

## DESCRIPTION

**Title of Invention:** AIR-CONDITIONING SYSTEM, AIR-CONDITIONING  
MANAGEMENT SERVER, AIR-CONDITIONING MANAGEMENT METHOD AND  
5 AIR-CONDITIONING MANAGEMENT PROGRAM

**Technical Field**

[0001] The present invention relates to an air-conditioning system, an air-conditioning  
management server, an air-conditioning management method and an air-conditioning  
10 management program. Especially, the present invention relates to an air-conditioning  
system, an air-conditioning management server, an air-conditioning management  
method and an air-conditioning management program to manage air-conditioning of a  
warehouse.

**Background Art**

15 [0002] A business operator of a refrigerated warehouse determines a set value of an air  
conditioner facility based on information such as air-conditioning temperature inside a  
warehouse and air flow simulation in the warehouse. However, temperature  
irregularity occurs due to events such as inflow of outside air at the storage and retrieval  
time, or change in loads arrangement inside the warehouse. In order to deal with the  
20 temperature irregularity, supercooling operation is generally performed. Then, electric  
power cost due to the supercooling operation has become a problem.

Patent Literature 1 discloses a technique to suitably select an energy-saving  
method accumulated beforehand and control an air-conditioning unit, based on input  
information such as a store floor area, set temperature, business hours of a store and  
25 electric charge.

## **Citation List**

### **Patent Literature**

[0003] Patent Literature 1: JP 2002-202998 A

### **Summary of Invention**

#### **5 Technical Problem**

[0004] In a case of a refrigerated warehouse, environment under consideration such as arrangement of loads, and carrying loads in and out dynamically changes. Therefore, it is difficult to sufficiently handle a dynamic environment change in a refrigerated warehouse only with selection and application of a static energy-saving method, as in

10 Patent Literature 1.

[0005] The present invention is aimed at realizing energy conservation of a refrigerated warehouse by performing air-conditioning control to cope with a dynamic environment change in the refrigerated warehouse.

### **Solution to Problem**

15 [0006] An air-conditioning system, according to one aspect of present invention, to manage air-conditioning of a warehouse, the air-conditioning system comprising a storage and retrieval server, an air-conditioning management server and a warehouse device, wherein

the storage and retrieval server includes an arrangement management unit to  
20 transmit, when arrangement of a load in the warehouse is changed, an arrangement change notification including arrangement information representing arrangement of the load at present in the warehouse, to the air-conditioning management server,

the air-conditioning management server includes:

an air-conditioning mode database that stores an arrangement pattern of the  
25 load in the warehouse and an air-conditioning mode used for air-conditioning control

over the warehouse by associating the arrangement pattern with the air-conditioning mode, and

a mode extraction unit to receive the arrangement change notification from the storage and retrieval server, to extract an air-conditioning mode corresponding to the arrangement pattern that is closest to the arrangement information included in the arrangement change notification, from the air-conditioning mode database, and to transmit a control instruction to instruct air-conditioning control over the warehouse by the air-conditioning mode extracted, to the warehouse device, and wherein

the warehouse device includes a control unit to receive the control instruction from the air-conditioning management server, and to perform air-conditioning control over the warehouse based on the control instruction.

#### **Advantageous Effects of Invention**

[0007] In an air-conditioning system according to the present invention, an arrangement management unit of a storage and retrieval server transmits an arrangement change notification including arrangement information representing arrangement of loads at present in a warehouse, to an air-conditioning management server, when arrangement of loads in the warehouse is changed. Then, a mode extraction unit of an air-conditioning management server extracts, from an air-conditioning mode database, an air-conditioning mode corresponding to an arrangement pattern closest to the arrangement information included in the arrangement change notification. Further, the mode extraction unit transmits a control instruction instructing air-conditioning control over a warehouse in the air-conditioning mode extracted to a warehouse device.

Therefore, the air-conditioning system according to the present invention makes it possible to perform air-conditioning control to cope with a dynamic environment change in a warehouse, and to realize energy conservation of the warehouse.

### **Brief Description of Drawings**

[0008] Fig. 1 is a configuration diagram of an air-conditioning system according to a first embodiment;

Fig. 2 is a configuration diagram of an air-conditioning management server  
5 according to the first embodiment;

Fig. 3 is a configuration diagram of a warehouse system according to the first embodiment;

Fig. 4 is a configuration diagram of a storage and retrieval server according to the first embodiment;

10 Fig. 5 is a diagram illustrating an example of an air-conditioning mode database according to the first embodiment;

Fig. 6 is a flow diagram of an air-conditioning management process according to the first embodiment;

15 Fig. 7 is a configuration diagram of an air-conditioning system according to a second embodiment;

Fig. 8 is a configuration diagram of a warehouse system according to the second embodiment;

Fig. 9 is a configuration diagram of a storage and retrieval server according to the second embodiment;

20 Fig. 10 is a configuration diagram of an air-conditioning management server according to the second embodiment;

Fig. 11 is a flow diagram of an initial data registration process according to the second embodiment;

25 Fig. 12 is a diagram illustrating an example of a request condition database according to the second embodiment;

Fig. 13 is a flow diagram of a model update process of a model update unit according to the second embodiment;

Fig. 14 is a diagram illustrating an example of a model database according to the second embodiment;

5 Fig. 15 is a flow diagram of a mode search process of a mode search unit according to the second embodiment;

Fig. 16 is a diagram illustrating an example of an air-conditioning mode database according to the second embodiment;

10 Fig. 17 is a flow diagram of a mode extraction process of a mode extraction unit according to the second embodiment; and

Fig. 18 is a flow diagram of a state monitoring process of a state monitoring unit according to the second embodiment.

### **Description of Embodiments**

[0009] Hereinafter, embodiments of the present invention will be described with  
15 reference to diagrams. In the diagrams, same parts or corresponding parts are denoted by same reference numerals. In the explanation of the embodiments, explanation for the same parts or the corresponding parts is omitted or simplified appropriately.

#### **[0010] First Embodiment**

##### **\*\*\*Explanation of Configuration\*\*\***

20 A configuration of an air-conditioning system 500 according to the present embodiment will be described with reference to Fig. 1.

The air-conditioning system 500 manages air-conditioning of a warehouse. The air-conditioning system 500 includes a warehouse system 100, a storage and retrieval server 200 and an air-conditioning management server 300. The warehouse  
25 system 100, the storage and retrieval server 200 and the air-conditioning management

server 300 communicate with one another via a network 400.

The warehouse system 100 includes a warehouse 110. Loads are warehoused and arranged in the warehouse 110. Otherwise, loads arranged in the warehouse 110 are delivered. Warehousing or delivery of loads is also called storage and retrieval of loads. A specific example of the warehouse 110 is a refrigerated warehouse to refrigerate loads.

[0011] A configuration of an air-conditioning management server 300 according to the present embodiment will be described with reference to Fig. 2.

The air-conditioning management server 300 is a computer. The air-conditioning management server 300 is equipped with a processor 910 as well as other hardware components such as a memory 921, an auxiliary storage device 922, an input interface 930, an output interface 940 and a communication device 950. The processor 910 is connected to other hardware components via a signal line to control those other hardware components.

[0012] The air-conditioning management server 300 is equipped with a communication control unit 310, a mode extraction unit 320 and an air-conditioning mode database 330, as functional components.

[0013] The communication control unit 310 is provided in the communication device 950.

Functions of the mode extraction unit 320 are realized by software.

The air-conditioning mode database 330 is provided in a memory 921 or an auxiliary storage device 922.

[0014] The processor 910 is a device to execute an air-conditioning management program. The air-conditioning management program is a program to realize the functions of the mode extraction unit 320.

The processor 910 is an integrated circuit (IC) to perform arithmetic processing.

The processor 910 is, as a specific example, a central processing unit (CPU), a digital signal processor (DSP) or a graphics processing unit (GPU).

[0015] The memory 921 is a storage device to temporarily store data. The memory

5 921 is, as a specific example, a static random access memory (SRAM) or a dynamic random access memory (DRAM).

The auxiliary storage device 922 is a storage device to store data. The

auxiliary storage device 922 is, as a specific example, an HDD. Further, the auxiliary storage device 922 may be a portable storage medium such as an SD (registered

10 trademark) memory card, a compact flash (CF), a NAND flash, a flexible disk, an optical disk, a compact disk, a Blue-ray (registered trademark) disk, a digital versatile disk (DVD), etc. HDD is an abbreviation for hard disk drive. SD (registered trademark) is an abbreviation for secure digital. CF is an abbreviation for compact flash. DVD is an abbreviation for digital versatile disk.

15 [0016] The input interface 930 is a port connected to an input device such as a mouse, a keyboard, or a touch panel. The input interface 930 is a universal serial bus (USB) terminal. The input interface 930 may be a port connected to a local area network (LAN).

The output interface 940 is a port whereto a cable of an output apparatus such

20 as a display is connected. The output interface 940 is, specifically, a USB terminal or a high definition multimedia interface (HDMI) (registered trademark) terminal. The display is, specifically, a liquid crystal display (LCD).

[0017] The communication device 950 includes a receiver and a transmitter. The communication device 950 is connected to a communication network such as a LAN,

25 the Internet or a telephone line wirelessly. The communication device 950 is,

specifically, a communication chip or a network interface card (NIC).

[0018] The air-conditioning management program is read by the processor 910, and executed by the processor 910. The memory 921 stores not only the air-conditioning management program but also an operating system (OS). The processor 910 executes

5 the air-conditioning management program while executing the OS. The air-conditioning management program and the OS may be stored in the auxiliary storage device 922. The air-conditioning management program and the OS stored in the auxiliary storage device 922 are loaded into the memory 921, and executed by the processor 910. A part or all of the air-conditioning management program may be  
10 incorporated in the OS.

[0019] The air-conditioning management server 300 may include a plurality of processors replacing the processor 910. The plurality of processors share execution of the air-conditioning management program. Each processor is a device to execute the air-conditioning management program in the same manner as the processor 910.

15 [0020] The data, information, signal values, variable values used, processed or output by the air-conditioning management program are stored in the memory 921, the auxiliary storage device 922, or a register or a cache memory inside the processor 910.

[0021] The communication control unit 310 communicates with a communication control unit of a warehouse device 120 or the storage and retrieval server 200.

20 The air-conditioning mode database 330 stores an arrangement pattern of loads in the warehouse, and an air-conditioning mode used for air-conditioning control of the warehouse, by associating the arrangement pattern with the air-conditioning mode. Further, the air-conditioning mode database 330 stores each of a storage time and a retrieval time of loads in and from the warehouse, and an air-conditioning mode, by  
25 associating each of the storage time and the retrieval time of the loads with the

air-conditioning mode. The air-conditioning mode is a suitable control method of an air-conditioning related facility for each time of storage and retrieval, or for each arrangement pattern of loads.

The mode extraction unit 320 receives the arrangement change notification 22 from the storage and retrieval server 200. The mode extraction unit 320 extracts an air-conditioning mode corresponding to an arrangement pattern closest to the arrangement information included in the arrangement change notification 22 from the air-conditioning mode database 330. The mode extraction unit 320 transmits a control instruction 21 to instruct air-conditioning control over the warehouse in the air-conditioning mode extracted, to the warehouse system 100. Further, the mode extraction unit 320 receives a storage and retrieval start notification 23 representing start of storage and retrieval of loads from the storage and retrieval server 200. The mode extraction unit 320 extracts an air-conditioning mode corresponding to the time of storage or the time of retrieval from the air-conditioning mode database 330 based on the storage and retrieval start notification 23. The mode extraction unit 320 transmits a control instruction 21 instructing air-conditioning control over the warehouse in the air-conditioning mode extracted, to the warehouse system 100.

[0022] A configuration of the warehouse system 100 according to the present embodiment will be described with reference to Fig. 3.

The warehouse system 100 includes the warehouse 110, the warehouse device 120 and an air-conditioning related facility 130.

The warehouse device 120 is a computer. The warehouse device 120 includes hardware components such as a processor 910, a memory 921, an auxiliary storage device 922, an input interface 930, an output interface 940 and a communication device 950. However, in Fig. 3, description of these hardware components is omitted. The

warehouse device 120 includes a communication control unit 101 and a control unit 102 as functional components.

[0023] The communication control unit 101 controls communication with an external network.

5           The control unit 102 receives a control instruction 21 from the air-conditioning management server 300. The control unit 102 performs air-conditioning control over the warehouse 110 based on the control instruction 21. That is, the control unit 102 monitors and controls the air-conditioning related facility 130 based on the control instruction 21. The control unit 102 is also called an apparatus monitoring control  
10   unit.

[0024] The communication control unit 101 is provided in the communication device 950.

The functions of the control unit 102 are realized by software.

A warehouse program and an OS stored in the auxiliary storage device 922 are  
15   loaded into the memory 921, and executed by the processor 910.

The hardware of the warehouse device 120 is similar to that of the air-conditioning management server 300.

[0025] The air-conditioning related facility 130 is a device such as an air conditioner 103, a chiller 104, a ventilator 105, an air curtain 106, a material handling device 107,  
20   and air-conditioning related equipment 108. The air-conditioning related facility 130 is installed in the warehouse 110. The material handling device 107 moves loads.

The air-conditioning related equipment 108 is a collective term for other air-conditioning related devices such as a dock shelter.

[0026] A configuration of the storage and retrieval server 200 according to the present  
25   embodiment will be described with reference to Fig. 4.

The storage and retrieval server 200 is a computer. The storage and retrieval server 200 is equipped with hardware components such as a processor 910, a memory 921, an auxiliary storage device 922, an input interface 930, an output interface 940 and a communication device 950. However, in Fig. 4, description of these hardware components is omitted. The storage and retrieval server 200 includes a communication control unit 210, an arrangement management unit 220 and an arrangement database 230, as functional components.

[0027] The communication control unit 210 controls communication with an external network.

When arrangement of loads in the warehouse 110 is changed, an arrangement management unit 220 transmits an arrangement change notification 22 including arrangement information representing a present arrangement of loads in the warehouse 110 to the air-conditioning management server 300. Further, the arrangement management unit 220 transmits a storage and retrieval start notification 23 representing start of storage and retrieval of loads to the air-conditioning management server 300. That is, the arrangement management unit 220 notifies the air-conditioning management server 300 of an arrangement pattern of loads when storage or retrieval is started or completed, and when arrangement of loads inside the warehouse is updated.

The arrangement database 230 stores arrangement information of loads inside the warehouse 110.

[0028] The communication control unit 210 is provided in the communication device 950.

The functions of the arrangement management unit 220 are realized by software.

The arrangement database 230 is installed in the memory 921 or the auxiliary

storage device 922.

The storage and retrieval program and the OS stored in the auxiliary storage device 922 are loaded into the memory 921, and executed by the processor 910.

The hardware of the storage and retrieval server 200 is similar to that of the  
5 air-conditioning management server 300.

[0029] The “unit” of the mode extraction unit 320, the control unit 102 and the arrangement management unit 220 may be replaced with “process,” “procedure” or “step.” Further, the “process” of an air-conditioning management process, a mode extraction process, a control process and an arrangement management process may be  
10 replaced with “program,” “program product” or “computer-readable storage medium recording a program.”

The air-conditioning management program makes a computer execute each process, each procedure or each step being “process,” “procedure” or “step” with which “unit” of each unit mentioned above is replaced. Further, an air-conditioning  
15 management method is a method performed by executing the air-conditioning management program by the air-conditioning management server 300.

The air-conditioning management program may be stored and provided in a computer-readable storage medium. Further, the air-conditioning management program may be provided as a program product.

20 [0030] Fig. 5 is a diagram illustrating an example of the air-conditioning mode database 330 according to the present embodiment.

In the air-conditioning mode database 330, a warehouse environment 31 representing the environment of the warehouse 110, and an air-conditioning mode 32 the most suitable for the warehouse environment 31 are set.

25 Specific examples of the warehouse environment 31 are pieces of information

such as an arrangement pattern of loads in the warehouse 110, and a storage time of loads to the warehouse 110 or a retrieval time of loads from the warehouse 110. The air-conditioning mode 32 includes set values of an air-conditioning related facility such as air direction and air volume.

5 [0031] \*\*\*Description of Operation\*\*\*

An operation of an air-conditioning management process S300 according to the present embodiment will be described with reference to Fig. 6.

The air-conditioning management process S300 is a process performed by the air-conditioning management server 300.

10 [0032] In a step S301, the communication control unit 310 judges whether a storage and retrieval start notification 23 is received from the storage and retrieval server 200. When the storage and retrieval start notification 23 is received, the procedure proceeds to a step S302. When the storage and retrieval start notification 23 is not received, the procedure proceeds to a step S305.

15 In the step S302, by using the storage and retrieval start notification 23, the mode extraction unit 320 searches for an air-conditioning mode at the time of storage and retrieval, from the air-conditioning mode database 330. The mode extraction unit 320 transmits a control instruction 21 to instruct air-conditioning control in the air-conditioning mode extracted from the air-conditioning mode database 330, to the  
20 warehouse 110.

[0033] In a step S303, the communication control unit 310 judges whether a storage and retrieval completion notification 24 is received from the storage and retrieval server 200. The storage and retrieval completion notification 24 includes arrangement information representing arrangement of loads at the time when retrieval is completed.

25 When the storage and retrieval completion notification 24 is received, the procedure

proceeds to a step S304. When the storage and retrieval completion notification 24 is not received, the step S303 is repeated until these are received.

[0034] In the step S304, the mode extraction unit 320 searches for an air-conditioning mode from the air-conditioning mode database 330 based on present arrangement

5 information in the warehouse 110. Specifically, the mode extraction unit 320 searches for an air-conditioning mode from the air-conditioning mode database 330 by using the arrangement information included in the storage and retrieval completion notification 24. The mode extraction unit 320 searches for an air-conditioning mode 32 corresponding to the warehouse environment 31 closest to the arrangement information included in the  
10 storage and retrieval completion notification 24. The mode extraction unit 320 transmits a control instruction 21 to instruct air-conditioning control in the air-conditioning mode extracted from the air-conditioning mode database 330, to the warehouse 110.

[0035] In a step S305, the communication control unit 310 judges whether an

15 arrangement change notification 22 is received from the storage and retrieval server 200. The arrangement change notification 22 is a notification including arrangement information at the time when arrangement of loads is changed, in the warehouse 110.

When the arrangement change notification 22 is received, the procedure returns to the step S304. That is, in the step S304, the mode extraction unit 320 searches for an

20 air-conditioning mode from the air-conditioning mode database 330 based on arrangement information after arrangement in the warehouse 110 is changed.

Specifically, the mode extraction unit 320 searches for an air-conditioning mode 32 corresponding to a warehouse environment 31 closest to the arrangement information included in the arrangement change notification 22. The mode extraction unit 320

25 transmits a control instruction 21 to instruct air-conditioning control in the

air-conditioning mode extracted from the air-conditioning mode database 330 to the warehouse 110. When the arrangement change notification 22 is not received, the process from the step S301 is repeated.

[0036] \*\*\*Other Configuration\*\*\*

5 <Variation 1>

In the present embodiment, the functions of the mode extraction unit 320, the control unit 102 and the arrangement management unit 220 are realized by software. As a variation, the functions of the mode extraction unit 320, the control unit 102 and the arrangement management unit 220 may be realized by hardware.

10 In a case wherein each element of the functional elements is realized by hardware, a server or a device including each element includes an electronic circuit 909 instead of the processor 910. The air-conditioning management server 300 will be described hereinafter. The same is applicable also to the warehouse device 120 and the storage and retrieval server 200, as to the air-conditioning management server 300.

15 [0037] The air-conditioning management server 300 is equipped with the electronic circuit 909, a memory 921, an auxiliary storage device 922, an input interface 930 and an output interface 940.

[0038] The electronic circuit 909 is a dedicated electronic circuit that realizes the functions of the mode extraction unit 320.

20 The electronic circuit 909 is, specifically, a single circuit, a composite circuit, a processor that is made into a program, a processor that is made into a parallel program, a logic IC, a gate array (GA), an application specific integrated circuit (ASIC), or a field-programmable gate array (FPGA). GA is an abbreviation for application specific integrated circuit. FPGA is an abbreviation for a field-programmable gate array.

25 The functions of the mode extraction unit 320 may be realized by one

electronic circuit, or may be realized by a plurality of electronic circuits in a distributed manner.

As another variation, a part of the functions of the mode extraction unit 320 may be realized by an electronic circuit, and the other functions may be realized by software.

[0039] Each of the processors and electronic circuits is also referred to as “processing circuitry.” That is, in the air-conditioning management server 300, the functions of the mode extraction unit 320 are realized by processing circuitry. Similarly, in the warehouse device 120, the functions of the control unit 102 are realized by processing circuitry. Further, in the storage and retrieval server 200, the functions of the arrangement management unit 220 are realized by processing circuitry.

[0040] \*\*\*Description of Effect of Present Embodiment\*\*\*

It is possible for the air-conditioning system 500 according to the present embodiment to extract an air-conditioning mode in accordance with a present storage and retrieval operation or a present arrangement of loads, by taking information from the storage and retrieval server as a trigger. Therefore, the air-conditioning system 500 according to the present embodiment, it is possible to obtain an effect such that an air-conditioning state is automatically adjusted in accordance with change in the circumstances in a warehouse.

[0041] Second Embodiment

In the present embodiment, parts different from those of the first embodiment will be described. The same configuration as that of the first embodiment is denoted by the same reference numerals, for which description may be omitted.

[0042] \*\*\*Explanation of Configuration\*\*\*

The configuration of an air-conditioning system 500a according to the present

embodiment will be described with reference to Fig. 7.

In Fig. 7, a part different from that of Fig. 1 of the first embodiment is that the air-conditioning system 500a includes a manager terminal 600. The manager terminal 600 is a terminal device such as a personal computer, a smart phone, or a tablet computer used by a manger of the warehouse 110. In the air-conditioning system 500a according to the present embodiment, a warehouse system 100a, a storage and retrieval server 200a, an air-conditioning management server 300a and a manager terminal 600 communicate with one another via a network 400.

[0043] The configuration of the warehouse system 100a according to the present embodiment will be described with reference to Fig. 8.

In Fig. 8, a part different from that of Fig. 3 of the first embodiment is that the warehouse system 100a includes an environment measurement sensor 109. The warehouse system 100a includes a warehouse device 120a, an air-conditioning related facility 130 and environment measurement sensors 109.

A plurality of environment measurement sensors 109 are installed inside the warehouse 110. The environment measurement sensors 109 measure an air-conditioning environment such as temperature, humidity, air volume or carbon dioxide concentration, and transmit measurement results to a control unit 102a.

The control unit 102a transmits a state of the warehouse 110 at the time when air-conditioning control over the warehouse 110 is performed by using an air-conditioning mode instructed by the control instruction 21 to the air-conditioning management server 300a, as a warehouse state notification 25. The control unit 102a transmits an operating state in each facility and sensing information of the environment measurement sensors 109 as the warehouse state notification 25, to the air-conditioning management server 300a periodically via the communication control unit 101. The

operating state of each facility includes information such as set temperature, blowout temperature, air volume, air direction or opening and closing of a door. The control unit 102a controls a plurality of air-conditioning related facilities 130 based on the control instruction 21 transmitted from the air-conditioning management server 300a.

5 [0044] The configuration of the storage and retrieval server 200a according to the present embodiment will be described with reference to Fig. 9.

In Fig. 9, a part different from that in Fig. 4 of the first embodiment is that the storage and retrieval server 200a includes a storage and retrieval plan database 240.

The storage and retrieval plan database 240 stores a storage and retrieval plan  
10 representing a plan of storage and retrieval of loads in the warehouse 110. The storage and retrieval plan includes an arrangement plan representing arrangement of loads at the time of storage and retrieval. The storage and retrieval plan includes information such as date and time, size and weight of loads, a storage and retrieval ID to identify storage and retrieval, and an arrangement plan inside the warehouse 110.

15 The arrangement management unit 220a notifies the air-conditioning management server 300a of the arrangement information of the loads or the storage and retrieval plan when storage or retrieval is started or completed, or arrangement of the loads inside the warehouse or the storage and retrieval plan is updated.

[0045] The configuration of the air-conditioning management server 300a according to  
20 the present embodiment will be described with reference to Fig. 10.

In Fig. 10, a part different from that in Fig. 2 of the first embodiment is that the air-conditioning management server 300a includes a mode search unit 340, a simulator unit 350, a model update unit 360 and a state monitoring unit 370 in addition to the communication control unit 310 and the mode extraction unit 320a. Further, a part  
25 different from that in Fig. 2 is that the air-conditioning management server 300a

includes a request condition database 331, a model updating database 332 and a model database 333 in addition to the air-conditioning mode database 330a.

[0046] The model database 333 is registered by the manager of the warehouse 110 by use of the manager terminal 600. The model database 333 stores an environment  
5 model of the warehouse 110 such as facility design CAD data of the warehouse 110, a device model, and arrangement and piping information of the air-conditioning related facilities 130, an arrangement pattern of loads, and storage and retrieval schedule. The facility design CAD data is information necessary for air-conditioning simulation of a refrigerated warehouse. The device model of the air-conditioning related facility 130  
10 is a model of a device such as each device installed in the refrigerated warehouse, i.e., an air conditioner, a chiller, a ventilator, a dock shelter or an air curtain. The arrangement and piping information is information on arrangement of each device installed in the refrigerated warehouse, and piping. The arrangement pattern and the storage and retrieval schedule of the loads are acquired from the storage and retrieval  
15 server 200a.

[0047] The request condition database 331 is registered by the manager of the warehouse 110 by use of the manager terminal 600. The request condition database 331 stores a request air-conditioning condition of the warehouse 110 requested by the manager. That is, the request condition database 331 stores a request condition  
20 representing a state requested as an environment of the warehouse 110.

The simulator unit 350 performs an air-conditioning simulation by using the environment model stored in the model database 333 as a parameter.

[0048] The mode search unit 340 searches for a combination of operations of an air-conditioning related facility that keeps the warehouse 110 to meet the request  
25 condition, and that saves energy, in accordance with a daily storage and retrieval plan,

based on the environment model of the model database 333.

The air-conditioning mode database 330a stores an air-conditioning mode based on the daily storage and retrieval plan searched for, and an estimated operation state of each air-conditioning related facility 130 and the environment measurement sensors 109 when the air-conditioning mode is performed. The estimated operation state includes information such as air volume, air direction or temperature.

The state monitoring unit 370 monitors an operational status of the air-conditioning related facilities 130 of an actual warehouse 110, or information from the environment measurement sensors 109. When divergence between information from the environment measurement sensors 109 and the estimated operation state of each of the air-conditioning related facilities stored in the air-conditioning mode database 330a becomes a permissible value or more, the state monitoring unit 370 transmits collection information of the model of a relevant air-conditioning related facility to the model update unit 360.

The model update unit 360 acquires storage and retrieval plan information from the storage and retrieval server 200a. The model update unit 360 updates the air-conditioning environment model, such as an arrangement state of loads or an opening or closing state of the door, in the environment model stored in the model database 333. Further, the model update unit 360 updates the device model of the environment model based on the collection information of the facility model from the state monitoring unit 370.

The mode extraction unit 320a retrieves a suitable air-conditioning mode from the air-conditioning mode database 330a at the time of execution of the storage and retrieval plan. The mode extraction unit 320a transmits a control instruction 21 to instruct the control unit 102a of the warehouse system 100a on a control method of the

air-conditioning related facilities 130.

[0049] \*\*\*Description of Operation\*\*\*

Next, operations of each device of the air-conditioning system 500a according to the present embodiment will be described.

5 With reference to Fig. 11, an initial data registration process according to the present embodiment will be described.

In a step S501, the manager terminal 600 accepts an input of building information 321 such as facility design CAD data necessary for air-conditioning simulation of the warehouse 110, from a manager performing air-conditioning  
10 monitoring of a refrigerated warehouse. The manager terminal 600 transmits the building information 321 to the air-conditioning management server 300a via the network 400.

In a step S502, the manager terminal 600 accepts equipment information 323 on equipment such as an air conditioner, a chiller, a ventilator, a dock shelter and an air  
15 curtain, from the manager. The equipment information 323 includes types of equipment, arrangement of equipment and piping information. The manager terminal 600 transmits the equipment information 323 to the air-conditioning management server 300a via the network 400. The equipment information 323 is also called an equipment model.

20 In a step S503, the manager terminal 600 accepts a request condition from the manager. The manager terminal 600 transmits the request condition to the air-conditioning management server 300a via the network 400.

[0050] The request condition transmitted to the air-conditioning management server 300a is stored in the request condition database 331 of the air-conditioning management  
25 server 300a. Further, the building information 321 and the equipment information 323

transmitted to the air-conditioning management server 300a are stored in the model database 333 as an environment model.

[0051] Fig. 12 is a diagram illustrating an example of the request condition database 331 according to the present embodiment.

5           In the request condition database 331, as a specific example, it is set such a request condition that temperature is -20 degrees Celsius, a permissible temperature range is  $\pm 3$  degrees Celsius, a degree of humidity is 80% and a permissible humidity range is  $\pm 10\%$ .

[0052] With reference to Fig. 13, a model update process of the model update unit 360  
10 according to the present embodiment will be described.

          The model update unit 360 receives a storage and retrieval plan from the storage and retrieval server 200a, and generates an environment model representing environment of a warehouse including an arrangement pattern in the warehouse at the time of storage and retrieval in and from the warehouse, based on the storage and  
15 retrieval plan.

[0053] After the initial data registration process is completed, in a step S601, the model update unit 360 acquires arrangement information of loads inside the warehouse 110 from the storage and retrieval server 200a. The model update unit 360 stores the arrangement information acquired in the arrangement information 322 of the model  
20 updating database 332. The model update unit 360 updates an arrangement pattern of the environment model in the model database 333 to a present state based on the arrangement information 322.

          In a step S602, the model update unit 360 acquires the storage and retrieval plan from the storage and retrieval server 200a.

25           In a step S603, the model update unit 360 generates environment models of the

warehouse 110 for each storage and retrieval plan ID, and adds the environment models to the model database 333 in addition to the storage and retrieval plan IDs.

[0054] Fig. 14 is a diagram illustrating an example of the model database 333 according to the present embodiment.

5 In the model database 333, storage and retrieval plan IDs 341, environment model IDs 342 and environment models 343 are set.

In Fig. 14, two environment models of an environment model: A-a, wherein a dock shelter is in an open state, and an environment model: A-b, wherein change in load arrangement is completed and the dock shelter is in a closed state, are added to the  
10 model database 333 for one storage and retrieval plan ID: A. The environment model ID 342 is denoted by, specifically, a storage and retrieval plan ID + a brunch number.

[0055] In a step S604, the model update unit 360 judges whether an update notification of the storage and retrieval plan is received from the storage and retrieval server 200a, or an update request of the environment model is received from the state  
15 monitoring unit 370. When the update notification or the update request of the environment model is received, the procedure returns to the step S603. In the step S603, the model update unit 360 generates or updates an environment model for each storage and retrieval plan ID, based on the update notification or the update request of the environment model. When neither of the update notification nor the update request  
20 of the environment model is received, the step S604 is repeated.

As described above, update of the model database 333 is performed by using as a trigger an update notification of a storage and retrieval plan from the storage and retrieval server 200a, or an update request of an environment model from a state monitoring unit 370 to be described below.

25 [0056] A mode search process of the mode search unit 340 according to the present

embodiment will be described with reference to Fig. 15.

The mode search unit 340 searches for an air-conditioning mode that meets a request condition by simulating air-conditioning control over the warehouse 110 by using an environment model. The mode search unit 340 updates the air-conditioning mode database 330a by associating the air-conditioning mode searched for with the environment model.

[0057] In a step S701, the mode search unit 340 judges whether the model database 333 is updated. When the model database 333 is updated, the procedure proceeds to a step S702.

In a step S702, the mode search unit 340 inputs the environment model of the environment model ID updated in the simulator unit 350.

In a step S703, the mode search unit 340 searches for a combination of operations of the air-conditioning related facilities, which meets the request condition and which saves energy the most.

In a step S704, the mode search unit 340 sets in the air-conditioning mode database 330a a state of the warehouse 110 at the time when air-conditioning control over the warehouse 110 by the air-conditioning mode is simulated, as a predictive value. Specifically, the mode search unit 340 stores, in the air-conditioning mode database 330a, the air-conditioning mode searched for, and estimated operation states of each of the air-conditioning related facilities and environment measurement sensors, in addition to the environment model ID.

[0058] Fig. 16 is a diagram illustrating an example of the air-conditioning mode database 330a according to the present embodiment.

In the air-conditioning mode database 330a of Fig. 16, an environment model ID 351, an air-conditioning mode 352 and a predictive value 353 are set. The

environment model ID 351 identifies the environment model. The environment model includes the warehouse environment 31. The environment model ID 351 in the air-conditioning mode database 330a of Fig. 16 corresponds to the environment model ID 342 in the model database 333.

5 [0059] A mode extraction process of the mode extraction unit 320a according to the present embodiment will be described with reference to Fig. 17.

In a step S801, the mode extraction unit 320a judges whether a storage and retrieval start notification 23 is received from the storage and retrieval server 200a. Specifically, the storage and retrieval start notification 23 represents start of storage in  
10 the storage and retrieval plan A. That is, the environment model ID becomes A-a.

In a step S802, the mode extraction unit 320a searches for a corresponding air-conditioning mode from the air-conditioning mode database 330a based on the storage and retrieval start notification 23. Specifically, an air-conditioning mode corresponding to the environment model ID “A-a” is extracted.

15 In a step S803, the mode extraction unit 320a transmits a control instruction 21 to instruct the control unit 102a of the warehouse system to perform the air-conditioning mode extracted.

In a step S804, the mode extraction unit 320a judges whether an update notification of the air-conditioning mode currently being performed is received from the  
20 air-conditioning mode database 330a. When the update notification of the air-conditioning mode is received, the procedure proceeds to the step S805. When the update notification of the air-conditioning mode is not received, the procedure returns to the step S801.

In a step S805, the mode extraction unit 320a searches for an air-conditioning  
25 mode again from the air-conditioning mode database 330a. The mode extraction unit

320a transmits a control instruction 21 to instruct the control unit 102a of the warehouse system to perform the air-conditioning mode searched for again.

[0060] A state monitoring process of the state monitoring unit 370 according to the present embodiment will be described with reference to Fig. 18.

5           In a step S901, the state monitoring unit 370 monitors an operational status of the air-conditioning related facilities and information from the environment measurement sensor. The state monitoring unit 370 judges whether the operational status of the air-conditioning related facilities and the information from the environment measurement sensor become other than the permissible values of the estimated  
10 operation states stored in the air-conditioning mode database 330a. When they become other than the permissible values of the estimated operation states, the procedure proceeds to the step S902.

          In the step S902, the state monitoring unit 370 transmits correction information of the equipment model of a relevant air-conditioning related facility to the model  
15 update unit 360. A schematic example of the correction information is information such as correction of a blowout temperature from D to E in a case wherein a frequency is A, a suction temperature is B, and an air volume is C, of the air conditioner A.

[0061] \*\*\*Description of Effect of Present Embodiment\*\*\*

          As described above, in the air-conditioning system 500a according to the  
20 present embodiment, an air-conditioning mode that meets a request condition with small energy is searched for beforehand, based on information from the storage and retrieval server. Then, in the air-conditioning system 500a according to the present embodiment, an air-conditioning mode searched for in accordance with actual storage and retrieval is performed. Thus, by the air-conditioning system 500a according to the present  
25 embodiment, even when the air-conditioning mode searched for does not match the

reality due to a phenomenon such as deterioration of the air-conditioning related facility, it is possible to correct a mismatching environment model in accordance with the reality. Thus, by the air-conditioning system 500a according to the present embodiment, it is possible to optimize an air-conditioning state with a higher degree of accuracy.

5 [0062] In the first and second embodiments as described above, each unit of each device in the air-conditioning system is described as an independent functional block. However, the configuration of each device in the air-conditioning system may not be the configurations of the embodiments as described above. The functional block of each device in the air-conditioning system may have any configuration if only the function  
10 block of each device in the air-conditioning system can realize the functions described in the embodiments as described above. Further, each device in the air-conditioning system may be not one device, but a system configured by a plurality of devices.

Further, a plurality of parts of the first and second embodiments may be combined and implemented. Meanwhile, one part of these embodiments may be  
15 implemented. Otherwise, these embodiments may be combined and implemented in any manner, either fully or partially.

That is, in the first embodiment and the second embodiments, free combination of each embodiment, variation of arbitrary components of each embodiment, or abbreviation of arbitrary components in each embodiment is possible.

20 [0063] The above embodiments are essentially preferable examples, and not aimed at limiting the scope of the present invention, the scope of application of the present invention, and the scope of use of the present invention. Various alterations can be made to the embodiments described above as needed.

#### **Reference Signs List**

25 [0064] 21: control instruction; 22: arrangement change notification; 23: storage and

retrieval start notification; 24: storage and retrieval completion notification; 25: warehouse state notification; 31: warehouse environment; 32, 352: air-conditioning mode; 100, 100a: warehouse system; 102, 102a: control unit; 103: air conditioner; 104: chiller; 105: ventilator; 106: air curtain; 107: material handling device; 108:

5 air-conditioning related equipment; 109: environment measurement sensor; 110: warehouse; 120, 120a: warehouse device; 130: air-conditioning related facility; 200, 200a: storage and retrieval server; 220, 220a: arrangement management unit; 230: arrangement database; 240: storage and retrieval plan database; 300, 300a: air-conditioning management server; 101, 210, 310: communication control unit; 320,

10 320a: mode extraction unit; 321: building information; 322: arrangement information; 323: equipment information; 330, 330a: air-conditioning mode database; 331: request condition database; 332: model updating database; 333: model database; 340: mode search unit; 341: storage and retrieval plan ID; 342, 351: environment model ID; 343: environment model; 350: simulator unit; 353: predictive value; 360: model update unit;

15 370: state monitoring unit; 400: network; 500, 500a: air-conditioning system; 600: manager terminal; 909: electronic circuit; 910: processor; 921: memory; 922: auxiliary storage device; 930: input interface; 940: output interface; 950: communication device; S300: air-conditioning management process

## CLAIMS

[Claim 1] An air-conditioning system to manage air-conditioning of a warehouse,  
the air-conditioning system comprising a storage and retrieval server, an

5 air-conditioning management server and a warehouse device, wherein

the storage and retrieval server includes an arrangement management unit to  
transmit, when arrangement of a load in the warehouse is changed, an arrangement  
change notification including arrangement information representing arrangement of the  
load at present in the warehouse, to the air-conditioning management server,

10 the air-conditioning management server includes:

an air-conditioning mode database that stores an arrangement pattern of the  
load in the warehouse and an air-conditioning mode used for air-conditioning control  
over the warehouse by associating the arrangement pattern with the air-conditioning  
mode, and

15 a mode extraction unit to receive the arrangement change notification from the  
storage and retrieval server, to extract an air-conditioning mode corresponding to the  
arrangement pattern that is closest to the arrangement information included in the  
arrangement change notification, from the air-conditioning mode database, and to  
transmit a control instruction to instruct air-conditioning control over the warehouse by  
20 the air-conditioning mode extracted, to the warehouse device, and wherein

the warehouse device includes a control unit to receive the control instruction  
from the air-conditioning management server, and to perform air-conditioning control  
over the warehouse based on the control instruction.

[Claim 2] The air-conditioning system as defined in claim 1, wherein

25 the air-conditioning mode database stores each of a storage time and a retrieval

time of the load in the warehouse, and the air-conditioning mode, by associating the each of the storage time and the retrieval time of the load in the warehouse with the air-conditioning mode,

the arrangement management unit transmits a storage and retrieval start  
5 notification representing start of storage and retrieval of the load, to the air-conditioning management server, and

the mode extraction unit extracts, when the storage and retrieval start notification is received from the storage and retrieval server, an air-conditioning mode corresponding to the storage time or the retrieval time, from the air-conditioning mode  
10 database, based on the storage and retrieval start notification, and transmits the control instruction to instruct air-conditioning control over the warehouse in the air-conditioning mode extracted, to the warehouse device.

[Claim 3] The air-conditioning system as defined in claim 2, wherein

the storage and retrieval server includes a storage and retrieval plan database to  
15 store a storage and retrieval plan representing a plan of storage and retrieval of the load in and from the warehouse, the storage and retrieval plan including an arrangement plan representing arrangement of the load at the storage time and the retrieval time,

the air-conditioning management server includes a model update unit to receive the storage and retrieval plan from the storage and retrieval server, and to generate an  
20 environment model representing an environment of the warehouse including an arrangement pattern of the load in the warehouse at the storage time and the retrieval time in and from the warehouse, based on the storage and retrieval plan,

and the air-conditioning mode database stores the environment model and the air-conditioning mode, by associating the environment model with the air-conditioning  
25 mode.

[Claim 4]        The air-conditioning system as defined in claim 3, wherein the air-conditioning management server includes:

                 a request condition database to store a request condition representing a state requested as an environment of the warehouse, and

5                a mode search unit to search for an air-conditioning mode that meets the request condition by simulating air-conditioning control over the warehouse by using the environment model, to associate the air-conditioning mode searched for with the environment model, and to update the air-conditioning mode database.

[Claim 5]        The air-conditioning system as defined in claim 4, wherein

10              the mode search unit sets a state of the warehouse at the time when air-conditioning control over the warehouse in the air-conditioning mode is simulated, in the air-conditioning mode database, as a predictive value,

                 the control unit transmits a state of the warehouse at the time when air-conditioning control over the warehouse is performed by using the air-conditioning mode instructed by the control instruction, as a warehouse state notification, to the

15              air-conditioning management server, and

                 the air-conditioning management server includes a state monitoring unit to correct the environment model, based on the warehouse state notification and the predictive value.

20    [Claim 6]        An air-conditioning management server that is included in an air-conditioning system to manage air-conditioning of a warehouse, the air-conditioning system including a storage and retrieval server, an air-conditioning management server and a warehouse device, the air-conditioning management server comprising:

                 an air-conditioning mode database that stores an arrangement pattern of a load

25              in the warehouse and an air-conditioning mode used in air-conditioning control over the

warehouse, by associating the arrangement patter with the air-conditioning mode, and

a mode extraction unit to receive, when arrangement of the load in the warehouse is changed, an arrangement change notification that is transmitted from the storage and retrieval server, and that includes arrangement information representing

5 arrangement of the load at present in the warehouse, to extract an air-conditioning mode corresponding to the arrangement pattern closest to the arrangement information included in the arrangement change notification, from the air-conditioning mode database, and to transmit a control instruction to instruct air-conditioning control over the warehouse in the air-conditioning mode extracted, to the warehouse device.

10 [Claim 7] An air-conditioning management method of an air-conditioning system to manage air-conditioning of a warehouse, the air-conditioning system including a storage and retrieval server, an air-conditioning management server and a warehouse device, the air-conditioning management method comprising:

by the storage and retrieval server, transmitting, when arrangement of a load in  
15 the warehouse is changed, an arrangement change notification including arrangement information representing arrangement of the load at present in the warehouse, to the air-conditioning management server,

by the air-conditioning management server, including an air-conditioning mode database that stores an arrangement pattern of the load in the warehouse and an

20 air-conditioning mode used in air-conditioning control over the warehouse, by associating the arrangement pattern with the air-conditioning mode,

by the air-conditioning management server, receiving the arrangement change notification from the storage and retrieval server, extracting an air-conditioning mode corresponding to the arrangement pattern closest to the arrangement information

25 included in the arrangement change notification, from the air-conditioning mode

database, and transmitting a control instruction to instruct air-conditioning control over the warehouse in the air-conditioning mode extracted, to the warehouse device, and

by the warehouse device, receiving the control instruction from the air-conditioning management server, and based on the control instruction, performing  
5 air-conditioning control over the warehouse.

[Claim 8] An air-conditioning management program of an air-conditioning management server that is included in an air-conditioning system to manage air-conditioning of a warehouse, the air-conditioning system including a storage and retrieval server, an air-conditioning management server and a warehouse device,

10 wherein the air-conditioning management server includes an air-conditioning mode database that stores an arrangement pattern of a load in the warehouse and an air-conditioning mode used in air-conditioning control over the warehouse, by associating the arrangement pattern with the air-conditioning mode,

the air-conditioning management program making the air-conditioning  
15 management server being a computer perform a mode extraction process, when arrangement of the load in the warehouse is changed, to receive an arrangement change notification that is transmitted from the storage and retrieval server, the arrangement change notification including arrangement information representing arrangement of the load at present in the warehouse, to extract an air-conditioning mode corresponding to  
20 the arrangement pattern closest to the arrangement information included in the arrangement change notification, from the air-conditioning mode database, and to transmit a control instruction to instruct air-conditioning control over the warehouse in the air-conditioning mode extracted, to the warehouse device.