# COMMUNICATION METHOD, APPARATUS, AND SYSTEM

**[0001]** This application claims priority to Chinese Patent Application No. 202410391220.5, filed with the China National Intellectual Property Administration on March 30, 2024 and entitled "COMMUNICATION METHOD, APPARATUS, AND SYSTEM", which is incorporated herein by reference in its entirety.

## TECHNICAL FIELD

**[0002]** This application relates to the field of communication technologies, and in particular, to a communication method, apparatus, and system.

## BACKGROUND

**[0003]** In ranging communication technologies, ranging signals may be wireless carrier signals with high-frequency bandwidths. The wireless carrier signal with the high-frequency bandwidth has a narrow time domain and high resolution, and therefore has a strong multipath resolution capability, and can ensure high ranging accuracy in complex multipath environments. Currently, ranging signals achieve ranging and positioning between devices by sending and receiving pulse sequences.

**[0004]** In related technologies, a ranging part of a ranging signal includes at least one ranging subsequence, and each ranging subsequence includes a plurality of ranging symbols. The plurality of ranging symbols are formed by repeated channel code sequences having good autocorrelation properties, or each ranging symbol is generated based on a random code sequence.

**[0005]** However, when the plurality of ranging symbols are formed by the repeated channel code sequences having good autocorrelation properties, security performance of the ranging part is poor, making it susceptible to interception or interference by attack signals. When each ranging symbol is generated based on the random code sequence, partial autocorrelation is weak, leading to poorer channel estimation quality that can be obtained by a receiver, which in turn causes low ranging result accuracy.

## SUMMARY

**[0006]** This application provides a communication method, apparatus, and system, to implement high-precision positioning and provide security protection for ranging information.

**[0007]** According to a first aspect, this application provides a communication method. The method includes: sending a transmission frame, where the transmission frame includes a ranging sequence field, the ranging sequence field includes at least one ranging subsequence, the ranging subsequence includes a plurality of ranging symbols, and the ranging sequence field is used to perform channel impulse response (channel impulse response, CIR) estimation. A first ranging symbol in the plurality of ranging symbols is generated based on a first original code sequence in an original code sequence set, the original code sequence set includes a plurality of original code sequences, and the first original code sequence is randomly obtained from the original code sequence set in a symmetric encryption manner.

**[0008]** For example, when there are a plurality of ranging subsequences, there may be a gap (gap) between two adjacent ranging subsequences. There is no signal in the gap, a length of the gap is greater than or equal to 0, and the length of the gap may be customized. A specific value of the gap is not limited in embodiments of this application.

**[0009]** For example, the first ranging symbol may be generated by performing time domain spreading (spreading) on the first original code sequence, or may be generated by performing time domain spreading on the first original code sequence followed by sequence spreading. This is not limited in embodiments of this application.

**[0010]** The original code sequence may be configured as a code sequence having a good autocorrelation property. Beneficial effect is as follows: A transmitter sends a ranging sequence field with a good autocorrelation property, and a receiver can obtain a high-quality channel estimate via a correlator to perform correlation calculation for ranging. This ensures stability of high-precision ranging performance. In addition, the original code sequence is randomly selected from the preset original code sequence set in the symmetric encryption manner. This ensures security of the ranging sequence field, implements high-precision positioning, and provides security protection for ranging information.

**[0011]** In a possible implementation, a second ranging symbol in the plurality of ranging symbols is generated based on a second original code sequence in the original code sequence set, and the first original code sequence is the same as the second original code sequence.

**[0012]** In this implementation, the first ranging symbol is the same as the second ranging symbol. For example, any two ranging symbols in a single ranging subsequence are generated based on a same original code sequence in the original code sequence set.

**[0013]** In a possible implementation, a second ranging symbol in the plurality of ranging symbols is generated based on a second original code sequence in the original code sequence set, and the first original code sequence is different from the second original code sequence.

**[0014]** In this implementation, the first ranging symbol is different from the second ranging symbol. For example, any two ranging symbols in a single ranging subsequence are generated based on different original code sequences in the original code sequence set.

**[0015]** In a possible implementation, the at least one ranging subsequence includes a first ranging subsequence and a second ranging subsequence, the ranging subsequence includes N ranging symbols, an $i^{th}$ ranging symbol in the first ranging subsequence is the same as an $i^{th}$ ranging symbol in the second ranging subsequence, and $1 \leq i \leq N$.

**[0016]** In this implementation, the $i^{th}$ ranging symbol in the first ranging subsequence is the same as the $i^{th}$ ranging symbol in the second ranging subsequence.

**[0017]** In a possible implementation, the at least one ranging subsequence includes a first ranging subsequence and a second ranging subsequence, the ranging subsequence includes N ranging symbols, an $i^{th}$ ranging symbol in the first ranging subsequence is different from an $i^{th}$ ranging symbol in the second ranging subsequence, and $1 \leq i \leq N$.

**[0018]** In this implementation, the $i^{th}$ ranging symbol in the first ranging subsequence is different from the $i^{th}$ ranging symbol in the second ranging subsequence.

**[0019]** In a possible implementation, the plurality of original code sequences are one-to-one mapped to a plurality of sequence identifiers, the first original code sequence in the original code sequence set is mapped to a first sequence identifier, the first sequence identifier is generated in the symmetric encryption manner, and the first original code sequence is obtained from the original code sequence set through mapping by using the first sequence identifier.

**[0020]** For example, the sequence identifier may be an index (index). The transmitter may generate, in the symmetric encryption manner, a random number within an index range included in the original code sequence set, and then map the random number to an index in the original code sequence set based on the random number, to obtain, an original code sequence to which the index is mapped as the first original code sequence.

**[0021]** According to a second aspect, this application provides a communication method. The method includes: receiving a transmission frame, where the transmission frame includes a ranging sequence field, the ranging sequence field includes at least one ranging subsequence, and the ranging subsequence includes a plurality of ranging symbols; and performing CIR estimation by using a first original code sequence and a first ranging symbol in the plurality of ranging symbols, where the first original code sequence is randomly obtained from an original code sequence set in a symmetric encryption manner, and the original code sequence set includes a plurality of original

code sequences.

**[0022]** In a possible implementation, a second ranging symbol in the plurality of ranging symbols is generated based on a second original code sequence in the original code sequence set, and the first original code sequence is the same as the second original code sequence.

**[0023]** In a possible implementation, a second ranging symbol in the plurality of ranging symbols is generated based on a second original code sequence in the original code sequence set, and the first original code sequence is different from the second original code sequence.

**[0024]** In a possible implementation, the at least one ranging subsequence includes a first ranging subsequence and a second ranging subsequence, the ranging subsequence includes N ranging symbols, an $i^{th}$ ranging symbol in the first ranging subsequence is the same as an $i^{th}$ ranging symbol in the second ranging subsequence, and $1 \leq i \leq N$.

**[0025]** In a possible implementation, the at least one ranging subsequence includes a first ranging subsequence and a second ranging subsequence, the ranging subsequence includes N ranging symbols, an $i^{th}$ ranging symbol in the first ranging subsequence is different from an $i^{th}$ ranging symbol in the second ranging subsequence, and $1 \leq i \leq N$.

**[0026]** In a possible implementation, the plurality of original code sequences are one-to-one mapped to a plurality of sequence identifiers, the first original code sequence in the original code sequence set is mapped to a first sequence identifier, the first sequence identifier is generated in the symmetric encryption manner, and the first original code sequence is obtained from the original code sequence set through mapping by using the first sequence identifier.

**[0027]** According to a third aspect, this application provides a transmission frame. The transmission frame includes: a ranging sequence field, where the ranging sequence field includes at least one ranging subsequence, the ranging subsequence includes a plurality of ranging symbols, and the ranging sequence field is used to perform CIR estimation. A first ranging symbol in the plurality of ranging symbols is generated based on a first original code sequence in an original code sequence set, the original code sequence set includes a plurality of original code sequences, and the first original code sequence is randomly obtained from the original code sequence set in a symmetric encryption manner.

**[0028]** In a possible implementation, a second ranging symbol in the plurality of ranging symbols is generated based on a second original code sequence in the original code sequence set, and the first original code sequence is the same as the second original code sequence.

**[0029]** In a possible implementation, a second ranging symbol in the plurality of ranging symbols is generated based on a second original code sequence in the original code sequence set, and the first original code sequence is different from the second original code sequence.

**[0030]** In a possible implementation, the at least one ranging subsequence includes a first

ranging subsequence and a second ranging subsequence, the ranging subsequence includes N ranging symbols, an $i^{th}$ ranging symbol in the first ranging subsequence is the same as an $i^{th}$ ranging symbol in the second ranging subsequence, and $1 \leq i \leq N$.

**[0031]** In a possible implementation, the at least one ranging subsequence includes a first ranging subsequence and a second ranging subsequence, the ranging subsequence includes N ranging symbols, an $i^{th}$ ranging symbol in the first ranging subsequence is different from an $i^{th}$ ranging symbol in the second ranging subsequence, and $1 \leq i \leq N$.

**[0032]** In a possible implementation, the plurality of original code sequences are one-to-one mapped to a plurality of sequence identifiers, the first original code sequence in the original code sequence set is mapped to a first sequence identifier, the first sequence identifier is generated in the symmetric encryption manner, and the first original code sequence is obtained from the original code sequence set through mapping by using the first sequence identifier.

**[0033]** According to a fourth aspect, this application provides a communication apparatus. The apparatus includes: a module configured to send a transmission frame, where the transmission frame includes a ranging sequence field, the ranging sequence field includes at least one ranging subsequence, the ranging subsequence includes a plurality of ranging symbols, and the ranging sequence field is used to perform CIR estimation. A first ranging symbol in the plurality of ranging symbols is generated based on a first original code sequence in an original code sequence set, the original code sequence set includes a plurality of original code sequences, and the first original code sequence is randomly obtained from the original code sequence set in a symmetric encryption manner.

**[0034]** In a possible implementation, the communication apparatus is further configured to implement transmission of a Bluetooth signal or a wireless fidelity (wireless fidelity, Wi-Fi) signal, and at least one of a SparkLink module, a Bluetooth module, and a Wi-Fi module shares at least one of a radio frequency (radio frequency, RF) unit, a modem (Modem) unit, a media access control (medium access control, MAC) unit, and a central processing unit (central processing unit/processor, CPU).

**[0035]** In a possible implementation, the communication apparatus is further configured to implement transmission of the Bluetooth signal, but does not support transmission of the Wi-Fi signal, the SparkLink module and the Bluetooth module are located in a same subsystem of the communication apparatus, and the subsystem and a power management unit (power management unit, PMU) are integrated into the communication apparatus.

**[0036]** In a possible implementation, the communication apparatus is further configured to implement transmission of the Bluetooth signal or the Wi-Fi signal, at least one of the Bluetooth module or the Wi-Fi module performs coexistence communication with the SparkLink module via

different antennas, and a coexistence policy is channel avoidance.

**[0037]** In a possible implementation, the communication apparatus is further configured to: determine a type of a peer device and/or a service latency of the peer device, and determine, according to a link selection policy, a link corresponding to the peer device and/or a service to perform data transmission.

**[0038]** In a possible implementation, that the communication apparatus is further configured to determine the type of the peer device and/or the service latency of the peer device includes: determining the type of the peer device, where the type of the peer device includes an audio device type or a non-audio device type; and determining the service latency of the peer device when the type of the peer device is the audio device type.

**[0039]** In a possible implementation, the link selection policy includes: when the service latency is greater than a first value, performing data transmission after establishing an asynchronous unicast link or an asynchronous multicast link; or when the service latency is less than the first value and greater than a second value, establishing the asynchronous unicast link or the asynchronous multicast link, and performing data transmission after synchronization is implemented by adding a timestamp to a data packet; or when the service latency is less than the second value, first establishing the asynchronous unicast link, and then performing data transmission after establishing a synchronous unicast link or a synchronous multicast link.

**[0040]** In a possible implementation, the communication apparatus is further configured to: determine a type of a peer device and/or a service latency of the peer device, and determine, according to a frame format selection policy, a frame format type corresponding to the type of the peer device and/or a service type of the peer device. The frame format type includes a SparkLink radio frame type 1, a SparkLink radio frame type 2, a SparkLink radio frame type 3, or a SparkLink radio frame type 4.

**[0041]** In a possible implementation, that the communication apparatus is further configured to determine the type of the peer device and/or the service latency of the peer device includes: determining the type of the peer device, where the type of the peer device includes an audio device type or a non-audio device type; and determining the service latency of the peer device when the type of the peer device is the audio device type.

**[0042]** In a possible implementation, the frame format selection policy includes: when a service latency requirement of the peer device is less than first duration, selecting the SparkLink radio frame type 1 to perform broadcast access, and switching to the SparkLink radio frame type 2 through physical layer parameter negotiation after a connected state is entered; or when the service latency requirement of the peer device is less than the first duration, and a service anti-interference capability requirement is greater than a set threshold, selecting the SparkLink radio

frame type 1 to perform broadcast access, and switching to the SparkLink radio frame type 2 or the SparkLink radio frame type 3 through physical layer parameter negotiation after the connected state is entered; or when the type of the peer device is a device that supports only the SparkLink radio frame type 1 or a device whose maximum transmit power is greater than a first power threshold, selecting the SparkLink radio frame type 1 to perform broadcast access; or when the service type of the peer device is an internet of things (internet of things, IOT) ultra-long-distance coverage service, when a distance between the peer device and the communication apparatus is greater than a first threshold, selecting the SparkLink radio frame type 4 to perform broadcasting and connection; or when the distance between the peer device and the communication apparatus is less than or equal to the first threshold, switching to the SparkLink radio frame type 2 or the SparkLink radio frame type 3 through physical layer parameter negotiation.

**[0043]** In a possible implementation, a second ranging symbol in the plurality of ranging symbols is generated based on a second original code sequence in the original code sequence set, and the first original code sequence is the same as the second original code sequence.

**[0044]** In a possible implementation, a second ranging symbol in the plurality of ranging symbols is generated based on a second original code sequence in the original code sequence set, and the first original code sequence is different from the second original code sequence.

**[0045]** In a possible implementation, the at least one ranging subsequence includes a first ranging subsequence and a second ranging subsequence, the ranging subsequence includes N ranging symbols, an $i^{th}$ ranging symbol in the first ranging subsequence is the same as an $i^{th}$ ranging symbol in the second ranging subsequence, and $1 \leq i \leq N$.

**[0046]** In a possible implementation, the at least one ranging subsequence includes a first ranging subsequence and a second ranging subsequence, the ranging subsequence includes N ranging symbols, an $i^{th}$ ranging symbol in the first ranging subsequence is different from an $i^{th}$ ranging symbol in the second ranging subsequence, and $1 \leq i \leq N$.

**[0047]** In a possible implementation, the plurality of original code sequences are one-to-one mapped to a plurality of sequence identifiers, the first original code sequence in the original code sequence set is mapped to a first sequence identifier, the first sequence identifier is generated in the symmetric encryption manner, and the first original code sequence is obtained from the original code sequence set through mapping by using the first sequence identifier.

**[0048]** According to a fifth aspect, this application provides a communication apparatus. The apparatus includes a module configured to receive a transmission frame, and a module configured to perform CIR estimation by using a first original code sequence and a first ranging symbol in a plurality of ranging symbols. The transmission frame includes a ranging sequence field, the ranging sequence field includes at least one ranging subsequence, and the ranging subsequence

includes a plurality of ranging symbols. The first original code sequence is randomly obtained from an original code sequence set in a symmetric encryption manner, and the original code sequence set includes a plurality of original code sequences.

**[0049]** In a possible implementation, the communication apparatus is further configured to implement transmission of a Bluetooth signal or a Wi-Fi signal, and at least one of a SparkLink module, a Bluetooth module, and a Wi-Fi module shares at least one of an RF unit, a modem unit, a MAC unit, and a CPU.

**[0050]** In a possible implementation, the communication apparatus is further configured to implement transmission of the Bluetooth signal, but does not support transmission of the Wi-Fi signal, the SparkLink module and the Bluetooth module are located in a same subsystem of the communication apparatus, and the subsystem and a PMU are integrated into the communication apparatus.

**[0051]** In a possible implementation, the communication apparatus is further configured to implement transmission of the Bluetooth signal or the Wi-Fi signal, at least one of the Bluetooth module or the Wi-Fi module performs coexistence communication with the SparkLink module via different antennas, and a coexistence policy is channel avoidance.

**[0052]** In a possible implementation, the communication apparatus is further configured to: determine a type of a peer device and/or a service latency of the peer device, and determine, according to a link selection policy, a link corresponding to the peer device and/or a service to perform data transmission.

**[0053]** In a possible implementation, that the communication apparatus is further configured to determine the type of the peer device and/or the service latency of the peer device includes: determining the type of the peer device, where the type of the peer device includes an audio device type or a non-audio device type; and determining the service latency of the peer device when the type of the peer device is the audio device type.

**[0054]** In a possible implementation, the link selection policy includes: when the service latency is greater than a first value, performing data transmission after establishing an asynchronous unicast link or an asynchronous multicast link; or when the service latency is less than the first value and greater than a second value, establishing the asynchronous unicast link or the asynchronous multicast link, and performing data transmission after synchronization is implemented by adding a timestamp to a data packet; or when the service latency is less than the second value, first establishing the asynchronous unicast link, and then performing data transmission after establishing a synchronous unicast link or a synchronous multicast link.

**[0055]** In a possible implementation, when the communication apparatus is a non-audio device, the communication apparatus is further configured to perform data transmission over the

asynchronous unicast link or the asynchronous multicast link.

**[0056]** In a possible implementation, the communication apparatus is further configured to: determine a type of a peer device and/or a service latency of the peer device, and determine, according to a frame format selection policy, a frame format type corresponding to the type of the peer device and/or a service type of the peer device. The frame format type includes a SparkLink radio frame type 1, a SparkLink radio frame type 2, a SparkLink radio frame type 3, or a SparkLink radio frame type 4.

**[0057]** In a possible implementation, that the communication apparatus is further configured to determine the type of the peer device and/or the service latency of the peer device includes: determining the type of the peer device, where the type of the peer device includes an audio device type or a non-audio device type; and determining the service latency of the peer device when the type of the peer device is the audio device type.

**[0058]** In a possible implementation, the frame format selection policy includes: when a service latency requirement of the peer device is less than first duration, selecting the SparkLink radio frame type 1 to perform broadcast access, and switching to the SparkLink radio frame type 2 through physical layer parameter negotiation after a connected state is entered; or when the service latency requirement of the peer device is less than the first duration, and a service anti-interference capability requirement is greater than a set threshold, selecting the SparkLink radio frame type 1 to perform broadcast access, and switching to the SparkLink radio frame type 2 or the SparkLink radio frame type 3 through physical layer parameter negotiation after the connected state is entered; or when the type of the peer device is a device that supports only the SparkLink radio frame type 1 or a device whose maximum transmit power is greater than a first power threshold, selecting the SparkLink radio frame type 1 to perform broadcast access; or when the service type of the peer device is an IOT ultra-long-distance coverage service, when a distance between the peer device and the communication apparatus is greater than a first threshold, selecting the SparkLink radio frame type 4 to perform broadcasting and connection; or when the distance between the peer device and the communication apparatus is less than or equal to the first threshold, switching to the SparkLink radio frame type 2 or the SparkLink radio frame type 3 through physical layer parameter negotiation.

**[0059]** In a possible implementation, when the communication apparatus is a non-audio device, the communication apparatus is further configured to: select the SparkLink radio frame type 1 to perform broadcast access, and switch to the SparkLink radio frame type 2 through physical layer parameter negotiation for data transmission after entering the connected state.

**[0060]** According to a sixth aspect, this application provides a communication apparatus. The apparatus includes one or more processors; and a memory, configured to store one or more

computer programs or instructions. When the one or more computer programs or instructions are executed by the one or more processors, the one or more processors are caused to implement the method according to any one of the first aspect.

**[0061]** According to a seventh aspect, this application provides a communication apparatus, including a processor, configured to perform the method according to any one of the first aspect.

**[0062]** According to an eighth aspect, this application provides a communication apparatus. The apparatus includes one or more processors; and a memory, configured to store one or more computer programs or instructions. When the one or more computer programs or instructions are executed by the one or more processors, the one or more processors are caused to implement the method according to any one of the second aspect.

**[0063]** According to a ninth aspect, this application provides a communication apparatus, including a processor, configured to perform the method according to any one of the second aspect.

**[0064]** According to a tenth aspect, this application provides a communication apparatus. The apparatus includes a processing circuit and an interface circuit. The interface circuit is configured to: couple to a memory outside the communication apparatus, and provide a communication interface for the processing circuit to access the memory. The processing circuit is configured to execute program instructions in the memory, to implement the method according to any one of the first aspect and the second aspect.

**[0065]** During specific implementation, the communication apparatus may be a chip, an input circuit may be an input pin, an output circuit may be an output pin, and the processing circuit may be a transistor, a gate circuit, a trigger, various logic circuits, or the like. An input signal received by the input circuit may be received and input by, for example, but not limited to, a receiver, a signal output by the output circuit may be output to, for example, but not limited to, a transmitter and transmitted by the transmitter, and the input circuit and the output circuit may be a same circuit, where the circuit is used as the input circuit and the output circuit at different moments. Specific implementations of the processor and the various circuits are not limited in embodiments of this application.

**[0066]** In an implementation, the communication apparatus may be a wireless communication device, that is, a computer device supporting a wireless communication function. Specifically, the wireless communication device may be a terminal, for example, a smartphone, or may be a radio access network device, for example, a base station. A network chip may also be referred to as a system on chip (system on chip, SoC), or referred to as a SoC chip for short. A communication chip may include a baseband processing chip and a radio frequency processing chip. The baseband processing chip is also sometimes referred to as a modem (modem) or a baseband chip. The radio frequency processing chip is also sometimes referred to as a radio frequency transceiver

(transceiver) or a radio frequency chip. In a physical implementation, some or all of chips of the communication chip may be integrated into the SoC chip. For example, the baseband processing chip is integrated into the SoC chip, and the radio frequency processing chip is not integrated into the SoC chip. The interface circuit may be the radio frequency processing chip in the wireless communication device, and the processing circuit may be the baseband processing chip in the wireless communication device.

**[0067]** In another implementation, the communication apparatus may be a part of components in a wireless communication device, for example, an integrated circuit product like a network chip or a communication chip. The interface circuit may be an input/output interface, an interface circuit, an output circuit, an input circuit, a pin, a related circuit, or the like on the chip or a chip network. The processor may alternatively be embodied as a processing circuit or a logic circuit.

**[0068]** According to an eleventh aspect, this application provides a computer-readable storage medium. The computer-readable storage medium stores program code, and when the program code is executed by a processor, the method according to any one of the first aspect and the second aspect is implemented.

**[0069]** According to a twelfth aspect, this application provides a chip, including at least one processor. The at least one processor is configured to perform the method according to any one of the first aspect and the second aspect.

**[0070]** Optionally, the chip further includes a memory. The at least one processor is configured to execute code in the memory, and when the at least one processor executes the code, the chip is caused to implement the method according to any one of the first aspect and the second aspect.

**[0071]** Optionally, the chip may alternatively be an integrated circuit.

**[0072]** According to a thirteenth aspect, this application provides a computer program product including instructions. When the computer program product runs on a computer, the computer is caused to implement the method according to any one of the first aspect and the second aspect.

**[0073]** According to a fourteenth aspect, this application provides a communication system. The system includes a transmitter and a receiver. The transmitter includes the communication apparatus according to the fourth aspect, the sixth aspect, the seventh aspect, or the tenth aspect, and the receiver includes the communication apparatus according to the fifth aspect, the eighth aspect, the ninth aspect, or the tenth aspect.

## BRIEF DESCRIPTION OF DRAWINGS

**[0074]** FIG. 1 is a diagram of a format of a ranging sequence field according to an embodiment of this application;

**[0075]** FIG. 2 is a diagram of a format of a ranging subsequence according to an embodiment of this application;

**[0076]** FIG. 3 is a diagram of a process of generating a first ranging symbol according to an embodiment of this application;

**[0077]** FIG. 4 is a diagram of a format of a ranging sequence field according to an embodiment of this application;

**[0078]** FIG. 5 is a diagram of a format of another ranging sequence field according to an embodiment of this application;

**[0079]** FIG. 6 is a diagram of a format of still another ranging sequence field according to an embodiment of this application;

**[0080]** FIG. 7 is a diagram of a format of yet another ranging sequence field according to an embodiment of this application;

**[0081]** FIG. 8 is a diagram of a structure of a communication system according to an embodiment of this application;

**[0082]** FIG. 9 is a schematic flowchart of a communication method according to an embodiment of this application;

**[0083]** FIG. 10 is a schematic flowchart of another communication method according to an embodiment of this application;

**[0084]** FIG. 11 is a diagram of a chip architecture according to an embodiment of this application;

**[0085]** FIG. 12 is a diagram of another chip architecture according to an embodiment of this application;

**[0086]** FIG. 13 is a diagram of still another chip architecture according to an embodiment of this application;

**[0087]** FIG. 14 is a diagram of yet another chip architecture according to an embodiment of this application;

**[0088]** FIG. 15 is a diagram of a chip module framework according to an embodiment of this application;

**[0089]** FIG. 16 is a diagram of another chip module framework according to an embodiment of this application;

**[0090]** FIG. 17 is a diagram of still another chip module framework according to an embodiment of this application;

**[0091]** FIG. 18 is a diagram of a framework of a software static policy according to an embodiment of this application;

**[0092]** FIG. 19 is a diagram of a framework of a hardware arbitration time division policy

according to an embodiment of this application;

**[0093]** FIG. 20 is a schematic flowchart of a type of link establishment according to an embodiment of this application;

**[0094]** FIG. 21 is a schematic flowchart of another type of link establishment according to an embodiment of this application;

**[0095]** FIG. 22 is a schematic flowchart of still another type of link establishment according to an embodiment of this application;

**[0096]** FIG. 23 is a schematic flowchart of yet another type of link establishment according to an embodiment of this application;

**[0097]** FIG. 24 is a schematic flowchart of still yet another type of link establishment according to an embodiment of this application;

**[0098]** FIG. 25 is a schematic flowchart of a further type of link establishment according to an embodiment of this application;

**[0099]** FIG. 26 shows four different radio frame types defined in a SparkLink protocol;

**[00100]** FIG. 27 is an application example of a frame format in a scenario according to an embodiment of this application;

**[00101]** FIG. 28 is an application example of a frame format in another scenario according to an embodiment of this application;

**[00102]** FIG. 29 is an application example of a frame format in still another scenario according to an embodiment of this application;

**[00103]** FIG. 30 is an application example of a frame format in yet another scenario according to an embodiment of this application;

**[00104]** FIG. 31 is a diagram of a structure of an electronic device according to an embodiment of this application;

**[00105]** FIG. 32 is a block diagram of a communication apparatus according to an embodiment of this application; and

**[00106]** FIG. 33 is a diagram of a structure of a communication apparatus according to an embodiment of this application.

## DESCRIPTION OF EMBODIMENTS

**[00107]** To make objectives, technical solutions, and advantages of this application clearer, the following clearly and describes the technical solutions in this application with reference to accompanying drawings in this application. It is clear that the described embodiments are merely some rather than all of embodiments of this application. All other embodiments obtained by a

person of ordinary skill in the art based on embodiments of this application without creative efforts shall fall within the protection scope of this application.

**[00108]** In the specification, embodiments, claims, and accompanying drawings of this application, the terms "first", "second", and the like are merely intended for distinguishing and description, and shall not be understood as indicating or implying relative importance, or indicating or implying a sequence. In addition, the terms "include", "have", and any variant thereof are intended to cover non-exclusive inclusion, for example, include a series of steps or units. A method, system, product, or device is not necessarily limited to those steps or units expressly listed, but may include other steps or units not expressly listed or inherent to such a process, method, product, or device.

**[00109]** It should be understood that in this application, "at least one (item)" refers to one or more and "a plurality of" refers to two or more. The term "and/or" is used for describing an association relationship between associated objects, and represents that three relationships may exist. For example, "A and/or B" may represent the following three cases: Only A exists, only B exists, and both A and B exist, where A and B may be singular or plural. The character "/" generally indicates an "or" relationship between the associated objects. The expression "at least one of the following items (pieces)" or a similar expression means any combination of these items, including a single item (piece) or any combination of a plurality of items (pieces). For example, at least one of a, b, or c may indicate a, b, c, a and b, a and c, b and c, or a, b, and c, where a, b, and c may be singular or plural.

**[00110]** In a ranging communication technology, a narrow impulse (impulse) signal like a nanosecond (nanosecond, ns)-level impulse signal or a picosecond (picosecond, ps)-level impulse signal is used to transmit data, for example, a narrow impulse signal of a nanosecond level is used to transmit data in an impulse radio ultra-wideband (Impulse Radio UWB, IR-UWB). The narrow impulse signal has high resolution, and therefore has a strong multipath resolution capability, and can ensure centimeter-level ranging accuracy in complex multipath environments (for example, an indoor environment).

**[00111]** In a current ranging communication technology, ranging between devices is implemented by sending and receiving a ranging part in a transmission frame. Embodiments of this application provide a format of a transmission frame, to provide a security protection capability for ranging information while implementing a high-precision ranging capability, thereby implementing effective and secure high-precision ranging. The format of the transmission frame can be applied to various application technologies and devices of ranging communication systems, for example, technologies and devices including but not limited to communication, positioning, and sensing. The transmission frame may be sent based on an impulse signal, and is applicable to

the current ranging communication technology.

**[00112]** The transmission frame provided in embodiments of this application includes a ranging sequence field. The ranging sequence field includes at least one ranging subsequence, the ranging subsequence includes a plurality of ranging symbols, and the ranging sequence field is used to perform CIR estimation.

**[00113]** For example, when there are a plurality of ranging subsequences, there may be a gap between two adjacent ranging subsequences. There is no signal in the gap, a length of the gap is greater than or equal to 0, and the length of the gap may be customized. A specific value of the gap is not limited in embodiments of this application. That is, a ranging sequence field in one transmission frame is divided into a plurality of ranging subsequences, and the plurality of ranging subsequences are sent and received based on a specific gap.

**[00114]** FIG. 1 is a diagram of a format of a ranging sequence field according to an embodiment of this application. FIG. 1 shows M ranging subsequences (a ranging subsequence 0 to a ranging subsequence M−1) included in the ranging sequence field, and there is a gap between two adjacent ranging subsequences. Each ranging subsequence includes $N_s$ ranging symbols (a ranging symbol 0 to a ranging symbol $N_s-1$), and M and $N_s$ are integers greater than 1. FIG. 1 shows only ranging symbols included in the ranging subsequence 1. For the other ranging subsequences, refer to the ranging subsequence 1. Details are not described herein again in embodiments of this application.

**[00115]** Each ranging symbol may include one code sequence P(0) to P($N_p$–1), a length of the ranging sequence field is determined by a quantity of ranging symbols and a length $N_p$ of each ranging symbol, and the quantity of ranging symbols and the length of each ranging symbol may be customized. Specific values of the quantity of ranging symbols and the length of each ranging symbol are not limited in embodiments of this application.

**[00116]** FIG. 2 is a diagram of a format of a ranging subsequence according to an embodiment of this application. FIG. 2 shows $N_s$ ranging symbols S(0) to S($N_s$–1) in one ranging subsequence. The ranging symbol S(i) includes a code sequence $P_i$=P(i, 0) to P(i, $N_p$–1), where $0 \le i \le N_s-1$.

**[00117]** A first ranging symbol in a plurality of ranging symbols is generated based on a first original code sequence in an original code sequence set, the original code sequence set includes a plurality of original code sequences, and the first original code sequence is randomly obtained from the original code sequence set in a symmetric encryption manner.

**[00118]** Symmetric encryption is also referred to as a transmit (transmit, TX)-receive (receive, RX) symmetric key. A transmitter and a receiver randomly obtain first original code sequences by using a same key, that is, a first original code sequence obtained by the transmitter is consistent with a first original code sequence obtained by the receiver. Only when the transmitter and the receiver use the same key to obtain the consistent first original code sequences, a CIR correlation

accumulator can be correctly controlled to perform effective CIR calculation, so as to correctly measure a distance and/or other positioning information.

**[00119]** The first ranging symbol is any one of the plurality of ranging symbols. For a manner of generating each ranging symbol in a ranging sequence field, refer to that of the first ranging symbol. Details are not described herein again in embodiments of this application.

**[00120]** For example, the first ranging symbol may be generated by performing time domain spreading on the first original code sequence, or may be generated by performing time domain spreading on the first original code sequence followed by sequence spreading. This is not limited in embodiments of this application.

**[00121]** The time domain spreading manner may include: performing a Kronecker product (Kronecker product) of the first original code sequence and a first time domain spreading code sequence, where a Kronecker product is performed on each value in the first original code sequence and a corresponding value in the first time domain spreading code sequence. The first time domain spreading code sequence may be randomly generated, or may be selected from a plurality of pre-stored time domain spreading code sequences. For example, a codebook (codebook) including the plurality of time domain spreading code sequences is pre-generated, and the first time domain spreading code sequence is directly selected from the codebook. The time domain spreading manner, and a form, a length, an obtaining manner, and the like of the first time domain spreading code sequence may all be customized. This is not limited in embodiments of this application.

**[00122]** For another example, the first ranging symbol may alternatively be generated by performing time domain spreading and scrambling on the first original code sequence, or may be generated by performing scrambling after successively performing time domain spreading and sequence spreading on the first original code sequence. In this embodiment of this application, a code sequence obtained by performing time domain spreading on the first original code sequence or sequentially performing time domain spreading and sequence spreading on the first original code sequence is referred to as a first initial ranging symbol. There are a plurality of ranging symbols in the ranging subsequence, and therefore, there are also a plurality of initial ranging symbols. The scrambling manner includes scrambling the plurality of initial ranging symbols by using a first scrambling code sequence, to obtain the plurality of ranging symbols.

**[00123]** For one ranging subsequence, a length of the first scrambling code sequence is the same as a quantity of ranging symbols, in other words, the length of the first scrambling code sequence is the same as a quantity of initial ranging symbols. Values in the first scrambling code sequence one-to-one correspond to the plurality of initial ranging symbols, and each initial ranging symbol is multiplied by a corresponding value in the first scrambling code sequence, to obtain the plurality

of ranging symbols. FIG. 1 or FIG. 2 is used as an example. If the quantity of ranging symbols is $N_s$, the length of the first scrambling code sequence is $N_s$, and $N_s$ values of the first scrambling code sequence one-to-one correspond to the $N_s$ ranging symbols.

**[00124]** The first scrambling code sequence may be randomly generated, or may be selected from a plurality of pre-stored scrambling code sequences. For example, a codebook including the plurality of scrambling code sequences is pre-generated, and the transmitter directly selects the first scrambling code sequence from the codebook. A form, an obtaining manner, and the like of the first scrambling code sequence may all be customized. This is not limited in embodiments of this application.

**[00125]** FIG. 3 is a diagram of a process of generating a first ranging symbol according to an embodiment of this application. For a process of generating a first initial ranging symbol, also refer to related descriptions in FIG. 3. As shown in FIG. 3, first, time domain spreading is performed on a first original code sequence $C_i$ by using a first time domain spreading code sequence $d_L^i$ to obtain a first channel code sequence Pi=P(i, 0) to P(i, Np−1), where L in $d_L^i$ represents a length of the first time domain spreading code sequence. A formula for performing time domain spreading by using a Kronecker product is as follows:

$$[P(i, 0)\ P(i, 1)\ ...\ P(i, Np-1)]=C_i \otimes d_L^i$$

**[00126]** Herein, ⊗ represents the Kronecker product. It is assumed that a length of $C_i$ is $N_c$. In this case, a length of the obtained first channel code sequence is $N_p=N_c \times L$.

**[00127]** After the first channel code sequence $P_i$ is obtained by performing time domain spreading on $C_i$ by using $d_L^i$, in an example, the first channel code sequence $P_i$ may be directly used as the first ranging symbol, that is, S(i)=Pi=[P(i, 0) P(i, 1) ... P(i, $N_p$−1)]. In another example, as shown in FIG. 3, sequence spreading may be performed on the first channel code sequence to obtain the first ranging symbol. The sequence spreading manner may include: adding a prefix sequence and/or a suffix sequence to the first channel code sequence. The sequence spreading manner is not limited in embodiments of this application.

**[00128]** In this embodiment of this application, each original code sequence in an original code sequence set may be a sequence having a good correlation property, for example, may be a binary code sequence or a ternary code sequence. A form of the original code sequence is not limited in embodiments of this application. The sequence having a good correlation property is not easily interfered by an external signal, so that when CIR estimation is performed based on a ranging sequence field, high precision of the CIR estimation can be maintained, thereby maintaining high-precision ranging.

**[00129]** In addition, a plurality of original code sequences in the original code sequence set are

one-to-one mapped to a plurality of sequence identifiers. A transmitter first generates a first sequence identifier in a symmetric encryption manner, and the first sequence identifier generated by the transmitter through encryption is consistent with a first sequence identifier generated by a receiver through encryption. Then, an original code sequence, in the original sequence set, to which the first sequence identifier is mapped is obtained as the first original code sequence.

**[00130]** For example, the sequence identifier may be an index. The transmitter may generate, in the symmetric encryption manner, a random number within an index range included in the original code sequence set, and then map the random number to an index in the original code sequence set, to obtain an original code sequence to which the index is mapped as the first original code sequence.

**[00131]** For example, refer to Table 1 and Table 2. Table 1 and Table 2 each show one original code sequence set. Original code sequences in the original code sequence set are sequences having good correlation properties. Table 1 and Table 2 are described by using sequence identifiers as indexes.

Table 1

| Index | Original code sequence |
|---|---|
| 0 | −1, −1, −1, −1, −1, 1, 1, 1, 1, 1, 1, −1, 1, −1, 1, −1, 1, 1, −1, −1, 1, 1, −1, 1, 1, 1, −1, 1, 1, −1, 1, −1, −1, 1, −1, −1, 1, 1, 1, −1, −1, −1, 1, −1, 1, 1, 1, 1, −1, −1, 1, −1, 1, −1, −1, −1, 1, 1, −1, −1, −1, −1, 1 |
| 1 | −1, −1, −1, −1, −1, 1, −1, −1, −1, −1, 1, 1, −1, −1, −1, 1, −1, 1, −1, −1, 1, 1, 1, 1, −1, 1, −1, −1, −1, 1, 1, 1, −1, −1, 1, −1, −1, 1, −1, 1, −1, 1, 1, 1, −1, 1, 1, −1, −1, 1, 1, −1, 1, −1, 1, −1, 1, 1, 1, 1, 1, 1 |
| 2 | −1, −1, −1, −1, −1, 1, 1, 1, −1, −1, −1, −1, 1, −1, −1, 1, −1, −1, −1, 1, 1, −1, 1, 1, −1, −1, 1, −1, 1, 1, −1, 1, −1, 1, 1, 1, −1, 1, 1, 1, 1, −1, −1, 1, 1, −1, −1, −1, 1, −1, 1, −1, 1, −1, −1, 1, 1, 1, 1, 1, 1, −1, 1 |
| ⋮ | ⋮ |
| 15 | −1, −1, −1, −1, −1, 1, −1, 1, 1, 1, 1, 1, 1, −1, −1, 1, −1, 1, −1, 1, −1, −1, −1, 1, 1, −1, −1, 1, 1, 1, 1, −1, 1, 1, 1, −1, 1, −1, 1, 1, −1, 1, −1, −1, 1, 1, −1, −1, 1, 1, −1, −1, −1, 1, −1, 1, −1, −1, −1, −1, 1, 1, 1 |
| ⋮ | ⋮ |
| ⋮ | ⋮ |

Table 2

| Index | Original code sequence |
|---|---|
| 0 | −1, −1, −1, −1, −1, 1, −1, 1,1, 1, 1, 1, 1, −1, −1, 1, −1, 1, −1, 1, −1, −1, −1, 1, 1, −1, −1, 1, 1, 1, 1, −1, 1, 1, 1, −1, 1, −1, 1, 1, −1, 1, −1, −1, 1, 1, −1, 1, 1, −1, −1, −1, 1, −1, −1, 1, −1, −1, −1, −1, 1, 1, 1 |
| 1 | −1, −1, −1, −1, −1, 1, 1, 1, −1, −1, −1, −1, 1, −1, −1, 1, −1, −1, −1, 1, 1, −1, 1, 1, −1, −1, 1, −1, 1, 1, −1, 1, −1, 1, 1, 1, −1, 1, 1, 1, 1, −1, −1, 1, 1, −1, −1, −1, 1, −1, 1, −1, 1, −1, −1, 1, 1, 1, 1, 1, 1, −1, 1 |
| 2 | −1, −1, −1, −1, −1, 1, 1, 1, 1, 1, 1, −1, 1, −1, 1, −1, 1, 1, −1, −1, 1, 1, −1, 1, 1, 1, −1, 1, 1, −1, 1, −1, −1, 1, −1, −1, 1, 1, 1, −1, −1, −1, 1, −1, 1, 1, 1, 1, −1, −1, 1, −1, 1, −1, −1, −1, 1, 1, −1, −1, −1, −1, 1 |
| ⋮ | ⋮ |
| 16 | −1, −1, −1, −1, −1, 1, −1, −1, −1, −1, 1, 1, −1, −1, −1, 1, −1, 1, −1, −1, 1, 1, 1, 1, −1, 1, −1, −1, −1, 1, 1, 1, −1, −1, 1, −1, −1, 1, −1, 1, 1, 1, −1, 1, 1, −1, −1, 1, 1, −1, 1, −1, 1, −1, 1, 1, 1, 1, 1, 1 |
| ⋮ | ⋮ |
| ⋮ | ⋮ |

**[00132]** It should be noted that Table 1 and Table 2 are merely examples for description, and a quantity, a length, and a specific form of the original code sequence in the original code sequence set are not limited in embodiments of this application.

**[00133]** In this embodiment of this application, for different ranging symbols in a ranging subsequence, there are a plurality of original code sequence selection manners. The following describes the plurality of original code sequence selection manners.

**[00134]** Original code sequence selection manner 1:

**[00135]** A second ranging symbol in a plurality of ranging symbols in a single ranging subsequence is generated based on a second original code sequence in the original code sequence set, and the first original code sequence is the same as the second original code sequence. The second ranging symbol is also any one of the plurality of ranging symbols. For a manner of generating the second ranging symbol, refer to that of the first ranging symbol. Details are not described herein again in embodiments of this application. In this example, the first ranging symbol and the second ranging symbol are generated based on a same original code sequence. For example, any two ranging symbols in the single ranging subsequence are generated based on a same original code sequence in the original code sequence set. In a process of generating the

ranging symbols based on the original code sequence, if there is no scrambling process, the first ranging symbol is the same as the second ranging symbol.

**[00136]** Original code sequence selection manner 2:

**[00137]** A second ranging symbol in a plurality of ranging symbols in a single ranging subsequence is generated based on a second original code sequence in the original code sequence set, and the first original code sequence is different from the second original code sequence. In this example, the first ranging symbol and the second ranging symbol are generated based on different original code sequences. For example, any two ranging symbols in the single ranging subsequence are generated based on different original code sequences in the original code sequence set. In a process of generating the ranging symbols based on the original code sequences, if there is no scrambling process, the first ranging symbol is different from the second ranging symbol.

**[00138]** When there are a plurality of ranging subsequences, in this embodiment of this application, for different ranging subsequences, there are a plurality of original code sequence selection manners. The following describes the plurality of original code sequence selection manners.

**[00139]** Original code sequence selection manner 3:

**[00140]** At least one ranging subsequence includes a first ranging subsequence and a second ranging subsequence, the ranging subsequence includes N ranging symbols, an $i^{th}$ ranging symbol in the first ranging subsequence is the same as an $i^{th}$ ranging symbol in the second ranging subsequence, and $1 \leq i \leq N$. In this example, the $i^{th}$ ranging symbol in the first ranging subsequence and the $i^{th}$ ranging symbol in the second ranging subsequence are generated based on a same original code sequence.

**[00141]** Original code sequence selection manner 4:

**[00142]** At least one ranging subsequence includes a first ranging subsequence and a second ranging subsequence, the ranging subsequence includes N ranging symbols, an $i^{th}$ ranging symbol in the first ranging subsequence is different from an $i^{th}$ ranging symbol in the second ranging subsequence, and $1 \leq i \leq N$. In this example, the $i^{th}$ ranging symbol in the first ranging subsequence and the $i^{th}$ ranging symbol in the second ranging subsequence are generated based on different original code sequences.

**[00143]** It may be understood that, in a process of generating a plurality of same ranging symbols, only one original code sequence needs to be obtained in the symmetric encryption manner, and a plurality of repeated ranging symbols are separately generated by using the original code sequence.

**[00144]** The foregoing original code sequence selection manners for different ranging symbols in the ranging subsequence may be combined with the original code sequence selection manners

for different ranging subsequences. For example, FIG. 4 to FIG. 7 are respectively diagrams of formats of ranging sequence fields according to embodiments of this application. FIG. 4 to FIG. 7 each show M ranging subsequences (a ranging subsequence 0 to a ranging subsequence M−1) included in the ranging sequence field, and there is a gap between two adjacent ranging subsequences. Each ranging subsequence includes $N_s$ ranging symbols. The following uses an example in which there is no scrambling process in the process of generating the ranging symbols based on the original code sequences for description.

**[00145]** A ranging sequence 1 shown in FIG. 4 is a combination of the original code sequence selection manner 1 and the original code sequence selection manner 4.

**[00146]** As shown in FIG. 4, $N_s$ ranging symbols in a single ranging subsequence are the same, that is, the $N_s$ ranging symbols in the single ranging subsequence are generated based on a same original code sequence. In addition, $i^{th}$ ranging symbols in the M ranging subsequences are different, that is, the $i^{th}$ ranging symbols in the M ranging subsequences are generated based on different original code sequences. Specifically, the $N_s$ ranging symbols in the ranging subsequence 0 are all $S^0$, that is, the ranging symbol $S^0$ is repeatedly sent in the ranging subsequence 0; the $N_s$ ranging symbols in the ranging subsequence 1 are all $S^1$, that is, the ranging symbol $S^1$ is repeatedly sent in the ranging subsequence 1; ...; and the $N_s$ ranging symbols in the ranging subsequence M−1 are all $S^{M-1}$, that is, the ranging symbol $S^{M-1}$ is repeatedly sent in the ranging subsequence M−1.

**[00147]** For example, when generating the M ranging subsequences in FIG. 4, the transmitter generates M random sequence identifiers (for example, M random numbers) in the symmetric encryption manner. Then, each random sequence identifier is mapped to an index in the original code sequence set, to generate $N_s$ repeated ranging symbols in one ranging subsequence based on an original code sequence to which each random sequence identifier is mapped.

**[00148]** For example, the sequence identifier is an index. It is assumed that the original code sequence set includes 64 original code sequences, and indexes corresponding to the 64 original code sequences are respectively 0 to 63. The transmitter generates M 6-bit (bit) random numbers (that is, generates random numbers in a range of 0 to 63) in the symmetric encryption manner: $r_0$, $r_1$, ..., and $r_{M-1}$. The transmitter maps $r_i$ to an index $r_i$ in the original code sequence set, to generate the ranging symbol $S^i$ based on an original code sequence to which $r_i$ is mapped, where the ranging subsequence i includes $N_s$ repeated ranging symbols $S^i$, and $0 \le i \le M-1$.

**[00149]** Specifically, the transmitter maps $r_0$ to an index $r_0$ in the original code sequence set, to generate the ranging symbol $S^0$ based on an original code sequence to which $r_0$ is mapped, where the ranging subsequence 0 includes $N_s$ repeated ranging symbols $S^0$. By analogy, the ranging symbol $S^1$ is generated based on an original code sequence to which $r_1$ is mapped, where the ranging subsequence 1 includes $N_s$ repeated ranging symbols $S^1$; ...; and the ranging symbol $S^{M-1}$

is generated based on an original code sequence to which $r_{M-1}$ is mapped, where the ranging subsequence M−1 includes $N_s$ repeated ranging symbols $S^{M-1}$.

**[00150]** A ranging sequence 2 shown in FIG. 5 is a combination of the original code sequence selection manner 2 and the original code sequence selection manner 3.

**[00151]** As shown in FIG. 5, $N_s$ ranging symbols in a single ranging subsequence are different from each other, that is, any two ranging symbols in the single ranging subsequence are generated based on different original code sequences. In addition, $i^{th}$ ranging symbols in the M ranging subsequences are the same, that is, the $i^{th}$ ranging symbols in the M ranging subsequences are generated based on a same original code sequence, and the M ranging subsequences are repeated. Specifically, the $N_s$ ranging symbols in the ranging subsequence 0 are respectively S(0), S(1), ..., and S($N_s$−1); the $N_s$ ranging symbols in the ranging subsequence 1 are also respectively S(0), S(1), ..., and S($N_s$−1); and the $N_s$ ranging symbols in the ranging subsequence M−1 are also respectively S(0), S(1), ..., and S($N_s$−1). That is, S(0), S(1), ..., and S($N_s$−1) are sequentially sent in the ranging subsequence 0, and content that is the same as that of the ranging subsequence 0 is repeatedly sent in the subsequent ranging subsequences.

**[00152]** For example, when generating the M ranging subsequences in FIG. 5, the transmitter generates $N_s$ random sequence identifiers (for example, $N_s$ random numbers) in the symmetric encryption manner. Then, each random sequence identifier is mapped to an index in the original code sequence set, to generate a ranging symbol based on an original code sequence to which each random sequence identifier is mapped.

**[00153]** For example, the sequence identifier is an index. It is still assumed that the original code sequence set includes 64 original code sequences, and indexes corresponding to the 64 original code sequences are respectively 0 to 63. The transmitter generates $N_s$ 6-bit random numbers (that is, generates random numbers in a range of 0 to 63) in the symmetric encryption manner: $r_0$, $r_1$, ..., and $r_{Ns-1}$. The transmitter maps $r_i$ to an index $r_i$ in the original code sequence set, to generate the ranging symbol S(i) based on an original code sequence to which $r_i$ is mapped, where $0 \le i \le N_s - 1$.

**[00154]** Specifically, the transmitter maps r0 to an index $r_0$ in the original code sequence set, to generate the ranging symbol S(0) based on an original code sequence to which $r_0$ is mapped, and generate the ranging symbol S(1), ..., and S($N_s$−1) by analogy. Each ranging subsequence is formed by sequentially concatenating S(0), S(1), ..., and S($N_s$−1).

**[00155]** A ranging sequence 3 shown in FIG. 6 is a combination of the original code sequence selection manner 2 and the original code sequence selection manner 4.

**[00156]** As shown in FIG. 6, $N_s$ ranging symbols in a single ranging subsequence are different from each other, that is, any two ranging symbols in the single ranging subsequence are generated

based on different original code sequences. In addition, $i^{th}$ ranging symbols in the M ranging subsequences are different, that is, the $i^{th}$ ranging symbols in the M ranging subsequences are generated based on different original code sequences. Specifically, the $N_s$ ranging symbols in the ranging subsequence 0 are respectively $S^0(0)$, $S^0(1)$, ..., and $S^0(N_s-1)$; the $N_s$ ranging symbols in the ranging subsequence 1 are respectively $S^1(0)$, $S^1(1)$, ..., and $S^1(N_s-1)$; ...; and the $N_s$ ranging symbols in the ranging subsequence M−1 are respectively $S^{M-1}(0)$, $S^{M-1}(1)$, ..., and $S^{M-1}(N_s-1)$. That is, $S^0(0)$, $S^0(1)$, ..., and $S^0(N_s-1)$ are sequentially sent in the ranging subsequence 0, $S^1(0)$, $S^1(1)$, ..., and $S^1(N_s-1)$ are sequentially sent in the ranging subsequence 1, ..., and $S^{M-1}(0)$, $S^{M-1}(1)$, ..., and $S^{M-1}(N_s-1)$ are sequentially sent in the ranging subsequence M−1.

**[00157]** For example, when generating the M ranging subsequences in FIG. 6, the transmitter generates $M\times N_s$ random sequence identifiers (for example, $M\times N_s$ random numbers) in the symmetric encryption manner. Then, each random sequence identifier is mapped to an index in the original code sequence set, to generate a ranging symbol based on an original code sequence to which each random sequence identifier is mapped.

**[00158]** For example, the sequence identifier is an index. It is still assumed that the original code sequence set includes 64 original code sequences, and indexes corresponding to the 64 original code sequences are respectively 0 to 63. The transmitter generates $M\times N_s$ 6-bit random numbers (that is, generates random numbers in a range of 0 to 63) in the symmetric encryption manner.

$$\begin{bmatrix} r(0,0) & r(0,1) & \cdots & r(0,\ N_s-1) \\ r(1,0) & r(1,1) & \cdots & r(1,\ N_s-1) \\ \vdots & \vdots & \ddots & \vdots \\ r(M-1,0) & r(M-1,1) & \cdots & r(M-1,\ N_s-1) \end{bmatrix}$$

**[00159]** The transmitter maps r(i, j) to an index r(i, j) in the original code sequence set, to generate the ranging symbol $S^i(j)$ based on an original code sequence to which r(i, j) is mapped. The ranging subsequence i is formed by sequentially concatenating $S^i(0)$, $S^i(1)$, ..., and $S^i(N_s-1)$.

**[00160]** Specifically, the transmitter maps r(0, 0) to an index r(0, 0) in the original code sequence set, to generate the ranging symbol $S^0(0)$ based on an original code sequence to which r(0, 0) is mapped, and generate the ranging symbols $S^0(1)$, ..., and $S^0(N_s-1)$ by analogy. The ranging subsequence 0 is formed by sequentially concatenating $S^0(1)$, ..., and $S^0(N_s-1)$. The ranging symbols $S^1(0)$, $S^1(1)$, ..., and $S^1(N_s-1)$ are generated by analogy, and the ranging subsequence 1 is formed by sequentially concatenating $S^1(0)$, $S^1(1)$, ..., and $S^1(N_s-1)$; ...; and the ranging symbols $S^{M-1}(0)$, $S^{M-1}(1)$, ..., and $S^{M-1}(N_s-1)$ are generated, and the ranging subsequence M−1 is formed by sequentially concatenating $S^{M-1}(0)$, $S^{M-1}(1)$, ..., and $S^{M-1}(N_s-1)$.

**[00161]** A ranging sequence 4 shown in FIG. 7 is a combination of the original code sequence

selection manner 1 and the original code sequence selection manner 3.

**[00162]** As shown in FIG. 7, $N_s$ ranging symbols in a single ranging subsequence are the same, that is, the $N_s$ ranging symbols in the single ranging subsequence are generated based on a same original code sequence. In addition, $i^{th}$ ranging symbols in the M ranging subsequences are the same, that is, the $i^{th}$ ranging symbols in the M ranging subsequences are generated based on a same original code sequence, and the M ranging subsequences are repeated. Specifically, the $N_s$ ranging symbols in the ranging subsequence 0 to the ranging subsequence M−1 are all S, that is, the ranging symbol S is repeatedly sent in the ranging subsequence 0, and content that is the same as that of the ranging subsequence 0 is repeatedly sent in the subsequent ranging subsequences.

**[00163]** For example, when generating the M ranging subsequences in FIG. 7, the transmitter generates one random sequence identifier (for example, one random number) in the symmetric encryption manner. Then, the random sequence identifier is mapped to an index in the original code sequence set, to generate a ranging symbol based on an original code sequence to which the random sequence identifier is mapped.

**[00164]** The original code sequence set shown in the foregoing embodiment is merely an example for description, and does not limit an original code sequence set. The quantity of original code sequences included in the original code sequence set may be adjusted based on an actual application. Correspondingly, a range to which a random number generated in the symmetric encryption manner belongs is also adjusted based on an actual application.

**[00165]** For example, the transmission frame provided in embodiments of this application may further include a synchronization (synchronization, SYNC) field. The SYNC field may include at least one repeated preamble symbol, and the preamble symbol is used for time-frequency synchronization.

**[00166]** The transmission frame may further include a start-of-frame delimiter (start-of-frame delimiter, SFD) field after the SYNC field, and the SFD field is used to determine a start position of a subsequent field.

**[00167]** The transmission frame may further include a physical layer header (physical layer header, PHR) field and a payload (Payload) field. The PHR field includes rate information, at least one piece of length information, and a check code. The rate information indicates a rate of the payload field. The at least one piece of length information includes length information indicating a length of the payload field. The check code is used to check PHR information data. The payload field is used to carry data.

**[00168]** The transmission frame may further include a security sequence field, and the security sequence field is used to perform security verification. For example, the security sequence field may include one code sequence, and the code sequence in the security sequence field may be a

random code sequence or may be generated based on the random code sequence.

**[00169]** In conclusion, according to the transmission frame provided in embodiments of this application, the transmission frame includes the ranging sequence field, the ranging sequence field includes the at least one ranging subsequence, the ranging subsequence includes the plurality of ranging symbols, and the ranging sequence field is used to perform CIR estimation. The first ranging symbol in the plurality of ranging symbols is generated based on the first original code sequence in the original code sequence set, the original code sequence set includes the plurality of original code sequences, and the first original code sequence is randomly obtained from the original code sequence set in the symmetric encryption manner. The original code sequence may be configured as a code sequence having a good autocorrelation property. In this way, the transmitter sends the ranging sequence field having a good autocorrelation property, and the receiver can obtain a high-quality channel estimate via a correlator to perform correlation calculation for ranging. This ensures stability of high-precision ranging performance. In addition, the original code sequence is randomly selected from the preset original code sequence set in the symmetric encryption manner. This ensures security of the ranging sequence field, implements high-precision positioning, and provides security protection for the ranging information.

**[00170]** Embodiments of this application provide a communication method, to flexibly adapt to different high-precision positioning and communication application scenarios and devices. The method may be applied to a communication system, and the communication system includes a transmitter and a receiver. The transmitter and the receiver each may include only an ultra-wideband system, and the transmitter and the receiver communicate with each other through an ultra-wideband technology. In this case, the method is applicable to the foregoing transmission frame that supports an ultra-wideband standalone operation mode. Alternatively, the transmitter and the receiver each may include an ultra-wideband system and a narrowband system, and the transmitter and the receiver may communicate with each other through an ultra-wideband technology or a narrowband technology. In this case, the method is applicable to the foregoing transmission frame that supports a narrowband-assisted ultra-wideband operation mode. The narrowband system uses a carrier signal with a narrow bandwidth to transmit data, and has advantages such as low operating power consumption and low operating costs. For example, the narrowband system may include a Wi-Fi system, a Bluetooth (Bluetooth, BT) system, and a ZigBee (ZigBee) system.

**[00171]** The communication system provided in embodiments of this application is applicable to a SparkLink system. The transmitter may be a grant (grant, G)-node in the SparkLink system, and the receiver may be a terminal (terminal, T)-node in the SparkLink system. Alternatively, the transmitter may be a T-node in the SparkLink system, and the receiver may be a G-node in the

SparkLink system. This is not limited in embodiments of this application.

**[00172]** The communication system may have a plurality of possible application scenarios. A transmitter mentioned in the following embodiments may be an initiating station in ranging communication, and a receiver is a responding station; or the transmitter is a responding station, and the receiver is an initiating station. For example, the transmitter may be a positioning device (for example, a terminal device or an anchor) in a ranging positioning scenario, and the receiver is a mobile tag (tag); or the transmitter is a mobile tag, and the receiver is a positioning device (for example, a terminal device or an anchor). In other words, the communication method provided in this application is not only applicable to a scenario in which the initiating station (the positioning device) sends a signal to the responding station (or the mobile tag) and the responding station (or the mobile tag) performs signal synchronization, but also applicable to a scenario in which the responding station (or the mobile tag) sends a signal to the initiating station (the positioning device) and the initiating station (the positioning device) performs signal synchronization. This is not limited in embodiments of this application.

**[00173]** For another example, both the transmitter and the receiver may be terminal devices. The terminal device may be a terminal device having receiving and sending functions, or may be a chip or a chip system disposed in the terminal device. The terminal device may also be referred to as user equipment (user equipment, UE), an access terminal, a terminal unit, a terminal station, a mobile station, a remote station, a remote terminal, a mobile device, a wireless communication device, a terminal agent, a terminal apparatus, or the like.

**[00174]** The terminal device may include at least one of a mobile phone (mobile phone), a cellular phone (cellular phone), a cordless phone, a session initiation protocol (session initiation protocol, SIP) phone, a wireless local loop (wireless local loop, WLL) station, a personal digital assistant (personal digital assistant, PDA), a handheld device having a wireless communication function (for example, a mobile phone, a foldable electronic device, a handheld computer, a tablet computer, a stylus, or a wireless mouse), a computing device (for example, a desktop computer, a laptop computer, a notebook computer, a super mobile personal computer, or a netbook), another processing device connected to a wireless modem, a set-top box, a router, a camera, a smart screen, a smart stereo, a remote control, a smart television, a vehicle-mounted device, a vehicle-mounted screen, a vehicle-mounted stereo, a vehicle key, a wearable device (for example, a smart watch, a smart band, or a wireless headset), an electronic conference whiteboard, an unmanned aerial vehicle, a helicopter, an aircraft, a ship, a robot, a robot arm, a terminal device in a 5G system, a terminal device in an evolved public land mobile network (public land mobile network, PLMN), an augmented reality (augmented reality, AR) device, a virtual reality (virtual reality, VR) device, an artificial intelligence (artificial intelligence, AI) device, a smart home device (for example, a

refrigerator, a television, an air conditioner, a washing machine, an electric cooker, a desk lamp, or an electric meter), a smart city device, or the like. A specific technology and a specific device form that are used by the UE are not limited in embodiments of this application.

**[00175]** For example, FIG. 8 is a diagram of a structure of a communication system according to an embodiment of this application. In FIG. 8, an example in which a transmitter is an anchor and a receiver is a mobile tag is used for description. The communication system includes at least one transmitter and one receiver. It should be understood that in FIG. 8, only an example in which the communication system includes one transmitter and one receiver is used for description. The communication system is not limited to including more other devices. For example, the communication system may further include more receivers.

**[00176]** It should be noted that, in embodiments of this application, a device configured to send a transmission frame is referred to as a transmitter, and a device configured to receive a transmission frame is referred to as a receiver. The transmitter may alternatively receive a signal, and the receiver may alternatively send a signal. A function of the device is not limited in embodiments of this application.

**[00177]** FIG. 9 is a schematic flowchart of a communication method according to an embodiment of this application. The method is applied to a transmitter in a communication system. The method may include the following procedure.

**[00178]** 101: Send a transmission frame, where the transmission frame includes a ranging sequence field, the ranging sequence field includes at least one ranging subsequence, the ranging subsequence includes a plurality of ranging symbols, the ranging sequence field is used to perform CIR estimation, a first ranging symbol in the plurality of ranging symbols is generated based on a first original code sequence in an original code sequence set, the original code sequence set includes a plurality of original code sequences, and the first original code sequence is randomly obtained from the original code sequence set in a symmetric encryption manner.

**[00179]** For related descriptions of the ranging sequence field, refer to the foregoing embodiments. For other formats of the transmission frame, refer to the foregoing embodiments. Details are not described herein again in embodiments of this application.

**[00180]** The transmitter sends the transmission frame in a narrow time domain signal form (for example, a narrow pulse form).

**[00181]** For example, when the transmitter is a source device, the transmitter first generates the transmission frame before sending the transmission frame. When the transmitter is a switching device (for example, a switch), the received transmission frame is directly sent.

**[00182]** FIG. 10 is a schematic flowchart of another communication method according to an embodiment of this application. The method is applied to a receiver in a communication system.

The method may include the following procedures.

**[00183]** 201: Receive a transmission frame, where the transmission frame includes a ranging sequence field, the ranging sequence field includes at least one ranging subsequence, and the ranging subsequence includes a plurality of ranging symbols.

**[00184]** 202: Perform CIR estimation by using a first original code sequence and a first ranging symbol in the plurality of ranging symbols, where the first original code sequence is randomly obtained from an original code sequence set in a symmetric encryption manner, and the original code sequence set includes a plurality of original code sequences.

**[00185]** For a manner in which the receiver obtains the first original code sequence in the symmetric encryption manner, related descriptions of the ranging sequence field, and other formats of the transmission frame, refer to the foregoing embodiments. Details are not described herein again in embodiments of this application.

**[00186]** In conclusion, according to the communication method provided in embodiments of this application, the transmitter sends the transmission frame, where the transmission frame includes the ranging sequence field, the ranging sequence field includes the at least one ranging subsequence, the ranging subsequence includes the plurality of ranging symbols, and the receiver performs CIR estimation by using the first original code sequence and the first ranging symbol in the plurality of ranging symbols, where the first original code sequence is randomly obtained from the original code sequence set in the symmetric encryption manner, and the original code sequence set includes the plurality of original code sequences. The original code sequence may be configured as a code sequence having a good autocorrelation property. In this way, the transmitter sends the ranging sequence field having a good autocorrelation property, and the receiver can obtain a high-quality channel estimate via a correlator to perform correlation calculation for ranging. This ensures stability of high-precision ranging performance. In addition, the original code sequence is randomly selected from the preset original code sequence set in the symmetric encryption manner. This ensures security of the ranging sequence field, implements high-precision positioning, and provides security protection for ranging information.

**[00187]** A sequence of the methods provided in embodiments of this application may be properly adjusted, and a process may alternatively be correspondingly added or deleted, and/or combined, or partially combined based on a situation. Any variation method readily figured out by a person skilled in the art within the technical scope disclosed in this application shall fall within the protection scope of this application. This is not limited in embodiments of this application.

**[00188]** For example, the solutions provided in embodiments of this application are applicable to SparkLink positioning (SparkLink positioning, SLP) or Bluetooth communication. In embodiments of this application, Bluetooth and Bluetooth low energy (Bluetooth low energy, BLE)

may refer to each other. SparkLink (SparkLink or NearLink), SparkLink low energy (SparkLink low energy, SLE), SparkLink basic (SparkLink basic, SLB), or SparkLink positioning (SparkLink positioning, SLP) may also refer to each other. Therefore, the transmitter may be a G-node in the SparkLink system, and the receiver may be a T-node in the SparkLink system.

**[00189]** The following describes some embodiments of the solutions provided in this application.

Embodiment 1

**[00190]** BT and SparkLink each may be a networking mode in which a plurality of pico networks (Piconets) may be overlapped, and both may use a 2.4 GHz frequency band and use a frequency hopping technology. Due to their similarities, a part of modules may be reused. This can save chip costs, area, and power consumption. Chip resources may be highly reused, and a plurality of chips may be quickly iterated.

**[00191]** BLE and SLP may share a radio frequency architecture and channel. FIG. 11 is a diagram of a chip architecture according to an embodiment of this application. It can be learned from FIG. 11 that resource sharing of a CPU, an RF unit, an analog baseband (analog baseband, ABB) unit, or a modem may be implemented using a design, and a part of modules at a MAC layer may be reused. This saves a chip area and reduces chip costs and power consumption.

**[00192]** FIG. 12 is a diagram of another chip architecture according to an embodiment of this application. It can be learned from FIG. 12 that MAC units of BT, SLP, and Wi-Fi are separately implemented, and an RF unit and a modem unit are shared by all the modes.

**[00193]** FIG. 13 is a diagram of still another chip architecture according to an embodiment of this application. It can be learned from FIG. 13 that MAC units of BT, SLP, and Wi-Fi are separately implemented, and modems of BT, SLP, and Wi-Fi are also separately implemented, and an RF unit is shared by all the modes.

**[00194]** FIG. 14 is a diagram of yet another chip architecture according to an embodiment of this application. It can be learned from FIG. 14 that MAC units of BT, SLP, and Wi-Fi are separately implemented, a modem is shared by some modes such as BT and SLP, and modems of other modes such as Wi-Fi are independently implemented, and RF is shared by all the modes.

Embodiment 2

**[00195]** An SLP chip may use a 14/28/40 nm process, may be packaged by using a chip scale package (chip size package, CSP), a ball grid array (ball grid array, BGA) package, a quad flat no-lead (quad flat no-lead, QFN) package, or the like, and may use a built-in flash memory (flash memory) or an external flash memory. Based on an application scenario, at least one of subsystems such as a PMU, a clock management unit (clock management unit, CMU), an active optical network (active optical network, AON), a wireless local area network (wireless local area network,

WLAN) or BT, SLP, a global navigation satellite system (global navigation satellite system, GNSS), an application (application, APP), and an audio (audio) may be selected to be placed on one chip, to minimize an area, maximize a function, and improve performance and reliability.

**[00196]** Embodiments of this application provide a chip design manner. SLP and another subsystem are integrated into one chip. Subsystems of the chip may be trimmed and combined based on different products. Different subsystems are connected through a bus.

**[00197]** FIG. 15 is a diagram of a chip module framework according to an embodiment of this application. It can be learned from FIG. 15 that, for a product that requires a functional module like Wi-Fi or a GNSS and that needs to be connected to both a Bluetooth device and a SparkLink device, BT and SLP may be classified into different systems, and then combined with a Wi-Fi system, the GNSS system, an always-on system (Always-On System), a PMU, a CMU, and a flash memory on one chip. Different subsystems are connected through a bus.

**[00198]** FIG. 16 is a diagram of another chip module framework according to an embodiment of this application. It can be learned from FIG. 16 that, for an endpoint device that does not require a functional module like Wi-Fi or a GNSS but requires an audio function, to save an area and costs, BLE and SLP may be combined into one subsystem, and then combined with an APP system, an audio system, an always-on system, a PMU, a CMU, a flash, and the like on one chip. Different subsystems are connected through a bus.

**[00199]** FIG. 17 is a diagram of still another chip module framework according to an embodiment of this application. It can be learned from FIG. 17 that, for an endpoint device that neither requires a functional module like Wi-Fi or a GNSS nor requires an audio function, to save an area and costs, BLE and SLP may be combined into one subsystem, and then combined with an always-on system, a CMU, a PMU, a flash, and the like on one chip. Different subsystems are connected through a bus.

Embodiment 3

**[00200]** A Wi-Fi 2.4 GHz frequency band ranges from 2412 MHz to 2472 MHz, and a BT/BLE/SLP frequency band ranges from 2402 MHz to 2480 MHz. Therefore, interference may occur. SLP and BT/BLE in a same core may be scheduled to allocate service slots via software. SLP and BT/BLE/Wi-Fi in different cores are not scheduled in a unified manner.

**[00201]** An embodiment of this application provides an SLP/BT/BLE/Wi-Fi coexistence solution. Based on whether SLP and BT/BLE/Wi-Fi share an antenna, coexistence scenarios are classified into a cross-antenna coexistence (using different antennas) scenario and a shared-antenna coexistence (using a same antenna) scenario, and different coexistence policies are provided.

**[00202]** For cross-antenna coexistence, if SLP and BT/BLE coexist, it may be ensured that

transmit and receive frequencies of SLP and BT/BLE are different (that is, frequency division multiplexing is performed). Software may perform processing in terms of a frequency hopping sequence (that is, code division multiplexing), a service period, and an interval (that is, time division multiplexing). If SLP and Wi-Fi coexist and an isolation degree cannot meet a requirement, a channel of a WLAN needs to be avoided (that is, channel avoidance) to reduce impact of the WLAN. In addition, an aggregation scheduling mechanism may be added to aggregate and send Wi-Fi data packets in bursts (that is, aggregation scheduling) to reduce a probability of WLAN interference.

**[00203]** In a case of shared-antenna coexistence, a software static policy or a hardware arbitration time division (packet traffic arbitration, PTA) policy may be used. Advantages of the software static policy are a low hardware requirement, a minimal software modification, and no dynamic RF switching (for example, an operation like RF recovery). Advantages of the PTA policy are faster service state switching and a smaller switching time granularity.

**[00204]** Coexistence of SLP and Wi-Fi is used as an example. FIG. 18 is a diagram of a framework of a software static policy according to an embodiment of this application. It can be learned from FIG. 18 that, the software static policy may include: After SLP is enabled, software configures a host (HOST) to notify Wi-Fi to exit a current radio frequency path. In this scenario, Wi-Fi may view an SLP enable flag, and the software may allow switching from the current radio frequency path to another radio frequency path. A chip needs to support software setting switching.

**[00205]** For example, FIG. 19 is a diagram of a framework of a hardware arbitration time division (PTA) policy according to an embodiment of this application. It can be learned from FIG. 19 that the hardware arbitration time division (PTA) policy includes: Time division is performed by any combination of a transmitter (TX) and a receiver (RX) of each party. A PTA module transmits an occupation status of a radio frequency channel to each party, uses different level signals to indicate that the radio frequency channel is occupied by SLP/BT/BLE/Wi-Fi, and notifies, via this signal, software or hardware to perform corresponding processing. Different services may alternatively be configured with different PTA priorities. A service with a high priority may preempt an air interface resource.

Embodiment 4

**[00206]** Asynchronous and synchronous data links are defined in a SparkLink standard. Asynchronous links are classified into asynchronous unicast and multicast links, and synchronous links are classified into synchronous unicast, multicast, and broadcast links. In embodiments of this application, a set of SLP link selection solutions is designed based on different data real-time requirements of different products. Different data links may be used for connections between different devices in different scenarios, to support requirements of different product application

scenarios.

**[00207]** FIG. 20 is a schematic flowchart of a type of link establishment according to an embodiment of this application. As shown in FIG. 20, a T-node sends a broadcast packet to a G-node, and then the G-node sends a scanning access request to the T-node. Further, the T-node sends a scanning access response to the G-node, and then the G-node and the T-node establish an asynchronous unicast link, and perform data transmission over the established asynchronous unicast link.

**[00208]** FIG. 21 is a schematic flowchart of another type of link establishment according to an embodiment of this application. As shown in FIG. 21, a T-node sends a broadcast packet to a G-node, and then the G-node sends a scanning access request to the T-node. Further, the T-node sends a scanning access response to the G-node, and then the G-node and the T-node establish an asynchronous multicast link, and perform data transmission over the established asynchronous multicast link.

**[00209]** For a product (for example, a non-audio device like a keyboard, a mouse, or a stylus) or a service that has no data real-time requirement (that is, a latency requirement (or a service latency) of the product or the service is greater than a first value), the asynchronous unicast link shown in FIG. 20 or the asynchronous multicast link shown in FIG. 21 may be established for data transmission.

**[00210]** FIG. 22 is a schematic flowchart of still another type of link establishment according to an embodiment of this application. As shown in FIG. 22, a T-node sends a broadcast packet to a G-node, and then the G-node sends a scanning access request to the T-node. Further, the T-node sends a scanning access response to the G-node, and then the G-node and the T-node establish an asynchronous unicast link, then establish a synchronous unicast link, and perform data transmission over the established synchronous unicast link.

**[00211]** FIG. 23 is a schematic flowchart of yet another type of link establishment according to an embodiment of this application. As shown in FIG. 23, a T-node sends a broadcast packet to a G-node, and then the G-node sends a scanning access request to the T-node. Further, the T-node sends a scanning access response to the G-node, and then the G-node and the T-node establish an asynchronous unicast link, then establish a synchronous multicast link, and perform data transmission over the established synchronous multicast link.

**[00212]** For a product (for example, an audio device like a headset or a microphone) or a service that has a data real-time requirement (that is, a latency requirement of the product or the service is less than a second value), as shown in FIG. 22 or FIG. 23, the asynchronous unicast link may be first established, and the synchronous unicast link or the synchronous multicast link is then established for data transmission.

**[00213]** FIG. 24 is a schematic flowchart of still yet another type of link establishment according to an embodiment of this application. As shown in FIG. 24, a T-node sends a broadcast packet to a G-node, and then the G-node sends a scanning access request to the T-node. Further, the T-node sends a scanning access response to the G-node, and then the G-node and the T-node establish an asynchronous unicast link, and perform data transmission after synchronization is implemented by adding a timestamp to a data packet.

**[00214]** FIG. 25 is a schematic flowchart of a further type of link establishment according to an embodiment of this application. As shown in FIG. 25, a T-node sends a broadcast packet to a G-node, and then the G-node sends a scanning access request to the T-node. Further, the T-node sends a scanning access response to the G-node, and then the G-node and the T-node establish an asynchronous multicast link, and perform data transmission after synchronization is implemented by adding a timestamp to a data packet.

**[00215]** For a product (for example, an audio device like a headset or a live microphone) or a service that has a data real-time requirement but does not have a particularly high real-time requirement (that is, a latency requirement of the product or the service is less than a first value and greater than a second value), the asynchronous unicast link or the asynchronous multicast link may alternatively be established, and synchronization is implemented by adding the timestamp to the data packet.

Embodiment 5

**[00216]** FIG. 26 shows four different radio frame types defined in a SparkLink protocol. Each frame format corresponds to a different sensitivity, frame length, modulation scheme, and synchronization sequence. In different scenarios, different frame formats may be selected through physical layer parameter negotiation to maximize a performance gain. The following provides several examples of selecting different frame formats in different scenarios.

**[00217]** FIG. 27 is an application example of a frame format in a scenario according to an embodiment of this application. For a low-latency product (for example, a keyboard, a mouse, a stylus, a toothbrush, or a microphone) or a service scenario (that is, a latency requirement of a product or a service is less than first duration), a frame format 1 is selected to perform broadcast access, and the frame format 1 is switched to a frame format 2 through physical layer parameter negotiation after a connected state is entered.

**[00218]** FIG. 28 is an application example of a frame format in another scenario according to an embodiment of this application. For a product (for example, a mobile phone or a headset audio) or a service scenario that has both a low latency (that is, a latency requirement of the product or a service is less than first duration) and an anti-interference requirement (that is, an anti-interference capability requirement of the product or the service is greater than a specified threshold), a frame

format 1 is selected to perform broadcast access, and the frame format 1 is switched to a frame format 2 or a frame format 3 through physical layer parameter negotiation after a connected state is entered.

**[00219]** FIG. 29 is an application example of a frame format in still another scenario according to an embodiment of this application. For an extremely low-cost device that supports only a Gaussian frequency shift keying (Gaussian frequency shift keying, GFSK) frame format (a maximum transmit power of the GFSK is higher than that of phase shift keying (phase shift keying, PSK)), or a device that is sensitive to the maximum transmit power (that is, the maximum transmit power is greater than a first power threshold), a frame format 1 is selected to perform broadcast access, and frame format switching is not performed subsequently.

**[00220]** FIG. 30 is an application example of a frame format in yet another scenario according to an embodiment of this application. In an IoT ultra-long-distance coverage scenario, a frame format 4 is selected to perform broadcasting and connection. After a distance is shortened, the frame format 4 may be switched to a frame format 2 or a frame format 3 through physical layer parameter negotiation. Otherwise, the frame format 4 is maintained.

**[00221]** It should be noted that the frame format 1 in embodiments of this application may also be referred to as a frame format corresponding to a SparkLink radio frame type 1, the frame format 2 in embodiments of this application may also be referred to as a frame format corresponding to a SparkLink radio frame type 2, the frame format 3 in embodiments of this application may also be referred to as a frame format corresponding to a SparkLink radio frame type 3, and the frame format 4 in embodiments of this application may also be referred to as a frame format corresponding to a SparkLink radio frame type 4.

**[00222]** FIG. 31 is a diagram of a structure of an electronic device according to an embodiment of this application. The electronic device 300 may be a transmitter or a chip or a functional module in the transmitter, or may be a receiver or a chip or a functional module in the receiver. As shown in FIG. 31, the electronic device 300 includes a processor 301, a transceiver 302, and a communication line 303.

**[00223]** The processor 301 is configured to perform any step in the method embodiment shown in FIG. 9 or FIG. 10, and when performing processes such as sending a transmission frame, the processor 301 may choose to invoke the transceiver 302 and the communication line 303 to complete a corresponding operation.

**[00224]** Further, the electronic device 300 may further include a memory 304. The processor 301, the memory 304, and the transceiver 302 may be connected through the communication line 303.

**[00225]** The transceiver 302 is configured to communicate with another device or another

communication network. The another communication network may be the Ethernet, a radio access network (radio access network, RAN), a wireless local area network (wireless local area network, WLAN), or the like. The transceiver 302 may be a module, a circuit, a transceiver, or any apparatus that can implement communication.

**[00226]** The transceiver 302 is mainly configured to receive and send a transmission frame and the like, and may include a transmitter and a receiver, which respectively send and receive the transmission frame and the like. An operation other than receiving and sending the transmission frame and the like is implemented by the processor, for example, generating the transmission frame.

**[00227]** The communication line 303 is configured to transmit information between components included in the electronic device 300.

**[00228]** In a design, the processor may be considered as a logic circuit, and the transceiver may be considered as an interface circuit.

**[00229]** The memory 304 is configured to store instructions. The instructions may be a computer program.

**[00230]** It should be noted that the memory 304 may exist independently of the processor 301, or may be integrated with the processor 301. The memory 304 may be configured to store the instructions, program code, some data, or the like. The memory 304 may be located inside the electronic device 300, or may be located outside the electronic device 300. This is not limited. The processor 301 is configured to execute the instructions stored in the memory 304, to implement the method provided in the following embodiment of this application.

**[00231]** In an example, the processor 301 may include one or more processors, for example, a processor 0 and a processor 1 in FIG. 31.

**[00232]** In an optional implementation, the electronic device 300 includes a plurality of processors. For example, in addition to the processor 301 in FIG. 31, the electronic device 300 may further include a processor 307.

**[00233]** In an optional implementation, the electronic device 300 further includes an output device 305 and an input device 306. For example, the input device 306 is a device, for example, a keyboard, a mouse, a microphone, or a joystick, and the output device 305 is a device, for example, a display or a speaker (speaker).

**[00234]** It should be noted that the electronic device 300 may be a chip system or a device having a structure similar to that in FIG. 31. The chip system may include a chip, or may include the chip and another discrete device. Actions, terms, and the like in embodiments of this application may be mutually referenced. This is not limited. In embodiments of this application, names of messages exchanged between devices, names of parameters in the messages, or the like are merely examples. Other names may alternatively be used during specific implementation. This

is not limited. In addition, a composition structure shown in FIG. 31 does not constitute a limitation on the electronic device 300. In addition to the components shown in FIG. 31, the electronic device 300 may include more or fewer components than those shown in FIG. 31, or some components may be combined, or different component arrangements may be used.

**[00235]** The processor and the transceiver described in this application may be implemented in an integrated circuit (integrated circuit, IC), an analog IC, a radio frequency integrated circuit, a mixed signal IC, an application-specific integrated circuit (application-specific integrated circuit, ASIC), a printed circuit board (printed circuit board, PCB), an electronic device, or the like. The processor and the transceiver may alternatively be produced by using various IC technologies, for example, a complementary metal-oxide-semiconductor (complementary metal-oxide-semiconductor, CMOS), an N-channel metal-oxide-semiconductor (N-channel metal-oxide-semiconductor, NMOS), a P-channel metal-oxide-semiconductor (positive channel metal-oxide-semiconductor, PMOS), a bipolar junction transistor (bipolar junction transistor, BJT), a bipolar CMOS (BiCMOS), silicon germanium (SiGe), and gallium arsenide (GaAs).

**[00236]** The transmission frame provided in embodiments of this application is described above, and the communication method provided in embodiments of this application is mainly described from a perspective of a device. It may be understood that, to implement the foregoing functions, the device includes corresponding hardware structures and/or software modules for executing the functions. A person of ordinary skill in the art should easily be aware that, in combination with algorithms and steps in the examples described in embodiments disclosed in this specification, 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 applications and design constraints of the technical solutions. A person skilled in the art may use different methods to implement the described functions for each particular application, but it should not be considered that the implementation goes beyond the scope of this application.

**[00237]** In embodiments of this application, a device may be divided into functional modules based on the foregoing method examples. For example, functional modules may be obtained through division based on corresponding functions, or two or more functions may be integrated into one transmitter or receiver. The integrated module may be implemented in a form of hardware, or may be implemented in a form of a software functional module. It should be noted that, in embodiments of this application, division into modules is an example, and is merely a logical function division. In actual implementation, another division manner may be used.

**[00238]** FIG. 32 is a block diagram of a communication apparatus according to an embodiment of this application. When the functional modules are obtained through division based on the corresponding functions, the communication apparatus 400 may include a transceiver module 401

and a processing module 402. For example, the communication apparatus may be a transmitter or a receiver, or may be a chip in the transmitter or the receiver, or another combined component or part that has a function of the communication apparatus. When the communication apparatus 400 is a transmitter or a receiver, the transceiver module 401 may be a transceiver, where the transceiver may include an antenna, a radio frequency circuit, and the like; and the processing module 402 may be a processor (or a processing circuit), for example, a baseband processor, where the baseband processor may include one or more CPUs. When the communication apparatus 400 is a component or a part having the foregoing functions, the transceiver module 401 may be a radio frequency unit, and the processing module 402 may be a processor (or a processing circuit), for example, a baseband processor. When the communication apparatus 400 is a chip system, the transceiver module 401 may be an input/output interface of a chip (for example, a baseband chip), and the processing module 402 may be a processor (or a processing circuit) of the chip system and may include one or more central processing units. It should be understood that, in this embodiment of this application, the transceiver module 401 may be implemented by the transceiver or a transceiver-related circuit component, and the processing module 402 may be implemented by the processor or a processor-related circuit component (or referred to as a processing circuit).

**[00239]** In some examples, this application further provides a communication apparatus 500. The communication apparatus 500 is configured to implement transmission of a SparkLink signal. The communication apparatus 500 may include:

a module configured to send a transmission frame, where the transmission frame includes a ranging sequence field, the ranging sequence field includes at least one ranging subsequence, the ranging subsequence includes a plurality of ranging symbols, and the ranging sequence field is used to perform CIR estimation. A first ranging symbol in the plurality of ranging symbols is generated based on a first original code sequence in an original code sequence set, the original code sequence set includes a plurality of original code sequences, and the first original code sequence is randomly obtained from the original code sequence set in a symmetric encryption manner.

**[00240]** Optionally, the module configured to send the transmission frame may be the transceiver module 401. The transceiver module 401 may be configured to perform all sending and receiving operations performed by the transmitter in the embodiment shown in FIG. 9, and/or configured to support another process of the technology described in this specification.

**[00241]** The transceiver module 401 may include a sending module and/or a receiving module, which are respectively configured to perform sending and receiving operations performed by the transmitter in the embodiment shown in FIG. 9.

**[00242]** Both the transceiver module and the processing module in this embodiment of this

application may be deployed in a SparkLink module, a Bluetooth module, or a Wi-Fi module. Alternatively, the transceiver module in this embodiment of this application may be deployed in the SparkLink module, the Bluetooth module, or the Wi-Fi module, and the processing module in this embodiment of this application may be deployed in another module of a module in which the processing module is located. Alternatively, the processing module in this embodiment of this application may be deployed in the SparkLink module, the Bluetooth module, or the Wi-Fi module, and the transceiver module in this embodiment of this application may be deployed in another module of a module in which the processing module is located. This is not specifically limited in embodiments of this application.

**[00243]** With reference to the foregoing solution, the communication apparatus 500 is further configured to implement transmission of the Bluetooth signal or the Wi-Fi signal, and at least one of the SparkLink module, the Bluetooth module, and the Wi-Fi module shares at least one of an RF unit, a modem unit, a MAC unit, and a CPU.

**[00244]** With reference to the foregoing solution, the communication apparatus 500 is further configured to implement transmission of the Bluetooth signal, but does not support transmission of the Wi-Fi signal, the SparkLink module and the Bluetooth module are located in a same subsystem of the communication apparatus 500, and the subsystem and a PMU are integrated into the communication apparatus 500.

**[00245]** With reference to the foregoing solution, the communication apparatus 500 is further configured to implement transmission of the Bluetooth signal or the Wi-Fi signal, at least one of the Bluetooth module or the Wi-Fi module performs coexistence communication with the SparkLink module via different antennas, and a coexistence policy is channel avoidance.

**[00246]** With reference to the foregoing solution, the communication apparatus 500 is further configured to: determine a type of a peer device and/or a service latency of the peer device, and determine, according to a link selection policy, a link corresponding to the peer device and/or a service to perform data transmission.

**[00247]** With reference to the foregoing solution, that the communication apparatus 500 is further configured to determine the type of the peer device and/or the service latency of the peer device includes: determining the type of the peer device, where the type of the peer device includes an audio device type or a non-audio device type; and determining the service latency of the peer device when the type of the peer device is the audio device type.

**[00248]** With reference to the foregoing solution, the link selection policy includes: when the service latency is greater than a first value, performing data transmission after establishing an asynchronous unicast link or an asynchronous multicast link; or when the service latency is less than the first value and greater than a second value, establishing the asynchronous unicast link or

the asynchronous multicast link, and performing data transmission after synchronization is implemented by adding a timestamp to a data packet; or when the service latency is less than the second value, first establishing the asynchronous unicast link, and then performing data transmission after establishing a synchronous unicast link or a synchronous multicast link.

**[00249]** With reference to the foregoing solution, the communication apparatus 500 is further configured to: determine a type of a peer device and/or a service latency of the peer device, and determine, according to a frame format selection policy, a frame format type corresponding to the type of the peer device and/or a service type of the peer device. The frame format type includes a SparkLink radio frame type 1, a SparkLink radio frame type 2, a SparkLink radio frame type 3, or a SparkLink radio frame type 4.

**[00250]** With reference to the foregoing solution, that the communication apparatus 500 is further configured to determine the type of the peer device and/or the service latency of the peer device includes: determining the type of the peer device, where the type of the peer device includes an audio device type or a non-audio device type; and determining the service latency of the peer device when the type of the peer device is the audio device type.

**[00251]** With reference to the foregoing solution, the frame format selection policy includes: when a service latency requirement of the peer device is less than first duration, selecting the SparkLink radio frame type 1 to perform broadcast access, and switching to the SparkLink radio frame type 2 through physical layer parameter negotiation after a connected state is entered; or when the service latency requirement of the peer device is less than the first duration, and a service anti-interference capability requirement is greater than a set threshold, selecting the SparkLink radio frame type 1 to perform broadcast access, and switching to the SparkLink radio frame type 2 or the SparkLink radio frame type 3 through physical layer parameter negotiation after the connected state is entered; or when the type of the peer device is a device that supports only the SparkLink radio frame type 1 or a device whose maximum transmit power is greater than a first power threshold, selecting the SparkLink radio frame type 1 to perform broadcast access; or when the service type of the peer device is an IOT ultra-long-distance coverage service, when a distance between the peer device and the communication apparatus is greater than a first threshold, selecting the SparkLink radio frame type 4 to perform broadcasting and connection; or when the distance between the peer device and the communication apparatus is less than or equal to the first threshold, switching to the SparkLink radio frame type 2 or the SparkLink radio frame type 3 through physical layer parameter negotiation.

**[00252]** With reference to the foregoing solution, a second ranging symbol in the plurality of ranging symbols is generated based on a second original code sequence in the original code sequence set, and the first original code sequence is the same as the second original code sequence.

**[00253]** With reference to the foregoing solution, a second ranging symbol in the plurality of ranging symbols is generated based on a second original code sequence in the original code sequence set, and the first original code sequence is different from the second original code sequence.

**[00254]** With reference to the foregoing solution, the at least one ranging subsequence includes a first ranging subsequence and a second ranging subsequence, the ranging subsequence includes N ranging symbols, an ith ranging symbol in the first ranging subsequence is the same as an ith ranging symbol in the second ranging subsequence, and $1 \leq i \leq N$.

**[00255]** With reference to the foregoing solution, the at least one ranging subsequence includes a first ranging subsequence and a second ranging subsequence, the ranging subsequence includes N ranging symbols, an ith ranging symbol in the first ranging subsequence is different from an ith ranging symbol in the second ranging subsequence, and $1 \leq i \leq N$.

**[00256]** With reference to the foregoing solution, the plurality of original code sequences are one-to-one mapped to a plurality of sequence identifiers, the first original code sequence in the original code sequence set is mapped to a first sequence identifier, the first sequence identifier is generated in the symmetric encryption manner, and the first original code sequence is obtained from the original code sequence set through mapping by using the first sequence identifier.

**[00257]** In some examples, this application further provides a communication apparatus 600. The communication apparatus 600 is configured to implement transmission of a SparkLink signal. The communication apparatus 600 may include:

a module configured to receive a transmission frame, and a module configured to perform CIR estimation by using a first original code sequence and a first ranging symbol in a plurality of ranging symbols. The transmission frame includes a ranging sequence field, the ranging sequence field includes at least one ranging subsequence, and the ranging subsequence includes a plurality of ranging symbols. The first original code sequence is randomly obtained from an original code sequence set in a symmetric encryption manner, and the original code sequence set includes a plurality of original code sequences.

**[00258]** Optionally, the module configured to receive the transmission frame may be the transceiver module 401, and the module that performs CIR estimation by using the first original code sequence and the first ranging symbol in the plurality of ranging symbols may be the processing module 402.

**[00259]** The transceiver module 401 may be configured to perform all receiving and sending operations performed by the receiver in embodiment shown in FIG. 10, and/or configured to support another process of the technology described in this specification. The processing module 402 may be configured to perform all operations other than the receiving and sending operations

performed by the receiver in the embodiment shown in FIG. 10, and/or configured to support another process of the technology described in this specification.

**[00260]** The transceiver module 401 may include a sending module and/or a receiving module, respectively configured to perform the sending and receiving operations performed by the receiver in the embodiment shown in FIG. 10.

**[00261]** Both the communication module and the processing module in this embodiment of this application may be deployed in a SparkLink module, a Bluetooth module, or a Wi-Fi module. Alternatively, the communication module in this embodiment of this application may be deployed in the SparkLink module, the Bluetooth module, or the Wi-Fi module, and the processing module in this embodiment of this application may be deployed in another module of a module in which the processing module is located. Alternatively, the processing module in this embodiment of this application may be deployed in the SparkLink module, the Bluetooth module, or the Wi-Fi module, and the communication module in this embodiment of this application may be deployed in another module of a module in which the processing module is located. This is not specifically limited in embodiments of this application.

**[00262]** With reference to the foregoing solution, the communication apparatus 600 is further configured to implement transmission of the Bluetooth signal or the Wi-Fi signal, and at least one of the SparkLink module, the Bluetooth module, and the Wi-Fi module shares at least one of an RF unit, a modem unit, a MAC unit, and a CPU.

**[00263]** With reference to the foregoing solution, the communication apparatus 600 is further configured to implement transmission of the Bluetooth signal, but does not support transmission of the Wi-Fi signal, the SparkLink module and the Bluetooth module are located in a same subsystem of the communication apparatus 600, and the subsystem and a PMU are integrated into the communication apparatus 600.

**[00264]** With reference to the foregoing solution, the communication apparatus 600 is further configured to implement transmission of the Bluetooth signal or the Wi-Fi signal, at least one of the Bluetooth module or the Wi-Fi module performs coexistence communication with the SparkLink module via different antennas, and a coexistence policy is channel avoidance.

**[00265]** With reference to the foregoing solution, the communication apparatus 600 is further configured to: determine a type of a peer device and/or a service latency of the peer device, and determine, according to a link selection policy, a link corresponding to the peer device and/or a service to perform data transmission.

**[00266]** With reference to the foregoing solution, that the communication apparatus 600 is further configured to determine the type of the peer device and/or the service latency of the peer device includes: determining the type of the peer device, where the type of the peer device includes

an audio device type or a non-audio device type; and determining the service latency of the peer device when the type of the peer device is the audio device type.

**[00267]** With reference to the foregoing solution, the link selection policy includes: when the service latency is greater than a first value, performing data transmission after establishing an asynchronous unicast link or an asynchronous multicast link; or when the service latency is less than the first value and greater than a second value, establishing the asynchronous unicast link or the asynchronous multicast link, and performing data transmission after synchronization is implemented by adding a timestamp to a data packet; or when the service latency is less than the second value, first establishing the asynchronous unicast link, and then performing data transmission after establishing a synchronous unicast link or a synchronous multicast link.

**[00268]** With reference to the foregoing solution, when the communication apparatus 600 is a non-audio device, the communication apparatus 600 is further configured to perform data transmission over the asynchronous unicast link or the asynchronous multicast link.

**[00269]** With reference to the foregoing solution, the communication apparatus 600 is further configured to: determine a type of a peer device and/or a service latency of the peer device, and determine, according to a frame format selection policy, a frame format type corresponding to the type of the peer device and/or a service type of the peer device. The frame format type includes a SparkLink radio frame type 1, a SparkLink radio frame type 2, a SparkLink radio frame type 3, or a SparkLink radio frame type 4.

**[00270]** With reference to the foregoing solution, that the communication apparatus 600 is further configured to determine the type of the peer device and/or the service latency of the peer device includes: determining the type of the peer device, where the type of the peer device includes an audio device type or a non-audio device type; and determining the service latency of the peer device when the type of the peer device is the audio device type.

**[00271]** With reference to the foregoing solution, the frame format selection policy includes: when a service latency requirement of the peer device is less than first duration, selecting the SparkLink radio frame type 1 to perform broadcast access, and switching to the SparkLink radio frame type 2 through physical layer parameter negotiation after a connected state is entered; or when the service latency requirement of the peer device is less than the first duration, and a service anti-interference capability requirement is greater than a set threshold, selecting the SparkLink radio frame type 1 to perform broadcast access, and switching to the SparkLink radio frame type 2 or the SparkLink radio frame type 3 through physical layer parameter negotiation after the connected state is entered; or when the type of the peer device is a device that supports only the SparkLink radio frame type 1 or a device whose maximum transmit power is greater than a first power threshold, selecting the SparkLink radio frame type 1 to perform broadcast access; or when

the service type of the peer device is an IOT ultra-long-distance coverage service, when a distance between the peer device and the communication apparatus is greater than a first threshold, selecting the SparkLink radio frame type 4 to perform broadcasting and connection; or when the distance between the peer device and the communication apparatus is less than or equal to the first threshold, switching to the SparkLink radio frame type 2 or the SparkLink radio frame type 3 through physical layer parameter negotiation.

**[00272]** With reference to the foregoing solution, when the communication apparatus 600 is a non-audio device, the communication apparatus 600 is further configured to: select the SparkLink radio frame type 1 to perform broadcast access, and switch to the SparkLink radio frame type 2 through physical layer parameter negotiation for data transmission after entering the connected state.

**[00273]** In another possible implementation, the transceiver module 401 in FIG. 32 may be replaced with the transceiver 302 in FIG. 31, and a function of the transceiver module 401 may be integrated into the transceiver 302; and the processing module 402 may be replaced with the processor 307, and a function of the processing module 402 may be integrated into the processor 307. Further, the communication apparatus 400 shown in FIG. 32 may further include a memory (not shown in the figure). When the transceiver module 401 is replaced with the transceiver 302, and the processing module 402 is replaced with the processor 307, the communication apparatus 400 in this embodiment of this application may be the electronic device 300 shown in FIG. 31.

**[00274]** FIG. 33 is a diagram of a structure of a communication apparatus according to an embodiment of this application. The communication apparatus is applicable to the scenario shown in the foregoing method embodiment. For ease of description, FIG. 33 shows only main parts of the communication apparatus, including a processor, a memory, a control circuit, and an input/output apparatus. The processor is mainly configured to: process a communication protocol and communication data, execute a software program, and process data of the software program. The memory is mainly configured to store the software program and data. The control circuit is mainly configured to supply power and transmit various electrical signals. The input/output apparatus is mainly configured to: receive data input by a user, and output data to the user.

**[00275]** When the communication apparatus is a transmitter or a receiver, the control circuit may be a main board; the memory includes a medium having a storage function, for example, a hard disk, a RAM, or a ROM; the processor may include a baseband processor and a central processing unit, the baseband processor is mainly configured to process the communication protocol and the communication data, and the central processing unit is mainly configured to: control the entire communication apparatus, execute the software program, and process the data of the software program; the input/output apparatus includes a display, a keyboard, a mouse, and

the like; and the control circuit may further include or be connected to a transceiver circuit or a transceiver, for example, a network cable interface, and is configured to send or receive data or a signal, for example, perform data transmission and communication with another device. Further, the control circuit may further include an antenna, configured to receive and send a transmission frame, and configured to perform data/request transmission with another device.

**[00276]** According to the methods provided in embodiments of this application, this application further provides a computer program product. The computer program product includes computer program code, and when the computer program code is run on a computer, the computer is caused to perform the method according to any one of embodiments of this application.

**[00277]** An embodiment of this application further provides a computer-readable storage medium. All or some of the procedures in the foregoing method embodiments may be completed by a computer or an apparatus having a communication capability by executing a computer program or instructions, to control related hardware. The computer program or the group of instructions may be stored in the computer-readable storage medium. When the computer program or the group of instructions are executed, the procedures of the foregoing method embodiments may be included. The computer-readable storage medium may be an internal storage unit of the transmitter or the receiver in any one of the foregoing embodiments, for example, a hard disk or a memory of the transmitter or the receiver. The computer-readable storage medium may alternatively be an external storage device of the transmitter or the receiver, for example, a plug-in hard disk, a smart media card (smart media card, SMC), a secure digital (secure digital, SD) card, or a flash card (flash card), configured for the transmitter or the receiver. Further, the computer-readable storage medium may further include both the internal storage unit and the external storage device of the transmitter or the receiver. The computer-readable storage medium is configured to store the computer program or the instructions and another program and data that are required by the transmitter or the receiver. The computer-readable storage medium may be further configured to temporarily store data that has been output or is to be output.

**[00278]** A person of ordinary skill in the art may be aware that, in combination with the examples described in embodiments disclosed in this specification, units and algorithm steps can be implemented by electronic hardware or a combination of computer software and electronic hardware. Whether the functions are performed by hardware or software depends on particular applications and design constraints of the technical solutions. A person skilled in the art may use different methods to implement the described functions for each particular application, but it should not be considered that the implementation goes beyond the scope of this application.

**[00279]** It may be clearly understood by a person skilled in the art that, for the purpose of convenient and brief description, for a detailed working process of the foregoing apparatus, refer

to a corresponding process in the foregoing method embodiments. Details are not described herein again.

**[00280]** In the several embodiments provided in this application, it should be understood that the disclosed apparatus and method may be implemented in other manners. For example, the described apparatus embodiments are merely examples. For example, division into units is merely logical function division and may be other division in actual implementation. For example, a plurality of units or components may be combined or integrated into another system, or some features may be ignored or not performed. In addition, the displayed or discussed mutual couplings or direct couplings or communication connections may be implemented through some interfaces. The indirect couplings or communication connections between the apparatuses or units may be implemented in electronic, mechanical, or other forms.

**[00281]** The units described as separate parts may or may not be physically separate, and parts displayed as units may or may not be physical units, may be located in one position, or may be distributed on a plurality of network units. Some or all of the units may be selected based on actual requirements to achieve the objectives of the solutions of embodiments.

**[00282]** In addition, functional units in embodiments of this application may be integrated into one processing unit, each of the units may exist alone physically, or two or more units are integrated into one unit.

**[00283]** When the functions are implemented in a form of a software functional unit and sold or used as an independent product, the functions may be stored in a computer-readable storage medium. Based on such an understanding, the technical solutions in this application essentially, or the part contributing to the conventional technology, or a part of the technical solutions may be implemented in a form of a software product. The computer software product is stored in a storage medium and includes several instructions for instructing a computer device (a personal computer, a server, a network device, or the like) to perform all or some of the steps of the methods in embodiments of this application. The foregoing storage medium includes any medium that can store program code, for example, a USB flash drive, a removable hard disk, a ROM, a RAM, a magnetic disk, or an optical disc.

**[00284]** The foregoing descriptions are merely specific implementations of this application, but are not intended to limit the protection scope of this application. Any variation or replacement readily figured out by a person skilled in the art within the technical scope disclosed in this application shall fall within the protection scope of this application. Therefore, the protection scope of this application shall be subject to the protection scope of the claims.

## CLAIMS

1. A communication method, wherein the method comprises:

sending a transmission frame, wherein the transmission frame comprises a ranging sequence field, the ranging sequence field comprises at least one ranging subsequence, the ranging subsequence comprises a plurality of ranging symbols, and the ranging sequence field is used to perform channel impulse response CIR estimation, wherein

a first ranging symbol in the plurality of ranging symbols is generated based on a first original code sequence in an original code sequence set, the original code sequence set comprises a plurality of original code sequences, and the first original code sequence is randomly obtained from the original code sequence set in a symmetric encryption manner.

2. The method according to claim 1, wherein a second ranging symbol in the plurality of ranging symbols is generated based on a second original code sequence in the original code sequence set, and the first original code sequence is the same as the second original code sequence.

3. The method according to claim 1, wherein a second ranging symbol in the plurality of ranging symbols is generated based on a second original code sequence in the original code sequence set, and the first original code sequence is different from the second original code sequence.

4. The method according to any one of claims 1 to 3, wherein the at least one ranging subsequence comprises a first ranging subsequence and a second ranging subsequence, the ranging subsequence comprises N ranging symbols, an $i^{th}$ ranging symbol in the first ranging subsequence is the same as an $i^{th}$ ranging symbol in the second ranging subsequence, and $1 \leq i \leq N$.

5. The method according to any one of claims 1 to 3, wherein the at least one ranging subsequence comprises a first ranging subsequence and a second ranging subsequence, the ranging subsequence comprises N ranging symbols, an $i^{th}$ ranging symbol in the first ranging subsequence is different from an $i^{th}$ ranging symbol in the second ranging subsequence, and $1 \leq i \leq N$.

6. The method according to any one of claims 1 to 5, wherein the plurality of original code sequences are one-to-one mapped to a plurality of sequence identifiers, the first original code sequence in the original code sequence set is mapped to a first sequence identifier, the first sequence identifier is generated in the symmetric encryption manner, and the first original code sequence is obtained from the original code sequence set through mapping by using the first sequence identifier.

7. A communication method, wherein the method comprises:

receiving a transmission frame, wherein the transmission frame comprises a ranging sequence field, the ranging sequence field comprises at least one ranging subsequence, and the ranging

subsequence comprises a plurality of ranging symbols; and

performing channel impulse response CIR estimation by using a first original code sequence and a first ranging symbol in the plurality of ranging symbols, wherein the first original code sequence is randomly obtained from an original code sequence set in a symmetric encryption manner, and the original code sequence set comprises a plurality of original code sequences.

8. The method according to claim 7, wherein a second ranging symbol in the plurality of ranging symbols is generated based on a second original code sequence in the original code sequence set, and the first original code sequence is the same as the second original code sequence.

9. The method according to claim 7, wherein a second ranging symbol in the plurality of ranging symbols is generated based on a second original code sequence in the original code sequence set, and the first original code sequence is different from the second original code sequence.

10. The method according to any one of claims 7 to 9, wherein the at least one ranging subsequence comprises a first ranging subsequence and a second ranging subsequence, the ranging subsequence comprises N ranging symbols, an $i^{th}$ ranging symbol in the first ranging subsequence is the same as an $i^{th}$ ranging symbol in the second ranging subsequence, and $1 \leq i \leq N$.

11. The method according to any one of claims 7 to 9, wherein the at least one ranging subsequence comprises a first ranging subsequence and a second ranging subsequence, the ranging subsequence comprises N ranging symbols, an $i^{th}$ ranging symbol in the first ranging subsequence is different from an $i^{th}$ ranging symbol in the second ranging subsequence, and $1 \leq i \leq N$.

12. The method according to any one of claims 7 to 11, wherein the plurality of original code sequences are one-to-one mapped to a plurality of sequence identifiers, the first original code sequence in the original code sequence set is mapped to a first sequence identifier, the first sequence identifier is generated in the symmetric encryption manner, and the first original code sequence is obtained from the original code sequence set through mapping by using the first sequence identifier.

13. A transmission frame, wherein the transmission frame comprises:

a ranging sequence field, wherein the ranging sequence field comprises at least one ranging subsequence, the ranging subsequence comprises a plurality of ranging symbols, and the ranging sequence field is used to perform channel impulse response CIR estimation, wherein

a first ranging symbol in the plurality of ranging symbols is generated based on a first original code sequence in an original code sequence set, the original code sequence set comprises a plurality of original code sequences, and the first original code sequence is randomly obtained from the original code sequence set in a symmetric encryption manner.

14. The transmission frame according to claim 13, wherein a second ranging symbol in the

plurality of ranging symbols is generated based on a second original code sequence in the original code sequence set, and the first original code sequence is the same as the second original code sequence.

15. The transmission frame according to claim 13, wherein a second ranging symbol in the plurality of ranging symbols is generated based on a second original code sequence in the original code sequence set, and the first original code sequence is different from the second original code sequence.

16. The transmission frame according to any one of claims 13 to 15, wherein the at least one ranging subsequence comprises a first ranging subsequence and a second ranging subsequence, the ranging subsequence comprises N ranging symbols, an $i^{th}$ ranging symbol in the first ranging subsequence is the same as an $i^{th}$ ranging symbol in the second ranging subsequence, and $1 \leq i \leq N$.

17. The transmission frame according to any one of claims 13 to 15, wherein the at least one ranging subsequence comprises a first ranging subsequence and a second ranging subsequence, the ranging subsequence comprises N ranging symbols, an $i^{th}$ ranging symbol in the first ranging subsequence is different from an $i^{th}$ ranging symbol in the second ranging subsequence, and $1 \leq i \leq N$.

18. The transmission frame according to any one of claims 13 to 17, wherein the plurality of original code sequences are one-to-one mapped to a plurality of sequence identifiers, the first original code sequence in the original code sequence set is mapped to a first sequence identifier, the first sequence identifier is generated in the symmetric encryption manner, and the first original code sequence is obtained from the original code sequence set through mapping by using the first sequence identifier.

19. A communication apparatus, wherein the communication apparatus is configured to implement transmission of a SparkLink signal, and the apparatus comprises:

a module configured to send a transmission frame, wherein the transmission frame comprises a ranging sequence field, the ranging sequence field comprises at least one ranging subsequence, the ranging subsequence comprises a plurality of ranging symbols, and the ranging sequence field is used to perform channel impulse response CIR estimation, wherein

a first ranging symbol in the plurality of ranging symbols is generated based on a first original code sequence in an original code sequence set, the original code sequence set comprises a plurality of original code sequences, and the first original code sequence is randomly obtained from the original code sequence set in a symmetric encryption manner.

20. The apparatus according to claim 19, wherein the communication apparatus is further configured to implement transmission of a Bluetooth signal or a wireless fidelity Wi-Fi signal, and at least one of a SparkLink module, a Bluetooth module, and a Wi-Fi module shares a radio frequency RF unit.

21. The apparatus according to claim 19 or 20, wherein the communication apparatus is further configured to implement transmission of the Bluetooth signal, but does not support transmission of the Wi-Fi signal, the SparkLink module and the Bluetooth module are located in a same subsystem of the communication apparatus, and the subsystem and a power management unit PMU are integrated into the communication apparatus.

22. The apparatus according to any one of claims 19 to 21, wherein the communication apparatus is further configured to implement transmission of the Bluetooth signal or the Wi-Fi signal, at least one of the Bluetooth module or the Wi-Fi module performs coexistence communication with the SparkLink module via different antennas, and a coexistence policy is channel avoidance.

23. The apparatus according to any one of claims 19 to 22, wherein the communication apparatus is further configured to: determine a type of a peer device and/or a service latency of the peer device, and determine, according to a link selection policy, a link corresponding to the peer device and/or a service to perform data transmission.

24. The apparatus according to claim 23, wherein the communication apparatus is specifically configured to:

determine the type of the peer device, wherein the type of the peer device comprises an audio device type or a non-audio device type; and

determine the service latency of the peer device when the type of the peer device is the audio device type.

25. The apparatus according to claim 23 or 24, wherein the link selection policy comprises:

when the service latency is greater than a first value, performing data transmission after establishing an asynchronous unicast link or an asynchronous multicast link; or

when the service latency is less than the first value and greater than a second value, establishing the asynchronous unicast link or the asynchronous multicast link, and performing data transmission after synchronization is implemented by adding a timestamp to a data packet; or

when the service latency is less than the second value, first establishing the asynchronous unicast link, and then performing data transmission after establishing a synchronous unicast link or a synchronous multicast link.

26. A communication apparatus, wherein the communication apparatus is configured to implement transmission of a SparkLink signal, and the apparatus comprises:

a module configured to receive a transmission frame, wherein the transmission frame comprises a ranging sequence field, the ranging sequence field comprises at least one ranging subsequence, and the ranging subsequence comprises a plurality of ranging symbols; and

a module configured to perform channel impulse response CIR estimation by using a first

original code sequence and a first ranging symbol in the plurality of ranging symbols, wherein the first original code sequence is randomly obtained from an original code sequence set in a symmetric encryption manner, and the original code sequence set comprises a plurality of original code sequences.

27. The apparatus according to claim 26, wherein the communication apparatus is further configured to implement transmission of a Bluetooth signal or a wireless fidelity Wi-Fi signal, and at least one of a SparkLink module, a Bluetooth module, and a Wi-Fi module shares a radio frequency RF unit.

28. The apparatus according to claim 26 or 27, wherein the communication apparatus is further configured to implement transmission of the Bluetooth signal, but does not support transmission of the Wi-Fi signal, the SparkLink module and the Bluetooth module are located in a same subsystem of the communication apparatus, and the subsystem and a power management unit PMU are integrated into the communication apparatus.

29. The apparatus according to any one of claims 26 to 28, wherein the communication apparatus is further configured to implement transmission of the Bluetooth signal or the Wi-Fi signal, at least one of the Bluetooth module or the Wi-Fi module performs coexistence communication with the SparkLink module via different antennas, and a coexistence policy is channel avoidance.

30. The apparatus according to any one of claims 26 to 29, wherein the communication apparatus is further configured to: determine a type of a peer device and/or a service latency of the peer device, and determine, according to a link selection policy, a link corresponding to the peer device and/or a service to perform data transmission.

31. The apparatus according to claim 30, wherein the communication apparatus is specifically configured to:

determine the type of the peer device, wherein the type of the peer device comprises an audio device type or a non-audio device type; and

determine the service latency of the peer device when the type of the peer device is the audio device type.

32. The apparatus according to claim 30 or 31, wherein the link selection policy comprises:

when the service latency is greater than a first value, performing data transmission after establishing an asynchronous unicast link or an asynchronous multicast link; or

when the service latency is less than the first value and greater than a second value, establishing the asynchronous unicast link or the asynchronous multicast link, and performing data transmission after synchronization is implemented by adding a timestamp to a data packet; or

when the service latency is less than the second value, first establishing the asynchronous

unicast link, and then performing data transmission after establishing a synchronous unicast link or a synchronous multicast link.

33. A communication apparatus, wherein the apparatus comprises:

one or more processors; and

a memory, configured to store one or more computer programs or instructions, wherein

when the one or more computer programs or instructions are executed by the one or more processors, the one or more processors are caused to implement the method according to any one of claims 1 to 6 or the method according to any one of claims 7 to 12.

34. A communication system, wherein the system comprises a transmitter and a receiver, wherein

the transmitter comprises the communication apparatus according to any one of claims 19 to 25 or the communication apparatus according to claim 33, and the receiver comprises the communication apparatus according to any one of claims 26 to 32 or the communication apparatus according to claim 33.

35. A chip, wherein the chip comprises:

a processing circuit and an interface circuit, wherein

the interface circuit is configured to: couple to a memory outside the chip, and provide a communication interface for the processing circuit to access the memory; and

the processing circuit is configured to execute program instructions in the memory, to implement the method according to any one of claims 1 to 6 or the method according to any one of claims 7 to 12.

36. A computer-readable storage medium, wherein

the computer-readable storage medium stores program code, and when the program code is executed by a processor, the method according to any one of claims 1 to 6 or the method according to any one of claims 7 to 12 is implemented.

37. A computer program product, wherein the computer program product comprises instructions, and when the computer program product runs on a computer, the computer is caused to implement the method according to any one of claims 1 to 6 or the method according to any one of claims 7 to 12.