Abstract: A system network for monitoring an action or state of a subject comprising a server capable of receiving information from a bridge transceiver and processing the information; a bridge transceiver capable of receiving information from a sensor and transferring information to the server; a detector sensor in communication with the bridge transceiver, a sensor, associated with a subject, in communication with the bridge transceiver; wherein the bridge transceiver receives information from the sensors and passes information to the server to monitor an action or state of the subject.
HEALTH MONITORING AND EVALUATION SYSTEM

Technical Field

The present inventions related to systems and methods to monitor the an action or state of a subject, particularly a health state, using various sensors associated with a network.

Background

There is a huge economic and social demand to address the upcoming healthcare needs of the elderly and the chronically ill in the 21st century. An aging population is one common challenge faced by many developed countries. While on one hand a prolonged average life-span certainly reflects on the improved quality of living, on the other hand it presents a lot of economical and social problems never faced before. In Australia, 13% of the population is aged 65 years and over in year 2002 and it is expected that, by the year 2051, this number will increase to 26%. This is considerably lower than figures already current for many European countries. Reports have also shown that within this group of the population, 93% have at least one chronic disease in 2004 and this age group consumes 28.3% of the government expenditure on providing health services. Apart from this economical implication, a large proportion of this age group lives in private dwellings. Whether this reflects on the severely insufficient places in aged-care facilities or is purely a matter of choice, better support for the healthcare need of the elderly living alone should become a major social consideration in the 21st century.

In recent years, technological advances in the areas of sensor instrumentation, short and medium range wireless communication platforms together with the ever increasing computational power in silicon IC running at a significantly reduced power consumption rate have made health telecare a reality. In general, health telecare refers to the mode of healthcare delivery in which certain types of traditional healthcare services previously carried out face-to-face with a healthcare staff can now be delivered remotely to the recipients’ homes using information technology and telecommunications infrastructure.

The present inventors have now developed a low-cost, low-power health telecare system that encompasses the abilities to unobtrusively collect multiple types of data from both static and mobile sensors pervasively deployed with timing accuracy, transfer such
data over either a homogeneous or hybrid wireless network to a server, and perform data fusion to extract vital information about the health status of the person being monitored.

Summary of Invention

In a first aspect, the present invention provides a system network for monitoring an action or state of a subject comprising:

(a) a server capable of receiving information from a bridge transceiver and processing the information;
(b) a bridge transceiver capable of receiving information from a sensor and transferring information to the server;
(c) a detector sensor in communication with the bridge transceiver,
(d) a sensor, associated with a subject, in communication with the bridge transceiver;

wherein the bridge transceiver receives information from the sensors and passes information to the server to monitor an action or state of the subject.

The system may further include a mobile sensor associated with an object in communication with the bridge transceiver.

The server may receive information from the bridge transceiver through hard wiring or via radio frequency transmission. Preferably, information is passed by radio frequency transmission. One example of which is a wireless local area network (LAN).

Preferably, the network comprises a plurality of detector sensors placed in a space to monitor different inputs including actions or states of a subject.

The sensors can be a motion sensor, pressure sensor, weight sensor, ambient temperature or ambient humidity detector, thermometer, or sensors worn on the body that monitor a range of physiological variables including, but not limited to, body and limb movement, energy expenditure, cardiac performance such as ECG, body temperature, pulse oximetry, blood pressure. Humidity or moisture sensors can also be incorporated to detect wetness, for example arising from incontinence.

The sensors can also be associated (worn) with a staff member to identify their function (i.e. nurse, nurse's aide, etc) or can be attached to a piece of equipment including, but not limited to, a medications trolley, meal tray or a weighing system.

The detector sensors can be placed in one room or suite occupied by one subject to monitor that subject in its environment via the bridge transceiver and server. In this
regard, the network can be adapted to monitor a room of the home of a subject. The detector sensors can be placed in several rooms or suites occupied by one subject to monitor that subject in its environment via the bridge transceiver and server. In this regard, the network can be adapted to monitor the home or living environment of a subject. Alternatively, the detector sensors may be positioned in a plurality of spaces occupied by a number of subjects and the server receives and processes information on a plurality of subjects from a plurality of bridge transceivers. In this form, the network can be placed in a nursing home, hostel or hospital to assist in the care of the residents.

The mobile sensor can measure and transmit actions or states of a subject or object selected from, but not limited to, identity, position, activity, movement, rate of movement, health state such as blood pressure, body temperature, ECG, pulse, oximetry.

The network is also capable of monitoring the actions or states of a plurality of subjects by each having a mobile sensor capable of identifying the subject. For example, the mobile sensors may differentiate between a patient, health worker such as physician, nurse or nurse's aid. In this regard, it is possible to record the frequency and time of visits by various health workers to monitor the degree of assistance a patient may require during a stay in a hospital or nursing home.

It is also envisaged to provide mobile sensors to apparatus that may be used in the care of a subject. Examples include, but not limited to, medication cart, meal cart, wheel chair, measurements trolley. It will be appreciated that any object that can be used in the care of or in association with a person could be monitored or located by the network.

The detector sensors can transmit all received data or may process data and only send required information to the bridge transceiver and/or the server.

Preferably, the subject is a resident of a healthcare or aged care facility and the health state of the resident is monitored by the network.

In a second aspect, the present invention provides a system for monitoring a state of a subject comprising:

- a bridge transceiver capable of receiving information from a plurality of sensors and transmitting the information;
- a plurality of sensors capable of transmitting information to the bridge transceiver; and
a data processing apparatus comprising a central processing unit (CPU), a
memory operably connected to the CPU, the memory containing a program adapted to
be executed by the CPU, wherein the CPU and memory are operably adapted to receive
information from the bridge transceiver and record or monitor information on the state of
a subject.

In a third aspect, the present invention provides a data processing apparatus for
monitoring a state of a subject comprising:

a CPU;

a memory operably connected to the CPU, the memory containing a program
adapted to be executed by the CPU, wherein the CPU and memory are operably
adapted to receive information from a plurality of bridge transceivers and monitor a state
of a subject.

Preferably, the CPU and memory are operably adapted to receive information
from a plurality of bridge transceivers and monitor the state of one or more subjects.

Preferably, the data processing apparatus further stores the information received
from the bridge transceiver.

In a fourth aspect, the present invention provides a computer readable memory,
encoded with data representing a programmable device, comprising:

means for receiving information from a bridge transceiver;

means for processing the information from the bridge transceiver; and

means to record the processed information to monitor or record a state of a
subject.

In a fifth aspect, the present invention provides a computer program element
comprising a computer program code to make a programmable device:

receive information from a bridge transceiver on a state of a subject;

analyze the received information; and

record the information to monitor a state of the subject.

In a sixth aspect, the present invention provides a bridge transceiver capable of
receiving information from a plurality of sensors capable of sensing a state or action of a
subject, processing the information and transmitting the information to a server to record
and monitor the state of a subject.
In a seventh aspect, the present invention provides a method for monitoring a state of a subject comprising:

providing a mobile sensor to a subject;
sensing information on the subject from a plurality of sensors in communication with a bridge transceiver; and
transmitting the information from the bridge transceiver to a server where the information is processed and the state of the subject is monitored.

Preferably, the state is selected from location (physical location and proximity to various objects and other subjects), mobility and activity, resting, eating, sleeping, socialising, receiving care, medications and treatments, toileting, and health state,

Preferably, the health state relates to medication needs, transferring needs, toileting needs/personal hygiene, mobility needs/falls/bed-ridden, need for meals/eating/drinking, behavioral/wandering, need for supervision/complex and special care, clinical care needs, and emotional, social, psychological health and wellness.

Throughout this specification, unless the context requires otherwise, the word "comprise", or variations such as "comprises" or "comprising", will be understood to imply the inclusion of a stated element, integer or step, or group of elements, integers or steps, but not the exclusion of any other element, integer or step, or group of elements, integers or steps.

Any discussion of documents, acts, materials, devices, articles or the like which has been included in the present specification is solely for the purpose of providing a context for the present invention. It is not to be taken as an admission that any or all of these matters form part of the prior art base or were common general knowledge in the field relevant to the present invention as it existed in Australia before the priority date of each claim of this specification.

In order that the present invention may be more clearly understood, preferred embodiments will be described with reference to the following drawings and examples.
Brief Description of the Drawings

Figure 1 shows a schematic of a network adapted to monitor one subject.

Figure 2 shows a schematic of a network adapted to monitor several subjects.

Figure 3 shows a high level block diagram of the network hardware adapted to monitor multiple subjects.

Mode(s) for Carrying Out the Invention

METHOD

Sensors

Examples of suitable sensors include the following:

Mobile sensor forms network bridge - detecting ID tag proximities supplied to subject, staff and equipment

PIR (passive infrared sensor) - infrared sensors measures activity levels in a room or area

Pressure sensors - bed, couch, seats

Triaxial accelerometer - gait, falls, activity

Ambient - conditions: temp, light (located together with the PIR)

The combined sensor network is able to constantly infer the extent and type of subject, such as a resident of a care facility, capabilities and activities, and also external resources required to fully meet these needs. A change in subject's health status can also be ascertained to specifically provide timely medical attention to the subject. Any medical intervention is optional for the purposes of the system according to the present invention and is a secondary consideration. A change in subject abilities or function due to increasing health problems however is important for the facility to be able to record and respond with appropriate allocation of resources and application for funding. Using the same sensor network to double up as a security system for ensuring resident safety from external threats is also a secondary consideration.

One strength of the system according to the present invention lies in being able to measure a nursing home's resource requirements by monitoring a number of key activities automatically over a continuous period of time. More conventional resource estimation measures currently used in nursing homes rely on extrapolating from known properties of resident behavior, function and health status. These are more indirect and
less objective measures that remain static even though the underlying behaviors may fluctuate over time, and rely on regularly updating resident records that impose a significant burden on the facility. A challenge met by the system according to the present invention is to accurately classify and characterise the majority of activities and resident functions that are taking place within the nursing home environment for the combination of sensor data that are constantly being received and recorded.

System Implementation

The major features of the system according to the present invention are its scalability, pervasiveness, unobtrusiveness and readiness to integrate with various existing building configurations.

The system can be broken down functionally into four different layers. These include data collection; data conditioning (by sensors units equipped with intelligence); data transfer (via hard wire or radio frequency (RF) communication link in a homogeneous or hybrid configuration either directly to the server or by way of a bridge transceiver); and data management (by end server).

From the hardware perspective the system consists of a few standalone devices, each spanning across one or more functional layers as described above. In one embodiment, the sensor units, for instance, were designed to take advantage of a dual-microcontroller architecture. A generic motherboard provides access to an 802.15.4-based, ZigBee ready RF module controlled by an ultra low power, 16-bit microcontroller. Connection pins are provided on the motherboard to allow various daughter boards to be "piggybacked" to form different sensor units. Each daughter board consists of a specific type of sensor controlled by another microcontroller. The whole unit is supplied by a single Lithium-polymer rechargeable battery permanently connected to the motherboard under the control of a charging and protective circuit.

The robustness of this sensor unit design provides many advantages. This includes better system scalability since a different sensing unit can be produced by simply designing a different daughter board with the particular sensing element. The system cost can also be reduced since various types of off-the-shelf sensors can be deployed by ensuring the correct interface is provided on the daughter board to access the RF section on the motherboard. The unit is also more efficient in power usage since the RF section (including the microcontroller) can be put to sleep mode if not transmitting or receiving and likewise for the sensing part. This counts heavily towards the system
obtrusiveness as a whole since having a long-lasting system will imply less disturbances to the user in terms of battery recharging. If desired, the motherboard can even be used as a standalone device to provide identification information.

Apart from acting as static sensors collecting ambient data such as movement within a room, weight generated by a person lying in bed, or even simple parameters such as light intensity, temperature and humidity, the sensor units are expandable to become mobile to provide vital information about the health status of a person. ECG, heart rate, body temperature, blood pressure and oxygen content data can all be collected by specifically-built daughter boards (or multiple sensors can also be integrated into a single daughter board). The whole sensor unit is designed to fit within a clip-worn box of dimensions 55(W) x 70(H) x 17(D) mm, making it ideal for uninterrupted and pervasive data collection.

A daughter board, namely the Triax device, has been built to collect acceleration data in three axes and also integrate an alarm button and a voice circuit for emergency assistance. Details on the Triax device can be found in International publication WO 2005/016143 entitled "A monitoring apparatus for an ambulatory subject and a method for monitoring the same" (MedCare Systems Pty Ltd, Australia). The device has been developed previously for an ambulatory subject that includes a portable monitor mountable on subject that includes an accelerometer that determines the instant acceleration of subject in one or more determined directions. The device further includes a processing unit that determines at least one instant ambulatory performance indicia of subject from the determined instant acceleration, determines at least one designated performance threshold from at least one previously determined instant ambulatory performance indicia and initiates an event under predetermined conditions that is communicated to remote receiver for the attention of carer, providing remote monitoring and supervision of subject based on ambulatory performance of subject.

Optionally, data conditioning circuitry can be included on each daughter board to perform specific functions such as input scaling and filtering before the data signal is fed into the microcontroller via an on-chip, 16-channel A/D converter and stored in the built-in RAM. The microcontroller then transfers the digitized data to the microcontroller on the motherboard for transmission via an SPI interface. An extra 512 kB flash RAM chip can be available on the daughter board to buffer data should the communication link between the microcontrollers become temporarily unavailable or the data collection rate exceed the data transfer/transmission rate. Each sampled data is time-stamped at the
point of sampling to ensure that the signal can be correctly reconstructed in the end regardless of when the signal is being transmitted.

The software that resides in the microcontroller on the daughter board provides intelligence to decide if all data collected should be transferred to the motherboard. For example, the Triax device collects data of 2 bytes in length at a sampling rate of 45 Hz. To transfer all this data continuously would consume a great deal of bandwidth and power. Eventually this can potentially block other sensor units from transmitting their data via the RF link. Therefore the microcontroller has been programmed with enough intelligence to execute the option of analyzing the data and deciding on an appropriate posture classification or energy level for that set of data. This will then generate a status summary for the data collected that can be transferred to the motherboard for transmission.

The data transfer layer takes care of data exchange between the sensor units and the end server via the bridge transceiver. The sensor units and the end server can utilize the same motherboard design with different software to perform different network roles. Depending on application and building configuration, a homogeneous or a hybrid network topology can be deployed. In the case of monitoring an aged individual living alone the simple star network such as the one in Figure 1 can be used which sees the end server also acting as the 802.15.4 PAN (Personal Area Network) coordinator while the sensor units are the PAN nodes. Up to 65536 logical nodes can be supported within the same 802.15.4 PAN. The typical range of the 802.15.4 standard (100 meters indoor and over 200 meters outdoor line-of-sight with the inverted-F PCB antenna have been tested) would be able to provide coverage for all areas within a house so that one coordinator is sufficient.

In Figure 1, the system network 10 for a room 20 includes a mobile sensor 11 on a subject 12. Various detector sensors 13 in the room 20 are in communication with a bridge transceiver 14 via radio transmission 17 and relay information to a server 15 via radio transmission 18 to monitor the subject in the room 20.

To cover an area larger than the typical range of a 802.15.4 network, as in the case of an aged-care facility, a hybrid network can be deployed. A hybrid network takes the form of multiple 802.15.4 PANs integrating with an 802.11 WLAN. Each room 20 maintains an individual 802.15.4 star-typed network but the coordinator is connected to another piece of specifically-designed hardware which transforms 802.15.4 signals to 802.11 signals. Such a coordinator is called a bridge transceiver 14. An example of such a network topology for multiple areas is shown in Figure 2.
In Figure 2, the system network 10 includes mobile sensors 11a, 11b, 11c, 11d on four subjects 12a, 12b, 12c, 12d. Various detector sensors 13a, 13b, 13c, 13d are in communication via radio transmission 17 with a bridge transceiver 14a, 14b, 14c, 14d in each room 20a, 20b, 20c, 20d and relay information to the bridge transceivers 14a, 14b, 14c, 14d which is relayed via radio transmission 18 to a server 15 to monitor the subjects 12a, 12b, 12c, 12d in rooms 20a, 20b, 20c, 20d. Four subjects 12a, 12b, 12c, 12d in four different rooms 20a, 20b, 20c, 20d are depicted in Figure 2 as an example to explain the system. It will be appreciated that the system network according to the present invention can be expanded to many different subjects in a large number of possible areas.

All bridge transceivers 14 are in turn, network nodes of the larger network coordinated by the end server 15. As such, the data transfer layer is designed to maximize flexibility and scalability and can be readily integrated into any existing building structures since no wires or cables are involved.

Finally, the end server 15 performs all the functions of managing the data received including data fusion, data reconstruction, data storage, feature extraction and alert generation, just to name a few. The server 15 also has direct control over when sensors 13 should start and stop collecting data and when bridges should send accumulated sensor data to the server. The server 15 is also capable of ensuring each individual sensor 13 is time-synchronized with the server to guarantee the accuracy of each time-stamp applied on each sampled data.

Figure 3 provides a hardware design view on the network suitable for monitoring multiple subjects. Each bridge transceiver 14 can support up to a total of 65536 static sensors plus mobile sensors 11 as described above. All the sensors 11, 13 are battery powered and the bridge transceiver 14 is typically permanently connected to the mains power supply. The battery used is of a Lithium-polymer type with a capacity of 900 mAh. The rabbit module (RCM3000 RabbitCore Development Kit) provides an easy to use UART-to-802.11 WLAN interface which relays collected data from the 802.15.4 PAN to the 802.11 WLAN bridge (the D-Link DWL-G810 has been trialled) and commands from the end server in the opposite direction. The 802.11 WLAN bridge trialled is of a Linksys router model WRT54G and has a maximum throughput of 54 Mbps. A Dell Latitude D510 laptop serves simultaneously as the DHCP server and the end server 15.

Both the static sensors 13 and mobile sensors 11 can share the same motherboard but differ only in terms of the daughter board design. The motherboards and the static sensor daughter boards were all installed with a Texas Instrument MSP430F1612 microcontroller and the mobile sensor daughter boards with a Texas Instrument.
Instrument MSP430F1611 microcontroller due to differences in RAM requirements. Communications between the motherboard and daughter board microcontrollers are, however, SPI universally.

5 System Application

One useful application of this system is to provide an alternative to the existing Resident Classification Scale (RCS), or more recently the newly release Aged care Funding Instrument (ACFI) used by the Australian healthcare sector. Similar classification schema exist in other countries and therefore the same principles apply.

The Commonwealth Government of Australia adopts a comprehensive but lengthy process in determining the level of financial subsidy each resident living in an aged-care facility should receive. The Residential Care Manual (RCM) (Department of Health and Ageing, C.A., The Residential Care Manual. 2001) documents this procedure. Each aged-care centre is required to perform a classification appraisal for new residents and annually for existing residents.

The appraisal process is score-based. Every resident assessed will be given a rating for each of the twenty-one appraisal questions listed on the RCM. Pre-defined weights are then applied to these ratings before they are added to generate a final score. This score corresponds to one of the eight classification categories, with Category One the highest. A higher category reflects the higher degree of care provided to the resident and justifies a higher level of government subsidy.

Despite the comprehensiveness of the RCM that ensures taxpayer money is spent on those who need them most, the whole appraisal system is manual, is subject to manipulation and consumes significant amount of time for the aged-care facility staff.

The system according to the present invention can potentially deliver an automated version of the appraisal system to comply with the RCM but at a reduced cost and increased objectivity. Static and mobile sensor units can be deployed to target some of the care areas of focus as described by the RCM as shown in Table 1.
TABLE 1. Some focus care areas for RCM

<table>
<thead>
<tr>
<th>Patient Measurement</th>
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</thead>
<tbody>
<tr>
<td>Communication</td>
</tr>
<tr>
<td>Mobility</td>
</tr>
<tr>
<td>Eating and Drinking</td>
</tr>
<tr>
<td>Personal Hygiene</td>
</tr>
<tr>
<td>Toileting</td>
</tr>
<tr>
<td>Bladder Management</td>
</tr>
<tr>
<td>Bowel Management</td>
</tr>
<tr>
<td>Problem Wandering or Intrusive Behaviour</td>
</tr>
<tr>
<td>Emotional Dependence</td>
</tr>
<tr>
<td>Social and Human Needs of Resident</td>
</tr>
<tr>
<td>Technical and Complex Nursing Procedures</td>
</tr>
</tbody>
</table>

For instance, the care area of "Toileting" relates to the degree of assistance required by the resident to use a toilet. This includes any kind of toilet such as a commode, urinal, bedpan or a continence sheet. A resident with problems of attending the toilet independently will most likely require assistance from the nursing staff. As a result, the triaxial accelerometry sensor data which provides mobility information, will reflect the relative inactiveness of the resident. Identification tags worn by the resident and the staff will show the relatively higher frequency of the two people located in the same room while at the same time both the motion sensor and light sensor situated in the toilet record some activities. If a humidity sensor is deployed, then wetness can be identified immediately and registered for urgent attention. All this data will be collected and analyzed by the end server to decide that for this aspect of living the resident does require a higher level of care.

Different types of sensors can be used to objectively measure a specific care area of focus. Examples include, but not limited to,

Body worn sensors including ECG, triaxial accelerometers, body temperature sensors, humidity sensors.

Weight sensors for in bed weighing and detection of movement into and out of bed.
Pressure sensors at foot of bed
Infrared sensors to identify movement NOT associated with RF tagged individuals
ie visitors
Ambient condition sensors (temperature, light and humidity)
Function (ID) sensors associated with specific function of a person or an object or
a piece of equipment.

System for aged care facility
The following clarify a few assumptions and limitations of the sensors used for the
present invention for monitoring residents in an aged care facility.
The level of resident activity can be accurately determined from the Triax
measurement. Assume certain basic types of activities such as standing, sitting, lying
and walking can also be ascertained using the Triax.
Assume that persons wearing ID tags (mobile sensors) in the facility are the
resident and all facility staff, whether or not they are directly involved in the resident's
care. Visitors are not given ID tags. One can never be totally confident how many
persons are in a room at any time, since there may be persons who are not wearing ID
tags.
The level of activity of one or more persons in a room can be determined through
the passive infrared sensor (PIRS) that returns an analogue signal. The particular
person(s) generating activity detected on a PIRS cannot be determined with any
certainty. If only one resident is in a room wearing a Triax, it is unclear how closely
correlated the activities registered on the PIRS and the Triax will be. It is safe to assume
however that the activity registered on the Triax is far more sensitive than that of the
PIRS so that if there is no activity registered on a Triax, activities registered from the
PIRS are from other persons in the room and not from the resident.
The location of a person wearing an ID tag can be determined if the person is in a
room containing a Bridge, although the exact location within the room cannot be easily
determined. The location of a resident within a room can be inferred using correlated
information from both pressure sensors and the Triax.
It cannot be assumed that all residents in a nursing home have their own private
rooms, since it usual for nursing homes to have at least a few rooms with multiple co-
locating residents, (funding and resource allocation applies facility-wide). To simplify this
example, the assumption will be residents all have their own private rooms, and later there will be separate example on adapting sensor technology for co-locating residents.

Aside from a resident's private room, other areas or rooms within the nursing home that could have a Bridge installed include the dining room, recreational and activity areas; and ideally the bathroom (private or shared) and the nurses station.

The activities performed by a resident and/or the services provided can be inferred indirectly from staff roles and the equipment that are in the same room as the resident. It is preferred to have adequate detail about key objects and persons with the resident to allow the system to discriminate the care and resource requirements for the resident.

Some of the staff roles that may be important to identify using tags include:

- Registered nurse (RN)
- Enrolled purse (EN) who may or may not be approved for medication administration
- Assistant in Nursing (AIN) or nurse's aid
- Allied Staff
- Physiotherapist
- Occupational Therapist
- Podiatrist

Other staff not directly involved in resident care:

- Kitchen hand
- Maintenance
- Hair dresser
- General practitioner (GP)

Some of the equipment that could be tagged include:

- Heavy lifting
- Wheel chairs
- Commode chairs
- Mobility aids, for example frames, walkers, and the like
- Meal trays
Medications trolley
Measurements trolley

It may not be necessary to know exactly what is happening to a resident at all times, but it may be useful to obtain only the least possible information that is necessary to allow the facility to accurately estimate resident care and resource needs (or any other purpose for sensor monitoring). For instance, it may not be relevant for the facility's funding purposes to know that a resident was sitting at a particular location, only the fact that they were sitting at the time.

One can make certain assumptions for the purposes of simplifying the logical analysis. The probability of a visitor sitting in the resident's favorite arm chair is either negligible or is negated by other factors, so that whenever the chair sensor is activated it can be assumed it is always the resident that is in the chair (if also the resident's ID tag is detected in the same room).

**Sensor states and transitions**

The following outline defines the possible states and transitions that can be registered using each sensor.

**ID tag**: Applies to resident, staff or equipment

**States**: In proximity at certain location, No location

**Transitions**: location 1 <--> location 2; location <--> no location

**PIRS**

**Activity**: Level depending on activity; Pressure sensors; Applies to bed, seats, chairs, for example

**State**: on, off

**Transitions**: on -> off; off -> on

**Triax**

**Activity type**: Quantitative

**States**: standing; walking; sitting; lying; undetermined; sleep; resting

**Transitions** (multiple, including): stand <-> walking; stand <-> sitting; sitting <-> lying; sitting <-> sleep; any <-> undetermined

**Qualitative**: walking style; swaying or unsteadiness
Events: stumbles, falls

Activity level

Quantitative:

States: activity; no activity

Transitions: activity <-> no activity

Qualitative

Energy expenditure

Activity level

Ambient

Temperature

Light

Understanding the nursing home domain

Only simple rules need be used to interpret data coming from the system, in order to simplify discussions and understanding of the nursing home domain and to make conclusions about possible activities and services occurring in a facility at any one time:

Any equipment (or group of equipment) that is common to all residents and is together with a particular resident, the particular service represented by this equipment is being delivered to the resident during this time. This includes:

Medication trolley: Administering medications.

Medications trolley

Heavy lifting equipment

Specialised transferring needs

Commode

Specialised toileting needs

Wheel chair

Specialised mobility needs

Meal tray

Any equipment is that is tagged that belongs to the resident, its use by the resident is being registered when it leaves the resident's room together with the resident.
If this equipment and the resident appear in another location, then an assessment can be made about the distance the equipment is used in addition to the timing. The type of equipment in this case could be mobility aids such as a walking stick, frame or wheel chair.

An assessment can be made about the services rendered by the staff to the resident based on the role of the staff who is accompanying the resident and also the equipment that is with the staff at the same time. The allowable tasks according to role should be taken into account. For instance:

If a medication trolley is with a resident, then up to 2 staff in the same room with the role of either EN (approved for administering medications) or RN who are present in the same room can be allocated the particular role of administering medications to the resident. If there is an AIN present, it is assumed they are not there to administer medications since it is not part of their role.

If there is a meal tray in the resident's room, then up to one staff member is there to assist the resident to eat.

Any staff present with other equipment such as a commode or the mechanical lifter are there to assist the patient in toileting and transfers.

Allied health staff or other staff such as a hairdresser, are there to render a specific service which is registered.

If an RN, EN or AIN are in a resident's room without any equipment, more information could be derived from what is happening to the resident during this time from the ID tag, Triax and pressure sensors in order to get clues about the staff's presence. For instance:

If staff are disappearing from the room together with the resident, they may be assisting with their mobility.

If the staff and the resident are appearing later in the bathroom, they may be there to assist in toileting or showering.

If the staff and resident appear in the dining room, they are either assisting with mobility or assisting with meals.

If there are changes in the state of the bed sensors (on -> off) to the chair sensors (off -> on) then the staff are assisting with transfers.

If two staff are present to assist in mobility, transfers, changing etc this is demonstrates a higher level of resident care need compared to if one staff member was
present. In some cases, services rendered to residents can be more heavily weighted when a staff member is present with a higher level of expertise. An RN is usually considered a more expensive and expert resource compared to an EN or AIN, so therefore their presence may also suggest a higher care need for the resident.

In most cases, it would be difficult to differentiate staff having a supervisory role as opposed to physically assisting with resident activities. This would be relevant to distinguish, say, while assisting in eating, mobility, transfers, etc. This latter point may or may not be important depending on whether the concern is that a staff resource is being used up irrespective of the motive, as opposed to assessing specifically the resident's abilities or effort put in by the staff.

In a room that only registers the single resident occupant, if there is activity registered from the PIRS while at the same time there is no activity registered from the resident's Triax, it is assumed the activity is coming from an unknown number of visitors (as all staff and other residents would be detected if they were in the room). This can be used as an indicator of a resident's level of socialisation which could also include times when two resident tags are in the same bedroom. Whenever there is a staff member and a single resident together in a room, then the measure of socialisation no longer applies as any undifferentiated PIRS activity cannot be further attributed to a visitor, however the resident's time would now be tied to the reasons for the staff member's presence, taking precedence over any social activities. Social visits however can be underestimated if visits are occurring outside a resident's room.

Correlating activities with ambient light detected in the room gives a good indication of the timing of sleep and also is relevant when relating behavioral changes and activities with the presence of night/day or surrounding light.

Examples of nursing home activities or services that can be assessed

Eating & drinking

Presence of meal tray in room

Presence of staff together with tray in the same room signifying assistance required

Presence of resident in dining room, and method used to arrive to dining room (walk, assistance, wheelchair)

Mobility - type and extent
Assess: Independent; Mobility aids; Walking stick; Frame; Wheelchair

Falls
Assistance required
Bed-ridden/prolonged sedentariness

Extent of mobility/activity

Sensors
Triax signal: gait characteristics and use of aids; falls and supervision requirement; bed/chair use; energy expenditure/activity level

Mobility aids can be tagged to assess extent of use when accompanying resident

Staff present suggesting assistance requirement (independent, 1 or 2 staff)
Resident mobility limited to when only staff are present suggests resident quite dependent for mobility

Bed and chair pressure sensor activity suggesting extent of bed/chair use
Resident appearance in different areas detected by ID tag (distances traveled)

Transfers - Correlated with what would be expected from mobility - Assess; Independent; Type of transfers and assistance required; Use of heavy lifting equipment

Sensors
Triax
Transition changes (from sitting to standing, lying to standing, and vice versa)

Pressure sensors
Robust transition changes from bed to chair.

Presence of staff during transition changes suggesting assistance required (independent, 1 or 2 staff)

Transfers limited to when only staff are present suggesting resident quite dependent for transfers

Presence of staff who are trained for transfers and bed turns ('dressers')
Use of heavy equipment during transfers suggest an even higher level of dependency and resource expense

Wandering or intrusive

Crossing outside perimeters
Appearance in uninvited areas (other resident rooms)

Mobility activity assessed by triax

Personal hygiene

Assess

Dressing, undressing; Grooming; Showering

Sensors

Usually relates to activity immediately after getting out of bed, just before getting into bed or activity surrounding showering.

Cues from bed sensor, ID tag in bathroom/shower,

Note: Triax transition to/from sleep mode or removal from person corresponds to sleep/wake, dressing and showering times (? cue)

Presence of staff during these times suggesting assistance required.

Commode chair (used in showers) or other auxiliary equipment suggesting even higher dependency level.

Toileting

Assess

Independent

Assistance required each time

Use of commode or bed pan

Frequency and toileting pattern, correlate with day/night cycle

Sensors

Detect resident in toilet area to assess toilet habit and frequency

Staff present (independent 1, 2 staff); getting to the toilet, +/- using the toilet

Use of commode

Lack of resident presence in toilet, suggesting use of bedpan (+/- commode chair and/or bed sensor activity) in room

(A continence sensor (detecting moisture) attached to the bed sensor would be useful in this regard)

Medication needs

Presence of medication trolley in room plus 1 or 2 staff authorised to dispense medications
Resource assessment based on accumulated staff time (taking into account number and staff role) spent with resident and medication trolley.

Requirements for supervision

This grouping includes difficult behaviors such as confusion, verbal, physical, disruptive, inappropriate and dependency. Time for socialising and other requirements for staff supervision is also included.

This is the default grouping when the reason for the presence of staff together with a resident in a room cannot be ascertained with any certainty.

Night/day habits can give clues to disruptive behavior, e.g. staff presence in a resident's room at night for no other cause (such as toileting), suggests disruptive behavior or confusion.

Other staff services:

Allied Staff - Assessing the type of allied staff and time spent with resident identified by ID tag, including physiotherapist, podiatrist, speech pathologist and occupational therapist.

Softer services - Hair dressing, manicurist, etc.

GP - would be ideal to track GP (from individual ID tag) attending their residents' medical care (ID tag can be picked up when GP visits NH and returned when finished or can be taken by GP).

Complex and special care nursing

Assess

Clinical measurements

Complex pain management

Wound management

Palliative care

Special feeds

Stoma care

Sensors can be assessed by detecting combinations of equipment and staff tagged by ID. Includes:

Measurements: Measurement trolley

Pain: allied health (+/- masseur), TENS machine or other equipment
Wound: allied health, bed turns by 'dresser' staff
Palliative: intensive care nursing, ongoing bed rest, allied health, pain management, medical team
Special feeds: tagged feeding equipment, suctioning equipment

Social Interaction - Previously mentioned, PIR activity in resident room without Triax activity from resident and no other staff ID tag detected suggests visitor presence that can be used as a measure of socialisation.
Other measures include:
Presence and activity in recreational areas
Presence and activity with staff or volunteers involved in recreational activities
Persisting resident presence in other resident's room

Multiple residents in the same area

When multiple residents are living together in shared rooms or are otherwise in the same area such as the dining room, then the focus on individual resident activities and services becomes very much reduced as it difficult to infer information from the PIRS and bridge transceiver regarding:
where a particular activity is originating from,
which resident a service or resource it is targeted at, or
if there is more than one service being conducted in a room, wrong assumptions about the extent of assistance required for each service can be made.

This may not be a problem if the facility is mainly concerned about the absolute staff resources being used up and not on the individual resident care needs or the particular service supplied. For instance, if there are 4 residents in a room with a medication trolley and three staff, the fact that medications are being administered and three staff are being used up for whatever reason, may be enough information for a facility to make a claim on resource requirements. From the point of view of most facilities, however, the focus is very much being able to characterise and respond to individual resident care needs, and a consistent view is required for monitoring residents, whether they are in an individual room or not.

When there are multiple resident's in an area, only a best guess attempt can be made about where an appropriate activity or resource should be apportioned. Although
every attempt should be made to correctly analyse the situation and determine the resident(s) responsible for a set of sensor information, in the absence of any additional information about the particular involvement of a resident, the activity or service should be allocated equally amongst all residents in the area. Additional information could come from:

The Triax sensor and the bed/chair pressure sensors. These sensors are more personally identifying (with certain assumptions in the latter case) and can give clues to the weighting of resources allocated to residents.

An understanding of the nursing home environment and certain assumptions about staff roles and equipment use will also give more discriminating detail.

Any resident data extraneous to the system can provide a lot of additional information if available e.g. administering medications electronically can give detailed information on medication timing and staff participation more accurately.

In the example of 4 residents in a room:

There is a medication trolley, an RN, EN (unapproved for administering medication) and an AIN. With this information only, one can deduce:

The RN can only administer medications and does so to all residents. The time spent on medications and level of assistance (1 staff) is divided equally amongst all residents in 4 ways.

The AIN and EN can only 'supervise' (default behavior) 4 ways.

There is a commode chair now in the room

The AIN and EN (2 staff assistance) and the commode together make up a resource which is divided 4 ways, until the commode, AIN and 1 resident leave the room where there are now only 3 residents (equally) receiving medications and one EN supervisory role.

The resident, AIN and commode chair may appear in the bathroom/toilet where now the resource is dedicated to the resident.

If there is a change in state of the pressure sensor for the bed or chair, the EN (1 staff) has changed her status from a 'supervisory' role for 3 residents, to assisting in a transfer for 1 resident.

The 3 residents are still considered as having their medications administered until the medication trolley leaves the room. Any remaining staff in the room have a 'supervisory' role in the absence of any further activity.
Some of the above assumptions may be incorrect for what is actually occurring in the room at that particular moment, but can be statistically valid over a longer period of time for any resident. A particularly disruptive resident however can negatively weigh all other 3 residents in the same room as being disruptive (or requiring lots of supervision), when this is not in fact the case. One would expect the more disruptive resident to have more state changes in their pressure sensors and Triax measures compared to the more placid residents in the same room, thereby focusing attention towards the disruptive resident and away from the general 'supervisory' role. These state changes however may be misinterpreted as transfers or assistance with mobility, unless more robust analysis of signals can be made (e.g., bed pressure sensor variation with no persisting change in state (on -> off -> on), or agitation in the Triax signals).

The same principles of sensor analysis applied to residents living together in the same room, also apply to residents who are together in common areas such as dining room or shared bathrooms. The dining area is a commonly used for dispensing medications to residents while having meals. The staff resources assisting with meals and medications would be shared amongst all residents who are in the same area, unless there was more information localising the particular resources being used or occupied.

20 Multiple choices and conflict resolution

Many situations will arise when a choice needs to be made about a particular combination of sensor data that has several possible scenarios. Two cases need to be taken into account: multiple equipment and/or multiple staff in a room of one or more residents.

In the case of multiple equipment, it is probably safer to assume the services represented by the equipment are occurring at the same time rather than being mutually exclusive. Therefore if both a medication trolley and a meal tray are the same room together with a single resident, both the meal and the medications administration are occurring together. This is preferable to assuming that medications are being administered until the medication trolley leaves the room, after which the resident is assumed to resume eating (this relies on pre-defining a service priority). This will be true until a particular activity binds the use of the equipment by a resident (+/- staff) to the exclusion of other equipment. This is simpler to analyse and fits in better when there are multiple residents in the room with multiple equipment, i.e. all residents share equally all
services at the same time until there is more information localising a particular service or activity to a resident.

In the case of multiple staff in the room, staff are bound to a particular activity and/or equipment in the room (taking into account also their roles and allowable tasks), and do not share across multiple services. If there are no tasks/services to assign to, the staff member has a 'supervisory' role. There should be a priority set about what a services a staff member exclusively binds to depending on the set of circumstances indicated by the sensors. In the previous example with the medication trolley and meal tray in a resident's room, if there is also an RN in the room, the RN is assisting with medications, not with meals. What happens when instead of an RN, there is an AIN? The AIN is assisting with the meals and medications are not being administered unless there is a staff approved to administer medications bound to this activity.

Analysis

The above discussions would naively suggest that making the analysis system context aware would be a simple matter of associating various combinations of heterogeneous signals through a number of rules based on knowledge and assumptions about the nursing home domain. The situation however is far more complicated and the following section introduces some of the current analysis techniques of 'ubiquitous computing', with further discussion on specifically adapting these techniques to the problem.

The expert analysis of the sensor data can be broken down into two parts.

Mapping between the low level signals and the actual activity or service

Reasoning about what is occurring in the monitored environment

Mapping signals with activity or service

The type of data that is generated from the sensors can be broken down into several forms that include but are not limited to:

Analog data

Triax activity level

Triax orientation, action - standing, sitting, lying, walking, indeterminate

Triax events - force threshold
In reality, sensor data can suffer the problems of being noisy, lossy and difficult to interpret. Specifically, research into the properties of the RFID tag has shown that the signals can be affected by various factors including the angle of the tag to the reader (in addition to the distance between them), and signals can be reflected by metal and blocked by water and people.

Sensors can also produce an overwhelming flood of information, and it is preferred to store, transmit and process this data in a timely efficient manner. One method used to combine and analyse heterogeneous sensor information employs simple heuristics or rules to tie event signals to a resource or activity, however this method lacks the ability to handle uncertainty and complexity in the data and does not often take into account prior context knowledge. Preparing sufficient rules is also complex and difficult due to oversights and exceptional contexts when trying to encompass all possible activities and the ways each activity can be performed, particularly with the accompanying sensing technology difficulties.

An alternative stream of sensor analysis research is based on probabilistic models, exploiting correlations and statistical relationships between attributes collected by the devices, gradually building a predictable model of the world. This model is further enhanced with dynamic probabilistic model techniques that take into account changes to attributes that evolve over time, in addition to the changes in the spatial sensor network environment. Such models have the advantage of easier storage and more efficient querying (smaller number of attributes approximating the much larger volume of sensor data) and provide probabilistic guarantees to the correctness of the information [database].

Examples of techniques from this group used in sensor analysis include Bayesian learning, Dynamic Bayesian Networks, Markovian Models, fuzzy rules; and others based on varying contributions from support vector and neural networks. Mixture-models have
also been used to develop a probabilistic model predicting clustered and cyclical behavior patterns.

When grouping research methods and objectives for the studies described in the quoted literature, and comparing this to the system monitoring objectives and intended facility set-up, there are a couple of notable differences. Firstly, all studies have their sensor monitoring applied to a single person within fairly controlled and static surroundings and no other persons to interact with. Secondly most of the studies are primarily concerned with characterising a monitored person's behavioral patterns, or underlying activities providing a tailored reaction or response to either the predictable behavior or any deviations from it, for instance, health status monitoring, intelligent ambience etc.

In contrast, a nursing home facility is a much more complex and dynamic environment characterised by multiple person interactions and multiple activities occurring simultaneously. Residents with vastly different abilities can be moved to different living quarters with varying configurations of beds, chairs, bathrooms etc., making it immensely difficult to learn and predict individual activities or behaviors to any level of accuracy.

Fortunately, the objectives for system according to the monitoring by the present invention differs from the other sensor research in that it aims to establish the occurrence of key events that reflect the context of activities and services associated with a resident, for the purposes of determining the resource requirements of both the facility and resident. This is in effect a tallying of key resource markers that is a lot more tolerant of misrepresentations or errors, if in the long term its ability to determine resource requirements is at least as accurate (and hopefully more accurate) compared to current conventional manual methods.

It is should be noted that dynamic probabilistic models may also fail to assess a state transition or subject status accurately, particularly when considering that even an a simple classifiable action amongst residents, say a transfer, is made up of a large variety of action combinations +/- interaction with staff and equipment. It may be that some events may be simpler and as accurate to analyse using robust heuristic methods, depending on the final nature and uncertainty in the data.

Thus, a combination of robust rules and probabilistic models (dynamic or static) can be used at this level of signal analysis in order to mitigate data complexity, identify noteworthy contexts and build into the data model uncertainty and prior knowledge about context and sensor properties. It should be noted that Triax analysis already uses both
heuristic and probabilistic methods in order reduce the complexity of the raw signal to a few known states, actions and events.

**Reasoning about what is occurring in the monitored environment**

This essentially abstracts the analysis at a higher level, taking in determinate states and activities from the separated and summarised data that has been pre-analysed from the raw signals, and relating this to the nursing home domain. The analysis at this level in essence follows the logic that has been introduced above bringing logically together resident functions, activities and services which are used to determine the resource requirements for the facility and the needs of its residents.

A rule-based inference engine will be the primary method used for relating the sensor information together, as logic and associations are not hard-coded and rules can take into account variations in context interpretations depending on resident circumstances, sensor set up, spatial variations, facility policy etc. For instance, identifying two residents in the same bedroom may be a marker of socialisation between the two residents, while at the same time this could also be interpreted as an intrusion if one of the residents is a known wanderer.

The simplest rule-based analysis would involve only stateless sessions. Most of the earlier descriptions of logic in this document only assume recent knowledge of the domain in making conclusions about activities and services. Stateful sessions involve having memory of past events in order to make conclusions of the current state. For instance, when a new ID tag (from staff or another resident) appears in the room, it is safe to assume the new person is not sitting on a particular chair with a pressure sensor, if the sensor is indicating there is someone already sitting in the chair and there has been no change in state transition from on to off in the meantime. In a stateless session, the person sitting in the chair is ambiguous when two ID tags are identified in the same room. Backward chaining would integrate nicely with a stateful rule engine to determine and select allowable state changes particularly when trying to fill in gaps in knowledge when tracking the location and activities of a resident.
SUMMARY

As shown in Table 2, the overall system has been designed with scalability, pervasiveness and unobtrusiveness in mind. The hardware components are modular, small in volume, power efficient and intelligent. More importantly, its preferred wireless nature means that it can be retro-fitted into existing houses or buildings without the need of any modifications to the building structure itself. Its modular design concept implies that the components can be upgraded or replaced individually without affecting others.

TABLE 2. System network structure outline

<table>
<thead>
<tr>
<th>Function Level</th>
<th>Hardware</th>
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<tbody>
<tr>
<td>Data management</td>
<td>Server</td>
</tr>
<tr>
<td>Data transfer</td>
<td>Generic motherboard</td>
</tr>
<tr>
<td>Data conditioning</td>
<td>Bridge transceiver motherboard</td>
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<tr>
<td>Data collection</td>
<td>Bridge transceiver motherboard</td>
</tr>
</tbody>
</table>

The flexibility of the system according to the present invention, suggests that if adopted on a wide basis both in individual homes and nursing homes, the system can alleviate the pressure on Government healthcare systems by: (a) ensuring those elderly living alone are regularly monitored for health status changes and existing chronic conditions; and (b) providing a cost-effective, accurate and objective solution to determining the level of subsidy to nursing home residents.

It will be appreciated by persons skilled in the art that numerous variations and/or modifications may be made to the invention as shown in the specific embodiments without departing from the spirit or scope of the invention as broadly described. The present embodiments are, therefore, to be considered in all respects as illustrative and not restrictive.
Claims:

1. A system network for monitoring an action or state of a subject comprising:
   a server capable of receiving information from a bridge transceiver and processing the information;
   a bridge transceiver capable of receiving information from a sensor and transferring information to the server;
   a detector sensor in communication with the bridge transceiver,
   a sensor, associated with a subject, in communication with the bridge transceiver;
   wherein the bridge transceiver receives information from the sensors and passes information to the server to monitor an action or state of the subject.

2. The system network according to claim 1 wherein the bridge transceiver receives information from the sensors via radio frequency transmission.

3. The system network according to claim 1 or 2 wherein the server receives information from the bridge transceiver via radio frequency transmission.

4. The system network according to any one of claims 1 to 3 wherein the network comprises a plurality of detector sensors and/or a plurality of bridge transceivers placed in a space to monitor different actions or states of a subject.

5. The system network according to any one of claims 1 to 4 wherein the detector sensors are selected from the group consisting of environmental and physiological sensors, motion sensor, pressure sensor, weight sensor, ambient temperature or ambient humidity detector, ECG sensor, triaxial accelerometry sensor, blood pressure sensor, pulse oximetry sensor, and body temperature sensor.

6. The system network according to any one of claims 1 to 5 wherein the detector sensors and the bridge transceiver are placed in space occupied by a subject to monitor that subject in its environment.

7. The system network according to any one of claims 1 to 5 wherein the detector sensors and bridge transceivers are positioned in a plurality of spaces occupied by a number of subjects and the system monitors a plurality of subjects.

8. The system network according to any one of claims 1 to 7 wherein the mobile sensor measures and transmits actions or states of a subject selected from the group consisting of identity, position, activity, movement, rate of movement, heath
state, blood pressure, body temperature, ECG, pulse, blood oxygen saturation, body temperature

9. The system network according to any one of claims 1 to 8 wherein the network monitors the actions or states of a plurality of subjects by each having a mobile sensor capable of identifying the subject.

10. The system network according to claim 9 wherein the subject is a patient, health worker, physician, care giver, nurse or aid.

11. The system network according to any one of claims 1 to 10 wherein the mobile sensors are also installed to apparatus that may be used in the care of a subject.

12. The system network according to claim 11 wherein the apparatus is selected from medication cart, meal cart, wheel chair, measurement trolley, heavy lifting equipment, commode, specialised toileting needs apparatus, specialised mobility needs apparatus.

13. The system network according to any one of claims 1 to 12 wherein the detector sensors transmit all received data or process the data and only send required information or a combination of the two approaches depending on detector sensor type, to the bridge transceiver.

14. The system network according to any one of claims 1 to 12 wherein the bridge transceiver transmits all received data or processes the data and sends required data to the server.

15. The system network according to any one of claims 1 to 14 wherein the subject is a resident of a healthcare or aged care facility and the health state of the resident is monitored.

16. A system for monitoring a state of a subject comprising:

   a bridge transceiver capable of receiving information from a plurality of sensors and transmitting the information;

   a plurality of sensors capable of transmitting information to the bridge transceiver;

   and

   a data processing apparatus comprising a central processing unit (CPU), a memory operably connected to the CPU, the memory containing a program adapted to be executed by the CPU, wherein the CPU and memory are operably adapted to receive information from the bridge transceiver and record or monitor information on the state of a subject.
17. A data processing apparatus for monitoring a state of a subject comprising:

- a CPU;
- a memory operably connected to the CPU, the memory containing a program adapted to be executed by the CPU, wherein the CPU and memory are operably adapted to receive information from a plurality of bridge transceivers and monitor a state of a subject.

18. The data processing apparatus according to claim 17 wherein the CPU and memory are operably adapted to receive information from a plurality of bridge transceivers and monitor the state of one or more subjects.

19. The data processing apparatus according to claim 17 or 18 further stores the information received from the bridge transceiver.

20. A computer readable memory, encoded with data representing a programmable device, comprising:

- means for receiving information from a bridge transceiver;
- means for processing the information from the bridge transceiver; and
- means to record the processed information to monitor or record a state of a subject.

21. A computer program element comprising a computer program code to make a programmable device:

- receive information from a bridge transceiver on a state of a subject;
- analyze the received information; and
- record the information to monitor a state of the subject.

22. A bridge transceiver capable of receiving information from a plurality of sensors capable of sensing a state or action of a subject, processing the information and transmitting the information to a server to record and monitor the state of a subject.

23. A method for monitoring a state of a subject comprising:

- providing a mobile sensor to a subject;
- sensing information on the subject from a plurality of sensors in communication with a bridge transceiver; and
transmitting the information from the bridge transceiver to a server where the information is processed and the state of the subject is monitored.

24. The method according to claim 23 wherein the state is selected from location (physical location and proximity to various objects and other subjects), mobility and activity, resting, eating, sleeping, socialising, receiving care, medications and treatments, toileting, and health state,

25. The method according to claim 24 wherein the health state relates to medication needs, transferring needs, toileting needs/personal hygiene, mobility needs/falls/bed-ridden, need for meals/eating/drinking, behavioral/wandering, need for supervision/complex and special care, clinical care needs, and emotional, social, psychological health and wellness.

26. The method according to any one of claims 23 to 25 wherein the subject is a resident of a healthcare or aged care facility and the health state of the resident is monitored.
### INTERNATIONAL SEARCH REPORT

**International application No.**

PCT/AU2007/001757

#### A. CLASSIFICATION OF SUBJECT MATTER

**Int. Cl.**

**G06Q 50/00** (2006.01)

According to International Patent Classification (IPC) or to both national classification and IPC

#### B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic database consulted during the international search (name of data base and, where practicable, search terms used)

Internet, USPTO and DWPI using keywords: health care, aged care, medical care, remote, monitor, sensor, RFID, tag, transceiver, receiver, transmitter, relay, server

#### C. DOCUMENTS CONSIDERED TO BE RELEVANT

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<td>U S 7134996 B 2 (BARDY) 14 November 2006 See whole document, in particular: Abstract; Column 5, Line 33 - Column 6, Line 38; Column 10, Lines 7 - 20</td>
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* Special categories of cited documents
  
  "X" document defining the general state of the art which is not considered to be of particular relevance
  
  "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
  
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  "P" document published prior to the international filing date but later than the priority date claimed
  
  "F" document member of the same patent family

Date of the actual completion of the international search

11 December 2007

Date of mailing of the international search report

U DEC 2007

*Authorized officer*

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Form PCT/ISA/210 (second sheet) (April 2007)
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This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

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Due to data integration issues this family listing may not include 10 digit Australian applications filed since May 2001.

END OF ANNEX