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# Supporting Health and Wellbeing: Can Smart Housing Help Revolutionise Health and Care?

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## Introduction

This report has been written by the Digital Health and Care Institute (DHI) on behalf of the Scottish Government's Innovation and Next Generation Solution Technologies Steering Group to assess the potential of smart technologies and applications in support of the health and wellbeing of citizens.

The DHI is one of eight Innovation Centres (IC) in Scotland and is a collaboration between the University of Strathclyde and the Glasgow School of Art. It is part funded by Scottish Government to support innovation between academia, the public and third sectors and businesses with a focus on harnessing innovation to seek and solve key challenges for the health and care sector - transforming great ideas into real solutions.

The concept of future proofing our housing has steadily gained momentum over the last few years as the elderly population continues to grow in Scotland, the UK and the rest of the developed world. In Scotland the number of citizens aged 75 and over has been projected to increase by 27% from 2016-2026 and by 79% between 2016-2041<sup>[1]</sup>. However, this rise in momentum is not solely attributed to the increasing pressure brought on by an aging population. The commercial demand for more integrated products and services in the home has increased massively as consumers look for further developments in smart technology in the home. These allow for control of multiple home systems ranging from energy and water consumption to entertainment and leisure. These consumer driven advances in smart housing present massive opportunities to support the health and wellbeing of Scotland's population. This coupled with public policy recognising the benefits of good quality housing to health and wellbeing, and emphasising preventative rather than reactive approaches, presents the smart housing sector with a clear pathway into the Scottish health and care market. Recent research by the Institution of Mechanical Engineers suggests that adapting homes to meet the needs of current elderly residents could help reduce the onset of frailty, which in turn can reduce the risk of hospitalisation<sup>[2]</sup>. The research claims that physical inactivity costs the NHS £10bn a year UK wide, with £2.5bn spent on care as a result of poor housing. From this, the research infers that allowing vulnerable people to remain in unsuitable homes is costing the NHS some £414 million per year in treatment costs alone<sup>[2]</sup>.

## What is a 'Smart Home'?

A smart home is defined as a home that provides its resident's with comfort, security, energy efficiency and personal convenience<sup>[3]</sup>. The term commonly applies to houses that have appliances, lighting, heating, TV's, security etc. interconnected to communicate with each other and which can be remotely controlled by a central system. This control system should be accessible at all times in any location (both inside and outside the home). Amiribesheli et al state that a true smart home system should bring together multiple components within a layered architecture, see figure 1<sup>[4]</sup>. These layers each have their own function beginning with data collection at the physical layer (via sensors, cameras etc.), this is then transmitted through the communications layer, to the processing layer, the analysis and results are then accessed/ viewed and acted upon via the interface layer<sup>[4]</sup>. These layers consist of hardware and/or software components that in turn can be seen in a vast range of digital technologies and services.



Fig 1. A breakdown of smart home's architecture<sup>[4]</sup>

For the most part the approach to smart housing exists within two categories:

- **Purpose built smart housing.**

Purpose built smart houses are created to be adaptable and modular, incorporating systems and technologies within their conceptualisation, design and built that make a house 'Smart'. These houses are sometimes prefabricated, allowing residents to change their home depending on their desires and/or needs. The benefit of purpose-built housing is just that: they are purpose built to cater to the users' life circumstances whilst having the underlying infrastructure for further integration of smart technology.

- **Retrofitted smart housing.**

Retrofitted smart houses are dwellings within the current housing stock that have been fitted with new or modified smart home technologies, equipment or services unavailable or not included at the point of construction. The benefit of retrofitting smart housing is that every single residence can become a smart home with the integration of the right technologies. It has been estimated that retrofitting housing for energy efficiency and lower emissions alone can cost costs £17,000<sup>[5]</sup>. In 2016, approximately 85% of the UK's housing stock had been built prior to 1990, from this we can infer, despite there being no definitive costing, that retrofitting housing would be significantly cheaper than replacing all of the current housing stock with smart homes<sup>[2]</sup>. There is also potential for the cost relief seen by NHS and social care services to negate the cost of retrofitting homes<sup>[2]</sup>.

Smart home technology seeks to support users to have a better quality of life and allow for users to live independently in the comfort of their own homes. The application of smart home technology can be seen predominantly in energy control, security, light management, entertainment and fall detection, to name a few. Smart home sensors, actuators and cameras can collect data about the resident and their home. This can help enable automation of home systems or help caregivers to better control the home environment of their client, serving to track and predict their actions, and overall health and wellbeing <sup>[4]</sup>.

Retrofitting is the most likely route that the smart house market will take due to the already extensive existing current housing stock. There are many organisations that work within both of these categories across the UK and Europe, ranging from small smart house specific organisations to large multi-national companies with smart housing branches.

### **Corporate smart home technology**

The aforementioned increase in commercial demand can be seen across multiple international corporations. British Gas' HIVE system this offers a more basic range smart technologies to supplement their energy plans, focussing on energy efficiency and basic smart lighting and security systems. This is again seen with Nest who are partnered with Google to provide a similar service to that of the HIVE system. This trend exists across the majority of already established corporations with Apple, Samsung, Panasonic, Sony and BOSCH all offering a range of smart bulbs, sensors doorbells speakers and TV's. All of which can be controlled via each company's own bespoke platform, or (like in nests case) are partnered with Google whose home hub brings together all of their smart technology into one platform. Though these companies have all entered into the market there is still no true market leader in smart home technology. This has allowed for SME's to survive and flourish in the market with many small smart home developers existing at regional, national and global levels.

## Smart housing SMEs:

The following examples represent just a high-level look at this side of the market and detail some of the work performed, before consideration is given to opportunities within the health and care environment.

Name of Organisation	Location	Link to website
<b>Purpose built smart housing</b>		
<b>Cleverhouse</b>	Offices in Glasgow and Edinburgh	<a href="http://www.cleverhouse.co.uk">www.cleverhouse.co.uk</a>
<p>Cleverhouse is a specialist home automation and smart wiring systems company, focussed on multi-room entertainment, home cinema, wireless, intelligent lighting, home (full house) networking and home security. Their home automation aims to deliver intuitive user-friendly home control for customers, through integration with the latest smart home products. Cleverhouse work in partnership with architects, builders and contractors throughout the entire design process, additionally they offer bespoke solutions to individual customers.</p> <p>In the Cleverhouse's smart home, electrical and mechanical services are controlled centrally via a main processor. Heating, lighting, security and audio-visual systems are fully integrated onto a touchscreen, tablet or smart phone that allow changes to room environment and entertainment to be made by the user. Cleverhouse smarthomes can be controlled from other locations by either PC or phone. This allows for secure login to check CCTV cameras or adjust lighting and climate control to ensure home security and functionality whilst the customer is away.</p>		
<b>Carbon Dynamic</b>	Unit 17 Cromarty Firth Industrial Park, Scotland	<a href="http://www.carbondynamic.com/about-hayden">www.carbondynamic.com/about-hayden</a>
<p>Carbon Dynamic offers an alternative to the mainstream form of smart housing. Rather than smart housing via integration of technology, carbon dynamic is a world leader in modular offsite manufacturing. Buildings are designed to meet the needs of the resident, manufactured off-site at Carbon Dynamic's Invergordon Factory, before being installed on site. The methodology employed by Carbon Dynamic allows for additional modules to be added to their housing allowing for modifications to housing whenever they are required. For example, there Salvesen assisted living pod designed to create an accessible living space for a resident with mobility issues. In Phase 1a of the DHI, Carbon Dynamic, NHS Highland and Albyn Housing worked together to create a prototype digital brokering service as part of a 15-bed development of new supportive housing in the Highlands.</p>		
<b>Neat-living</b>	Hamilton International Technology Park, Blantyre, G72 0AG	<a href="http://www.neat-living.com">www.neat-living.com</a>
<p>Similar to Carbon dynamic, Neat-Living offer precision engineered housing focusing on space and energy efficiency tailored to the specific needs of the home owner. These houses are designed to be transformable, customisable and affordable, allowing for the opportunity to introduce health, care and wellbeing features into your home whenever required.</p>		

<b>Baufritz</b>	German based company with UK base at The Workplace/ Oakington Rd, Girton, Cambridge CB3 0QH	<a href="http://www.baufritz.com/uk">www.baufritz.com/uk</a>
<p>Baufritz offer bespoke design and building services. Baufrizt focus on healthy and ecological living conditions, integrating eco friendly technology into innovative design processes to create an all encompassing smart home experience. Baufrizt's design focuses on providing air quality, allergy compliant construction, intelligent ventilation, organic insulation, electro smog protection and all building materials are tested for harmful substances.</p>		
<b>Trivselhus</b>	Sweden	<a href="http://www.trivselhus.co.uk">www.trivselhus.co.uk</a>
<p>Trivselhus are a Swedish based company that partner with developers and communities in the UK to develop eco-efficient smart homes. One of these developments is their Milton Keynes based Sommar Places development.</p> <p>Sommar Places focus on the design of Swedish styled sustainable, energy efficient housing. Their ethos incorporates smart housing technology into their development as they believe smart home technology brings an ultra-modern edge to their modern design, small-scale development. With Apple HomeKit and intelligent accessories fitted as standard, a fully connected Sommar Place home puts the residents lighting, heating, power and home security at their command, wherever they are. Apples HomeKit is simple to use and is fully secured by end-to-end encryption, and the Trivselhus Climate shield helps deliver zero carbon buildings, with low heating requirements and an open platform to include future technology within the home.</p>		
<b>Holbrun HIFI</b>	441 Holburn Street, Aberdeen, AB10 7GU	<a href="http://www.holburnhifi.co.uk">www.holburnhifi.co.uk</a>
<p>Holburn advise they work with clients to develop Smart Home Systems that are customised to the individual's needs. As every client has their own requirements and priorities, Holburn advises that every system should be designed accordingly. Holburn place most of their emphasis on:</p> <ul style="list-style-type: none"> <li>• Home Entertainment</li> <li>• Lighting</li> <li>• Heating</li> <li>• Security</li> <li>• CCTV</li> </ul> <p>Holburn marketing materials state that they combine the most up to date technology into one user-controlled system and include support packages in their service to keep hardware and software up to date.</p>		

<b>Netthings</b>	NetThings Ltd, 14 New Mart Road, Edinburgh, EH14 1RL	<a href="http://www.netthings.co.uk">www.netthings.co.uk</a>
<p>Netthings is an Internet of Things (IoT) company that has developed its own web-enabled monitoring and control system for small commercial and residential properties. Netthings energy management platform, is advertised as an easy to install real-time energy monitoring system for heating and water utilities. The system has a wall mounted in house display, is self-learning and profile normal energy use, flagging when users exceed normal levels of use.</p>		
<b>Appello</b>	Appello, Wylie House, Unit 740, Ampress Lane, Lymington, Hampshire, SO41 8LW	<a href="http://www.appello.co.uk/about">www.appello.co.uk/about</a>
<p>Appello advise they are focused on transforming lives through Technology Enabled Care Services (TECS). Their service provides 24-hour support via their TECS monitoring call centre. This delivers proactive and reactive monitoring and supports the health, safety and security of more vulnerable people than any other centre of its kind. Appello help housing, and health and social care organisations to deliver better outcomes that improve the lives of their customers, patients and residents.</p> <p>Appello offer a Smart Living Solutions package, which is a suite of digital assisted living services that integrate both safety and wellbeing technologies into the user's home, enabling people to lead independent, engaged lives for longer. These solutions create a digital environment that enables audio and video communication, along with valuable data insights, to flow between properties, individual's homes, site support staff, and your Monitoring Centre.</p> <p>Appello have an application that works in unison with a central wall mounted LivingHub to help control the smart house and living technologies.</p>		
<b>Homecontrol</b>	32/7 Hardengreen Industrial Estate, Dalkeith, Midlothian, EH22 3NX	<a href="http://www.homecontrolscotland.co.uk">www.homecontrolscotland.co.uk</a>
<p>Home Control are an Edinburgh based team of Home Technology Experts, specialising in the Design, Supply and Installation of Home Entertainment Systems and Smart Home Solutions. These integrate top if the range products from popular smart tech retailers (i.e. Sonos, nest, etc.) all to prvide a range of smart home:</p> <ul style="list-style-type: none"> <li>• Automation</li> <li>• Entertainment</li> <li>• Cinema</li> <li>• Networks</li> <li>• Security</li> </ul>		
<b>R.B. Grant</b>	Office 17, Myregormie Place, Kirkcaldy, Fife, Scotland, KY1 3NA	<a href="http://www.rbgrant.co.uk/domestic/home-automation">www.rbgrant.co.uk/domestic/home-automation</a>
<p>R.B. Grant Electrical Contractors design, supply and install home automation systems to control all aspects of the home. These home automation systems allow you to control the home environment using smart home technology. Electrical control allows you to adjust and alter lighting, appliances and machinery to suit environmental changes. Home automation can be controlled effectively with a LCD screen, via the telephone line, remote control automation, internet, wireless systems or on a smart phone.</p>		

<b>The Smart Home Company</b>	Health & Wellbeing Innovation Centre, Treliske, Truro, Cornwall, TR1 3FF	<a href="http://www.tshc.co.uk">www.tshc.co.uk</a>
<p>The smart home company offer bespoke smart housing specific to their customers individual needs. Theses automated services include:</p> <ul style="list-style-type: none"> <li>• Entertainment</li> <li>• Home Cinema</li> <li>• Light &amp; Comfort</li> <li>• Security &amp; Access</li> <li>• Home Network</li> </ul>		
<b>YourSmartHome</b>	Willian Way, Letchworth, Hertfordshire, SG6 2HJ	<a href="http://www.yoursmarthome.co.uk">www.yoursmarthome.co.uk</a>
<p>YSH design and install bespoke smart home systems for individuals houses or work space. Their smart home control solution aims to bring all features of the home together in on device, i.e. tablet or smartphone. This enables lighting, audio visual, climate and security to be controlled from anywhere with just the touch of a button.</p>		
<b>HAS Group Automation</b>	37 Glenrock Business Park, Bothar Na Mine, Galway	<a href="http://www.homeautomation.ie">www.homeautomation.ie</a>
<p>HAS Integration home Automation bring together smart home solutions such as smart:</p> <ul style="list-style-type: none"> <li>• Home security systems</li> <li>• Home cinema</li> <li>• Audio/video</li> <li>• Automated Shading</li> <li>• Lighting design</li> <li>• Networking</li> </ul>		
<b>Smartzone</b>	Unit 12 Southside, Business, Park, Togher, Cork, T12 FR50, Ireland	<a href="http://www.smartzone.ie">www.smartzone.ie</a>
<p>Smartzone offer:</p> <ul style="list-style-type: none"> <li>• Security and monitoring of homes and businesses</li> <li>• Energy control over heating and hot water usage from any location</li> <li>• Automation of lighting and locks</li> <li>• Advanced video for door access and home monitoring</li> <li>• Water control that can shut off water automatically when required</li> </ul>		

<b>Alcove</b>	2-8 Victoria Avenue, Bishopsgate, London, EC2M 4NS	<a href="http://www.youralcove.com">www.youralcove.com</a>
<p>Alcove offer a complete suite of care technologies to create an IoT care technology ecosystem to assist older and/or disabled adults to live comfortably at home. Using integrated sensors, wearables, Amazon's Alexa and Alcove's home communication aid, Alcove hope to replace Telecare services in the digital age.</p> <p>Alcove offer wireless movement sensors to monitor resident's activity levels, door sensors to detect visitors or how often the fridge is used, smart doorbells, bed pads, chair pads, moisture, smoke and extreme heat sensors. All of the technologies can be controlled by a central control application.</p> <p>A more detailed review of Alcoves technology can be seen here: <a href="http://www.youralcove.com/pages/retirement-villages">www.youralcove.com/pages/retirement-villages</a></p>		
<b>Savant</b>	RGB Communications, Unit 2, Lambourn Business Park, Hungerford, Berkshire RG17 7RY	<a href="http://www.savanteurope.co.uk">www.savanteurope.co.uk</a>
<p>Savant provide home control and automation services, bringing together climate, lighting and entertainment together to be controlled by a user-friendly interface. The savant smart home blue print is configurable, so it can to meet the needs of any home owner.</p> <p>Savant focus predominantly on the entertainment aspects of smart housing.</p>		
<b>FIBARO</b>	Poznań, Poland	<a href="http://www.fibaro.com/en/smart-home-in-use">www.fibaro.com/en/smart-home-in-use</a>
<p>The FIBARO system is made up of mutually compatible products that create a wireless network that provides the user with complete control, also providing security and entertainment. Their system provides smart control for lighting, gates and blinds, air conditioning, safety, security, multimedia, garden and mood. These services are provided through a suite combined with motion, flood, door, smoke and carbon monoxide sensors; smart shutters and heat controllers; up to date intercom and remote technologies.</p> <p>The smart FIBARO home can be controlled via messenger Applications and FIBARO devices are compatible with Apple's Homekit platform.</p>		
<b>BOSCH</b>	Germany	<a href="http://www.bosch-smarthome.com">www.bosch-smarthome.com</a>
<p>The BOSCH smart home system products allow users to automatically control day-to-day processes within the home. These networked devices communicate with one another to automatically adjust to changing circumstances in real time. The system ensures enhanced climate efficiency and security, as well as smart lighting and a vast array of smart home solutions that provide greater convenience within the home.</p>		
<b>Gigaset</b>	Germany	<a href="http://www.gigaset.com/hq_en/cms/smart-home-overview.html">www.gigaset.com/hq_en/cms/smart-home-overview.html</a>
<p>The Gigaset smart home system focuses on smart security measures using motion sensors, alarms and cameras to provide a suite of smart security options. All Gigaset products are easily controlled by a central control application.</p>		

### Companies that build purpose built smart housing and retrofitting services

<b>Loxone</b>	German company, UK base, Reading, RG7 4GB	<a href="http://www.loxone.com/enen">www.loxone.com/enen</a>
<p>Loxone promote smart housing as a modern living model for everybody. Providing automation of heating, lighting, and more as non-invasively as possible, meaning the Loxone smart home knows what to do instead of having to be commanded via central control mechanisms. This is done using the Loxone autopilot design feature within the Loxone application, it allows designers to create logic patterns that infer different command prompts in sequence to each other (as in 'if' this happens then then 'this' happens). Loxone offer smart home features such as:</p> <ul style="list-style-type: none"> <li>• Access, security &amp; safety – offers a variety of biometric or data-based system (card, fob or code)</li> <li>• Energy management</li> <li>• Lighting – colour, type and intensity of light can be controlled in Loxone homes</li> <li>• Multimedia – smart control of the most modern media technology</li> <li>• Shading – automated window shading</li> <li>• Temperature control and ventilation– control the flow temperature is either directly via the Miniserver or via the heating system's user interface</li> <li>• Wellness – smart regulation of leisure facilities</li> </ul>		
<b>Blackwood: CleverCogs</b>	160 Dundee Street Edinburgh EH11 1DQ	<a href="http://www.blackwoodgroup.org.uk/clevercogs">www.blackwoodgroup.org.uk/clevercogs</a>
<p>CleverCogs is Blackwood's digitally enhance care system, purpose built to help users keep their independence, and to remain in control of their lives from their own home. Blackwood is a Scottish housing and care provider focussing on supporting citizens with disabilities. CleverCogs utilises a central touch screen device as a home hub. Blackwood can build bespoke care plans around individuals, helping to control care, safety, housing, home automation, information, digital inclusion and health and wellbeing.</p> <p>The CleverCogs technology is compatible across multiple touch screen devices and allows the user the to be able to control their tv, open their curtains, communicate with their family and carers, and more. Additionally, it can support the delivery of technology enabled care via features like the automated medication and appointment prompts. A key feature of CleverCogs is its provision of a simplified access option to the internet, this helps support those with lest digital technology experience remain independent and in control at home. This feature also aims to boost digital skills development that will in turn boost social interaction and self-management of health and care requirements. In a Carnegie trust review it was found that CleverCogs helps improve health and the ability to live independently, whilst also increasing digital participation, self-management and improved mental and physical wellbeing <sup>[6]</sup>.</p>		

From the list above, it is clear that the current smart home market still trends towards the provision of comfort, entertainment and security rather than focussing on smart housing for improved health and wellbeing. Even so, the majority of systems are highly adaptable to ensure their smart homes can remain relevant as technology continues to develop. Consequently, this means the market is ready made to integrate smart digital health technologies, services and other products. As the focus put on this sector as a tool for helping with health and care of residents continues to grow, the market will develop rapidly in the immediate future. This can be seen in projections for the sector estimating that expenditure for home healthcare will increase from \$99.5bn in 2016 to \$144.9bn in 2021<sup>[7]</sup>. Though there are currently several organisations such as Alcove (see above) that provide a more health and care specific approach to smart home development and technologies.

For further information regarding the smart home market, CBInsights created a smart home market map listing 60 companies involved in the smart home sector, while this list is large it does not encapsulate the entire sector. The breakdown is as follows<sup>[8]</sup>:

- **Energy & Utilities:** These are companies that utilise sensors, monitoring tech, and data to conserve water and energy. This includes companies such as Tado, which created a product that automatically detects a user's proximity to the residence and adjusts the temperature accordingly, with added control from their smartphone app.
- **Smart Locks:** Startups such as August provide alternative solutions to traditional keys with virtual keys and other electronic locks. A number of these companies' products also allow users to see and speak with visitors remotely.
- **General Smart Home Solutions:** Instead of producing a single smart gadget, these companies build or distribute multi-device systems that automate several parts of your home, such as Netatmo's security, weather, air care, and energy solutions and monitoring or IOTAS's smart apartments.
- **Kitchen & Home Appliance:** These include household products that function as a conventional appliance or device, yet offer advantages through connectivity, such as Innit, which is currently developing a cooking system built on machine learning and high tech sensors that can detect what is being made and adjust heating and cooking time appropriately throughout the process.
- **Home Robots:** This category is home to companies that produce robots specifically for maintenance and assistance in a home environment. These include social robotic assistant Jibo, and Rokid, a smart home device that use AI and deep learning to deliver information and perform tasks via voice and visual interactions.
- **Monitoring & Security:** These are companies that offer indoor or outdoor security and monitoring through installed cameras to keep an eye on homes, kids, the elderly, and pets. Companies in the space include Smartfrog and Ring.

- **Wi-Fi & Cybersecurity:** These startups provide Wi-Fi and cybersecurity solutions to connect and protect smart devices within the home. CUJO, a smart firewall that protects a user's connected home from criminal hackers, just raised \$8.5M in funding this past month, and Eero and Starry, two more companies offering home Wi-Fi systems, raised \$50M and \$30M, respectively, in Series B in the past year.
- **Health & Wellness:** These are products that assist home occupants in maintaining their health and lifestyle, such as Sleepace, a non-wearable smart device that can monitor and help improve sleep quality, or Awair, which detects airborne and environmental irritants.
- **Alarm Systems:** These companies provide traditional alarm systems equipped with advanced monitors and sensors to detect fire, floods, or other property damage and help protect your home. One company, Cocoon Labs, has developed a smart home security device that utilizes low level sound waves to detect and alert the homeowner of any disturbances within the home.
- **Audio & Media:** These companies provide media solutions that range from a hanging computer to display decorative art (Electric Objects) to whole-home wireless music systems (Sonos).
- **Platforms:** Companies in this category do not produce their own consumer products but help others integrate AI and connectivity into their own smart home products. One example here would be Arrayent, which helps major consumer brands transform traditional products into connected devices.
- **Lighting:** These companies provide home lighting solutions such as smart switches (Deako) and smart bulbs (LIFX).
- **Miscellaneous:** Startups in this category have particularly unique offerings, such as Uzer, a company that developed a smart home barcode scanner that makes recycling more fun and efficient, or Nucleus, an internet-connected intercom system that helps people communicate with others on the same system.

## Smart Homes for Health and Care

The industry's primary focus for how smart homes can benefit the health and care of users is in its ability to improve and change the approaches of care for the elderly, those with mobility issues, long-term chronic conditions (i.e. Chronic Obstructive Pulmonary Disorder) and cognitive disorders (i.e. dementia).

We are already in a position in which healthcare providers can deliver certain health services in the home that have previously been confined to the hospital setting <sup>[9]</sup>.

This is often referred to as 'Hospital at Home'. This encompasses multiple models, with some targeting long-term condition care, rehabilitation services or post-operation services. The majority of these models require nursing staff to deliver them, meaning they are not a completely viable option for relieving resource pressures on healthcare services <sup>[9]</sup>. In the United States and Australia changes to healthcare delivery, such as the Affordable Care Act, have promoted the adoption of these models of care. However, as the pressures of demographic changes associated with an aging population (increase in chronic illness, comorbidities etc.) is pushing towards more technology enabled models of community care <sup>[9]</sup>. In a 2017 review, Pham et al outlined several smart home health projects based across Europe, Japan and the US <sup>[7]</sup>. The table below summarises these smart home projects:

Smart home project	Country	Description
<b>Aging In Place, Tiger place</b> <sup>[10]</sup>	USA	Starting in 2000, the Aging in Place project has continuously developed with a focus of allowing older adults to live independently at home. It incorporates an integrated sensor network that monitors the health of the user and helps improve their overall safety. Over the years additional features have been added to support nursing/care staff to alert them in the instance of a medical emergencies or gradual changes in health. The below image outlines the basics of the integrated sensor network <sup>[7, 10]</sup> .
<b>Gator tech Smart House</b> <sup>[11]</sup>	USA	The Gator Tech Smart House was developed at the University of Florida Mobile and Pervasive Computing Laboratory. The Gator Tech Smart House has been in development since 2000, with the goal of creating an assistive environments for self-sensing homes for the purposes of remote monitoring and health intervention services <sup>[7, 11]</sup> .
<b>Centre for Advanced Studies in Adaptive Systems (CASAS)</b> <sup>[12]</sup>	USA	The goal of CASAS smart home work is to design a 'smart home in a box'. The CASAS smart home in a box has both a software and hardware component. The CASAS software architecture (see below) has a layered approach similar to Amiribesheli et al <sup>[4]</sup> . This allows for actions and information to through the layers to and from the physical layer, with their aim being that these layers are ready made for current and future technology to be integrated seamlessly into the modern smart home. The CASAS physical layer includes a range of sensors and actuators, using a Zigbee wireless mesh (a low-cost, low-power wireless mesh network) to communicate with the software architecture <sup>[12]</sup> .

<p><b>Centre for Advanced Studies in Adaptive Systems (CASAS)</b> <sup>[12]</sup></p>	<p>USA</p>	<p>The goal of CASAS smart home work is to design a 'smart home in a box'. The CASAS smart home in a box has both a software and hardware component. The CASAS software architecture (see below) has a layered approach similar to Amiribesheli et al <sup>[4]</sup>. This allows for actions and information to through the layers to and from the physical layer, with their aim being that these layers are ready made for current and future technology to be integrated seamlessly into the modern smart home. The CASAS physical layer includes a range of sensors and actuators, using a Zigbee wireless mesh (a low-cost, low-power wireless mesh network) to communicate with the software architecture <sup>[12]</sup>.</p>
<p><b>Future Care Lab</b> <sup>[13]</sup></p>	<p>Germany</p>	<p>The Future Care Lab at Furtwangen University has developed technical assistance systems and technology-supported services for nursing care, to allow those with care needs to live independently at home. The Future Care Lab acts as a testing environment to help develop, integrate and evaluate technical assistance systems and services <sup>[12]</sup>.</p> <p>Technologies integrated into the Future Care Lab include: smart-home components (sensors and actuators); active lighting systems; touch, language or gesture-controlled systems; systems for 2D- and 3D localization; portable vital signs sensors and assistance robotics. They also offer a range of low-threshold aids and rehabilitation technologies <sup>[13]</sup>.</p>
<p><b>VictoryaHome</b> <sup>[14]</sup></p>	<p>Europe</p>	<p>The VictoryaHome project has been tested across Europe in the Netherlands, Norway, Portugal and Sweden. The projects mission is to support people in taking care of themselves and others and has led to the development of the VictoryHome system and services. this was achieved through the use of a user-centred design methodology to test and evaluate the service.</p> <p>The services comprise of a social robot and the SerenityApp, which jointly provide activity monitoring, fall detection and an automatic medication dispenser. Additionally, it has an online platform to access emergency response centres. The Application provides family, friends and carers an overview of the user's health and wellbeing as can be seen below <sup>[14]</sup>.</p>

Pham et al's summary highlights that the majority of smart home projects require additional wearable and home sensors outside of their overarching systems architecture. Their report shows that while no one project provides an all-encompassing service their cloud-based smart home environment can bring multiple systems together into a singular smart home <sup>[7]</sup>.

## Conclusion

Currently, the Smart Home sector is disjointed, operating in disparate silos. However, an integrated platform of multiple digital health, smart home services with other non-health consumer services will inevitably be the next step for the sector. Connections are already being made between the two product streams; smart lighting provides a more seamless living space for elderly users alongside other automated services. This, along with open systems architectures could help create Smart Home environments that are accessible for public and private health and care services.

In the Agile Aging Alliance 2019 report, DHI CEO George Crooks argued that a more feasible option for smart house providers would be to collaborate with health and care providers to develop standardised smart health kits. These kits of interoperable technologies "should be contextually aware of what the other devices are doing and be able to share and adapt to information without human intervention" <sup>[15]</sup>. These kits could be tailor made for each individual users health and care requirements, and would be a better alternative to complete refurbishment or purchasing a bespoke smart home.

If this can be achieved then we can begin to take full advantage of remote monitoring and emergency response systems to ensure the health, safety and wellbeing of at-risk members of society, such as the elderly. While simultaneously employing smart design techniques to build new homes and/or redesign our current homes to create smart environments in the home and perhaps beyond to the neighbourhood, town and city.

## References

1. Scottish Government (2017). Summary: Age Demographics. Accessed 08.11.18 from: <https://www2.gov.scot/Topics/People/Equality/Equalities/DataGrid/Age/AgePopMig>
2. Institute of Mechanical Engineers (2018). Healthy Homes: Accommodating an Aging Population. Accessed 02.11.18 from: <https://www.imeche.org/docs/default-source/1-oscar/reports-policy-statements-and-documents/imeche-healthy-homes-report.pdf?sfvrsn=2>
3. IoT Agenda (2018). Smart home or building (home automation or domotics). Accessed 02.11.18 from: <https://internetofthingsagenda.techtarget.com/definition/smart-home-or-building>
4. Amiribesheli, M. Benmansour, A. Bouchachia, H. (2015) A review of smart homes in healthcare. Journal of Ambient Intelligence and Humanised Computing. 6:495-517
5. Fiona Harvey (2018). UK's housing stock needs massive retrofit to meet climate targets. Guardian. Accessed on 04/12/2018 from: <https://www.theguardian.com/environment/2018/oct/11/uks-housing-stock-needs-massive-retrofit-to-meet-climate-targets>
6. Carnegie trust (2018). Living Digitally – An evaluation of the CleverCogs digital care and support system
7. Pham M. Mengitse Y. Weihua Sheng HD. (2017). Delivering home healthcare through cloud-based smart home environment (CoSHE). Future Generation Computer Systems. 88:129-140. Accessed from: <https://www.sciencedirect.com/science/article/pii/S0167739X17302194>
8. CBInsights (2017) Smart Home Market Map: 60 Startups In Home Automation, Smart Appliances, And More. Accessed 02.11.18 from: <https://www.cbinsights.com/research/smart-home-market-map-company-list/>
9. Leff B. Malone M. Capezuti E. Palmer R. (2015) Geriatrics Models of Care: Hospital at Home. Accessed from: [https://link.springer.com/chapter/10.1007%2F978-3-319-16068-9\\_14#citeas](https://link.springer.com/chapter/10.1007%2F978-3-319-16068-9_14#citeas)
10. Rantz, M. J., Skubic, M., Miller, S. J., Galambos, C., Alexander, G., Keller, J., & Popescu, M. (2013). Sensor technology to support Aging in Place. Journal of the American Medical Directors Association, 14(6), 386-91.
11. Helal, Sumi & C. Mann, William & El-Zabadani, Hicham & King, Jeffrey & Kaddoura, Youssef & Jansen, Erwin. (2005). The Gator Tech Smart House: A Programmable Pervasive Space. Computer. 38. 50- 60. 10.1109/MC.2005.107.
12. Cook, D. J., Crandall, A. S., Thomas, B. L., & Krishnan, N. C. (2012). CASAS: A Smart Home in a Box. Computer, 46(7), 10.1109/MC.2012.328.
13. Hochschule Furtwangen University. (2018). Future Care Lab. Accessed 23/11/18 from: <https://www.hs-furtwangen.de/en/faculties/health-safety-society/labs/future-care-lab/>
14. VictoryaHome (2018) accessed on 23/11/18 from: <http://www.victoryahome.eu/>
15. Agile Ageing Alliance (2019) Neighbourhoods of the Future, Better Homes for Older Adults: Improving Construction, Health, Care, Design, Technology & Finance. Accessed on 06/02/19 from: [https://www.agileageing.org/site\\_files/5944/upload\\_files/NeighbourhoodsoftheFuture2019\\_250119.pdf?dl=1](https://www.agileageing.org/site_files/5944/upload_files/NeighbourhoodsoftheFuture2019_250119.pdf?dl=1)

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