CITRENZ
COMPUTING AND INFORMATION TECHNOLOGY RESEARCH AND EDUCATION NEW ZEALAND

Journal of Applied Computing and Information Technology

ISSN 2230-4398, Volume 18, Issue 2, 2014

Incorporating the NACCQ publications:
Bulletin of Applied Computing and Information Technology, ISSN 1176-4120
Journal of Applied Computing and Information Technology, ISSN 1174-0175

Refereed Article A1:

A minimally intrusive monitoring system that utilizes electricity consumption as a proxy for wellbeing

Hunt, T.D., Rajendran, D., Nikora, M., Bennett, S. & Fendall, A. (2014). A minimally intrusive monitoring system that utilizes electricity consumption as a proxy for wellbeing. *Journal of Applied Computing and Information Technology*, 18(2). Retrieved August 6, 2014 from http://www.citrenz.ac.nz/jacit/JACIT1802/2014Hunt_Monitoring.html

Abstract

The purpose of this work was to test the hypothesis: `Off-the-shelf domestic electricity meters can be utilised to assist in monitoring the wellbeing of elderly people` Many studies have shown that it is, in theory, possible to use domestic electricity consumption to determine `activities of daily living` but the availability of systems for actual use is very limited. This work followed the Design Science Research Methodology to create a Java application running on the Google App Engine cloud service that interfaced with both electricity meters and voice and text services. The system was implemented and tested over a three month period with one older person and their carer. Results demonstrated that the technology readily succeeds in meeting the study`s initial objectives. The need for more sophisticated decision logic was apparent and a method to determine whether a home is currently occupied is likely to improve the ability to create more timely alerts.

Keywords

independent living, assisted living, wellbeing, electricity monitoring, Google App Engine

1. Introduction

Many countries are dealing with reduced child birth rates whilst at the same time managing the increased aging of their populations. This raises problems for their ability to provide quality care (Lai, 2008; van Nimwegen & van Erf, 2010). There is a growing industry devoted to caring for the elderly, ranging from independent living arrangements to full nursing care (Health and Welfare Information Association & Japan National Council of Social Welfare, 2013). The cost of providing such care is widely seen as being a large burden on many countries (van Nimwegen & van Erf, 2010), whether state or privately funded. Disabled people (both physically and cognitively) are another sector of society who require care service provisions (Baxter & Glendinning, 2011). It is likely that as industry and society find ways to deal with the growing needs of the elderly, so the needs of the disabled may also be addressed.

This work describes the design, development and deployment of a novel minimally intrusive monitoring system (henceforth referred to as MIMS) that utilizes the maturing of domestic energy monitoring devices and cloud computing. MIMS has been designed to work with individuals or organisations that wish to monitor vulnerable people living alone; so that alerts are generated when there is a deviation from the person's normal behaviour.

2. Methodology

2.1 Research

The Design Science Research Methodology (DSRM) has been followed in this work (Peffers, Tuunanen, Rothenberger, & Chatterjee, 2007; Hevner, March, Park, & Ram, 2004). DSRM provides a framework that is well suited to the creation of artefacts in the Information Systems arena. The main activities of the methodology are: 1) Problem identification and motivation, 2) Definition of the objectives for a solution, 3) Design and development, 4) Demonstration, 5) Evaluation and 6) Communication. The methodology allows for retrospective application to a piece of research that has already occurred – as perhaps often happens in practice. The last activity of Communication is, of course, partly happening in the writing of this paper, but has also occurred through the involvement of interested parties.

2.2 Software

In the initial stages of the work, the roles of client, designer and developer were performed by the same person. The Unified Process (UP) for software development utilisation was constrained by this fact. Once the work was introduced to third parties, the UP allowed for revisiting earlier stages of the cycle, such as requirements gathering, so that the artefact being developed could be modified to meet the needs of the intended audience. This is consistent with "The evaluation of the artefact then provides feedback information and a better understanding of the problem in order to improve both the quality of the product and the design process." (Hevner et al, 2004).

Object Oriented (OO) Design and Analysis is often used along with the UP as a modern technique for creation of software artefacts and was adopted in this work. In addition, the Unified Modelling Language (UML) was used to document the stages of the work where appropriate.

3. Problem Identification and Motivation

As mentioned in the introduction, the big picture problem has been identified as the issue of an aging population that will require affordable care. However, this paper focusses on a narrower question: "Is it possible to use the latest developments in consumer devices to create an acceptable system for helping to 'keep an eye' on vulnerable people living on their own?" The definitions of "vulnerable" and "intrusive" should take into account the needs of the individual and what is appropriate for each person. The more care that a person requires, the more intrusion may be acceptable to keep that person safe. More intrusive solutions may be not acceptable for independent elderly people who are able to manage their lives in normal circumstances, but for people with social interaction and communication impairments (for example autism), intrusive solutions may be necessary to prevent self-injurious behaviours.

3.1 Options for care

The traditional method that a society uses to look after its older people is to have them live in the same residence as their adult children. A variation of this is the 'granny annex' (Wapner, Demick, Yamamoto, & Takahashi, 1996) where the elderly parents live in a closely located but fully self-contained home. Here the adult children can easily monitor the wellbeing of their parents.

Either the older person or their adult children may not be, or want to be, in a position to closely share the living arrangements just described. If there is a need for care then a popular option is to use a residential care facility (Dudman & Meyer, 2012). Various levels of care can be provided and can change as the needs of the older person change. Nursing homes are able to provide a high level of care that would be very difficult for most lay people to provide, although this level of care is expensive (Netten et al, 2001; Szczepura, Nelson, & Wild, 2008).

3.2 A Technical solution

There is an increasing use of technology to assist with the care of the elderly (Hyysalo, 2004). A major driver for this is to reduce the costs of providing care. In some cases technology is being used to provide older people with companionship. Although the aim of using technology is to provide a level of care that would be too costly if the market labour rate had to be used, many of the technical solutions are still likely to be relatively costly for many people and societies (Zwijsen, Niemeijer, & Hertogh, 2011). Kerbler (2012) discusses the term telecare that uses management, ICT and service networks to provide health and social care in the home. He discusses three generations of telecare from safety-alarm systems that can be manually activated, to intelligent systems that use sensors to determine if a person is acting in a typical manner (Monekosso & Remagnino, 2007) and finally to the third generation that enhances the "quality of the user's life rather than his independence and safety".

3.3 Security and ethical considerations

There are many concerns around the type of technology that is being used for Assisted and Independent Living schemes (Herzog & Lind, 2003; Rauhala & Topo, 2003).

It is important that private data being collected to monitor someone stays secure (Herzog & Lind, 2003). There are already sufficient security protocols (Sahare, Joshi, & Gehlot, 2012) that have been developed by the Information and Communications Technology (ICT) industry that will suffice if they are properly implemented; for example the banking sector relies on the ability to communicate and store data securely.

A major concern with monitoring people is the inadvertent ability to intrude into the person's personal life (Rauhala & Topo, 2003). In an overview of the literature (Zwijsen, Niemeijer, & Hertogh, 2011) concerning the ethics of assistive technologies, the concepts of obtrusiveness and autonomy are discussed. Although the terms are not always clearly defined, one interesting proposal is, "that users of AT [Assisted Technology] should be able to decide when they are being monitored and when to turn a monitoring device off". The ability to cancel false activations of a fall detector was seen as a positive feature of one device (Brownsell & Hawley, 2004) and this feature could be implemented in all situations where alerts are being sent, thereby increasing the level of autonomy.

3.4 Electricity monitoring

In parallel to the situation of the aging population is the growing awareness and interest in reducing energy use (Murphy, 2011). There is a growing market in devices that monitor the electricity usage of homes with the intended outcome being that if a person can easily see the correlation between appliance use and electricity charges they will reduce their energy consumption. A number of devices have now become available that can easily be installed by the average user (AlertMe, 2013; Blue Line Innovations, 2010; Current Cost, 2013; Enistic, 2012; NetRC Systems Inc, 2013; P3 International Corporation, 2013; Powerhouse Dynamics, 2013; Sailwider Electronics, n.d.; thinkeco, n.d.; wattvision, 2013).

A person's electricity usage is likely to give an indication of the wellbeing of that resident and some of the available devices can be configured to allow remote access to the data. However, the current devices for measuring electricity usage are not usually configured to automatically alert a concerned adult child or other care giver (henceforth referred to as a Carer) of a possible need to intervene (for example, call them to ask if they are alright). In addition the alerts that can be sent are aimed at informing an individual rather than being a tool an organisation could use as a central means of monitoring a number of people. For example the eMonitor from Powerhouse Dynamics does allow the creation of text and email alerts when "your electric bill has passed a certain threshold" (Powerhouse Dynamics, 2013) and the device from wattvision allows you to "track your graph as well as the graphs of your friends and family" (wattvision, 2013), although to do this it appears that you need to make the data available on a public website.

A common scale used to measure the health of the elderly is the Activities of Daily Living (ADL) (Katz, 1983) and some studies have used electricity usage in an attempt to measure this. Franco, Gallay, and Berenguer (2008) measured the electricity used by room lights and individual domestic appliances and concluded that "Eating was the most accurately measured ADL; toileting and bathing results were less accurate. The system appears to be a promising component of home telecare". Tang, Deng, and Xiong (2005) monitored water, electricity and gas usage monitored and reported that "A model of the changing amount of the elderly's activities can be built with the inferential arithmetic and the accumulated data. And based on this model, the health and security status can be predicted and abnormality can be inferred".

3.5 Making electricity usage data available

Although the literature has reported the successful use of electricity monitoring for determining ADL, there still is a lack of actual services that exist outside of the research field. Given the recent advances in technologies previously discussed, this study aims to show that the time is now right to implement a low cost and readily accessible service.

The EnviR electricity meter from Current Cost (Current Cost, 2013) enables users to view their electricity usage on a display that they can locate in a convenient location. The company also sells devices that automatically send this data to a secure website where users can graphically view current and historical electricity usage, (see Figures 1 and 2). It is now possible for a third party to also view it for the purpose of determining if the usage is typical. Atypical usage may be an indication that the person is in need of support. The ability to view consumption data on a website is a feature of many of the devices referenced earlier. However, a better solution for the Carer is to be sent alerts when a situation has occurred, or even a daily alert just to say that everything looks normal. Current Cost provides the ability to pass data onto the Xively service (Xively by LogmeIn, 2014) from where it is possible to create alerts that are triggered when the current electricity usage matches a particular condition for example above 2000W or below 50 W. When a trigger occurs, the software makes an HTTP POST request to a URL that the user will have had to setup previously to receive such requests. This service is provided for a technical audience rather than the layperson and only limited functionality is available for creating alerts based on historical data. However an Application Programming Interface (API) provides access and retrieval of data which allows another program to analyse the data and create these alerts.

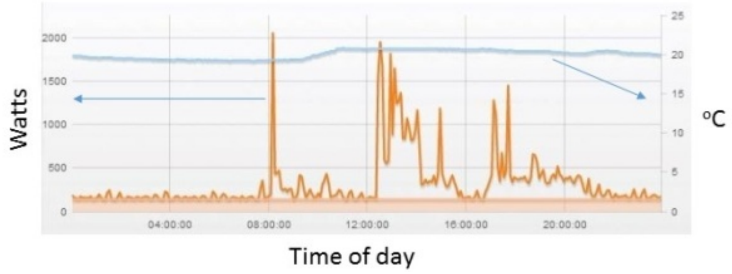

Figure 1. The lower plot shows the electricity use for a single day for the entire house being monitored. The upper plot shows the room temperature.

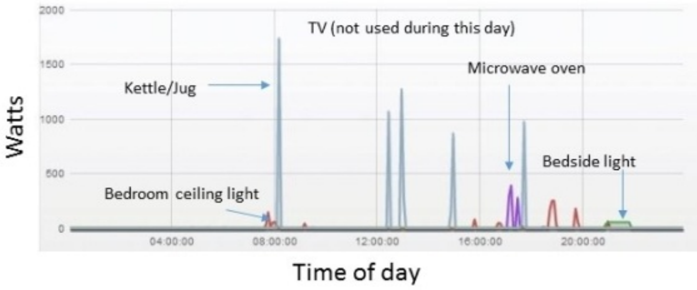

Figure 2. This graph shows the same day/house as for Figure 1, but plots the usage of individual appliances.

3.6 Using a cloud resource to provide an always on service

As previously stated, the intention of this work is to provide an alert when the electricity usage is atypical. A simple way to achieve this would be to constantly monitor the power usage and send an alert when the value went above or below a predetermined trigger value. The trigger value could be different for different times of day.

An alternative method would be to compare the current value with historical values to try to determine if the current value deviates from the normal. This means that the program that will provide the alert needs to be continuously running and have access to the historical data. A large number of providers of various cloud services exist (Vaquero, Rodero-Merino, Caceres, & Lindner, 2009) with the major providers being Google App Engine (GAE) (Google, 2012), Windows Azure (Microsoft, 2013) and Amazon Web Services (Amazon web services, 2013).

4. Defining Objectives of a Solution

The following objectives have been identified.

4.1 Low cost

Solutions to monitor people already exist but they are often too expensive for individuals or organisations to implement. This work aims to create a solution that is affordable for individuals on low incomes or organisations that are involved with providing community services.

4.2 Low intrusion

Current solutions are often not acceptable due to their intrusion into people's lives. The use of cameras in someone's home is obviously invasive to most people, but even devices of much lower intrusion are also not satisfactory; for example, requiring someone to wear a device may be too high an intrusion, due to the person not wanting, or not remembering, to wear it.

4.3 Globally available

A solution that is globally available has the potential to help more people than a more locally focused one: the more users, the lower the potential cost per user. The availability of hardware and cloud services that work in most developed countries means that there is no need to develop a local specialised service. Any service developed will have to be tested locally to determine any potential issues.

4.4 End user acceptable

Intrusion and cost and their impact on the likelihood of acceptance have already been discussed. Other aspects that may have a bearing are the ease of setup and ease of monitoring, as well as safety.

4.5 Highly reliable

Given the seriousness of the service that the project wants to provide, high reliability is crucial. The project wants a service that not only alerts Carers when there is a problem, but also does not cause unnecessary concern through false positives.

4.6 Ethical

Monitoring of vulnerable people has the potential for abuse if not performed in an ethical manner. We want to produce a system that allows automatic monitoring of people without the need for the Carer to be aware of the daily habits of the person being monitored. We also do not want the system to be seen as a replacement for human contact, but rather as augmenting an acceptable level of social involvement. However, this paper does not enter the debate of how society should care for their vulnerable citizens.

5. MIMS Design and development

The design was based on the idea of using off-the-shelf (OTS) sensors and globally available cloud services. We did not want to build bespoke devices that would not be easily available for others to acquire: we did not want to get into the business of manufacturing. An advantage of using OTS devices is that they have already been approved for domestic use and are unlikely to be a safety concern or affect a person's house or contents insurance. To an extent the design of MIMS depended on the actual choice of sensors and cloud services as each product offered different capabilities.

5.1 Sensor choice

Although there are many types of devices available for monitoring domestic electricity usage, there were a limited number that met all our needs. In evaluating these devices it was obvious that the setup from 'Current Cost' (discussed in section 3.5), best met the requirements of low cost, ease of installation and access to data.

5.2 Choice of cloud service provider

In this project, both GAE and Windows Azure were trialled to determine if they were suitable. It was considered that the Windows Azure development environment was easier to use and more stable than GAE: however the lack of a maximum monthly charge was found to be unacceptable and made this service unusable. The main issues with GAE were the difficulties in setting up the development environment but once set up, the actual service has so far proved very reliable.

5.3 Data flow overview

The Current Cost system measures electricity use either through a current clamp or by inline wall socket sensors. Both methods send electricity usage data wirelessly (433MHz) from the sensor to a central receiver that also displays the usage on a display, see Figure 3. The receiver/display has a wired connection to another device (called the 'NetSmart') that is in turn wired into the home's internet modem/broadband connection. The data is then automatically sent to the company's cloud service where it is eventually made available via a RESTful API interface provided by Xively.

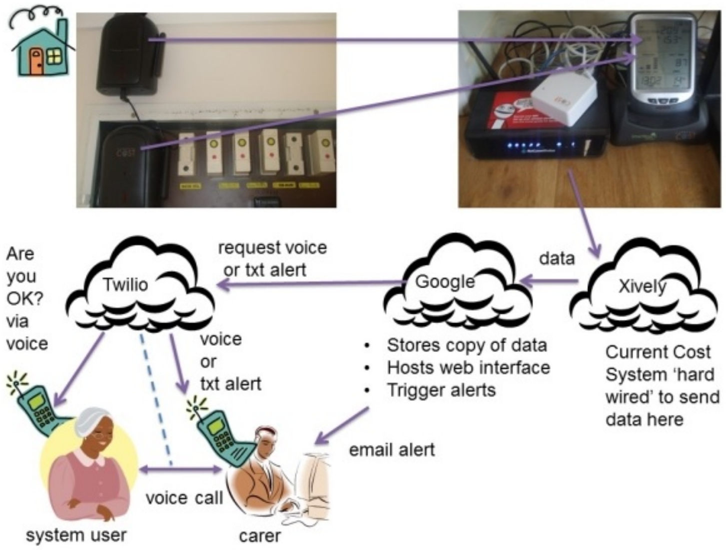

Figure 3. Schematic of the data flow between sensors, receivers and cloud services.

The MIMS logic is an application running on GAE that uses a regularly timed process (known as a 'cron job') to request the data from Xively every five minutes. As data arrives it is stored in the database and then analysed to see if any conditions have been met to cause further data processing.

The GAE application can send out emails directly and also interfaces with the voice and text service provided by Twilio. Depending on the logic configuration, the application may first contact the person being monitored and if the person fails to answer or requires assistance, then MIMS can contact the Carer via email, voice or text message.

5.4 User interface

The MIMS web interface is also part of the GAE application and allows users to set up, configure and interact with the system. Google provides the Google Web Tools (GWT) technology to allow creation of the web interface using the Java programming language. Google supports the Eclipse Integrated Development Environment (IDE) for developing both the Graphical User Interface (GUI) and database side of the applications running on GAE.

There are many options available for transferring data between the GUI and database (known as the datastore). After experimenting with a number of the technologies, we chose to use Remote Procedure Calls (RPC) with Java Data Objects (JDO). Although Google recommends their users use third party tools to hide some of the complexity of using these technologies, the authors encountered many compatibility and dependency issues. We were also concerned about the possibility of being 'locked in' to a technology from a particular vendor and preferred to use the open standards of RPC and JDO. We failed to use RPC/JDO to automatically pass objects that consisted of other non-standard objects but ended up with a robust transfer process that is not dependant on the reliability of third party frameworks.

Different screens were developed for different users of the application. Access to these screens is controlled by the use of the Google user authentication service, which was chosen over the more open standard of OAuth, as it proved much simpler to implement. The Google Authentication Service uses a Google email address as the means of authentication. Screens were developed for four levels of access: Owners, Administrators, Carers and System Users (the people being monitored). The owner of the MIMS (the person who installed the application) only has the ability to create Administrators. Administrators can setup Organisations and Carers. The information for the Organisation includes the details on its associated Twilio account (for text and voice calls) as well as an account balance that can be used for charging and billing purposes (if required). Each Carer is assigned to an organisation and the contact details for the Carer entered. Carers can then log in to set up System Users, Meters and Triggers.

Each System User has contact information entered so that the system can contact them and to allow them to log in. The options are given for the method of contact (email/text/voice) and whether the System User is to be notified before the Carer. Meters are software representations of the electricity meter and record the authentication details of the electricity meter to allow the MIMS to automatically gather the required data. The MIMS uses triggers as the logic method to determine whether an alert should be raised.

6. Demonstration and Evaluation

6.1 Testing in researchers' homes

MIMS was developed in an iterative manner using the home of one of the authors. During this time the system went through a number of iterations as various parts of MIMS were built. At the end of the process MIMS was then deployed to two other homes belonging to other researchers to verify that it worked in a variety of home situations.

6.2 Independent participant

The next stage of the testing was to deploy MIMS to the home of a participant from the cohort of target system users. We presented MIMS to a group from a local organisation (Age Concern) that provides services for older people. Although the uptake of participants was low (only one eventuated) we were able to proceed with testing in a more realistic environment. We obtained informed consent from the participant who was living a very independent and active life. It was made very clear that we were still in the research phase and MIMS was there to help us learn, and not to provide a robust monitoring service at this stage. At the time of writing, data have been collected for four months and data collection is ongoing.

From a technical perspective MIMS performed in a similar manner as when installed in the homes of the researchers.

6.3 Low cost

The ultimate cost of MIMS will depend on the operating profit that a company providing the service aims to achieve. However it is possible to calculate the costs of the system before profit is added. The major difference between this project and other systems is the use of off-the-shelf equipment that is being produced for domestic power consumption monitoring and avoid the use of a dedicated call centre. The services listed in are mostly personal alarm based, and although are not a direct comparison with the system developed, do give an indication of the market pricing of monitoring services.

Table 1. A selection of currently available home monitoring services. Costs are higher in New Zealand than elsewhere. * See text below for explanation of additional costs.

Company / Solution		Type of service	Initial / setup cost (NZ$)	Yearly cost (NZ$)	5 year total (NZ$)	Geographic availability
St John (2014)		Personal alert button	0	1040	5200	New Zealand
Bupa (2014)		Personal alert button	0	1066	5330	New Zealand
			299	702	3809	New Zealand
Mepacs (2014)		Personal alert button	0	396	1980	Australia (Victoria)
BaptistCare (2014)		Personal alert button	197	442	2407	Australia
SA Ambulance Service (2013)		Personal alert button	589	384	2509	Australia
			0	600	3000	
This work	Single sensor	Sensors to monitor activity	368	60*	368	Trials in New Zealand
	Multiple sensors		615	80*	715	

The system developed in this work costs between NZ$268 and NZ$515 to purchase the hardware, depending on how many sensors are used. Current Cost state that a qualified electrician is not needed to install the device, but they do recommend using one if the power is going to be monitored at the switch board. We estimate the cost of an electrician to do this work to be $100. On top of these costs there will be the cost of Xively, Google App Engine and Twilio services. If more than one sensor is used, Xively charge $20 per year after the first two years. During the course of this work we have stayed below the point that Google charge for their services (free quota), but if more users were to be monitored this would no longer be the case. We anticipate that the costs of actual resource use on a per-user basis to be less than $50 per year, but could be significantly less. The cost of the Twilio service is dependent on how many alerts are sent and how often the User to Carer voice connection is used. However, given that the service is designed for the occasional need for intervention, the Twilio costs are likely to be below $10 per year.

The main cost-saving features of MIMS are the low ongoing costs of monitoring achieved by sending alerts directly to the person's Carer rather than via a call centre.

6.4 Low intrusion

There are two different aspects of intrusion: the disturbance to the user, and the effect of being monitored.

Unlike other systems where the user is required to wear a neck or wrist device the user does not have to significantly change their lifestyle for MIMS to work. However, there were still instances of disturbance. First of all the initial setting up of MIMS in the person's home required a two hour visit by the researchers and electrician. It is likely that this time could be significantly reduced when not in a research setting and when the installation procedure becomes routine. The location of the user's modem meant that the network connection was beside the user's bedside, which resulted in the monitor being inconveniently placed on the bedside table. She also became concerned about the cost of the electricity being used to power the equipment and was considering withdrawing from the study due to cost. Although we felt that the costs were low compared with her TV system on standby, it was still a cost for a person on low income and so these costs were covered by the research.

The user did not raise any concerns about being 'watched'. In fact the opposite was true in that she now knew that she was using a system that had the potential to inform her Carer if she was inactive for an extended period.

6.5 Globally available

The concept of using 'off-the-shelf' devices along with cloud services gives our system the potential of being globally available. The Current Cost device can be bought through a number of website outlets and the Current Cost website also list partners in 17 countries in Europe, three in the Americas (including the US), two in Africa as well as Australia and New Zealand. Use in other countries may depend on the available power supply and a lawfully available radio frequency.

Consideration of various time zones has been part of the development process. When triggers are set up, the start and end times need to be in the local time zone. The time used needs to be aware of the time zones of the three cloud services being used as well as that of the actual user. In the spirit of rapid prototyping this need was not always adhered to, but the developers are confident there is no 'show stopper' in making sure time zones are taken into account.

6.6 End user (System User) acceptable

We have demonstrated that MIMS is regarded by the System User as being capable of low intrusion. We designed the system to be flexible in dealing with alerts. MIMS can be set up to call the Carer directly or first try to call the System User. This way the Carer is less informed – making a less intrusive system. The System User can also disable monitoring if they wish to, through a website. However this was found to be inconvenient and the System User requested that a text based method for disabling the system would be more useful. Unfortunately the Twilio service does not provide a New Zealand based phone number that can receive text messages. As MIMS is currently being tested in New Zealand, we did not think it suitable to expect System Users to incur the cost of sending a text to an overseas number. Hopefully this will change in the near future.

The Current Cost hardware has performed flawlessly and continuously from the initial 'first looks' through to the current deployment. This supports the claim by Current Cost that nearly three million devices have been sold. The GAE and Twilio cloud services have also shown to be very robust and no instances of their services failing have occurred during this work. Although the software we developed was designed to be robust (and has proven to be so), we accept that we are still operating at a small scale and the code will have much room for improvement; for example more use of queuing requests could be implemented to allow for complete recovery from a mid-process failure. However, this does not detract from the robustness of the basic premise of the technical approach followed in the design and implementation.

Of more interest is the question of 'Can electricity usage monitoring be used to reliably alert Carers of a potential problem?' MIMS currently uses logic based on a single point of measurement to determine if an alert should be raised. Although the logic worked soundly, it is by no means the best logic to provide a reliable determination of whether there is a problem. For example, on one occasion where it was known that the System User was leaving the property for an extended period, MIMS did not alert the Carer as soon as might be reasonably desired. The decision to alert the Carer was based on whether the System User's electricity consumption had (not) risen above 600 Watts at any point during the day. On the day she left the premises this level was achieved by having breakfast at home, so it wasn't until the end of the following day, that an alert was raised. Therefore if something serious had happened to the System User on the first day (after breakfast) the Carer would still not have been informed until the end of the next day – 8pm for the logic being used. Further to this, it was also realised that the logic will fail when the System User starts to use their heat pump with the automatic timer function. This now seems obvious but it does highlight the need to create robust logic for determining when an alert should be raised. Further it also highlighted the fact that it would be very useful to determine if the System User was on the property or not.

We believe that we have built a flexible system that can be used in an ethical manner and the current trial has been implemented with due consideration of ethical concerns. The nature of the data being collected (electricity usage) is inherently minimally intrusive and therefore helps to create an ethical means of monitoring. MIMS has been designed so that the degree of control given to the end user can be varied: more autonomy for more independent and higher functioning System Users and less autonomy for more dependant persons.

Two examples of features giving control to the System User are:

- If MIMS 'thinks' there may be a problem, it can first try to contact the System User to give them the opportunity to 'cancel' the potential alert to the Carer. In this way, the System User can change their normal behaviour without the system immediately informing the Carer.
- The System User can disable the monitoring for a set period of time - for example they are leaving their residence or perhaps having a party!

We acknowledge that MIMS could be used in an unethical manner but would respond that this is the case for many technologies and the risk of this happening does not outweigh the potential benefits of the system.

7. Conclusions and discussion

We have shown that the availability of 'off-the-shelf' consumer devices for domestic electricity measurement along with cloud services can form the basis of a low cost, minimally intrusive system for monitoring the wellbeing of people living independently. The system developed (MIMS) has potential to be used in a global setting.

Further work needs to be done on the development and implementation of more useful and robust logic for determining if the person being monitored requires assistance - especially in a timely manner. The means by which the System User interacts with MIMS can also be improved, in particular providing a text-based interface to give them more control and autonomy.

MIMS is capable of calling the System User first to see if they need assistance. However, there needs to be more work done on the ability of MIMS to distinguish between a person answering the phone and voice mail answering. This may just involve requiring the System User to press a number on the phone to indicate that all is well.

The ability to determine if a person is on the property or not was also highlighted. If MIMS knows this then it would be possible to write logic that monitors on a smaller time interval, yet avoid the creation of too many false positives.

It was disappointing to have a low number of participants involved in the trail. The reasons for this may have been partly due to our requirement for the users to have an internet connection as only half of the group did. It was also felt that we were not able to explain clearly to this particular group what the purpose of the trial was. Ongoing work is looking at using a 3G network connection and also involving the Carers more in the recruitment process.

8. Acknowledgements

We are greatly indebted to Age Concern Hamilton who gave us a platform for recruiting participants and even more so to the anonymous users of the system - thank you.

9. References

AlertMe. (2013). *Products and services*. Retrieved February 15, 2013, from https://www.alertme.com/how-we-do-it/products-and-services/

Amazon web services. (2013). *Amazon web services*. Retrieved February 15, 2013, from http://aws.amazon.com/

BaptistCare. (2014). *Our Services*. Retrieved May 8, 2014 from https://baptistcare.org.au/

Baxter, K., & Glendinning, G. (2011). Making choices about support services: disabled adults\u2019 and older people\u2019s use of information. *Health and Social Care in the Community, 19*(3), 272-279.

Blue Line Innovations. (2010). *Energy Monitor*. RetrievedFebruary 15, 2013, from http://www.bluelineinnovations.com/

Brownsell, S., & Hawley, M. 2. (2004). Automatic fall detectors and the fear of falling. *Journal of Telemedicine and Telecare, 10*(5), 262-267.

Bupa. (2014, 05 08). *Medical Alarms*. Retrieved from http://www.bupa.co.nz/medical-alarms/

Current Cost. (2013). *Save money and cut your electricity waste: Products*. Retrieved February 11, 2013, from http://currentcost.com/products.html

Dudman, J., & Meyer, J. (2012). Understanding residential home issues to meet health-care needs. *British Journal of Community Nursing, 17*(9), 434-438.

Enistic. (2012). *Plug-in smart meters*. RetrievedFebruary 15, 2013, from http://www3.enistic.com/enistic-plug-in-meters

Franco, G. C., Gallay, F., & Berenguer, M. (2008). Non-invasive monitoring of the activities of daily living of elderly people at home \u2013 a pilot study of the usage of domestic appliances. *Journal of*

Telemedicine and Telecare, 14(5), 231-235.
Google. (2013,). *Google Developers: Google App Engine: Users Java API Overview*. Retrieved February 12, 2013, from https://developers.google.com/appengine/docs/java/users/overview
Health and Welfare Information Association & Japan National Council of Social Welfare. (2013). *40th Int. Home Care & Rehabilitation Exhibition.* Retrieved February 15, 2013, from http://www.hcrjapan.org/english/hcr2013/pdf/general_information.pdf
Herzog, A., & Lind, L. (2003). Network solutions for home health care applications. *Technology & Health Care, 11*(2), 77-87.
Hevner, A. R., March, S. T., Park, J., & Ram, S. (2004). Design science in information systems research. *MIS Quarterly, 28*(1), 75-105.
Hyysalo, S. (2004). Technology nurtured \u2013 Collectives in maintaining and implementing technology for elderly care. *Science Studies, 17*(2), 23-43.
Katz, S. (1983). Assessing self-maintenance: Activities of daily living, mobility, and instrumental activities of daily living. *Journal of the American Geriatrics Society, 31*(12), 721-727.
Kerbler, B. (2012). Ageing at home with the help of information and communication technologies. *Geografski Zbornik / Acta Geographica Slovenica, 52*(1), 166-179.
Lai, O.-K. (2008). The enigma of Japanese ageing-in-place practice in the information age: Does digital gadget help the (good) practice for inter-generation care? *Ageing International 32* (3), 236-255.
mepacs. (2014). *Home*. Retrieved May 8, 2014, from http://mepacs.com.au/
Microsoft. (2013). *Windows Azure*. Retrieved February 15, 2013, from http://www.windowsazure.com/en-us/
Monekosso, D. N., & Remagnino, P. (2007). Monitoring behavior with an array of sensors. *Computational Intelligence, 23*(4), 420-438.
Murphy, T. W. (2011). Energy on the home front. *AIP Conference Proceedings, 1401*(1), 353-366.
NetRC Systems Inc. (2013). *NetRC1 WiFi remote power switch*. Retrieved February 15, 2013, from http://www.mynetrc.com/home/info
Netten, A., Darton, R., Beebbington, A., Forder, J., Brown, P., & Mummery, K. (2001). Residential and nursing home care of elderly people with cognitive impairment: prevalence, mortality and costs. *Aging & Mental Health, 5*(1), 14-22.
P3 International Corporation. (2013). *Kill a watt*. Retrieved February 15, 2013, from http://www.p3international.com/products/special/p4400/p4400-ce.html
Peffers, K., Tuunanen, T., Rothenberger, M. A., & Chatterjee, S. (2007). A design science research methodology for information systems research. *Journal of Management Information Systems 24*(3), 45-78.
Powerhouse Dynamics. (2013). *Residential eMonitor Overview*. Retrieved February 15, 2013, from http://www.powerhousedynamics.com/residential-energy-efficiency/
Rauhala, M., & Topo, P. (2003). Independent living, technology and ethics. *Technology and Disability, 15*(3), 205-214.
SA Ambulance Service. (2013). *Home*. Retrieved May 8, 2014, from http://www.saambulance.com.au/
Sahare, S., Joshi, M., & Gehlot, M. (2012). A survey paper: Data security in local networks using distributed firewalls. *International Journal on Computer Science and Engineering, 4*(9), 1617-1622.
Sailwider Electronics. (n.d.). *Manufacturer of smart electricity energy saving monitor and control system*. Retrieved February 15, 2013, from http://www.sailwider-smartpower.com/
St John. (2014). *Medical alarm equipment*. Retrieved May 8, 2014, from http://www.stjohn.org.nz/Medical-Alarms/Medical-Alarm-Devices/
Szczepura, A., Nelson, S., & Wild, D. (2008). In-reach specialist nursing teams for residential care homes: uptake of services, impact on care provision and cost-effectiveness. *BMC Health Services Research, 8*, 269-283.
Tang, Y., Deng, F., & Xiong, J. Y. (2005). The investigation of the elder's monitoring system based on life supplying line. *IEEE International Conference on Industrial Technology.* Hong Kong: IEEE.
thinkeco. (n.d.). *All Products*. Retrieved February 15, 2013, from http://themodlet.com/products.html
van Nimwegen, N., & van Erf, R. (2010). Europe at the crossroads: Demographic challenges and international migration. *Journal of Ethnic and Migration Studies, 36*(9), 1359-1379.
Vaquero, L. M., Rodero-Merino, L., Caceres, J., & Lindner, M. (2009). A break in the clouds: Towards a cloud definition. *ACM SIGCOMM Computer Communication Review, 39*(1), 50-55.
Wapner, S., Demick, J., Yamamoto, T., & Takahashi, T. (1996). *Handbook of Japan-United States environment-behavior research.* New York: Plenum Press.
wattvision. (2013). *Consumer Products*. Retrieved February 15, 2013, from http://www.wattvision.com/info/products
Xively by LogmeIn. (2014, 05 08). *Your connected business starts with Xively by LogMeIn*. Retrieved May 8, 2014, from https://xively.com/
Zwijsen, S. A., Niemeijer, A. R., & Hertogh, C. M. (2011). Ethics of using assistive technology in the care for community-dwelling elderly people: An overview of the literature. *Aging & Mental Health, 15*(4), 419-427.

Journal of Applied Computing and Information Technology (JACIT): ISSN 2230-4398
(Incorporating the Bulletin of Applied Computing and Information Technology, NACCQ: ISSN 1176-4120 and
Journal of Applied Computing and Information Technology, NACCQ: ISSN 1174-0175)

Michael Verhaart, Donald Joyce and Nick Wallingford (Eds.).

An Open Access Journal, DOAJ #22304398, (✓zotero)