

in all exchange operations of all time information exchanged between the first device and the second device for determining the distance between the first device and the second device.

In this way, the second device can accurately associate time information obtained by the second device through exchange with the first device with a time difference that is obtained by the second device through measurement and that has a same measurement sequence number, so as to obtain an accurate distance.

In some implementations, the first symbol may be an S^{th} one in one or more ranging symbols sent by the first device in one distance measurement process, and the second symbol may be an S^{th} one in one or more ranging symbols received by the first device in one distance measurement process.

For example, S is 1. Alternatively, the first device may send N first symbols in one distance measurement process, where the first moment is a sending moment of the 1st first symbol in the N first symbols, and N is a positive integer. The first device may receive M second symbols in this distance measurement process, where the second moment is a receiving moment of the 1st received second symbol in the M second symbols, and M is a positive integer. Correspondingly, the third moment may be a moment at which the second device receives the 1st first symbol

in the N first symbols, and the fourth moment is a moment at which the second device sends the 1st second symbol in the M second symbols.

In some possible implementations, if the first symbol includes a cyclic prefix (cyclic prefix, CP), the first moment may be a sending moment of a starting point of the CP of the first symbol. Similarly, the third moment may be a moment at which the second device receives the starting point of the CP of the first symbol.

If the first symbol does not include a CP, the first moment is a sending moment of a starting point of the first symbol. Similarly, the third moment may be a moment at which the second device receives the starting point of the first symbol.

If the second symbol includes a CP, the second moment may be a receiving moment of a starting point of the CP of the second symbol. Similarly, the fourth moment may be a moment at which the second device sends the starting point of the CP of the second symbol.

If the second symbol does not include a CP, the second moment is a sending moment at which the first device receives a starting point of the second symbol. Similarly, the fourth moment may be a moment at which the second device sends the starting point of the second symbol.

In some possible implementations, the first moment may be a moment at which the starting point of the first symbol arrives at a first antenna connector of the first device, and the second moment may be a moment at which the starting point of the second symbol arrives at the first antenna connector.

In an example, the device 101 may be a management node in the SparkLink Basic (SparkLink Basic, SLB) standard/SparkLink Low Energy (SparkLink Low Energy, SLE) standard, and the device 102 may be a terminal node in the SLB/SLE. The device 101 is a G node, and the device 102 is a T node.

5 In another example, the device 101 may be a master device (master) in the Bluetooth low energy (Bluetooth Low Energy, BLE) standard, and the device 102 may be a slave device (slave) in the Bluetooth low energy (Bluetooth Low Energy, BLE) standard. The device 101 is a G node, and the device 102 is a T node.

10 In still another example, the device 101 may be an access point (AP) in the Wi-Fi standard, and the device 102 may be a station (STA) in the Wi-Fi standard. The device 101 is a G node, and the device 102 is a T node.

The system shown in FIG. 1 may be used in a plurality of scenarios, for example, may be used in an in-vehicle wireless positioning scenario, an indoor positioning scenario, an indoor navigation scenario, or an indoor ranging scenario, or may be used in another wide area wireless communication scenario or local area wireless communication scenario.

An example in which the system shown in FIG. 1 includes a plurality of slave nodes and is used in an in-vehicle positioning scenario is used below for description with reference to FIG. 2.

As shown in FIG. 2, in the in-vehicle positioning scenario, positioning anchors may be respectively deployed on four corners of a vehicle, and positioning anchors are deployed on a center console, rear view mirrors, and a ceiling (that is, a top inside the vehicle) of the vehicle, to position a vehicle key used as a to-be-positioned node. The vehicle key may include a vehicle key that has a positioning function in a conventional form, or may include a mobile phone, a wearable device, or the like that may be used to unlock a vehicle, or serve as a vehicle key. The positioning anchor may also be referred to as a positioning node, a positioning base station, or a positioning beacon (beacon), and may be referred to as an anchor (anchor) for short. The to-be-positioned node may be referred to as a positioning tag (tag) or a measured node, and may be referred to as a tag for short.

It may be understood that, that the positioning anchors are deployed on the corners of the vehicle, the central control console, the rear view mirrors, or the ceiling is merely an example. An in-vehicle wireless device such as a display screen, a microphone, a speaker, a camera, and a T-BOX inside the vehicle, or a camera of a 360-degree all-around application outside the vehicle may also be reused as a positioning anchor.

In the scenario shown in FIG. 2, any node may act as a node G. For example, the node G may be a vehicle key, and all anchors in the vehicle are T nodes. For another example, the node G is any anchor in the vehicle, and other anchors and the vehicle key are all T nodes.

The ranging symbol carrying the foregoing ZC sequence may be referred to as a positioning reference signal (Positioning Reference Signal, PRS). In addition to the PRS carrying the ZC sequence, an existing channel state information reference signal (CSI-RS) or sounding reference signal (SRS) in the SLB may also be used as the ranging symbol.

5 In some implementations of this embodiment of this application, a unit of each measurement time may be a picosecond (ps). For example, a unit of the first moment, the second moment, the third moment, and the fourth moment may be ps. Similarly, a unit of the first time difference and the second time difference may be ps.

10 In an example, the first device may send first configuration information to the second device. The first configuration information may include one or more of the following information: a quantity of times of measurement, an identifier of a first radio frame in each measurement, a time-frequency resource of the first symbol in each measurement, an identifier of a second radio frame in each measurement, and a time-frequency resource of the second symbol in each measurement. An example format of the first configuration information is shown in the following table.

Field	Description
P	Quantity of times of measurement, where P is a positive integer.
Radio frame identifier 1-1	An identifier or a number of a radio frame on which the first symbol is located in the first measurement, where an example of the first symbol is a G link ranging symbol;
Bitmap (bitmap)	Indicating a resource that is in the radio frame identifier 1-1 and that is used to carry the first symbol, where the bitmap may include R_1 bits, R_1 is a quantity of symbol resources in a radio frame indicated by the radio frame identifier 1-1, the R_1 bits are in a one-to-one correspondence with R_1 symbol resources in the radio frame, a symbol resource corresponding to a bit with a value of 1 carries the first symbol, and a symbol resource corresponding to a bit with a value of 0 does not carry the first symbol;
Radio frame identifier 1-2	An identifier or a number of a radio frame on which the second symbol is located in the first measurement, where an example of the second symbol is a T link ranging symbol;
Bitmap	Indicating a symbol resource that is in a radio frame indicated by the radio frame identifier 1-2 and that carries the second symbol, where the bitmap may include K_1 bits, K_1 is a quantity of symbol resources in the radio frame indicated by the radio frame identifier 1-2, the K_1 bits are in a one-to-one correspondence with K_1 symbol

embodiment shown in FIG. 14, and the processing module 1702 may be configured to implement S330, S321, and S370 in the embodiment shown in FIG. 14.

In another example, the apparatus 1700 may be used in the second device. In this example, the apparatus 1700 may be configured to implement an operation implemented by the second
5 device in any one of the foregoing methods. The transceiver module 1701 may be configured to implement a receiving operation and a sending operation, and the processing module 1702 may be configured to implement operations such as obtaining, determining, recording, and configuration.

For example, the transceiver module 1701 may be configured to implement the operations implemented by the second device in S310, S320, and S350 in the embodiment shown in FIG. 3,
10 and the processing module 1702 may be configured to implement S340 in the embodiment shown in FIG. 3.

For another example, the transceiver module 1701 may be configured to implement the operations implemented by the second device in S310, S320, S325, S350, and S351 in the embodiment shown in FIG. 11, and the processing module 1702 may be configured to implement
15 S340 and S342 in the embodiment shown in FIG. 11.

For another example, the transceiver module 1701 may be configured to implement the operations implemented by the second device in S310, S320, S305, S350, and S351 in the embodiment shown in FIG. 14, and the processing module 1702 may be configured to implement
20 S322 and S340 in the embodiment shown in FIG. 14.

FIG. 18 is a diagram of a structure of a measurement apparatus according to another embodiment of this application. The apparatus 1800 shown in FIG. 20 may be configured to perform a method performed by the first device in any one of the foregoing methods, or configured to perform a method performed by the second device in any one of the foregoing methods.

As shown in FIG. 20, the apparatus 1800 in this embodiment includes a memory 1801, a
25 processor 1802, a communication interface 1803, and a bus 1804. The memory 1801, the processor 1802, and the communication interface 1803 are communicatively connected to each other by using the bus 1804.

The memory 1801 may be a read-only memory (read-only memory, ROM), a static storage device, a dynamic storage device, or a random access memory (random access memory, RAM).
30 The memory 1801 may store a program. When the program stored in the memory 1801 is executed by the processor 1802, the processor 1802 is configured to perform the steps performed by the first device in any one of the foregoing methods, or the processor 1802 is configured to perform the steps performed by the second device in any one of the foregoing methods.

The processor 1802 may be a general-purpose central processing unit (Central Processing
35 Unit, CPU), a microprocessor, an application-specific integrated circuit (Application-Specific

CLAIMS

1. A measurement method, comprising:

sending, by a first device, a first symbol;

receiving, by the first device, a second symbol from a second device, wherein the first symbol
5 and the second symbol are carried on a same radio frame or different radio frames; and

determining, by the first device, a first time difference, wherein the first time difference is a
time interval between a first moment at which the first device sends the first symbol and a second
moment at which the first device receives the second symbol, and the first time difference is used
to determine a distance between the first device and the second device.

2. The method according to claim 1, wherein the method further comprises:

receiving, by the first device, first time information from the second device, wherein the first
time information is used to determine a second time difference, and the second time difference is
a time interval between a third moment at which the second device receives the first symbol and a
fourth moment at which the second device sends the second symbol; and

determining, by the first device, the distance between the first device and the second device
15 based on the first time difference and the second time difference.

3. The method according to claim 1 or 2, wherein the first symbol and/or the second symbol
are/is generated based on a ZC sequence, and the ZC sequence is generated in the following
manner:

$$d(n) = \begin{cases} \exp\left(-j\frac{\pi un(n+1)}{41}\right), n = 0, 1, \dots, 18 \\ 0, n = 19 \\ \exp\left(-j\frac{\pi un(n+1)}{41}\right), n = 20, 21, \dots, 38 \end{cases}, \text{ wherein}$$

n represents a subcarrier sequence number, u is a preset value, and $d(n)$ represents a ZC
sequence on an n^{th} subcarrier.

4. The method according to claim 3, wherein u is any integer from a to b, a is a positive integer
greater than 1, b is a positive integer less than 39, and a is less than b.

5. The method according to any one of claims 1 to 4, wherein the radio frame comprises a G
link symbol, an SG symbol, and a T link symbol, or the radio frame comprises a G link symbol, a
T link symbol, and an ST symbol; and

the first symbol is a G link ranging symbol and the second symbol is a T link ranging symbol,
or the first symbol is a T link ranging symbol and the second symbol is a G link ranging symbol,
wherein the G link ranging symbol is carried on a resource used to transmit a G link symbol and/or
a resource used to transmit an SG symbol, and the T link ranging symbol is carried on a resource
used to transmit a T link symbol and/or a resource used to transmit an ST symbol.

6. The method according to any one of claims 1 to 5, wherein when the first symbol and the second symbol are carried on the same radio frame, a switching gap GAP exists between the first symbol and the second symbol.

7. The method according to any one of claims 1 to 5, wherein when the first symbol and the second symbol are carried on the different radio frames, the first symbol is carried on a first radio frame, and the second symbol is carried on a second radio frame, wherein

when the first symbol is carried on the resource used to transmit the G link symbol and/or the resource used to transmit the SG symbol, and the second symbol is carried on the resource used to transmit the T link symbol and/or the resource used to transmit the ST symbol, the first radio frame further comprises a T link symbol, and the second radio frame further comprises a G link symbol; or

when the first symbol is carried on the resource used to transmit the T link symbol and/or the resource used to transmit the ST symbol, and the second symbol is carried on the resource used to transmit the G link symbol and/or the resource used to transmit the SG symbol, the first radio frame further comprises a G link symbol, and the second radio frame further comprises a T link symbol.

8. The method according to any one of claims 1 to 7, wherein the method further comprises: receiving, by the first device, the first time information from the second device, wherein the first time information is used to determine the second time difference, and the second time difference is the time interval between the third moment at which the second device receives the first symbol and the fourth moment at which the second device sends the second symbol; and

receiving, by the first device, first measurement information from the second device, wherein the first measurement information indicates a measurement exchange sequence number corresponding to the first time information.

9. The method according to any one of claims 1 to 8, wherein the first symbol is the 1st one of M ranging symbols sent by the first device in the radio frame, the second symbol is the 1st one of N ranging symbols received by the first device in the radio frame, N is a positive integer, and M is a positive integer.

10. The method according to any one of claims 1 to 9, wherein the first moment is a moment at which a starting point of the first symbol arrives at a first antenna connector of the first device, and the second moment is a moment at which a starting point of the second symbol arrives at the first antenna connector; or

the first moment is a moment at which a starting point of a cyclic prefix CP of the first symbol arrives at the first antenna connector of the first device, and the second moment is a moment at which a starting point of a CP of the second symbol arrives at the first antenna connector.

11. The method according to any one of claims 1 to 10, wherein the method further comprises:
sending, by the first device, first configuration information to the second device, or receiving,
by the first device, the first configuration information from the second device, wherein

the first configuration information indicates at least one of the following content: a
5 Transaction ID corresponding to measurement, an identifier of the radio frame, a first resource that
is in the radio frame and that carries the first symbol, and a second resource that is in the radio
frame and that is used to carry the second symbol.

12. The method according to claim 11, wherein the first configuration information indicates
the first resource and/or the second resource by using a bitmap.

10 13. The method according to any one of claims 2 to 12, wherein the method further comprises:
sending, by the first device, a third symbol;

determining, by the first device, a third time difference, wherein the third time difference is a
time interval between the second moment at which the first device receives the second symbol and
a fifth moment at which the first device sends the third symbol; and

15 receiving, by the first device, second time information from the second device, wherein the
second time information is used to determine a fourth time difference, and the fourth time
difference is a time interval between the third moment at which the second device sends the second
symbol and a sixth moment at which the second device receives the third symbol; and

the determining, by the first device, the distance between the first device and the second
20 device based on the first time difference and the second time difference comprises:

determining, by the first device, the distance between the first device and the second device
based on the first time difference, the second time difference, the third time difference, and the
fourth time difference.

14. The method according to claim 13, wherein when the first symbol and the second symbol
25 are carried on the first radio frame, the third symbol is carried on the second radio frame; or when
the first symbol is carried on the first radio frame, the second symbol and the third symbol are
carried on the second radio frame, wherein

the second radio frame is located after the first radio frame.

15. The method according to any one of claims 1 to 14, wherein the radio frame further
30 comprises a ranging symbol used to measure a distance between the first device and a third device,
or comprises a ranging symbol used to measure a distance between the second device and the third
device.

16. A measurement apparatus, wherein the measurement apparatus is used in a first device,
and the apparatus comprises:

35 a sending module, configured to send a first symbol;

a receiving module, configured to receive a second symbol from a second device, wherein the first symbol and the second symbol are carried on a same radio frame or different radio frames; and

a processing module, configured to determine a first time difference, wherein the first time difference is a time interval between a first moment at which the first device sends the first symbol and a second moment at which the first device receives the second symbol, and the first time difference is used to determine a distance between the first device and the second device.

17. The apparatus according to claim 16, wherein the receiving module is further configured to receive first time information from the second device, wherein the first time information is used to determine a second time difference, and the second time difference is a time interval between a third moment at which the second device receives the first symbol and a fourth moment at which the second device sends the second symbol; and

the processing module is further configured to determine the distance between the first device and the second device based on the first time difference and the second time difference.

18. The apparatus according to claim 16 or 17, wherein the first symbol and/or the second symbol are/is generated based on a ZC sequence, and the ZC sequence is generated in the following manner:

$$d(n) = \begin{cases} \exp\left(-j\frac{\pi un(n+1)}{41}\right), n = 0, 1, \dots, 18 \\ 0, n = 19 \\ \exp\left(-j\frac{\pi un(n+1)}{41}\right), n = 20, 21, \dots, 38 \end{cases}, \text{ wherein}$$

n represents a subcarrier sequence number, u is a preset value, and $d(n)$ represents a ZC sequence on an n^{th} subcarrier.

19. A measurement apparatus, comprising a processor and a memory, wherein the memory stores computer instructions; and

the processor is configured to execute the computer instructions stored in the memory, to enable the communication apparatus to perform the method according to any one of claims 1 to 15.

20. A computer-readable storage medium, storing a computer program or instruction, and when the computer program or instruction is run, the method according to any one of claims 1 to 15 is implemented.