

METHOD AND APPARATUS FOR CONTROLLING AIR CONDITIONING UNIT, ELECTRONIC DEVICE, AND READABLE STORAGE MEDIUM

CROSS-REFERENCES TO RELATED APPLICATIONS

5 **[0001]** This application claims priorities to Chinese Patent Application No. 202111453483.7 filed on December 01, 2021 and entitled “METHOD AND APPARATUS FOR CONTROLLING AIR CONDITIONING UNIT, ELECTRONIC DEVICE, AND READABLE STORAGE MEDIUM,” the entire disclosure of which is incorporated herein by reference.

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FIELD

[0002] The present disclosure relates to the technical field of compressors, and more particular, to a method and apparatus for controlling an air conditioning unit, an electronic device, and a readable storage medium.

BACKGROUND

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[0003] At present, a multi-compressor water chilling (heat pump) unit in the industry is typically composed of a plurality of air conditioners of a same model or a same specification. This design can allow the unit to control each compressor in a simple manner. A typical method for controlling the air conditioning unit is to approximately consider that for compressors (not all compressors) that are operating, each compressor has a same refrigerating capacity and operation efficiency according to a principle of equal power or
20 current. When loading the unit, each compressor is loaded with a same power ratio or a same current ratio until a power or current of the operating compressor reaches its full capacity, and

then the unloaded compressors are started. Similarly, when unloading the unit, each compressor is unloaded (reduced) by an equal power or current until a minimum refrigerating capacity limit of the compressor has been reached, at which point one of the operating compressors is closed.

- 5 **[0004]** However, two obvious defects occur in the above method for controlling the air conditioning unit described above. First, when a plurality of compressors employed by a water chilling (heat pump) unit has different models and specifications, this control method cannot well perform refrigerating capacity distribution of each compressor and determination of an increase or decrease in the number of compressors in operation. Second, although the
- 10 related control method may allow a refrigerating capacity of the unit to satisfy requirements of a user's water system by adjusting an operation parameter of the compressor, this control method lacks a basis on a principle of optimal compressor efficiency, resulting in poor energy efficiency of the air conditioning unit.

SUMMARY

- 15 **[0005]** In view of this, the present disclosure provides a method and apparatus for controlling method an air conditioning unit, an electronic device, and a readable storage medium, to at least adapt to a situation where various compressors in the air conditioning unit have different types and specifications. Moreover, energy efficiency of the air conditioning unit can be improved.
- 20 **[0006]** According to some embodiments of the present disclosure, provided is a method for controlling an air conditioning unit. The method is applied in the air conditioning unit. The air conditioning unit may include a plurality of compressors. The method may include: determining a load adjustment target value of the air conditioning unit; obtaining an operation condition parameter of each of the plurality of compressors, and calculating first optimal
- 25 efficiency and a first workload of each of the plurality of compressors based on the operation condition parameter, in which a maximum of the first workload represents a maximum refrigerating capacity or a maximum heating capacity of the compressor at the first optimal efficiency, and a minimum of the first workload represents a minimum refrigerating capacity

or a minimum heating capacity of the compressor at the first optimal efficiency; obtaining second optimal efficiency and a second workload of the air conditioning unit by performing cross-permutation and combination calculation on the first optimal efficiency and the first workload of each of the plurality of compressors, in which a maximum of the second workload represents a maximum refrigerating capacity or a maximum heating capacity of the air conditioning unit at the second optimal efficiency, and a minimum of the second workload represents a minimum refrigerating capacity or a minimum heating capacity of the air conditioning unit at the first optimal efficiency; determining target optimal efficiency and a target workload from the second optimal efficiency and the second workload of the air conditioning unit based on the load adjustment target value; and controlling, based on the target optimal efficiency and the target workload, the air conditioning unit to perform a refrigeration operation or a heating operation.

[0007] In some embodiments of the present disclosure, the air conditioning unit may include a controller of the air conditioning unit, the plurality of compressors, a sensor of the plurality of compressors, a controller of the plurality of compressors, and an actuator of the plurality of compressors.

[0008] In some embodiments of the present disclosure, said determining the load adjustment target value of the air conditioning unit may include: determining, by the controller of the air conditioning unit, the load adjustment target value of the air conditioning unit based on a target water temperature and a change curve of a current water temperature.

[0009] In some embodiments of the present disclosure, said obtaining the operation condition parameter of each of the plurality of compressors may include: obtaining, by the sensor of the plurality of compressors, the operation condition parameter of the compressor.

[0010] In some embodiments of the present disclosure, the controller of the compressor has a performance database pre-stored thereon. The performance database may include a correspondence between the operation condition parameter of the compressor and the first optimal efficiency and the first workload of the compressor. Said calculating the first optimal efficiency and the first workload of each of the plurality of compressors based on the operation condition parameter may include: inputting the operation condition parameter into the performance database and outputting the first optimal efficiency and the first workload of

the compressor.

[0011] In some embodiments of the present disclosure, said obtaining the second optimal efficiency and the second workload of the air conditioning unit by performing cross-permutation and combination calculation on the first optimal efficiency and the first workload of each of the plurality of compressors may include: performing, by the controller of the air conditioning unit, the cross-permutation and combination calculation on the first optimal efficiency and the first workload of each of the plurality of compressors to obtain the second optimal efficiency and the second workload of the air conditioning unit.

[0012] In some embodiments of the present disclosure, said determining the target optimal efficiency and the target workload from the second optimal efficiency and the second workload of the air conditioning unit based on the load adjustment target value may include: determining third optimal efficiency and a third workload from the second optimal efficiency and the second workload of the air conditioning unit, in which a minimum of the third workload is smaller than the load adjustment target value, and the load adjustment target value is smaller than a maximum of the third workload; and determining a maximum of the third optimal efficiency as the target optimal efficiency and a third workload corresponding to the target optimal efficiency as the target workload.

[0013] In some embodiments of the present disclosure, the maximum of the third optimal efficiency corresponds to a plurality of third workloads. Said determining the third workload corresponding to the target optimal efficiency as the target workload may include: determining a compressor operation time corresponding to the plurality of third workloads corresponding to the maximum of the third optimal efficiency; and determining one of the plurality of third workloads corresponding to a minimum of the compressor operation time as the target workload.

[0014] In some embodiments of the present disclosure, said determining the target optimal efficiency and the target workload from the second optimal efficiency and the second workload of the air conditioning unit based on the load adjustment target value may include: calculating, when there is no third workload, a difference between the minimum of the second workload and the load adjustment target value; determining a second workload corresponding to a minimum of the difference as the target workload; and determining second optimal

efficiency corresponding to the target workload as the target optimal efficiency.

[0015] In some embodiments of the present disclosure, said controlling, based on the target optimal efficiency and the target workload, the air conditioning unit to perform the refrigeration operation or heating operation may include: controlling the actuator of the compressor based on the target optimal efficiency and the target workload, to allow each of the plurality of compressors to perform the refrigeration operation or heating operation.

[0016] In some embodiments of the present disclosure, the air conditioning unit is a water chilling unit or a heat pump unit.

[0017] According to other embodiments of the present disclosure, further provided is an apparatus for controlling an air conditioning unit. The apparatus is applied in the air conditioning unit. The air conditioning unit may include a plurality of compressors. The apparatus may include: a load adjustment target value determination module configured to determine a load adjustment target value of the air conditioning unit; a first optimal efficiency and first workload calculation module configured to obtain an operation condition parameter of each of the plurality of compressors and calculate first optimal efficiency and a first workload of each of the plurality of compressors based on the operation condition parameter, in which a maximum of the first workload represents a maximum refrigerating capacity or a maximum heating capacity of the compressor at the first optimal efficiency, and a minimum of the first workload represents a minimum refrigerating capacity or a minimum heating capacity of the compressor at the first optimal efficiency; a second optimal efficiency and second workload calculation module configured to obtain second optimal efficiency and a second workload of the air conditioning unit by performing cross-permutation and combination calculation on the first optimal efficiency and the first workload of each of the plurality of compressors, in which a maximum of the second workload represents a maximum refrigerating capacity or a maximum heating capacity of the air conditioning unit at the second optimal efficiency, and a minimum of the second workload represents a minimum refrigerating capacity or a minimum heating capacity of the air conditioning unit at the first optimal efficiency; a target optimal efficiency and target workload calculation module configured to determine target optimal efficiency and a target workload from the second optimal efficiency and the second workload of the air conditioning unit based on the load

adjustment target value; and an air conditioning unit operation module configured to control, based on the target optimal efficiency and the target workload, the air conditioning unit to perform a refrigeration operation or a heating operation.

5 [0018] In some embodiments of the present disclosure, the air conditioning unit may include a controller of the air conditioning unit, the plurality of compressors, a sensor of the plurality of compressors, a controller of the plurality of compressors, and an actuator of the plurality of compressors.

10 [0019] In some embodiments of the present disclosure, the load adjustment target value determination module may be further configured to determine, by the controller of the air conditioning unit to determine, based on a target water temperature and a change curve of a current water temperature, the load adjustment target value of the air conditioning unit.

[0020] In some embodiments of the present disclosure, the first optimal efficiency and first workload calculation module may be configured to obtain, by the sensor of the plurality of compressors, the operation condition parameter of the compressor.

15 [0021] In some embodiments of the present disclosure, the controller of the compressor may have a performance database pre-stored thereon. The performance database may include a correspondence between the operation condition parameter of the compressor and the first optimal efficiency and the first workload of the compressor. The first optimal efficiency and first workload calculation module may be further configured to input the operation condition
20 parameter into the performance database and output the first optimal efficiency and the first workload of the compressor.

[0022] In some embodiments of the present disclosure, the second optimal efficiency and second workload calculation module may be further configured to perform, by the controller of the air conditioning unit, the cross-permutation and combination calculation on the first
25 optimal efficiency and the first workload of each of the plurality of compressors to obtain the second optimal efficiency and the second workload of the air conditioning unit.

[0023] In some embodiments of the present disclosure, the target optimal efficiency and target workload calculation module may be further configured to: determine third optimal efficiency and a third workload from the second optimal efficiency and the second workload
30 of the air conditioning unit, in which a minimum of the third workload is smaller than the load

adjustment target value, and the load adjustment target value is smaller than a maximum of the third workload; and determine a maximum of the third optimal efficiency as the target optimal efficiency and a third workload corresponding to the target optimal efficiency as the target workload.

5 **[0024]** According to yet another embodiment of the present disclosure, provided is an electronic device. The electronic device includes a processor and a memory. The memory has computer-executable instructions stored thereon. The computer-executable instruction is executable by the processor. The processor is configured to implement, when executing the computer-executable instruction, the method for controlling the air conditioning unit as
10 described above.

[0025] According to still yet another embodiment of the present disclosure, provided is a computer-readable storage medium. The computer-readable storage medium has computer-executable instructions thereon. The computer-executable instruction, when invoked and executed by a processor, causes the processor to implement the method for controlling the air
15 conditioning unit as described above.

BRIEF DESCRIPTION OF THE DRAWINGS

[0026] In order to clearly explain technical solutions according to the specific implementations of the present disclosure or in the related art, drawings used in the description of the specific implementations or the related art are briefly introduced below.

20 Obviously, the drawings described below are merely some implementations of the present disclosure. Based on these drawings, other drawings can be obtained by those skilled in the art without creative effort.

[0027] FIG. 1 is a schematic diagram of a dual-compressor water-cooled water chilling (heat pump) unit system according to some embodiments of the present disclosure.

25 **[0028]** FIG. 2 is a flowchart of a method for controlling an air conditioning unit according to some embodiments of the present disclosure.

[0029] FIG. 3 is a flowchart of another method for controlling an air conditioning unit according to some embodiments of the present disclosure.

[0030] FIG. 4 is a schematic diagram of a principle of a control system for an air conditioning unit according to some embodiments of the present disclosure.

[0031] FIG. 5 is a logical schematic diagram of a method for controlling an air conditioning unit according to some embodiments of the present disclosure.

5 [0032] FIG. 6 is a schematic diagram of a compressor performance database and an operation principle according to some embodiments of the present disclosure.

[0033] FIG. 7 is a schematic structural diagram of an apparatus for controlling an air conditioning unit according to some embodiments of the present disclosure.

10 [0034] FIG. 8 is a schematic structural diagram of an electronic device according to some embodiments of the present disclosure.

DETAILED DESCRIPTION OF THE EMBODIMENTS

[0035] In order to make the objects, technical solutions, and advantages of the present disclosure more apparent, technical solutions of the present disclosure will be clearly and completely described below in combination with accompanying drawings. Obviously, the
15 embodiments described below are only a part of the embodiments of the present disclosure, rather than all of the embodiments. Based on the embodiments of the present disclosure, other embodiments obtained by those of ordinary skill in the art without creative labor shall fall within the scope of the present disclosure.

[0036] At present, referring to a schematic diagram of a dual-compressor water-cooled
20 water chilling (heat pump) unit system, a multi-compressor water chilling (heat pump) unit in the industry is generally composed of a plurality of air conditioners of a same model or a same specification, that is, a compressor 1 and a compressor 2 in FIG. 1 have the same model and specification. This design can allow the unit to control each of the plurality of compressors in a simple manner. A typical method for controlling the air conditioning unit in
25 the industry is to approximately consider that for compressors (not all compressors) that are operating, each compressor has a same refrigerating capacity and operation efficiency according to a principle of equal power or current. When loading the unit, each compressor is loaded with a same power ratio or a same current ratio until a power or current of the

operating compressor reaches its full capacity, and then the unloaded compressors are started. Similarly, when unloading the unit, each compressor is unloaded (reduced) by an equal power or current until a minimum refrigerating capacity limit of the compressor has been reached, at which point one of the operating compressors is closed.

5 **[0037]** However, two obvious defects occur in the above method for controlling the air conditioning unit described above. First, when a plurality of compressors employed by a water chilling (heat pump) unit has different models and specifications, this control method cannot well perform refrigerating capacity distribution of each compressor and determination of an increase or decrease in the number of compressors in operation. Second, although the
10 related control method may allow a refrigerating capacity of the unit to satisfy requirements of a user's water system by adjusting an operation parameter of the compressor, this control method lacks a basis on a principle of optimal compressor efficiency, resulting in poor energy efficiency of the air conditioning unit. Based on this, the embodiments of the present disclosure provide a method and apparatus for controlling an air conditioning unit, an
15 electronic device, and a readable storage medium, and specifically relate to an optimal energy efficiency method for controlling the multi-compressor water chilling (heat pump) unit.

[0038] In order to facilitate understanding of the embodiments, firstly, a method for controlling an air conditioning unit according to the embodiments of the present disclosure will be described below in detail.

20 **[0039]** The method for controlling the air conditioning unit according to the embodiments of the present disclosure will be described in detail below with reference to the accompanying drawings.

[0040] An embodiment of the present disclosure provides a method for controlling an air conditioning unit. The method is applied in the air conditioning unit. The air conditioning unit
25 may include a plurality of compressors. FIG. 2 shows a flowchart of a method for controlling an air conditioning unit. As illustrated in FIG. 2, the method for controlling the air conditioning unit may include operations at blocks S202 to S210.

[0041] At block S202, a load adjustment target value of the air conditioning unit is determined.

30 **[0042]** The air conditioning unit according to the embodiments of the present disclosure

may include the plurality of compressors. The compressors may have a same model or a same specification, or may have different models and specifications. The compressors may be used for refrigerating or heating. Correspondingly, the above air conditioning unit may be a water chilling unit or a heat pump unit.

5 **[0043]** In addition, the load adjustment target value of the air conditioning unit may be understood as a user's desired refrigerating capacity or heating capacity of the air conditioning unit during its operation. The user may input a target water temperature. The load adjustment target value of the air conditioning unit may be calculated based on the target water temperature inputted by the user.

10 **[0044]** At block S204, an operation condition parameter of each of the plurality of compressors is obtained, and first optimal efficiency and a first workload of each of the plurality of compressors are calculated based on the operation condition parameter.

15 **[0045]** In addition, the operation condition parameter of the compressor may include parameters such as a temperature, humidity, and current of the compressor. A maximum of the first workload represents a maximum refrigerating capacity or a maximum heating capacity of the compressor at the first optimal efficiency. A minimum of the first workload represents a minimum refrigerating capacity or a minimum heating capacity of the compressor at the first optimal efficiency.

20 **[0046]** At block S206, second optimal efficiency and a second workload of the air conditioning unit are obtained by performing cross-permutation and combination calculation on the first optimal efficiency and the first workload of each of the plurality of compressors.

25 **[0047]** In addition, a maximum of the second workload represents a maximum refrigerating capacity or a maximum heating capacity of the air conditioning unit at the second optimal efficiency. A minimum of the second workload represents a minimum refrigerating capacity or a minimum heating capacity of the air conditioning unit at the first optimal efficiency.

30 **[0048]** After the first optimal efficiency and the first workload of each of the plurality of compressors are determined, permutation and combination may be performed on the first optimal efficiency and the first workload of each of the plurality of compressors in various manners, to obtain the second optimal efficiency and the second workload of the air

conditioning unit.

[0049] At block S208, target optimal efficiency and a target workload are determined from the second optimal efficiency and the second workload of the air conditioning unit based on the load adjustment target value.

5 **[0050]** Based on a predetermined screening rule, one best efficiency and one best workload may be determined from the second optimal efficiency and the second workload of each of the plurality of air conditioning units based on the load adjustment target value, and the best efficiency and the best workload are referred to as the target optimal efficiency and the target workload. The above-mentioned screening rule may be set based on an optimal
10 efficiency principle of the compressor. In this way, a control strategy for multi-compressor refrigerating capacity distribution and compressor number addition and reduction is carried out. Therefore, the compressor can be at the optimal efficiency, and the air conditioning unit can be at optimal energy efficiency.

[0051] At block S210, the air conditioning unit is controlled based on the target optimal
15 efficiency and the target workload to perform a refrigeration operation or a heating operation.

[0052] After the target optimal efficiency and the target workload are determined, it is possible to control, based on the target optimal efficiency and the target workload, the compressor in the air conditioning unit to operate or close, to control the air conditioning unit to perform a refrigeration operation or a heating operation.

20 **[0053]** According to the method and apparatus for controlling the air conditioning unit, the electronic device, and the readable storage medium according to the embodiments of the present disclosure, the first optimal efficiency and the first workload of each compressor are calculated based on the operation condition parameter. The second optimal efficiency and the second workload of the air conditioning unit are determined based on the first optimal
25 efficiency and the first workload of each compressor. The target optimal efficiency and the target workload are determined from the second optimal efficiency and the second workload. Moreover, the air conditioning unit is controlled, based on the target optimal efficiency and the target workload, to perform a refrigeration operation or a heating operation.

[0054] Another method for controlling the air conditioning unit according to the
30 embodiments of the present disclosure will be described in detail below with reference to the

accompanying drawings.

[0055] This embodiment provides another method for controlling the air conditioning unit. The method is implemented on the basis of the above embodiments and focuses on descriptions for specific implementation steps of determining the target optimal efficiency and the target workload from the second optimal efficiency and the second workload of each of the plurality of air conditioning units based on the load adjustment target value. A flowchart of another method for controlling the air conditioning unit is illustrated in FIG. 3. As illustrated in FIG. 3, the method for controlling the air conditioning unit in this embodiment includes operation at block S302.

[0056] At block S302, a load adjustment target value of the air conditioning unit is determined.

[0057] In some embodiments, the air conditioning unit may include a controller of the air conditioning unit (also referred to as a unit controller), a plurality of compressors, a sensor of the plurality of compressors, a controller of the plurality of compressors, and an actuator of the plurality of compressors. FIG. 4 illustrates a schematic diagram of a principle of a control system for an air conditioning unit. Referring to FIG. 4, the air conditioning unit in FIG. 4 includes n compressors. Each of the n compressors correspondingly has a controller, an actuator, and a sensor. The controller of the air conditioning unit is in a communication connection with the controller of each of the n compressors.

[0058] In addition, a sensor of a first compressor to n th compressor may collect parameters such as a pressure, a temperature, and a current. An actuator of the first compressor to the n th compressor may perform compressor capacity adjustment and compressor rotational speed adjustment. A controller of the first compressor to the n th compressor has stored thereon a database or a mathematical model (function, equation, association, or the like) between a refrigerating (heating) capacity and efficiency and actuator action parameters of the respective compressor in different operation conditions.

[0059] In addition, when the compressors have the same model and specification or the number of compressors is small, it is possible to dispense with the compressor controller. Instead, all of correlation relationships among functions, software, and databases of the compressor controller and the sensor and actuator of the compressor are integrated into the

unit controller. In addition, all of correlation relationships among functions, software and databases of the unit controller and a sensor and actuator of the unit actuator are integrated into the compressor controller. Therefore, the unit controller can be removed.

[0060] In some embodiments, the load adjustment target value of the air conditioning unit may be determined by the controller of the air conditioning unit based on a target water temperature and a change curve of a current water temperature.

[0061] FIG. 5 shows a logical schematic diagram of a method for controlling an air conditioning unit. Referring to FIG. 5, the unit controller may calculate a load adjustment target value of unit refrigeration (heating) based on a target water temperature set by the user and a change curve of a current actual water temperature.

[0062] At block S304, an operation condition parameter of each of the plurality of compressors is obtained. First optimal efficiency and a first workload of each of the plurality of compressors are calculated based on the operation condition parameter.

[0063] In some embodiments, the sensor of the plurality of compressors may obtain the operation condition parameter of the compressor. The controller of the compressor may input the operation condition parameter into the performance database to output the first optimal efficiency and the first workload of the compressor.

[0064] As illustrated in FIG. 5, the controller of the first compressor to the nth compressor can obtain the operation condition parameter of the compressor by calculating parameters collected by the corresponding sensor and actuator. Since the performance database is pre-stored by the controller of the compressor, based on an actual operation condition parameter of the compressor as an input, the optimal efficiency of the compressor and a maximum refrigerating (heating) capacity and a minimum refrigerating (heating) capacity of the compressor at the optimal efficiency are calculated according to the performance database in the compressor controller, i.e., the first optimal efficiency and the first workload.

[0065] In addition, reference may be made to a schematic diagram of a compressor performance database and an operation principle illustrated in FIG. 6. As illustrated in FIG. 6, the compressor may operate between the maximum of the first workload and the minimum of the first workload at the optimal efficiency.

[0066] At block S306, second optimal efficiency and a second workload of the air

conditioning unit are obtained by performing cross-permutation and combination calculation on the first optimal efficiency and the first workload of each of the plurality of compressors.

[0067] In some embodiments, the controller of the air conditioning unit may obtain the second optimal efficiency and the second workload of the air conditioning unit by performing cross-permutation and combination calculation on the first optimal efficiency and the first workload of each of the plurality of compressors.

[0068] As illustrated in FIG. 5, after the unit controller receives the optimal efficiency and the maximum refrigerating (heating) capacity and minimum refrigerating (heating) capacity uploaded by the controller of each compressor, the cross-permutation and combination calculation is performed on numbers and serial numbers of compressors that are operating, to obtain optimal unit efficiency and a maximum refrigerating (heating) capacity and minimum refrigerating (heating) capacity at the optimal unit efficiency under various operation combination of the compressors.

[0069] In addition, the above cross-permutation and combination may be a weighted calculation. For example, first optimal efficiency of the first compressor is 85%, and a first workload of the first compressor is 500-700, so a weight is 83%; first optimal efficiency of a second compressor is 83%, and a first workload of the second compressor is 200-4700, so a weight is 300. Therefore, it is possible to obtain that the second optimal efficiency of the air conditioning unit = $(85\% \times 600 + 83\% \times 300)/900 = 84.33\%$, the minimum of the second workload = $(500 \times 600 + 200 \times 300)/900 = 400$, and the maximum of the second workload = $(500 \times 700 + 200 \times 2700)/900 = 988.89$.

[0070] At block S308, third optimal efficiency and a third workload are determined from the second optimal efficiency and the second workload of the air conditioning unit. A minimum of the third workload is smaller than the load adjustment target value. Moreover, the load adjustment target value is smaller than a maximum of the third workload; and

[0071] At block S310, a maximum of the third optimal efficiency is determined as the target optimal efficiency. Moreover, a third workload corresponding to the target optimal efficiency is determined as the target workload.

[0072] The embodiments of the present disclosure may provide a manner of multi-level screening of the target workload. In a first-level condition screening, only a compressor

operation combination (i.e., the third optimal efficiency and the third workload) is remained in which a minimum refrigerating (heating) capacity at the unit optimal efficiency < the load adjustment target value of the unit < a maximum refrigerating (heating) capacity at the unit optimal efficiency, and then sorting is performed from a high efficiency value to a low optimal efficiency value of the unit. Finally, the highest optimal efficiency is an optimal solution of an optimal method for controlling unit energy efficiency.

[0073] When the optimal solution of the first-level condition screening is not unique (i.e., the maximum of the third optimal efficiency corresponds to a plurality of third workloads), a second-level condition screening is carried out. In the second-level condition screening, a compressor operation time corresponding to the plurality of third workloads corresponding to the maximum of the third optimal efficiency is determined, and one of the plurality of third workloads corresponding to a minimum of the compressor operation time is determined as the target workload. When there are two or more optimal solutions, a screening condition is an operation combination with a “minimum” operation duration of the compressor, thereby ensuring a balanced service life of each compressor.

[0074] When the optimal solution of the first-level condition screening is 0 (i.e., there is no third workload), the second-level condition screening is further performed. In the second-level condition screening, when there is no third workload, a difference between the minimum of the second workload and the load adjustment target value is calculated. A second workload corresponding to a minimum of the difference is determined as the target workload. Second optimal efficiency corresponding to the target workload is determined as the target optimal efficiency.

[0075] When the optimal solution is 0, in order to ensure the user’s refrigerating (heating) capacity demand, an operation combination is performed in which the load adjustment target value of the unit is smaller than the minimum refrigerating (heating) capacity at the optimal efficiency of the unit and the minimum refrigerating (heating) capacity at the optimal efficiency of the unit minus an overall target value of unit load adjustment is equal to minimum min.

[0076] At block S312, the air conditioning unit is controlled based on the target optimal efficiency and the target workload to perform the refrigeration operation or the heating

operation.

[0077] In some embodiments, the actuator of the compressor may be controlled based on the target optimal efficiency and the target workload, to allow each of the plurality of compressors to perform the refrigeration operation or the heating operation.

5 [0078] Generally, when the compressor operates in its optimal efficiency interval, the compressor operates with good reliability and safety. In this way, stability of the unit is improved, and a risk of compressor failure is lowered. Therefore, the method according to the embodiments of the present disclosure can not only improve operation energy efficiency of the unit and achieve energy conservation and emission reduction, but also improve stability of
10 the unit and reduce the risk of failure of the compressor.

[0079] In the method according to the embodiments of the present disclosure, for the multi-compressor water chilling (heat pump) unit, regardless of whether the model and specification and the performance characteristics of the plurality of compressors in the air conditioning unit are the same, the refrigerating capacity that should be reached by each
15 compressor may be well calculated and allocated. Moreover, it is possible to perform control on an increase and decrease in the number of compressors in operation.

[0080] In the method according to the embodiments of the present disclosure, the permutation and combination calculation of various compressors at the optimal efficiency may be performed, and the optimal solution may be determined on the premise of satisfying
20 the user's requirements of the refrigeration (heating) capacity based on the actual operation condition of each compressor. In this way, the multi-compressor water chilling (heat pump) unit can operate in an optimal energy efficiency state during the load adjustment. Therefore, power consumption of the unit is saved, and energy conservation and emission reduction of the building is achieved.

25 [0081] When the compressor operates in its optimal efficiency interval, the compressor operates with good reliability and safety. Therefore, the above method according to the embodiments of the present disclosure improves the stability of the unit and reduces the risk of the failure of the compressor.

[0082] An apparatus for controlling an air conditioning unit provided according to the
30 embodiments of the present disclosure will be described in detail below with reference to the

accompanying drawings.

[0083] Corresponding to the above method embodiments, an embodiment of the present disclosure provides an apparatus for controlling an air conditioning unit. FIG. 7 shows a schematic structural diagram of an apparatus for controlling an air conditioning unit.

5 Referring to FIG. 7, the apparatus is applied in the air conditioning unit. The air conditioning unit may include a plurality of compressors. The apparatus for controlling the air conditioning unit may include a load adjustment target value determination module 71, a first optimal efficiency and first workload calculation module 72, a second optimal efficiency and second workload calculation module 73, a target optimal efficiency and target workload calculation
10 module 74, and an air conditioning unit operation module 75.

[0084] The load adjustment target value determination module 71 is configured to determine a load adjustment target value of the air conditioning unit.

[0085] The first optimal efficiency and first workload calculation module 72 is configured to obtain an operation condition parameter of each of the plurality of compressors and
15 calculate first optimal efficiency and a first workload of each compressor based on the operation condition parameter. A maximum of the first workload represents a maximum refrigerating capacity or a maximum heating capacity of the compressor at the first optimal efficiency. A minimum of the first workload represents a minimum refrigerating capacity or a minimum heating capacity of the compressor at the first optimal efficiency.

20 **[0086]** The second optimal efficiency and second workload calculation module 73 is configured to obtain second optimal efficiency and a second workload of the air conditioning unit by performing cross-permutation and combination calculation on the first optimal efficiency and the first workload of each of the plurality of compressors. A maximum of the second workload represents a maximum refrigerating capacity or a maximum heating capacity
25 of the air conditioning unit at the second optimal efficiency. A minimum of the second workload represents a minimum refrigerating capacity or a minimum heating capacity of the air conditioning unit at the first optimal efficiency.

[0087] The target optimal efficiency and target workload calculation module 74 is configured to determine target optimal efficiency and a target workload from the second
30 optimal efficiency and the second workload of the air conditioning unit based on the load

adjustment target value.

[0088] The air conditioning unit operation module 75 is configured to control, based on the target optimal efficiency and the target workload, the air conditioning unit to perform a refrigeration operation or a heating operation.

5 **[0089]** With the apparatus for controlling the air conditioning unit according to the embodiments of the present disclosure, the first optimal efficiency and the first workload of each of the plurality of compressors are calculated based on the operation condition parameter. The second optimal efficiency and the second workload of the air conditioning unit are obtained by performing cross-permutation and combination calculation on the first optimal
10 efficiency and the first workload of each of the plurality of compressors. The target optimal efficiency and a target workload are determined from the second optimal efficiency and the second workload, and the air conditioning unit is controlled based on the target optimal efficiency and the target workload to perform the refrigeration operation or the heating operation.

15 **[0090]** In the apparatus, regardless of whether the model and specification and the performance characteristics of the plurality of compressors in the air conditioning unit are the same, the refrigerating capacity or heating capacity that should be reached by each compressor may be well calculated and allocated. Moreover, it is possible to perform control on an increase and decrease in the number of compressors in operation. Further, the
20 permutation and combination calculation of various compressors at the optimal efficiency may be performed, and the optimal solution may be determined on the premise of satisfying the user's requirements of the refrigeration (heating) capacity based on the actual operation condition of each compressor. In this way, the multi-compressor water chilling (heat pump) unit can operate in an optimal energy efficiency state during the load adjustment. Therefore,
25 power consumption of the unit is saved, and energy conservation and emission reduction of the building is achieved.

[0091] The air conditioning unit may include a controller of the air conditioning unit, the plurality of compressors, a sensor of the plurality of compressors, a controller of the plurality of compressors, and an actuator of the plurality of compressors.

30 **[0092]** The load adjustment target value determination module may be further configured

to determine, by the controller of the air conditioning unit, based on a target water temperature and a change curve of a current water temperature, the load adjustment target value of the air conditioning unit.

5 [0093] The first optimal efficiency and first workload calculation module may be configured to obtain, by the sensor of the plurality of compressors, the operation condition parameter of the compressor.

[0094] The controller of the compressor may have a performance database pre-stored thereon. The performance database may include a correspondence between the operation condition parameter of the compressor and the first optimal efficiency and the first workload
10 of the compressor. The first optimal efficiency and first workload calculation module may be further configured to input the operation condition parameter into the performance database and output the first optimal efficiency and the first workload of the compressor.

[0095] The second optimal efficiency and second workload calculation module may be further configured to perform, by the controller of the air conditioning unit, the cross-
15 permutation and combination calculation on the first optimal efficiency and the first workload of each of the plurality of compressors to obtain the second optimal efficiency and the second workload of the air conditioning unit.

[0096] The target optimal efficiency and target workload calculation module may be further configured to determine third optimal efficiency and a third workload from the second
20 optimal efficiency and the second workload of the air conditioning unit. A minimum of the third workload is smaller than the load adjustment target value. The load adjustment target value is smaller than a maximum of the third workload. The target optimal efficiency and target workload calculation module may be further configured to determine a maximum of the third optimal efficiency as the target optimal efficiency and a third workload corresponding to
25 the target optimal efficiency as the target workload.

[0097] The maximum of the third optimal efficiency may correspond to a plurality of third workloads. The target optimal efficiency and target workload calculation module may be further configured to determine a compressor operation time corresponding to the plurality of third workloads corresponding to the maximum of the third optimal efficiency, and determine
30 one of the plurality of third workloads corresponding to a minimum of the compressor

operation time as the target workload.

[0098] The target optimal efficiency and target workload calculation module may be further configured to: calculate, when there is no third workload, a difference between the minimum of the second workload and the load adjustment target value; determine a second workload corresponding to a minimum of the difference as the target workload; and determine second optimal efficiency corresponding to the target workload as the target optimal efficiency.

[0099] The air conditioning unit operation module may be further configured to control the actuator of the compressor based on the target optimal efficiency and the target workload, to allow each of the plurality of compressors to perform the refrigeration operation or heating operation.

[00100] The air conditioning unit is a water chilling unit or a heat pump unit.

[00101] Those skilled in the art can clearly understand that, for convenience and conciseness of the description, for a specific operation process of the above apparatus for the air conditioning unit, reference may be made to a corresponding process in the above embodiments of the method for controlling the air conditioning unit, and details thereof will be omitted herein.

[00102] An electronic device according to embodiments of the present disclosure will be described in detail below with reference to the accompanying drawings.

[00103] The embodiments of the present disclosure further provide an electronic device, which is configured to run the method for controlling the air conditioning unit. Referring to a schematic structural diagram of an electronic device as illustrated in FIG. 8, the electronic device may include a memory 100 and a processor 101. The memory 100 has one or more computer instructions stored thereon. The one or more computer instructions are executed by the processor 101 to implement the above method for controlling the air conditioning unit.

[00104] In some embodiments of the present disclosure, the electronic device illustrated in FIG. 8 may further be configured to include a bus 102 and a communication interface 103. The processor 101, the communication interface 103, and the memory 100 are connected through the bus 102.

[00105] In addition, the memory 100 may include a high-speed Random Access Memory

(RAM), and may also include a non-volatile memory, such as at least one disk memory. A communication connection between a system network element and at least one of other network elements may be implemented through the at least one communication interface 103 (which may be wired or wireless). Moreover, the Internet, a wide area network, a local area network, a metropolitan area network, or the like may be used. The bus 102 may be an Industry Standard Architecture (ISA) bus, a Peripheral Component (PCI) bus, or an Extended Industry Standard Architecture (EISA) bus. The buses may be divided into an address bus, a data bus, a control bus, etc. For the convenience of description, only one bidirectional arrow is used in FIG. 8. However, it does not mean that there is only one bus or one type of bus.

[00106] The processor 101 may be an integrated circuit chip with signal processing capability. In an implementation, the steps of the above methods may be implemented by hardware integrated logic circuits in the processor 101 or instructions in a form of software. The above processor 101 may be a general-purpose processor, including a Central Processing Unit (CPU), a Network Processor (NP), etc.; and may further be a Digital Signal Processor (DSP), an Application Specific Integrated Circuit (ASIC), a Field-Programmable Gate Array (FPGA) or other programmable logic devices, a discrete gate or a transistor logic device, and a discrete hardware component. The methods, steps, and logical block diagrams disclosed in the embodiments of the present disclosure may be implemented or performed by the processor 101. The general-purpose processor may be a microprocessor or any conventional processor. The steps of the methods disclosed in the embodiments of the present disclosure may be directly embodied as being performed and completed by a hardware decoding processor, or by a combination of hardware and software modules in the decoding processor. The software module may be located in a storage medium well-known in the field such as a random access memory, a flash memory, a Read-Only Memory (ROM), a Programmable ROM (PROM), an electrically erasable programmable memory, a register, etc. The storage medium is located in the memory 100, and the processor 101 can read information from the memory 100, and completes the steps in the above method in combination with hardware thereof.

[00107] Embodiments of the present disclosure also provide a computer-readable storage medium. The computer-readable storage medium has computer-executable instructions

thereon. The computer-executable instruction, when invoked and executed by a processor, may cause the processor to implement the method for controlling the air conditioning unit as described above, and thus the specific implementation of the method may refer to that of the method embodiments, and details thereof will be omitted herein.

5 **[00108]** In the method and apparatus for controlling the air conditioning unit, and a computer program product of the electronic device according to the embodiments of the present disclosure, the computer program product may include a computer-readable storage medium having program codes stored thereon. Instructions included in the program code can execute the method in the above method, and thus the specific implementation of the method
10 may refer to that of the method embodiments, and details thereof will be omitted herein.

[00109] Those skilled in the art can clearly understand that, for the convenience and conciseness of the description, for the specific operation processes of the systems and/or apparatus described above, reference may be made to the corresponding processes in the above method, and details thereof will be omitted here.

15 **[00110]** In addition, in the description of the embodiments of the present disclosure, unless otherwise clearly specified and limited, terms such as “installed,” “connected with,” “connected to,” and the like should be understood in a broad sense. For example, it may be a fixed connection or a detachable connection or connection as one piece; a mechanical connection or an electrical connection; a direct connection or an indirect connection through
20 an intermediate; or an internal communication of two components. For those of ordinary skill in the art, the specific meaning of the above-mentioned terms in the present disclosure can be understood according to specific circumstances.

[00111] When the function is implemented in the form of a software functional unit and sold or used as a standalone product, it can be stored in a computer-readable storage medium.

25 Based on such understanding, all or part of the technical solutions according to the present disclosure, or the part thereof that contributes to the related art, can be embodied in the form of a software product. The computer software product may be stored in a storage medium and contain instructions to enable a computer device, such as a personal computer, a server, or a network device, etc., to perform all or part of the steps of the method described in each of the
30 embodiments of the present disclosure. The storage medium may include various mediums

capable of storing program codes, such as a Universal Serial Bus flash drive, a mobile hard disk, an ROM, an RAM, a magnetic disk, or an optical disc.

[00112] In the description of the embodiments of the present disclosure, the orientation or the position indicated by technical terms such as “center,” “over,” “below,” “left,” “right,” “vertical,” “horizontal,” “inner,” and “outer,” should be construed to refer to the orientation and the position as shown in the drawings, and is only for the convenience of describing the embodiments of the present disclosure and simplifying the description, rather than indicating or implying that the pointed device or element must have a specific orientation, or be constructed and operated in a specific orientation, and therefore cannot be understood as a limitation of the embodiments of the present disclosure. In addition, the term “first,” “second,” “third” is only for descriptive purposes, rather than indicating or implying relative importance.

[00113] Finally, it should be noted that the embodiments described above are merely specific implementations of the present disclosure and are used only to illustrate, rather than limit the technical solutions of the present disclosure, and the scope of the present disclosure is not limited thereto. Although the present disclosure has been described in detail with reference to the foregoing embodiments, it is conceivable for those skilled in the art that, within the technical scope disclosed in the present disclosure, modifications can be made or can be easily conceived to the technical solutions described in the foregoing embodiments, or equivalent replacements can be made to some of the technical features in the technical solutions described in the foregoing embodiments. These modifications, changes, or replacements, which do not depart the essence of corresponding technical solutions from the spirit and scope of the technical solutions of the embodiments of the present disclosure, shall fall within the scope of the present disclosure. Therefore, the scope of the present disclosure should be defined only by claims.

[00114] INDUSTRIAL APPLICABILITY

[00115] Embodiments of the present disclosure provide a method and apparatus for controlling an air conditioning unit, an electronic device, and a readable storage medium. The method includes: determining a load adjustment target value of the air conditioning unit; obtaining an operation condition parameter of each of the plurality of compressors, and calculating first optimal efficiency and a first workload of each of the plurality of compressors

based on the operation condition parameter; obtaining second optimal efficiency and a second workload of the air conditioning unit by performing cross-permutation and combination calculation on the first optimal efficiency and the first workload of each of the plurality of compressors; determining target optimal efficiency and a target workload from the second optimal efficiency and the second workload of the air conditioning unit based on the load adjustment target value; and controlling, based on the target optimal efficiency and the target workload, the air conditioning unit to perform a refrigeration operation or a heating operation. In this way, various compressors of different models and specifications in the air conditioning unit can be adapted. Further, it is possible to enhance the energy efficiency of the air conditioning unit.

[00116] In addition, it should be understood that the method and apparatus for controlling the air conditioning unit, the electronic device, and the readable storage medium of the present disclosure may be reproduced and may be applied to various applications. For example, the air control method and apparatus for the conditioning unit, the electronic device, and the readable storage medium of the present disclosure may be applied to the technical field of air conditioners.

CLAIMS

What is claimed is:

1. A method for controlling an air conditioning unit, the method being applied in the air conditioning unit comprising a plurality of compressors, the method comprising:

5 determining a load adjustment target value of the air conditioning unit;

 obtaining an operation condition parameter of each of the plurality of compressors, and calculating first optimal efficiency and a first workload of each of the plurality of compressors based on the operation condition parameter, wherein a maximum of the first workload represents a maximum refrigerating capacity or a maximum heating capacity of the
10 compressor at the first optimal efficiency, and wherein a minimum of the first workload represents a minimum refrigerating capacity or a minimum heating capacity of the compressor at the first optimal efficiency;

 obtaining second optimal efficiency and a second workload of the air conditioning unit by performing cross-permutation and combination calculation on the first optimal efficiency
15 and the first workload of each of the plurality of compressors, wherein a maximum of the second workload represents a maximum refrigerating capacity or a maximum heating capacity of the air conditioning unit at the second optimal efficiency, and wherein a minimum of the second workload represents a minimum refrigerating capacity or a minimum heating capacity of the air conditioning unit at the first optimal efficiency;

20 determining target optimal efficiency and a target workload from the second optimal efficiency and the second workload of the air conditioning unit based on the load adjustment target value; and

 controlling, based on the target optimal efficiency and the target workload, the air conditioning unit to perform a refrigeration operation or a heating operation.

25 2. The method according to claim 1, wherein the air conditioning unit comprises a controller of the air conditioning unit, the plurality of compressors, a sensor of the plurality of compressors, a controller of the plurality of compressors, and an actuator of the plurality of compressors.

3. The method according to claim 2, wherein said determining the load adjustment target

value of the air conditioning unit comprises:

determining, by the controller of the air conditioning unit, the load adjustment target value of the air conditioning unit based on a target water temperature and a change curve of a current water temperature.

5 4. The method according to claim 2 or 3, wherein said obtaining the operation condition parameter of each of the plurality of compressors comprises:

obtaining, by the sensor of the plurality of compressors, the operation condition parameter of the compressor.

5. The method according to any one of claims 2 to 4, wherein:

10 the controller of the compressor has a performance database pre-stored thereon, the performance database comprising a correspondence between the operation condition parameter of the compressor and the first optimal efficiency and the first workload of the compressor; and

15 said calculating the first optimal efficiency and the first workload of each of the plurality of compressors based on the operation condition parameter comprises:

inputting the operation condition parameter into the performance database and outputting the first optimal efficiency and the first workload of the compressor.

20 6. The method according to any one of claims 2 to 5, wherein said obtaining the second optimal efficiency and the second workload of the air conditioning unit by performing the cross-permutation and combination calculation on the first optimal efficiency and the first workload of each of the plurality of compressors comprises:

25 performing, by the controller of the air conditioning unit, the cross-permutation and combination calculation on the first optimal efficiency and the first workload of each of the plurality of compressors to obtain the second optimal efficiency and the second workload of the air conditioning unit.

7. The method according to any one of claims 1 to 6, wherein said determining the target optimal efficiency and the target workload from the second optimal efficiency and the second workload of the air conditioning unit based on the load adjustment target value comprises:

30 determining third optimal efficiency and a third workload from the second optimal efficiency and the second workload of the air conditioning unit, wherein a minimum of the

third workload is smaller than the load adjustment target value, and wherein the load adjustment target value is smaller than a maximum of the third workload; and

determining a maximum of the third optimal efficiency as the target optimal efficiency and a third workload corresponding to the target optimal efficiency as the target workload.

5 8. The method according to claim 7, wherein:

the maximum of the third optimal efficiency corresponds to a plurality of third workloads; and

said determining the third workload corresponding to the target optimal efficiency as the target workload comprises:

10 determining a compressor operation time corresponding to the plurality of third workloads corresponding to the maximum of the third optimal efficiency; and

determining one of the plurality of third workloads corresponding to a minimum of the compressor operation time as the target workload.

15 9. The method according to claim 7, wherein said determining the target optimal efficiency and the target workload from the second optimal efficiency and the second workload of the air conditioning unit based on the load adjustment target value comprises:

calculating, when there is no third workload, a difference between the minimum of the second workload and the load adjustment target value;

20 determining a second workload corresponding to a minimum of the difference as the target workload; and

determining second optimal efficiency corresponding to the target workload as the target optimal efficiency.

25 10. The method according to any one of claims 2 to 9, wherein said controlling, based on the target optimal efficiency and the target workload, the air conditioning unit to perform the refrigeration operation or the heating operation comprises:

controlling the actuator of the compressor based on the target optimal efficiency and the target workload, to allow each of the plurality of compressors to perform the refrigeration operation or the heating operation.

30 11. The method according to any one of claims 1 to 10, wherein the air conditioning unit is a water chilling unit or a heat pump unit.

12. An apparatus for controlling an air conditioning unit, the apparatus being applied in the air conditioning unit comprising a plurality of compressors, the apparatus comprising:

a load adjustment target value determination module configured to determine a load adjustment target value of the air conditioning unit;

5 a first optimal efficiency and first workload calculation module configured to obtain an operation condition parameter of each of the plurality of compressors and calculate first optimal efficiency and a first workload of each of the plurality of compressors based on the operation condition parameter, wherein a maximum of the first workload represents a maximum refrigerating capacity or a maximum heating capacity of the compressor at the first
10 optimal efficiency, and wherein a minimum of the first workload represents a minimum refrigerating capacity or a minimum heating capacity of the compressor at the first optimal efficiency;

a second optimal efficiency and second workload calculation module configured to obtain second optimal efficiency and a second workload of the air conditioning unit by
15 performing cross-permutation and combination calculation on the first optimal efficiency and the first workload of each of the plurality of compressors, wherein a maximum of the second workload represents a maximum refrigerating capacity or a maximum heating capacity of the air conditioning unit at the second optimal efficiency, and wherein a minimum of the second workload represents a minimum refrigerating capacity or a minimum heating capacity of the
20 air conditioning unit at the first optimal efficiency;

a target optimal efficiency and target workload calculation module configured to determine target optimal efficiency and a target workload from the second optimal efficiency and the second workload of the air conditioning unit based on the load adjustment target value; and

25 an air conditioning unit operation module configured to control, based on the target optimal efficiency and the target workload, the air conditioning unit to perform a refrigeration operation or a heating operation.

13. The apparatus according to claim 12, wherein the air conditioning unit comprises a controller of the air conditioning unit, the plurality of compressors, a sensor of the plurality of
30 compressors, a controller of the plurality of compressors, and an actuator of the plurality of

compressors.

14. The apparatus according to claim 13, wherein the load adjustment target value determination module is further configured to determine, by the controller of the air conditioning unit, based on a target water temperature and a change curve of a current water temperature, the load adjustment target value of the air conditioning unit.

15. The apparatus according to claim 13 or 14, wherein the first optimal efficiency and first workload calculation module is further configured to obtain, by the sensor of the plurality of compressors, the operation condition parameter of the compressor.

16. The apparatus according to any one of claims 13 to 15, wherein:
the controller of the compressor has a performance database pre-stored thereon, the performance database comprising a correspondence between the operation condition parameter of the compressor and the first optimal efficiency and the first workload of the compressor; and

the first optimal efficiency and first workload calculation module is further configured to input the operation condition parameter into the performance database and output the first optimal efficiency and the first workload of the compressor.

17. The apparatus according to any one of claims 13 to 16, wherein the second optimal efficiency and second workload calculation module is further configured to perform, by the controller of the air conditioning unit, the cross-permutation and combination calculation on the first optimal efficiency and the first workload of each of the plurality of compressors to obtain the second optimal efficiency and the second workload of the air conditioning unit.

18. The apparatus according to any one of claims 13 to 17, wherein the target optimal efficiency and target workload calculation module is further configured to:

determine a third optimal efficiency and a third workload from the second optimal efficiency and the second workload of the air conditioning unit, wherein a minimum of the third workload is smaller than the load adjustment target value, and wherein the load adjustment target value is smaller than a maximum of the third workload; and

determine a maximum of the third optimal efficiency as the target optimal efficiency and a third workload corresponding to the target optimal efficiency as the target workload.

19. An electronic device, comprising:

a processor; and

a memory having computer-executable instructions stored thereon, the computer-executable instructions being executable by the processor,

wherein the processor is configured to implement, when executing the computer-executable instructions, the method according to any one of claims 1 to 11.

20. A computer-readable storage medium, having computer-executable instructions stored thereon, wherein the computer-executable instructions, when invoked and executed by a processor, causes the processor to implement the method according to any one of claims 1 to 11.