Innovation, Sciences et Développement économique Canada
Office de la Propriété Intellectuelle du Canada

Innovation, Science and Economic Development Canada
Canadian Intellectual Property Office

CA 2866291 C 2023/05/09

(11)(21) 2 866 291

(12) BREVET CANADIEN CANADIAN PATENT

(13) C

(86) Date de dépôt PCT/PCT Filing Date: 2013/05/17
(87) Date publication PCT/PCT Publication Date: 2013/11/21
(45) Date de délivrance/Issue Date: 2023/05/09
(85) Entrée phase nationale/National Entry: 2014/09/30
(86) N° demande PCT/PCT Application No.: CN 2013/075845
(87) N° publication PCT/PCT Publication No.: 2013/170791

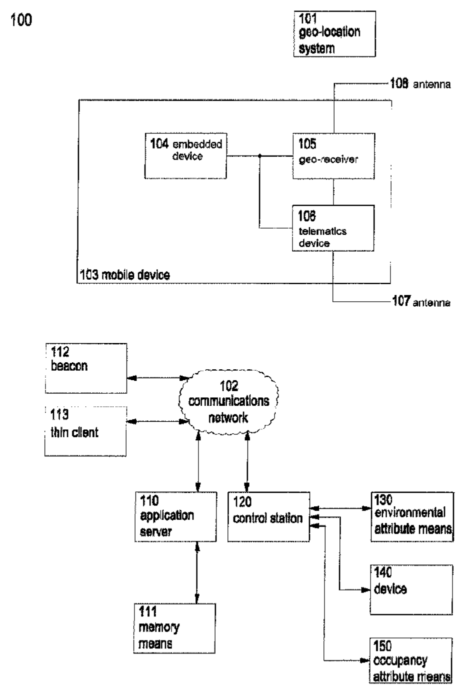
(51) Cl.Int./Int.Cl. *H04W 4/029* (2018.01), *G08B 21/18* (2006.01), *H04W 4/12* (2009.01), *G06Q 50/12* (2012.01), *G01J 1/42* (2006.01)

(72) Inventeur/Inventor:
CHAN, MARK KIT JIUN, CN

(73) Propriétaires/Owners:
CHAN, HUN MAN LENA, HK;
CHAN, MARK KIT JIUN, CN

(74) Agent: ADE & COMPANY INC.

(54) Titre : MECANISME DE CONTROLE D'INFORMATION
(54) Title: INFORMATION CONTROL SYSTEM



(57) Abrégé/Abstract:
A system and method is used to characterize a user with properties, such as location in relation to established geo-fences, speed of traverse, projected traveling time required for a particular distance, etc. Those properties contribute to yielding a quantitative result in the calculated lead time period prior to the user arriving at a monitored space, including but not limited to a rented room in a hotel, and a house. The method uses the user's arrival time to estimate the setback temperature, which is the indoor temperature of a monitored space maintained during unattended time periods. The method also uses the user's arrival time to estimate the heated water volume to be provided, as well as, to house watch other property management interests.

ABSTRACT

A system and method is used to characterize a user with properties, such as location in relation to established geo-fences, speed of traverse, projected traveling time required for a particular distance, etc. Those properties contribute to yielding a quantitative result in the calculated lead time period prior to the user arriving at a monitored space, including but not limited to a rented room in a hotel, and a house. The method uses the user's arrival time to estimate the setback temperature, which is the indoor temperature of a monitored space maintained during unattended time periods. The method also uses the user's arrival time to estimate the heated water volume to be provided, as well as, to house watch other property management interests.

Description

Title of Invention:

Information Control System

Technical Field

[0001] The present invention relates to a user location tracking system ("tracking system") and methods to locate user carried mobile devices, such as those used in digital cellular systems, personal communications systems ("PCS"), enhanced specialized mobile radios ("ESMRs"), radio frequency ("RF") based tracking systems (Bluetooth, WiFi), and other wireless communications systems. More particularly, but not exclusively, the present disclosure relates to methods that employ the location of the individually tracked user to determine the time at which the user arrives ("arrival time") at a monitored space, including the corresponding rented room at a hotel ("rented room"), and the total number of tracked users at a monitored space for control of the related conditions.

Background Art

[0002] A residing guest ("user") at a hotel contributes to energy consumption in the use of a rented room through two primary utility sources: Heating, Ventilating and Air-Conditioning system ("HVAC") and heated water. In conventional HVAC systems, the temperature within a rented room is raised or lowered at multiple operating levels. The indoor temperature is typically maintained at three different levels. The setpoint level is often selected by the user when the rented room is attended. The comfort level is maintained at a few degrees from the setpoint temperature for energy conservation when the rented room is unoccupied while allowing speedy resume to the setpoint level. The free level is used for maximal energy conservation of an unrented room. In furtherance, housekeeping services are preferably provided to the rented room during guest unattended moments. Other services such as control of devices and security pertaining to a monitored space are currently enacted with other automation systems.

Technical Problem

Common problem of the comfort level of a monitored space often being the setback temperature either too far away from the setpoint temperature to provide satisfactory comfort when someone returns to the rented room, or too close to the setpoint temperature to achieve adequate energy savings. Indoor temperature at comfort level requires a drive time to be resumed to setpoint temperature; the corresponding estimated minimal required drive time is therefore overly inaccurate. The "Short Cycling" phenomenon may result from insufficient operating times, leading to overshooting the user's setpoint temperature and unbounded up/down temperature cycles within a given time period. The result is unavoidable damage to the HVAC system and shortening of the general operative life span.

Heated water at setpoint temperature must also be readily supplied to the monitored space. Water heaters fall into one of two categories: 1. tankless type water heaters, and 2. storage tank type water heaters. Consumption of heated water greatly varies within different times of the day and during different seasons of the year notwithstanding, the volume is also dependent on the number of users being onsite. Should the heated water supply be planned on basis of the projected number of users being at the monitored space during the day, the volume of heated water allocated on the per user basis can be maintained at an interrelated level.

In addition, the devices within a monitored space are not restricted for use of intended users. Home appliances are largely automated through programmed configurations and distant control, but are unable to respond in accordance with user identification.

DESCRIPTION OF THE INVENTION

Technical Solution

The present invention provides a system and methods to determine the user's arrival time at an unoccupied monitored space for determination of the setback temperature, the quantity of heated water consumption, scheduling of service provisions. The operative modes of devices related to the monitored space are changed in accordance with detected or expected presence of intended users.

Advantageous Effects

The setback temperature of the unoccupied monitored space can be drifted to the farthest level from the user configured setpoint level, and is driven to the setpoint level in accordance with the system determined arrival times of one or more users. The quantity of readily supplied heated water is drifted and driven in accordance with expected number of users remaining or arriving in the monitored space. Maximal energy savings can be achieved. In furtherance, change of operative modes of devices related to the rented room with restriction to intended users, not only enhances user experience, it also renders strengthened security.

In various aspects, a system is disclosed for locating and recording with respect to time a proximity log related to location of a user carried mobile device encompassing one or more transmitters for wireless communication. In one embodiment, said mobile device is further equipped with location analysis functionality and selectively transmits a message encompassing the proximity log on its location relative to a predetermined geo-fence area. The system includes an application server that receives the message and determines the user's arrival time at the rented room. In furtherance, the application server proceeds with the calculation of the total number of tracked users with respect to time during the day. In a further aspect, the control station sends obtained attributes to the application server, and controls connected attribute station and external devices in accordance with received proximity logs sent from the application server. The control station includes but not limited to a Building Management System, and a gateway with internet and WLAN connectivity.

In one embodiment, the application server estimates the drive time of temperature response in a HVAC controlled room by the following steps: obtaining the indoor temperature at a beginning point, intermediate points and an end point of the prior drive operation; calculating a drive curve using the beginning, intermediate and end temperatures; and using the drive curve to estimate a time at which the desired temperature will be reached. In an alternative embodiment, estimating the drive time may comprise the steps of: obtaining a plurality of indoor temperature data samples over a period of time corresponding to the prior drive operation; calculating a plurality of drive curve sections, each section calculated using a subset of data samples; conjoining all calculated drive curve sections.

In another embodiment, a method for calculating the quantity of heated water consumption during the day. The application server projects the daily peaks of actual water consumption by utilizing the consumption rate versus time on basis of historic operations, composing a curve of the daily consumption rate versus time, and using the projected number of users at the hotel on basis of a plurality of received proximity logs, and therefore the arrival times of tracked users, to project the time at which the daily peaks of heated water consumption will be reached.

In a further embodiment of the method, the application server estimates the time duration of each rented room being in an unoccupied status and composes a schedule of housekeeping service in priority. The dynamic information is stored in a server connected memory means. In yet a further embodiment of a method for determining and setting the operative modes of selected devices related with the rented room, on the basis of the concurrent user location and in accordance with preset operating parameters or user authorization.

DESCRIPTION OF DRAWINGS

The drawings constitute to embodiments of the present invention and serve to depict the apparatuses infrastructure and operating principles.

FIG.1 is a block diagram representation of the present invention of the tracking system.

FIG.2A depicts a traveling trace of user carried mobile device with respect to a polygonal geo-fenced area.

FIG.2B depicts the locations of user carried mobile device at different instantaneous times with respect to a circular geo-fenced area.

FIG.3 is a graph depicting the calculated thermal drift & drive relationships within a monitored space, using a non-linear equation.

FIG.4 is a graph depicting the thermal drift & drive relationships within a monitored space, identifying recorded data samples over a period of time.

FIG.5 is a flow chart depicting a method to calculate setback room temperature settings, and the projected heated water consumption quantity, using the user location and projected user's arrival time at a hotel.

FIG.6A is a graph depicting the historic heated water consumption rate on an average day at a hotel.

FIG.6B is a graph depicting the recorded heated water consumption rate, and projected heated water consumption rate based on a plurality of projected users' arrival times at a hotel.

FIG.7depicts a schedule for allocating human resources in service provisions with prioritization in accordance with rented room users' arrival times.

FIG.7B is a flow chart depicting a method to house watch a monitored space.

BEST MODE

The present invention may be better understood with reference to embodiments depicted by supporting drawings, however, it is not intended that the invention be restricted to those depicted embodiments. Those skilled in the art will recognize that variations and modifications can be made without departing from the true scope of the invention as defined by the claims. It is therefore intended to include within the invention all such variations and modifications as fall within the scope of the appended claims and equivalents thereof.

FIG.1 illustrates the present invention in environment **100**, in which certain preferences in geo-fence details, operating parameters and controls information are selectively sent from application server **110** to mobile device **103**. Mobile device **103** is enabled to transmit preferred messages to application server **110** for data logging. Application server **110** performs projection of the arrival time at the rented room of the user carrying mobile device **103**. At any time, the user can send a manually entered arrival time through mobile device **103** to application server **110**.

Geo-location system **101** is a terrestrial or satellite based positioning system;

some of which include but not limited to the Beidou Navigation System, Differential GPS ("DGPS"), Eurofix DGPS, Global Positioning System ("GPS"), pertaining to the Global Navigation Satellite System ("GNSS"). In other types of positioning systems, geo-location system **101** comprising cellular communication towers, or other systems providing reference points, transmit RF signals that are received by mobile device **103**.

Mobile device **103** encompasses embedded device **104** (e.g. an onboard computer with memory means (not shown) and limited functionality), geo-receiver **105**, telematics device **106** and the corresponding antennae **108**, **107**. Embedded device **104** is wirelessly loaded with operating parameters, which include but not limited to the geo-fence boundary definitions, the clock time, and the polling interval, etc. Mobile devices **103** include a cellular phone, and a handheld device possessing wireless communication connectivity, such as a tablet computer, and the like.

Typically, geo-receiver **105** processes geo-location system **101** sent signals received by antenna **108**, for obtainment of the concurrent location of mobile device **103**. In one embodiment, mobile device **103** determines its location by engaging in the trilateration process. Telematics device **106** transmits to application server **110** via antenna **107** – at constant or variable specific frequency in time as per the preconfigured polling interval – coded wireless messages comprising the present location and a unique identifier of mobile device **103**. In an alternative embodiment, mobile device **103** transmits to application server **110** by telematics device **106** via antenna **107** said coded wireless messages at a defined polling interval in accordance with received application server **110** sent periodic probe requests.

Application server **110** receives information encompassing the mobile device

103 location and unique identifier via network **102**. Application server **110** executes a program which calculates the lead time period pertaining to the user's arrival time at the related rented room. Alternatively, application server **110** assigns a predefined lead time period on the basis of the geo-fenced area – related to a geo-fence boundary – in which mobile device **103** is located. The lead time period and the operating parameters of mobile device **103** may be changed in accordance with change in the mobile device **103** located geo-fenced area. Application server **110** may be any equipment capable of facilitating two way communications with telematics device **106** on mobile device **103**. In another embodiment, mobile device **103** calculates the lead time period pertaining to the user's arrival time at the related rented room; it sends the most updated proximity log – encompassing at least the calculated lead time period and the unique identifier – to application server **110** in said coded wireless messages.

A library of predefined geo-fence boundaries, the polling interval at constant or variable frequency directing data logging between application server **110** and mobile device **103**, quantitative calculations performed by application server **110**, and other information such as personal data of the user, is stored in memory means **111** and retrieved by application server **110** via a wired or wireless communicative network. Memory means **111**, working with or within application server **110**, can be any device, including magnetic, optical or solid-state memory; where stored information can be changed via a communicatively connected thin client **113**.

In an outdoor environment for use with geo-location system **101**, network **102** uses a combination of wireless and landline communication infrastructure such as a cellular telecommunication system and the internet, provides two-way data logging between telematics device **106** and application server **110**.

On the other hand, the wireless and landline communication infrastructure of network **102** pertinent to an indoor tracking system, as depicted in FIG.1, typically encompasses a combination of WLAN/Ethernet. Wherein, user carried mobile device **103** possessing Bluetooth communicative components and functionality is continually tracked through a node based mesh network (not shown) constructed on basis of a plurality of Bluetooth beacons **112**. Bluetooth beacon **112** transmits a signal to_mobile device **103** in the indoor environment, and transports the returning signal to the communicatively connected application server **110**. Operatively similar to said outdoor tracking system, the proximity log encompassing the lead time period pertaining to the user's arrival time at the related rented room is obtained by application server **110** on basis of the position of mobile device **103**.

Referring to FIG.2A, geo-fenced area **203** is the area within a polygonal geo-fence boundary **204**. The geo-fenced area **203** has a center-of-mass **201**, and a computed circular approximation **205** with radius **202**, corresponding to the maximum offset between the computed center-of-mass **201** and the furthest edge of geo-fence boundary **204**. The dotted trace **220** depicts an exemplary path of mobile device **103** crossing geo-fence boundary **204** and traveling away from center-of-mass **201**, being the related rented room at a hotel, as in one embodiment.

In FIG.2A, a zone of Level 0 is defined as an area beyond circular approximation **205**: a zone of Level 1 may be defined as the area within circular approximation **205**. Application server **110** can alter the shape of geo-fence boundary **204** within zone Level 1, in accordance with preconditioning factors pertinent to traffic conditions, time of the day, the unique identifier of mobile device **103** and characteristics of the user or the related rented room, etc.

In one embodiment, application server **110** correlates the data pertinent to the real-time location of the user carrying mobile device **103** to a preconfigured lead time period Δt_a, which is the time period between the concurrent time and the projected user's arrival time at center-of-mass **201**. For instance, a preconfigured value is assigned for lead time period Δt_{a1} when mobile device **103** is at position **211**, and within the geo-fenced area **203**; another preconfigured value is assigned for lead time period Δt_{a2} when mobile device **103** is at position **212**, which is outside geo-fence boundary **204**.

Referring now to FIG.2B, illustrated is geo-fenced area **253** pertaining to circular geo-fence boundary **254**. Geo-fence boundary **254** having radius **252** has been defined around central point **251**, being the rented room at the hotel, as in one embodiment. The dotted trace **221** depicts an exemplary path of mobile device **103** crossing geo-fence boundary **254** and traveling toward central point **251**. A zone of Level 0 is defined as an area outside geo-fence boundary **254**: a zone of Level 1 is the area within geo-fence boundary **254**. Application server **110** can alter the coverage of zone Level 1 within geo-fence boundary **254**, in accordance with preconditioning factors pertinent to traffic conditions, time of the day, the unique identifier of mobile device **103** and characteristics of the user or the related rented room, etc.

In an alternative embodiment, application server **110** correlates the data pertinent to the real-time location of mobile device **103** to a mathematical calculation of lead time period Δt_a, as follows:

$$\Delta t_a = \gamma \cdot d / v \qquad [1]$$

where Δt_a is the lead time period between the concurrent time and the projected user's arrival time at the rented room of central point **251**; γ represents a preconfigured factor pertinent to the uncertain preconditions affecting lead time period Δt_a, such as time of the day, the unique identifier of mobile device **103** and characteristics of the user or the related rented room, etc.; d is the distance between the concurrent location of the monitored mobile device **103** and central point **251**; v is the user's velocity of travel, which may be calculated, using:

$v = (d_2 - d_1) / (t_2 - t_1)$ [2]

where v, is periodically calculated on basis of the time difference to travel from one location to another. For instance, v is indicated by the difference between d_1 (traversal distance between first position **261** and central point **251**), and d_2 (traversal distance between second position **262** and central point **251**), divided by the difference of t_1 (instantaneous time recorded at first position **261**), and t_2 (instantaneous time recorded at second position **262**). Other formulae and methods may seem fit in different situations where appropriate and therefore can also be applied for calculation of lead time period Δt_a. Application server **110** performs the calculations and sends the calculated values of lead time period Δt_a to control station **120** and other systems.

Those skilled in the art will appreciate that the exemplary methods disclosed herein may be applied to any geo-fenced area represented by any number of shapes and sizes. A geo-fence around a center of mass may range in complexity from a line to a highly irregular shape which more accurately follows the landscape of the hotel premises and neighborhood. There are a number of methods for constructing these geo-fences which will be apparent to one skilled in the art.

Thermal Drift & Drive Relationships

FIG.3 illustrates an exemplary temperature change in an indoor space, wherein the outdoor temperature is lower than indoor setpoint temperature T_{set} of the space. Ambient temperature T_{amb} is the temperature at which indoor temperature T(t) will theoretically reach in accordance with indefinite increase in time t, when the HVAC heating operation is off; it is at a constant level in this case for demonstration purposes.

Drift curve **300-1** represents the “drift process” of indoor temperature T(t) with respect to time, beginning at a rapid rate decreasing from setpoint temperature T_{set} as indoor temperature T(t) approaches the steady-state temperature, which is substantially the same as ambient temperature T_{amb}. Drive curve **300-2** represents the “drive process” of indoor temperature T(t) of the space being driven from ambient temperature T_{amb} up to setpoint temperature T_{set} in relation to time during a HVAC heating operation. The drive rate is decreasing as indoor temperature T(t) approaches setpoint temperature T_{set}. The required time period to drift indoor temperature T(t) from one level to another varies in accordance with time and season, as well as other factors such as the weather and energy sinks within the space. In contrast, drive curve **300-2** is dependent on the unique space environment, and HVAC system performance. The data pertaining to the relationships between temperature responses to HVAC operation must be obtained to project the time period for indoor temperature T(t) to drift from one point to another, as well as the time to drive indoor temperature T(t) from one point to another. For a cooled room on a warm day, the principles are the same, yet the directions of increasing temperature on the y-axis would be inverted.

In one embodiment, mathematical functions may be used to describe the temperature responses through drift curve **300-1** and drive curve **300-2**. In an exemplary use case, Newton's Law of Cooling is used for calculation of the drift and drive performances. The rate of change of indoor temperature T(t) over time dT/dt, is proportional to the difference between indoor temperature T(t) and ambient temperature T_{amb}. A differential equation is used in a mathematical form, as follows:

$$S\, dT / (T - T_{amb}) = k \cdot S\, dt \quad [3]$$

where indoor temperature T(t) corresponds to a drift process from setpoint temperature T_{set} to ambient temperature T_{amb}. Solving the differential equation, we yield an equation having indoor temperature T(t) as a function of time:

$$T(t) = T_{amb} + (T_{set} - T_{amb})\, e^{-kt} \quad [4]$$

where k is a constant dependent on the surrounding environment within the space. Having measured indoor temperature T(t) at any time t, and knowing ambient temperature T_{amb}, the value of k can be easily sorted.

In an alternative embodiment, application server **110** obtains ambient temperature T_{amb}, indoor temperature T(t) pertaining to the drift and drive data from environmental attribute means **130**, records, and stores the data in memory means **111**. In yet another embodiment, application server **110** receives a data feed from control station **120**, or other external sources, comprising drift and drive data of indoor temperature T(t), and ambient temperature T_{amb}. Calculations, data recording and external information source pertaining to obtainment of drift data, drive data and ambient temperature T_{amb}, can be continually processed, stored in memory means **111**, and used for studying indoor temperature T(t) responses versus time t during a HVAC cooling or heating operation in a space.

FIG.4 illustrates an exemplary indoor temperature T(t) response in accordance with drift curve **400-1** and drive curve **400-2**. Dotted curve **400-3** of the fluctuating ambient temperature T_{amb} varies in compliance with outdoor temperature changes during the day.

Setback temperature T_{sb} is a temperature level of an unoccupied rented room maintained by a HVAC system, which is intended to resume to setpoint temperature T_{set} within a short time after user entry. The required time to drive setback temperature T_{sb} to setpoint temperature T_{set} is recovery time period Δt_r – which is dependent on the HVAC system capacity. It is better expressed as:

$\Delta t_r = t_{set} - t_{sb}$ [5]

where t_{set} is the time at which indoor temperature T(t) is driven toward setpoint temperature T_{set}; t_{sb} is the starting time of the drive process, at which indoor temperature T(t) equals to setback temperature T_{sb}.

In one embodiment, application server **110** calculates recovery time period Δt_r on the basis of the obtained user's arrival lead time period Δt_a, then extrapolates the corresponding indoor setback temperature T_{sb}, based on the relationships between the temperature responses and time in a drift process and a drive process. Attention is drawn with care to make sure that recovery time period Δt_r should be within lead time period Δt_a to complete drive of setback temperature T_{sb} to setpoint temperature T_{set}:

$\Delta t_r \le \Delta t_a$

Or,

$\Delta t_r = \alpha \cdot \Delta t_a$ [6]

where α represents a preconfigured factor mathematically describing the uncertainty affecting lead time period Δt_a. In another embodiment, recovery time period Δt_r is also expressed as:

$\Delta t_r = r \cdot | T_{set} - T_{sb} |$ [7]

where recovery rate r (expressed in unit time per unit temperature, such as seconds per ^{o}C) is the rate for the HVAC system to drive indoor temperature toward setpoint temperature T_{set}. Recovery rate r is calculated as follows:

$r = (T_{set} - t) / | T_{set} - T(t) |$ [8]

where T(t) is the indoor temperature of the space during any time t.

Data encompassing recovery rate r in relation with ambient temperature T_{amb} can be stored in memory means **111**. Any technique of calculating and combining the most recently calculated recovery rate r and an archived recovery rate r can also be utilized.

Other than recovery rate r yielded by equation [8] or others, the manufacturer of the HVAC system also provides the recommended recover rate r_m under different ambient conditions for assurance of optimal operative efficacies and equipment life span. Therefore, recovery rate r should be maintained at a rate not exceeding the recommended recover rate r_m:

$r \leq r_m$

Or,

$r = \beta \cdot r_m$ [9]

where β represents a preconfigured factor mathematically describing variables affecting recovery rate r in a temperature drive operation. Substituting equations [6] and [9] into equation [7]:

$T_{sb} = T_{set} - (\alpha \cdot \Delta t_a) / (\beta \cdot r_m)$ [10]

setback indoor temperature T_{sb} of a space using lead time period Δt_a, is yielded.

These drift and drive parameters are used in the methods of the invention for determining the corresponding setback temperature T_{sb}, as shown in flow chart **500** of FIG.5. Typically, application server **110** determines the values of setback temperature T_{sb} in the unoccupied rented room, while receiving different location related information pertaining to mobile device **103**. It is realized that application server **110** receives information encompassing whether the rented room status is unoccupied, from a separate system.

At step **510**, application server **110** periodically receives data pertaining to the rented room from control station **120**, including setpoint temperature T_{set}, indoor temperature T(t) and ambient temperature T_{amb}, and stores the data in memory means **111** for mathematical establishment of thermal drift & drive relationships as illustrated in an exemplary graphical form in FIG.4. It is worthwhile to point out that the objective conditions – such as ambient temperature T_{amb} – are continuously changing; said thermal drift & drive relationships are on a continually updated mathematical platform that affects the calculated results.

In one embodiment, a user carrying mobile device **103** departs from the rented room. At step **520**, application server **110** receives the proximity log from mobile device **103** carried by the user of the rented room – said information including but not limited to indicating the operative environment for tracking mobile device **103** being outdoor or indoor based. At the same time, application server **110** determines if the rented room is unoccupied on basis of information received from at least one other communicatively connected system. Application server **110** analyzes the proximity log and ends the process if the rented room status is identified as "checked-out". Conversely, application server **110** projects the time at which the user will return to the rented room and determines a corresponding setback indoor temperature T_{sb}, on basis of archived numerical thermal drift and drive data. The process proceeds to step **530**.

Referring to FIG.2B, application server **110** receives the proximity log from mobile device **103** corresponding to the first position **261** recorded at the first instantaneous time t_1, and determines the value of d_1 (traversal distance between first position **261** and central point **251**). At step **530**, application server **110** – in one embodiment – uses a preconfigured value of lead time period Δt_{a1} on basis of position **261** being outside geo-fenced area **253**, and calculates the corresponding recovery time period Δt_{r1}, using equation [6]. Application server **110** extrapolates the corresponding setback indoor temperature T_{sb1}, based on the temperature responses in a drift process and drive process of the rented room as shown in FIG.4. Alternatively, application server **110** calculates setback temperature T_{sb1} by using equation [10]. At step **540**, application server **110** sends data pertaining to setback temperature T_{sb1} to control station **120**, for controlling HVAC system of environmental attribute means **130** in maintaining temperature of the rented room at a less energy demanding setback temperature T_{sb1}. The process returns to step **510**.

In a further embodiment, application server **110** receives the proximity log from mobile device **103** corresponding to the second position **262** recorded at the second instantaneous time t_2, and determines the value of d_2 (traversal distance between second position **262** and central point **251**). At step **530**, application server **110** calculates the user's velocity of travel v, using equation [2]:

$$v = (d_2 - d_1) / (t_2 - t_1) \quad [2]$$

substituting velocity v into equation [1] to yield lead time period Δt_{a2}, application server **110** calculates the corresponding recovery time period Δt_{r2}, using equation [6].

Application server **110** extrapolates the corresponding setback indoor temperature T_{sb2}, based on the temperature responses in a drift process and drive process of the rented room as shown in FIG.4. Alternatively, application server **110** calculates setback temperature T_{sb2} by using equation [10]. At step **540**, application server **110** sends data pertaining to setback temperature T_{sb2} to control station **120**. Control station **120** initiates HVAC system of environmental attribute means **130** for adjusting indoor temperature T(t) from setback temperature T_{sb1} to setback temperature T_{sb2}. Setback temperature T_{sb2} will be driven to setpoint temperature T_{set} within recovery time period Δt_{r2}.

Provision of Heated Water and Services

In another aspect of the invention, the tracking system is applied to projection of the total number of tracked users at the hotel with respect to time. Having obtained each tracked user's time of departing, and time of arriving at the hotel in accordance with the user's proximity log, yields the estimated number of total users at the hotel during any time of the day. In furtherance, the settings of the temperature and the reserve volume in the hotel water heater system of environmental attribute means **130** can be projected.

The hotel's daily heated water consumption pattern is a function of the number of users and time, whereas, controls in heated water supply apply to the water flow, as well as, the heat flow. FIG.6A illustrates the heated water consumption rate on a typical day at a hotel having an occupancy rate of 70% in an exemplary profile **600**: recorded peaks exist between 6 a.m. – 7 a.m. (90% – 100% users on-site), 12 p.m. – 1 p.m. (30% – 45% users on-site), and 7 p.m.– 8 p.m. (60 – 80% users on-site).

An exemplary profile **601** in FIG.6B depicts the heated water consumption rate on an average day at a hotel with a 90% occupancy rate; wherein recorded data is available up to the concurrent time at 9:30 a.m. The typical historic records stored in memory means **111** (FIG.1) including but not limited to the archived profile **600**, and the projected number of users at the hotel, are attributes to establishing profile **601**. The first recorded peak **601-1** exists between 6 a.m. – 7 a.m. (90% – 100% users on-site).

In one embodiment, application server **110** projects the total number of users at the hotel at any time, by subtracting each departed tracked user with respect to the recorded departure time, and adding an arriving tracked user with respect to the projected arrival time at the hotel, in addition to an estimated number of residing untracked users. The typical per user consumption rate of heated water at peak demand is 45 liter/hour, whereas a typical daily per user consumption of heated water at 60 – 160 liters. The projection on heated water consumption rate may be segregated into 9:30 a.m. to 1:30 p.m. with a prime accuracy within 4 hours from concurrent time, and at a secondary accuracy from 1:30 p.m. to 12 a.m. The projected peak **601-2** at 12 p.m –1 p.m. and projected peak **601-3** at 7 p.m. – 9 p.m. are shown in profile **601**, which is continually amended with most recently recorded and calculated lead time period Δt_a pertinent to each tracked user.

In yet another embodiment, application server **110** calculates the required volume of heated water in a storage tank type water heater at setpoint temperature, typically between 48°C to 60°C, which is readily for use. Energy conservation may be achieved by consistently maintaining a minimal 30 liter per user of heated water volume, or V, at setpoint temperature. The total required heated water volume in storage at any time, V_{tot}, can be found:

$$V_{tot} = n \cdot V \quad [11]$$

where n is total number of users at the hotel.

The heated water consumption ΔV within a time period Δt can be sought, using the following equation:

$\Delta V = n \cdot Q \cdot \Delta t$ [12]

where Q is the per user flow rate of heated water use.

Application server **110** continually projects the total number of users n, for establishment of a database pertaining to profile **601**. At step **540** of FIG.5, application server **110** transports the related information to one or more separate systems, which includes at least one of control station **120**, and water heater system of environmental attribute means **130**.

Resource Allocation and Service Provision

The tracking system of the invention also applies to human resources allocation in hotelier operations. Referring to FIG.7A, table 700 is an exemplary dynamic schedule indicating priority in providing housekeeping services in a five storey hotel. This schedule can be displayed via a communicatively connected device, including but not limited to mobile device **103**, and thin client **113** (FIG.1).

Slot **701** shows the clock time used by the tracking system. Slot **702** indicates different states of a rented room. Application server **110** receives a message from a separate, communicatively connected system indicating the status of each hotel room as "not rented", "unoccupied", etc. Referring to FIG.2A, the lead time period Δt_a of a user pertaining to a rented room at center-of-mass **201** is determined on the basis of a single geo-fence boundary **204** with geo-fenced area **203** pertaining to 20 minute traffic time. The lead time period Δt_a relating to the time period before the user returns to center-of-mass **201** is determined at "20 minutes", given the tracked user location is within the geo-fenced area. The lead time period Δt_a is suggested at "20 minutes+" otherwise. Application server **110** changes the lead time period Δt_a related to each unoccupied rented room in table **700** in accordance with the periodically updated proximity log of the corresponding tracked user. The housekeeping staff can prioritize the unoccupied rented rooms to be serviced; and change the room status through said communicatively connected device as "room cleaned", upon completion of the housekeeping task.

House Watching a Monitored Space

The tracking system of the invention house watches a monitored space in accordance with the continually updated attributes, as well as, proximity logs of one or more mobile devices **103** carried by the related tracked users. In one aspect, the tracking system determines the security status, and the operative modes of a plurality of devices **140** within or related to a monitored house, in accordance with an exemplary process **750** in FIG.7B.

Referring to FIG.1, application server **110** determines whether one or more mobile devices **103** are within or outside the pertinent monitored house, in accordance with the corresponding proximity logs. At step **751** of process **750**, application server **110** periodically receives signal transmissions, including but not limited to data comprising the occupancy attribute from occupancy attribute means **150** pertaining to the monitored house, as well as, said one or more mobile devices **103**.

At step **752**, application server **110** analyzes the signal transmissions. In one embodiment, signal transmissions are disrupted or discontinued – application server **110** sends a probe signal to control station **120** via network **102**, and the response is incompliant with preconfigured parameters. At step **753**, application server **110** sends an alert to a third party, comprising at least one of the property management, security organization, mobile device **103**, and thin client **113**. In a contrary embodiment, signal transmissions incompliance between control station **120** and application server **110** are not experienced, process **750** proceeds to step **754**. Wherein, application server **110** analyzes said occupancy attribute.

In one embodiment, application server **110** determines that the house is "occupied", or, application server **110** receives a message comprising change in said occupancy of the house; wherein, such change comprises a few aspects. In one exemplary aspect, device **140** comprising a door lock detects a visiting party's attempt to switch the locked state to unlocked state, and sends a corresponding signal to application server **110**.

At step **755**, application server **110** analyzes the proximity logs of said one or more mobile devices **103**. If application server **110** fails to verify the identities of occupants in the occupied house, or, the identity of said visiting party attempting to switch the locked state to the unlocked state of a door lock pertinent to the unoccupied house, an alert is sent to said third party in accordance with step **753**. In a different embodiment, the identities of occupants are verified, alternatively, the identity of said visiting party is verified. In a further embodiment, application server **110** determines in accordance with the proximity logs, one or more mobile device **103** are approaching the house within a close proximity threshold. Process **750** proceeds to step **756**.

At step **756**, application server **110** distinguishes said verified occupants, or verified said visiting party, or verified said approaching one or more mobile device **103**, by analyzing the identifiers and the corresponding proximity logs. In accordance with the results of identity distinguishment, application server **110** sends one or more signals for receipt by said plurality of devices **140** to change the operative mode from an "unattended state" to a "user configured state", or, from an "unattended state" to a "management state". In one embodiment, application server **110** receives the audit trail from a door lock pertaining to device **140**, records in memory means **111** (FIG.1) and sends to said third party time-in and time-out of all entries and exits, in accordance with the results of identity verification and distinguishment.

In an alternative embodiment, application server **110** determines that the monitored house is “unoccupied”. At step **757**, application server **110** sends to control station **120**, one or more signals for receipt by a plurality of devices **140**, to change the operative mode to an “unattended state”. Process **750** proceeds to step **758**.

At step **758**, application server **110** determines if there is change, including but not limited to the pertinence between said one or more mobile devices **103**, and said monitored house. In one embodiment, application server **110** determines no said change – process **750** returns to step **751**. In an alternative embodiment, application server **110** determines said change. In one exemplary aspect, the pertinence between said one or more mobile devices **103** and said house – being a lease – is discontinued upon check-out. Process **750** is ended.

Accordingly, while the present invention has been described herein in detail in relation to one or more preferred embodiments, it is to be understood that this disclosure is only illustrative and exemplary of the present invention and is made merely for the purpose of providing a full and enabling disclosure of the invention. The foregoing disclosure is not intended to be construed to limit the present invention or otherwise exclude any such other embodiments, adaptations, variations, modifications or equivalent arrangements, the present invention being limited only by the claims appended hereto and the equivalents thereof.

Mode for Invention

The invention relates to a tracking system that governs control of indoor climate and water supply reserve, operative modes of selected devices and sending of projected arrival time of related users of a monitored space.

Industrial Applicability

One aspect of the invention relates to energy optimization in a rented hotel room and a house, and to activate on-demand device operation.

In a further aspect, a schedule with dynamic data pertaining to projected time of user arriving at said monitored space provides planning of provision of services and allocation of manpower.

In yet another aspect, the system enables security of said monitored space by generating and sending an alert upon detection of unidentified occupancy. And, the system enables communicatively connected devices to trigger alert while being opened/closed by unidentified user.

Sequent List Text

External Device – communicatively connected to the system, including but not limited to a door lock, a light fixture, a home appliance, a safe, etc.

Thin Client – a network linked electronic device with computing capacity, such as a microcomputer or a handheld personal digital assistant ('PDA'), etc.

Off Mode – power disconnection.

Operative Mode – a device with power connection operating at an unspecified level.

Management State – an operative mode of a device operating at configurations imposed by property management, including but not limited to reduced power consumption.

Unattended State – an operative mode of a device operating at different levels, comprising: reduced power consumption, including but not limited to “sleep” mode and “standby” mode; alternatively, a device is configured to set off an alarm if the physical state is changed, including but not limited to “locked” to “unlocked”, “closed” to “open”; and, code/PIN entry for attempt of open or use. User Configured State – an operative mode of a device performing at one or more user specified levels, selected from functions, security level, or power consumption.

CLAIMS:

1. A system for controlling an environmental attribute of a monitored space in accordance with a geographic location of a mobile device in relation to said monitored space, comprising:

an application server having computing capability, which processes information received via a network, from a communicatively connected control station controlling an environmental attribute means, and which receives with respect to time a geographic location or a proximity log pertaining to said geographic location from said mobile device;

a control station for monitoring a level of said environmental attribute and for driving said environmental attribute through controlling said environmental attribute means, and sending a detected level of said environmental attribute to said application server, and,

a mobile device adapted to send said geographic location or said proximity log to said application server,

in which said application server, or said control station, establishes and records in a communicatively connected memory a drive relationship, which describes with respect to time the change of said environmental attribute for being driven to a set point from an ambient level or from a farthest level relative to said set point, and which represents a predetermined level of said environmental attribute, and,

in which said application server, or said control station, establishes and records in said communicatively connected memory a drift relationship, which describes with respect to time the change of said environmental attribute when drifting from said set point toward said ambient level or toward said farthest level relative to said set point,

in which said application server determines with respect to time a setback point of said environmental attribute in accordance with said established drive relationship and drift relationship, by calculating a time of arrival of said mobile device at said monitored space on the basis of said geographic location or said proximity log, wherein said geographic location is sent to said application server from said mobile device, or is calculated on the basis of said proximity log sent to said application server from said mobile device, in which said setback point is determined by said application server, or said control station, such that a setback recovery time period representing a length of time that said environmental attribute takes to be driven from said setback point to said set point by said control station, through controlling said environmental attribute means in accordance with said established drive relationship, is equal to or less than a lead time period between the present time and said calculated time of arrival of said mobile device at said monitored space,

in which said control station allows said environmental attribute to drift toward said setback point, and drives said environmental attribute so it reaches said set point at said calculated time of arrival, and,

in which said application server assigns said lead time period for said mobile device to arrive at said monitored space as one preconfigured value when said geographic location is within a geofence area comprising said monitored space within thereof, and assigns said lead time period for said mobile device to arrive at said monitored space as another preconfigured valuewhen said geographic location is outside of said geofence area.

2. The system of claim 1, in which said geographic location is sent tosaid application server from said mobile device for determination of said lead time period.

3. The system of claim 1, wherein said proximity log sent to said application server from said mobile device, comprises said lead time period.

4. The system of claim 1, in which said application server is adapted to alter said geofence area in accordance with preconditioning factors pertinent to selected traffic conditions, time, as well as, characteristics of user pertaining to said mobile device or said mobile device.

5. The system of any one of claims 1 to 4, in which said monitored space is a guest

room in a hotel, a house, or an office unit in a commercial building.

6. The system of any one of claims 1 to 5, in which said environmental attribute is indoor temperature, and in which said environmental attribute means comprises a temperature sensor, and at least one of a heating unit, an air conditioning unit and a ventilating unit.

7. The system of any one of claims 1 to 5, in which said environmental attribute is humidity, and in which said environmental attribute means comprises a humidity sensor, and at least one of a humidifier and a dehumidifier.

8. The system of any one of claims 1 to 7, further comprises an occupancy attribute means adapted to indicate whether said monitored space is occupied, and wherein said control station allows said environmental attribute to drift toward said setback point when said occupancy attribute means indicates said monitored space is unoccupied.

9. The system of any one of claims 1 to 5, in which said application server sends a signal to a communicatively connected door lock, pertaining to switching between a locked state and an unlocked state, or determines in accordance with said proximity log whether said mobile device is within a close proximity threshold of said monitored space.

10. The system of any one of claims 1 to 5, in which said environmental attribute is a heated water reserve quantity at a temperature in a storage tank, and in which said environmental attribute means comprises a sensor for measuring said heated water reserve quantity in said storage tank and a replenishment unit, wherein said established drive relationship and drift relationship describe with respect to time replenishment and consumption, respectively, of said heated water reserve quantity in the storage tank.

11. The system of any one of claims 1 to 5, in which said environmental attribute is a

temperature of heated water reserve in a storage tank, and in which said environmental attribute means comprises a sensor for measuring said temperature and a water heating unit.

12. The system of any one of claims 1 to 11, in which said network comprises an indoor and outdoor tracking system used by said mobile device to determine with respect to time said geographic location, in which said application server is a network connected server, including at least one of a device with computing capability and said network connection, and a cloud-based server with internet connection.

13. A method of controlling an environmental attribute of a monitored space in accordance with a geographic location or a proximity log pertaining to said geographic location of a mobile device in relation to said monitoredspace, comprising:

monitoring a level of said environmental attribute and driving said environmental attribute, and,

sending a detected level of said environmental attribute,

receiving said geographic location or said proximity log,

establishing and recording a drive relationship, which describes with respect to time the change of said environmental attribute for being driven to a set point from an ambient level or from a farthest level relative to said set point, and which represents a predetermined level of said environmental attribute, and,

establishing and recording a drift relationship, which describes with respect to time the change of said environmental attribute when drifting from said set point toward said ambient level or toward said farthest level relative to said set point,

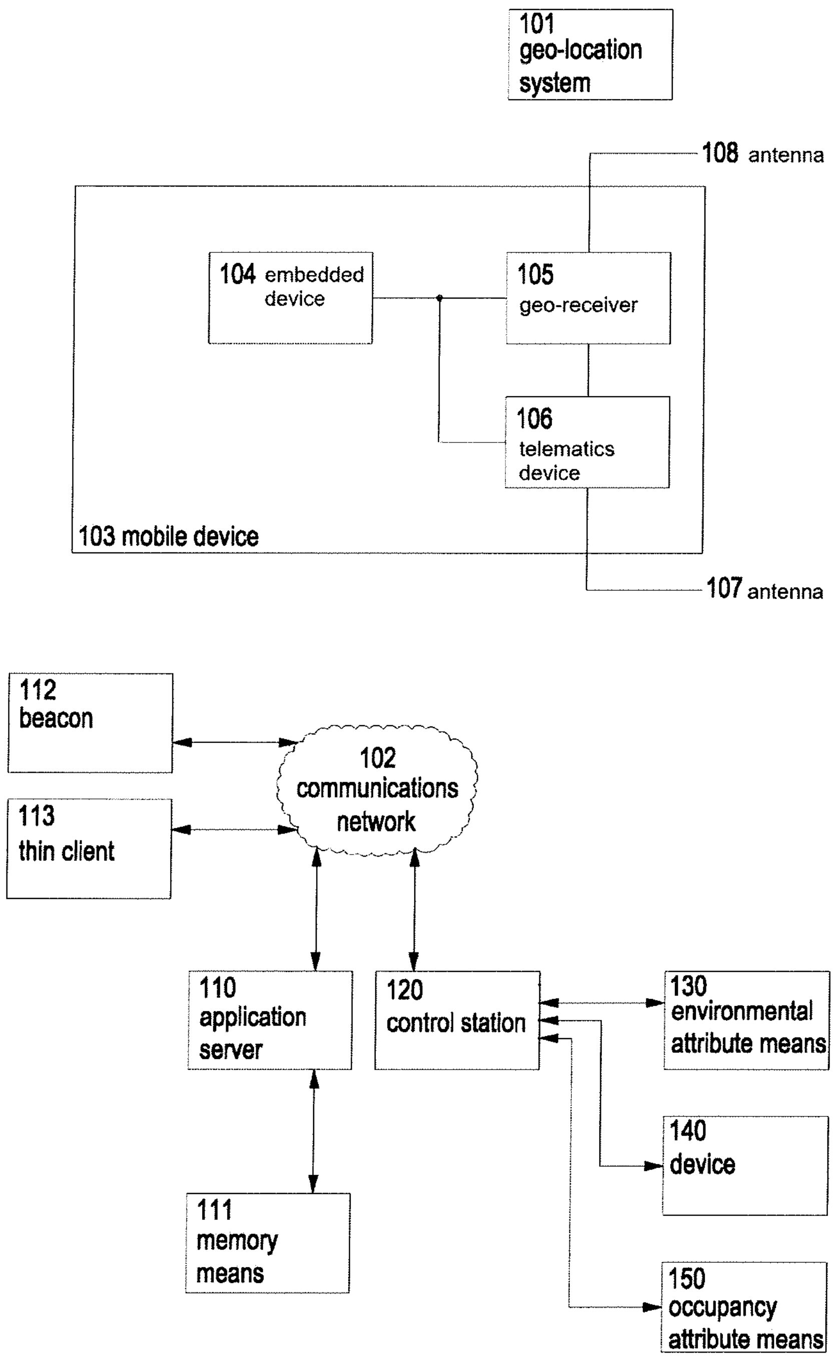
determining with respect to time a setback point of said environmental attribute in accordance with said established drive relationship and drift relationship, by calculating a time of arrival of said mobile device at said monitored space on the basis of said geographic location or said proximity log, wherein said setback point is determined such that a setback recovery time period representing a length of time that said environmental attribute takes to be driven from said setback point to said set point in accordance with said established drive relationship is equal to or less than a lead time period between the present time and said calculated time of arrival of said mobile device at said monitored space,

allowing said environmental attribute to drift toward said setback point, and driving said environmental attribute so it reaches said set point at said calculated time of arrival, and,

assigning said lead time period for said mobile device to arrive at said monitored space as one preconfigured value when said geographic location is within a geofence area comprising said monitored space within thereof, and assigning said lead time period for said mobile device to arrive at said monitored space as another preconfigured value when said present geographic location is outside of said geofence area.

FIG. 1

100



101
geo-location
system
108 antenna
104 embedded
device
105
geo-receiver
106
telematics
device
103 mobile device
107 antenna
112
beacon
102
communications
network
113
thin client
110
application
server
120
control station
130
environmental
attribute means
140
device
111
memory
means
150
occupancy
attribute means

FIG. 2A

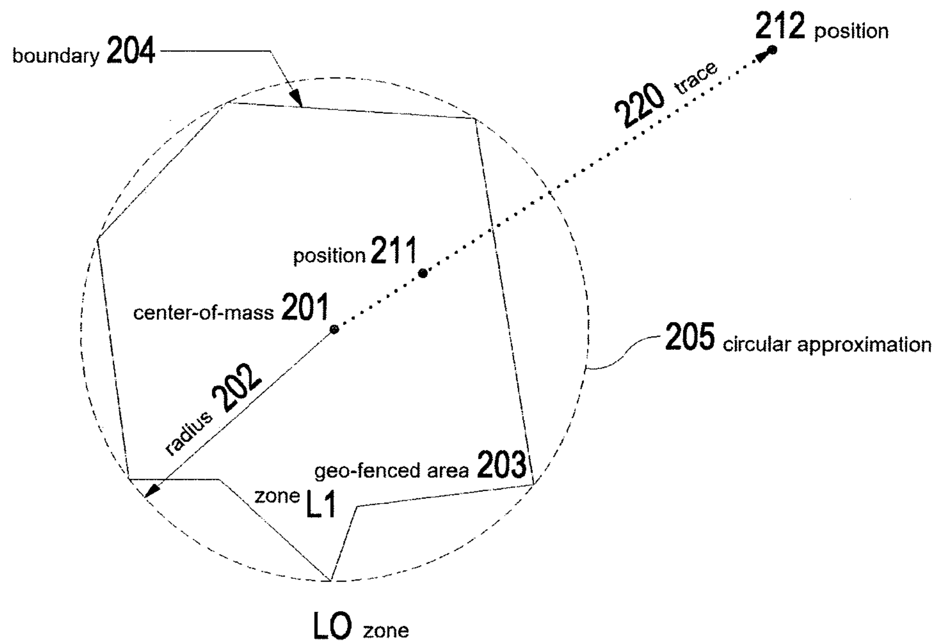
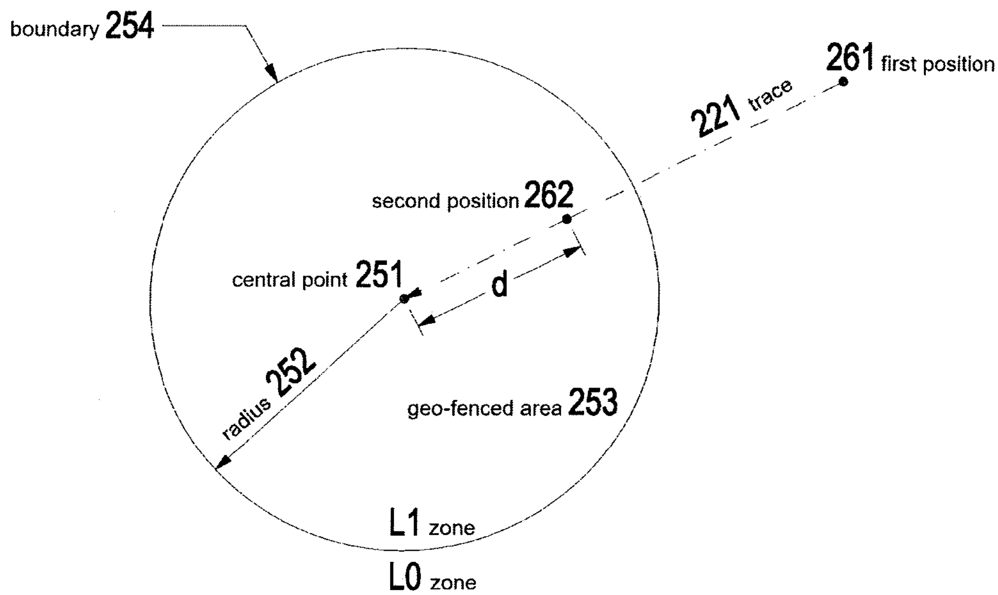


FIG. 2B



Date Reçue/Date Received 2020-04-23

FIG. 3

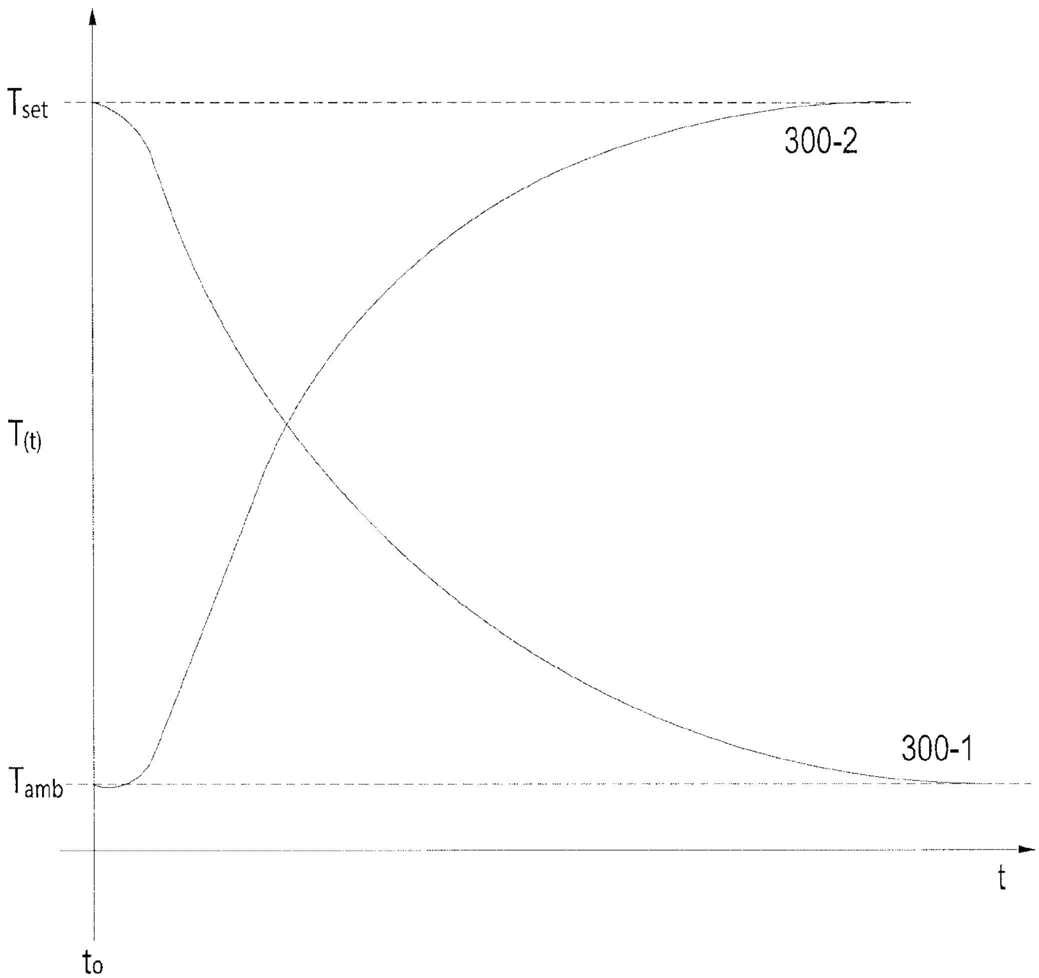
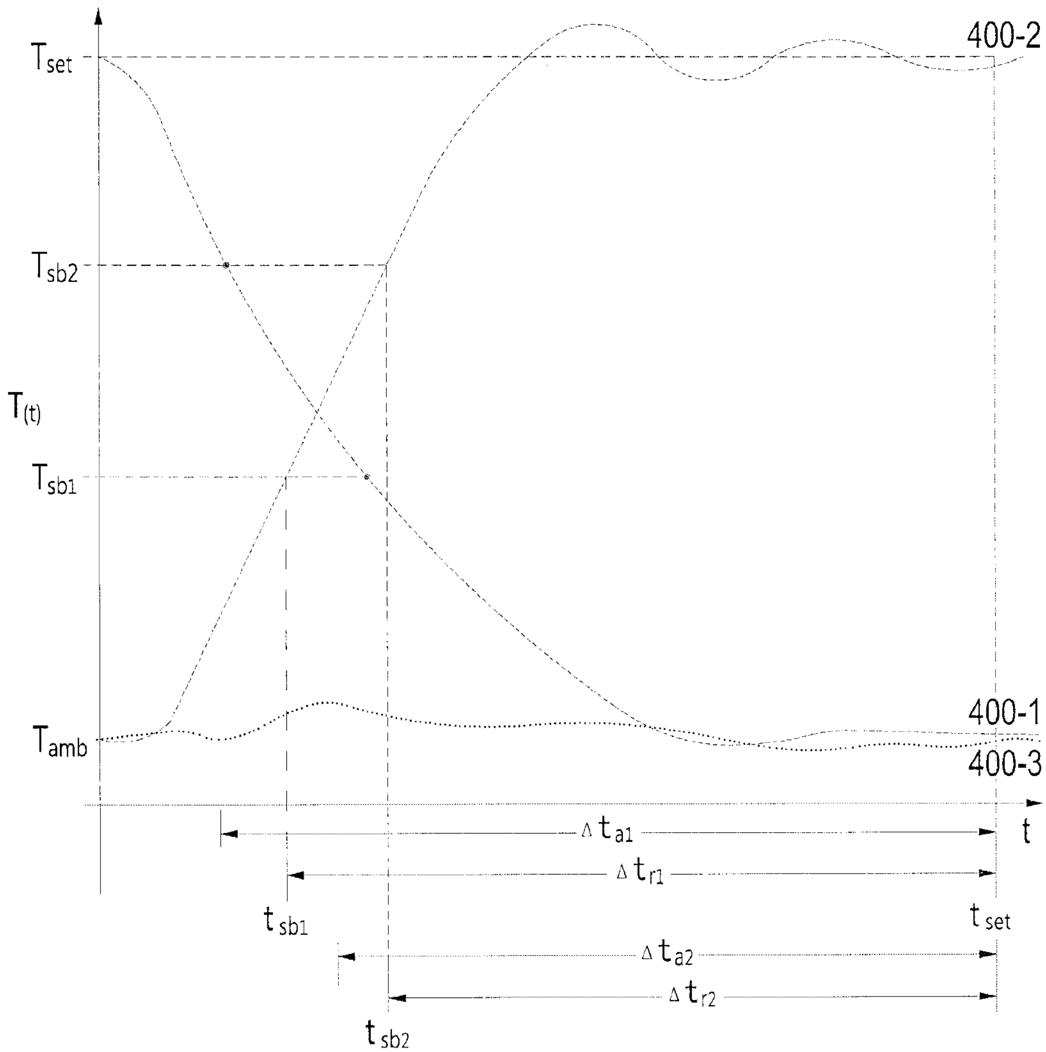


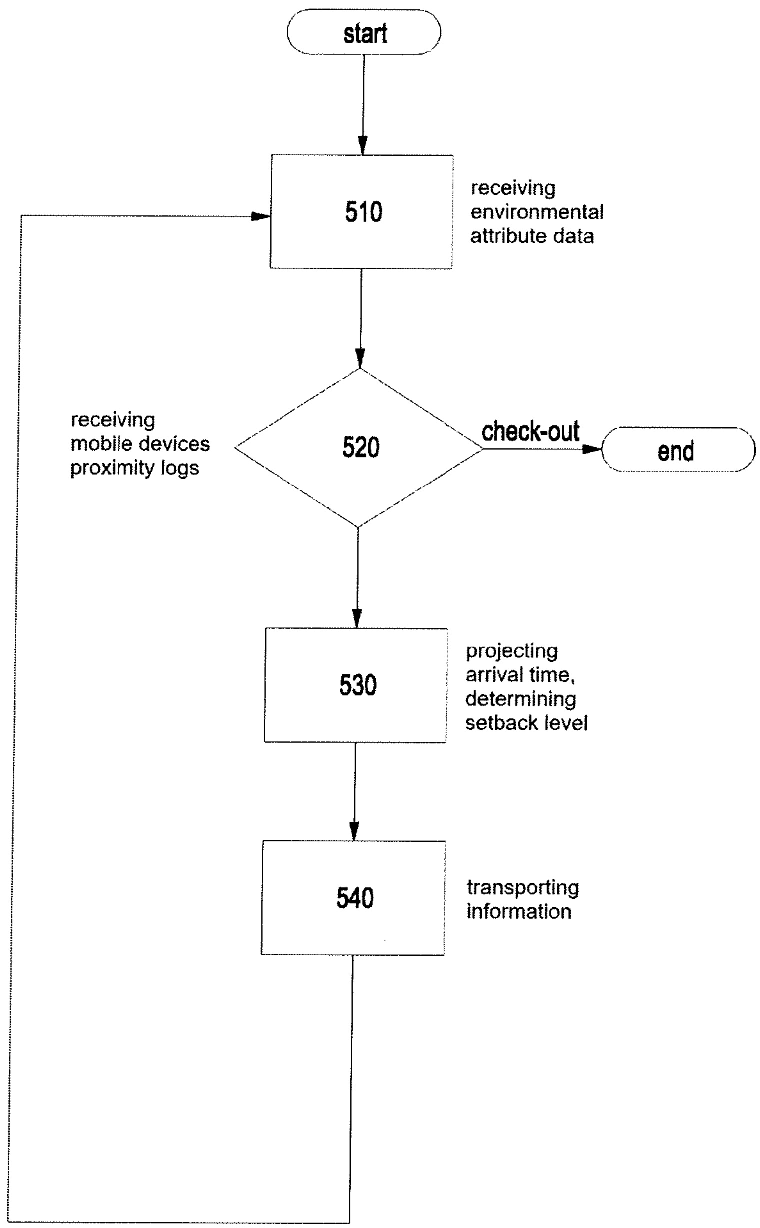
FIG. 4



400-2
Tset
Tsb2
T(t)
Tsb1
400-1
Tamb
400-3
Δ ta1
t
Δ tr1
tsb1
tset
Δ ta2
Δ tr2
tsb2

FIG. 5

500



Date Reçue/Date Received 2020-04-23

FIG. 6A

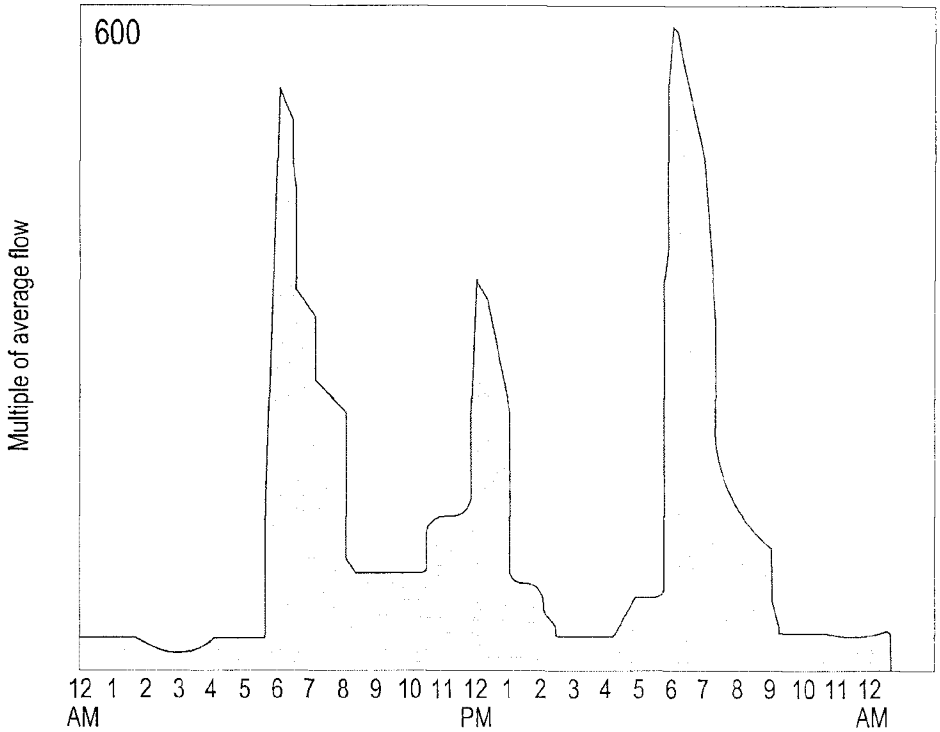

600
Multiple of average flow
12 1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12
AM
PM
AM

FIG. 6B

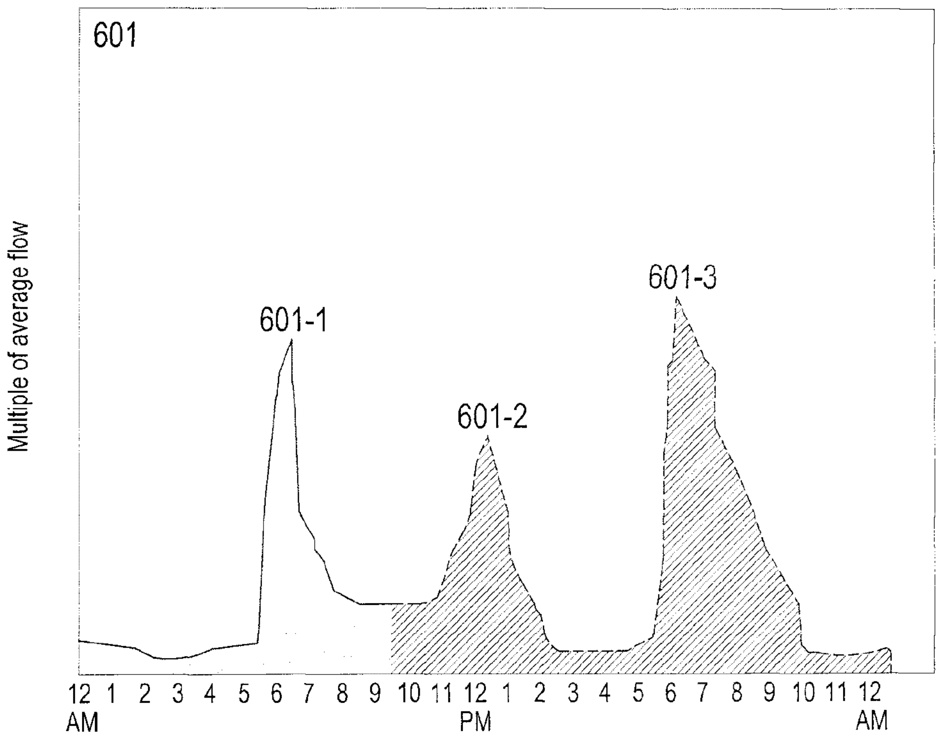

601
601-1
601-2
601-3
Multiple of average flow
12 1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12
AM
PM
AM

FIG. 7A

700

701

09:30 a.m.

LEVEL 5	501 ● tenant in room	502 Δta = 20 min	503 Δta = 20 min	504 ● tenant in room	505 ✓ room cleaned
LEVEL 4	401 Δta = 20 min	402 Δta = 20 min	403 Δta = 20 min +	404 Δta = 20 min +	405 Δta = 20 min +
LEVEL 3	301 ✓ room cleaned	302 ✓ room cleaned	303 Δta = 20 min	304 ● tenant in room	305 not rented
LEVEL 2	201 ● tenant in room	202 not rented	203 not rented	204 Δta = 20 min	205 not rented
LEVEL 1	101 not rented	102 not rented	103 not rented	104 Δta = 20 min	105 ✓ room cleaned

702

not rented

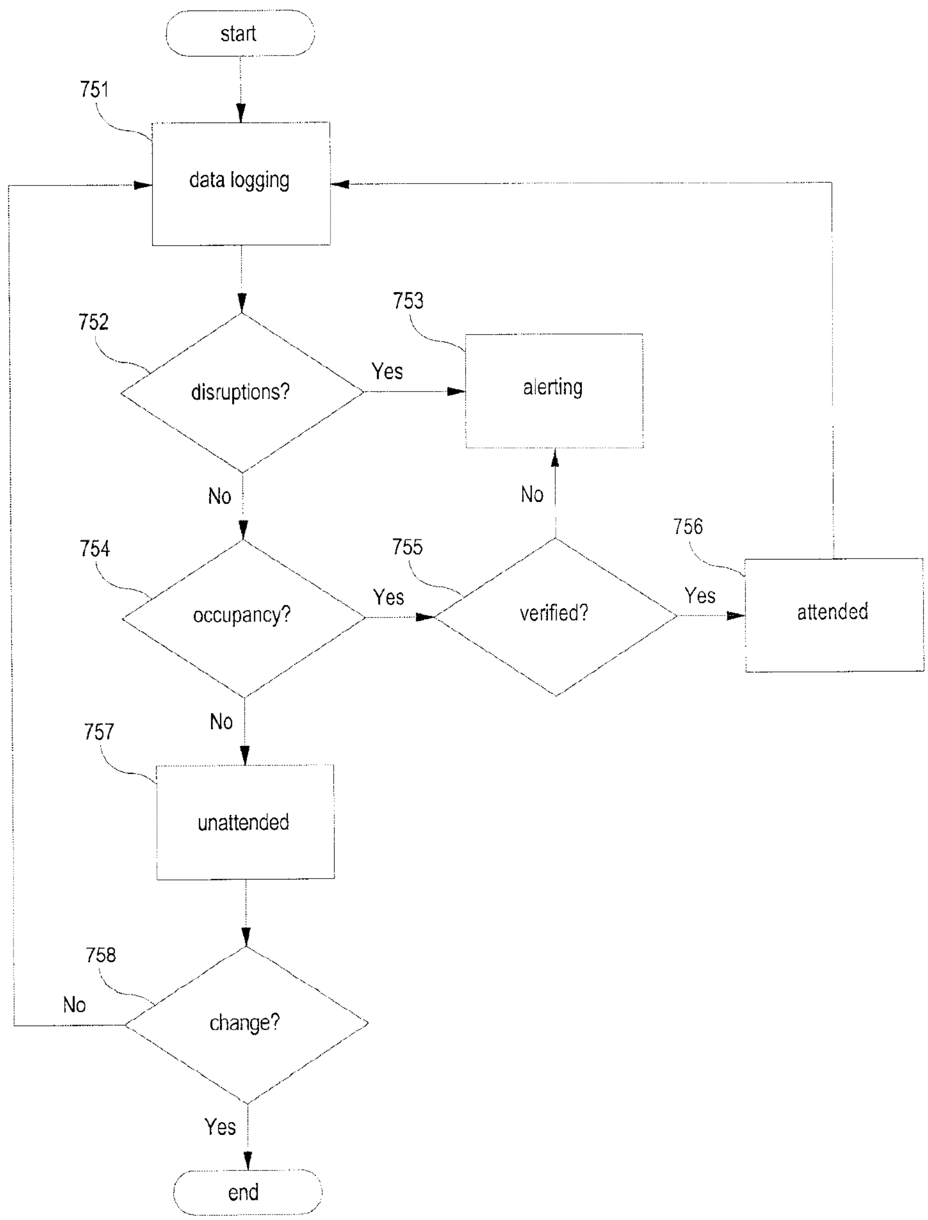
Δta = 20 min + (tenant outside 20 minutes geo-fence)

Δta = 20 min (tenant within 20 minutes from hotel)

✓ room cleaned

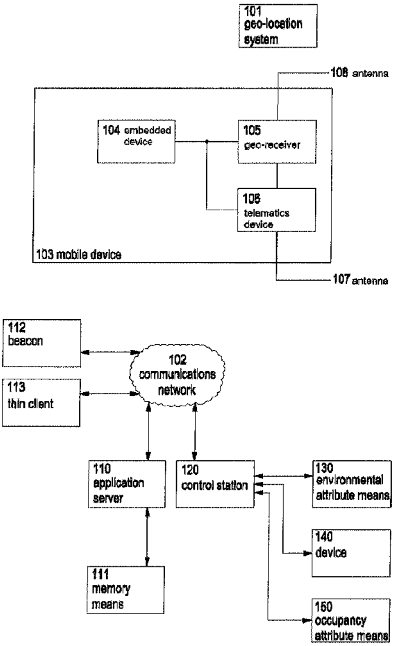
● tenant in room

FIG. 7B
750



start
751
data logging
752
disruptions?
Yes
753
alerting
No
No
754
occupancy?
Yes
755
verified?
Yes
756
attended
No
757
unattended
758
No
change?
Yes
end

100



101
geo-location
system
108 antenna
104 embedded
device
105
geo-receiver
106
telematics
device
103 mobile device
107 antenna
112
beacon
113
thin client
102
communications
network
110
application
server
120
control station
130
environmental
attribute means
140
device
111
memory
means
150
occupancy
attribute means