

INDOOR POSITIONING SYSTEM

The present application relates to an indoor positioning system for identifying position of a mobile device. The indoor positioning system includes both devices and methods
5 for locating the mobile device.

Systems that can locate, track, record, monitor and analyse geographical positions or locations of mobile devices often utilize satellite signals, inertial and non-inertial sensors to track these mobile devices.

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However, a system of satellite and receiver tracking is normally useful for outdoor tracking applications and limitations exist when applying the system of satellite and receiver tracking to indoor navigation.

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In indoor environment and in close proximity of buildings, a line of sight of satellites may be substantially obscured and satellite to receiver signals may be highly attenuated or blocked. As a result, satellite to receiver signals are much weaker in indoor environments than outdoors. With the weakened signals, the system of satellite to receiver tracking has difficulty in receiving satellite signals and calculating accurate
20 positions of a receiver by analysing the deteriorated signals.

An alternative of inertial tracking system use readings from sensors such as gyroscopes and accelerometers to estimate relative paths of objects. However, the inertial tracking systems may accumulate large errors over time due to factors such as drift in sensor
25 offsets, sensitivity, and measurement limitations of the sensors, as well as limitations of the location determining methods (e.g., algorithms) implemented by such systems. Additionally, size and cost requirements on tracking objects may necessitate the use of less expensive and robust inertial sensors, potentially increasing drift in the alternative of inertial tracking system. While some man-made objects such as cars and robots use
30 known motion models to aid in their tracking, an apparent lack of a comprehensive model that captures and describes complexity of human locomotion can further add to inertial errors while tracking personnel.

Signal analysis methods that use signals of the same or different frequencies from

different reference points to compute a geographical location of an object may be unfeasible due to a need to install reference devices at particular tracking locations, and may further have large instantaneous errors, and outliers, due to multi-path effects of signals travelling through various building materials.

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A further alternative system of using magnetic field sensors and compasses may provide an accurate detection of a heading angle in the absence of magnetic interference. However, data acquired from these devices may often be inaccurate in buildings due to interference from the building structure, electric lines, and other local magnetic sources. As such, valid compass angles, though available at some building locations, often cannot be depended on at each point in time over a data collection time interval.

Hence, known systems have different drawbacks in providing reliable and accurate position information of an object (e.g. a mobile device), especially if used indoors.

The present application aims to provide one or more new and useful indoor positioning system for tracking and locating positions of a mobile device. The indoor positioning system includes one or more devices for identifying positions of the mobile device. The application also intends to present one or more new and useful methods of using, configuring, maintaining, upgrading and servicing the indoor positioning system for tracking and locating the position of the mobile device. Essential features of the application are provided by one or more independent claims, whilst advantageous features of the application are presented by their dependent claims respectively.

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An indoor positioning system comprises one or more an acoustic transmitters projecting an isotropic, omnidirectional encoded modulated signal and a receiver having a demodulator with a software application that computes a location with respect to the position of the acoustic transmitter based on the projected encoded modulated signal. The projected encoded modulated signal contains information relating to an indoor environment which is acquired by the receiver providing a display for the indication of the location of the receiver on a diagrammatic representation of the indoor environment.

The current application can be used in the indoor or outdoor environment for tracking

of children, tracking of inventory and locating a booth in a convention or an exhibition. In the three listed examples, the acoustic transmitters are to be strategically located to achieve a wide coverage of transmitting modulated signals. The user holding the handheld receiver with a built-in microphone receiving the signals have an installed software application that demodulates, decodes and interprets the signals with reference to a lookup table. The computed result of the software application indicates the location of the receiver on the tactile display of the receiver. The computed result primarily the location of the receiver is also transmitted to a remote computer via a wireless network for tracking and storing the last known location of the receiver. The user herein are the children in a department store, a worker in a warehouse, a visitor to the exhibition. The software application is also known as the software programme which is residing in the receiver.

The accompanying figures (Figs.) illustrate embodiments and serve to explain principles of the disclosed embodiments. It is to be understood, however, that these figures are presented for purposes of illustration only, and not for defining limits of relevant inventions.

Fig. 1 illustrates a tracking grid having a plurality of triangles tessellated with no overlaps whereby at least three acoustic transmitters are located at the three vertices of a triangle;

Fig. 2 illustrates an indoor positioning system in which a receiver is held by a human user standing in the three spheres of coverage by the three acoustic transmitters;

Fig. 3 illustrates an indoor positioning system comprising the acoustic transmitter modulating a baseband signal and the receiver demodulating the transmitted signal;

Fig. 4 illustrates a diagrammatic representation of the BPSK output wave along with its given input;

Fig. 5 illustrates a block diagram of the BPSK modulation at the acoustic transmitter;

Fig. 6 illustrates a block diagram of the BPSK demodulation at the receiver;

Fig. 7 illustrates a first embodiment of the indoor positioning system of a process flow of a software application residing in the receiver with no feedback to a

local tracking server;

Fig. 8 illustrates a second embodiment of the indoor positioning system of a process flow of a software application residing in the receiver with feedback to a local tracking server;

5 Fig. 9 illustrates a third embodiment of the indoor positioning system of a process flow of a software application residing in the receiver with feedback to a local tracking server and communicating with an application server;

Fig. 10 illustrates a fourth embodiment of the indoor positioning system of a process flow of a local tracking server managing a plurality of acoustic transmitters.

10 Fig. 11 illustrates a fifth embodiment of the indoor positioning system of a process flow of a local applications server communicating collaborating with the receiver;

Fig. 12 illustrates a sixth embodiment of the indoor positioning system of a process flow of a local applications server with the local tracking server and the receiver.

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Exemplary, non-limiting embodiments of the present application will now be described with references to the above-mentioned figures.

20 Figs. 1 and 2 show a tracking grid 100 using the acoustic transmitters 102 tessellated in triangle.

In particular, Fig. 1 illustrates a tracking grid 100 having a plurality of triangles tessellated with no overlaps whereby at least three acoustic transmitters 102 are located at the three vertices of a triangle.

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The three straight sides of the triangle are of different lengths. The length of each side of the triangle is approximately five metres, 5m.

30 In a first triangle 108, the three acoustic transmitters 102 with carrier frequencies 104 f_1 , f_2 and f_3 are positioned on each of the three vertices. A one side of the first triangle 108 having the acoustic transmitters 102 with carrier frequencies 104 f_1 and f_2 tessellates with a one side of a second triangle 110 using the same acoustics

transmitters 102. The remaining vertex of the second triangle 110 has an acoustic transmitter with a different transmitting carrier frequency 104 of f_3 .

The function of the acoustic transmitter 102 transmits a carrier frequency 104 (f_1 or f_2 or f_3) with a modulating signal (not shown) riding on the carrier frequency 104. The frequency of the carrier signal ranges from 20Hz to 20,000Hz. The modulating signal contains information comprising a building identity code, a storey identity code and an electronic identity of the acoustic transmitter 102.

The arrangement of the acoustic transmitters 102 in a triangle shape provides a means for a receiver 110 to compute its location as shown in Fig. 2 by trilateration or the process of determining the absolute or relative locations of points by measurement of distances, using the geometry of circles, spheres or triangles. The distances between the acoustic transmitters 102 are known and useful in the location tracking.

The receiver 110 has a software application that determines and processes only each of three acoustic frequencies from transmitters 102 of immediate or nearest proximity. In other words, the software application eliminates acoustic signals of duplicated frequencies, and does not process acoustic signals further than the nearest transmitter when determining the exact location of the receiver 110.

Fig. 2 illustrates an indoor positioning system in which a receiver 110 is in the three spheres representing the coverage of the modulated signals by the three acoustic transmitters 102. The three spheres are indicated by three different broken lines intersecting one another. The spheres are isotropic and omnidirectional providing a point of reference for the receiver 110 to compute its location.

The three acoustic transmitters 102 are positioned in a triangle formation. The distances between the three acoustic transmitters 102 are known as they are positioned on a ceiling or at a plane higher than the receiver 110.

The receiver 110 comprises a built-in microphone (not shown) to receive at least one modulated signal, an on-board processor for processing the acquired modulated signal, an algorithm that extracts the information from the modulated signal and computes the

location of the receiver 110 and a tactile display for inputting of information and for displaying of the location of the receiver 110.

5 A human user holding a receiver 110 being in the spherical coverage of the acoustic transmitters 102 received at least three modulated signals from the three acoustic transmitters 102.

10 The receiver 110 having the built-in microphone acquires the three modulated signals. An algorithm in the receiver 110 demodulates the modulated signals to retrieve the three information comprising the building identity codes, the storey identity codes and the electronic identities of the acoustic transmitters.

15 The building identity codes and the storey identity codes are identical from the three acoustic transmitters since the user is standing under the ceiling assuming the building code is "123456" and the storey identity code is "01". The algorithm in the receiver 110 will search for a lookup table containing the corresponding representation of the codes as well as a relevant floor plan.

20 To find the exact location of the receiver 110, the algorithm uses the electronic identity codes of the three transmitters 102 and lookup a table for the corresponding distances between the acoustic transmitters 102. The sequence of receipt of the transmitted signals over a period of time indicates the length of time the transmitted signals takes to reach the receiver 110.

25 Assuming the speed of the transmitted signal in dry air at 20°C at sea level is a constant at 343^m/s or three hundred forty-three metres per second. The distance between one acoustic transmitter 102 to the receiver 110 can then be calculated by the product of the speed of the transmitted signal and the time taken from the one acoustic transmitter 102 to the receiver 110. The shortest distance between the acoustic transmitter 102 and the receiver 110 will indicate an approximate location from that acoustic transmitter
30 102. For more accurate location tracking, more than one acoustic transmitter is required.

Fig. 2 shows the receiver 110 being in the three spheres of the acoustic transmitters 102 having carrier frequencies 104 f_1 , f_2 and f_3 .

The intersections of the surfaces of three spheres is found by formulating the equations for the three sphere surfaces and then solving the three equations for the three unknowns, x , y , and z . To simplify the calculations, the equations are formulated so that the centres of the spheres are on the $z = 0$ plane. Also, the formulation is such that one centre is at the origin $P1(0,0)$, and one other is on the x -axis $P2(d,0)$.

Starting with the equations of the three spheres where the radii of the three spheres are r_1 , r_2 and r_3 . x , y and z are the coordinates in a three dimensional Cartesian coordinate system. $P1$, $P2$ and $P3$ are the centres of the three spheres with coordinates $(0,0)$, $(d,0)$ and (i,j) respectively.

$$r_1^2 = x^2 + y^2 + z^2$$

$$r_2^2 = (x - d)^2 + y^2 + z^2$$

$$r_3^2 = (x - i)^2 + (y - j)^2 + z^2$$

Using radii r_1 , r_2 to eliminate y and z from the equation to solve for x , yields

$$x = \frac{r_1^2 - r_2^2 + d^2}{2d}$$

The first two spheres having the transmitting frequency of f_1 and f_2 intersect in more than one point which implies

$$d - r_1 < r_2 < d + r_1$$

Substituting

$$x = \frac{r_1^2 - r_2^2 + d^2}{2d}$$

into

$$r_1^2 = x^2 + y^2 + z^2 \quad (\text{formula for the first sphere})$$

$$y^2 + z^2 = r_1^2 - x^2$$

$$y^2 + z^2 = r_1^2 - \frac{(r_1^2 - r_2^2 + d^2)^2}{4d^2}$$

Substituting

$$z^2 = r_1^2 - x^2 - y^2 \quad (\text{formula for the first sphere})$$

into the formula for the third sphere, $r_3^2 = (x - i)^2 + (y - j)^2 + z^2$ results

$$y = \frac{r_1^2 - r_3^2 + i^2 + j^2}{2j} - \frac{i}{j}x$$

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the x and y coordinates of the solution point are found, the formula for the first sphere to find the z-coordinate is

$$z = \pm \sqrt{r_1^2 - x^2 - y^2}$$

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The last part can be visualized as taking the circle found from intersecting the first and second sphere and intersecting that with the third sphere.

15 If that circle falls entirely outside or inside of the sphere, z is equal to the square root of a negative number: no real solution exists. If that circle touches the sphere on exactly one point, z is equal to zero. If that circle touches the surface of the sphere at two points, then z is equal to plus or minus the square root of a positive number.

20 The computed result will then be displayed on the display of the receiver 110 indicating a building name, a storey number on the floor plan relating to the building. For example, the display on the receiver 110 will display the building name as "You are now at ABC Complex on storey 1 at unit number #01--01".

25 Fig. 3 illustrates an indoor positioning system comprising the acoustic transmitter 102 modulating a baseband signal using binary phase shift keying (BPSK) and the receiver 110 demodulating the transmitted signal. It is to be noted that the BPSK modulation and Varicode are used as an example to illustrate the current application and is not limiting. Other types of modulation typically BPSK31 and BPSK63 and encoding techniques are conceivable as well. Varicode is a Huffman code for use in PSK31

30 supporting all ASCII characters. BPSK31 has a symbol rate of 31.25 baud operating in a bandwidth of 62.5Hz whilst BPSK63 has a symbol rate of 62.5 baud operating in a bigger bandwidth of 125Hz.

The acoustic transmitter 102 comprises a balance modulator 114 which has a carrier sine wave 116 as a first input, a carrier wave generator 118 which generates the carrier sine wave 116, a binary data sequence 120 as a second input and a phase shifted wave 122 as an output connected to a transmitting speaker 112.

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The modulation of BPSK or binary phase shift keying is done using a balance modulator 114, which multiplies the two signals 116,120 applied at the input. For a zero binary input, the phase will be 0° and for a high input, the phase reversal is 180° .

10 The binary data sequence 120 represents the information that is to be packed onto the carrier sine wave 116.

The receiver 110 has BPSK demodulator comprises a mixer 124 with a local oscillator 126 circuit, a bandpass filter 128 and a two-input detector 130 circuit. Demodulation
15 comprises two stages, a first stage is the demodulation stage 132 and a second stage is the recovery stage 134.

The receiver 110 makes use of a built-in microphone 136 to receive the BPSK signal 138. The band-limited message signal is then recovered using the mixer 124 circuit in
20 conjunction with the carrier signal and then pass to the band pass filter 128. The first stage of demodulation 132 gets completed. The baseband signal 140 which is band limited is obtained and this signal is used to regenerate the binary message bit stream 120.

25 In the next stage of demodulation or the recovery stage 134, the bit clock rate 142 is needed at the detector 130 circuit to produce the original binary message signal 120. The bit rate 142 is a sub-multiple of the carrier frequency 104.

The recovered base band signal is processed by the receiver 110's on-board computer
30 providing a visual display of the location of the receiver 110 on the floor plan 144.

Fig. 4 illustrates a diagrammatic representation of the BPSK 138 output wave along with its given input binary data sequence 120 plotted in voltage with respect to time. The phase change of 180° is evident in transitioning from a binary "0" to a binary "1" or

from a binary “1” to a binary “0” where the peak to peak sine wave is -1 Volt to 1 Volt. The binary data sequence 120 binary “1” is represented by 1 Volt, 1V and binary “0” is represented 0 Volt, 0V. The output sine wave 122 of the modulator will be the direct input carrier 116 or the inverted (180° phase shifted) input carrier 116, which is a function of the data signal 120.

Fig. 5 illustrates a block diagram of the BPSK modulation at the acoustic transmitter 102.

- 10 The acoustic transmitter 102 provides an electronic transmitter identity code 146, a storey identity code 148 and a building identity code 150 to an encoder 152. The encoder 152 uses PSK31 Varicode for use on phase shift keying (PSK) modulation as it demands less power and no need for huge antenna erection. After the encoding, the output binary data sequence 120 is termed as the baseband signal, $x_m(t)$ 140. The baseband signal 140 is then sent to the balance modulator 114 and mixed 124 with the carrier sine wave, $x_c(t)$ 116 producing a modulated output signal, $y(t) = x_m(t) + x_c(t)$ 138. The modulated output signal 138 is then sent to the transmitter speaker 112 to be broadcasted.
- 20 For example, the building identity code 150 is a six-digit decimal number “123456” represented by Varicode in a stream of binary input data sequence 120 to the modulator 114:

	1011011011 ₂	1 ₁₀
25	1011101101 ₂	2 ₁₀
	1101110111 ₂	3 ₁₀
	1011101011 ₂	4 ₁₀
	1101011111 ₂	5 ₁₀
	1011101111 ₂	6 ₁₀

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The binary data input sequence 120 to the encoder 152 is the concatenation of the above streaming bits.

Fig. 6 illustrates a block diagram of the BPSK demodulation at the receiver 110.

The modulated signal, $y(t)$ 138 is mixed with the carrier frequency 104 and the output is fed into a bandpass filter 128. The filtered signal is then fed into a detector 130 with a bit clock 142. From the detector 130 to a decoder 154 using Varicode to retrieve the electronic transmitter identity code 146, the storey identity code 148 and the building identity code 150.

The receiver 110 receives the analogue modulated signal, $y(t)$ 138 through the built-in microphone. The receiver 110 having the on-board software application goes through a list of known carrier frequencies to match the carrier frequency 104 of the modulated signal in order to obtain the baseband signal 140. The receiver 110 has a built-in demodulator circuit and is able to generate the carrier frequency 104 and the bit clock 142.

Fig. 7 illustrates another embodiment of the indoor positioning system process flow of a software application residing in the receiver 110 with no feedback to a local tracking server.

The other embodiment of an indoor positioning system comprising an acoustic transmitter 102 sending an encoded signal to a receiver 110 whereby the receiver has a software application having a floor plan of an indoor environment with the locations of the acoustic transmitters 102.

The receiver 110 in proximity with an acoustic transmitter 102 receives the encoded signal through a microphone or a signal receiving means. The software application comprising the steps of demodulating the encoded signal, decoding the signal, identifies the acoustic transmitter from the decoded signal and performs a search of the location of the acoustic transmitter 102 in its software application and then indicating the location of the acoustic transmitter 102 on the floorplan providing an approximate location of the receiver 110 visually on the display screen of the receiver 110.

At an indoor environment, the human user hand carries the receiver 110 with the power on 200. In the next step 202, the human user has to ascertain whether a software application is installed in the receiver. Assuming there is a software application installed

in the receiver, the human user starts the on-board software application 206 to activate the built-in microphone 208. However, if the software application is not available on the receiver 110, the user has to download the software application 204 either from the local area network or the telco network.

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The software application detects and identifies the relevant signals 210 transmitted from the acoustic transmitters 102 inside the indoor environment. The relevant signals are processed 212. The processing involves demodulation and decoding so as to obtain the information 214 specifically the building identity code 150, the storey identity code 148 and the electronic transmitter identity code 146. The building identity code 150 indicates the name of the building, the storey identity code 148 indicates the level in the building and the electronic transmitter identity code 146 indicates the unique identity number of the acoustic transmitter. Based on the obtained information, the software application is able to retrieve the relevant floorplan of the building. The software application filters and selects 214 the relevant acoustic transmitters 102 in proximity and then indicate the exact location on the floorplan 218 which is displayed on the display of the receiver 110. The software application will reiterate the process until the software application is terminated by the human user.

Fig. 8 illustrates a second embodiment of the indoor positioning system of a process flow of a software application residing in the receiver 110 with a feedback to a local tracking server. The process of acquiring the acoustic transmitters 102 is similar. Additionally, the location of the receiver 110 and the acoustic transmitter identity code is updated in the local tracking server through the wireless network. The software application will reiterate the process until the software application is terminated by the human user.

Fig. 9 illustrates a third embodiment of the indoor positioning system of a process flow of a software application residing in the receiver 110 with feedback to a local tracking server and communicating with an application server. In addition to the update of the receiver 110 location, information from the application server is sent 222 through the wireless network to the receiver 110. The information can be advertisements or events that is taking place or about to take place in the future at that location. The location of

the receiver 110 is determined by the locations of the acoustic transmitters 102 through trilateration.

Fig. 10 illustrates a fourth embodiment of the indoor positioning system of a process flow of a local tracking server managing a plurality of acoustic transmitters 102.

A plurality of acoustic transmitters 102 is connected to the local tracking server providing known locations and identity codes of the connected acoustic transmitters 102. The connection may be a hard wired connection or a wireless connection. Wireless connection may employ a router attached to each acoustic transmitter 102 or some other wireless technology like Bluetooth or Infrared.

The local tracking server upon initiation 300 will have a list of location of the acoustic transmitters in the indoor environment 302 loaded into its memory bank. Relocation or new installation of the acoustic transmitters 102 will be automatically added into the local tracking server when the acoustic transmitters 102 are connected to the local tracking server directly or via the wireless network.

The local tracking server further provides a plurality of carrier frequencies and modified encoded signals to one or a group of acoustic transmitters at any one time. In other words, different carrier frequencies can be assigned to the different acoustic transmitters 304 and customized encoded signal can be accorded to the same set of acoustic transmitters 306 thus a remote site can control a broad network of acoustic transmitters 102.

The receiver 110 with its network capability enabled establishes a connection to a wireless network that is remotely connected to the local tracking server. The local tracking server checks the validity and authenticity 308 of the request from the receiver 110 to prevent fraudulent access.

The local tracking server then performs an eligibility check 310 of the receiver 110 when communicating with the receiver 110. The check establishes the software compatibility includes communication protocol and software application version.

After authenticating 308 and eligibility 310 check, the local tracking server will check the presence of the software application 202 installed in the receiver 110. If it was not installed, the local tracking device will prompt the user to download the software application 204. The downloading can be either over the telco network through a download application of the receiver 110 or a dedicated download site provided by a local server over the local area network.

After installation, the initiated software application provides a floorplan 312 of the indoor environment which includes the locations of the acoustic transmitters 102 and the corresponding identity codes 146, the storey identity code 148 and the building identity code 150. These information is then uploaded to the local tracking server via the wireless network where the information is verified.

The software application will then go through the same process similar to the earlier embodiments 1 to 3. The receiver regularly sends information to the local tracking server 314. Information includes but not limiting to the transmitter identity code 146, the storey identity code 148 and the building identity code 150. The frequency of update is ideally short as the human user is highly mobile.

At the local tracking server, the server checks the information received from the acoustic transmitters 102. In particular, checking the building identity code 316, checking the storey identity code 318 and checking the transmitter identity code 320. If the building identity code 150 were not irretrievable, a message will be sent to the receiver 110 informing the user. For example, the message will read "The building name is not found." 322. If the storey identity code 148 were not irretrievable, another message will be sent to the receiver 110 that reads "A floorplan for this storey is not found." 324. If the transmitter identity code 146 were not irretrievable, a different message will be sent to the receiver 110 that reads "Your location cannot be determined." 326.

If any or all of the three identity code were missing or unable to be obtained, the remote local tracking server automatically reloads the floor plan 312 with the acoustic transmitters location and identity code as well the building identity code on the receiver

110. The reloading will update a part of the software application with the building identity code 150, the storey identity code 148 and the transmitter identity code 146.

5 If the extraction of the three information were successful, the receiver will regularly update the local tracking server on its location and the process reiterates as long as the receiver 110 with the software application is initiated and the receiver 110 is in the vicinity of the indoor environment.

10 Fig. 11 illustrates a fifth embodiment of the indoor positioning system of a process flow of a local applications server collaborating with the receiver 110.

15 Upon initiation 400 of the local applications server, it is loaded with the name of the building, floor plans for the multiple storeys of the building and the location and identity code of the acoustic transmitters in the building 402. In other words, the applications server is loaded with a directory of the building's occupants. The building herein is also known as the indoor environment. The local applications server establishes a wireless connection with the receiver 110.

20 The local applications server via the wireless local area network sends a message to the user seeking permission 404 to push information to the receiver 110. If the response 406 were a "OK", the receiver 110 installed with the software application informs the local applications server of its location via the wireless network. Conversely, if the response is negative, communication between the applications server and the receiver 110 will cease.

25 The location information as discussed earlier remains relevant in this embodiment. The local applications server acquires the three information from the receiver 410 specifically the building, acoustic transmitter and the storey identity codes to facilitate the pushing of relevant information to the receiver 110. The applications server also
30 acquires information about the time spent at a specific location, the path taken from a point to the other point. The information collected provides a basis for the study of user behaviour and habits.

The services of the occupants in the building is provided in the applications server 412. Upon the user's approval for pushing of information 416 to the receiver 110, the services of the occupants stored in the applications server are sent to the receiver 110. The information sent to the receiver is based on the location of the receiver.

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Further user information collection 414 specifically name, age, gender and other details are filled in a form manually on the tactile display of the receiver 110 provided by the software application installed in the receiver 110 during the software application installation phase. The user information is then uploaded onto the local applications server and/or the local tracking server via the wireless network concurrently.

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Fig. 12 illustrates a sixth embodiment of the indoor positioning system of a process flow of a local applications server communicating with the local tracking server and the receiver 110. The local applications server and the local tracking server collaborates with the receiver 110 to provide seamless information transfer to the receiver 110

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The location of the receiver 110 is retrieved from the local tracking server 418. The applications server having a database of the occupants and their services are sent to the receiver 110 via the wireless local area network when inside in the coverage of the acoustic transmitters 102 be it indoor or outdoor environment. The location of the receiver 110 provides a reference for the applications server to push relevant information targeted to that particular location.

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In use, the indoor positioning system provides a passive tracking and an interactive tracking mode.

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In the passive tracking mode, the receiver with the built-in microphone acquires the transmitted modulated signals from a plurality of acoustic transmitters. The software application in the receiver computes its location based on the acquired signals that is propagated in the air by the acoustic transmitters. The acoustic transmitters are passive devices that continually emits a modulated signal from the transmitting speakers which are inaudible to the human ears. The receiver locates itself and displays its location on the floor plan on the display of the receiver. There is no communication feedback to the acoustic transmitters from the receiver.

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In the interactive tracking mode, the receiver operates similar to the receiver in the passive tracking mode. Additionally, the receiver sends its location to another computer via the wireless network (GSM, LTE, WiFi). The computer in return sends information relating to the locality around the receiver also through the same wireless network. As the user with the receiver moves around the coverage of the acoustic transmitters, the receiver will be constantly updated with the information send from the computer.

Access to the applications server and the local tracking server are restricted to authorized personnel. Authorized personnel are granted access to maintain the system comprises adding, deleting and editing information specifically adding or changing occupants' information, adding or changing users' information. In the interactive tracking mode, the authorized personnel in addition to the latter services provided are capable to set the carrier frequencies and set the encoded messages to the acoustic transmitters individually or to many.

In the application, unless specified otherwise, the terms "comprising", "comprise", and grammatical variants thereof, intended to represent "open" or "inclusive" language such that they include recited elements but also permit inclusion of additional, non-explicitly recited elements.

As used herein, the term "about", in the context of concentrations of components of the formulations, typically means +/- 5% of the stated value, more typically +/- 4% of the stated value, more typically +/- 3% of the stated value, more typically, +/- 2% of the stated value, even more typically +/- 1% of the stated value, and even more typically +/- 0.5% of the stated value.

Throughout this disclosure, certain embodiments may be disclosed in a range format. The description in range format is merely for convenience and brevity and should not be construed as an inflexible limitation on the scope of the disclosed ranges. Accordingly, the description of a range should be considered to have specifically disclosed all the possible sub-ranges as well as individual numerical values within that range. For example, description of a range such as from 1 to 6 should be considered to have specifically disclosed sub-ranges such as from 1 to 3, from 1 to 4, from 1 to 5,

from 2 to 4, from 2 to 6, from 3 to 6 etc., as well as individual numbers within that range, for example, 1, 2, 3, 4, 5, and 6. This applies regardless of the breadth of the range.

- It will be apparent that various other modifications and adaptations of the application
- 5 will be apparent to the person skilled in the art after reading the foregoing disclosure without departing from the spirit and scope of the application and it is intended that all such modifications and adaptations come within the scope of the appended claims.

Reference Numerals

	100	tracking grid
	102	acoustic transmitter
5	104	carrier frequency
	106	first triangle
	108	second triangle
	110	receiver
	112	transmitting speaker
10	114	balance modulator
	116	carrier sine wave
	118	carrier wave generator
	120	binary data sequence
	122	phase shifted wave
15	124	mixer
	126	local oscillator
	128	bandpass filter
	130	two-input detector
	132	demodulation stage
20	134	recovery stage
	136	microphone
	138	BPSK signal / modulated output signal
	140	baseband signal
	142	bit clock rate
25	144	floor plan
	146	transmitter identity code
	148	storey identity code
	150	building identity code
	152	encoder
30	154	decoder
	200	switching on the receiver
	202	checking presence of software application
	204	downloading software application
	206	starting the software application

	208	activating the microphone
	210	detecting acoustic signal
	212	processing the acoustic signal
	214	obtaining information from the acoustic signal
5	216	filtering and selecting of acoustic transmitters
	218	marking the location on the floorplan
	220	updating local server of receiver location
	222	updating receiver with relevant information
	300	initiating the local tracking server
10	302	loading the list of location of acoustic transmitters
	304	controlling carrier frequencies
	306	controlling encoded signals
	308	checking validity and authenticity of request
	310	checking eligibility of the receiver
15	312	providing a floorplan of location of acoustic transmitters
	314	sending information the local tracking server
	316	checking for building identity code
	318	checking for storey identity code
	320	checking for transmitter identity code
20	322	"The building name is not found."
	324	"A floorplan for this storey is not found."
	326	"Your location cannot be determined."
	400	initiating the applications server
	402	loading building name, floor plans and identity codes of acoustic
25		transmitters
	404	seeking user's permission
	406	checking user's response
	408	end of communication with applications server
	410	acquiring information from the receiver
30	412	storing of occupants' information
	414	storing of users' information
	416	pushing of occupants' information to the receiver
	418	acquiring information from the local tracking server

Claims

1. An indoor positioning system for identifying position of a receiver comprising:
 - at least one acoustic transmitter for transmitting an acoustic signal carrying location information of the acoustic transmitter; and
 - an acoustic receiver for receiving the acoustic signal and determining a location of the acoustic signal receiver according to the acoustic signal.
2. The indoor positioning system of claim 1, wherein the at least one acoustic transmitter and acoustic receiver are integrated as a transceiver for transmitting and receiving acoustic signals on location information of the transceiver.
3. The indoor positioning system of claim 1 or 2, wherein the at least one acoustic transmitter comprises an encoder (e.g. modulator) for encoding the location information.
4. The indoor positioning system of any of the preceding claims, wherein the acoustic receiver comprises
 - a microphone (i.e. acoustic or audio signal transducer, audio signal receiver) for acquiring the acoustic signal;
 - a decoder (e.g. demodulator) for extracting the location information; and
 - an output (e.g. display screen) for notifying a user of the acoustic receiver on the location information.
5. The indoor tracking system of any of the preceding claims, wherein the at least one acoustic transmitter is configured to transmit isotropic or omnidirectional acoustic signals.
6. The indoor tracking system of any of the preceding claims, wherein the at least one acoustic transmitter comprises multiple pieces of acoustic transmitters that are separated apart from each other.

- 5 7. The indoor tracking system of claim 6, wherein
the at least one acoustic transmitter comprises a first acoustic transmitter, a
second acoustic transmitter and a third acoustic transmitter that are distributed
apart from each other for broadcasting acoustic signals of disparate frequencies
respectively.
- 10 8. The indoor tracking system of claim 6 or 7, wherein
the multiple pieces of acoustic transmitters are grouped together in forming a
predetermined geometric pattern for tessellating an indoor area.
9. The indoor tracking system of any of the preceding claims, wherein
the acoustic transmitter is configured to transmit at least one baseband acoustic
signal of predetermined frequency.
- 15 10. The indoor tracking system of any of the preceding claims 6 to 8, wherein
a distance between two immediately neighbouring acoustic transmitters is less
than five metres.
- 20 11. The indoor tracking system of any of the preceding claims, wherein
the acoustic transmitter is operable to consume electric power of substantially
less than five Watts for projecting the acoustic signal at a predetermined
frequency.
- 25 12. The indoor tracking system of any of the preceding claims, wherein
the encoder, the decoder or both are configured to operate with acoustic signals
inaudible to human generally.
- 30 13. The indoor tracking system of any of the preceding claims, wherein
the encoder, the decoder or both are configured to operate with acoustic signals
having frequencies from 20 Hertz to 20,000 Hertz.

14. The indoor tracking system of any of the preceding claims, wherein the transmitter is configured to provide the acoustic signal having transmitter identification information, storey identification information, building identification information, or a combination of any of these information.

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15. A method for encoding a baseband acoustic signal comprising:

- encoding an electronic identity code (e.g. acoustic transmitter identity code using Varicode);
- encoding a storey identity code (using Varicode);
- encoding a building identity code (using Varicode code);
- mixing a carrier frequency with the baseband signal for generating a modulated acoustic signal; and
- transmitting the modulated acoustic signal via a speaker.

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- 15 16. A method for decoding an encoded acoustic signal by an acoustic signal receiver comprising:

- Receiving an encoded acoustic signal;
- filtering the baseband signal using a bandpass filter to eliminate unwanted noises,
- detecting a phase change using a phase detector with an input of a bit clock for restoring the baseband signal,
- decoding the baseband signal to retrieve the electronic identity code (acoustic transmitter identity code) using Varicode,
- decoding the baseband signal to retrieve the storey identity code using Varicode and
- decoding the baseband signal to retrieve the building identity code using Varicode.

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17. An indoor positioning system for tracking at least a receiver comprising
- at least one acoustic transmitter for transmitting acoustic signal carrying identification information of the acoustic transmitter and environment detail of the at least one transmitter;
 - an acoustic signal receiver for receiving and interpreting the acoustic signal to determine location of the acoustic signal receiver; and
 - a computer connected to the at least one acoustic signal transmitter for operating the at least one acoustic transmitter.
18. The indoor positioning system of claim 17, wherein the computer comprises a computing server that is connected to the at least one acoustic signal transmitter by cables, radio wave or internet.
19. The indoor positioning system of claim 17 or 18, wherein the computer is operable to regulate a carrier frequency or encode the identification information.
20. The indoor positioning system of any of the preceding claims 17 to 19, wherein the at least one acoustic signal transmitter or computer is configured to receive information using wireless technologies through the local area network like GSM, LTE, WiFi, Bluetooth, or Infrared and updating the memory device.
21. An indoor positioning device comprising:
- at least one acoustic signal transmitter for generating acoustic signal to an ambient environment; and
 - an operator computer operable with the at least one acoustic signal transmitter for encoding the acoustic signals.

22. The indoor position device of claim 21, wherein
the at least one acoustic signal transmitter comprises a first acoustic signal
transmitter, a second acoustic signal transmitter and a third acoustic signal
5 transmitter that are spaced apart at predetermined distances between each
other for covering a geographical area.
23. An indoor positioning application device comprising:
an application computer operable with the operator computer of claim 21;
10 wherein the application computer is configured to provide broadcast
geographical information to the at least one acoustic signal transmitter, the
operator computer, a acoustic signal receiver of the at least one acoustic signal
transmitter or a combination of any of these.
- 15 24. An indoor position tool comprising:
- an acoustic receiver for receiving an acoustic signal carrying with
geographical location information;
 - a microprocessor connected to the acoustic signal receiver for processing
the acoustic signal and extracting the geographical location information;
20 and
 - an output terminal further connected to the microprocessor for displaying
the geographical location information.
25. The indoor positioning tool of claim further comprising
25 an acoustic signal transmitter for broadcasting an acoustic signal having
information of geographical location of the indoor position tool.