Co-Designing Equitable Internet of Things Solutions with Lifetime Communities

Dirk Pesch[1], Patrick Mulvihill[2], Kieran Delaney[1], Jane O'Flynn[3]

[1]Nimbus Research Centre, Cork Institute of Technology, Cork, Ireland
[2]Independent Living Ireland and Amicitia, Athenry, Co. Galway, Ireland
[3]Health Innovation Hub Ireland, Cork Institute of Technology, Cork, Ireland

Abstract

The Internet of Things (IoT) is one of the leading developments in the ICT sector today. The IoT offers the potential for a vast range of applications from smart homes to energy efficiency, to connected health and assisted living. IoT for assisted living is expected to alleviate many of the problems that our health systems suffer from in dealing with an increased number of older and also disabled people. While these technologies have the potential to help older people live on their own safer and for longer, there are significant challenges around equity, inclusion and adoption. There are also challenges with access as online access often reflects (and exacerbates) offline economic, social, and cultural disparities. In this paper we describe two avenues of research; firstly we are investigating the use and design of smart home and assisted living technologies, specifically fall detection technologies, and how they are suited to the concept of lifetime communities. Secondly, we are exploring how a co-design approach, based on the principles of Universal Design (UD), developed with representatives of such lifetime communities, can guide us to better, more inclusive assisted living technology and associated sustainable business models.

Introduction

Technology is viewed as the solution to many of our societal problems without recognizing that these problems are often not amenable to a simple technological fix. As new technologies continue to emerge, it is essential to change this dynamic and move towards new approaches that place people at the centre of how these problems are solved. The Internet of Things (IoT) is one of the leading drivers of change in the technology sector today. The applications and opportunities of IoT appear vast and there is much excitement about their potential. Applications under development range from smart homes to energy efficiency, to connected health and assisted living. However, over the past hundred years, innovation has largely been delivered within a technology-focused, top-down, market-based system that values what is seen as 'positive' disruption and largely ignores existing social and institutional conditions and needs. The emergence of the Internet of Things, heralding statements such as its expected value is to exceed one trillion euros in the EU by 2020 is somewhat representative of this approach. It is based on assumptions that technology can make our homes better places to live and cities and communities more economically prosperous and equal. While this can become true, it ignores the 'negative' aspects of the disruptive push, where the new solutions have to find a way to work beside existing legacy technologies and to work within social 'norms' and practices that change relatively slowly. The approach we advocate here is social enterprises that put their social mission first and then seek innovative solutions which can drive revenues at an enterprise level. This ensures that they are both economically viable and capable of delivering a positive social impact.

Within this context, we are currently undertaking two projects that assess and co-design IoT based assisted living technologies for lifetime communities. The objective of a lifetime

community is to foster healthy and successful ageing across the lifespan with benefits for all residents from the young to the old and people with temporary or permanent disabilities alike. A smart lifetime community creates an ecosystem made of stakeholders including the public, community groups, businesses and local authorities. Such communities recognise the importance of citizen engagement to understand better their needs and also to enable people in the community to improve their daily lives and community themselves. In the project we considered the Amicitia lifetime community. Amicitia delivers technology and social supports to empower socially disadvantaged members of society and build smart, sustainable communities (Amicitia 2018, ILI 2018a). Amicitia's enterprise model is guided by the United Nations Sustainable Development Goals (UN 2015) and Universal Design practices. It includes a technology platform, which will build on the features of existing smart technologies and extend these, using the next generation 'Internet of Things' applications to support the elderly and those with disabilities.

IoT technology can play an important role in the success of Lifetime Communities. While it is well understood by designers and developers of smart homes and home health-monitoring technologies that involvement of the community is important for the success of these technologies (Reeder et al. 2013), the reality is that such involvements are still the exception than the norm. We studied the suitability of fall detection technologies to the concept of lifetime communities by assessing how well fall detection technologies comply with the seven principles of universal design (Connell et al. 1997), which promote accessibility, equity and inclusivity. We found that current technologies, while increasingly functional and sophisticated, are lacking in these features. This is leading to a lack of access and widespread use of fall detection technologies. We are also studying how co-design methodologies involving a communities of practice approach and real participatory experiments in rural communities can lead to more equitable, accessible and inclusive assistive technologies. Our hypothesis is that such a co-design approach using universal design principles will lead to more equitable IoT technologies for lifetime communities. We are currently in the process of testing this hypothesis in a project developing and deploying a community assisted living platform in conjunction with local community groups in Mitchelstown, Co. Cork, Ireland.

IoT for smart homes and assisted living - challenges in delivering equitable access in lifetime communities

Smart homes can play a significant role in the success of a smart city or community. A smart home uses smart technology devices that allow the home and its contents (including its occupants) to be monitored. It can sense physical parameters (temperature, light, smoke and carbon monoxide sensors), detect events (intruder, fall and water detection) and control appliances within the home (Chan et al., 2008), (Alam et al., 2012). Figure 1 shows the breadth of smart home technologies ranging from entertainment, to comfort, to security management and access control. Recently the monitoring of occupants' activities and health has also become part of smart home technology. This technology can assist the occupants in many daily tasks and can often be controlled automatically or remotely via a user's smartphone, computer and more recently voice controlled via Amazon Alexa, Microsoft Cortana, Apple Siri and Google Smart Hub enabled devices.

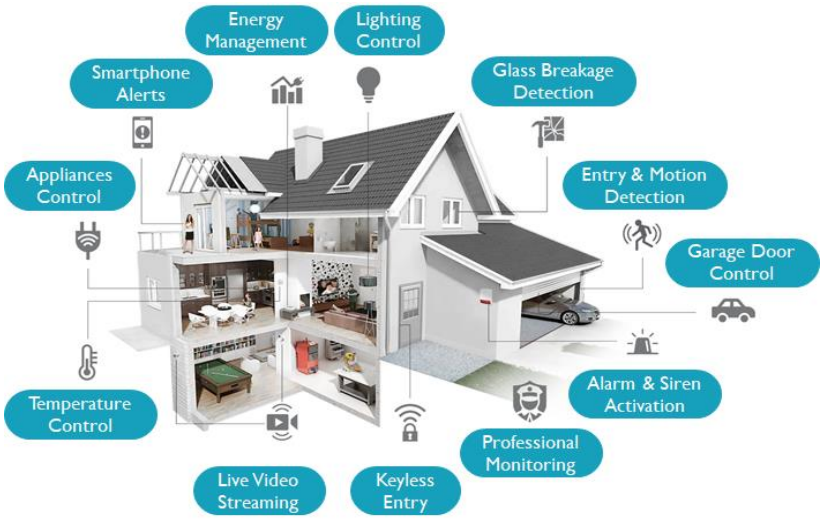


Figure 1: *The ABC's Smart Home Technologies, (Corvello 2017)*

As IoT for smart home and communities encompasses a broad variety of technologies, we focused on fall detection technologies. Falls are a highly significant risk factor to health for an ageing population. There is on average a 15% likelihood of a long lie resulting from a fall for those aged 65 years and over (Bloch 2012) and with lie times of more than 72 hours increasing mortality by 67% (Gurley et al. 1996).

We assessed fall detection technologies using the Universal Design (UD) methodology. UD has seven principles: Equitable Use, Flexibility in Use, Simple and Intuitive Use, Perceptible Information, Tolerance for Error, Low Physical Effort, and Size and Space for Approach and Use. We reviewed a wide range of assistive and fall detection approaches and technologies, both from the scientific literature and commercially available products.

We also engaged with stakeholders to gathered primary data through interviews with individuals and groups from various different backgrounds. This included 35 meetings or visits with 64 stakeholders as well as individual interviews with a further 67 participants from 9 different categories including elderly people, family members and care givers, health care professionals and technologists. Our findings can be summarised as follows:

- High degree of fragmentation with many barriers to integration.
- Major problems with interoperability of assistive technologies with other smart technologies within the home.
- Despite significant research and development newer technologies have low maturity and lack person centric-design
- Lack of supportive infrastructure, helping people to access assistive technologies
- Lack of integration of assistive technologies into the wider health care services system.
- Costs of assistive technologies were cited as a barrier to uptake although 46% of users were willing to pay more for better technologies and services, such as automatic fall detection and alerting.

We found that fall detection products show weak application of Universal Design methods, particularly in supporting the needs of older people (Thilo et al. 2016). There are significant design issues, particularly around accessibility, levels of flexibility and adaptability, the cost and reliability of the products, as well the level of support available, and the lack of integration

in the services they provide. Reliability is another key issue with fall detection technologies having varying degrees of accuracy with commercial automatic fall detection technologies showing accuracy of between 87% down to just over 70%, which means between 2 and 3 in 10 falls are undetected (Preece 2018, Chaudhuri et al. 2015). The interviews showed that technological advances are leading to solutions being introduced that are not well understood by users and not well supported after installation and commissioning. This 'delivery' stage is often viewed as the final 'successful' step rather than the initial stage of operation. We found that users' perception of fall detection services can even be negative, with wearable fall detection technology carrying a stigma or privacy concerns. Fall schemes, while providing support, can also act to label people. This can have an isolating effect. We found that simple technologies such as pull cords, alert strips are in use and well understood. However, newer technologies originating both in the smart built environment as well as consumer devices, such as wearable technologies are advancing fast but are often not known or are at an early development stage and not yet commercially available.

Exploring Participation and Co-Design in Lifetime Communities

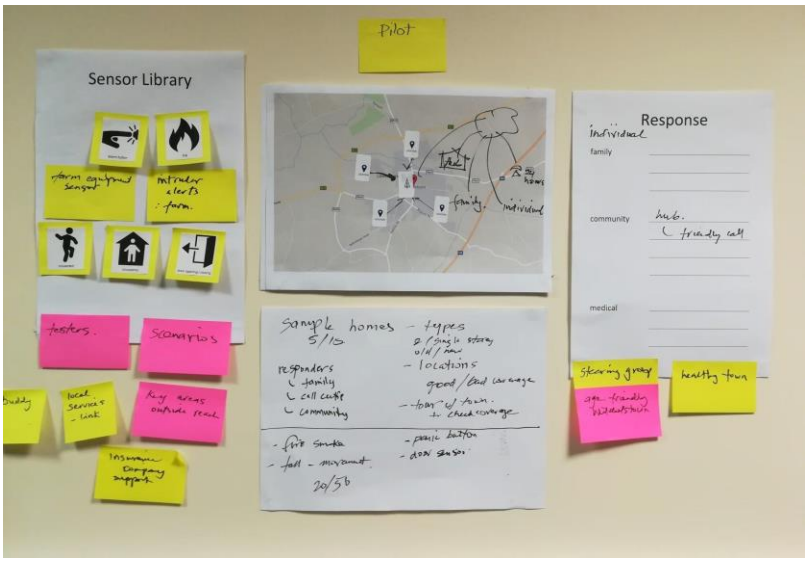
State agencies and funding organisations have a role to play to promote better ways to design assistive technologies. In 2017, a Small Business Innovation Research (SBIR) call set the challenge to deliver innovative ways that help elderly citizens of Cork city and county in Ireland maintain a good quality of life. Importantly, it was formulated as a two phase process which encouraged us to first make sense of the challenge as an internal process before embarking on a more collaborative synthesis process for the design. Solutions sought should address one or more of the effects of being / feeling isolated and insecure and in particular increase the resilience of older people to respond to the impacts of critical events. This framing of the project helped to define a person (older people) a place (living at home) and an action based goal (maintain a good quality of life and feel safe and secure). Early iterations of the proposed solutions seek to blend offline and online discussions through civic engagement tools, create supportive data networks using IoT sensors and open data resources and incorporate health and social care services such as a friendly call service for older people at risk of loneliness and isolation.

We then began exploratory activities identifying the appropriate community to work with and design solutions to this challenge. The Age-Friendly council in the rural town of Mitchelstown in Co. Cork, Ireland represents a perfect user group to introduce the project, its assumptions, hopes and aspirations. The council is made up of a diverse group of stakeholders from the health services, retirement organisations, local councillors and community activists. All stakeholders on the project were mapped in the early stages with participants broadly broken down into the following categories:

Community Development	**Age-Friendly Associations**	**Health & Social Care**	**Research & Development**
Cork County Council; Mitchelstown Community Council; Ballyhoura Development; Enterprise Ireland.	Age-Friendly Council; Age Friendly Cork; Mitchelstown Active Retirement Group; Muintir na Tire.	Health Service Executive; Alzheimers Association Ireland	Amicitia & Independent Living Ireland; Nimbus Centre; Health Innovation Hub;

Mapping of stakeholders helped to create a mental model that links elements and relationships of the project together. Design thinking processes were then employed to facilitate group discussions and build a dynamic to help move the project along successfully. Design thinking can be viewed as a five stage process:

1. First it was important to **empathise** and understand the local context through interviews and meetings.
2. This helps to **define** the challenges, pain points and the people involved that you are seeking to help.
3. From this point the group collectively **ideate** and work together to prioritise solutions.
4. Designers and developers create simple **prototypes** often using paper and pens in the early stages.
5. These help to inform future discussions which are **tested** on with the community to gain further feedback.



This process can be seen as cyclical and iterative with feedback from testing helping to inform new ideas and more advanced prototypes. Most importantly, at each stage of the process the community feel they have a voice in the design process and are fully invested in the project.

Moving Forward - towards more Equitable Solutions

Breaking down Silos

New IoT solutions will need to integrate and interoperate with existing legacy systems and technologies; this will need to be achieved in a manner that is person-centric, so it must form coherent solutions in everyday life. Holistic design approaches can be readily used to solve problems that need stakeholder skills across numerous domains and to promote user participation in the design stage. However, it needs to work through a new community culture where the complexity of the problems is fully understood and solutions developed and tested in that context.

Encouraging Collaboration and Co-Design

Increasingly, the importance of involving multiple stakeholders in the design of new technological solutions is highlighted (Reeder et al. 2013, Thilo et al. 2016). Person-centric design processes, such as following Universal Design Principles are key to addressing the needs of the user of a product or service. Co-design activities, which include all stakeholders (end-users, developers, researchers and service providers) have been shown to be very beneficial to the design of successful products and services. However, co-design mind-set and methodology is not broadly adopted or even well understood. This will need to be addressed if the potential for more equitable solutions is to be realised. Lifetime communities utilising models of social innovation can be enablers of person-centric design processes and provide strategies which promote more holistic solutions.

New IoT Culture and Craft

The Maker movement has emerged as a new form of craft culture that uses easy to use electronics and software technologies to build creative digital technologies. This could be developed into a new IoT craft culture where communities using easily usable and accessible electronic and software technologies build their own IoT based solutions for assisted living, mobility, security, or other types of community smart digital infrastructure. While the technology is currently not available to support this, the design methodologies and development paths are already visible.

Synthesis and Scaling

There is an increasing appreciation that change does not happen along a linear curve but rather as part of a complex adaptive system. Products and services need to be designed for networks of interdependent humans nested within larger ecosystems that relate to them. The mission of the Amicitia social enterprise is to co-create open and innovative projects that can enrich local communities and empower the most socially disadvantaged members of society. It is a broad objective by design; relying on adductive reasoning and leaving the project open to collaboration from the outset. Framing a project in such a manner can begin the process of building collaborative networks. The concept of lifetime communities helps to further refine the target population. We can then begin to synthesise market needs, technology trends and business requirements into solutions which will support the development of these communities.

Conclusions

Our current research is focused on two avenues, each informing our perspective on how to provide more effective and equitable solutions using IoT. Firstly, by investigating the use of assisted living technologies within the context of lifetime communities, we recognize the need to prioritize the Lifetime Community's central objective to foster healthy and successful ageing across the lifespan within a social community setting including younger adults, working families, people with temporary or permanent disabilities and older adults alike. We explored answers to the question of how to design smart home and assisted living technologies that are suited to the concept of lifetime communities; that is how they are accessible, equitable, adaptable and flexible to the needs of all ages and abilities. We found that these solutions had limited usability and flexibility in supporting elderly or disabled people and were often not equitable enough, which results in poor uptake of the technology.

Secondly, we are exploring how practical co-design and participatory approaches, with representatives of the community, can guide us to better, more inclusive assisted living technology and associated sustainable business models. In our ongoing attempts to answer this question, we are in the process of developing IoT devices and a platform for assisted living technologies within a lifetime community that follows the UD philosophy. The key in this is that the technologies are equitable, suitable, accessible and available to a broad range of members of the community, from young to old, from able to disabled. The question we are asking is whether a platform design under such principles can better support older citizens to maintain a good quality of life, participate in their community and feel secure in their homes. Building on the experience of the lifetime community exemplar, Amicitia in Athenry, Co. Galway, Ireland, we are deploying such an IoT system for assisted and community living in the Age Friendly County town of Mitchelstown, Co. Cork, Ireland.

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