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Conference papers

Liverpool Telecare Pilot: case studies

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ABSTRACT

Telecare services use information and communications technology (ICT) to support the provision of care to people in their own homes. This paper describes a pilot telecare service employed by Liverpool (UK) City Council to support a sample of their frail and elderly social services users. The pilot has been running for over two years and has been deployed for 21 individuals in Liverpool. In this paper we present the pilot system and provide real example cases which help to illustrate the benefits of such a system.

Keywords: elderly, ICT, telecare

Introduction

It is widely acknowledged that the rising elderly population and falling carer support ratio, witnessed in most developed countries, renders many of the current care provision models for older people unsustainable.[1–3] In the future, adult social care must embrace new models that help to effectively manage the labour-centric nature of social care and assist with the efficient use of the available resources. One potentially important innovation within the care domain is the ability to remotely support care provision by means of information and communications technology (ICT) to people, known as service users, in their own homes; this is often referred to as telecare. The appeal of telecare for service users is the promise of increased choice and independence through the provision of enhanced safety and security. Interest in telecare has existed for a number of years, but recently the impetus in the UK has increased, partly fuelled by central government and the introduction of Preventative Technology Grants.[4] These grants are designed to allow councils and their primary care trust (PCT) partners to implement telecare initiatives.

The concept of telecare constitutes a broad proposition that encompasses a number of different technologies and addresses a number of specific care issues. Currently, many research groups are active in examining different approaches to telecare provision.[5–7] In this paper we report on a pilot telecare service that began in Liverpool, UK in February 2004 and is due to conclude by the end of 2006. An overview of the pilot is provided which focuses on the unique aspects of the system deployed in Liverpool. Real-life examples are also provided to demonstrate the value of such a system.

Liverpool Telecare Pilot

Overview

The pilot service[8] is provided by British Telecom (BT) and Liverpool Direct Ltd (LDL) to Liverpool City Council (LCC). Over the duration of the pilot the telecare solution has been installed in the homes of 21 of LCC's elderly and frail social services' clients. The solution was designed to assist LCC in maintaining the independence, safety and security of such individuals within their own homes. Consequently, it is also seen as helping to prevent, or delay, a move to the next level of care support such as sheltered accommodation or nursing homes. The Liverpool collaboration builds upon earlier work undertaken by BT in conjunction with the Anchor Trust[9] and the UK collaborative Millennium Homes project.[10] The aim is to provide a proactive monitoring solution that can automatically flag situations of cause for concern relating to the well-being of a service user within their own home.

Service model

The Liverpool telecare system does not require the monitored service user to wear or carry any devices, nor are they required to interact with a complex user interface. The system uses ambient sensors to continually monitor the service user's activity levels and behavioural patterns within their home, combined with intelligent data analysis to determine situations of cause for concern resulting from a departure from the individual service user's normal behaviour. The service provision model uses a direct connection into Liverpool's existing call centre infrastructure, operated by LDL, and their social service delivery teams, to allow for the direct action of social services in response to such situations that are flagged to them.

When a cause for concern is identified it is communicated to remote servers for action to be taken. The first response of the server is to deliver an automated voice message to the service user via their normal telephone. The automated call alerts the service user to the situation and asks whether they are OK or are in need of assistance. The service user responds by pressing an appropriate key on the telephone keypad. If the service user does not cancel the alert, then it is escalated as an alarm to the LDL call centre. This is achieved through the combination of a second automated telephone call (this time to the LDL call centre) and the updating of a dedicated web-based terminal in the call centre. The terminal provides the call centre operator with access to additional information about the service user and the type of alarm raised, together with carer contact details and a summary of recent activity within the service user's home. The operator can either intervene directly by calling the service user for themselves, or by alerting a third party such as a local carer (typically a relative or neighbour). Once an alarm has been dealt with the system also maintains a log of the operator's comments on the particular alarm. An overview of this service model is shown in Figure 1.

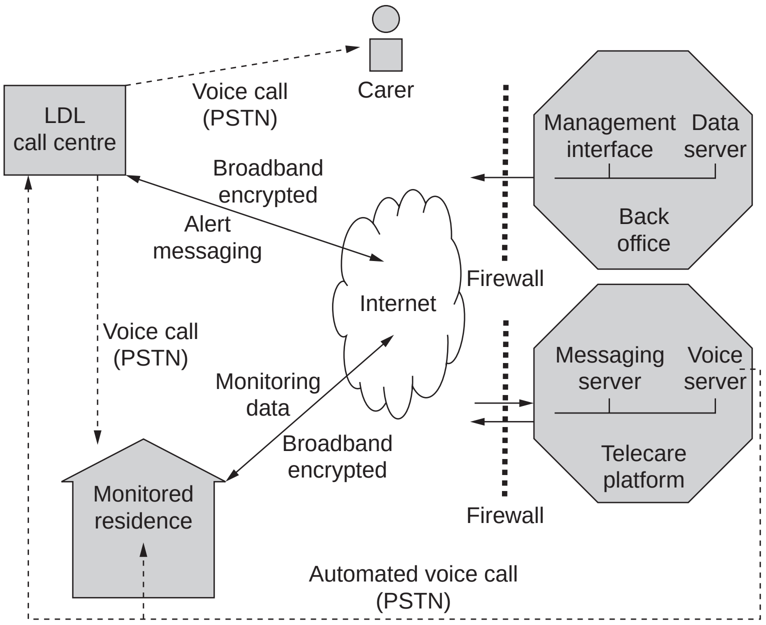

Figure 1 Overview of interactions forming the telecare service

Technical overview

The telecare system comprises a single monitoring unit that is located within the home environment, usually referred to as the residential monitoring unit (RMU). It acts as a gateway for any wireless or wired sensors located within the home and the remote server systems. An always-on connection between the RMU and the servers is maintained using an ADSL broadband network connection.[11] Activity levels of the service user are derived from wireless sensors such as passive infrared motion detectors and other sensors (bed occupancy, toilet usage, fridge/freezer usage, door/window opening, and so on) connected to wireless transmitters; a typical installation consists of approximately 20 sensors. The data generated by the various sensors are processed within the RMU on a single-board computer, which hosts a telecare software client.

The telecare software determines two types of situation that may be a cause for concern. The first relates to the activity levels of the service user whilst they are in their home and flags instances when there is an abnormal duration of lack of activity or lack of room change. The second type of situation relates to the status of devices within the home, such as doors and windows being left open or the temperature being too low. This latter type of situation uses fixed thresholds (typically separate for day and night) for the allowable duration of such events. These durations are agreed with the service user and their carers. The former situations are of the most interest and are where this telecare system differentiates itself from other offerings.

Algorithmic overview

The system deployed in Liverpool uses adaptive threshold algorithms to create personalised thresholds, based on an individual's behavioural patterns, for abnormal activity detection. The approach aims to create thresholds that are optimal for the individual service user, the time of day and the room occupied. The need to incorporate these three aspects can be seen in Figure 2, which shows an example of the typical daily activity profile for two service users involved in the Liverpool Pilot. Comparison of the less active service user in Figure 2(a) and the more active service user in Figure 2(b) shows that activity levels vary dramatically by service user, time of day and room. A satisfactory telecare system should employ an alerting protocol that is capable of accounting for such lifestyle variations.

The two algorithms deployed, 'lack of activity' and 'lack of room change', initially use a set of generic thresholds as starting values. The algorithms then automatically adapt these thresholds over time, as the individual's behaviour is learned. This approach differs from existing telecare systems that utilise fixed thresholds and typically do not differentiate between time of day or room. Traditionally, these thresholds can either be (a) subjectively fixed at values appropriate for the user in question, or (b) fixed for the entire user base using some form of aggregation method. The drawback of the former technique is that it is an extensive and laborious task to subjectively fix each of the thresholds for the different room zones and time periods of all service users. The latter technique is much simpler, but due to lifestyle variations among

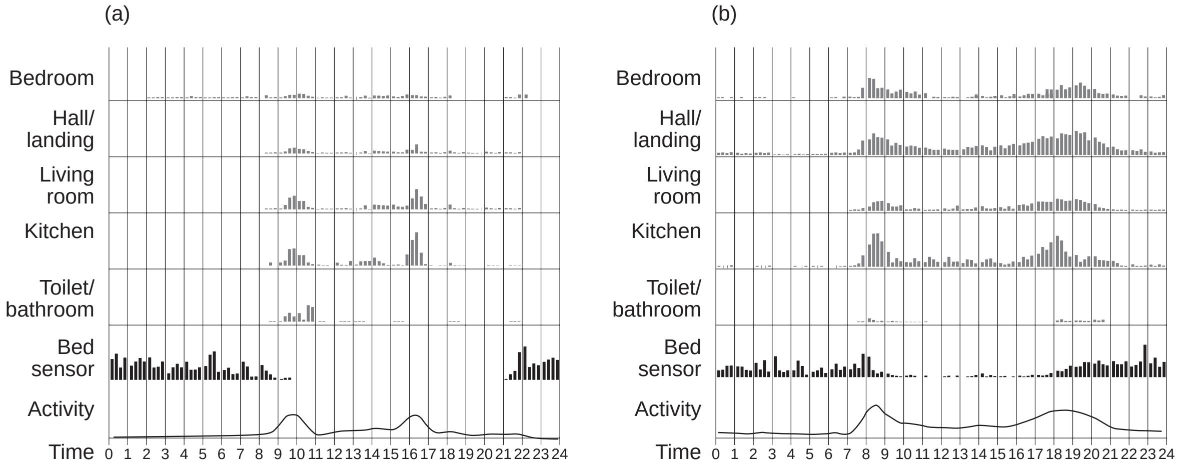

Figure 2 Activity profiles. The first five rows show the level of activity for particular rooms, the next the activity for the bed pressure sensor, and the final row the overall level of motion detected in the home. The figures show data averaged over 20 weeks. Profiles are shown for a less active service user (a) and a more active service user (b).

individuals such a 'one size fits all' solution is unlikely to be suitable. The less active service user would receive a very high number of alerts (that is, over-sensitive and constituting an annoyance); on the other hand, the more active service user would receive an extremely low number of alerts (that is, too insensitive and with a slow response to genuine events). In general, existing solutions do not employ motion sensors in each room of the home either. Typically, they deploy just one or two motion sensors and therefore an inherent form of aggregation is again used; gross thresholds are applied to multiple rooms and a similar sensitivity level problem exists.

The algorithmic approach developed for use in Liverpool provides time resolution for the thresholds by dividing the day into six four-hour time periods, each period having an independent threshold associated with it. Similarly, the service user dwellings are divided into five independent zones: lounge, kitchen, bathroom/toilet, hall/landing and bedroom. This ensures the thresholds are appropriate for the individual rooms, whilst still adopting a pragmatic standard across differing accommodation types and sizes. The combination of zones and time periods therefore produces 30 independent thresholds for each service user. The thresholds are determined using a Bayesian decision theory approach which allows the thresholds to be created automatically and in a near-optimal manner.

Discussion

The service users involved in the pilot were referred to the pilot team by social services from their existing client base. To provide guidance on client selection, a set of suitability criteria was provided. The criteria stipulated that service users should live alone, be frail but relatively mobile, and not be recipients of frequent care visits. However, the criteria were not rigidly enforced and the final pilot user base was perhaps a more accurate reflection of the social service client base. Typically the service users were aged over 80 years and lived alone but had a high dependency on social services; they often had mobility problems. They included 'complex cases' (such as very frail users with dementia living in their own homes and in receipt of multiple home care services) and referrals to occupational therapists within the local PCT. The pilot has been running since February 2004 and the duration of each service user's involvement with the pilot has varied greatly, from over 12 months to just a few weeks. The variation exists because service users joined the pilot at different times and also because, for a variety of reasons, some of the service users moved from their dwellings during the course of the pilot.

The pilot has helped to examine both the benefits of telecare and also the challenges faced when offering such a service. The clearest evidence of the benefits of such a system comes from the anecdotal evidence provided by the LDL terminal entries associated with each alarm. Two examples are provided here to give an indication of the value of the system to the individual service users; the comments have been paraphrased to maintain anonymity:

- Example 1: A no-activity alarm indicated that the service user had been detected entering their bathroom late at night but no movement had been detected for approximately 30 minutes. The terminal entry read: 'Rang service user, who said she felt very ill; I then rang her daughter who was going round right away.'
- Example 2: A no-room-change alarm indicated that the service user had exceeded the threshold for time they would normally spend in the bedroom. The terminal comment read: 'Called service user. When she answered she was out of breath and said "I can't breathe" and the line went dead. I called an ambulance and also her carer who was not at home at the time. Ambulance is en route.'

The first example is particularly pertinent as it demonstrates that even short durations of inactivity can represent causes for concern. As previously mentioned, telecare thresholds will always need to be a balance between increased sensitivity and false alarms. Other authors have examined methods of threshold setting,[12–14] but a unique aspect of the adaptive threshold-setting algorithms used in Liverpool is that they address the issue of sensitivity in a very direct manner through the use of utility values.[15] These values allow real-life decision-making influences to be reflected in the threshold-setting procedure. There is still a sensitivity compromise, but adopting a utility theory-based approach ensures it is made in an equitable and evidence-based manner for all service users. The adoption of such an approach allows the sensitivity of the system to vary according to the activity level of each individual service user: relatively high thresholds will exist for service users who are regularly inactive and relatively low thresholds will exist when extended periods of inactivity are unusual.

The sensitivity trade-off influences the number of false-positive and false-negative events that occur. The false negatives, occasions when a situation of concern existed and an alarm was not generated, were not examined in detail by the research team as detailed care notes were not available. However, an indication of false positives, occasions when alarms were raised and a situation of concern did not exist, was available. The most frequent (and serious) example of false positives occurred when a service user had left their dwelling and alarms were still raised. The source of these was not a result of the threshold-setting procedure but of intermittent transmission problems between the wireless door sensors and the RMUs. These problems meant that on occasions door sensor events were missed and the system believed a service user was motionless in their hall, when in reality the dwelling was vacant. This was particularly concerning as a carer would not receive a response if they attempted to contact the service user at the dwelling. To partially compensate for this the call-centre operators were, where possible, provided with details of the day-care schedules for the service users. This allowed them to confirm the service user was well, and the alarm could be cancelled, by contacting the relevant day-care centre. Such local knowledge was also provided by the informal carers and developed by the LDL operators themselves through their interactions with the service users.

The Liverpool Pilot has enabled various aspects of telecare to be examined in more depth, including new sensor technologies, novel adaptive algorithms and the integration of telecare within social services. Additionally, the project has contributed to the development of new algorithms and collected a large quantity of lifestyle data for a potential telecare user base. It did not, however, attempt to rigorously track the type of information necessary for constructing confusion matrices, Receiver Operating Characteristic curves and other techniques used in the evaluation of the performance of statistical classification algorithms.[16] Costs and care outcomes were also not tracked and consequently cost–utility analyses were not undertaken. The decision not to track such information was primarily due to the scale of the pilot, the numerous influential factors and the extreme difficulty in gathering the necessary information. However, it is acknowledged that both these pieces of work would have been useful, particularly in the context of understanding the financial implications of such systems and in creating the necessary business cases.

Conclusions

The Liverpool Pilot is believed to be unique in its trialling of a decision theory-based adaptive algorithm approach to activity threshold setting. This is valuable as the widespread impact of telecare is reliant on the creation of systems that are flexible enough to meet the requirements of as diverse a user base as possible.[17] The pilot also helped to highlight the technological challenges still to be faced, including the collection of reliable data using robust, low-cost and low-maintenance sensor networks, and the development of more advanced algorithms. The pilot is undergoing independent evaluation and, at the time of writing, the evaluator's report is still pending. Preliminary output has shown overwhelming support for the system across stakeholder groups. Reassurance for the service users in having 'someone watching over them' is a key factor and goes beyond any reassurance derived from the existing community alarm devices that most users in the pilot had and retained. This also suggests value in a degree of false-positive alarms to provide a reminder and assurance that the system is in operation. An increased level of confidence that reassurance can provide offers additional positive benefits. For instance, it has been observed by carers that one service user who was prone to falls has fallen less since being in the pilot. This is believed to be as a result of the user's increased level of confidence brought about by the system.

Through small-scale trials, such as the Liverpool Pilot, it is difficult to quantify the benefits of telecare for a particular stakeholder. The complexity of its potential impact on health, housing, social care outcomes and economic outcomes make the benefits of telecare difficult to articulate clearly.[18] It is generally recognised that there is growing anecdotal evidence, like that given here, in support of a positive impact for telecare on the care provision for elderly and frail individuals.[18] However, rigorous cost–utility analysis for telecare does not yet exist. The challenges ahead would seem to lie as much in defining workable business cases, and service provision models, as they do in developing new technologies.

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CONFLICTS OF INTEREST

None.

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