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(54) Title: SYSTEMS, METHODS AND APPARATUS FOR IMPROVING ENERGY CONSUMPTION EFFICIENCY OF APPLIANCES SERVING A FACILITY

(57) Abstract: Methods, systems and apparatus directed to energy consumption efficiency of appliances serving rooms of a facility are disclosed. The systems and methods can compile (302) energy consumption measurements over multiple guest stays for each of the rooms and energy consumption measurements for each guest stay to define respective guest profiles. Further, the systems and methods can analyze (306) the energy consumption measurements for different pairings of rooms and guest profiles to perform a room allocation (308) providing energy consumption efficiency for the facility.

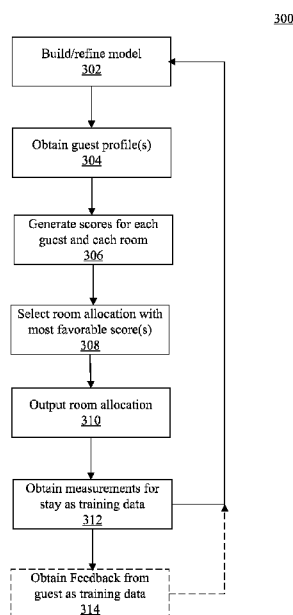


FIG. 3

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SYSTEMS, METHODS AND APPARATUS FOR IMPROVING ENERGY CONSUMPTION EFFICIENCY OF APPLIANCES SERVING A FACILITY

TECHNICAL FIELD

The present invention is directed generally to energy consumption efficiency of appliances. More particularly, various inventive methods, systems and apparatus disclosed herein relate to energy consumption efficiency of appliances serving rooms of a facility that
5 are allocated to different guests.

BACKGROUND

Energy consumption of appliances serving a large facility can incur substantial costs. For example, energy consumption accounts for 60 to 70% of the utility costs of a
10 typical hotel. Appliances that serve rooms of the hotel, for example, include air heating and cooling devices and lighting devices, and known methods for improving energy consumption efficiency typically focus on the operation of the individual devices themselves. The operation of such devices can be centrally monitored and controlled through “Internet of Things” (IoT) technology using sensor networks that are deployed throughout the facility. In
15 particular, known methods often control the operation of appliances to limit their energy consumption, which may result in dissatisfaction of guests at the facility if the limitation on the appliances lowers the comfort level of their rooms.

SUMMARY

The limitation of known energy consumption control methods to the operation of individual appliances themselves fails to recognize other means of improving energy consumption efficiency that need not affect the comfort level of guests. The inventors of the present application have recognized that the energy efficiency of appliances serving a facility can be improved through intelligent allocation of the rooms served by the appliances. For
20 example, the inventors have recognized that different rooms have different energy consumptions due to various factors. For example, a room that is located in an area of the facility that receives a large amount of sunlight can result in the use of less energy by heating and lighting devices to provide an adequate temperature and lighting level. In turn, certain guests may prefer warmer or brighter rooms than others. In accordance with an exemplary
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aspect of the present application, the energy consumption characteristics of both the rooms of a facility and guests can be leveraged to, for example, pair high energy consumption users to the most energy efficient rooms. Similarly, low energy consumption users can be paired with less energy-efficient rooms. Thus, in this way for example, room allocation based on measurements of energy consumption characteristics of both rooms and guests can be intelligently implemented in order to improve the energy efficiency of the system of appliances of a facility as a whole. Moreover, as discussed herein below, the room allocation can be implemented in a way in which guest comfort levels are maintained while ensuring a high energy efficiency of the appliances.

Generally, in one aspect, a system for improving energy consumption efficiency of a plurality of appliances serving a plurality of rooms of a facility includes a score generator. The score generator is implemented by at least one hardware processor and is configured to compile, for each given room of the plurality of rooms, an aggregate of measurements of energy consumption by at least one given appliance serving the given room over multiple guest stays in the given room. The score generator is further configured to compile a plurality of guest profiles, wherein at least one particular guest profile is based on particular measurements of energy consumption by at least one particular appliance serving at least one particular stay at the facility. In addition, the score generator is configured to analyze the aggregate of measurements and the particular guest profile to determine respective energy efficiency levels for different pairings between the plurality of rooms and the particular guest profile. The system also includes a recommender that is implemented by at least one hardware processor and is configured to allocate one of the rooms to a guest based on the respective energy efficiency levels for the different pairings to improve the energy consumption efficiency of the facility.

In an exemplary embodiment of the system, the allocation of the room to the guest is implemented based on a determination that a pairing between the allocated room and the guest provides a temperature and/or humidity meeting at least one predetermined threshold.

In accordance with one embodiment, the score generator is configured to analyze the aggregate of measurements by assessing an average percentage of total energy consumed by at least one given appliance for serving the given room. Additionally, in accordance with one embodiment, the score generator is configured to analyze the particular guest profile by assessing an average percentage of total energy consumed by at least one particular appliance for serving the particular stay. Further, in accordance with one

embodiment, the score generator is configured to analyze the aggregate of measurements and the particular guest profile by determining a matrix product of values denoting the aggregate of measurements and values denoting the particular measurements.

In one exemplary embodiment, the score generator is configured to weight at least a subset of the energy efficiency levels based on at least one of: temperature measurements compiled in the aggregate of measurements, humidity measurements compiled in the aggregate of measurements, noise level measurements compiled in the aggregate of measurements, light level measurements compiled in the aggregate of measurements, light settings compiled in the aggregate of measurements or temperature settings compiled in the aggregate of measurements.

In one embodiment, the score generator is configured to generate allocation scores based on the energy efficiency levels and the recommender is configured to select room allocations for a plurality of guests such that a combination of a subset of the different pairings providing a highest total of allocation scores is selected.

In one aspect, a method for improving energy consumption efficiency of a plurality of appliances serving a plurality of rooms of a facility is implemented by at least one hardware processor. In the method, for each given room of the plurality of rooms, an aggregate of measurements of energy consumption by at least one given appliance serving the given room over multiple guest stays in the given room is compiled. The method further includes compiling a plurality of guest profiles, wherein at least one particular guest profile is based on particular measurements of energy consumption by at least one particular appliance serving at least one particular stay at the facility. In addition, the method includes analyzing the aggregate of measurements and the particular guest profile to determine respective energy efficiency levels for different pairings between the plurality of rooms and the particular guest profile. Further, one of the rooms is allocated to a guest based on the respective energy efficiency levels for the different pairings to improve the energy consumption efficiency of the facility.

In an exemplary embodiment of the method, the allocation of the room to the guest is implemented based on a determination that a pairing between the allocated room and the guest provides a temperature and/or humidity meeting at least one predetermined threshold.

In accordance with one embodiment, the analyzing comprises assessing an average percentage of total energy consumed by at least one given appliance for serving the given room. Additionally, in accordance with one embodiment, the analyzing comprises

assessing an average percentage of total energy consumed by at least one particular appliance for serving the particular stay. Further, in accordance with one embodiment, the score generator is configured to analyze the aggregate of measurements and the particular guest profile by determining a matrix product of values denoting the aggregate of measurements and values denoting the particular measurements.

In one exemplary embodiment, the analyzing comprises weighting at least a subset of the energy efficiency levels based on at least one of: temperature measurements compiled in the aggregate of measurements, humidity measurements compiled in the aggregate of measurements, noise level measurements compiled in the aggregate of measurements, light level measurements compiled in the aggregate of measurements, light settings compiled in the aggregate of measurements or temperature settings compiled in the aggregate of measurements.

In one embodiment, the analyzing comprises generating allocation scores based on the energy efficiency levels and the allocation comprises selecting room allocations for a plurality of guests such that a combination of a subset of the different pairings providing a highest total of allocation scores is selected.

In accordance with another exemplary embodiment, the method can be performed by at least one hardware processor. Here, a non-transitory storage medium stores computer-readable program code that is configured to cause the one or more hardware processors to perform the method when processor(s) executes the code.

The term “processor” is used herein generally to describe various apparatus relating to the operation of one or more systems described herein. A processor can be implemented in numerous ways (e.g., such as with dedicated hardware) to perform various functions discussed herein. For example, a processor can include one or more microprocessors and associated circuitry that may be programmed using software (e.g., microcode) to perform various functions discussed herein. A processor can be implemented wholly or partially as dedicated hardware to perform functions described herein. Examples of hardware processors that may be employed in various embodiments of the present disclosure include, but are not limited to, conventional microprocessors, application specific integrated circuits (ASICs), and field-programmable gate arrays (FPGAs).

In various implementations, a processor may be associated with one or more computer-readable storage mediums (generically referred to herein as “memory,” e.g., volatile and non-volatile computer memory such as RAM, PROM, EPROM, and EEPROM, floppy disks, compact disks, optical disks, magnetic tape, etc.). In some implementations, the

storage mediums may be encoded with one or more programs that, when executed by one or more processors, perform at least some of the functions discussed herein. Various storage mediums may be fixed within a processor or may be transportable, such that the one or more programs stored thereon can be loaded into a processor so as to implement various aspects of the present invention discussed herein. The terms “program” or “computer program” are used herein in a generic sense to refer to any type of computer code (e.g., software or microcode) that can be employed to program one or more processors. In some implementations, computer readable signal mediums may be encoded with one or more programs that, when executed by one or more processors, perform at least some of the functions discussed herein. For example, a signal medium can be an electromagnetic medium, such as a radio frequency medium, and/or an optical medium, through which a data signal is propagated.

The term “addressable” is used herein to refer to a device (e.g., a processor) that is configured to receive information (e.g., data) intended for multiple devices, including itself, and to selectively respond to particular information intended for it. The term “addressable” often is used in connection with a networked environment (or a “network,” discussed further below), in which multiple devices are coupled together via some communications medium or media.

In one network implementation, one or more devices coupled to a network may serve as a controller for one or more other devices coupled to the network (e.g., in a master/slave relationship). In another implementation, a networked environment may include one or more dedicated controllers that are configured to control one or more of the devices coupled to the network. Generally, multiple devices coupled to the network each may have access to data that is present on the communications medium or media; however, a given device may be “addressable” in that it is configured to selectively exchange data with (i.e., receive data from and/or transmit data to) the network, based, for example, on one or more particular identifiers (e.g., “addresses”) assigned to it.

The term “network” as used herein refers to any interconnection of two or more devices (including controllers or processors) that facilitates the transport of information (e.g. for device control, data storage, data exchange, etc.) between any two or more devices and/or among multiple devices coupled to the network. As should be readily appreciated, various implementations of networks suitable for interconnecting multiple devices may include any of a variety of network topologies and employ any of a variety of communication protocols. Additionally, in various networks according to the present disclosure, any one

connection between two devices may represent a dedicated connection between the two systems, or alternatively a non-dedicated connection. In addition to carrying information intended for the two devices, such a non-dedicated connection may carry information not necessarily intended for either of the two devices (e.g., an open network connection).

- 5 Furthermore, it should be readily appreciated that various networks of devices as discussed herein may employ one or more wireless, wire/cable, and/or fiber optic links to facilitate information transport throughout the network.

The term “user-interface” as used herein refers to an interface between a human user or operator and one or more devices that enables communication between the user and the device(s). Examples of user-interfaces that may be employed in various implementations of the present disclosure include, but are not limited to, switches, potentiometers, buttons, dials, sliders, a mouse, keyboard, keypad, various types of game controllers (e.g., joysticks), track balls, display screens, various types of graphical user-interfaces (GUIs), touch screens, microphones and other types of sensors that may receive some form of human-generated stimulus and generate a signal in response thereto.

It should be appreciated that all combinations of the foregoing concepts and additional concepts discussed in greater detail below (provided such concepts are not mutually inconsistent) are contemplated as being part of the inventive subject matter disclosed herein. In particular, all combinations of claimed subject matter appearing at the end of this disclosure are contemplated as being part of the inventive subject matter disclosed herein. It should also be appreciated that terminology explicitly employed herein that also may appear in any disclosure incorporated by reference should be accorded a meaning most consistent with the particular concepts disclosed herein.

25 BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings, like reference characters generally refer to the same parts throughout the different views. Also, the drawings are not necessarily to scale, emphasis instead generally being placed upon illustrating the principles of the invention.

FIG. 1 illustrates a high level block/flow diagram of a scoring system and method in accordance with exemplary embodiments of the present application.

FIG. 2 illustrates a high level block/flow diagram of a system for improving energy consumption efficiency of a plurality of appliances serving a plurality of rooms of a facility in accordance with exemplary embodiments of the present application.

FIG. 3 illustrates a high level flow diagram of a method for improving energy consumption efficiency of a plurality of appliances serving a plurality of rooms of a facility in accordance with exemplary embodiments of the present application

5 DETAILED DESCRIPTION

In accordance with aspects of the present application, energy consumption characteristics of both rooms of a facility and guests can be determined in order to intelligently allocate the rooms to guests in a way that improves the energy efficiency of the system of appliances of a facility as a whole. Sensor networks, such as, for example, lighting
10 IoT sensor networks, can be leveraged to obtain energy consumption measurements, as well as factors that affect energy consumption, to determine both room and guest energy consumption tendencies. An IoT sensor network, for example, provides an excellent means of obtaining energy consumption data, guest activity and factors affecting energy
15 consumption, as a sensor network can be densely deployed across the facility and sensor data is highly accessible in real-time or near real-time. Further, the data from sensor networks can also be employed to ensure a high comfort level and satisfying overall experience for the guest while at the same time improving energy consumption efficiency.

In accordance with exemplary embodiments, an automatic scoring system can obtain data from an IoT system, such as, for example, a lighting IoT system comprising a
20 sensor network to assess energy consumption data, guest convenience data as well as user data and feedback. Referring to FIG. 1, a high level block/flow diagram of an exemplary scoring system and method 100 is illustratively depicted. In accordance with an exemplary embodiment, a room scoring or allocation system 120 can receive several types of sensor
25 data 110 from the sensor network. For example, for each room of a given facility, the room scoring system 120 can receive measures of noise level 102 in the room and/or aisle outside the room, measures of light levels 106 in the room, lighting settings 106 for lighting devices in the room and measurements of temperature and/or relative humidity 108. In addition, the room scoring system 120 can also receive room temperature settings 110 as well as
30 measures of energy consumption 112 by appliances in the given room. Here, the room scoring system 120 can determine, at block 114, from one or more of these measurements: a comfort level of the room based on, for example, room temperature, relative humidity, noise level, light level, etc.; energy consumption of appliances serving the room; and a convenience level provided by the room based on, for example, the distance from the room to the elevator, cafeteria, gym, etc. As discussed above, different rooms could have different energy

efficiencies due to different conditions. For example, if a room has multiple walls exposed to the exterior, such as, for example, a corner room, heating or cooling appliances may consume a relatively greater amount of energy to heat or cool the room compared to other rooms with less walls exposed to the exterior. Similarly, a room that is located in an area of the facility that receives a large amount of sunlight can result in the use of less energy by heating and lighting appliances to provide an adequate temperature and lighting level. Additionally, the system 120 can determine implicit guest feedback from the measurements. For example, the system 120 can infer guest comfort level preferences in response to detecting that the user had changed lighting and/or temperature settings upon entering the room. Here, presence of guests can be determined from presence sensors of the sensor network that can be disposed in rooms or aisles outside of the rooms. In addition, the system 120 can consider any feedback by users or guests who may provide comments or suggestions during the stay or after check-out.

In turn, energy consumption characteristics, and comfort and convenience preferences are dependent on individual guests. For example, certain guests may prefer warmer room temperatures compared to others, thereby requiring relatively more energy to heat the room. Guest profiles can be constructed to estimate the energy consumption characteristics and optionally comfort level and convenience preferences of a guest. The information 124-140 for the guest profile can be provided by the guest or otherwise determined by the system 120. For example, the guest profile can be constructed to include the guest gender(s) 124, guest age(s) 126, the number of guests 128 for a given stay, medical disabilities 130 of the guest(s) in order to provide convenient rooms to guests with disabilities, and the trip type of the guest, such as whether the trip of the guest is a personal trip or a business trip. As discussed in further detail herein below, exemplary embodiments can assess both an aggregate of energy consumption measures for each room compiled over multiple stays, and energy consumption characteristics for particular guests to allocate rooms in such a way that the most energy efficient rooms are allocated to high energy consumers to maximize the efficiency of energy use by the system of appliances of the facility as a whole.

In accordance with one exemplary aspect, the room scoring system 120 can determine a baseline score 116 defining an energy efficiency level for each room/guest combination based on the respective energy consumption characteristics determined for the room and the guest. Further, the room scoring system 120 can weight the baseline score 116 based on comfort level, unit energy consumption, convenience level and/or user-feedback. For example, as indicated above, one or more baseline scores 116 can be weighted to favor

selection of room/guest combination that provides a guest with disabilities with a room conveniently located near an elevator, a reception area, or on a ground floor. Thus, the weights can be tailored based on aspects of the guest profiles, such as, for example, gender, age, etc., as illustrated in FIG. 1. Further, the room scoring system 120 can output allocation scores for each room and guest combination. Table 1 below provides an example of allocation scores output by the room scoring system 120.

Table 1 – Allocation Scores

	Room 1	. . .	Room J	. . .	Room M
User 1	3			2	3
. . . .		4		1	
User i	1				4
. . . .		3		5	
User N	1		4	3	4

Here, the weighting can be implemented such that a room providing the same comfort level as another room will be provided with a higher score than the other room if the room has a higher energy consumption efficiency level than the other room. Similarly, a room that is located in a more convenient area of the facility will be provided with a higher score than another room if the rooms share the same energy efficiency and comfort levels.

Further, a recommender system can select room/guest combinations providing the highest total score. It should be noted that historical data can train the system and a collaborator filtering can help find a room for a guest from the rest of the available rooms that best suits him or her. In this way, when a new guest checks in, the recommend system will find the most energy efficient room, and the recommendation can also optionally optimize energy efficiency for the whole facility for the day, so the global energy efficiency, comfort levels, and convenience can be obtained. It should also be noted that if a new guest does not have a record for any room, a predetermined guest profile that is most similar to the characteristics of the guest can be selected to provide a room recommendation for the guest. Alternatively or additionally, as discussed in further detail herein below, matrix completion techniques can be employed to predict a guest profile for a guest. It should be further noted

that, in accordance with exemplary embodiments, the system 100 can be configured to learn and adapt to customer needs and personalization with the room recommendation. Here, the scoring system and/or the recommender system can be refined based on ratings and feedback provided by guests. Further, the effectiveness of the recommendation can be assessed by the scoring system 120 based on sensor data, customer data and feedback can be used to measure the effectiveness of the recommendation. Thus, the adequacy of the recommendations can be improved along with guest satisfaction. Further, guest feedback can be collected in order to improve room configuration. For example, based on guest feedback, rooms can be redecorated and/or appliances in the room can be reconfigured, replaced or relocated, and the effectiveness of the room reconfiguration can be assessed based sensor data from the sensor network and/or based on further guest feedback. Further details describing particular exemplary embodiments of scoring and recommender systems are described herein below with respect to FIGS. 2 and 3.

With reference now to FIG. 2, an exemplary embodiment of a room allocation system 200 for a given facility is illustratively depicted. Here, the facility can be any facility that provides rooms to guests. For example, the facility can be a hotel, multiple hotels in a given locale, a motel, multiple motels in proximity in a given locale, one or more bed and breakfast facilities, rentable houses within a given area, rooms within one or more buildings in a given area, an office building for allocation of offices and/or office spaces as the rooms, a commercial building for allocation of retail spaces and/or any combination of these exemplary facilities, among other facilities. It should be understood that a “room” as discussed herein can, in some embodiments, be interpreted as a unit, such as, for example, an apartment or an office space, comprising a plurality of rooms that is used by a given guest. The system 200 can comprise a room selection system 202, which can include a score generator 208, a recommender 210 and a score model 206, which can be stored in a storage medium 204, such as in memory and/or a hard-drive storage of a computer system 201 or in a cloud-based storage system. Each processing element of the room selection system 202, such as for example, the score generator 208 and recommender 210, for example, can be implemented by one or more hardware processors of the computer system 201, which can be remote from the given facility, and can receive data from and/or transmit data to any one or more of the other elements of the system 200 that are disposed at the given facility through a wide area network, such as, for example, the internet. For example, any one or more of the score generator 208 and/or recommender 210 can be implemented in a cloud computing system and the model 206 can be stored in a storage medium of the cloud. Alternatively or

additionally, the computer system 201 can be implemented in one or more computers disposed at the given facility, and can receive data from and/or transmit data to any one or more of the other elements of the system 200 that are disposed at the given facility through a local area network, such as, for example, a Wi-Fi, Bluetooth and/or an Ethernet network.

Alternatively or additionally, the computer system 201 can be partially implemented by one or more hardware processors disposed at the given facility and partially implemented by one or more hardware processors disposed remotely (e.g., in a cloud computing system), where any one or more of the score generator 208, the recommender 210 and/or the storage medium 204 can be distributed, partly or wholly, locally or remotely. In addition, the user-interface 212 can be implemented in a computer system 203 at the given facility, or the user-interface 212 can be part of the computer system 201. It should be noted that the computer system 201 and/or the computer system 203 can be implemented wholly or partially in one or more of personal computer(s), sever(s), tablet(s), smart phones, other smart devices, or any other computer device.

The room allocation system 200 can include Internet of Things (IoT) sensors 214₁ -214_n disposed in each or some the rooms of the facility and/or outside of the rooms of the facility, such as hallways or passageways outside of the rooms. Sensors 214₁ -214_n can include any one or more of light level sensors, noise level sensors, lighting device sensors that sense light settings of the lighting device, temperature sensors, relative humidity sensors, climate control appliance sensors that sense room temperature settings of the climate control appliance, presence sensors, among other sensors. Any one or more of the sensors 214₁ -214_n can be part of a lighting IoT sensor network. As noted above, the sensors 214₁ -214_n can communicate with the room selection system 202 through a local area network and/or a wide area network.

In addition, the room allocation system 200 can include devices 216₁ -216_m disposed in each or some of the rooms of the facility and/or outside of the rooms of the facility. Here, the devices 216₁ -216_m can include lighting devices that can provide light settings of the lighting device and/or climate control appliances that can provide temperature settings of the climate control appliance. Similar to the sensors, the devices 216₁ -216_m can communicate with the room selection system 202 through a local area network and/or a wide area network.

Further, the room allocation system 200 can include guest interfaces 218₁ -218_j. Any one or more interfaces 218₁ -218_j can be disposed in each or some of the rooms of the facility and can be incorporated in, for example, a smart television or other computer

device provided to guests in the rooms, such as, for example, a wall-mounted electronic panel. Alternatively or additionally, each or some of the guest interfaces 218_i -218_j can be a guest computer device, such as, for example, a smart phone, a tablet or a personal computer owned or used by guests. The guest interfaces 218_i -218_j can transmit to the score generator 208, over, for example a local or wide area network as discussed above, guest information for building or refining the score model 206, as discussed in more detail herein below with respect to method embodiments.

The room allocation system 200 can also include an energy consumption monitor 220. Here, the energy consumption monitor 220 can be implemented by at least one hardware processor, optionally utilizing a storage medium, to measure energy consumption of any devices and/or appliances in all or some of the rooms available at the given facility. For example, the energy consumption monitor 220 can communicate with or be implemented in a Heating, ventilation, and air conditioning (HVAC) system to monitor energy consumption of heating devices and/or air-conditioning units employed to control the climate or other resources available to guests in rooms at the given facility. Alternatively or additionally, the energy consumption monitor 220 can communicate with or be implemented in a lighting network, such as an IoT lighting network, to monitor energy consumption of lighting devices employed to control the lighting atmosphere of rooms at the given facility. Alternatively or additionally, the energy consumption monitor 220 can be implemented by the computer system 201 or 203. Data defining the monitored energy consumption can be provided by the energy consumption monitor 220 to the score generator 208 through a local area network and/or a wide area network, or through a communication bus within the computer system 201. Further details concerning the elements of room allocation system 200 in accordance with various exemplary embodiments are described herein below with below with respect to the method 300 of FIG. 3.

Referring now to FIG. 3, with continuing reference to FIG. 2, a method 300 for allocating rooms of a facility is illustratively depicted. In particular, the method 300 is a method for improving energy consumption efficiency of a plurality of appliances serving a plurality of rooms of a facility. The steps of the method 300 can be implemented by one or more of the hardware processors discussed herein above. For example, the one or more processors can be configured to implement software stored on the storage medium 204 that causes the one or more processors to perform the method 300.

In accordance with the method 300, the score generator 208, at step 302, can build and/or refine the score model 206. Here, the score model 206 comprises an aggregation

of data defining appliance characteristics in each or some of the rooms of the given facility and an aggregation of guest profiles. For example, to build an initial model 206, the score generator 208 can obtain and compile several measurements from the energy consumption monitor 220, sensors 214₁ -214_n and/or devices 216₁ -216_m for each guest stay and for each room. For example, the score generator 208 can obtain from the energy consumption monitor 220 measurements of energy consumption of appliances in a given room for a given guest stay. For example, the score generator 208 can obtain from the energy consumption monitor 220: a measure of the energy consumption of one or more climate control appliances that heat and/or cool the given room for a given guest stay; a measure of the energy consumption of at least one lighting device in the given room for the given stay; a measure of the energy consumed in heating water for the given room for the given stay; and/or a measure of the energy consumed by other devices in the room, such as for example, wall and/or table electrical outlets that can be used to power a television, refrigerator, iron, hair dryer, and any other device for which the guest(s) uses the outlets. Optionally, the score generator 208 can, as indicated above, obtain: light levels in the given room for the given guest stay from light level sensors in the given room; noise levels from noise level sensors inside or outside of the given room; lighting setting(s) selected by the guest from lighting device(s) or from lighting device sensor(s) of the lighting device(s) in the given room; temperature readings from temperature sensor(s) in the given room; relative humidity measurements from humidity sensor(s) in the given room; and/or temperature settings of a climate control appliance from climate control appliance sensor(s) or from the climate control appliance in the given room. Additionally, the score model 206 can correlate each of these measurements for the given stay to the particular guest(s) that used the room during the stay. Specifically, the score model 206 can include a guest profile for the particular guest(s) that used the room during the stay and can compile and correlate each of these measurements for the given stay to the guest profile for inclusion in the guest profile. In addition, the score model 206 can correlate other respective measurements to other guest profiles for their respective stays. Further, the score model 206 can compile measurement data for multiple stays for a given guest(s) and correlate this compiled measurement data to the guest profile of the given guest(s). Moreover, the score model 206 can compile the measurements from the energy consumption monitor 220, sensors 214₁ -214_n and/or devices 216₁ -216_m described above for multiple stays by different guests in an aggregate of measurement data for the given room. Further, the score model 206 can include this aggregate of measurement data for each or some of the rooms at the given facility. As discussed herein below, these aggregates of measurement data obtained both for

a room and for a guest profile can be employed to provide a score to implement a room allocation.

It should be noted that if the given guest has stayed at facility the multiple times, then the averages of the measurements for all or a subset of stays can be correlated to the given guest profile in the model 206. In addition, the score model 206 need not be limited to data from one facility. For example, measurement data (which can be the same measurement data discussed above, a subset of the measurement data discussed above, or different measurement data) from different facilities, whether operated by the same person/entities or different people/entities, can be aggregated into the score model 206 and correlated to the guest profile of the given guest for use by the score generator 208 and the recommender 210 for purposes of allocating rooms in accordance with method 300.

At step 304, the score generator 208 can obtain a current guest profile for a given guest(s) for a given stay. Here, the data for the guest profile can at least partially be obtained from the user-interface 212 disposed, for example, at a reception area of the given facility, where the guest provides the information to a receptionist or check-in clerk, who then enters the information in the user-interface for provision to the score generator 208 through a local or wide area network. Alternatively, the guest profile or the information for the guest profile can be provided by the guest through one or more of the guest interfaces 218₁ -218_j, which, in turn provides the guest profile or the information for the guest profile to the score generator 208 through a local or wide area network. Further, the guest profile can be generated by the user-interface/guest interface, or can be generated by the score generator 208 using the information received from the user-interface/guest interface. The guest profile can also be generated by a combination of information received from the user-interface 212 and from one or more of the guest interfaces 218₁ -218_j. The guest profile can include measurements of energy consumption by one or more appliances within one or more rooms and associated with one or more previous room allocations measured or received during one or more previous guest stays by the guest or a similar guest. For example, during a first guest stay or previous guest stay, the guest may be allocated a room and the guest profile can be populated or updated to include measurements of energy consumption by one or more appliances within the respective room. In all of these cases, the guest profile can include the gender of the guest(s), the age(s) of the guest, the number of guests for the given stay, whether the stay is business or personal, medical information about the guest(s), such as, for example, whether the guest(s) has a disability in order to provide a room that better

meets his needs, and/or other information. In addition, the guest profile can be stored in the score model 206 for future reference, as indicated in the description of step 306 below.

It should be noted that an abbreviated form of the method 300 can be performed initially for a plurality of iterations in order to build an initial score model 206.

5 For example, the method can proceed from step 304 directly to step 312, where, at step 312, the score generator 208 can obtain measurements for a given stay as discussed in detail herein above with respect to step 302. Initially, the score generator 208 can set up the structure for the score model 206 at step 302 and proceed through several iterations of steps 304 and 312 for different guests (and for even the same guest(s)) for different stays in order
10 to populate the score model 206. The score generator 208 can proceed through several iterations of steps 304 and 312 for different guests (and for even the same guest(s)) for different stays in order to populate the score model 206 and change or modify one or more future room allocations for one or more guests. Optionally, the abbreviated form of method 300 can also include step 314, discussed in more detail herein below, in order to build the
15 model.

After obtaining personal data for a current guest profile for a given guest(s) for a given stay at step 304 and after a sufficiently constructed score model 206 is obtained, the method 300 can proceed to step 306, at which the score generator 208 can generate scores for each guest(s) and each room. In particular, the score generator 208 can analyze the aggregate
20 of measurements of energy consumption by one or more appliances serving a given room over multiple guest stays in the given room, and can analyze one or more particular guest profiles to determine respective energy efficiency levels for different pairings between rooms and guest profiles. It should be understood that guest(s) can refer to one or more people staying in a room. Preliminarily, at step 306, the score generator 208 can cross-reference the
25 current guest profile to guest profiles stored in the score model 206. Here, the score generator 208 can select a stored guest profile matching the given guest. For example, the score generator 208 can select the stored guest profile in the score model 206 belonging to the given guest if the given guest previously stayed at the facility and had his or her previous guest profile stored in the model 206. Alternatively, if the difference between the current
30 guest profile for the given guest and the previous profile for the given guest exceeds a difference threshold, then the score generator 208 can select another guest profile stored in the score model 206 that is most similar to the current guest profile of the given user. Moreover, if the given guest has never stayed at the facility, or even if the guest has previously stayed at the facility, then the score generator 208 can select the guest profile

stored in the score model 206, as matching the given guest, that is most similar to the current guest profile of the given user. In each case, the features of the guest profiles, such as, for example, the gender of the guest(s), the age(s) of the guest, the number of guests for the given stay, whether the stay is business or personal and medical information can, for example, be modeled to have values in a vector. Further, the current guest profile can be analyzed with each guest profile stored in the score model 206 and the stored guest profile that is most similar to the current guest profile can be determined by finding the stored guest profile that has the shortest Euclidean distance, Manhattan distance, and/or some other appropriate measure. In addition, some of the elements of the guest profiles such as, for example, medical condition, number of guests, or age, can be weighted when finding the shortest distance measure.

In accordance with one or more embodiments, the selected guest profile can be a guest profile that is constructed for the guest by the score generator 208. For example, in accordance with an exemplary embodiment, the score generator 208 can construct the selected guest profile using a matrix completion technique. For example, the score generator 208 can obtain a current guest profile for the guest that includes personal information, such as, for example, any one or more of a gender of the guest(s), the age(s) of the guest, the number of guests for the given stay, whether the stay is business or personal, medical information, etc., and can predict any one or more other aspects of the guest profile, such as energy consumption, room light settings, room light level, room temperature settings, etc. for this particular guest using guest profiles from other guests. Here, the unknown entries in the guest profile for the current guest can be derived from some or all of the other entries of known guest profiles stored in the score model 206. For example, Table 2 below denotes a matrix including personal information, such as gender, which is denoted by values $Gender_1$, $Gender_2$, $Gender_3$. . . $Gender_n$ from known guest profiles and $Gender_C$ for the current guest for which the guest profile is constructed, age, which is denoted by known values Age_1 , Age_2 , Age_3 . . . Age_n from known guest profiles and known value Age_C for the current guest, the trip type, which is denoted by known values $Trip_1$, $Trip_2$, $Trip_3$. . . $Trip_n$ from known guest profiles and known value $Trip_C$ for the current guest. Although not shown here, the matrix can include other personal information, such as medical information and number of guests, for example. In addition, the matrix of Table 2 includes measurements made for previous stays by guests, such as energy consumption values, which are denoted by known values E_consum_1 , E_consum_2 , E_consum_3 . . . E_consum_n from known guest profiles, light level measurements, denoted by known values L_level_1 , L_level_2 , L_level_3 . . . L_level_n from

- known guest profiles, and determined temperature (Temp.) settings, denoted by known values $T_level_1, T_level_2, T_level_3 \dots T_level_n$ from known guest profiles. In addition, although not shown here for brevity purposes, the matrix of Table 2 can include any other measurements made by the room allocation system discussed herein, such as, for example,
- 5 noise levels, room light settings, temperature and relative humidity measurements, etc. In addition, the $E_consum_1, E_consum_2, E_consum_3 \dots E_consum_n$ can include multiple values denoting energy consumption of lighting devices, heating devices, and other devices, as discussed in further detail herein below. Further, the matrix of Table 2 can include one or more known convenience values, which are denoted by $Conven_1, Conven_2, Conven_3 \dots$
- 10 $Conven_n$, which can have different values indicating a preference for one or more of a ground level room, proximity to an elevator, proximity to a gym, or any one or more convenience preferences described herein, among others.

Table 2 – Matrix Employed to Predict Values of Guest Profile

	Gender	Age	Trip type	.	Energy Consumption Values	Light Level	Temp. Settings	Convenience	.
Guest 1	Gender ₁	Age ₁	Trip ₁		E-consum ₁	L_level ₁	T_level ₁	Conven ₁	
Guest 2	Gender ₂	Age ₂	Trip ₂		E-consum ₂	L_level ₂	T_level ₂	Conven ₂	
Guest 3	Gender ₃	Age ₃	Trip ₃		E-consum ₃	L_level ₃	T_level ₃	Conven ₃	
.									
.									
.									
Guest n	Gender _n	Age _n	Trip _n		E-consum _n	L_level _n	T_level _n	Conven _n	
Current guest	Gender _c	Age _c	Trip _c		X _{EC}	X _L	X _T	X _C	
.									
.									
.									

Here, the unknown values for the guest profile of the current guest, including, for example, light level (X_L), one or more energy consumption values (X_{EC}), light level (X_L), temperature settings (X_T), convenience preference (X_C), etc., can be predicted based on at least some or all other known values of the matrix in Table 2. For example, as understood by those of ordinary skill in the art, any one or more matrix completion techniques applied in current recommender systems can be employed to predict the unknown values such as, for example, matrix factorization, singular value decomposition (SVD) methods, such as, for example, SVD++, K-nearest neighbor (KNN) algorithms, and extensions of any of these methods into the time domain, in addition to other matrix completion methods. Thus, in this way, for example, the score generator 208 can derive elements of and/or complete the selected guest profile, which can be based on particular measurements of energy consumption and/or any other values of known guest profiles of the matrix of Table 2. Continuing with step 306, the score generator 208 can retrieve the measurements correlated to the selected guest profile in the score model 206 at step 302 discussed above. For example, the score generator 208 can retrieve energy consumption measurements of various appliances as discussed above, and optionally, other measurements, such as light level measurements, temperature measurements, that were correlated to the selected guest profile. In addition, the score generator 208 can reference the aggregate of measurement data, discussed above with respect to step 302, for each room or for each available room. For example, as noted above, the aggregate of measurement data can include energy consumption measurements. Table 3 below provides an example of energy consumption measurements that can be referenced by the score generator 208.

Table 3 – Room energy consumption profiling

	Energy Consumption (E_R)	Heating (R_H)	Hot Water (R_{HW})	Lighting (R_L)	Other (R_O)
Room A	10 KWh	50 %	25 %	10 %	20 %
Room B	8 KWh	40 %	20 %	15 %	25 %
Room C	12 KWh	60 %	15 %	15 %	10 %
....					

Each percentage of Table 3 constitutes an average percentage of total energy (E_R) consumed by each corresponding appliance serving the respective room. For example,

for Room A, one or more heating appliances consume on average 50% of the total energy consumed by appliances serving the room. Similarly, for Room A, one or more lighting device appliances consume on average 10% of the total energy consumed by appliances serving the room. In turn, Table 4 below provides an example of energy consumption measurements correlated to the selected guest profile that can be retrieved and employed by the score generator 208 to determine energy consumption scores and/or an energy efficiency scores.

Table 4 – Guest energy consumption profiling

	Heating (G_H)	Hot Water (G_{HW})	Lighting (G_L)	Other (G_O)
Guest A	50% (21 °C)	30 %	5 %	15 %
Guest B	70% (24 °C)	10 %	10 %	10 %
Guest C	60% (22 °C)	10 %	15 %	15 %
....				

As noted in Table 4, the selected guest profiles for different guests can be retrieved together to determine room allocation for multiple guests simultaneously. However, it should be understood that the methods described herein can also be performed on-the-fly for one guest at a time, as discussed herein below. In addition, although three rooms and three sets of correlated measurements for three guest profiles are illustrated for explanatory purposes, it should be noted that many more rooms and guest profiles can be considered for the room allocation by the method 300.

Continuing with step 306, the score generator 208 can determine an energy consumption score (E_c) for each guest/room combination. For example, the score generator 208 can determine a matrix product of values denoting the aggregate of energy consumption measurements for a given room and values denoting energy consumption measurements of a guest profile. In particular, the score generator 208 can perform a matrix multiplication between elements of the aggregate of measurement data for the room and corresponding elements of the measurement data correlated to the selected guest profile. For example, in accordance with one embodiment, the score generator 208 can determine the energy consumption score (E_c) for a given guest/room combination as follows:

$$E_c = E_R [R_H \quad R_{HW} \quad R_L \quad R_O] \cdot \begin{bmatrix} G_H \\ G_{HW} \\ G_L \\ G_O \end{bmatrix} \quad (1)$$

where E_R is the average energy consumption (over multiple, different stays) for the given room, R_H is the percentage of the energy consumption (E_R) consumed by air heating appliance(s) for the given room, R_{HW} is the percentage of the energy consumption (E_R) consumed for heating water for the given room, R_L is the percentage of the energy consumption (E_R) consumed by lighting device(s) that light the given room, R_O is the percentage of the energy consumption (E_R) consumed by other devices such as, for example, the energy consumed through electrical outlets and/or by other devices, as discussed above with respect to step 302, G_H is the percentage of the total energy consumption consumed by air heating appliance(s) during the stay(s) correlated to the selected guest profile in the score model 206, G_{HW} is the percentage of the total energy consumption consumed for heating water during the stay(s) correlated to the selected guest profile in the score model 206, G_L is the percentage of the total energy consumption consumed by lighting device(s) during the stay(s) correlated to the selected guest profile in the score model 206, R_O is the percentage of the total energy consumption consumed by other devices such as, for example, the energy consumed through electrical outlets and/or by other devices, as discussed above with respect to step 302, during the stay(s) correlated to the selected guest profile in the score model 206. It should be noted that this determination is merely exemplary, as other energy consumption measurements can be added and/or one or more of the energy consumption measurements can be removed.

Table 5, below, provides the values of the energy consumption score (E_c) for the various guest/room combinations for the examples illustrated in Tables 3 and 4.

Table 5 – Room/guest energy consumption

	Guest A	Guest B	Guest C
Room A	3.6	3.1	3.7
Room B	2.4	2.7	2.6
Room C	4.4	5.5	4.9

In accordance with exemplary embodiments, the energy consumption score (E_c) can be employed as a final score for purposes of selecting room allocations. However, in

accordance with preferred embodiments, the score generator 208 can normalize the energy consumption score into an efficiency score. For example, each of the scores in Table 5 can be normalized into an energy efficiency score that is on a scale of, for example, 0 to 5, where low energy consumption scores have high energy efficiency scores and high energy consumption scores have low energy efficiency scores. Table 6 below provides the values of the energy efficiency score for the various guest/room combinations illustrated in Table 5.

Table 6 – Room/guest energy efficiency score

	Guest A	Guest B	Guest C
Room A	3	3	3
Room B	5	4	5
Room C	3	2	2

Both an energy consumption score and an energy efficiency score can respectively be denoted as an energy efficiency level of a room/guest combination or pairing, and either an energy consumption score or an energy efficiency score can be used as a final score or as a baseline score in accordance with various exemplary embodiments.

Optionally, the score generator 208 can weight the energy consumption scores and/or the energy efficiency score, which can be used as baseline scores, with one or more factors. For example, the score generator 208 can weight certain energy consumption scores and/or the energy efficiency scores for convenience. For example, the score generator 208 can weight certain energy consumption scores and/or the energy efficiency scores based on a location of the respective room in the facility. For example, in response to determining that the current guest profile or the selected guest profile indicates that the guest has a disability that would render it convenient to have a room that is close to an elevator, is close to the reception area, is close to an exit, is close to a cafeteria, is close to a gym and/or is on a ground-level floor, then the score generator 208 can weight the score for guest/room combination for this room favorably. For example, in this case, the energy efficiency score for this guest/room combination can be weighted to be higher (and/or the energy consumption score can be weighted to lower). Here, “close to” an area should be understood to mean that the room has a relatively shorter distance to the area than other rooms or other available rooms. In addition, the score generator 208 can implement this convenience weighting based on guest-preferences specified in the current and/or selected profile, which

can be provided as part of guest-feedback, where, for example, the guest indicates a preference for proximity to any one or more of these areas, for example. Further, the score generator 208 can be configured to weight scores for rooms that provide a greater comfort level. Here, the score generator 208 can weight the energy consumption scores and/or the energy efficiency scores based on at least one of: temperature measurements compiled in an aggregate of measurements for a given room and/or for a given guest profile, humidity measurements compiled in the aggregate of measurements for the given room and/or for the given guest profile, noise level measurements compiled in the aggregate of measurements for the given room and/or for the given guest profile, light level measurements compiled in the aggregate of measurements for the given room and/or for the given guest profile, light settings compiled for the given room and/or the given guest profile in the aggregate of measurements for the given room and/or for the given guest profile or temperature settings compiled in the aggregate of measurements for the given room and/or for the given guest profile. For example, based on the aggregate of measurement data for a given room, the score generator 208 can weight the energy consumption scores and/or energy efficiency scores for rooms that provide a higher comfort level determined by the score generator 208 in terms of any one or more of average room temperature, average relative humidity, average noise level, average light level, etc. For example, the weighting can be implemented such that, in response to determining that guest profile/room combinations provide the same or similar (within a predetermined threshold) energy consumption scores and/or the energy efficiency scores, but provide different comfort levels, the score generator 208 can determine which particular rooms provide average comfort levels that are closer to a predetermined ideal comfort level than other rooms having the same or similar energy consumption/efficiency scores and weight the scores for these particular rooms so that the particular rooms are allocated to one or more guests. Further, in accordance with exemplary embodiments, the score generator 208 can weight rooms that provide average comfort levels that are closer to a predetermined ideal comfort level in response to determining that a guest has a preference for these types of rooms based on guest-preferences specified in the current and/or selected profile, which can be provided as part of guest-feedback. Additionally or alternatively, in accordance with exemplary embodiments, the weighting can be implemented such that any room allocation provides a minimum thermal comfort level. For example, a room/guest pairing that meets a minimum thermal comfort level can correspond to a room/guest pairing that provides a temperature above (or between) a minimum temperature threshold (or between a minimum temperature threshold and a maximum temperature

threshold) and/or that provides a humidity that is below a maximum humidity threshold (or between a minimum humidity threshold and a maximum humidity threshold). A room/guest pairing can include settings (e.g., temperature setting, humidity setting, power level) for one or more appliances serving a respective room to meet or be greater than the minimum temperature threshold. A room/guest pairing can include settings (e.g., temperature setting, humidity setting, power level) for one or more appliances serving a respective room to meet or be less than the maximum humidity threshold. Here, the minimum thermal comfort level or any of the thresholds can be a predetermined ideal, can be specified by the guest or can be predicted by the score generator based on a matching profile or using, for example, matrix completion techniques, as discussed above. Thus, the score generator 208 can assess each room/guest pairing and determine whether the room/guest pairing meet a minimum thermal comfort level. For any room/guest pairing that provides a temperature and/or humidity that fails to meet the corresponding temperature and/or humidity thresholds, the score generator 208 can remove the pairing from consideration for allocation or can weight the pairing so that it is not selected. For example, the score generator 208 can weight the score for any such pairing in Table 6 so that it is zero or close to zero.

It should be noted that the score generator 208 can apply any one or more of these weighting schemes together. Further, in accordance with exemplary embodiments the score generator 208 can determine the weighting factors applied in any one or more of these weighting schemes such that a minimum desired energy consumption/energy efficiency is obtained. Here, the weighting factors can be determined through, for example, trial and error during building and/or refining of the score model 206 at step 302.

In any one or more of these embodiments, the score generator 208 can transmit and/or store the energy consumption scores and/or the energy efficiency scores, which can be optionally weighted as discussed above, as allocation scores for use by the recommender 210 at step 308. For example, the score generator 208 can transmit the allocation scores to the recommender 210 through a communication bus within the computer system 201, or through a local area network and/or a wide area network. Additionally or alternatively, the score generator 208 can transmit the allocation scores to the storage medium 204 through a communication bus within the computer system 201, or through a local area network and/or a wide area network, for storage in the storage medium 204. Here, the recommender 210 can retrieve the allocation scores from the storage medium 204 through the communication bus within the computer system 201, or through the local area network and/or the wide area network.

It should be noted that a matrix completion technique can optionally be employed to predict an allocation score of a current guest based on other allocation scores. As discussed above, the allocation scores can be energy consumption scores, energy efficiency scores, weighted energy consumption scores or weighted energy efficiency scores.

5 For example, Table 7 below illustrates a matrix that can be used to predict an allocation score for a current guest. As with Table 2, the matrix of Table 7 can include personal information of the current guest and past guests, a gender of the guest(s), such as, for example, the age(s) of the guest, the number of guests for the given stay, whether the stay is business or personal, medical information, etc. In addition, the allocation scores for known, past guests, Guests 1-
 10 n, can be determined as discussed above. For example, the allocation scores for past guests can correspond to the scores provided in Tables 5 or 6 above. Here, the allocation scores for pairings between Guest 1 and Room A, Guest 2 and Room A, Guest 3 and Room A . . . Guest n and Room A are respectively denoted as A-score_{1A}, A-score_{2A}, A-score_{3A} . . . A-score_{nA}; the allocation scores for pairings between Guest 1 and Room B, Guest 2 and Room B, Guest
 15 3 and Room B . . . Guest n and Room B are respectively denoted as A-score_{1B}, A-score_{2B}, A-score_{3B} . . . A-score_{nB}; the allocation scores for pairings between Guest 1 and Room C, Guest 2 and Room C, Guest 3 and Room C . . . Guest n and Room C are respectively denoted as A-score_{1C}, A-score_{2C}, A-score_{3C} . . . A-score_{nC}; etc.

Table 7 – Matrix Employed to Predict Allocation Score

	Gender	Age	Trip type	...	Allocation Score for Room A	Allocation Score for Room B	Allocation Score for Room A	...
Guest 1	Gender ₁	Age ₁	Trip ₁		A-score _{1A}	A-score _{1B}	A-score _{1C}	
Guest 2	Gender ₂	Age ₂	Trip ₂		A-score _{2A}	A-score _{2B}	A-score _{2C}	
Guest 3	Gender ₃	Age ₃	Trip ₃		A-score _{3A}	A-score _{3B}	A-score _{3C}	
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.								
.								
Guest n	Gender _n	Age _n	Trip _n		A-score _{nA}	A-score _{nB}	A-score _{nC}	
Current guest	Gender _c	Age _c	Trip _c		X _{SA}	X _{SB}	X _{SC}	
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.								
.								

After determining the allocation scores for past guests, the allocation scores of the current guest can be predicted based on at least some or all other known values of the matrix in Table 7 using one or more matrix completion techniques discussed above with respect to Table 2. Here, the allocation scores of the current guest are denoted as X_{SA} for the pairing between the current guest and Room A, X_{SB} for the pairing between the current guest and Room B, X_{SC} for the pairing between the current guest and Room C, etc. For example, as understood by those of ordinary skill in the art, any one or more matrix completion techniques applied in current recommender systems can be employed to predict the unknown values X_{SA} , X_{SB} , X_{SC} , etc. Such techniques can include, for example, matrix factorization, SVD methods, such as, for example, SVD++, KNN algorithms, and extensions of any of these methods into the time domain, in addition to other matrix completion methods. Thus, in this way, for example, the score generator 208 can derive the allocation scores of the current guest, which can be based on the respective energy efficiency levels for different

guest/room pairings of other guests, to improve the energy consumption efficiency of the facility. The energy efficiency levels can include energy consumption levels for one or more appliances serving a respective room or settings (e.g., temperature, humidity, light level, climate control, power level) for one or more appliances serving a respective room. It should also be noted that the matrix completion technique can also optionally be applied to, for example, predict energy consumption scores or energy efficiency scores, and these predicted scores can be subsequently weighted as discussed in detail herein above to obtain the final allocation score for the current guest. In addition, it should also be understood that the energy consumption scores, energy efficiency scores, weighted energy consumption scores, weighted energy efficiency scores and/or allocation scores can be determined for a plurality of current guests simultaneously or in succession.

At step 308, the recommender 210 can obtain the allocation scores as discussed above and can allocate rooms to guests based on the respective energy efficiency levels for the different pairings to improve the energy consumption efficiency of the facility. Here, the recommender 210 can select a room allocation providing the most favorable or highest allocation score(s). In particular, the recommender 210 can select room allocations such that a combination of a subset of the different pairings provide a highest total of allocation scores is selected. For example, the recommender 210 can analyze the scores of Table 6 above as the allocation scores and can implement the room allocation such that the recommender 210 allocates Room A to Guest B, allocates Room B to Guest C and allocates Room C to Guest A, where in this case the total of allocation scores is 11. The recommender 210 can equivalently implement a similar allocation if the energy consumption scores (which can be optionally weighted) are the basis of the allocation scores, where the allocation is performed such that the lowest energy consumption scores are obtained. Here, based in the scores of Table 5, the recommender 210 would implement the same room allocation as the allocation implemented on the basis of Table 6. The recommender 210 can generate a room allocation for a subsequent guest stay that is different from a previous room allocation associated with one or more previous guest stays by the guest or one or more similar guests having similar guest profiles. For example, the recommender 210 can allocate one of said plurality of rooms to a guest based on the respective energy efficiency levels for said different pairings for a subsequent room allocation to improve the energy consumption efficiency of the facility from at least one previous room allocation.

At step 310, the recommender 210 can output the room allocation(s) selected at step 308. For example, the recommender 210 can output the room allocation(s) to the

user-interface 212 through a local area network and/or a wide area network, or through a communication bus within the computer system 201 if the user-interface 212 is part of the computer system 201. For example, a receptionist at the facility may obtain the allocations through the user-interface and provide guests with the necessary access devices, such as, for example, key cards, access codes or keys, to enter and utilize the rooms allocated to them. Alternatively or additionally, the recommender 210 can output the room allocation(s) to devices comprising one or more of Guest Interfaces 216₁-216_m through, for example, a local area network and/or a wide area network to inform the guests and identify which rooms of the facility they are respectively allocated. For example, as discussed above, the devices comprising the Guest Interfaces 216₁-216_m can be a computer device, such as, for example, a smart phone, a tablet or a personal computer owned or used by guests. Further, in accordance with exemplary embodiments, the recommender 210 can, for example, provide access codes with the room allocations to the devices comprising the Guest Interfaces 216₁-216_m to enable the guests to access their respectively allocated rooms. For example, these devices can be smart phones equipped to wirelessly transmit the access codes to an electronic door lock to enable the guest to access the rooms. The room allocation can include settings for one or more appliances serving the respective room. The settings can be applied to the one or more appliances to change, modify or cause the one or more appliances to meet, for example, a desired comfort level, minimum threshold, maximum threshold, settings for a particular appliance and/or settings determined for the respective guest, room or guest/room pairing and the corresponding one or more appliances. The settings can include, but are not limited to, light level settings, noise level settings, temperature settings, humidity settings, and/or climate control settings.

It should be noted that, while the examples described above were implemented by allocating rooms to a group of guests simultaneously, the method 300 can be performed such that a single room can be allocated to a guest at a given time. For example, here, the score generator 208 can determine the score for one selected guest profile and for every available room. For example, in this case the scores in the first columns for Guest A in Tables 5 and 6 can be determined, and the recommender 210 can select the guest profile/room combination having the highest allocation score (which can be a weighted version of the energy efficiency score). Alternatively, the recommender 210 can use the energy consumption scores as the allocation scores, and can select the guest profile/room combination having the lowest energy consumption score (which can be a weighted as discussed above).

At step 312, the score generator 208 can obtain measurements for each of the guest stays for the rooms allocated to the respective guests. For example, the score generator 208 can obtain any one or more or all of the measurements from energy consumption monitor 220, IoT sensors 214₁-214_n, and/or the devices 214₁-214_n as discussed in detail herein above with respect to step 302, while the guests are occupying or using their allocated rooms.

The method may then proceed to step 302, at which the score generator 208 can refine the score model 206 by updating the aggregate of measurement data of each of the rooms allocated at step 308 with the measurements obtained at step 312 as training data. In addition, the score generator 208 can refine and train the model 206 by correlating, as discussed in detail above with respect to step 302, the respective measurement data obtained at step 312 for each of the stays to the respective current guest profile(s) obtained at 304 as training data. These guest profiles with which the score model 206 is refined can be referenced in future iterations of the method 300 for additional guests and/or additional stays at the facility to determine new allocation scores as discussed above with respect to step 306.

Future room allocations for a guest can be modified or changed based in part on measurement data received during previous guest stays associated with previous room allocations, the refined guest profile(s) and/or the refined score model. The method can continually refine the score model 206 by updating the aggregate of measurement data for previous room allocations to change an output or room allocation for future guest stays for a given guest.

Optionally, prior to refining the score model 206 at the iteration of step 302, the score generator 208 can obtain feedback from the guest(s). For example, the guest can provide the feedback through one or more of the Guest Interfaces 216₁-216_m, or can provide the feedback to a receptionist at the facility, who then can provide the score generator 208 with the feedback through the user-interface 212. Here, the feedback could indicate that the allocated room had a low comfort level or a low convenience level. As a result, the score generator 208 can provide an indication in the guest profile for this stay such that the score generator 208 weights rooms with higher comfort levels or higher convenience levels, respectively, favorably for this particular guest or guest profile in the manner discussed above with respect to step 306 when generating an allocation score for this particular guest or guest profile in a future iteration of the method 300. Similarly, the feedback could indicate that the allocated room had a high comfort level or a high convenience level that was liked by the guest and the score generator 208 can provide an indication in the guest profile for this stay such that the score generator weights the allocated room or rooms that are similar to the

allocated room favorably for this particular guest or guest profile in the manner discussed above with respect to step 306 when generating an allocation score for this particular guest or guest profile in a future iteration of the method 300. The method 300 can then proceed to step 302 to refine the score model 206 with the updated guest profile as discussed above.

5 In accordance with the principles of the application described herein, exemplary embodiments can leverage energy consumption characteristics of both rooms of a facility and guests to intelligently allocate the rooms to guests and thereby improve the energy efficiency of the appliances of a facility as a whole. Further, the allocation can be performed in such a way that guest comfort levels and convenience can be maintained or
10 maximized while at the same time improving the energy efficiency of the facility.

While several inventive embodiments have been described and illustrated herein, those of ordinary skill in the art will readily envision a variety of other means and/or structures for performing the function and/or obtaining the results and/or one or more of the advantages described herein, and each of such variations and/or modifications is deemed to
15 be within the scope of the inventive embodiments described herein. More generally, those skilled in the art will readily appreciate that all parameters, dimensions, materials, and configurations described herein are meant to be exemplary and that the actual parameters, dimensions, materials, and/or configurations will depend upon the specific application or applications for which the inventive teachings is/are used. Those skilled in the art will
20 recognize, or be able to ascertain using no more than routine experimentation, many equivalents to the specific inventive embodiments described herein. It is, therefore, to be understood that the foregoing embodiments are presented by way of example only and that, within the scope of the appended claims and equivalents thereto, inventive embodiments may be practiced otherwise than as specifically described and claimed. Inventive embodiments of
25 the present disclosure are directed to each individual feature, system, article, material, kit, and/or method described herein. In addition, any combination of two or more such features, systems, articles, materials, kits, and/or methods, if such features, systems, articles, materials, kits, and/or methods are not mutually inconsistent, is included within the inventive scope of the present disclosure.

30 All definitions, as defined and used herein, should be understood to control over dictionary definitions, definitions in documents incorporated by reference, and/or ordinary meanings of the defined terms.

The indefinite articles “a” and “an,” as used herein in the specification and in the claims, unless clearly indicated to the contrary, should be understood to mean “at least one.”

The phrase “and/or,” as used herein in the specification and in the claims, should be understood to mean “either or both” of the elements so conjoined, i.e., elements that are conjunctively present in some cases and disjunctively present in other cases. Multiple elements listed with “and/or” should be construed in the same fashion, i.e., “one or more” of the elements so conjoined. Other elements may optionally be present other than the elements specifically identified by the “and/or” clause, whether related or unrelated to those elements specifically identified. Thus, as a non-limiting example, a reference to “A and/or B”, when used in conjunction with open-ended language such as “comprising” can refer, in one embodiment, to A only (optionally including elements other than B); in another embodiment, to B only (optionally including elements other than A); in yet another embodiment, to both A and B (optionally including other elements); etc.

As used herein in the specification and in the claims, “or” should be understood to have the same meaning as “and/or” as defined above. For example, when separating items in a list, “or” or “and/or” shall be interpreted as being inclusive, i.e., the inclusion of at least one, but also including more than one, of a number or list of elements, and, optionally, additional unlisted items. Only terms clearly indicated to the contrary, such as “only one of” or “exactly one of,” or, when used in the claims, “consisting of,” will refer to the inclusion of exactly one element of a number or list of elements. In general, the term “or” as used herein shall only be interpreted as indicating exclusive alternatives (i.e. “one or the other but not both”) when preceded by terms of exclusivity, such as “either,” “one of,” “only one of,” or “exactly one of.” “Consisting essentially of,” when used in the claims, shall have its ordinary meaning as used in the field of patent law.

As used herein in the specification and in the claims, the phrase “at least one,” in reference to a list of one or more elements, should be understood to mean at least one element selected from any one or more of the elements in the list of elements, but not necessarily including at least one of each and every element specifically listed within the list of elements and not excluding any combinations of elements in the list of elements. This definition also allows that elements may optionally be present other than the elements specifically identified within the list of elements to which the phrase “at least one” refers, whether related or unrelated to those elements specifically identified. Thus, as a non-limiting example, “at least one of A and B” (or, equivalently, “at least one of A or B,” or, equivalently

“at least one of A and/or B”) can refer, in one embodiment, to at least one, optionally including more than one, A, with no B present (and optionally including elements other than B); in another embodiment, to at least one, optionally including more than one, B, with no A present (and optionally including elements other than A); in yet another embodiment, to at least one, optionally including more than one, A, and at least one, optionally including more than one, B (and optionally including other elements); etc.

It should also be understood that, unless clearly indicated to the contrary, in any methods claimed herein that include more than one step or act, the order of the steps or acts of the method is not necessarily limited to the order in which the steps or acts of the method are recited.

In the claims, as well as in the specification above, all transitional phrases such as “comprising,” “including,” “carrying,” “having,” “containing,” “involving,” “holding,” “composed of,” and the like are to be understood to be open-ended, i.e., to mean including but not limited to. Only the transitional phrases “consisting of” and “consisting essentially of” shall be closed or semi-closed transitional phrases, respectively, as set forth in the United States Patent Office Manual of Patent Examining Procedures, Section 2111.03.

CLAIMS:

1. A system for improving energy consumption efficiency of a plurality of appliances serving a plurality of rooms of a facility comprising:

a score generator (208), implemented by at least one hardware processor, configured to:

5 compile, for each given room of said plurality of rooms, an aggregate of measurements of energy consumption by at least one given appliance, of said plurality of appliances, serving said given room over multiple guest stays in said given room,

compile a plurality of guest profiles, wherein at least one particular guest profile of said plurality of guest profiles is based on particular measurements of energy
10 consumption by at least one particular appliance, of said plurality of appliances, serving at least one particular stay at said facility associated with at least one previous room allocation, and

analyze the aggregate of measurements and said particular guest profile to determine respective energy efficiency levels for different pairings between said
15 plurality of rooms and said particular guest profile; and

a recommender (210), implemented by at least one hardware processor, configured to allocate one of said plurality of rooms to a guest based on the respective energy efficiency levels for said different pairings for a subsequent room allocation to improve the energy consumption efficiency of the facility from the at least one previous room allocation.

20 2. The system of claim 1, wherein the allocation of the one of said plurality of rooms to the guest is implemented based on a determination that a pairing between the allocated room and the guest provides a temperature and/or relative humidity meeting at least one predetermined threshold.

25 3. The system of claim 1, wherein the score generator (208) is configured to analyze the aggregate of measurements by assessing an average percentage of total energy consumed by each of said at least one given appliance for serving said given room.

4. The system of claim 1, wherein the score generator (208) is configured to analyze said particular guest profile by assessing an average percentage of total energy consumed by each of said at least one particular appliance for serving the particular stay.

5. The system of claim 1, wherein the score generator (208) is configured to analyze the aggregate of measurements and said particular guest profile by determining a matrix product of values denoting the aggregate of measurements and values denoting said particular measurements.

6. The system of claim 1, wherein the score generator (208) is configured to weight at least a subset of said energy efficiency levels based on at least one of temperature measurements compiled in said aggregate of measurements, humidity measurements compiled in said aggregate of measurements, noise level measurements compiled in said aggregate of measurements, light level measurements compiled in said aggregate of measurements, light settings compiled in said aggregate of measurements or temperature settings compiled in said aggregate of measurements.

7. The system of claim 1, wherein the at least one particular guest profile comprises a plurality of particular guest profiles, wherein the score generator (208) is configured to generate allocation scores based on said energy efficiency levels and wherein the recommender (210) is configured to select room allocations for a plurality of guests such that a combination of a subset of said different pairings providing a highest total of allocation scores is selected.

8. A method (300), implemented by at least one hardware processor, for improving energy consumption efficiency of a plurality of appliances serving a plurality of rooms of a facility comprising:

compiling (302) for each given room of said plurality of rooms, an aggregate of measurements of energy consumption by at least one given appliance, of said plurality of appliances, serving said given room over multiple guest stays in said given room,

wherein the compiling (302) further comprises compiling a plurality of guest profiles, wherein at least one particular guest profile of said plurality of guest profiles is based on particular measurements of energy consumption by at least one particular appliance,

of said plurality of appliances, serving at least one particular stay at said facility associated with at least one previous room allocation;

analyzing (306) the aggregate of measurements and said particular guest profile to determine respective energy efficiency levels for different pairings between said plurality of rooms and said particular guest profile; and

allocating (308) one of said plurality of rooms to a guest based on the respective energy efficiency levels for said different pairings for a subsequent room allocation to improve the energy consumption efficiency of the facility from the at least one previous room allocation.

9. The method of claim 8, wherein the allocating is implemented based on a determination that a pairing between the allocated room and the guest provides a temperature and/or humidity meeting at least one predetermined threshold.

10. The method of claim 8, wherein the analyzing (306) comprises assessing an average percentage of total energy consumed by each of said at least one given appliance for serving said given room.

11. The method of claim 8, wherein the analyzing (306) comprises assessing an average percentage of total energy consumed by each of said at least one particular appliance for serving the particular stay.

12. The method of claim 8, wherein the analyzing (306) comprises determining a matrix product of values denoting the aggregate of measurements and values denoting said particular measurements.

13. The method of claim 8, wherein the analyzing (306) comprises weighting at least a subset of said energy efficiency levels based on at least one of temperature measurements compiled in said aggregate of measurements, humidity measurements compiled in said aggregate of measurements, noise level measurements compiled in said aggregate of measurements, light level measurements compiled in said aggregate of measurements, light settings compiled in said aggregate of measurements or temperature settings compiled in said aggregate of measurements.

14. The method of claim 8, wherein the at least one particular guest profile comprises a plurality of particular guest profiles, wherein the analyzing (306) comprises generating allocation scores based on said energy efficiency levels and wherein the allocating (308) comprises selecting room allocations for a plurality of guests such that a combination of a subset of said different pairings providing a highest total of allocation scores is selected.

15. A non-transitory storage medium storing computer-readable program code configured to cause at least one hardware processor to perform a method for improving energy consumption efficiency of a plurality of appliances serving a plurality of rooms of a facility when the at least one processor executes the code, said method comprising:

compiling (302) for each given room of said plurality of rooms, an aggregate of measurements of energy consumption by at least one given appliance of said plurality of appliances over multiple guest stays in said given room,

wherein the compiling (302) further comprises compiling a plurality of guest profiles, wherein at least one particular guest profile of said plurality of guest profiles is based on particular measurements of energy consumption by at least one particular appliance, of said plurality of appliances, serving at least one particular stay at said facility associated with at least one previous room allocation;

analyzing (306) the aggregate of measurements and said particular guest profile to determine respective energy efficiency levels for different pairings between said plurality of rooms and said particular guest profile; and

allocating (308) one of said plurality of rooms to a guest based on the respective energy efficiency levels for said different pairings for a subsequent room allocation to improve the energy consumption efficiency of the facility from the at least one previous room allocation.

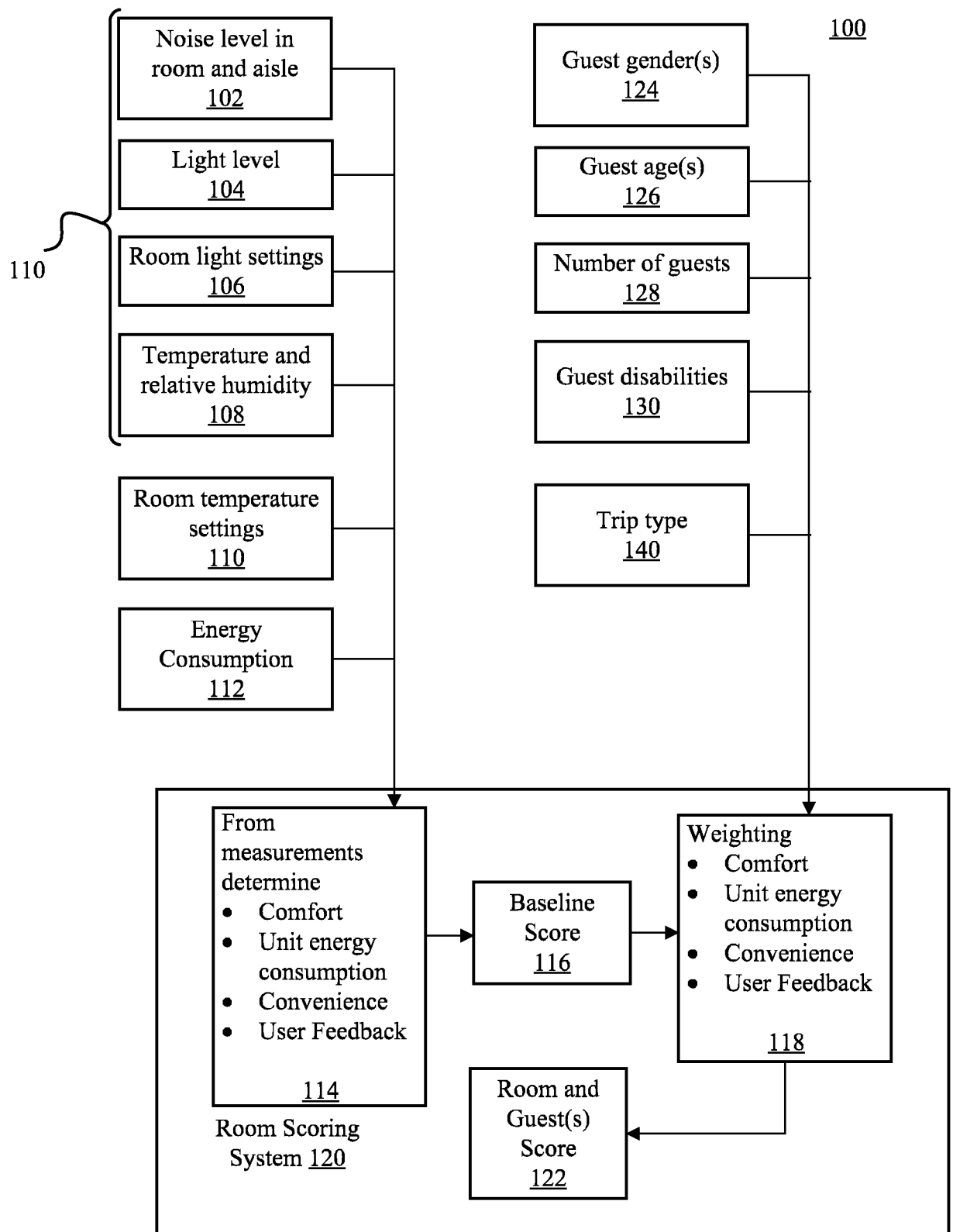


FIG. 1

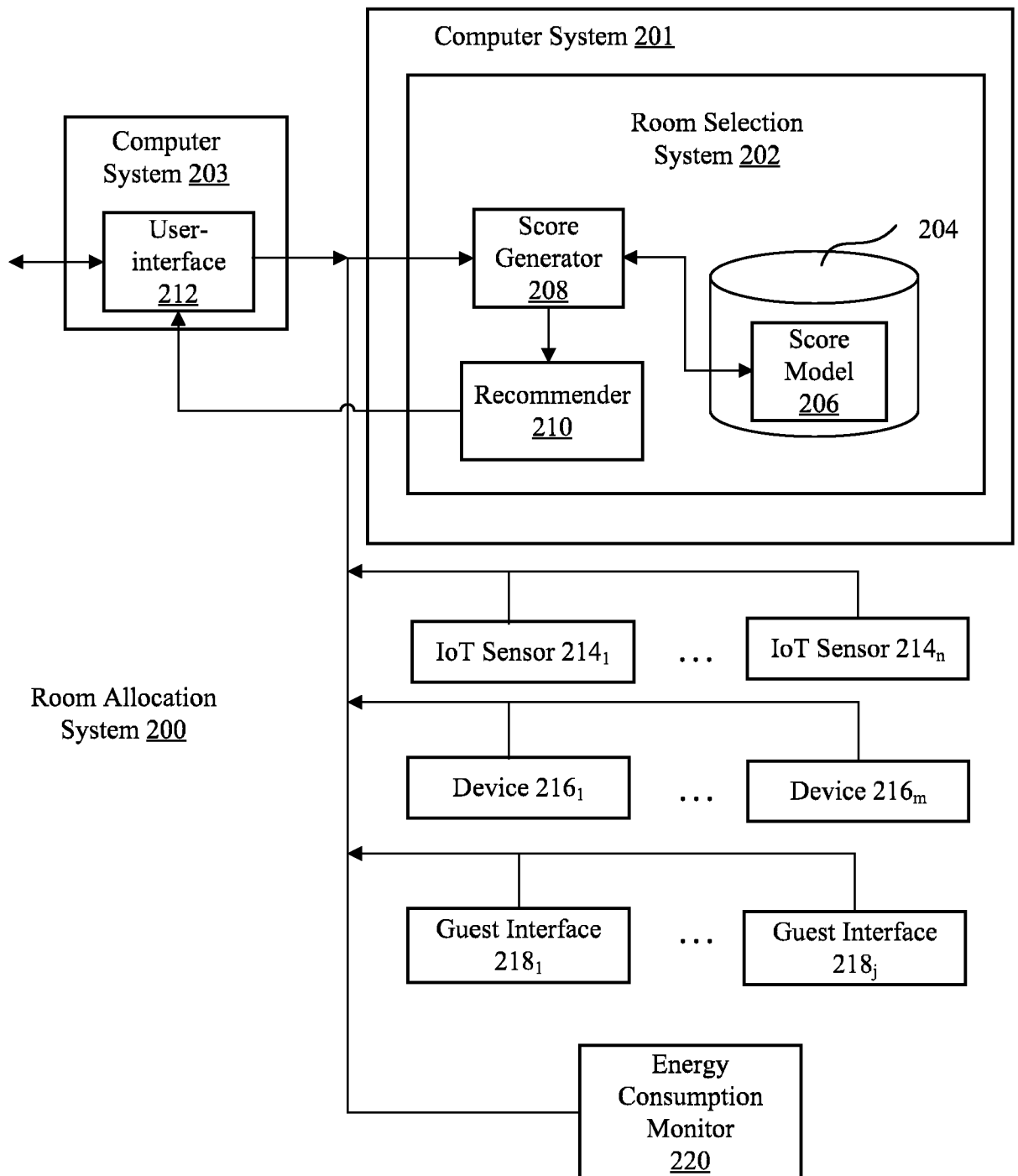
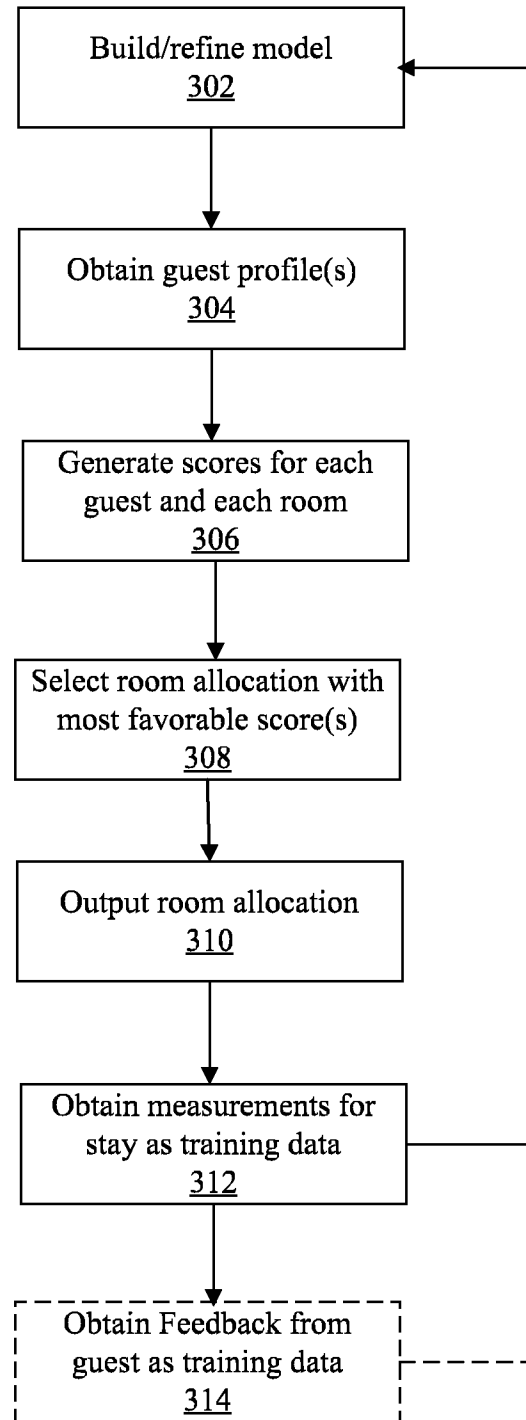


FIG. 2

300**FIG. 3**

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2021/076470

A. CLASSIFICATION OF SUBJECT MATTER INV. G06Q10/06 G06Q30/00 G06Q50/12 ADD.		
According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED Minimum documentation searched (classification system followed by classification symbols) G06Q		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) EPO-Internal, WPI Data		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2008/215441 A1 (BRUGGEMEIER WOLFGANG [DE] ET AL) 4 September 2008 (2008-09-04) paragraph [0002] - paragraph [0009] paragraph [0048] - paragraph [0054] abstract; figure 1 -----	1-15
X	CN 107 463 154 B (SAMSUNG ELECTRONICS CN R&D CT; SUMSUNG ELECTRONICS CO LTD) 3 July 2020 (2020-07-03) page 1 - page 3 -----	1-15
☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.		
* Special categories of cited documents : "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier application or patent but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance;; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance;; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "&" document member of the same patent family		
Date of the actual completion of the international search 13 December 2021		Date of mailing of the international search report 22/12/2021
Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016		Authorized officer Härdeman, David

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2021/076470

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2008215441 A1	04-09-2008	US 2008215441 A1	04-09-2008
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CN 107463154 B	03-07-2020	NONE	
