COMMUNICATION METHOD AND APPARATUS

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority to Chinese Patent Application No. 202410333638.0, filed with the China National Intellectual Property Administration on March 21, 2024 and entitled "COMMUNICATION METHOD AND APPARATUS", 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 and apparatus.

BACKGROUND

[0003] Communication sequences widely exist in the long term evolution (long term evolution, LTE)/new radio (new radio, NR) standard protocol. Common sequence evaluation indicators include: auto-correlation, cross-correlation, sequence capacity, frequency offset resistance, peak-to-average power ratio, dual-domain constant modulus, and the like.

[0004] Currently, in the LTE/NR protocol, a physical random access channel (physical random access channel, PRACH) uses a ZC (Zadoff-Chu) sequence; a demodulation reference signal (demodulation reference signal, DMRS) corresponding to data carried on an orthogonal frequency division multiplexing (orthogonal frequency division multiplexing, OFDM) waveform uses a Gold sequence; a DMRS corresponding to data carried on a discrete Fourier transform spread orthogonal frequency division multiplexing (discrete Fourier transform spread orthogonal frequency division multiplexing, DFT-S-OFDM) waveform uses the ZC sequence; a sounding reference signal (sounding reference signal, SRS) uses the ZC sequence; and a synchronization signal uses an m sequence (primary synchronization signal) and the Gold sequence (secondary synchronization signal). The Gold sequence has a large sequence capacity but exhibits randomized interference. The ZC sequence is a Sarwate (Sarwate) bound-achieving sequence with an ideal auto-correlation function, but an ambiguity function has a multi-peak characteristic, and a sequence capacity is limited.

[0005] With the development of communication, communication scenarios continue to

diversify, and the scale continues to expand. Therefore, a sequence applicable to a plurality of physical channels and physical signals is urgently needed to improve communication performance.

SUMMARY

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

[0007] According to a first aspect, this application provides a communication method. The method may be applied to a first communication apparatus, and the first communication apparatus may be a signal transmitting end. The first communication apparatus may be a terminal device, or may be a processor, a chip, a system-on-chip, a circuit, a functional module, or the like in the terminal device. Alternatively, the first communication apparatus may be an access network device, or may be a processor, a chip, a system-on-chip, a circuit, a functional module, or the like in the access network device. The method may include: determining a first signal, and sending the first signal. The first signal is determined based on a first sequence, and the first sequence is determined based on a base sequence and an auxiliary sequence. The base sequence is an ideal auto-correlation function sequence, the auxiliary sequence is a cyclic shift sequence, and an ambiguity function of the first sequence is equal to zero within a maximum delay spread and a maximum Doppler spread; or the base sequence is an optimal auto-ambiguity function sequence, the auxiliary sequence is a quadratic polynomial exponential sequence, and an ambiguity function of the first sequence is less than or equal to an ambiguity function threshold within a maximum delay spread and a maximum Doppler spread.

[0008] According to the foregoing communication method, the first sequence is constructed based on the base sequence and the auxiliary sequence, so that the first sequence may be used for a plurality of physical channels and physical signals, and the first signal is transmitted based on the first sequence, thereby improving communication performance.

[0009] In a possible design, the first sequence is determined based on the base sequence and the auxiliary sequence, and satisfies:

$$r_{u,k,l}^{(\Delta_{\mathrm{T}},\Delta_{\mathrm{F}})}(n) = b_u(n) \cdot s_{u,k,l}^{(\Delta_{\mathrm{T}},\Delta_{\mathrm{F}})}(n), n = 0,1,\dots,N-1$$

where is the first sequence, is the base sequence, is the auxiliary sequence, represents a sequence length of the first sequence, represents the maximum delay spread, represents the maximum Doppler spread, represents a base sequence number of the base sequence, and and are integers.$r_{u,k,l}^{(\Delta_{\mathrm{T}},\Delta_{\mathrm{F}})}(n) b_u(n) s_{u,k,l}^{(\Delta_{\mathrm{T}},\Delta_{\mathrm{F}})}(n) N \Delta_{\mathrm{T}} \Delta_{\mathrm{F}} u k l$

[0010] The first sequence is constructed based on a unified expression, so that the first

sequence can be used for a plurality of physical channels and physical signals, and the first signal is transmitted based on the first sequence, thereby simplifying a communication protocol and improving communication performance.

[0011] In a possible design, the base sequence is the ideal auto-correlation function sequence, and satisfies:

$$b_u(n) = e^{-\frac{j\pi un(n+1)}{P}}, n = 0,1, \dots, N-1$$

or the base sequence is an optimal auto-ambiguity function sequence, and satisfies:

$$b_u(n) = e^{-\frac{j2\pi un^3}{P}}, n = 0,1, \dots, N-1$$

where is the base sequence, represents the sequence length of the first sequence, represents a maximum prime number that is not greater than the sequence length , represents the base sequence number of the base sequence, and .$b_u(n)NPNuu \in \{1,2, \dots, P-1\}$

[0012] According to this design, a base sequence having a wide-area zero-ambiguity characteristic or a full-domain low-ambiguity characteristic can be flexibly constructed, to further flexibly construct a first sequence applicable to a plurality of scenarios.

[0013] In a possible design, the auxiliary sequence satisfies:

$$s_{u,k,l}^{(\Delta_T,\Delta_F)}(n) = e^{-\frac{j2\pi f_{u,k}^{(\Delta_T,\Delta_F)} n^2}{P} - \frac{j2\pi g_{u,l}^{(\Delta_T,\Delta_F)} n}{N}}, n = 0,1, \dots, N-1$$

where is the auxiliary sequence, represents the sequence length of the first sequence, represents the maximum prime number that is not greater than the sequence length , represents the maximum delay spread, represents the maximum Doppler spread, represents the base sequence number of the base sequence, represents an auxiliary sequence number of the auxiliary sequence, represents a cyclic shift of the auxiliary sequence, represents an auxiliary sequence number index, and represents a cyclic shift index.$s_{u,k,l}^{(\Delta_T,\Delta_F)}(n)NPN\Delta_T\Delta_F uf_{u,k}^{(\Delta_T,\Delta_F)} g_{u,l}^{(\Delta_T,\Delta_F)} kl$

[0014] According to this design, a large-capacity zero-ambiguity zone or low-ambiguity zone characteristic can be flexibly constructed, to obtain a first sequence applicable to a plurality of scenarios.

[0015] In a possible design, the first signal is a random access preamble sequence, and that the first signal is determined based on the first sequence includes: The random access preamble sequence is the first sequence. In this way, the first sequence may be applied to a random access channel, thereby increasing a quantity of random access preambles, and enabling the random access preamble to support various Doppler frequency shifts.

[0016] In a possible design, when the ambiguity function of the first sequence is equal to zero within the maximum delay spread and the maximum Doppler spread, the auxiliary sequence number of the auxiliary sequence is equal to zero, and the cyclic shift of the auxiliary sequence

satisfies:$f_{u,k}^{(\Delta_{\mathrm{T}},\Delta_{\mathrm{F}})}\,g_{u,l}^{(\Delta_{\mathrm{T}},\Delta_{\mathrm{F}})}$

$$g_{u,l}^{(\Delta_{\mathrm{T}},\Delta_{\mathrm{F}})} = (\tau_l - u^{-1}\nu_l) \bmod P$$

where represents the maximum prime number that is not greater than , represents the sequence length of the first sequence, represents the maximum delay spread, represents the maximum Doppler spread, represents the base sequence number of the base sequence, , represents a minimum positive integer that satisfies , represents a cyclic shift in delay domain, represents a cyclic shift in Doppler domain, an ambiguity function of is equal to zero within the maximum delay spread and the maximum Doppler spread, and represents the cyclic shift index.$PNN\Delta_{\mathrm{T}}\Delta_{\mathrm{F}}uu \in \{1,2,\dots,P-1\}u^{-1}(u^{-1}u) \bmod P = 1\tau_l\nu_l g_{u,l}^{(\Delta_{\mathrm{T}},\Delta_{\mathrm{F}})}l$

[0017] According to this design, the ambiguity function of the first sequence can be equal to zero within the maximum delay spread and the maximum Doppler spread, thereby satisfying a zero-ambiguity zone characteristic.

[0018] In a possible design, a first sequence set is determined, where the first sequence set is obtained by sequentially traversing the cyclic shift of the auxiliary sequence and the base sequence number of the base sequence, and the first sequence set includes the first sequence. In this way, collisions between random access preambles used in different cells can be reduced, thereby reducing interference.

[0019] In a possible design, when the ambiguity function of the first sequence is less than or equal to the ambiguity function threshold within the maximum delay spread and the maximum Doppler spread, the auxiliary sequence number of the auxiliary sequence satisfies:$f_{u,k}^{(\Delta_{\mathrm{T}},\Delta_{\mathrm{F}})}$

$$f_{u,k}^{(\Delta_{\mathrm{T}},\Delta_{\mathrm{F}})} = 3uk\Delta_{\mathrm{T}}$$

and the cyclic shift of the auxiliary sequence satisfies:$g_{u,l}^{(\Delta_{\mathrm{T}},\Delta_{\mathrm{F}})}$

$$g_{u,l}^{(\Delta_{\mathrm{T}},\Delta_{\mathrm{F}})} = l\Delta_{\mathrm{F}}$$

where represents the maximum delay spread, represents the maximum Doppler spread, represents the base sequence number of the base sequence, , represents the maximum prime number that is not greater than , represents the sequence length of the first sequence, , and represents rounding down. $\Delta_{\mathrm{T}}\Delta_{\mathrm{F}}uu \in \{1,2,\dots,P-1\}PNNk \in \{0,1,\dots,\lfloor P/\Delta_{\mathrm{T}}\rfloor - 1\}, l \in \{0,1,\dots,\lfloor N/\Delta_{\mathrm{F}}\rfloor - 1\}\lfloor\ \ \rfloor$

[0020] According to this design, the ambiguity function of the first sequence can be less than or equal to the ambiguity function threshold within the maximum delay spread and the maximum Doppler spread, thereby satisfying a low-ambiguity zone characteristic.

[0021] In a possible design, a second sequence set is determined, where the second sequence set is obtained by sequentially traversing the cyclic shift of the auxiliary sequence, the auxiliary

sequence number of the auxiliary sequence, and the base sequence number of the base sequence, and the second sequence set includes the first sequence. In this way, a capacity of the first sequence is large, and interference between different sequences in the second sequence set is reduced as much as possible.

[0022] In a possible design, the sequence length of the first sequence is a prime number, and is equal to the sequence length . In this way, a maximum value of a cross-ambiguity function of any two first sequences satisfies the exponential sum theorem.NPN

[0023] In a possible design, the first signal is a demodulation reference signal; and when the base sequence is the ideal auto-correlation function sequence, and the ambiguity function of the first sequence is equal to zero within the maximum delay spread and the maximum Doppler spread, a sequence capacity of the first sequence is positively correlated with a square of the sequence length of the first sequence; or when the base sequence is the optimal auto-ambiguity function sequence, and the ambiguity function of the first sequence is less than or equal to the ambiguity function threshold within the maximum delay spread and the maximum Doppler spread, a sequence capacity of the first sequence is positively correlated with a cube of the sequence length of the first sequence. In this way, a sequence capacity and an interference level of the demodulation reference signal can be configured based on different scenarios.

[0024] In a possible design, when data corresponding to the first signal is carried on an orthogonal frequency division multiplexing waveform, the base sequence is the optimal auto-ambiguity function sequence, the auxiliary sequence is the quadratic polynomial exponential sequence, the ambiguity function of the first sequence is less than or equal to the ambiguity function threshold within the maximum delay spread and the maximum Doppler spread, and that the first signal is determined based on the first sequence includes: The first signal is determined by performing frequency domain comb mapping or frequency division multiplexing mapping on the first sequence. In this way, the first sequence can be applied to the demodulation reference signal, thereby improving demodulation reference signal Doppler resistance performance, and increasing a quantity of non-orthogonal demodulation reference signal ports.

[0025] In a possible design, the first signal is determined based on the first sequence, and satisfies:

$$r^{(m,q)}(n) = e^{-\frac{j2\pi vq}{Q}} \cdot r_{u,k,l}^{(\Delta_{\mathrm{T}},\Delta_{\mathrm{F}})}(n), n = 0,1,\dots,N-1$$

where is the first signal, is the first sequence, represents the sequence length of the first sequence, represents the maximum delay spread, represents the maximum Doppler spread, represents a length of a frequency domain orthogonal cover code, represents a transmission comb index, , represents a quantity of transmission combs, represents a symbol position of the frequency

domain orthogonal cover code, , represents a frequency domain orthogonal cover code index, , represents the base sequence number of the base sequence, , represents the maximum prime number that is not greater than the sequence length , represents the auxiliary sequence number index, and represents the cyclic shift index. $r^{(m,q)}(n) r_{u,k,l}^{(\Delta_T,\Delta_F)}(n) N \Delta_T \Delta_F Q m m \in \{0,1,\dots,M-1\} M q q \in \{0,1,\dots,Q-1\} v v \in \{0,1,\dots,Q-1\} u u \in \{1,2,\dots,P-1\} P N k l$

[0026] According to this design, the first sequence can be applied to the demodulation reference signal.

[0027] In a possible design, when the first signal is determined by performing frequency domain comb mapping on the first sequence, the auxiliary sequence number of the auxiliary sequence satisfies: $f_{u,k}^{(\Delta_T,\Delta_F)}$

$$f_{u,k}^{(\Delta_T,\Delta_F)} = \frac{3u[(kM+m)\Delta_F - m]}{M}$$

and the cyclic shift of the auxiliary sequence satisfies: $g_{u,l}^{(\Delta_T,\Delta_F)}$

$$g_{u,l}^{(\Delta_T,\Delta_F)} = l\Delta_T$$

where represents the maximum delay spread, represents the maximum Doppler spread, represents the quantity of transmission combs, represents the transmission comb index, represents the base sequence number of the base sequence, , represents the maximum prime number that is not greater than the sequence length , represents the sequence length of the first sequence, , and represents rounding down. $\Delta_T \Delta_F M m u u \in \{1,2,\dots,P-1\} P N N (k \in \{0,1,\dots,\lfloor P/\Delta_F \rfloor - 1\}, m \in \{0,1,\dots,M-1\}) \vee (k \in \{\lfloor P/\Delta_F \rfloor\}, m \in \{0,1,\dots,\lfloor MP/\Delta_F \rfloor - M\lfloor P/\Delta_F \rfloor - 1\}), l \in \{0,1,\dots,\lfloor N/\Delta_T \rfloor - 1\} \lfloor \quad \rfloor$

[0028] According to this design, frequency domain comb mapping of the first sequence can be implemented, to generate the first signal.

[0029] In a possible design, when the first signal is determined by performing frequency division multiplexing mapping on the first sequence, the auxiliary sequence number of the auxiliary sequence satisfies: $f_{u,k}^{(\Delta_T,\Delta_F)}$

$$f_{u,k}^{(\Delta_T,\Delta_F)} = \frac{3u[(kMQ+mQ+q)\Delta_F - (mQ+q)]}{MQ}$$

and the cyclic shift of the auxiliary sequence satisfies: $g_{u,l}^{(\Delta_T,\Delta_F)}$

$$g_{u,l}^{(\Delta_T,\Delta_F)} = l\Delta_T$$

where represents the maximum delay spread, represents the maximum Doppler spread, represents the quantity of transmission combs, represents the length of the frequency domain orthogonal cover code, represents the transmission comb index, represents the symbol position of

the frequency domain orthogonal cover code, , represents the base sequence number of the base sequence, , represents the maximum prime number that is not greater than the sequence length , represents the sequence length of the first sequence, , and represents rounding down. $\Delta_{\mathrm{T}}\Delta_{\mathrm{F}}MQmqq \in \{0,1,\dots,Q-1\}uu \in \{1,2,\dots,P-1\}PNN(k \in \{0,1,\dots,\lfloor P/\Delta_{\mathrm{F}} \rfloor - 1\}, m \in \{0,1,\dots,M-1\}) \vee (k \in \{\lfloor P/\Delta_{\mathrm{F}} \rfloor\}, m \in \{0,1,\dots,\lfloor MP/\Delta_{\mathrm{F}} \rfloor - M\lfloor P/\Delta_{\mathrm{F}} \rfloor - 1\}), l \in \{0,1,\dots,\lfloor N/\Delta_{\mathrm{T}} \rfloor - 1\}\lfloor \quad \rfloor$

[0030] According to this design, frequency division multiplexing mapping of the first sequence can be implemented, to generate the first signal.

[0031] In a possible design, when data corresponding to the first signal is carried on a discrete Fourier transform spread orthogonal frequency division multiplexing waveform, the base sequence is the ideal auto-correlation function sequence, the auxiliary sequence is the cyclic shift sequence, and the ambiguity function of the first sequence is equal to zero within the maximum delay spread and the maximum Doppler spread, and that the first signal is determined based on the first sequence includes: The first signal is determined by performing frequency domain comb mapping on the first sequence. In this way, the first sequence can be applied to the demodulation reference signal.

[0032] In a possible design, the first signal is determined based on the first sequence, and satisfies:

$$r^{(m,0)}(n) = r_{u,k,l}^{(\Delta_{\mathrm{T}},\Delta_{\mathrm{F}})}(n), n = 0,1,\dots,N-1$$

where is the first signal, is the first sequence, represents the sequence length of the first sequence, represents the maximum delay spread, represents the maximum Doppler spread, represents the transmission comb index, , represents the quantity of transmission combs, represents the base sequence number of the base sequence, , represents the maximum prime number that is not greater than the sequence length , represents the auxiliary sequence number index, and represents the cyclic shift index. $r^{(m,0)}(n)r_{u,k,l}^{(\Delta_{\mathrm{T}},\Delta_{\mathrm{F}})}(n)N\Delta_{\mathrm{T}}\Delta_{\mathrm{F}}\,mm \in \{0,1,\dots,M-1\}Muu \in \{1,2,\dots,P-1\}PNkl$

[0033] According to this design, the first sequence can be applied to the demodulation reference signal.

[0034] In a possible design, the auxiliary sequence number of the auxiliary sequence is equal to zero, and the cyclic shift of the auxiliary sequence satisfies:$f_{u,k}^{(\Delta_{\mathrm{T}},\Delta_{\mathrm{F}})}g_{u,l}^{(\Delta_{\mathrm{T}},\Delta_{\mathrm{F}})}$

$$g_{u,l}^{(\Delta_{\mathrm{T}},\Delta_{\mathrm{F}})} = \left(\tau_l^{(m)} - uv_l^{(m)}\right) \bmod P$$

[0035] P represents the maximum prime number that is not greater than the sequence length , represents the sequence length of the first sequence, represents the maximum delay spread, represents the maximum Doppler spread, represents the transmission comb index, , represents the

quantity of transmission combs, represents the base sequence number of the base sequence, , represents a cyclic shift in delay domain, represents a cyclic shift in Doppler domain, an ambiguity function of is equal to zero within the maximum delay spread and the maximum Doppler spread, and represents the cyclic shift index. $NN\Delta_{\mathrm{T}}\Delta_{\mathrm{F}}mm \in \{0,1,\dots,M-1\}Muu \in \{1,2,\dots,P-1\}\tau_l^{(m)}\nu_l^{(m)}g_{u,l}^{(\Delta_{\mathrm{T}},\Delta_{\mathrm{F}})}l$

[0036] According to this design, frequency domain comb mapping of the first sequence can be implemented, to generate the first signal.

[0037] In a possible design, the first signal is a sounding reference signal, and that the first signal is determined based on the first sequence includes: The first signal is determined by performing frequency domain comb mapping on the first sequence. In this way, the first sequence can be applied to the sounding reference signal, and a peak-to-average power ratio of a time domain signal is reduced while a quantity of sounding reference signal ports is increased.

[0038] In a possible design, the first signal is determined based on the first sequence, and satisfies:

$$r^{(p_i)}(n,l') = w_{\mathrm{TDM}}^{(p_i)}(l')r_{u,k,l}^{(\Delta_{\mathrm{T}},\Delta_{\mathrm{F}})}(n), n = 0,1,\dots,N-1$$

where is the first signal, represents a time domain orthogonal cover code, is the first sequence, represents an antenna port number, represents a time domain symbol index, represents the sequence length of the first sequence, represents the maximum delay spread, represents the maximum Doppler spread, represents the base sequence number of the base sequence, , represents the maximum prime number that is not greater than the sequence length , represents the auxiliary sequence number index, and represents the cyclic shift index.$r^{(p_i)}(n,l')w_{\mathrm{TDM}}^{(p_i)}(l')r_{u,k,l}^{(\Delta_{\mathrm{T}},\Delta_{\mathrm{F}})}(n)p_il'N\Delta_{\mathrm{T}}\Delta_{\mathrm{F}}uu \in \{1,2,\dots,P-1\}PNkl$

[0039] According to this design, the first sequence can be applied to the sounding reference signal.

[0040] In a possible design, when the ambiguity function of the first sequence is equal to zero within the maximum delay spread and the maximum Doppler spread, the auxiliary sequence number of the auxiliary sequence is equal to zero, and the cyclic shift of the auxiliary sequence satisfies:$f_{u,k}^{(\Delta_{\mathrm{T}},\Delta_{\mathrm{F}})}g_{u,l}^{(\Delta_{\mathrm{T}},\Delta_{\mathrm{F}})}$

$$g_{u,l}^{(\Delta_{\mathrm{T}},\Delta_{\mathrm{F}})} = \left(\tau_l^{(m)} - u\nu_l^{(m)}\right) \bmod P$$

where represents the maximum prime number that is not greater than the sequence length , represents the sequence length of the first sequence, represents the maximum delay spread, represents the maximum Doppler spread, represents the transmission comb index, , represents the quantity of transmission combs, represents the base sequence number of the base sequence, ,

represents a cyclic shift in delay domain, represents a cyclic shift in Doppler domain, an ambiguity function of is equal to zero within the maximum delay spread and the maximum Doppler spread, and represents the cyclic shift index. $PNN\Delta_{\mathrm{T}}\Delta_{\mathrm{F}}mm \in \{0,1,\dots,M-1\}Muu \in \{1,2,\dots,P-1\}\tau_l^{(m)}\nu_l^{(m)}g_{u,l}^{(\Delta_{\mathrm{T}},\Delta_{\mathrm{F}})}l$

[0041] According to this design, the ambiguity function of the first sequence can be equal to zero within the maximum delay spread and the maximum Doppler spread, thereby satisfying a zero-ambiguity zone characteristic.

[0042] In a possible design, when the ambiguity function of the first sequence is less than or equal to the ambiguity function threshold within the maximum delay spread and the maximum Doppler spread , the auxiliary sequence number of the auxiliary sequence satisfies:$f_{u,k}^{(\Delta_{\mathrm{T}},\Delta_{\mathrm{F}})}$

$$f_{u,k}^{(\Delta_{\mathrm{T}},\Delta_{\mathrm{F}})} = \frac{3u[(kM+m)\Delta_{\mathrm{F}} - m]}{M}$$

and the cyclic shift of the auxiliary sequence satisfies:$g_{u,l}^{(\Delta_{\mathrm{T}},\Delta_{\mathrm{F}})}$

$$g_{u,l}^{(\Delta_{\mathrm{T}},\Delta_{\mathrm{F}})} = l\Delta_{\mathrm{T}}$$

where represents the maximum prime number that is not greater than the sequence length , represents the sequence length of the first sequence, represents the maximum delay spread, represents the maximum Doppler spread, represents the quantity of transmission combs, represents the transmission comb index, , represents the base sequence number of the base sequence, , , and represents rounding down. $PNN\Delta_{\mathrm{T}}\Delta_{\mathrm{F}}Mmm \in \{0,1,\dots,M-1\}uu \in \{1,2,\dots,P-1\}(k \in \{0,1,\dots,\lfloor P/\Delta_{\mathrm{F}}\rfloor - 1\}, m \in \{0,1,\dots,M-1\}) \vee (k \in \{\lfloor P/\Delta_{\mathrm{F}}\rfloor\}, m \in \{0,1,\dots,\lfloor MP/\Delta_{\mathrm{F}}\rfloor - M\lfloor P/\Delta_{\mathrm{F}}\rfloor - 1\}), l \in \{0,1,\dots,\lfloor N/\Delta_{\mathrm{T}}\rfloor - 1\}\lfloor \quad \rfloor$

[0043] According to this design, the ambiguity function of the first sequence can be less than or equal to the ambiguity function threshold within the maximum delay spread and the maximum Doppler spread, thereby satisfying a low-ambiguity zone characteristic.

[0044] In a possible design, a sounding reference signal set is determined, where the sounding reference signal set is determined based on a first parameter, a peak-to-average power ratio of a sounding reference signal in the sounding reference signal set is less than a first threshold, and the sounding reference signal set includes the first signal. In this way, the peak-to-average power ratio of the time domain signal can be reduced while the quantity of sounding reference signal ports is increased.

[0045] In a possible design, the first parameter includes at least one of the following: a cubic metric of a time domain signal, power corresponding to a complementary cumulative distribution function of a time domain signal, or a peak value of a time domain signal. In this way, the sounding reference signal set can be determined according to a specific criterion.

[0046] In a possible design, first indication information is transmitted, where the first indication information indicates that the base sequence is the ideal auto-correlation function sequence or indicates that the base sequence is the optimal auto-ambiguity function sequence. In this way, the base sequence can be flexibly configured, and the first sequence can be obtained based on the base sequence.

[0047] According to a second aspect, this application provides a communication method. The method may be applied to a second communication apparatus, and the second communication apparatus may be a signal receiving end. The second communication apparatus may be an access network device, or may be a processor, a chip, a system-on-chip, a circuit, a functional module, or the like in the access network device. Alternatively, the second communication apparatus may be a terminal device, or may be a processor, a chip, a system-on-chip, a circuit, a functional module, or the like in the terminal device. The method may include: receiving a first signal. The first signal is determined based on a first sequence, and the first sequence is determined based on a base sequence and an auxiliary sequence. The base sequence is an ideal auto-correlation function sequence, the auxiliary sequence is a cyclic shift sequence, and an ambiguity function of the first sequence is equal to zero within a maximum delay spread and a maximum Doppler spread; or the base sequence is an optimal auto-ambiguity function sequence, the auxiliary sequence is a quadratic polynomial exponential sequence, and an ambiguity function of the first sequence is less than or equal to an ambiguity function threshold within a maximum delay spread and a maximum Doppler spread.

[0048] For each possible design of the second aspect, refer to a corresponding possible design of the first aspect, and repeated parts are not described.

[0049] According to a third aspect, this application further provides a communication apparatus. The communication apparatus may be a first communication apparatus, and the first communication apparatus may be a terminal device, or may be a processor, a chip, a system-on-chip, a circuit, a functional module, or the like in the terminal device. Alternatively, the first communication apparatus may be an access network device, or may be a processor, a chip, a system-on-chip, a circuit, a functional module, or the like in the access network device. The communication apparatus has a function of implementing the method in the first aspect or the possible design examples of the first aspect. The function may be implemented by hardware, or may be implemented by hardware executing corresponding software. The hardware or the software includes one or more modules corresponding to the foregoing function.

[0050] In a possible design, a structure of the communication apparatus may include a processing unit, and optionally, may further include a transceiver unit. These units may perform functions of the method in the first aspect or the possible design examples of the first aspect.

Details are not described herein again.

[0051] In a possible design, a structure of the communication apparatus includes one or more processors, and optionally further includes a memory and/or a transceiver. The transceiver is configured to receive and send data, a message, information, or the like, and is configured to communicate and interact with another device in a system. The processor is configured to support the communication apparatus in performing corresponding functions in the first aspect or the possible design examples of the first aspect. The memory is coupled to the processor, and stores program instructions and data necessary for the communication apparatus.

[0052] According to a fourth aspect, this application further provides a communication apparatus. The communication apparatus may be a second communication apparatus, and the second communication apparatus may be an access network device, or may be a processor, a chip, a system-on-chip, a circuit, a functional module, or the like in the access network device. Alternatively, the second communication apparatus may be a terminal device, or may be a processor, a chip, a system-on-chip, a circuit, a functional module, or the like in the terminal device. The communication apparatus has a function of implementing the method in the second aspect or the possible design examples of the second aspect. The function may be implemented by hardware, or may be implemented by hardware executing corresponding software. The hardware or the software includes one or more modules corresponding to the foregoing function.

[0053] In a possible design, a structure of the communication apparatus may include a processing unit, and optionally, may further include a transceiver unit. These units may perform functions of the method in the second aspect or the possible design examples of the second aspect. Details are not described herein again.

[0054] In a possible design, a structure of the communication apparatus includes one or more processors, and optionally further includes a memory and/or a transceiver. The transceiver is configured to receive and send data, a message, information, or the like, and is configured to communicate and interact with another device in a system. The processor is configured to support the communication apparatus in performing corresponding functions in the second aspect or the possible design examples of the second aspect. The memory is coupled to the processor, and stores program instructions and data necessary for the communication apparatus.

[0055] According to a fifth aspect, an embodiment of this application provides a communication system, and the communication system may include a first communication apparatus and a second communication apparatus. The first communication apparatus may be configured to implement the method in the first aspect or the possible design examples of the first aspect. The second communication apparatus may be configured to implement the method in the second aspect or the possible design examples of the second aspect.

[0056] According to a sixth aspect, an embodiment of this application provides a computer-readable storage medium. The computer-readable storage medium stores program instructions, and when the program instructions are run on a computer, the computer is caused to perform the method in the first aspect and any possible design of the first aspect or in the second aspect and any possible design of the second aspect in embodiments of this application. For example, the computer-readable storage medium may be any usable medium that can be accessed by the computer. As an example rather than a limitation, the computer-readable medium may include a non-transitory computer-readable medium, a random access memory (random access memory, RAM), a read-only memory (read-only memory, ROM), an electrically erasable programmable read-only memory (electrically EPROM, EEPROM), a CD-ROM or another optical disk storage, a magnetic disk storage medium or another magnetic storage device, or any other medium that can carry or store desired program code in a form of instructions or a data structure and that can be accessed by the computer.

[0057] According to a seventh aspect, an embodiment of this application provides a computer program product, including a computer program or instructions, and when the computer program or the instructions are run on a computer, the method in the first aspect or any possible design of the first aspect or in the second aspect or any possible design of the second aspect is performed.

[0058] According to an eighth aspect, this application further provides a chip or a system-on-chip, including one or more processors, where the processor is coupled to at least one memory, and is configured to read and execute program instructions stored in the memory, to cause the chip or the system-on-chip to implement the method in the first aspect or any possible design of the first aspect or in the second aspect or any possible design of the second aspect.

[0059] For each of the third aspect to the eighth aspect and technical effects that can be achieved in the aspects, refer to the foregoing descriptions of the technical effects that can be achieved in the first aspect, the possible solutions in the first aspect, the second aspect, or the possible solutions in the second aspect. Details are not described herein again.

BRIEF DESCRIPTION OF DRAWINGS

[0060] FIG. 1 is a diagram of an architecture of a communication system according to this application;

[0061] FIG. 2 is a flowchart of a communication method according to this application;

[0062] FIG. 3 is a diagram of a structure of a communication apparatus according to this application; and

[0063] FIG. 4 is a diagram of a structure of a communication apparatus according to this

application.

DESCRIPTION OF EMBODIMENTS

[0064] Embodiments of this application provide a communication method and apparatus to improve communication performance. The method and the apparatus in this application are based on a same technical concept. Because problem-resolving principles of the method and the apparatus are similar, mutual reference may be made to implementation of the apparatus and the method, and repeated parts are not described.

[0065] In the description of this application, words such as "first" and "second" are merely used for distinguishing between descriptions, and cannot be understood as an indication or implication of relative importance, nor can it be understood as an indication or implication of an order.

[0066] In the description of this application, "at least one (type)" means one or more (types), and "a plurality of (types)" means two or more (types). "At least one of the following items" or a similar expression thereof means any combination of these items, including any combination of singular items or plural items. 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.

[0067] In the descriptions of this application, "and/or" describes an association relationship between associated objects, and indicates that three relationships may exist. For example, A and/or B may indicate the following cases: Only A exists, both A and B exist, and only B exists, where A and B may be singular or plural. "/" indicates "or". For example, a/b indicates a or b.

[0068] To describe the technical solutions in embodiments of this application more clearly, the following describes a communication method and apparatus provided in embodiments of this application in detail with reference to the accompanying drawings.

[0069] The technical solutions in embodiments of this application may be applied to various communication systems, for example, a universal mobile telecommunications system (universal mobile telecommunications system, UMTS), a wireless local area network (wireless local area network, WLAN), a wireless fidelity (wireless fidelity, Wi-Fi) system, a fourth generation (4th generation, 4G) mobile communication system (for example, a long term evolution (long term evolution, LTE) system), a fifth generation (5th generation, 5G) mobile communication system (for example, a new radio (new radio, NR) system), and a future evolved communication system (for example, a sixth generation (6th generation, 6G) mobile communication system).

[0070] For example, FIG. 1 is a diagram of an architecture of a possible communication system to which embodiments of this application are applicable. As shown in FIG. 1, a communication

system 10 may include a radio access network (radio access network, RAN) 100 and a core network (core network, CN) 200. Optionally, the communication system 10 may further include the Internet 300.

[0071] The RAN 100 includes at least one RAN node (for example, 110a and 110b in FIG. 1 are collectively referred to as 110) and at least one terminal device (for example, 120a to 120j in FIG. 1 are collectively referred to as 120). The RAN 100 may further include another RAN node, for example, a wireless relay device and/or a wireless backhaul device (not shown in FIG. 1). The terminal device 120 is connected to the RAN node 110 in a wireless manner. The RAN node 110 is connected to the core network 200 in a wireless or wired manner. A core network device in the core network 200 and the RAN node 110 in the RAN 100 may be different physical devices, or may be a same physical device that integrates a logical function of the core network and a logical function of the radio access network.

[0072] The RAN 100 may be a cellular system related to the 3rd generation partnership project (3rd generation partnership project, 3GPP), for example, a 4G or 5G mobile communication system, or a future-oriented evolved system (for example, a 6G mobile communication system). The RAN 100 may alternatively be an open radio access network (open RAN, O-RAN or ORAN), a cloud radio access network (cloud radio access network, CRAN), or a Wi-Fi system. The RAN 100 may alternatively be a communication system that integrates two or more of the foregoing systems.

[0073] The RAN node 110 sometimes may also be referred to as a RAN entity, an access node, or the like, and forms a part of the communication system, to help the terminal device implement radio access. A plurality of RAN nodes 110 in the communication system 10 may be nodes of a same type, or may be nodes of different types. In some scenarios, roles of the RAN node 110 and the terminal device 120 are relative. For example, a network element 120i in FIG. 1 may be a helicopter or an uncrewed aerial vehicle, and may be configured as a mobile base station. For a terminal 120j that accesses the RAN 100 through the network element 120i, the network element 120i is a base station. However, for a base station 110a, the network element 120i is a terminal device. Both the RAN node 110 and the terminal device 120 are sometimes referred to as communication apparatuses. For example, in FIG. 1, the network elements 110a and 110b may be understood as communication apparatuses having base station functions, and the network elements 120a to 120j may be understood as communication apparatuses having terminal device functions.

[0074] The RAN node may also be expressed differently, for example, a network device. In this application, unless otherwise specified, a network device is used for description below.

[0075] In a possible scenario, the network device may also be referred to as an access network device. The access network device may be a base station (base station), an evolved NodeB

(evolved NodeB, eNodeB), an access point (access point, AP), a transmission reception point (transmission reception point, TRP), a next generation NodeB (next generation NodeB, gNB), a next generation base station in a 6G mobile communication system, a base station in a future mobile communication system, an access node in a Wi-Fi system, or the like. The access network device may be a macro base station (for example, 110a in FIG. 1), a micro base station or an indoor station (for example, 110b in FIG. 1), a relay node or a donor node, or a radio controller in a CRAN scenario. Optionally, the access network device may alternatively be a server, a wearable device, a vehicle, a vehicle-mounted device, or the like. For example, an access network device in a vehicle to everything (vehicle to everything, V2X) technology may be a road side unit (road side unit, RSU). All or a part of functions of the access network device in this application may alternatively be implemented through a software function running on hardware, or may be implemented through an instantiated virtualization function on a platform (for example, a cloud platform). The access network device in this application may alternatively be a logical node, a logical module, or software that can implement all or the part of the functions of the access network device.

[0076] In another possible scenario, a plurality of access network devices collaborate to assist a terminal device in radio access, with different access network devices each implementing a part of functions of a base station. For example, the access network device may be a central unit (central unit, CU), a distributed unit (distributed unit, DU), a CU-control plane (control plane, CP), a CU-user plane (user plane, UP), or a radio unit (radio unit, RU). The CU and the DU may be separately arranged, or may be included in a same network element, for example, a baseband unit (baseband unit, BBU). The RU may be included in a radio frequency device or a radio frequency unit, for example, included in a remote radio unit (remote radio unit, RRU), an active antenna unit (active antenna unit, AAU), or a remote radio head (remote radio head, RRH).

[0077] In different systems, the CU (or the CU-CP and the CU-UP), the DU, or the RU may also have different names, but a person skilled in the art may understand meanings thereof. For example, in an ORAN system, the CU may also be referred to as an open CU (open CU, O-CU), the DU may also be referred to as an open DU (open DU, O-DU), the CU-CP may also be referred to as an open CU-CP (open CU-CP, O-CU-CP), the CU-UP may also be referred to as an open CU-UP (open CU-UP, O-CU-UP), and the RU may also be referred to as an open RU (open RU, O-RU). Any of the CU (or the CU-CP or the CU-UP), the DU, and the RU in this application may be implemented by a software module, a hardware module, or a combination of the software module and the hardware module.

[0078] The terminal device may also be referred to as user equipment (user equipment, UE), a mobile station, a mobile terminal, or the like. The terminal device may be widely used in various scenarios, for example, device-to-device (device-to-device, D2D), vehicle-to-everything (vehicle-

to-everything, V2X) communication, machine-type communication (machine-type communication, MTC), an internet of things (internet of things, IoT), virtual reality, augmented reality, industrial control, autonomous driving, telemedicine, a smart grid, smart furniture, smart office, smart wearable, smart transportation, and a smart city. The terminal device may be a mobile phone, a tablet computer, a computer with a wireless transceiver function, a wearable device, a vehicle, an uncrewed aerial vehicle, a helicopter, an airplane, a ship, a robot, a mechanical arm, a smart home device, or the like. A device form of the terminal device is not limited in embodiments of this application.

[0079] In some scenarios, the network device may send a downlink signal to the terminal device, and the terminal device may send an uplink signal to the network device. In addition, network devices may also communicate with each other, and terminal devices may also communicate with each other.

[0080] The communication systems described in embodiments of this application are intended to describe the technical solutions in embodiments of this application more clearly, but do not constitute a limitation on the technical solutions provided in embodiments of this application. It can be learned by a person of ordinary skill in the art that the technical solutions provided in embodiments of this application are also applicable to similar technical problems with evolution of a network architecture and emergence of a new service scenario.

[0081] The following first explains and describes related terms and technologies in embodiments of this application. It should be noted that these explanations are intended to make embodiments of this application easier to understand, but should not be considered as limitations on the protection scope claimed in this application.

[0082] (1) Ambiguity function

[0083] The ambiguity function includes two types: an auto-ambiguity function (auto-ambiguity function, AAF) and a cross-ambiguity function (cross-ambiguity function, CAF).

[0084] The auto-ambiguity function refers to an inner product between a signal #A and a signal #B, where the signal #B is a signal obtained by performing delay transformation and Doppler shift transformation on the signal #A.

[0085] For example, the signal #A is a sequence , and an auto-ambiguity function of the sequence satisfies the following formula:$s(n)s(n)$

$$A(\tau,\nu)=\sum_{n=0}^{N-1}s(n)s^{*}[(n-\tau)\bmod N]e^{j2\pi n\nu/N}$$

where represents the auto-ambiguity function, represents the sequence (that is, the signal #B) obtained by performing delay transformation and Doppler frequency shift

transformation, represents a sequence length, represents a delay, , represents a Doppler frequency shift, and .$A(\tau,\nu)s^*[(n-\tau) \bmod N]e^{j2\pi n\nu/N}s(n)N\tau\tau \in \{0,1,\dots,N-1\}\nu\nu \in \{0,1,\dots,N-1\}$

[0086] For a constant modulus sequence , an optimal auto-ambiguity function sequence is defined as , where an operator represents a logical or.$|s(n)| = 1, n = 0,1,\dots,N-1|A(\tau,\nu)| = \begin{cases} N, & \tau = 0, \nu = 0 \\ \leq \sqrt{N}, & (\tau \neq 0) \vee (\nu \neq 0) \end{cases} \vee$

[0087] The cross-ambiguity function refers to an inner product between a signal #C and a signal #B, where the signal #B is a signal obtained by performing delay transformation and Doppler shift transformation on a signal #A, and the signal #A and the signal #C are in a same sequence set.

[0088] (2) Correlation function

[0089] The correlation function includes an auto-correlation function (auto-correlation function, ACF) and a cross-correlation function (cross-correlation function, CCF).

[0090] The auto-correlation function refers to an inner product between a signal #A and a signal #B, where the signal #B is a signal obtained by performing delay transformation on the signal #A.

[0091] For example, the signal #A is a sequence , and an auto-correlation function of the sequence satisfies the following formula:$s(n)s(n)$

$$C(\tau) = \sum_{n=0}^{N-1} s(n)s^*[(n-\tau) \bmod N]$$

where represents the auto-correlation function, represents the sequence (that is, the signal #B) obtained by performing delay transformation, represents a sequence length, represents a delay, , represents a Doppler frequency shift, and . $C(\tau)s^*[(n-\tau) \bmod N]s(n)N\tau\tau \in \{0,1,\dots,N-1\}\nu\nu \in \{0,1,\dots,N-1\}$

[0092] For a constant modulus sequence $|s(n)| = 1, n = 0,1,\dots,N-1$, an ideal auto-correlation function sequence is defined as $|C(\tau)| = \begin{cases} N, & \tau = 0 \\ 0, & \tau \neq 0 \end{cases}$.

[0093] The cross-correlation function refers to an inner product between a signal #C and a signal #B, where the signal #B is a signal obtained by performing delay transformation on a signal #A, and the signal #A and the signal #C are in a same sequence set.

[0094] (3) Zero-ambiguity zone (zero-ambiguity zone, ZAZ)

[0095] The zero-ambiguity zone means that an ambiguity function is equal to zero within a maximum delay spread and a maximum Doppler spread.

[0096] (4) Low-ambiguity zone (low-ambiguity zone, LAZ)

[0097] The low-ambiguity zone means that an ambiguity function value is less than or equal

to a preset ambiguity function threshold within the maximum delay spread and the maximum Doppler spread.

[0098] (5) Zero-correlation zone (zero-correlation zone, ZCZ)

[0099] The zero-correlation zone means that a correlation function is equal to zero within a maximum delay spread.

[00100] (6) Low-correlation zone (low-correlation zone, LCZ)

[00101] The low-correlation zone means that a correlation function value is less than a preset correlation function threshold within a maximum delay spread.

[00102] (7) Sequence capacity

[00103] The sequence capacity refers to a quantity of sequences included in a sequence set.

[00104] (8) Frequency domain comb mapping

[00105] The frequency domain comb mapping refers to resource mapping at equal intervals in frequency domain, for example, a demodulation reference signal (demodulation reference signal, DMRS) configuration type 1 in an NR protocol.

[00106] (9) Frequency division multiplexing mapping

[00107] The frequency division multiplexing mapping means that a sequence is mapped to different resources in frequency domain, for example, a DMRS configuration type 2 in an NR protocol.

[00108] The following describes in detail the communication method provided in embodiments of this application. According to the communication method in embodiments of this application, a first sequence may be constructed based on a base sequence and an auxiliary sequence, so that the first sequence may be used for a plurality of physical channels and physical signals, and a first signal is transmitted based on the first sequence, thereby improving communication performance.

[00109] In embodiments of this application, a device that sends the first signal may be understood as a signal transmitting end, and a device that receives the first signal may be understood as a signal receiving end. In this application, the transmitting end may be a first communication apparatus, and the receiving end may be a second communication apparatus. In some scenarios, the first communication apparatus may be an access network device, or may be a processor, a chip, a system-on-chip, a circuit, a functional module, or the like in the access network device, and the second communication apparatus may be a terminal device, or may be a processor, a chip, a system-on-chip, a circuit, a functional module, or the like in the terminal device. In some other scenarios, the first communication apparatus may be a terminal device, or may be a processor, a chip, a system-on-chip, a circuit, a functional module, or the like in the terminal device, and the second communication apparatus may be an access network device, or may be a processor, a chip, a system-on-chip, a circuit, a functional module, or the like in the access network device. In the

following descriptions of this application, the first communication apparatus and the second communication apparatus are used as examples to describe the communication method provided in embodiments of this application.

[00110] Based on the foregoing descriptions, an embodiment of this application provides a communication method. As shown in FIG. 2, a procedure of the method may include the following steps.

[00111] Step 201: A first communication apparatus determines a first signal. The first signal is determined based on a first sequence, and the first sequence is determined based on a base sequence and an auxiliary sequence. The base sequence is an ideal auto-correlation function sequence, the auxiliary sequence is a cyclic shift sequence, and an ambiguity function of the first sequence is equal to zero within a maximum delay spread and a maximum Doppler spread; or the base sequence is an optimal auto-ambiguity function sequence, the auxiliary sequence is a quadratic polynomial exponential sequence, and an ambiguity function of the first sequence is less than or equal to an ambiguity function threshold within a maximum delay spread and a maximum Doppler spread.

[00112] It should be understood that sequence names of the base sequence (base sequence) and the auxiliary sequence in embodiments of this application are merely examples, and descriptions of the base sequence and the auxiliary sequence may also be replaced with other names. For example, the base sequence may also be referred to as a root sequence. This is not limited in this application.

[00113] That the ambiguity function of the first sequence is equal to zero within the maximum delay spread and the maximum Doppler spread may also be understood as that the first sequence satisfies a zero-ambiguity zone, or may be understood as that the first sequence is a zero-ambiguity zone sequence. That the ambiguity function of the first sequence is less than or equal to the ambiguity function threshold within the maximum delay spread and the maximum Doppler spread may also be understood as that the first sequence satisfies a low-ambiguity zone, or may be understood as that the first sequence is a low-ambiguity zone sequence.

[00114] Optionally, the ambiguity function threshold may be , and represents a sequence length of the first sequence. Certainly, the ambiguity function threshold may alternatively be another value. This is not limited in this application.$\sqrt{N}N$

[00115] In an optional implementation, the first sequence is determined based on the base sequence and the auxiliary sequence, and may satisfy the following formula 1:

$$r_{u,k,l}^{(\Delta_T,\Delta_F)}(n) = b_u(n) \cdot s_{u,k,l}^{(\Delta_T,\Delta_F)}(n), n = 0,1,\dots,N-1 \qquad \text{Formula 1}$$

where is the first sequence, is the base sequence, is the auxiliary sequence, represents

a sequence length of the first sequence, represents the maximum delay spread, represents the maximum Doppler spread, represents a base sequence number of the base sequence, and and are integers.$r_{u,k,l}^{(\Delta_T,\Delta_F)}(n)b_u(n)s_{u,k,l}^{(\Delta_T,\Delta_F)}(n)N\Delta_T\Delta_F ukl$

[00116] k and represent parameters of the auxiliary sequence. For example, represents a parameter associated with a quadratic term coefficient in the auxiliary sequence, and represents a parameter associated with a linear term coefficient in the auxiliary sequence.lkl

[00117] The base sequence number of the base sequence may also be referred to as a root sequence number. In this application, the base sequence number represents a coefficient of a highest-degree term of the polynomial exponential sequence, and does not represent an order of the sequence, and the base sequence number is an integer.

[00118] In an example, when the base sequence is the ideal auto-correlation function sequence, the base sequence may satisfy the following formula 2:

$$b_u(n) = e^{-\frac{j\pi un(n+1)}{P}}, n = 0,1,\dots,N-1 \quad \text{Formula 2}$$

[00119] In another example, when the base sequence is the optimal auto-ambiguity function sequence, the base sequence may satisfy the following formula 3:

$$b_u(n) = e^{-\frac{j2\pi un^3}{P}}, n = 0,1,\dots,N-1 \quad \text{Formula 3}$$

[00120] In Formula 2 and Formula 3, is the base sequence, represents the sequence length of the first sequence, represents a maximum prime number that is not greater than the sequence length , represents the base sequence number of the base sequence, and $. b_u(n)NPNuu \in \{1,2,\dots,P-1\}$

[00121] In some embodiments, the auxiliary sequence may satisfy the following formula 4:

$$s_{u,k,l}^{(\Delta_T,\Delta_F)}(n) = e^{-\frac{j2\pi f_{u,k}^{(\Delta_T,\Delta_F)}n^2}{P}-\frac{j2\pi g_{u,l}^{(\Delta_T,\Delta_F)}n}{N}}, n = 0,1,\dots,N-1 \quad \text{Formula 4}$$

where is the auxiliary sequence, represents the sequence length of the first sequence, represents the maximum prime number that is not greater than the sequence length , represents the maximum delay spread, represents the maximum Doppler spread, represents the base sequence number of the base sequence, represents an auxiliary sequence number of the auxiliary sequence, represents a cyclic shift of the auxiliary sequence, represents an auxiliary sequence number index (which may also be understood as that represents a parameter associated with a quadratic term coefficient in the auxiliary sequence), and represents a cyclic shift index of the auxiliary sequence (which may also be understood as that represents a parameter associated with a linear term coefficient in the auxiliary sequence).$s_{u,k,l}^{(\Delta_T,\Delta_F)}(n)NPN\Delta_T\Delta_F uf_{u,k}^{(\Delta_T,\Delta_F)}g_{u,l}^{(\Delta_T,\Delta_F)}kkll$

[00122] It may be learned from the foregoing descriptions that, when the base sequence is the

optimal auto-ambiguity function sequence, the base sequence is a cubic polynomial exponential sequence, and correspondingly, the auxiliary sequence is a quadratic polynomial exponential sequence. Optionally, a degree of the highest-degree term of the base sequence may alternatively be greater than three, and correspondingly, the highest degree of the auxiliary sequence is one less than the highest degree of the base sequence. For example, the base sequence is a quartic polynomial exponential sequence, and the auxiliary sequence is a cubic polynomial exponential sequence. Certainly, the base sequence and the auxiliary sequence may alternatively be in other forms. This is not limited in this application. It should be noted that, for a polynomial exponential sequence with a degree greater than or equal to three, the ambiguity function of the base sequence has a full-domain single-peak characteristic, that is, a value of the ambiguity function of the base sequence is only at an origin, and other values are all less than . In the descriptions of embodiments of this application, only an example is used for description, in which the base sequence is the optimal auto-ambiguity function sequence, the base sequence is a cubic polynomial exponential sequence, and correspondingly, the auxiliary sequence is a quadratic polynomial exponential sequence.NN

[00123] Based on the foregoing descriptions, it may be understood that the first sequence obtained based on the base sequence and the auxiliary sequence may satisfy the exponential sum theorem, and the exponential sum theorem may also be referred to as a Weil bound on exponential sum (Weil bound on exponential sum) theorem. Therefore, the first sequence may also be referred to as a Weil exponential sum sequence, which is referred to as a W sequence for short.

[00124] The exponential sum theorem refers to: For a polynomial with a degree , a coefficient of the highest degree term satisfies , where represents ; coefficients of non-highest-degree terms satisfy , where represents a finite field , is a prime number, ; and the exponential sum satisfies , where represents the modulus. $p(n) = p_d n^d + p_{d-1} n^{d-1} + \cdots + p_1 n + p_0 d p_d \in \mathbb{Z}_P^* \mathbb{Z}_P^* \{1,2,\ldots,P-1\} p_0, p_1, \ldots, p_{d-1} \in \mathbb{Z}_P \mathbb{Z}_P \{0,1,\ldots,P-1\} P d \geq 1 \left| \sum_{n=0}^{P-1} e^{-j2\pi p(n)/P} \right| \left| \sum_{n=0}^{P-1} e^{-j2\pi p(n)/P} \right| \leq (d-1)\sqrt{P} |\cdot|$

[00125] It should be understood that in the descriptions of the exponential sum theorem, may correspond to in " represents a maximum prime number that is not greater than a sequence length " described in other parts of this application, or may be understood as having a same understanding meaning in the entire specification.$PPPNP$

[00126] Specifically, when $d = 2$, the exponential sum is reduced to a Gaussian sum $\left| \sum_{n=0}^{P-1} e^{-j2\pi (p_2 n^2 + p_1 n + p_0)/P} \right|$, that is, the Gaussian sum satisfies $\left| \sum_{n=0}^{P-1} e^{-j2\pi (p_2 n^2 + p_1 n + p_0)/P} \right| = \sqrt{P}$.

[00127] The first sequence determined according to the foregoing method may have a

characteristic of a large capacity and a low-ambiguity zone, and may be applied to a plurality of physical channels and physical signals. For example, the first sequence may be applied to a reference signal, random access, a synchronization signal (including a primary synchronization signal and a secondary synchronization signal), sequence modulation, and the like. In some embodiments, an application scope of the first sequence (a W sequence is used as an example for description) provided in embodiments of this application and a sequence in the current NR protocol may be shown in Table 1.

Table 1

Sequence usage	Sequence involved in the NR protocol	First sequence provided in embodiments of this application
Random access	Gold, ZC, or CGS	W
Reference signal	ZC	W
Synchronization signal	m or Gold	W
Sequence modulation	CGS	W
Sequence scrambling	Gold	----
Sequence frequency hopping	Gold	----

[00128] In Table 1, "----" indicates that the W sequence is not applicable to sequence scrambling and sequence frequency hopping.

[00129] It can be learned from Table 1 that the first sequence provided in embodiments of this application may be applied to a plurality of physical channels and physical signals.

[00130] Based on this, the first signal determined based on the first sequence may be the plurality of physical signals. Examples of applying the first sequence to different scenarios are described in detail below.

[00131] Scenario a1: The first sequence may be applied to a physical random access channel (physical random access channel, PRACH).

[00132] In the scenario a1, the first signal is a random access preamble sequence. The first sequence is used as the random access preamble sequence, that is, the first signal is the first sequence, namely, the first signal $x_{u,k,l}(n) = r_{u,k,l}^{(\Delta_T,\Delta_F)}(n), n = 0,1,\dots,N-1$.

[00133] The first signal is a time domain signal. Data corresponding to the first signal is transmitted by using a discrete Fourier transform spread orthogonal frequency division

multiplexing (discrete Fourier transform spread orthogonal frequency division multiplexing, DFT-s-OFDM) waveform, or it is understood that the data corresponding to the first signal is carried on the DFT-s-OFDM waveform, and a frequency domain signal may be obtained by performing discrete Fourier transform on the first signal. $y_{u,k,l}(n) = \sum_{m=0}^{N-1} x_{u,k,l}(m) \cdot e^{-\frac{j2\pi mn}{N}}, n = 0,1,\dots,N-1$

[00134] In the scenario a1, the sequence length of the first sequence is a prime number, and is equal to the sequence length . In an example, a value of may be .NPNNN $\in \{839,139,1151,571\}$

[00135] In the scenario a1, the first communication apparatus may transmit first indication information, where the first indication information indicates that the base sequence is the ideal auto-correlation function sequence or indicates that the base sequence is the optimal auto-ambiguity function sequence.

[00136] For example, in the scenario a1, the first communication apparatus may be a terminal device, or may be a processor, a chip, a system-on-chip, a circuit, a functional module, or the like in the terminal device, and the second communication apparatus may be an access network device, or may be a processor, a chip, a system-on-chip, a circuit, a functional module, or the like in the access network device.

[00137] In this way, the first communication apparatus may receive the first indication information, and correspondingly, the second communication apparatus may send the first indication information.

[00138] In some embodiments b1, if the first indication information indicates that the base sequence is the ideal auto-correlation function sequence, for the base sequence, refer to the foregoing Formula 2. Details are not described herein again.

[00139] Correspondingly, when the ambiguity function of the first sequence is equal to zero within the maximum delay spread and the maximum Doppler spread, the auxiliary sequence number of the auxiliary sequence is equal to zero. In other words, the quadratic term coefficient in the auxiliary sequence shown in the foregoing Formula 4 is 0. In this case, the auxiliary sequence is the cyclic shift sequence. The cyclic shift of the auxiliary sequence may satisfy:$f_{u,k}^{(\Delta_T,\Delta_F)} g_{u,l}^{(\Delta_T,\Delta_F)}$

$$g_{u,l}^{(\Delta_T,\Delta_F)} = (\tau_l - u^{-1}\nu_l) \bmod P;$$

where represents a maximum prime number that is not greater than , represents the sequence length of the first sequence, represents the maximum delay spread, represents the maximum Doppler spread, represents the base sequence number of the base sequence, , represents a minimum positive integer that satisfies , represents a cyclic shift in delay domain, represents a cyclic shift in Doppler domain, an ambiguity function of is equal to zero within the maximum delay spread and the maximum Doppler spread (which may also be understood as that satisfies the

zero-ambiguity zone), and represents the cyclic shift index (which may be understood as that represents a parameter associated with a linear term coefficient in the auxiliary sequence).$PNN\Delta_{\mathrm{T}}\Delta_{\mathrm{F}}uu \in \{1,2,\dots,P-1\}u^{-1}(u^{-1}u) \bmod P = 1\tau_l\nu_l g_{u,l}^{(\Delta_{\mathrm{T}},\Delta_{\mathrm{F}})} g_{u,l}^{(\Delta_{\mathrm{T}},\Delta_{\mathrm{F}})} ll$

[00140] For example, when is , and is , based on , it may be obtained that may be , and based on representing that the smallest positive integer satisfies , the final is represented as . For another example, when is , and is , based on , it may be obtained that may be , and based on representing that the smallest positive integer satisfies , the final is represented as . Others are similar. Examples are not enumerated herein. Other similar content in embodiments of this application is similar. This is not described one by one.$u2P7(u^{-1}u) \bmod P = 1u^{-1}4,11,18,\dots u^{-1}(u^{-1}u) \bmod P = 1u^{-1}4u3P31(u^{-1}u) \bmod P = 1u^{-1}21,52,83,\dots u^{-1}(u^{-1}u) \bmod P = 1u^{-1}21$

[00141] When the maximum Doppler spread , the zero-ambiguity zone may be reduced to the zero-correlation zone . In this case, the cyclic shift of the zero-correlation zone may correspond to an unrestricted set (unrestricted set) in the section 6.3.3.1 of the standard protocol 3GPP 38.211. When the maximum Doppler spread , the cyclic shift may correspond to a restricted set type A (restricted set type A) in the section 6.3.3.1 of the standard protocol 3GPP 38.211. When the maximum Doppler spread , the cyclic shift may correspond to a restricted set type B (restricted set type B) in the section 6.3.3.1 of the standard protocol 3GPP 38.211. It should be noted that, compared with the cyclic shift in the restricted set in the section 6.3.3.1 of the standard protocol 3GPP 38.211, more cyclic shifts () in the zero-ambiguity zone can be provided in embodiments of this application, and a higher moving speed () can be supported.$\Delta_{\mathrm{F}}= 1g_{u,l}^{(\Delta_{\mathrm{T}},\Delta_{\mathrm{F}})} g_{u,l}^{(\Delta_{\mathrm{T}},\Delta_{\mathrm{F}})} = l\Delta_{\mathrm{T}}, l \in \{0,1,\dots,\lfloor P/\Delta_{\mathrm{T}} \rfloor - 1\}\Delta_{\mathrm{F}}= 3\Delta_{\mathrm{F}}= 5\Delta_{\mathrm{F}}= 3,5\Delta_{\mathrm{F}}= 7,9,\dots$

[00142] In an optional manner, in Embodiment b1, the first communication apparatus may determine a first sequence set (which may also be referred to as the random access preamble set in Embodiment b1), and the first sequence set is obtained by sequentially traversing the cyclic shift of the auxiliary sequence and the base sequence number of the base sequence. The first sequence set includes the first sequence, or it may be understood as that the first sequence is included in the first sequence set, or it may be understood as that the first sequence is one of the sequences in the first sequence set.

[00143] Optionally, in Embodiment b1, the first sequence set may be generated by the second communication apparatus sequentially traversing the cyclic shift of the auxiliary sequence and the base sequence number of the base sequence, or may be predefined. The first sequence set is obtained based on sequentially traversing the cyclic shift of the auxiliary sequence and the base sequence number of the base sequence, so that interference can be reduced.

[00144] The second communication apparatus may send second indication information to the

first communication apparatus, where the second indication information may indicate the first sequence in the first sequence set, and the first communication apparatus may determine the first sequence in the first sequence set based on the second indication information.

[00145] Optionally, in Embodiment b1, to avoid collisions between random access preambles used in different cells, a quantity of sequences included in the first sequence set may be A, where A is a positive integer. For example, A may be 64. A may be predefined, or may be determined by the second communication apparatus.

[00146] In some embodiments b2, if the first indication information indicates that the base sequence is the optimal auto-ambiguity function sequence, for the base sequence, refer to the foregoing Formula 3. Details are not described herein again.

[00147] Correspondingly, when the ambiguity function of the first sequence is less than or equal to the ambiguity function threshold within the maximum delay spread and the maximum Doppler spread, the auxiliary sequence is a quadratic polynomial exponential sequence, and the auxiliary sequence number of the auxiliary sequence may satisfy:$f_{u,k}^{(\Delta_{\mathrm{T}},\Delta_{\mathrm{F}})}$

$$f_{u,k}^{(\Delta_{\mathrm{T}},\Delta_{\mathrm{F}})} = 3uk\Delta_{\mathrm{T}};$$

[00148] The cyclic shift of the auxiliary sequence may satisfy:$g_{u,l}^{(\Delta_{\mathrm{T}},\Delta_{\mathrm{F}})}$

$$g_{u,l}^{(\Delta_{\mathrm{T}},\Delta_{\mathrm{F}})} = l\Delta_{\mathrm{F}};$$

where represents the maximum delay spread, represents the maximum Doppler spread, represents the base sequence number, , represents the maximum prime number that is not greater than , represents the sequence length of the first sequence, , and represents rounding down.$\Delta_{\mathrm{T}}\Delta_{\mathrm{F}}uu \in \{1,2,\dots,P-1\}PNNk \in \{0,1,\dots,\lfloor P/\Delta_{\mathrm{T}}\rfloor - 1\}, l \in \{0,1,\dots,\lfloor N/\Delta_{\mathrm{F}}\rfloor - 1\}\lfloor \quad \rfloor$

[00149] In an optional manner, in Embodiment b2, the first communication apparatus may determine a second sequence set (which may also be referred to as the random access preamble set in Embodiment b2), and the second sequence set is obtained by sequentially traversing the cyclic shift of the auxiliary sequence, the auxiliary sequence number of the auxiliary sequence, and the base sequence number of the base sequence. The second sequence set includes the first sequence, or it may be understood as that the first sequence is included in the second sequence set, or it may be understood as that the first sequence is one of the sequences in the second sequence set.

[00150] Optionally, in Embodiment b2, the second sequence set may be generated by the second communication apparatus sequentially traversing the cyclic shift of the auxiliary sequence, the auxiliary sequence number of the auxiliary sequence, and the base sequence number of the base sequence, or may be predefined. The second sequence set is obtained based on sequentially

traversing the cyclic shift of the auxiliary sequence, the auxiliary sequence number of the auxiliary sequence, and the base sequence number of the base sequence, so that a capacity of the first sequence is large.

[00151] The second communication apparatus may send third indication information to the first communication apparatus, where the third indication information may indicate the first sequence in the second sequence set, and the first communication apparatus may determine the first sequence in the second sequence set based on the third indication information.

[00152] Optionally, in Embodiment b2, to avoid collisions between random access preambles used in different cells, a quantity of sequences included in the second sequence set may be B, where B is a positive integer. For example, B may be 1024. B may be predefined, or may be determined by the second communication apparatus.

[00153] It should be noted that, in the scenario a1, the maximum delay spread may be understood as a maximum round-trip delay, and being within the maximum Doppler spread may be understood as being within a maximum Doppler frequency shift. In other words, in the foregoing Embodiment b1, that the ambiguity function of the first sequence is equal to zero within the maximum delay spread and the maximum Doppler spread may be understood as that the ambiguity function of the first sequence is equal to zero within the maximum round-trip delay and the maximum Doppler frequency shift. Similarly, in the foregoing Embodiment b2, that the ambiguity function of the first sequence is less than or equal to the ambiguity function threshold within the maximum delay spread and the maximum Doppler spread may be understood as that the ambiguity function of the first sequence is less than or equal to the ambiguity function threshold within the maximum round-trip delay and the maximum Doppler frequency shift.

[00154] In another scenario a2, the first sequence may be applied to a demodulation reference signal (demodulation reference signal, DMRS).

[00155] In the scenario a2, the first signal determined based on the first sequence may be the demodulation reference signal. When the base sequence is the ideal auto-correlation function sequence (as shown in the foregoing Formula 2), and the ambiguity function of the first sequence is equal to zero within the maximum delay spread and the maximum Doppler spread, a sequence capacity of the first sequence is positively correlated with a square of the sequence length of the first sequence. Alternatively, when the base sequence is the optimal auto-ambiguity function sequence (as shown in the foregoing Formula 3), and the ambiguity function of the first sequence is less than or equal to the ambiguity function threshold within the maximum delay spread and the maximum Doppler spread, a sequence capacity of the first sequence is positively correlated with a cube of the sequence length of the first sequence.

[00156] In this application, "when..." may be replaced with a plurality of descriptions such as

"if..." and "in a case of...". This is not limited in this application.

[00157] In some embodiments c1, when data corresponding to the first signal is carried on the orthogonal frequency division multiplexing (orthogonal frequency division multiplexing, OFDM) waveform, the base sequence is the optimal auto-ambiguity function sequence, the auxiliary sequence is the quadratic polynomial exponential sequence, and the ambiguity function of the first sequence is less than or equal to the ambiguity function threshold within the maximum delay spread and the maximum Doppler spread.

[00158] In Embodiment c1, the first signal may be determined based on the first sequence through the following method: The first signal is determined by performing frequency domain comb mapping or frequency division multiplexing mapping on the first sequence.

[00159] For example, the first signal is determined based on the first sequence, and may satisfy:

$$r^{(m,q)}(n) = e^{-\frac{j2\pi vq}{Q}} \cdot r_{u,k,l}^{(\Delta_{\mathrm{T}},\Delta_{\mathrm{F}})}(n), n = 0,1,\dots,N-1;$$

where is the first signal, is the first sequence, represents the sequence length of the first sequence, represents the maximum delay spread, represents the maximum Doppler spread, represents a length of a frequency domain orthogonal cover code, represents a transmission comb index, , represents a quantity of transmission combs, represents a symbol position of the frequency domain orthogonal cover code, , represents a frequency domain orthogonal cover code index, , represents the base sequence number of the base sequence, , represents the maximum prime number that is not greater than the sequence length , represents the auxiliary sequence number index, and represents the cyclic shift index. When is equal to 1, the corresponding first signal is determined by performing frequency domain comb mapping on the first sequence. When is not equal to 1, the corresponding first signal is determined by performing frequency division multiplexing mapping on the first sequence. $r^{(m,q)}(n)r_{u,k,l}^{(\Delta_{\mathrm{T}},\Delta_{\mathrm{F}})}(n)N\Delta_{\mathrm{T}}\Delta_{\mathrm{F}}Qmm \in \{0,1,\dots,M-1\}Mqq \in \{0,1,\dots,Q-1\}vv \in \{0,1,\dots,Q-1\}uu \in \{1,2,\dots,P-1\}PNklQQ$

[00160] In an example, when the first signal is determined by performing frequency domain comb mapping on the first sequence, the auxiliary sequence number of the auxiliary sequence may satisfy:$f_{u,k}^{(\Delta_{\mathrm{T}},\Delta_{\mathrm{F}})}$

$$f_{u,k}^{(\Delta_{\mathrm{T}},\Delta_{\mathrm{F}})} = \frac{3u[(kM+m)\Delta_{\mathrm{F}}-m]}{M};$$

[00161] The cyclic shift of the auxiliary sequence may satisfy:$g_{u,l}^{(\Delta_{\mathrm{T}},\Delta_{\mathrm{F}})}$

$$g_{u,l}^{(\Delta_{\mathrm{T}},\Delta_{\mathrm{F}})} = l\Delta_{\mathrm{T}};$$

where represents the maximum delay spread, represents the maximum Doppler spread, represents the quantity of transmission combs, represents the transmission comb index, represents the base sequence number of the base sequence, , represents the maximum prime number that is

not greater than the sequence length , represents the sequence length of the first sequence, , and represents rounding down. $\Delta_{\mathrm{T}}\Delta_{\mathrm{F}}Mmuu \in \{1,2,\dots,P-1\}PNN(k \in \{0,1,\dots,\lfloor P/\Delta_{\mathrm{F}} \rfloor - 1\}, m \in \{0,1,\dots,M-1\}) \vee (k \in \{\lfloor P/\Delta_{\mathrm{F}} \rfloor\}, m \in \{0,1,\dots,\lfloor MP/\Delta_{\mathrm{F}} \rfloor - M\lfloor P/\Delta_{\mathrm{F}} \rfloor - 1\}), l \in \{0,1,\dots,\lfloor N/\Delta_{\mathrm{T}} \rfloor - 1\}\lfloor \quad \rfloor$

[00162] When the first signal is determined by performing frequency domain comb mapping on the first sequence, the first signal may correspond to the DMRS configuration type 1, and there may be a first relationship between the quantity of transmission combs and the length of the frequency domain orthogonal cover code, for example, the quantity of transmission combs and the length of the frequency domain orthogonal cover code.$MQM = 2Q = 1$

[00163] It should be noted that, according to the exponential sum theorem, values of the quantity of transmission combs and the maximum Doppler spread need to satisfy a condition: , where represents an integer domain. For example, or .$M\Delta_{\mathrm{F}}\, 3(\Delta_{\mathrm{F}} - 1)/M \in \mathbb{Z}\mathbb{Z}M = 2, \Delta_{\mathrm{F}} = 3M = 4, \Delta_{\mathrm{F}} = 5$

[00164] In still another example, when the first signal is determined by performing frequency division multiplexing mapping on the first sequence, the auxiliary sequence number of the auxiliary sequence may satisfy:$f_{u,k}^{(\Delta_{\mathrm{T}},\Delta_{\mathrm{F}})}$

$$f_{u,k}^{(\Delta_{\mathrm{T}},\Delta_{\mathrm{F}})} = \frac{3u[(kMQ+mQ+q)\Delta_{\mathrm{F}}-(mQ+q)]}{MQ};$$

[00165] The cyclic shift of the auxiliary sequence may satisfy:$g_{u,l}^{(\Delta_{\mathrm{T}},\Delta_{\mathrm{F}})}$

$$g_{u,l}^{(\Delta_{\mathrm{T}},\Delta_{\mathrm{F}})} = l\Delta_{\mathrm{T}};$$

where represents the maximum delay spread, represents the maximum Doppler spread, represents the quantity of transmission combs, represents the length of the frequency domain orthogonal cover code, represents the transmission comb index, represents the symbol position of the frequency domain orthogonal cover code, , represents the base sequence number of the base sequence, , represents the maximum prime number that is not greater than the sequence length , represents the sequence length of the first sequence, , and represents rounding down. $\Delta_{\mathrm{T}}\Delta_{\mathrm{F}}MQmqq \in \{0,1,\dots,Q-1\}uu \in \{1,2,\dots,P-1\}PNN(k \in \{0,1,\dots,\lfloor P/\Delta_{\mathrm{F}} \rfloor - 1\}, m \in \{0,1,\dots,M-1\}) \vee (k \in \{\lfloor P/\Delta_{\mathrm{F}} \rfloor\}, m \in \{0,1,\dots,\lfloor MP/\Delta_{\mathrm{F}} \rfloor - M\lfloor P/\Delta_{\mathrm{F}} \rfloor - 1\}), l \in \{0,1,\dots,\lfloor N/\Delta_{\mathrm{T}} \rfloor - 1\}\lfloor \quad \rfloor$

[00166] When the first signal is determined by performing frequency division multiplexing mapping on the first sequence, the first signal may correspond to the DMRS configuration type 2, and there may be a second relationship between the quantity of transmission combs and the length of the frequency domain orthogonal cover code, for example, the quantity of transmission combs and the length of the frequency domain orthogonal cover code.$MQM = 3Q = 2$

[00167] It should be noted that, according to the exponential sum theorem, values of the quantity of transmission combs , the length of the frequency domain orthogonal cover code, and the maximum Doppler spread need to satisfy a condition: , where represents an integer domain. For example, or .$MQ\Delta_{\mathrm{F}}\,3(\Delta_{\mathrm{F}}-1)/MQ\in\mathbb{Z}\mathbb{Z}M=3,Q=2,\Delta_{\mathrm{F}}=3M=3,Q=4,\Delta_{\mathrm{F}}=5$

[00168] In some embodiments c2, when data corresponding to the first signal is carried on a discrete Fourier transform spread orthogonal frequency division multiplexing waveform, the base sequence is the ideal auto-correlation function sequence, the auxiliary sequence is the cyclic shift sequence, and the ambiguity function of the first sequence is equal to zero within the maximum delay spread and the maximum Doppler spread.

[00169] In Embodiment c2, the first signal may be determined based on the first sequence through the following method: The first signal is determined by performing frequency domain comb mapping on the first sequence.

[00170] For example, the first signal is determined based on the first sequence, and may satisfy:

$$r^{(m,0)}(n)=r_{u,k,l}^{(\Delta_{\mathrm{T}},\Delta_{\mathrm{F}})}(n),n=0,1,\ldots,N-1;$$

where is the first signal, is the first sequence, represents the sequence length of the first sequence, represents the maximum delay spread, represents the maximum Doppler spread, represents the transmission comb index, , represents the quantity of transmission combs, represents the base sequence number of the base sequence, , represents the maximum prime number that is not greater than the sequence length , represents the auxiliary sequence number index, and represents the cyclic shift index. $r^{(m,0)}(n)r_{u,k,l}^{(\Delta_{\mathrm{T}},\Delta_{\mathrm{F}})}(n)N\Delta_{\mathrm{T}}\Delta_{\mathrm{F}}mm\in\{0,1,\ldots,M-1\}Muu\in\{1,2,\ldots,P-1\}PNkl$

[00171] For example, in Embodiment c2, the auxiliary sequence number of the auxiliary sequence is equal to zero, that is, the quadratic term coefficient in the auxiliary sequence shown in the foregoing Formula 4 is 0. In this case, the auxiliary sequence is the cyclic shift sequence. The cyclic shift of the auxiliary sequence may satisfy:$f_{u,k}^{(\Delta_{\mathrm{T}},\Delta_{\mathrm{F}})}g_{u,l}^{(\Delta_{\mathrm{T}},\Delta_{\mathrm{F}})}$

$$g_{u,l}^{(\Delta_{\mathrm{T}},\Delta_{\mathrm{F}})}=\left(\tau_l^{(m)}-uv_l^{(m)}\right)\bmod P;$$

where represents the maximum prime number that is not greater than the sequence length , represents the sequence length of the first sequence, represents the maximum delay spread, represents the maximum Doppler spread, represents the transmission comb index, , represents the quantity of transmission combs, represents the base sequence number of the base sequence, , represents a cyclic shift in delay domain, represents a cyclic shift in Doppler domain, an ambiguity function of is equal to zero within the maximum delay spread and the maximum Doppler spread (which may be understood as that satisfies the zero-ambiguity zone), and represents the cyclic shift

index.$PNN\Delta_{\mathrm{T}}\Delta_{\mathrm{F}}mm \in \{0,1,\dots,M-1\}Muu \in \{1,2,\dots,P-1\}\tau_l^{(m)}v_l^{(m)}g_{u,l}^{(\Delta_{\mathrm{T}},\Delta_{\mathrm{F}})}g_{u,l}^{(\Delta_{\mathrm{T}},\Delta_{\mathrm{F}})}l$

[00172] When the maximum Doppler spread , the zero-ambiguity zone is reduced to the zero-correlation zone , and represents rounding down. $\Delta_{\mathrm{F}}= 1g_{u,l}^{(\Delta_{\mathrm{T}},\Delta_{\mathrm{F}})}g_{u,l}^{(\Delta_{\mathrm{T}},\Delta_{\mathrm{F}})} = l\Delta_{\mathrm{T}}, l \in \{0,1,\dots,\lfloor P/\Delta_{\mathrm{T}}\rfloor - 1\}\lfloor \quad \rfloor$

[00173] In Embodiment c2, the first signal may correspond to the DMRS configuration type 1, and there may be a third relationship between the quantity of transmission combs and the length of the frequency domain orthogonal cover code, for example, the quantity of transmission combs and the length of the frequency domain orthogonal cover code.$MQM = 2Q = 1$

[00174] In some embodiments c3, when data corresponding to the first signal is carried on an orthogonal frequency division multiplexing waveform, the base sequence is the ideal auto-correlation function sequence, the auxiliary sequence is the cyclic shift sequence, and the ambiguity function of the first sequence is equal to zero within the maximum delay spread and the maximum Doppler spread.

[00175] In Embodiment c3, the first signal may be determined based on the first sequence through the following method: The first signal is determined by performing frequency domain comb mapping on the first sequence.

[00176] For example, the first signal is determined based on the first sequence, and may satisfy:

$$r^{(m,0)}(n) = r_{u,k,l}^{(\Delta_{\mathrm{T}},\Delta_{\mathrm{F}})}(n), n = 0,1,\dots,N-1;$$

where is the first signal, is the first sequence, represents the sequence length of the first sequence, represents the maximum delay spread, represents the maximum Doppler spread, represents the transmission comb index, , represents the quantity of transmission combs, represents the base sequence number of the base sequence, , represents the maximum prime number that is not greater than the sequence length , represents the auxiliary sequence number index, and represents the cyclic shift index. $r^{(m,0)}(n)r_{u,k,l}^{(\Delta_{\mathrm{T}},\Delta_{\mathrm{F}})}(n)N\Delta_{\mathrm{T}}\Delta_{\mathrm{F}}mm \in \{0,1,\dots,M-1\}Muu \in \{1,2,\dots,P-1\}PNkl$

[00177] For example, in Embodiment c3, the auxiliary sequence number of the auxiliary sequence is equal to zero, that is, the quadratic term coefficient in the auxiliary sequence shown in the foregoing Formula 4 is 0. In this case, the auxiliary sequence is the cyclic shift sequence. The cyclic shift of the auxiliary sequence may satisfy:$f_{u,k}^{(\Delta_{\mathrm{T}},\Delta_{\mathrm{F}})}g_{u,l}^{(\Delta_{\mathrm{T}},\Delta_{\mathrm{F}})}$

$$g_{u,l}^{(\Delta_{\mathrm{T}},\Delta_{\mathrm{F}})} = \left(\tau_l^{(m)} - uv_l^{(m)}\right) \bmod P;$$

where represents the maximum prime number that is not greater than the sequence length , represents the sequence length of the first sequence, represents the maximum delay spread, represents the maximum Doppler spread, represents the transmission comb index, , represents the

quantity of transmission combs, represents the base sequence number of the base sequence, , represents a cyclic shift in delay domain, represents a cyclic shift in Doppler domain, an ambiguity function of is equal to zero within the maximum delay spread and the maximum Doppler spread (which may be understood as that satisfies the zero-ambiguity zone), and represents the cyclic shift index.$PNN\Delta_{\mathrm{T}}\Delta_{\mathrm{F}}mm \in \{0,1,\dots,M-1\}Muu \in \{1,2,\dots,P-1\}\tau_l^{(m)}\nu_l^{(m)}g_{u,l}^{(\Delta_{\mathrm{T}},\Delta_{\mathrm{F}})}g_{u,l}^{(\Delta_{\mathrm{T}},\Delta_{\mathrm{F}})}l$

[00178] When the maximum Doppler spread , the zero-ambiguity zone is reduced to the zero-correlation zone , and represents rounding down. $\Delta_{\mathrm{F}}= 1g_{u,l}^{(\Delta_{\mathrm{T}},\Delta_{\mathrm{F}})}g_{u,l}^{(\Delta_{\mathrm{T}},\Delta_{\mathrm{F}})} = l\Delta_{\mathrm{T}}, l \in \{0,1,\dots,\lfloor P/\Delta_{\mathrm{T}}\rfloor - 1\}\lfloor \quad \rfloor$

[00179] In Embodiment c3, the first signal may correspond to the DMRS configuration type 1, and there may be a third relationship between the quantity of transmission combs and the length of the frequency domain orthogonal cover code, for example, the quantity of transmission combs and the length of the frequency domain orthogonal cover code.$MQM = 2Q = 1$

[00180] In some embodiments c4, when data corresponding to the first signal is carried on the discrete Fourier transform spread orthogonal frequency division multiplexing waveform, the base sequence is the optimal auto-ambiguity function sequence, the auxiliary sequence is the quadratic polynomial exponential sequence, and the ambiguity function of the first sequence is less than or equal to the ambiguity function threshold within the maximum delay spread and the maximum Doppler spread.

[00181] In Embodiment c4, the first signal may be determined based on the first sequence through the following method: The first signal is determined by performing frequency domain comb mapping or frequency division multiplexing mapping on the first sequence.

[00182] For example, the first signal is determined based on the first sequence, and may satisfy:

$$r^{(m,q)}(n) = e^{-\frac{j2\pi vq}{Q}} \cdot r_{u,k,l}^{(\Delta_{\mathrm{T}},\Delta_{\mathrm{F}})}(n), n = 0,1,\dots,N-1;$$

where is the first signal, is the first sequence, represents the sequence length of the first sequence, represents the maximum delay spread, represents the maximum Doppler spread, represents a length of a frequency domain orthogonal cover code, represents a transmission comb index, , represents a quantity of transmission combs, represents a symbol position of the frequency domain orthogonal cover code, , represents a frequency domain orthogonal cover code index, , represents the base sequence number of the base sequence, , represents the maximum prime number that is not greater than the sequence length , represents the auxiliary sequence number index, and represents the cyclic shift index. When is equal to 1, the corresponding first signal is determined by performing frequency domain comb mapping on the first sequence. When is not equal to 1, the corresponding first signal is determined by performing frequency division

multiplexing mapping on the first sequence. $r^{(m,q)}(n) r_{u,k,l}^{(\Delta_T,\Delta_F)}(n) N\Delta_T\Delta_F Qmm \in \{0,1,\dots,M-1\} Mqq \in \{0,1,\dots,Q-1\} vv \in \{0,1,\dots,Q-1\} uu \in \{1,2,\dots,P-1\} PNklQQ$

[00183] In an example, when the first signal is determined by performing frequency domain comb mapping on the first sequence, the auxiliary sequence number of the auxiliary sequence may satisfy: $f_{u,k}^{(\Delta_T,\Delta_F)}$

$$f_{u,k}^{(\Delta_T,\Delta_F)} = \frac{3u[(kM+m)\Delta_F - m]}{M};$$

[00184] The cyclic shift of the auxiliary sequence may satisfy: $g_{u,l}^{(\Delta_T,\Delta_F)}$

$$g_{u,l}^{(\Delta_T,\Delta_F)} = l\Delta_T;$$

where represents the maximum delay spread, represents the maximum Doppler spread, represents the quantity of transmission combs, represents the transmission comb index, represents the base sequence number of the base sequence, , represents the maximum prime number that is not greater than the sequence length , represents the sequence length of the first sequence, , and represents rounding down. $\Delta_T\Delta_F Mmuu \in \{1,2,\dots,P-1\} PNN(k \in \{0,1,\dots,\lfloor P/\Delta_F \rfloor - 1\}, m \in \{0,1,\dots,M-1\}) \vee (k \in \{\lfloor P/\Delta_F \rfloor\}, m \in \{0,1,\dots,\lfloor MP/\Delta_F \rfloor - M\lfloor P/\Delta_F \rfloor - 1\}), l \in \{0,1,\dots,\lfloor N/\Delta_T \rfloor - 1\} \lfloor \quad \rfloor$

[00185] When the first signal is determined by performing frequency domain comb mapping on the first sequence, the first signal may correspond to the DMRS configuration type 1, and there may be a first relationship between the quantity of transmission combs and the length of the frequency domain orthogonal cover code, for example, the quantity of transmission combs and the length of the frequency domain orthogonal cover code. $MQM = 2Q = 1$

[00186] It should be noted that, according to the exponential sum theorem, values of the quantity of transmission combs and the maximum Doppler spread need to satisfy a condition: , where represents an integer domain. For example, or . $M\Delta_F\, 3(\Delta_F - 1)/M \in \mathbb{Z}\mathbb{Z}M = 2, \Delta_F = 3M = 4, \Delta_F = 5$

[00187] In still another example, when the first signal is determined by performing frequency division multiplexing mapping on the first sequence, the auxiliary sequence number of the auxiliary sequence may satisfy: $f_{u,k}^{(\Delta_T,\Delta_F)}$

$$f_{u,k}^{(\Delta_T,\Delta_F)} = \frac{3u[(kMQ+mQ+q)\Delta_F - (mQ+q)]}{MQ};$$

[00188] The cyclic shift of the auxiliary sequence may satisfy: $g_{u,l}^{(\Delta_T,\Delta_F)}$

$$g_{u,l}^{(\Delta_T,\Delta_F)} = l\Delta_T;$$

where represents the maximum delay spread, represents the maximum Doppler spread, represents the quantity of transmission combs, represents the length of the frequency domain

orthogonal cover code, represents the transmission comb index, represents the symbol position of the frequency domain orthogonal cover code, , represents the base sequence number of the base sequence, , represents the maximum prime number that is not greater than the sequence length , represents the sequence length of the first sequence, , and represents rounding down. $\Delta_{\mathrm{T}}\Delta_{\mathrm{F}}MQmqq \in \{0,1,\dots,Q-1\}uu \in \{1,2,\dots,P-1\}PNN(k \in \{0,1,\dots,\lfloor P/\Delta_{\mathrm{F}}\rfloor - 1\}, m \in \{0,1,\dots,M-1\}) \vee (k \in \{\lfloor P/\Delta_{\mathrm{F}}\rfloor\}, m \in \{0,1,\dots,\lfloor MP/\Delta_{\mathrm{F}}\rfloor - M\lfloor P/\Delta_{\mathrm{F}}\rfloor - 1\}), l \in \{0,1,\dots,\lfloor N/\Delta_{\mathrm{T}}\rfloor - 1\}\lfloor \quad \rfloor$

[00189] When the first signal is determined by performing frequency division multiplexing mapping on the first sequence, the first signal may correspond to the DMRS configuration type 2, and there may be a second relationship between the quantity of transmission combs and the length of the frequency domain orthogonal cover code, for example, the quantity of transmission combs and the length of the frequency domain orthogonal cover code.$MQM = 3Q = 2$

[00190] It should be noted that, according to the exponential sum theorem, values of the quantity of transmission combs , the length of the frequency domain orthogonal cover code, and the maximum Doppler spread need to satisfy a condition: , where represents an integer domain. For example, or .$MQ\Delta_{\mathrm{F}}\ 3(\Delta_{\mathrm{F}} - 1)/MQ \in \mathbb{Z}\mathbb{Z}M = 3, Q = 2, \Delta_{\mathrm{F}} = 3M = 3, Q = 4, \Delta_{\mathrm{F}} = 5$

[00191] In the scenario a2, the DMRS may be an uplink DMRS, or may be a downlink DMRS.

[00192] When the DMRS is the uplink DMRS, the first communication apparatus may be a terminal device, or may be a processor, a chip, a system-on-chip, a circuit, a functional module, or the like in the terminal device, and the second communication apparatus may be an access network device, or may be a processor, a chip, a system-on-chip, a circuit, a functional module, or the like in the access network device.

[00193] Correspondingly, the first communication apparatus may receive the first indication information, and correspondingly, the second communication apparatus may send the first indication information. The first indication information indicates that the base sequence is the ideal auto-correlation function sequence, or indicates that the base sequence is the optimal auto-ambiguity function sequence.

[00194] Optionally, in the foregoing embodiment c1 or c4, the first communication apparatus may receive fourth indication information, where the fourth indication information indicates that the first signal is determined by performing frequency domain comb mapping on the first sequence, or the first signal is determined by performing frequency division multiplexing mapping on the first sequence. Correspondingly, the second communication apparatus may send the fourth indication information.

[00195] It should be understood that the fourth indication information in Embodiment c1 may

also be understood as indicating that the orthogonal frequency division multiplexing OFDM waveform corresponds to a manner in which the first signal is determined by performing frequency domain comb mapping on the first sequence, or indicating that the orthogonal frequency division multiplexing OFDM waveform corresponds to a manner in which the first signal is determined by performing frequency division multiplexing mapping on the first sequence.

[00196] In Embodiment c4, the fourth indication information may also be understood as indicating that the discrete Fourier transform spread orthogonal frequency division multiplexing waveform corresponds to a manner in which the first signal is determined by performing frequency domain comb mapping on the first sequence, or indicating that the discrete Fourier transform spread orthogonal frequency division multiplexing waveform corresponds to a manner in which the first signal is determined by performing frequency division multiplexing mapping on the first sequence.

[00197] When the DMRS is the downlink DMRS, the first communication apparatus may be an access network device, or may be a processor, a chip, a system-on-chip, a circuit, a functional module, or the like in the access network device, and the second communication apparatus may be a terminal device, or may be a processor, a chip, a system-on-chip, a circuit, a functional module, or the like in the terminal device.

[00198] Correspondingly, the first communication apparatus may send the first indication information, and correspondingly, the second communication apparatus may receive the first indication information.

[00199] Optionally, in the foregoing embodiment c1 or c4, the first communication apparatus may send the fourth indication information, and correspondingly, the second communication apparatus may receive the fourth indication information.

[00200] In still another scenario a3, the first sequence may be applied to a sounding reference signal (sounding reference signal, SRS).

[00201] In the scenario a2, the first signal determined based on the first sequence may be the sounding reference signal. The first signal is determined based on the first sequence, and may be implemented through the following method: The first signal is determined by performing frequency domain comb mapping on the first sequence.

[00202] For example, the first signal is determined based on the first sequence, and may satisfy:

$$r^{(p_i)}(n, l') = w_{\mathrm{TDM}}^{(p_i)}(l') r_{u,k,l}^{(\Delta_{\mathrm{T}}, \Delta_{\mathrm{F}})}(n), n = 0,1, \ldots, N-1;$$

where is the first signal, represents a time domain orthogonal cover code, is the first sequence, represents an antenna port number, represents a time domain symbol index, represents the sequence length of the first sequence, represents the maximum delay spread, represents the

maximum Doppler spread, represents the base sequence number of the base sequence, , represents the maximum prime number that is not greater than the sequence length , represents the auxiliary sequence number index, and represents the cyclic shift index.$r^{(p_i)}(n,l')w_{\mathrm{TDM}}^{(p_i)}(l')r_{u,k,l}^{(\Delta_{\mathrm{T}},\Delta_{\mathrm{F}})}(n)p_i l' N\Delta_{\mathrm{T}}\Delta_{\mathrm{F}} uu \in \{1,2,\dots,P-1\} PNkl$

[00203] In the scenario a3, the first communication apparatus may transmit first indication information, where the first indication information indicates that the base sequence is the ideal auto-correlation function sequence or indicates that the base sequence is the optimal auto-ambiguity function sequence.

[00204] For example, in the scenario a3, the first communication apparatus may be a terminal device, or may be a processor, a chip, a system-on-chip, a circuit, a functional module, or the like in the terminal device, and the second communication apparatus may be an access network device, or may be a processor, a chip, a system-on-chip, a circuit, a functional module, or the like in the access network device.

[00205] In this way, the first communication apparatus may receive the first indication information, and correspondingly, the second communication apparatus may send the first indication information.

[00206] In some embodiments d1, if the first indication information indicates that the base sequence is the ideal auto-correlation function sequence, for the base sequence, refer to the foregoing Formula 2. Details are not described herein again.

[00207] Correspondingly, when the ambiguity function of the first sequence is equal to zero within the maximum delay spread and the maximum Doppler spread, the auxiliary sequence number of the auxiliary sequence is equal to zero. In other words, the quadratic term coefficient in the auxiliary sequence shown in the foregoing Formula 4 is 0. In this case, the auxiliary sequence is the cyclic shift sequence. The cyclic shift of the auxiliary sequence may satisfy:$f_{u,k}^{(\Delta_{\mathrm{T}},\Delta_{\mathrm{F}})} g_{u,l}^{(\Delta_{\mathrm{T}},\Delta_{\mathrm{F}})}$

$$g_{u,l}^{(\Delta_{\mathrm{T}},\Delta_{\mathrm{F}})} = \left(\tau_l^{(m)} - uv_l^{(m)}\right) \bmod P;$$

where represents the maximum prime number that is not greater than the sequence length , represents the sequence length of the first sequence, represents the maximum delay spread, represents the maximum Doppler spread, represents the transmission comb index, , represents the quantity of transmission combs, represents the base sequence number of the base sequence, , represents a cyclic shift in delay domain, represents a cyclic shift in Doppler domain, an ambiguity function of is equal to zero within the maximum delay spread and the maximum Doppler spread (which may be understood as that satisfies the zero-ambiguity zone), and represents the cyclic shift index.$PNN\Delta_{\mathrm{T}}\Delta_{\mathrm{F}} mm \in \{0,1,\dots,M-1\} Muu \in \{1,2,\dots,P-1\} \tau_l^{(m)} v_l^{(m)} g_{u,l}^{(\Delta_{\mathrm{T}},\Delta_{\mathrm{F}})} g_{u,l}^{(\Delta_{\mathrm{T}},\Delta_{\mathrm{F}})} l$

[00208] When the maximum Doppler spread , the zero-ambiguity zone may be reduced to the zero-correlation zone , and represents rounding down. $\Delta_{\mathrm{F}}= 1 g_{u,l}^{(\Delta_{\mathrm{T}},\Delta_{\mathrm{F}})} g_{u,l}^{(\Delta_{\mathrm{T}},\Delta_{\mathrm{F}})} = l\Delta_T, l \in \{0,1,\dots,\lfloor P/\Delta_{\mathrm{T}} \rfloor - 1\} \lfloor \quad \rfloor$

[00209] In Embodiment d1, a value range of may be , , or , which corresponds to sounding reference signal configuration in the NR protocol.$M248$

[00210] In some embodiments d2, if the first indication information indicates that the base sequence is the optimal auto-ambiguity function sequence, for the base sequence, refer to the foregoing Formula 3. Details are not described herein again.

[00211] Correspondingly, when the ambiguity function of the first sequence is less than or equal to the ambiguity function threshold within the maximum delay spread and the maximum Doppler spread of the sequence, the auxiliary sequence number of the auxiliary sequence may satisfy:$f_{u,k}^{(\Delta_{\mathrm{T}},\Delta_{\mathrm{F}})}$

$$f_{u,k}^{(\Delta_{\mathrm{T}},\Delta_{\mathrm{F}})} = \frac{3u[(kM+m)\Delta_{\mathrm{F}}-m]}{M};$$

[00212] The cyclic shift of the auxiliary sequence may satisfy:$g_{u,l}^{(\Delta_{\mathrm{T}},\Delta_{\mathrm{F}})}$

$$g_{u,l}^{(\Delta_{\mathrm{T}},\Delta_{\mathrm{F}})} = l\Delta_{\mathrm{T}};$$

where represents the maximum prime number that is not greater than the sequence length , represents the sequence length of the first sequence, represents the maximum delay spread, represents the maximum Doppler spread, represents the transmission comb index, , represents the quantity of transmission combs, represents the base sequence number of the base sequence, , , and represents rounding down. $PNN\Delta_{\mathrm{T}}\Delta_{\mathrm{F}}mm \in \{0,1,\dots,M-1\}Muu \in \{1,2,\dots,P-1\}(k \in \{0,1,\dots,\lfloor P/\Delta_{\mathrm{F}} \rfloor - 1\}, m \in \{0,1,\dots,M-1\}) \vee (k \in \{\lfloor P/\Delta_{\mathrm{F}} \rfloor\}, m \in \{0,1,\dots,\lfloor MP/\Delta_{\mathrm{F}} \rfloor - M\lfloor P/\Delta_{\mathrm{F}} \rfloor - 1\}), l \in \{0,1,\dots,\lfloor N/\Delta_{\mathrm{T}} \rfloor - 1\} \lfloor \quad \rfloor$

[00213] In Embodiment d2, a value range of may be , , or , which corresponds to sounding reference signal configuration in the NR protocol.$M248$

[00214] In the scenario a3, the first communication apparatus may determine a sounding reference signal set, where the sounding reference signal set is determined based on a first parameter, a peak-to-average power ratio of a sounding reference signal in the sounding reference signal set is less than a first threshold, and the sounding reference signal set includes the first signal, or it may be understood as that the first signal is included in the sounding reference signal set, or it may be understood as that the first signal is one in the sounding reference signal set.

[00215] Optionally, the sounding reference signal set may be generated by the second communication apparatus based on the first parameter, or may be predefined.

[00216] The second communication apparatus may send fifth indication information to the first

communication apparatus, where the fifth indication information may indicate the first signal in the sounding reference signal set, and the first communication apparatus may determine the first signal in the sounding reference signal set based on the fifth indication information.

[00217] Optionally, the first parameter includes at least one of the following: a cubic metric of a time domain signal, power corresponding to a complementary cumulative distribution function (complementary cumulative distribution function, CCDF) of a time domain signal, a peak value of a time domain signal, or the like.

[00218] For example, the sounding reference signal set may include signals. For example, the second communication apparatus may determine signals with a minimum time domain signal cubic metric, or determine signals with a minimum power corresponding to the CCDF, or determine signals with a minimum peak value of a time domain signal as the sounding reference signal set, to ensure that the peak-to-average power ratio of the sounding reference signal in the sounding reference signal set is less than the first threshold.ΩΩΩΩ

[00219] For example, the Ω signals with the minimum time domain signal power corresponding to $\mathrm{CCDF} = 10^{-4}$.

[00220] Ω is predefined, or is determined by the second communication apparatus, and is a positive integer.Ω

[00221] Step 202: The first communication apparatus sends the first signal. Correspondingly, the second communication apparatus receives the first signal.

[00222] In this application, sending may also be described as outputting, transmitting, or the like. In other words, that the first communication apparatus sends the first signal may also be described as that the first communication apparatus outputs the first signal, or the first communication apparatus transmits the first signal, or the like.

[00223] Optionally, sending may be transmission between two apparatuses, or may be internal transmission of an apparatus, for example, transmission from a higher layer to a lower layer of an apparatus.

[00224] For example, when the first communication apparatus is an access network device, that the access network device sends the first signal may be understood as that the access network device sends the first signal to a terminal device (for example, a radio frequency unit of the access network device sends the first signal to the terminal device through an air interface), or may be understood as that a baseband unit of the access network device outputs the first signal to a radio frequency unit of the access network device.

[00225] After receiving the first signal, the second communication apparatus may parse the first signal.

[00226] According to the foregoing communication method, the first sequence is constructed based on the base sequence and the auxiliary sequence, so that the first sequence may be used for a plurality of physical channels and physical signals, and the first signal is transmitted based on the first sequence, thereby improving communication performance.

[00227] It should be noted that the foregoing described application of the first sequence (for example, the W sequence) is merely an example, and is not intended to limit application of the first sequence in this application. It should be understood that the first sequence is not limited to the applications listed in embodiments of this application. In addition, based on this application, some variations and changes of the first sequence may still fall within the protection scope of this application. For example, a deformation such as an overall phase shift of the first sequence or a constant offset of a polynomial coefficient of the first sequence does not change a property or a quantity of the first sequence. A sequence obtained by transforming the first sequence based on this may still fall within the protection scope of this application.

[00228] Based on the foregoing embodiments, an embodiment of this application further provides a communication apparatus. As shown in FIG. 3, a communication apparatus 300 may include a transceiver unit 301 and a processing unit 302. The transceiver unit 301 is used by the communication apparatus 300 for communication, for example, receiving information (a message or data) or sending information (a message or data), and the processing unit 302 is configured to control and manage an action of the communication apparatus 300. The processing unit 302 may further control a step performed by the transceiver unit 301.

[00229] For example, the communication apparatus 300 may specifically implement a function of the first communication apparatus or the second communication apparatus in the foregoing embodiments.

[00230] In an embodiment, when the communication apparatus 300 is configured to implement the function of the first communication apparatus in the embodiment shown in FIG. 2, the processing unit 302 may be configured to determine a first signal, where the first signal is determined based on a first sequence, and the first sequence is determined based on a base sequence and an auxiliary sequence; and the base sequence is an ideal auto-correlation function sequence, the auxiliary sequence is a cyclic shift sequence, and an ambiguity function of the first sequence is equal to zero within a maximum delay spread and a maximum Doppler spread; or the base sequence is an optimal auto-ambiguity function sequence, the auxiliary sequence is a quadratic polynomial exponential sequence, and an ambiguity function of the first sequence is less than or equal to an ambiguity function threshold within a maximum delay spread and a maximum Doppler spread; and the transceiver unit 301 may be configured to send the first signal.

[00231] In an optional implementation, the first sequence is determined based on the base

sequence and the auxiliary sequence, and satisfies:

$$r_{u,k,l}^{(\Delta_T,\Delta_F)}(n) = b_u(n) \cdot s_{u,k,l}^{(\Delta_T,\Delta_F)}(n), n = 0,1,\dots,N-1$$

where is the first sequence, is the base sequence, is the auxiliary sequence, represents a sequence length of the first sequence, represents the maximum delay spread, represents the maximum Doppler spread, represents a base sequence number of the base sequence, and and are integers.$r_{u,k,l}^{(\Delta_T,\Delta_F)}(n)b_u(n)s_{u,k,l}^{(\Delta_T,\Delta_F)}(n)N\Delta_T\Delta_F ukl$

[00232] In some embodiments, the base sequence is the ideal auto-correlation function sequence, and satisfies:

$$b_u(n) = e^{-\frac{j\pi un(n+1)}{P}}, n = 0,1,\dots,N-1$$

or the base sequence is an optimal auto-ambiguity function sequence, and satisfies:

$$b_u(n) = e^{-\frac{j2\pi un^3}{P}}, n = 0,1,\dots,N-1$$

where is the base sequence, represents the sequence length of the first sequence, represents a maximum prime number that is not greater than the sequence length , represents the base sequence number of the base sequence, and .$b_u(n)NPNuu \in \{1,2,\dots,P-1\}$

[00233] For example, the auxiliary sequence satisfies:

$$s_{u,k,l}^{(\Delta_T,\Delta_F)}(n) = e^{-\frac{j2\pi f_{u,k}^{(\Delta_T,\Delta_F)} n^2}{P} - \frac{j2\pi g_{u,l}^{(\Delta_T,\Delta_F)} n}{N}}, n = 0,1,\dots,N-1$$

where is the auxiliary sequence, represents the sequence length of the first sequence, represents the maximum prime number that is not greater than the sequence length , represents the maximum delay spread, represents the maximum Doppler spread, represents the base sequence number of the base sequence, represents an auxiliary sequence number of the auxiliary sequence, represents a cyclic shift of the auxiliary sequence, represents an auxiliary sequence number index, and represents a cyclic shift index.$s_{u,k,l}^{(\Delta_T,\Delta_F)}(n)NPN\Delta_T\Delta_F uf_{u,k}^{(\Delta_T,\Delta_F)} g_{u,l}^{(\Delta_T,\Delta_F)} kl$

[00234] In an example, the first signal is a random access preamble sequence, and that the first signal is determined based on the first sequence includes: The random access preamble sequence is the first sequence.

[00235] For example, when the ambiguity function of the first sequence is equal to zero within the maximum delay spread and the maximum Doppler spread, the auxiliary sequence number of the auxiliary sequence is equal to zero, and the cyclic shift of the auxiliary sequence satisfies:$f_{u,k}^{(\Delta_T,\Delta_F)} g_{u,l}^{(\Delta_T,\Delta_F)}$

$$g_{u,l}^{(\Delta_T,\Delta_F)} = (\tau_l - u^{-1}\nu_l) \bmod P$$

where represents the maximum prime number that is not greater than , represents the sequence length of the first sequence, represents the maximum delay spread, represents the

maximum Doppler spread, represents the base sequence number of the base sequence, , represents a minimum positive integer that satisfies , represents a cyclic shift in delay domain, represents a cyclic shift in Doppler domain, an ambiguity function of is equal to zero within the maximum delay spread and the maximum Doppler spread, and represents the cyclic shift index.$PNN\Delta_{\mathrm{T}}\Delta_{\mathrm{F}}uu \in \{1,2,\dots,P-1\}u^{-1}(u^{-1}u) \bmod P = 1\tau_l\nu_l g_{u,l}^{(\Delta_{\mathrm{T}},\Delta_{\mathrm{F}})}l$

[00236] Optionally, the processing unit 302 may be further configured to determine a first sequence set, where the first sequence set is obtained by sequentially traversing the cyclic shift of the auxiliary sequence and the base sequence number of the base sequence, and the first sequence set includes the first sequence.

[00237] For example, the ambiguity function of the first sequence is less than or equal to the ambiguity function threshold within the maximum delay spread and the maximum Doppler spread, the auxiliary sequence number of the auxiliary sequence satisfies:$f_{u,k}^{(\Delta_{\mathrm{T}},\Delta_{\mathrm{F}})}$

$$f_{u,k}^{(\Delta_{\mathrm{T}},\Delta_{\mathrm{F}})} = 3uk\Delta_{\mathrm{T}}$$

and the cyclic shift of the auxiliary sequence satisfies:$g_{u,l}^{(\Delta_{\mathrm{T}},\Delta_{\mathrm{F}})}$

$$g_{u,l}^{(\Delta_{\mathrm{T}},\Delta_{\mathrm{F}})} = l\Delta_{\mathrm{F}}$$

where represents the maximum delay spread, represents the maximum Doppler spread, represents the base sequence number of the base sequence, , represents the maximum prime number that is not greater than , represents the sequence length of the first sequence, , and represents rounding down. $\Delta_{\mathrm{T}}\Delta_{\mathrm{F}}uu \in \{1,2,\dots,P-1\}PNNk \in \{0,1,\dots,\lfloor P/\Delta_{\mathrm{T}}\rfloor - 1\}, l \in \{0,1,\dots,\lfloor N/\Delta_{\mathrm{F}}\rfloor - 1\}\lfloor \quad \rfloor$

[00238] Optionally, the processing unit 302 may be further configured to determine a second sequence set, where the second sequence set is obtained by sequentially traversing the cyclic shift of the auxiliary sequence, the auxiliary sequence number of the auxiliary sequence, and the base sequence number of the base sequence, and the second sequence set includes the first sequence.

[00239] In a possible manner, the sequence length of the first sequence is a prime number, and is equal to the sequence length .NPN

[00240] In another example, the first signal is a demodulation reference signal.

[00241] When the base sequence is the ideal auto-correlation function sequence, and the ambiguity function of the first sequence is equal to zero within the maximum delay spread and the maximum Doppler spread, a sequence capacity of the first sequence is positively correlated with a square of the sequence length of the first sequence; or

when the base sequence is the optimal auto-ambiguity function sequence, and the ambiguity function of the first sequence is less than or equal to the ambiguity function threshold

within the maximum delay spread and the maximum Doppler spread, a sequence capacity of the first sequence is positively correlated with a cube of the sequence length of the first sequence.

[00242] In a possible manner, when data corresponding to the first signal is carried on an orthogonal frequency division multiplexing waveform, the base sequence is the optimal auto-ambiguity function sequence, the auxiliary sequence is the quadratic polynomial exponential sequence, the ambiguity function of the first sequence is less than or equal to the ambiguity function threshold within the maximum delay spread and the maximum Doppler spread, and that the first signal is determined based on the first sequence includes: The first signal is determined by performing frequency domain comb mapping or frequency division multiplexing mapping on the first sequence.

[00243] For example, the first signal is determined based on the first sequence, and satisfies:

$$r^{(m,q)}(n) = e^{-\frac{j2\pi vq}{Q}} \cdot r_{u,k,l}^{(\Delta_{\mathrm{T}},\Delta_{\mathrm{F}})}(n), n = 0,1,\dots,N-1$$

where is the first signal, is the first sequence, represents the sequence length of the first sequence, represents the maximum delay spread, represents the maximum Doppler spread, represents a length of a frequency domain orthogonal cover code, represents a transmission comb index, , represents a quantity of transmission combs, represents a symbol position of the frequency domain orthogonal cover code, , represents a frequency domain orthogonal cover code index, , represents the base sequence number of the base sequence, , represents the maximum prime number that is not greater than the sequence length , represents the auxiliary sequence number index, and represents the cyclic shift index. $r^{(m,q)}(n) r_{u,k,l}^{(\Delta_{\mathrm{T}},\Delta_{\mathrm{F}})}(n) N \Delta_{\mathrm{T}} \Delta_{\mathrm{F}} \mathrm{Q} mm \in \{0,1,\dots,M-1\} Mqq \in \{0,1,\dots,Q-1\} vv \in \{0,1,\dots,Q-1\} uu \in \{1,2,\dots,P-1\} PNkl$

[00244] Optionally, when the first signal is determined by performing frequency domain comb mapping on the first sequence, the auxiliary sequence number of the auxiliary sequence satisfies: $f_{u,k}^{(\Delta_{\mathrm{T}},\Delta_{\mathrm{F}})}$

$$f_{u,k}^{(\Delta_{\mathrm{T}},\Delta_{\mathrm{F}})} = \frac{3u[(kM+m)\Delta_{\mathrm{F}} - m]}{M}$$

and the cyclic shift of the auxiliary sequence satisfies: $g_{u,l}^{(\Delta_{\mathrm{T}},\Delta_{\mathrm{F}})}$

$$g_{u,l}^{(\Delta_{\mathrm{T}},\Delta_{\mathrm{F}})} = l\Delta_{\mathrm{T}}$$

where represents the maximum delay spread, represents the maximum Doppler spread, represents the quantity of transmission combs, represents the transmission comb index, represents the base sequence number of the base sequence, , represents the maximum prime number that is not greater than the sequence length , represents the sequence length of the first sequence, , and represents rounding down. $\Delta_{\mathrm{T}} \Delta_{\mathrm{F}} M muu \in \{1,2,\dots,P-1\} PNN (k \in \{0,1,\dots,\lfloor P/\Delta_{\mathrm{F}} \rfloor - 1\}, m \in$

$\{0,1,\dots,M-1\}) \vee (k \in \{\lfloor P/\Delta_{\mathrm{F}} \rfloor\}, m \in \{0,1,\dots,\lfloor MP/\Delta_{\mathrm{F}} \rfloor - M\lfloor P/\Delta_{\mathrm{F}} \rfloor - 1\}), l \in$
$\{0,1,\dots,\lfloor N/\Delta_{\mathrm{T}} \rfloor - 1\}\lfloor \quad \rfloor$

[00245] Optionally, when the first signal is determined by performing frequency division multiplexing mapping on the first sequence, the auxiliary sequence number of the auxiliary sequence satisfies:$f_{u,k}^{(\Delta_{\mathrm{T}},\Delta_{\mathrm{F}})}$

$$f_{u,k}^{(\Delta_{\mathrm{T}},\Delta_{\mathrm{F}})} = \frac{3u[(kMQ + mQ + q)\Delta_{\mathrm{F}} - (mQ + q)]}{MQ}$$

and the cyclic shift of the auxiliary sequence satisfies:$g_{u,l}^{(\Delta_{\mathrm{T}},\Delta_{\mathrm{F}})}$

$$g_{u,l}^{(\Delta_{\mathrm{T}},\Delta_{\mathrm{F}})} = l\Delta_{\mathrm{T}}$$

where represents the maximum delay spread, represents the maximum Doppler spread, represents the quantity of transmission combs, represents the length of the frequency domain orthogonal cover code, represents the transmission comb index, represents the symbol position of the frequency domain orthogonal cover code, , represents the base sequence number of the base sequence, , represents the maximum prime number that is not greater than the sequence length , represents the sequence length of the first sequence, , and represents rounding down.$\Delta_{\mathrm{T}}\Delta_{\mathrm{F}}MQmqq \in \{0,1,\dots,Q-1\}uu \in \{1,2,\dots,P-1\}PNN(k \in \{0,1,\dots,\lfloor P/\Delta_{\mathrm{F}} \rfloor - 1\}, m \in$
$\{0,1,\dots,M-1\}) \vee (k \in \{\lfloor P/\Delta_{\mathrm{F}} \rfloor\}, m \in \{0,1,\dots,\lfloor MP/\Delta_{\mathrm{F}} \rfloor - M\lfloor P/\Delta_{\mathrm{F}} \rfloor - 1\}), l \in$
$\{0,1,\dots,\lfloor N/\Delta_{\mathrm{T}} \rfloor - 1\}\lfloor \quad \rfloor$

[00246] In another optional manner, when data corresponding to the first signal is carried on a discrete Fourier transform spread orthogonal frequency division multiplexing waveform, the base sequence is the ideal auto-correlation function sequence, the auxiliary sequence is the cyclic shift sequence, and the ambiguity function of the first sequence is equal to zero within the maximum delay spread and the maximum Doppler spread, and that the first signal is determined based on the first sequence includes:

[00247] The first signal is determined by performing frequency domain comb mapping on the first sequence.

[00248] For example, the first signal is determined based on the first sequence, and satisfies:

$$r^{(m,0)}(n) = r_{u,k,l}^{(\Delta_{\mathrm{T}},\Delta_{\mathrm{F}})}(n), n = 0,1,\dots,N-1$$

where is the first signal, is the first sequence, represents the sequence length of the first sequence, represents the maximum delay spread, represents the maximum Doppler spread, represents the transmission comb index, , represents the quantity of transmission combs, represents the base sequence number of the base sequence, , represents the maximum prime number that is not greater than the sequence length , represents the auxiliary sequence number index, and

represents the cyclic shift index. $r^{(m,0)}(n)r_{u,k,l}^{(\Delta_{\mathrm{T}},\Delta_{\mathrm{F}})}(n)N\Delta_{\mathrm{T}}\Delta_{\mathrm{F}}mm \in \{0,1,\dots,M-1\}Muu \in \{1,2,\dots,P-1\}PNkl$

[00249] In some embodiments, the auxiliary sequence number of the auxiliary sequence is equal to zero, and the cyclic shift of the auxiliary sequence satisfies:$f_{u,k}^{(\Delta_{\mathrm{T}},\Delta_{\mathrm{F}})}g_{u,l}^{(\Delta_{\mathrm{T}},\Delta_{\mathrm{F}})}$

$$g_{u,l}^{(\Delta_{\mathrm{T}},\Delta_{\mathrm{F}})} = \left(\tau_l^{(m)} - uv_l^{(m)}\right) \bmod P$$

where represents the maximum prime number that is not greater than the sequence length , represents the sequence length of the first sequence, represents the maximum delay spread, represents the maximum Doppler spread, represents the transmission comb index, , represents the quantity of transmission combs, represents the base sequence number of the base sequence, , represents a cyclic shift in delay domain, represents a cyclic shift in Doppler domain, an ambiguity function of is equal to zero within the maximum delay spread and the maximum Doppler spread, and represents the cyclic shift index. $PNN\Delta_{\mathrm{T}}\Delta_{\mathrm{F}}mm \in \{0,1,\dots,M-1\}Muu \in \{1,2,\dots,P-1\}\tau_l^{(m)}v_l^{(m)}g_{u,l}^{(\Delta_{\mathrm{T}},\Delta_{\mathrm{F}})}l$

[00250] In still another example, the first signal is a sounding reference signal, and that the first signal is determined based on the first sequence includes: The first signal is determined by performing frequency domain comb mapping on the first sequence.

[00251] For example, the first signal is determined based on the first sequence, and satisfies:

$$r^{(p_i)}(n,l') = w_{\mathrm{TDM}}^{(p_i)}(l')r_{u,k,l}^{(\Delta_{\mathrm{T}},\Delta_{\mathrm{F}})}(n), n = 0,1,\dots,N-1$$

where is the first signal, represents a time domain orthogonal cover code, is the first sequence, represents an antenna port number, represents a time domain symbol index, represents the sequence length of the first sequence, represents the maximum delay spread, represents the maximum Doppler spread, represents the base sequence number of the base sequence, , represents the maximum prime number that is not greater than the sequence length , represents the auxiliary sequence number index, and represents the cyclic shift index.$r^{(p_i)}(n,l')w_{\mathrm{TDM}}^{(p_i)}(l')r_{u,k,l}^{(\Delta_{\mathrm{T}},\Delta_{\mathrm{F}})}(n)p_il'N\Delta_{\mathrm{T}}\Delta_{\mathrm{F}}uu \in \{1,2,\dots,P-1\}PNkl$

[00252] For example, when the ambiguity function of the first sequence is equal to zero within the maximum delay spread and the maximum Doppler spread, the auxiliary sequence number of the auxiliary sequence is equal to zero, and the cyclic shift of the auxiliary sequence satisfies:$f_{u,k}^{(\Delta_{\mathrm{T}},\Delta_{\mathrm{F}})}g_{u,l}^{(\Delta_{\mathrm{T}},\Delta_{\mathrm{F}})}$

$$g_{u,l}^{(\Delta_{\mathrm{T}},\Delta_{\mathrm{F}})} = \left(\tau_l^{(m)} - uv_l^{(m)}\right) \bmod P$$

where represents the maximum prime number that is not greater than the sequence length , represents the sequence length of the first sequence, represents the maximum delay spread,

represents the maximum Doppler spread, represents the transmission comb index, , represents the quantity of transmission combs, represents the base sequence number of the base sequence, , represents a cyclic shift in delay domain, represents a cyclic shift in Doppler domain, an ambiguity function of is equal to zero within the maximum delay spread and the maximum Doppler spread, and represents the cyclic shift index. $PNN\Delta_{\mathrm{T}}\Delta_{\mathrm{F}}mm \in \{0,1,\dots,M-1\}Muu \in \{1,2,\dots,P-1\}\tau_l^{(m)}\nu_l^{(m)}g_{u,l}^{(\Delta_{\mathrm{T}},\Delta_{\mathrm{F}})}l$

[00253] For example, when the ambiguity function of the first sequence is less than or equal to the ambiguity function threshold within the maximum delay spread and the maximum Doppler spread , the auxiliary sequence number of the auxiliary sequence satisfies:$f_{u,k}^{(\Delta_{\mathrm{T}},\Delta_{\mathrm{F}})}$

$$f_{u,k}^{(\Delta_{\mathrm{T}},\Delta_{\mathrm{F}})} = \frac{3u[(kM+m)\Delta_{\mathrm{F}} - m]}{M}$$

and the cyclic shift of the auxiliary sequence satisfies:$g_{u,l}^{(\Delta_{\mathrm{T}},\Delta_{\mathrm{F}})}$

$$g_{u,l}^{(\Delta_{\mathrm{T}},\Delta_{\mathrm{F}})} = l\Delta_{\mathrm{T}}$$

where represents the maximum prime number that is not greater than the sequence length , represents the sequence length of the first sequence, represents the maximum delay spread, represents the maximum Doppler spread, represents the quantity of transmission combs, represents the transmission comb index, , represents the base sequence number of the base sequence, , , and represents rounding down. $PNN\Delta_{\mathrm{T}}\Delta_{\mathrm{F}}Mmm \in \{0,1,\dots,M-1\}uu \in \{1,2,\dots,P-1\}(k \in \{0,1,\dots,\lfloor P/\Delta_{\mathrm{F}}\rfloor - 1\}, m \in \{0,1,\dots,M-1\}) \vee (k \in \{\lfloor P/\Delta_{\mathrm{F}}\rfloor\}, m \in \{0,1,\dots,\lfloor MP/\Delta_{\mathrm{F}}\rfloor - M\lfloor P/\Delta_{\mathrm{F}}\rfloor - 1\}), l \in \{0,1,\dots,\lfloor N/\Delta_{\mathrm{T}}\rfloor - 1\}\lfloor \quad \rfloor$

[00254] Optionally, the processing unit 302 may be further configured to determine a sounding reference signal set, where the sounding reference signal set is determined based on a first parameter, a peak-to-average power ratio of a sounding reference signal in the sounding reference signal set is less than a first threshold, and the sounding reference signal set includes the first signal.

[00255] For example, the first parameter includes at least one of the following: a cubic metric of a time domain signal, power corresponding to a complementary cumulative distribution function of a time domain signal, or a peak value of a time domain signal.

[00256] In some embodiments, the transceiver unit 301 may be further configured to transmit first indication information, where the first indication information indicates that the base sequence is the ideal auto-correlation function sequence or indicates that the base sequence is the optimal auto-ambiguity function sequence.

[00257] In another embodiment, when the communication apparatus 300 is configured to implement the function of the second communication apparatus in the embodiment shown in FIG. 2, the transceiver unit 301 may be configured to receive a first signal, where the first signal is

determined based on a first sequence, and the first sequence is determined based on a base sequence and an auxiliary sequence; and the base sequence is an ideal auto-correlation function sequence, the auxiliary sequence is a cyclic shift sequence, and an ambiguity function of the first sequence is equal to zero within a maximum delay spread and a maximum Doppler spread; or the base sequence is an optimal auto-ambiguity function sequence, the auxiliary sequence is a quadratic polynomial exponential sequence, and an ambiguity function of the first sequence is less than or equal to an ambiguity function threshold within a maximum delay spread and a maximum Doppler spread; and the processing unit 302 may be configured to control the operation of the transceiver unit 301.

[00258] For detailed descriptions of the first signal, the first sequence, or the like, refer to the foregoing related descriptions. Details are not described herein again.

[00259] It should be noted that, in embodiments of this application, division into the units is an example, and is merely a logical function division. In actual implementation, another division manner may be used. 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 may be integrated into one unit. The integrated unit may be implemented in a form of hardware, or may be implemented in a form of a software functional unit.

[00260] When the integrated unit is implemented in the form of the software functional unit and sold or used as an independent product, the integrated unit may be stored in a computer-readable storage medium. Based on such understanding, a part of the technical solutions of this application that essentially or in other words makes contributions to the prior art, or all or a part of the technical solutions, may be embodied in the form of software product. The software product is stored in a storage medium and includes several instructions for instructing a computer device (which may be a personal computer, a server, or a network device) or a processor to perform all or a part of the steps of the methods in embodiments of this application. The foregoing storage medium includes any medium that can store program code, such as a USB flash drive, a removable hard disk, a read-only memory (read-only memory, ROM), a random access memory (random access memory, RAM), a magnetic disk, or an optical disc.

[00261] Based on the foregoing embodiments, an embodiment of this application further provides a communication apparatus. As shown in FIG. 4, a communication apparatus 400 may include one or more processors 402. Optionally, the communication apparatus 400 may further include a transceiver 401. Optionally, the communication apparatus 400 may further include at least one memory 403. The memory 403 may be disposed inside the communication apparatus 400, or may be disposed outside the communication apparatus 400. The processor 402 may control the transceiver 401 to receive and send information, a message, data, or the like.

[00262] Specifically, the processor 402 may be a central processing unit (central processing unit, CPU), a network processor (network processor, NP), or a combination of a CPU and an NP. The processor 402 may further include a hardware chip. The hardware chip may be an application-specific integrated circuit (application-specific integrated circuit, ASIC), a programmable logic device (programmable logic device, PLD), or a combination thereof. The PLD may be a complex programmable logic device (complex programmable logic device, CPLD), a field-programmable gate array (field-programmable gate array, FPGA), a generic array logic (generic array logic, GAL), or any combination thereof.

[00263] The transceiver 401, the processor 402, and the memory 403 are connected to each other. Optionally, the transceiver 401, the processor 402, and the memory 403 are connected to each other through a bus 404. The bus 404 may be a peripheral component interconnect (Peripheral Component Interconnect, PCI) bus, an extended industry standard architecture (Extended Industry Standard Architecture, EISA) bus, or the like. The bus may be classified into an address bus, a data bus, a control bus, and the like. For ease of representation, only one bold line represents the bus in FIG. 4, but this does not mean that there is only one bus or only one type of bus.

[00264] In an optional implementation, the memory 403 is configured to store a program and the like. Specifically, the program may include program code, and the program code includes computer operation instructions. The memory 403 may include a RAM, and may further include a non-volatile memory (non-volatile memory), for example, one or more magnetic disk memories. The processor 402 executes an application stored in the memory 403 to implement the foregoing functions, thereby realizing functions of the communication apparatus 400.

[00265] For example, the communication apparatus 400 may specifically implement a function of the first communication apparatus or the second communication apparatus in the foregoing embodiments.

[00266] In another embodiment, when the communication apparatus 400 implements a function of the first communication apparatus in the foregoing method embodiments, the transceiver 401 may implement receiving and sending operations performed by the first communication apparatus in the foregoing method embodiments; and the processor 402 may implement an operation other than the receiving and sending operations performed by the first communication apparatus in the foregoing method embodiments. Specifically, for related specific descriptions, refer to related descriptions in the foregoing embodiments. Details are not described herein again.

[00267] In an embodiment, when the communication apparatus 400 implements a function of the second communication apparatus in the foregoing method embodiments, the transceiver 401 may implement receiving and sending operations performed by the second communication apparatus in the foregoing method embodiments; and the processor 402 may implement an

operation other than the receiving and sending operations performed by the second communication apparatus in the foregoing method embodiments. Specifically, for related specific descriptions, refer to related descriptions in the foregoing embodiments. Details are not described herein again.

[00268] Based on the foregoing embodiments, an embodiment of this application provides a communication system, and the communication system may include a first communication apparatus, a second communication apparatus, and the like involved in the foregoing embodiments.

[00269] An embodiment of this application further provides a computer-readable storage medium. The computer-readable storage medium is configured to store a computer program or instructions. When the computer program or the instructions are executed by a computer, the computer may implement the communication method provided in the foregoing method embodiments.

[00270] An embodiment of this application further provides a computer program product. The computer program product is configured to store a computer program or instructions. When the computer program or the instructions are executed by a computer, the computer may implement the communication method provided in the foregoing method embodiments.

[00271] An embodiment of this application further provides a chip or a system-on-chip, including a logic circuit. The logic circuit is configured to perform the communication method provided in the foregoing method embodiments.

[00272] An embodiment of this application further provides a chip or a system-on-chip, including one or more processors. The one or more processors are coupled to at least one memory, and are configured to invoke a program in the memory, to cause the chip or the system-on-chip to implement the communication method provided in the foregoing method embodiments.

[00273] An embodiment of this application further provides a chip or a system-on-chip. The chip or the system-on-chip is coupled to at least one memory, and the chip or the system-on-chip is configured to implement the communication method provided in the foregoing method embodiments.

[00274] A person skilled in the art should understand that embodiments of this application may be provided as a method, a system, or a computer program product. Therefore, this application may use a form of hardware only embodiments, software only embodiments, or embodiments with a combination of software and hardware. In addition, this application may use a form of a computer program product that is implemented on one or more computer-usable storage media (including but not limited to a disk memory, a CD-ROM, an optical memory, and the like) that include computer-usable program code.

[00275] This application is described with reference to the flowcharts and/or block diagrams of the method, the device (system), and the computer program product according to this application.

It should be understood that computer program instructions may be used to implement each process and/or each block in the flowcharts and/or the block diagrams and a combination of a process and/or a block in the flowcharts and/or the block diagrams. These computer program instructions may be provided for a general-purpose computer, a dedicated computer, an embedded processor, or a processor of any other programmable data processing device to generate a machine, so that the instructions executed by a computer or a processor of any other programmable data processing device generate an apparatus for implementing a specific function in one or more processes in the flowcharts and/or in one or more blocks in the block diagrams.

[00276] These computer program instructions may be stored in a computer-readable memory that can instruct the computer or any other programmable data processing device to work in a specific manner, so that the instructions stored in the computer-readable memory generate an artifact that includes an instruction apparatus. The instruction apparatus implements a specific function in one or more processes in the flowcharts and/or in one or more blocks in the block diagrams.

[00277] The computer program instructions may alternatively be loaded onto a computer or another programmable data processing device, so that a series of operations and steps are performed on the computer or the another programmable device, so that computer-implemented processing is generated. Therefore, the instructions executed on the computer or the another programmable device provide steps for implementing a specific function in one or more procedures in the flowcharts and/or in one or more blocks in the block diagrams.

[00278] It is clear that a person skilled in the art can make various modifications and variations to this application without departing from the scope of this application. This application is intended to cover these modifications and variations of this application provided that they fall within the scope of protection defined by the following claims and their equivalent technologies.

CLAIMS

1. A communication method, comprising:

determining a first signal, wherein the first signal is determined based on a first sequence, the first sequence is determined based on a base sequence and an auxiliary sequence, the base sequence is an ideal auto-correlation function sequence, the auxiliary sequence is a cyclic shift sequence, and an ambiguity function of the first sequence is equal to zero within a maximum delay spread and a maximum Doppler spread; or the base sequence is an optimal auto-ambiguity function sequence, the auxiliary sequence is a quadratic polynomial exponential sequence, and an ambiguity function of the first sequence is less than or equal to an ambiguity function threshold within a maximum delay spread and a maximum Doppler spread; and

sending the first signal.

2. The method according to claim 1, wherein the first sequence is determined based on the base sequence and the auxiliary sequence, and satisfies:

$$r_{u,k,l}^{(\Delta_{\mathrm{T}},\Delta_{\mathrm{F}})}(n) = b_u(n) \cdot s_{u,k,l}^{(\Delta_{\mathrm{T}},\Delta_{\mathrm{F}})}(n), n = 0,1,\dots,N-1$$

wherein $r_{u,k,l}^{(\Delta_{\mathrm{T}},\Delta_{\mathrm{F}})}(n)$ is the first sequence, $b_u(n)$ is the base sequence, $s_{u,k,l}^{(\Delta_{\mathrm{T}},\Delta_{\mathrm{F}})}(n)$ is the auxiliary sequence, N represents a sequence length of the first sequence, Δ_{T} represents the maximum delay spread, Δ_{F} represents the maximum Doppler spread, u represents a base sequence number of the base sequence, and k and l are integers.

3. The method according to claim 1 or 2, wherein the base sequence is the ideal auto-correlation function sequence, and satisfies:

$$b_u(n) = e^{-\frac{j\pi un(n+1)}{P}}, n = 0,1,\dots,N-1$$

or the base sequence is an optimal auto-ambiguity function sequence, and satisfies:

$$b_u(n) = e^{-\frac{j2\pi un^3}{P}}, n = 0,1,\dots,N-1$$

wherein $b_u(n)$ is the base sequence, N represents the sequence length of the first sequence, P represents a maximum prime number that is not greater than the sequence length N, u represents the base sequence number of the base sequence, and $u \in \{1,2,\dots,P-1\}$.

4. The method according to any one of claims 1 to 3, wherein the auxiliary sequence satisfies:

$$s_{u,k,l}^{(\Delta_{\mathrm{T}},\Delta_{\mathrm{F}})}(n) = e^{-\frac{j2\pi f_{u,k}^{(\Delta_{\mathrm{T}},\Delta_{\mathrm{F}})} n^2}{P} - \frac{j2\pi g_{u,l}^{(\Delta_{\mathrm{T}},\Delta_{\mathrm{F}})} n}{N}}, n = 0,1,\dots,N-1$$

wherein $s_{u,k,l}^{(\Delta_{\mathrm{T}},\Delta_{\mathrm{F}})}(n)$ is the auxiliary sequence, N represents the sequence length of the first sequence, P represents the maximum prime number that is not greater than the sequence length N, Δ_{T} represents the maximum delay spread, Δ_{F} represents the maximum Doppler spread, u

represents the base sequence number of the base sequence, $f_{u,k}^{(\Delta_T,\Delta_F)}$ represents an auxiliary sequence number of the auxiliary sequence, $g_{u,l}^{(\Delta_T,\Delta_F)}$ represents a cyclic shift of the auxiliary sequence, k represents an auxiliary sequence number index, and l represents a cyclic shift index.

5. The method according to any one of claims 1 to 4, wherein the first signal is a random access preamble sequence, and that the first signal is determined based on the first sequence comprises:

the random access preamble sequence is the first sequence.

6. The method according to claim 5, wherein when the ambiguity function of the first sequence is equal to zero within the maximum delay spread and the maximum Doppler spread, the auxiliary sequence number $f_{u,k}^{(\Delta_T,\Delta_F)}$ of the auxiliary sequence is equal to zero, and the cyclic shift $g_{u,l}^{(\Delta_T,\Delta_F)}$ of the auxiliary sequence satisfies:

$$g_{u,l}^{(\Delta_T,\Delta_F)} = (\tau_l - u^{-1}\nu_l) \bmod P$$

wherein P represents the maximum prime number that is not greater than N, N represents the sequence length of the first sequence, Δ_T represents the maximum delay spread, Δ_F represents the maximum Doppler spread, u represents the base sequence number of the base sequence, $u \in \{1,2,\dots,P-1\}$, u^{-1} represents a minimum positive integer that satisfies $(u^{-1}u) \bmod P = 1$, τ_l represents a cyclic shift in delay domain, ν_l represents a cyclic shift in Doppler domain, an ambiguity function of $g_{u,l}^{(\Delta_T,\Delta_F)}$ is equal to zero within the maximum delay spread and the maximum Doppler spread, and l represents the cyclic shift index.

7. The method according to claim 6, wherein the method further comprises:

determining a first sequence set, wherein the first sequence set is obtained by sequentially traversing the cyclic shift of the auxiliary sequence and the base sequence number of the base sequence, and the first sequence set comprises the first sequence.

8. The method according to claim 5, wherein when the ambiguity function of the first sequence is less than or equal to the ambiguity function threshold within the maximum delay spread and the maximum Doppler spread, the auxiliary sequence number $f_{u,k}^{(\Delta_T,\Delta_F)}$ of the auxiliary sequence satisfies:

$$f_{u,k}^{(\Delta_T,\Delta_F)} = 3uk\Delta_T$$

and the cyclic shift $g_{u,l}^{(\Delta_T,\Delta_F)}$ of the auxiliary sequence satisfies:

$$g_{u,l}^{(\Delta_T,\Delta_F)} = l\Delta_F$$

wherein Δ_T represents the maximum delay spread, Δ_F represents the maximum Doppler spread, u represents the base sequence number of the base sequence, $u \in \{1,2,\dots,P-1\}$, P

represents the maximum prime number that is not greater than N, N represents the sequence length of the first sequence, $k \in \{0,1,\dots,\lfloor P/\Delta_{\mathrm{T}} \rfloor - 1\}, l \in \{0,1,\dots,\lfloor N/\Delta_{\mathrm{F}} \rfloor - 1\}$, and $\lfloor\ \rfloor$ represents rounding down.

9. The method according to claim 8, wherein the method further comprises:

determining a second sequence set, wherein the second sequence set is obtained by sequentially traversing the cyclic shift of the auxiliary sequence, the auxiliary sequence number of the auxiliary sequence, and the base sequence number of the base sequence, and the second sequence set comprises the first sequence.

10. The method according to any one of claims 6 to 9, wherein the sequence length N of the first sequence is a prime number, and P is equal to the sequence length N.

11. The method according to any one of claims 1 to 4, wherein the first signal is a demodulation reference signal; and

when the base sequence is the ideal auto-correlation function sequence, and the ambiguity function of the first sequence is equal to zero within the maximum delay spread and the maximum Doppler spread, a sequence capacity of the first sequence is positively correlated with a square of the sequence length of the first sequence; or

when the base sequence is the optimal auto-ambiguity function sequence, and the ambiguity function of the first sequence is less than or equal to the ambiguity function threshold within the maximum delay spread and the maximum Doppler spread, a sequence capacity of the first sequence is positively correlated with a cube of the sequence length of the first sequence.

12. The method according to claim 11, wherein when data corresponding to the first signal is carried on an orthogonal frequency division multiplexing waveform, the base sequence is the optimal auto-ambiguity function sequence, the auxiliary sequence is the quadratic polynomial exponential sequence, the ambiguity function of the first sequence is less than or equal to the ambiguity function threshold within the maximum delay spread and the maximum Doppler spread, and that the first signal is determined based on the first sequence comprises:

the first signal is determined by performing frequency domain comb mapping or frequency division multiplexing mapping on the first sequence.

13. The method according to claim 12, wherein the first signal is determined based on the first sequence, and satisfies:

$$r^{(m,q)}(n) = e^{-\frac{j2\pi vq}{Q}} \cdot r_{u,k,l}^{(\Delta_{\mathrm{T}},\Delta_{\mathrm{F}})}(n), n = 0,1,\dots,N-1$$

wherein $r^{(m,q)}(n)$ is the first signal, $r_{u,k,l}^{(\Delta_{\mathrm{T}},\Delta_{\mathrm{F}})}(n)$ is the first sequence, N represents the sequence length of the first sequence, Δ_{T} represents the maximum delay spread, Δ_{F} represents the maximum Doppler spread, Q represents a length of a frequency domain orthogonal cover

code, m represents a transmission comb index, $m \in \{0,1,\dots,M-1\}$, M represents a quantity of transmission combs, q represents a symbol position of the frequency domain orthogonal cover code, $q \in \{0,1,\dots,Q-1\}$, v represents a frequency domain orthogonal cover code index, $v \in \{0,1,\dots,Q-1\}$, u represents the base sequence number of the base sequence, $u \in \{1,2,\dots,P-1\}$, P represents the maximum prime number that is not greater than the sequence length N, k represents the auxiliary sequence number index, and l represents the cyclic shift index.

14. The method according to claim 12 or 13, wherein when the first signal is determined by performing frequency domain comb mapping on the first sequence, the auxiliary sequence number $f_{u,k}^{(\Delta_T,\Delta_F)}$ of the auxiliary sequence satisfies:

$$f_{u,k}^{(\Delta_T,\Delta_F)} = \frac{3u[(kM+m)\Delta_F - m]}{M}$$

and the cyclic shift $g_{u,l}^{(\Delta_T,\Delta_F)}$ of the auxiliary sequence satisfies:

$$g_{u,l}^{(\Delta_T,\Delta_F)} = l\Delta_T$$

wherein Δ_T represents the maximum delay spread, Δ_F represents the maximum Doppler spread, M represents the quantity of transmission combs, m represents the transmission comb index, u represents the base sequence number of the base sequence, $u \in \{1,2,\dots,P-1\}$, P represents the maximum prime number that is not greater than the sequence length N, N represents the sequence length of the first sequence, $(k \in \{0,1,\dots,\lfloor P/\Delta_F \rfloor - 1\}, m \in \{0,1,\dots,M-1\}) \vee (k \in \{\lfloor P/\Delta_F \rfloor\}, m \in \{0,1,\dots,\lfloor MP/\Delta_F \rfloor - M\lfloor P/\Delta_F \rfloor - 1\}), l \in \{0,1,\dots,\lfloor N/\Delta_T \rfloor - 1\}$, and $\lfloor\ \rfloor$ represents rounding down.

15. The method according to claim 12 or 13, wherein when the first signal is determined by performing frequency division multiplexing mapping on the first sequence, the auxiliary sequence number $f_{u,k}^{(\Delta_T,\Delta_F)}$ of the auxiliary sequence satisfies:

$$f_{u,k}^{(\Delta_T,\Delta_F)} = \frac{3u[(kMQ+mQ+q)\Delta_F - (mQ+q)]}{MQ}$$

and the cyclic shift $g_{u,l}^{(\Delta_T,\Delta_F)}$ of the auxiliary sequence satisfies:

$$g_{u,l}^{(\Delta_T,\Delta_F)} = l\Delta_T$$

wherein Δ_T represents the maximum delay spread, Δ_F represents the maximum Doppler spread, M represents the quantity of transmission combs, Q represents the length of the frequency domain orthogonal cover code, m represents the transmission comb index, q represents the symbol position of the frequency domain orthogonal cover code, $q \in \{0,1,\dots,Q-1\}$, u represents the base sequence number of the base sequence, $u \in \{1,2,\dots,P-1\}$, P represents the maximum prime number that is not greater than the sequence length N, N

represents the sequence length of the first sequence, $(k \in \{0,1,\dots,\lfloor P/\Delta_{\mathrm{F}} \rfloor - 1\}, m \in \{0,1,\dots,M-1\}) \vee (k \in \{\lfloor P/\Delta_{\mathrm{F}} \rfloor\}, m \in \{0,1,\dots,\lfloor MP/\Delta_{\mathrm{F}} \rfloor - M\lfloor P/\Delta_{\mathrm{F}} \rfloor - 1\}), l \in \{0,1,\dots,\lfloor N/\Delta_{\mathrm{T}} \rfloor - 1\}$, and $\lfloor \quad \rfloor$ represents rounding down.

16. The method according to claim 11, wherein when data corresponding to the first signal is carried on a discrete Fourier transform spread orthogonal frequency division multiplexing waveform, the base sequence is the ideal auto-correlation function sequence, the auxiliary sequence is the cyclic shift sequence, and the ambiguity function of the first sequence is equal to zero within the maximum delay spread and the maximum Doppler spread, and that the first signal is determined based on the first sequence comprises:

the first signal is determined by performing frequency domain comb mapping on the first sequence.

17. The method according to claim 16, wherein the first signal is determined based on the first sequence, and satisfies:

$$r^{(m,0)}(n) = r_{u,k,l}^{(\Delta_{\mathrm{T}},\Delta_{\mathrm{F}})}(n), n = 0,1,\dots,N-1$$

wherein $r^{(m,0)}(n)$ is the first signal, $r_{u,k,l}^{(\Delta_{\mathrm{T}},\Delta_{\mathrm{F}})}(n)$ is the first sequence, N represents the sequence length of the first sequence, Δ_{T} represents the maximum delay spread, Δ_{F} represents the maximum Doppler spread, m represents the transmission comb index, $m \in \{0,1,\dots,M-1\}$, M represents the quantity of transmission combs, u represents the base sequence number of the base sequence, $u \in \{1,2,\dots,P-1\}$, P represents the maximum prime number that is not greater than the sequence length N, k represents the auxiliary sequence number index, and l represents the cyclic shift index.

18. The method according to claim 16 or 17, wherein the auxiliary sequence number $f_{u,k}^{(\Delta_{\mathrm{T}},\Delta_{\mathrm{F}})}$ of the auxiliary sequence is equal to zero, and the cyclic shift $g_{u,l}^{(\Delta_{\mathrm{T}},\Delta_{\mathrm{F}})}$ of the auxiliary sequence satisfies:

$$g_{u,l}^{(\Delta_{\mathrm{T}},\Delta_{\mathrm{F}})} = \left(\tau_l^{(m)} - uv_l^{(m)}\right) \bmod P$$

wherein P represents the maximum prime number that is not greater than the sequence length N, N represents the sequence length of the first sequence, Δ_{T} represents the maximum delay spread, Δ_{F} represents the maximum Doppler spread, m represents the transmission comb index, $m \in \{0,1,\dots,M-1\}$, M represents the quantity of transmission combs, u represents the base sequence number of the base sequence, $u \in \{1,2,\dots,P-1\}$, $\tau_l^{(m)}$ represents a cyclic shift in delay domain, $v_l^{(m)}$ represents a cyclic shift in Doppler domain, an ambiguity function of $g_{u,l}^{(\Delta_{\mathrm{T}},\Delta_{\mathrm{F}})}$ is equal to zero within the maximum delay spread and the maximum Doppler spread, and

l represents the cyclic shift index.

19. A communication apparatus, comprising a unit or module configured to perform the method according to any one of claims 1 to 18.

20. A computer program product, wherein the computer program product comprises a computer program or instructions, and when the computer program or the instructions are executed, the method according to any one of claims 1 to 18 is implemented.