1{}^i, e_2{}^i, \ldots, e_{M^i-1}{}^i\}$, the additional information is

Y and $Y=\{y_0, y_1, y_2, \ldots, y_{N'-1}\}$, $i=0, 1, 2, \ldots, m-1$, N^i represents a quantity of element values of X^i, M^i represents a quantity of element values of E^i, and N' represents a quantity of element values of Y;

a first part of E^i is $\{e_0^i, e_1^i, e_2^i, \ldots e_{N^i-1}^i\}$, and the first part is generated by using the following method:

for($j=0$; $j<N^i$; $j=j+1$)

$e_j^i = x_j^i$; and

a second part of E^i is $\{e_{N^i}^i, e_{N^i+1}^i, e_{N^i+2}^i, \ldots e_{M^i-1}^i\}$, and the second part is generated by using the following method:

for($j=N^i$; $j<M^i$; $j=j+1$)

$e_j^i = x_{mod(j,N^i)}^i \,\hat{}\, y_{mod(j-N^i+\Delta^i,N')}$, where

mod represents a modulo operation, ^ represents an exclusive OR operation, and Δ^i represents a coupling sequence number offset value of the additional information.

[0101] In an embodiment, $\Delta^i=i*mod(\Sigma_{i=0}^{m-1}(M^i-N^i), N')$, where Σ represents a summation operation.

[0102] In an embodiment, additional information coupled in the m coupled codes is the same.

[0103] In an embodiment, the first codeword is a polar code.

[0104] When the communication apparatus **500** is configured to implement the function of the second apparatus in the foregoing method embodiments, the transceiver unit **520** is configured to receive m groups of log-likelihood ratios, where the m groups of log-likelihood ratios one-to-one correspond to m coupled codes, the m coupled codes one-to-one correspond to m second codewords, the m second codewords are obtained by repeatedly encoding m first codewords respectively, and m is a positive integer; and the processing unit **510** is configured to decode the m groups of log-likelihood ratios to obtain a decoding result of additional information and a decoding result of the m first codewords, where the coupled code includes a first part and a second part, the first part is the same as a first codeword that is in the m first codewords and that corresponds to the coupled code, and the second part is obtained by coupling the additional information with a second codeword that is in the m second codewords and that corresponds to the coupled code.

[0105] In an embodiment, the processing unit **510** is configured to: for one group of log-likelihood ratios in the m groups of log-likelihood ratios, decouple a second part of the group of log-likelihood ratios based on a first part of the group of log-likelihood ratios, to obtain a log-likelihood ratio of the additional information, where a quantity of element values in the first part of the group of log-likelihood ratios is equal to a quantity of element values in a first part of a coupled code that is in the m coupled codes and that corresponds to the group of log-likelihood ratios, and a quantity of element values in the second part of the group of log-likelihood ratios is equal to a quantity of element values in a second part of the coupled code that is in the m coupled codes and that corresponds to the group of log-likelihood ratios; determine the decoding result of the additional information based on log-likelihood ratios that are of the additional information and that respectively correspond to the m groups of log-likelihood ratios; and decouple the group of log-likelihood ratios based on the decoding result of the additional information, to obtain a decoding result of a first codeword corresponding to the group of log-likelihood ratios.

[0106] In an embodiment, the processing unit **510** is configured to: determine a sum value of the log-likelihood ratios that are of the additional information and that respectively correspond to the m groups of log-likelihood ratios; and decode the sum value to obtain the decoding result of the additional information.

[0107] In an embodiment, the processing unit **510** is configured to: decouple the second part of the group of log-likelihood ratios based on the decoding result of the additional information and the first part of the group of log-likelihood ratios, to obtain decoupling information of the group of log-likelihood ratios; and decode the decoupling information of the group of log-likelihood ratios to obtain the decoding result of the first codeword corresponding to the group of log-likelihood ratios.

[0108] In an embodiment, the group of log-likelihood ratios is L^i and $L^i=\{l_0^i, l_1^i, l_2^i, \ldots, l_{M^i-1}^i\}$, the decoupling information of the group of log-likelihood ratios is Q^i and $Q^i=\{q_0^i, q_1^i, q_2^i, \ldots, q_{M^i-1}^i\}$, the decoding result of the additional information is Ý and $Ý=\{ý_0, ý_1, \ldots ý_{N'-1}\}$, $i=0, 1, 2, \ldots, m-1$, M^i represents a quantity of element values of L^i and a quantity of element values of Q^i, N^i represents a quantity of element values of a first part of Q^i, and N' represents a quantity of element values of Ý;

the first part of Q^i is generated by using the following method:

for($j=0$; $j<N^i$; $j=j+1$)

$q_j^i = l_j^i$; and

a second part of Q^i is generated by using the following method:

for($j=N^i$; $j<M^i$; $j=j+1$)

$q_{mod(j,N^i)}^i = G(l_{mod(j-N^i+\Delta^i,N')}^i, q_{mod(j,N^i)}^i, ý_{mod(j-N^i+\Delta^i,N')})$, where

mod represents a modulo operation, Δ^i represents a coupling sequence number offset value of the additional information, and the function G represents a feedback decoupling log-likelihood ratio combination operation function.

[0109] In an embodiment, the group of log-likelihood ratios is L^i and $L^i=\{l_0^i, l_1^i, l_2^i, \ldots, l_{M^i-1}^i\}$, the log-likelihood ratio of the additional information is Z^i and $Z^i=\{z_0^i, z_1^i, z_2^i, \ldots, z_{N'-1}^i\}$, $i=0, 1, 2, \ldots, m-1$, N' represents a quantity of element values of Z^i, and M^i represents a quantity of element values of the group of log-likelihood ratios;

[0110] the log-likelihood ratio of the additional information is generated by using the following method:

$$\text{for } (j = N^i;\ j < M^i;\ j = j + 1)\ z^i_{mod(j-N^i+\Delta^i, N')} = z^i_{mod(j-N^i+\Delta^i, N')} + F\left(l^i_j,\ l^i_{mod(j, N^i)}\right),$$

where

[0111] mod represents a modulo operation, F represents a log-likelihood ratio decoupling operation function, and Δ^i represents a coupling sequence number offset value of the additional information.

[0112] In an embodiment, $\Delta^i = i * mod(\Sigma_{i=0}^{m-1}(E^i - N^i), N')$, where Σ represents a summation operation.

[0113] In an embodiment, the sum value of the log-likelihood ratios that are of the additional information and that respectively correspond to the m groups of log-likelihood ratios is Z and $z = \Sigma_{i=0}^{m-1} Z^i$. Z^i represents a log-likelihood ratio that is of the additional information and that corresponds to an i^{th} group of log-likelihood ratios.

[0114] In an embodiment, the first codeword is a polar code.

[0115] For more detailed descriptions about the processing unit **510** and the transceiver unit **520**, directly refer to related descriptions in the foregoing method embodiments. Details are not described herein again.

[0116] As shown in FIG. **6**, a communication apparatus **600** includes a processor **610** and an interface circuit **620**. The processor **610** and the interface circuit **620** are coupled to each other. It may be understood that the interface circuit **620** may be a transceiver or an input/output interface. In an embodiment, the communication apparatus **600** may further include a memory **630** that is configured to store instructions executed by the processor **610**, store input data required by the processor **610** to run instructions, or store data generated after the processor **610** runs instructions.

[0117] When the communication apparatus **600** is configured to implement the foregoing method embodiments, the processor **610** is configured to implement a function of the processing unit **510**, and the interface circuit **620** is configured to implement a function of the transceiver unit **520**.

[0118] It can be understood that the processor in embodiments of this application may be a central processing unit (CPU), or may be another general-purpose processor, a digital signal processor (DSP), an application-specific integrated circuit (ASIC), a field programmable gate array (FPGA) or another programmable logic device, a transistor logic device, a hardware component, or any combination thereof. The general-purpose processor may be a microprocessor or any regular processor or the like.

[0119] The method operations in embodiments of this application may be implemented in a hardware manner, or may be implemented in a manner of executing software instructions by the processor. The software instructions may include a corresponding software module. The software module may be stored in a random access memory, a flash memory, a read-only memory, a programmable read-only memory, an erasable programmable read-only memory, an electrically erasable programmable read-only memory, a register, a hard disk, a removable hard disk, and a compact disc read-only memory (CD-ROM) or any other form of storage medium well known in the art. For example, a storage medium is coupled to a processor, so that the processor can read information from the storage medium and write information into the storage medium. Certainly, the storage medium may be a component of the processor. The processor and the storage medium may be disposed in an ASIC. In addition, the ASIC may be located in the first apparatus or the second apparatus. Certainly, the processor and the storage medium may alternatively exist in the first apparatus or the second apparatus as discrete components.

[0120] All or some of the foregoing embodiments may be implemented by using software, hardware, firmware, or any combination thereof. When software is used to implement embodiments, all or a part of embodiments may be implemented in a form of a computer program product. The computer program product includes one or more computer programs or instructions. The computer program is a set of instructions that indicate each operation of an electronic computer or another device having a message processing capability, and is usually written in a program design language and runs on a target architecture. When the computer programs or instructions are loaded and executed on a computer, all or some of the procedures or functions in embodiments of this application are performed. The computer may be a general-purpose computer, a dedicated computer, a computer network, an access network device, a terminal device, or another programmable apparatus. The computer program or instructions may be stored in a computer-readable storage medium, or may be transmitted from a computer-readable storage medium to another computer-readable storage medium. For example, the computer program or instructions may be transmitted from a website, computer, server, or data center to another website, computer, server, or data center in a wired or wireless manner. The computer-readable storage medium may be any usable medium that can be accessed by the computer, or a data storage device, for example, a server or a data center, integrating one or more usable media. The usable medium may be a magnetic medium, for example, a floppy disk, a hard disk, or a magnetic tape; or may be an optical medium, for example, a digital video disc; or may be a semiconductor medium, for example, a solid-state drive. The computer-readable storage medium may be a volatile or non-volatile storage medium, or may include two types of storage media: a volatile storage medium and a non-volatile storage medium.

[0121] In embodiments of this application, unless otherwise stated or there is a logic conflict, terms and/or descriptions in different embodiments are consistent and may be mutually referenced, and technical features in different embodiments may be combined based on an internal logical relationship thereof, to form a new embodiment.

[0122] In this application, at least one means one or more, and a plurality of means two or more. The term "and/or" describes an association relationship between associated objects, and represents that three relationships may exist. For example, A and/or B may represent the following cases: Only A exists, both A and B exist, and only B exists, where A and B may be singular or plural. In the text descriptions of this application, the character "/" represents an "or" relationship between the associated objects. In a formula in this application, the character "/" represents a "division" relationship between the associated objects.

[0123] It may be understood that various numbers in embodiments of this application are merely used for differentiation for ease of description, and are not used to limit the scope of embodiments of this application. Sequence numbers of the foregoing processes do not mean an execution sequence, and the execution sequence of the processes should be determined based on functions and internal logic of the processes.

What is claimed is:

1. A communication method, comprising:

respectively encoding m first codewords to obtain m second codewords, wherein the second codeword is obtained by repeating the first codeword, and m is a positive integer;

separately coupling additional information with the m second codewords to obtain m coupled codes, wherein the coupled code comprises a first part and a second part, the first part is the same as a first codeword in the m first codewords and corresponding to the coupled code, and the second part is obtained by coupling the additional information with a second codeword in the m second codewords and corresponding to the coupled code; and

sending the m coupled codes.

2. The method according to claim **1**, wherein each element value of the second part is obtained by performing an exclusive OR operation on each element value in the additional information and each element value in the second codeword except the first codeword.

3. The method according to claim **2**, wherein an $(i+1)^{th}$ first codeword in the m first codewords is X^i and $X^i=\{x_0^i, x_1^i, x_2^i, \ldots, x_{N^i-1}^i\}$, an $(i+1)^{th}$ coupled code in the m coupled codes is E^i and $E^i=\{e_0^i, e_1^i, e_2^i, \ldots, e_{M^i-1}^i\}$, the additional information is Y and $Y=\{y_0, y_1, y_2, \ldots, y_{N'-1}\}$, $i=0, 1, 2, \ldots, m-1$, N^i represents a quantity of element values of X^i, M^i represents a quantity of element values of E^i, and N' represents a quantity of element values of Y;

a first part of E^i is $\{e_0^i, e_1^i, e_2^i, \ldots e_{N^i-1}^i\}$, and the first part is generated by using:
for(j=0; j<N^i; j=j+1)
$e_j^i = x_j^i$; and
a second part of E^i is $\{e_{N^i}^i, e_{N^i+1}^i, e_{N^i+2}^i, \ldots e_{M^i-1}^i\}$, and the second part is generated by using:
for(j=N^i; j<M^i; j=j+1)
$e_j^i = x_{mod(j,N^i)}^i \,\hat{}\, y_{mod(j-N^i+\Delta^i,N')}$, wherein
mod represents a modulo operation, ^ represents an exclusive OR operation, and Δ^i represents a coupling sequence number offset value of the additional information.

4. The method according to claim **3**, wherein

$$\Delta^i=i*\mathrm{mod}(\Sigma_{i=0}^{m-1}(M^i-N^i),N'),$$ wherein

Σ represents a summation operation.

5. The method according to claim **1**, wherein additional information coupled in the m coupled codes is the same.

6. The method according to claim **1**, wherein the first codeword is a polar code.

7. A communication method, comprising:

receiving m groups of log-likelihood ratios, wherein the m groups of log-likelihood ratios one-to-one correspond to m coupled codes, the m coupled codes one-to-one correspond to m second codewords, the m second codewords are obtained by repeatedly encoding m first codewords respectively, and m is a positive integer; and

decoding the m groups of log-likelihood ratios to obtain a decoding result of additional information and a decoding result of the m first codewords, wherein

the coupled code comprises a first part and a second part, the first part is the same as a first codeword in the m first codewords and corresponding to the coupled code, and the second part is obtained by coupling the additional information with a second codeword in the m second codewords and corresponding to the coupled code.

8. The method according to claim **7**, wherein decoding the m groups of log-likelihood ratios to obtain the decoding result of additional information and the decoding result of the m first codewords comprises:

for one group of log-likelihood ratios in the m groups of log-likelihood ratios, decoupling a second part of the group of log-likelihood ratios based on a first part of the group of log-likelihood ratios, to obtain a log-likelihood ratio of the additional information, wherein a quantity of element values in the first part of the group of log-likelihood ratios is equal to a quantity of element values in a first part of a coupled code in the m coupled codes and corresponding to the group of log-likelihood ratios, and a quantity of element values in the second part of the group of log-likelihood ratios is equal to a quantity of element values in a second part of the coupled code in the m coupled codes and corresponding to the group of log-likelihood ratios;

determining the decoding result of the additional information based on log-likelihood ratios of the additional information and respectively corresponding to the m groups of log-likelihood ratios; and

decoupling the group of log-likelihood ratios based on the decoding result of the additional information, to obtain a decoding result of a first codeword corresponding to the group of log-likelihood ratios.

9. The method according to claim **8**, wherein determining the decoding result of the additional information based on the log-likelihood ratios of the additional information and respectively corresponding to the m groups of log-likelihood ratios comprises:

determining a sum value of the log-likelihood ratios of the additional information and respectively corresponding to the m groups of log-likelihood ratios; and

decoding the sum value to obtain the decoding result of the additional information.

10. The method according to claim **8**, wherein decoupling the group of log-likelihood ratios based on the decoding result of the additional information, to obtain a decoding result of the first codeword corresponding to the group of the log-likelihood ratios comprises:

decoupling the second part of the group of log-likelihood ratios based on the decoding result of the additional information and the first part of the group of log-likelihood ratios, to obtain decoupling information of the group of log-likelihood ratios; and

decoding the decoupling information of the group of log-likelihood ratios to obtain the decoding result of the first codeword corresponding to the group of log-likelihood ratios.

11. The method according to claim **10**, wherein the group of log-likelihood ratios is L^i and $L^i=\{l_0^i, l_1^i, l_2^i, \ldots, l_{M^i-1}^i\}$, the decoupling information of the group of log-likelihood ratios is Q^i and $Q^i=\{q_0^i, q_1^i, q_2^i, \ldots, q_{M^i-1}^i\}$, the decoding result of the additional information is $\acute{Y}$ and $\acute{Y}=\{\acute{y}_0, \acute{y}_1, \ldots \acute{y}_{N'-1}\}$, $i=0, 1, 2, \ldots, m-1$, M^i represents a quantity of element values of L^i and a quantity of element values of Q^i, N^i represents a quantity of element values of a first part of Q^i, and N' represents a quantity of element values of $\acute{Y}$;

the first part of Q^i is generated by using:

$for(j=0; j<N^i; j=j+1)$

$q_j^i = l_j^i$; and

a second part of Q^i is generated by using:

$for(j=N^i; j<M^i; j=j+1)$

$q_{mod(j,N^i)}^i = G(l_{mod(j-N^i+\Delta^i,N')}^i, q_{mod(j,N^i)}^i, \acute{y}_{mod(j-N^i+\Delta^i,N')})$, wherein

mod represents a modulo operation, Δ^i represents a coupling sequence number offset value of the additional information, and the function G represents a feedback decoupling log-likelihood ratio combination operation function.

12. The method according to claim **8**, wherein the group of log-likelihood ratios is L^i and $L^i=\{l_0^i, l_1^i, l_2^i, \ldots, l_{M^i-1}^i\}$, the log-likelihood ratio of the additional information is Z^i and $Z^i=\{z_0^i, z_1^i, z_2^i, \ldots, z_{N'-1}^i\}$, $i=0, 1, 2, \ldots, m-1$, N' represents a quantity of element values of Z^i, and M^i represents a quantity of element values of the group of log-likelihood ratios;

the log-likelihood ratio of the additional information is generated by using:

$$\text{for } \left(j = N^i;\ j < M^i;\ j = j + 1\right) z^i_{mod\left(j-N^i+\Delta^i,N'\right)} = z^i_{mod\left(j-N^i+\Delta^i,N'\right)} + F\left(l^i_j, l^i_{mod\left(j,N^i\right)}\right),$$

wherein

mod represents a modulo operation, F represents a log-likelihood ratio decoupling operation function, and Δ^i represents a coupling sequence number offset value of the additional information.

13. The method according to claim **11**, wherein

$\Delta^i=i*mod(\Sigma_{i=0}^{m-1}(E^i-N^i),N')$, wherein

Σ represents a summation operation.

14. The method according to claim **9**, wherein the sum value of the log-likelihood ratios of the additional information and respectively corresponding to the m groups of the log-likelihood ratios is Z and $Z=\Sigma_{i=0}^{m-1} Z^i$, wherein

Z^i represents a log-likelihood ratio of the additional information and corresponding to an i^{th} group of log-likelihood ratios in the m groups of log-likelihood ratios.

15. The method according to claim **7**, wherein the first codeword is a polar code.

16. A communication apparatus, comprising:

a processor, and

a memory coupled to the processor to store instructions, which when executed by the processor, cause the processor to perform operations, the operations comprising:

respectively encoding m first codewords to obtain m second codewords, wherein the second codeword is obtained by repeating the first codeword, and m is a positive integer; and

separately coupling additional information with the m second codewords to obtain m coupled codes, wherein the coupled code comprises a first part and a second part, the first part is the same as a first codeword in the m first codewords and corresponding to the coupled code, and the second part is obtained by coupling the additional information with a second codeword in the m second codewords and corresponding to the coupled code; and

sending the m coupled codes.

17. The apparatus according to claim **16**, wherein each element value of the second part is obtained by performing an exclusive OR operation on each element value in the additional information and each element value in the second codeword except the first codeword.

18. The apparatus according to claim **17**, wherein an $(i+1)^{th}$ first codeword in the m first codewords is X^i and $X^i=\{x_0^i, x_1^i, x_2^i, \ldots, x_{N^i-1}^i\}$, an $(i+1)^{th}$ coupled code in the m coupled codes is E^i and $E^i=\{e_0^i, e_1^i, e_2^i, \ldots, e_{M^i-1}^i\}$, the additional information is Y and $Y=\{y_0, y_1, y_2, \ldots, y_{N'-1}\}$, $i=0, 1, 2, \ldots, m-1$, N^i represents a quantity of element values of X^i, M^i represents a quantity of element values of E^i, and N' represents a quantity of element values of Y;

a first part of E^i is $\{e_0^i, e_1^i, e_2^i, \ldots e_{N^i-1}^i\}$, and the first part is generated by using:

$for(j=0; j<N^i; j=j+1)$

$e_j^i = x_j^i$; wherein

a second part of E^i is $\{e_{N^i}^i, e_{N^i+1}^i, e_{N^i+2}^i, \ldots e_{M^i-1}^i\}$, and the second part is generated by using:

$for(j=N^i; j<M^i; j=j+1)$

$e_j^i = x_{mod(j,N^i)}^i \hat{} y_{mod(j-N^i+\Delta^i,N')}$, wherein

mod represents a modulo operation, ^ represents an exclusive OR operation, and Δ^i represents a coupling sequence number offset value of the additional information.

19. The apparatus according to claim **18**, wherein

$$\Delta^i = i * \mathrm{mod}(\Sigma_{i=0}^{m-1}(M^i - N^i), N'), \text{ wherein}$$

Σ represents a summation operation.

20. The apparatus according to claim **16**, wherein additional information coupled in the m coupled codes is the same.

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