The connected home

Designing and building technology into today's new homes

Guide

NHBC Foundation
Housing research & guidance

CEDIA™

NF67

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Acknowledgements

This report was researched and written by Cutland Consulting Limited.

The NHBC Foundation is grateful to Wendy Griffiths and Simon Buddle of CEDIA, the international trade association of companies that specialise in designing and installing electronic systems for the home, for their guidance during the development of this report. The Foundation would also like to thank Donna Leeding of Openreach and Ian Borthwick of the Institution of Engineering and Technology (IET) for their editorial input.

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Published by the NHBC Foundation
ISBN 978-0-9930691-7-8

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January 2016

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The NHBC Foundation

The NHBC Foundation, established in 2006, provides high-quality research and practical guidance to support the house-building industry as it addresses the challenges of delivering 21st-century new homes. To date, it has published more than 65 reports on a wide variety of topics, including the sustainability agenda, homeowner issues and risk management.

The NHBC Foundation is also involved in a programme of positive engagement with the government, academics and other key stakeholders, focusing on the current and pressing issues relevant to house building.

To find out more about the NHBC Foundation, please visit www.nhbcfoundation.org. If you have feedback or suggestions for new areas of research, please contact info@nhbcfoundation.org.

NHBC is the standard-setting body and leading warranty and insurance provider for new homes in the UK, providing risk management services to the house-building and wider construction industry. All profits are reinvested in research and work to improve the construction standard of new homes for the benefit of homeowners. NHBC is independent of the government and house builders. To find out more about the NHBC, please visit www.nhbc.co.uk.

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Foreword

The development of technology has been one of the most remarkable features of recent decades. It has transformed the working world beyond recognition and is changing the way we live in our 'connected homes'. Connectivity to the Internet at faster speeds is becoming increasingly important, and something that we now expect as a matter of course in just the same way as the supply of water and electricity.

This report looks at the home technologies that are already changing so many aspects of everyday lives, including our ability to work seamlessly from home, to stream movies on demand or to stay in close contact with relatives in distant places. It also outlines the implications of the 'Internet of Things' which is unlocking endless possibilities for automation and control, offering better comfort, improved energy efficiency and a range of other potential benefits.

Connected technologies will also become increasingly important in relation to people's health and well-being, allowing regular monitoring of health and activity levels and providing feedback to relatives and appropriate support agencies. This has obvious benefits for the elderly, enabling greater numbers of people to remain living at home independently and safely, for longer periods.

I hope that this report is of interest to designers and house builders, and helps inform their decision-making on the specification of new homes. In particular I hope that they consider the recommendation to install some additional hard wiring at construction stage in order to facilitate better data transmission around new homes. Doing so will facilitate integration of future technologies and help avoid the need for retrofitting, including unsightly cables tacked around skirting boards.

We are grateful for the support for this project from CEDIA.

RT. Hon. Nick Raynsford
Chairman, NHBC Foundation

1 Introduction

Introduction

A connected home, sometimes referred to as a 'smart' home, is loosely defined as one in which electrical devices are potentially connected to each other and are often connected to the Internet too. This provides maximum convenience to the residents in operating the home, and enables both the home and the residents to access a wide variety of external digital services.

As lifestyles become increasingly demanding, people expect more from their living environment and its associated technology. Technology has come a long way since the start of the 21st century, and the rate of progress is not slowing down. In the year 2000, having one television in the living room, a telephone socket in the hall and no Internet access was perfectly normal and acceptable. Fifteen years later the use of fixed (landline) home phones for making voice calls is becoming less important than access to mobile phone networks, and the provision of superfast broadband to the home is increasingly essential to support Internet-connected TVs in multiple rooms, music streaming, game playing, security and remote control of heating and lighting. According to marketing agency Raconteur, the penetration of 'smart home' technology is set to rise from 11% to 27% by 2020[1].

The so-called 'Internet of Things' (IoT) is also evolving rapidly. At its most esoteric and future-looking, the Internet of Things is about connecting previously mundane appliances such as fridges to the Internet so that they can, for example, automatically order more milk. However there are more immediately useful IoT applications that are closer to market, such as boilers which automatically inform a servicing company when they develop a fault.

1. Smart Technology & Living, Ractonteur, April 2015, http://raconteur.net/smart-technology-and-living

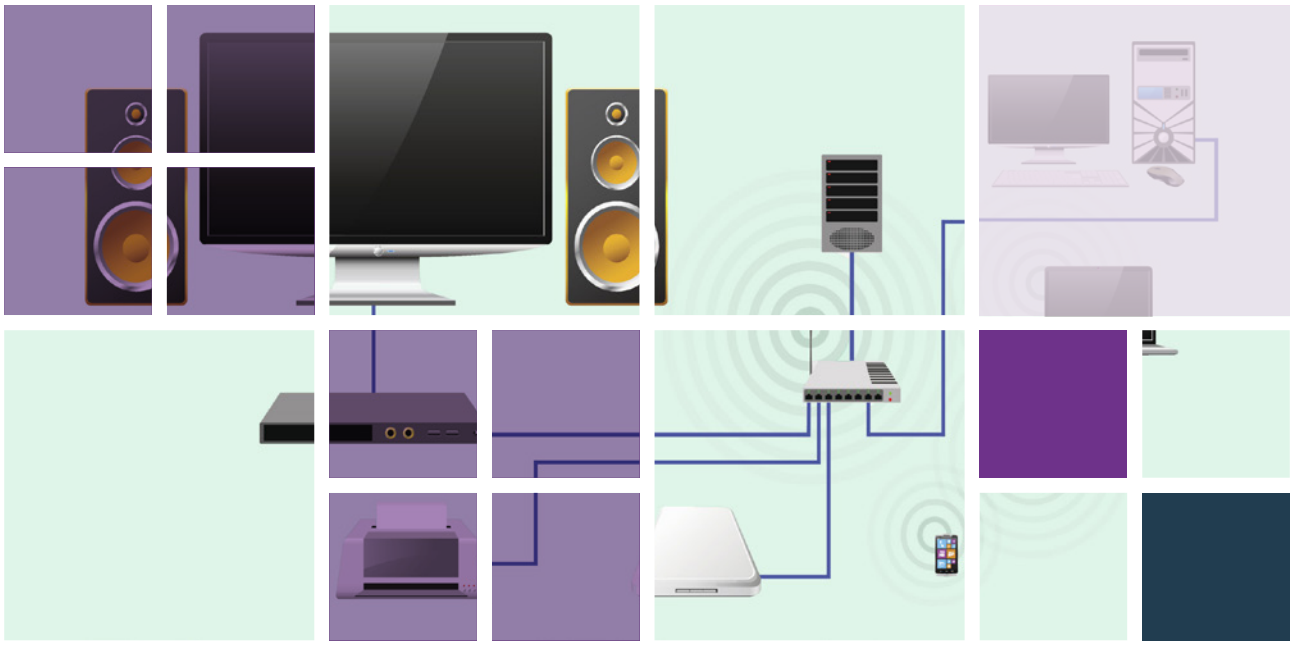
The homes that are built today should enable their residents to enjoy these present and future benefits, whether they are as simple as catching up on a missed TV programme or as important as helping an elderly relative to live independently for longer.

There is evidence that home purchasers are starting to prioritise better access to connected services (for example, favouring areas with superfast fibre broadband)[2]. This provides an opportunity for house builders to maximise the value of new homes by ensuring that they are ready for today's technologies as well as what is on the horizon. Even simple measures at construction stage such as the installation of a couple of wired data outlets can reap rewards for residents now and in the future.

This report describes the spectrum of types of connected home, and discusses the benefits of the different technologies. It identifies some of the challenges faced by those involved in the design, specification and construction of connected homes, and provides practical advice in support.

2. 'Smart Lives; Making smart smart', Energy Saving Trust 2015.
http://www.energysavingtrust.org.uk/sites/default/files/reports/EST_Smart%20Lives_2015.pdf

2 What is meant by a connected home?



A connected home is one in which technology enhances the lives of those who live in it (Figure 1). There is no single definition of a connected home; it is better thought of as a spectrum of electrical and digital applications, at one end of which is the here-and-now and at the other end a number of futuristic scenarios. Key components of the whole spectrum are a home network, a good quality broadband connection and devices that communicate across that network to support the needs of the users.

Figure 1 Typical components of today's connected home

At its simplest, today's connected home is one in which the occupiers enjoy reliable, fast access to online IT applications ('apps') throughout the home. Further along the spectrum might be conveniences such as remote lighting control or a smart thermostat that is programmed to turn the heating down when the last occupant leaves home in the morning. Only at the far extremes of the spectrum lie 'intelligent' appliances and advanced applications such as door entry controlled by face recognition and real-time medical monitoring for the elderly.

By definition, all connected technology requires a network of some sort to enable it to communicate. Modern computers and connected devices communicate with each other using a set of conventions known as Internet Protocol, or IP[3]. A home IP network[4], is formed by connecting individual devices such as smartphones, tablets and Internet-enabled TVs to a central device termed a 'hub'. The hub (Figure 2) typically consists of:

- A number of network ports (for direct connection using wires)
- A wireless or 'Wi-Fi' controller (for multiple wireless connections to the network),
- A router (which directs the data traffic on the network) and
- A modem (effectively the gateway through which the home network is connected to the external Internet).

Figure 2 A typical hub, which includes a router, Wi-Fi controller and wired network ports

3. Also referred to as TCP/IP

4. Sometimes referred to as LAN or Local area network

3 A brief history

Some of the benefits of connected living have been available for many years, although the take-up has generally been limited to wealthier early adopters. A number of developments have recently unlocked the benefits for a much wider section of society:

- The availability of cheaper broadband services has made access to the Internet fast and 'always-on' (unlike the preceding 'dial-up' technology)
- Wireless networking means that connected technologies can often be used without having to retrofit wiring within the home
- The rapid growth of smartphones has made using online apps an everyday activity for many people.

Because this technology works simply and reliably, lifestyles have changed. Many people who wouldn't have considered using Internet banking a short time ago now use it every day. A whole generation is accustomed to accessing TV and other entertainment 'on-demand' via the Internet from services such as BBC iPlayer, Netflix and Spotify. The same generation engages daily with social networking communities including Facebook, Twitter, Instagram and Snapchat. These people have grown up with the connected world, and they are now starting to buy homes.

It is interesting to note that banks and broadcasters did not find themselves in this position by accident. They foresaw a consumer demand and the efficiencies that connected solutions would offer their own business operations, and they planned carefully over many years to maximise those benefits. Similarly, house builders do not need to think of the advent of the connected home as a disruptive or threatening event. It is simply an evolution of the current situation, and it presents house builders with a similar opportunity to that of the banks and broadcasters to achieve significant benefits for their customers and for themselves.

4 A note on network speed

For devices to work well they need a connection which is both robust and has the appropriate speed. Activities such as surfing the Internet only require a low speed, whereas streaming media services (music and video) need much higher speeds. The types of activity that should be achievable with a download speed of 10 megabits per second (Mbit/s) are shown in Figure 3 below[5]. At peak times, however, if more people use these services simultaneously then a download speed greater than 10Mbit/s could be required.

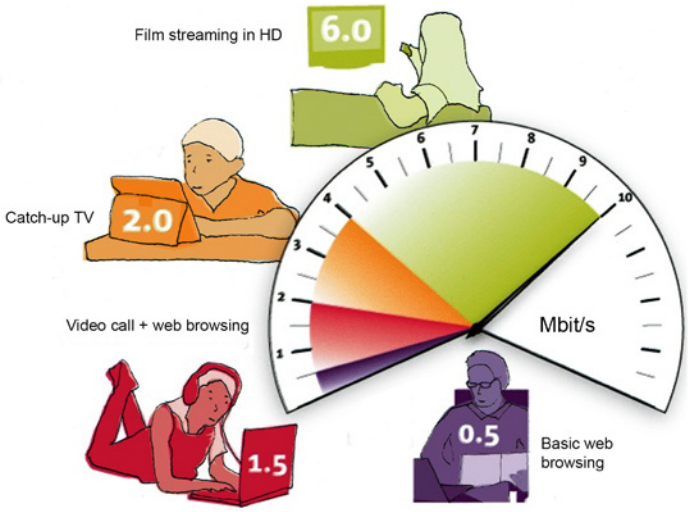


Figure 3 Why a household might need 10Mbit/s

5. Connection Nations 2015, Ofcom,Dec 2015 http://stakeholders.ofcom.org.uk/binaries/research/infrastructure/2015/downloads/connected_nations2015.pdf

The speed with which devices can communicate is governed by the physical and electrical characteristics of their wired or wireless network connections, termed the bandwidth[6]. The bandwidth depends upon two things: the speed of the signal from the external Internet into the home, and the speed available in the network around the home. The former is essentially under the control of the external telecommunications provider. It is interesting to note from Figure 4 that speeds have nearly doubled every two years[7,8].

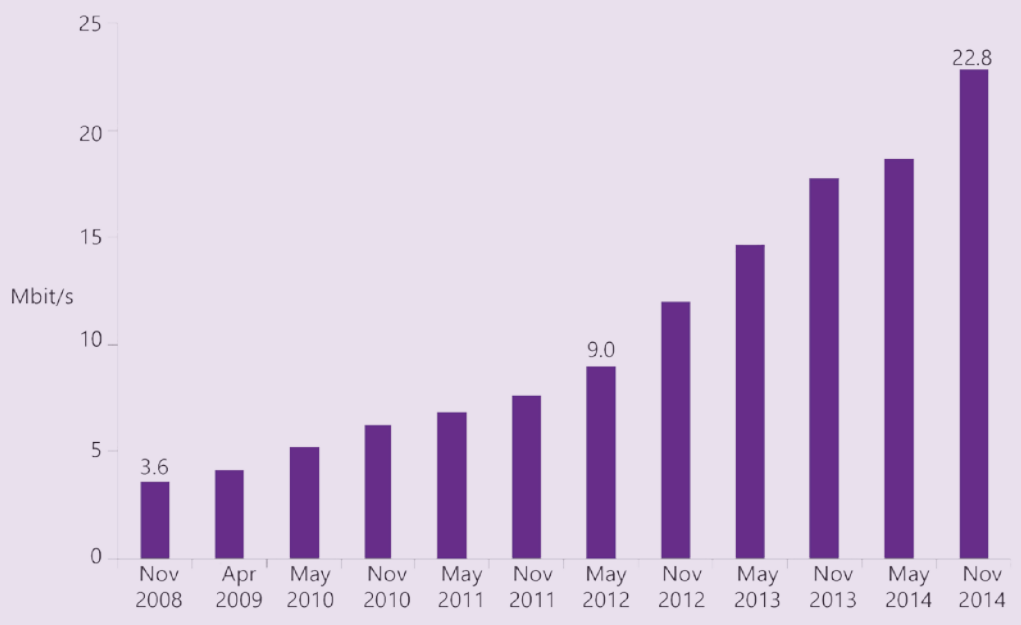


Figure 4 Average download speed for residential fixed broadband connections

The speed available within the home network, however, can make a significant difference, and is largely within the control of the house builder and residents. While wireless connections are generally the most convenient for home networks (especially for mobile devices), wired connections are much faster and are significantly more secure.

Wi-Fi was originally designed for the US market, where homes are more likely to be of timber frame construction and are often of single-storey design. As a result, residents of UK homes, which are typically of masonry construction and with multiple storeys, can suffer from a poor wireless signal in parts of the home. In these cases Wi-Fi may not have the necessary speed for emerging services such as ultra-high definition video.

Wireless should therefore be considered as a key part of a home network, but not the whole solution.

6. In network language, the term 'bandwidth' is often used interchangeably with the word 'speed'.

7. Ofcom, Feb 2015: http://media.ofcom.org.uk/news/2015/broadband-speeds-november2014/

8. Superfast broadband is also becoming increasingly widespread; this enables an entire film to be streamed in typically two minutes rather than two hours.

5 The spectrum of connected homes

There is a broad range of types of connected home. The spectrum of electrical and digital applications making up current and future connected homes essentially falls into three broad categories: today's basic features; at-market and near-market 'smarter' features; and the emerging 'Internet of Things'.

5.1 Today's basic features

At the simplest end of the spectrum, today's connected homes contain technology which is mature in market terms and which presents little in the way of challenges to the designers and house builders who may choose to adopt it. This technology includes the following:

- Home working
- Voice and video telecommunications
- Home entertainment
- Smart meters and energy display devices
- Basic lighting controls
- Heating system controls
- Automatic storage of locally generated energy
- Assisted living
- Fire and security systems
- Low-voltage DC outlets.

5.1.1 Home working

As more employers encourage flexible working and employees adjust to using laptops and accessing files from 'the Cloud' (remote file servers on the Internet), homes are increasingly becoming places to work as well as to live. The Office for National Statistics reported in 2014 that 'of the 30.2 million people in work in January to March 2014, 4.2 million were home workers, giving a home worker rate of 13.9% of those in work. This is the highest rate since comparable records began in 1998'. This study[9] counted only workers who spent at least half of their work time using their home; if employees who only occasionally work from home on an ad-hoc basis are also included, the true number is clearly higher.

With space at a premium, in many cases the home working environment consists of the kitchen or dining room table rather than a dedicated study. This is even more often the case for families who use home computers for personal tasks (emails, letters, school homework, etc). A robust Internet connection therefore needs to be available throughout the home.

5.1.2 Voice and video telecommunications

Traditional home telecommunications consisted of a single hard-wired telephone in the hallway. Using IP technology, however, a much wider range of services becomes possible. Internet telephone calls (known as 'VoIP' calls[10]) can provide voice and video communication using applications such as Skype and FaceTime.

9. 'Characteristics of Home Workers', ONS, 2014. http://www.ons.gov.uk/ons/dcp171776_365592.pdf

10. Voice over Internet Protocol

Such applications are widely used by businesses as well as in the home. They have the advantage of providing international calls cheaply or free, and usually with less signal degradation. VoIP telecommunications can also be used to solve problems of patchy mobile phone coverage.

5.1.3 Home entertainment

Television:

Television is no longer restricted to a single TV set in the corner of the living room with a limited range of channels. Now residents expect to have televisions in multiple rooms to which they can stream their choice of programme whenever they wish. The living room often doubles up as full-function media room with widescreen TV and surround sound. At the top end of the market there is a growing demand for dedicated home cinemas, sometimes with a projector and screen where, at the press of a button, the lights dim, the screen drops down from the ceiling and the cinema system starts. Conversely, many people now use hand-held smartphones, tablets or computers to catch up with the news, episodes of their favourite programmes and even whole films.

Critically, within the home there may be many people viewing different channels, programmes and video clips simultaneously, which means that a wireless network can become congested and slow. The advent of UHD (ultra-high definition, or '4K') TV is exacerbating this effect, but even a small amount of wired networking can significantly improve performance; section 6 describes what designers and house builders can do.

It is worth noting that while catch-up television and streamed video require a network connection, conventional television (both terrestrial digital and satellite) will continue to be broadcast over the air for many years to come. Homes will therefore continue to need aerials, coaxial wiring and TV sockets for the foreseeable future.

Gaming:

The annual consumer-spend in the UK on electronic gaming rose 13% in 2014 to £3.9 billion[11], outselling both music and video. Gaming now forms a large part of how homes are used for entertainment. Interactive games, where multiple players from around the globe can be playing simultaneously, require a fast connection and put a high demand on a home's network infrastructure. Gaming also impacts on where televisions are positioned in the home.

11. 'MCV News', February 2015. http://www.mcvuk.com/news/read/uk-games-market-worth-3-94bn-in-2014/0145088

Music:
The option to listen to CDs, MP3 players, radio stations and streamed music in multiple rooms is already common. Many devices can provide multi-room audio wirelessly, but again a robust internal network and a reliable Internet connection are key. Dedicated sound can be managed through in-wall or in-ceiling speakers, including 'invisible' speakers which are finished over with the relevant surface finish or even disguised as artwork.

5.1.4 Smart meters and energy display devices

Smart gas and electricity meters are intended to revolutionise the way energy is used in the home. Smart meters (Figure 5) can provide information to the resident, and also enable two-way communication between the meter and the energy supplier. Residents can view their instantaneous or historical energy consumption, and can make informed choices about how they use energy within their home. Energy suppliers can interrogate the meters remotely and rapidly produce accurate bills.

A central database of customer and consumption information is being built with the aspiration to enable 'next-working-day' supplier switching for consumers .

Today's smart meters exchange information with the energy suppliers using traditional radio communication technology, and transmit data to the home display using low-power radio signals. Future smart meters may use IP networks and have much more functionality, as discussed later in this section.

Figure 5 Smart gas and electricity meters

5.1.5 Basic lighting controls

Remote-controlled lighting dimmer switches are not new technology, but can legitimately claim to be part of the connected home. Devices commonly use encoded FM radio signals, but basic smartphone applications are starting to appear. The emergence of advanced lighting control systems is discussed later in this section.

5.1.6 Heating system controls

'Smart thermostats' typically enable residents to set up a temperature profile for each heating zone independently of the central programmer. Some smart thermostats also learn the response characteristics of the heating zone, and delay or advance the boiler firing accordingly. Residents are more likely to engage with such devices if they are provided with a simple, intuitive interface (eg. a tablet app). If the user interface is also provided on a smartphone, the home heating can be controlled remotely via the Internet just as easily as from within the home. In addition, the heating system can potentially detect the geographical location of the resident's phone and send them a reminder to boost the heating or hot water as they get closer to home.

Whether such systems (see Figure 6) reduce or increase the use of energy remains to be seen, but there is no doubt that they can enhance the modern lifestyle.

Figure 6 Remote and smart heating controls

5.1.7 Automatic storage of locally generated energy

The installation of solar photovoltaic (PV) panels on homes will increasingly lead to a distributed model of UK electricity generation. Electricity supply and demand do not necessarily match in terms of either geography or time of day, and the National Grid serves to move the electricity from where it is generated to where it is needed as well as to store it centrally at times of excess generation. It is more efficient, however, to use and store local generation in the immediate vicinity.

It is a standard function of PV system controllers to ensure local usage of available generation, but storage of excess generation at times of low demand is not yet the norm. One simple, low-cost method of effectively storing electricity locally is to turn on an immersion heater in the home when there is an excess of PV generation, so that the resulting hot water can be used later without the need for any additional energy. Such systems (see Figure 7) do not generally need to be Internet-connected, but the PV panels, immersion heater and controller can nevertheless be regarded as connected devices.

Figure 7 Controller that enables excess solar electricity to be stored as hot water

5.1.8 Assisted living

The UK has an ageing population. At the time of writing there were some 15 million people in the UK aged 60 or above, and this number is predicted to exceed 20 million by 2030[12]. Research shows that many people live longer (and more happily) when they are in their own home which is familiar to them. Various technologies are available which can provide flexibility and freedom for those living independently, allowing them to summon assistance from informal caregivers such as family members and formal services such as community

12. 'Later Life in the United Kingdom', Age UK, Oct 2015. http://www.ageuk.org.uk/Documents/EN-GB/Factsheets/Later_Life_UK_factsheet.pdf

health workers. Simple remote sensors and unobtrusive alarm activation buttons (including wearable versions) can be integrated easily into the home to provide discreet signalling when needed. Many stakeholders (eg. local authorities, housing associations, healthcare providers, insurers and relatives) are using this 'telecare' technology today. Good telecare combines effective local support with minimal intrusion.

5.1.9 Fire and security systems

Fire and security systems range from simple door entryphones to sophisticated detection and monitoring systems. One of the longest-established remote monitoring systems, BT's Redcare Classic, typically uses hard-wiring within the home and analogue phone lines to alert the monitoring centre, but technology is rapidly advancing. Sensors and alarms linked digitally within the home using wireless signals are now cheaply available. The standards which regulate police response to security alarms[13] assume that implementation is via the Internet for grade 2 systems and above[14].

5.1.10 Low-voltage DC outlets

The growth of ownership of personal digital devices – smartphones, tablets, watches, cameras – means that there is a constant demand for low voltage direct current (DC) charging points in the home. Many portable plug-in chargers inherently waste energy in the voltage conversion process, and their proliferation in the home can be unsightly. Chargers are beginning to standardise on the USB specification, which presents an opportunity to install mains AC sockets which incorporate USB outlets in the same faceplate (Figure 8). These combined sockets consume a negligible amount of energy when not in use, are more visually appealing and use fewer resources to manufacture.

Figure 8 Combined mains/USB socket

13. 'Scheme for the application of European standards for intrusion and hold-up alarm systems' (PD6662) and 'Alarm systems. Intrusion and hold-up systems. System requirements' (BSEN50131), both BSI .

14. Security systems are graded 1-4 depending on the assumed expertise of the intruders. Grade 1 represents opportunistic intruders with few tools, and grade 4 represents expert intruders with a full set of sophisticated equipment.

5.2 At-market and near-market smarter features

In the middle of the spectrum of connected homes are 'smarter' features which would not yet be considered mature in market terms but which are starting to become available. Designers and house builders are unlikely to routinely incorporate these yet, and indeed may decide only ever to incorporate them in premium homes, but the technologies are rapidly becoming cheaper and will one day be a normal expectation of many residents.

A smarter technology may be defined as anything with a degree of intelligence which offers the consumer enhanced control over how they use their home and/ or broadens their lifestyle choices. Smarter devices vary greatly in cost and complexity, but once again the common theme is the need for a home IP network and Internet connectivity.

Smarter features include the following:

- Low-occupancy setback of heating, ventilation and lighting
- Artistic lighting effects and mood music
- Proactive transport applications
- Occupant-sensing security
- Advanced telecare
- Appliance control based on smart meter data
- Low-voltage DC wiring circuits
- Miscellaneous esoteric applications.

5.2.1 Low-occupancy setback of heating, ventilation and lighting

Using conventional passive infra-red (PIR) movement sensors or technology such as smartwatches, a home automation system can deduce from the occupants' activity patterns whether they are up and about, have gone to bed or have left the home. The system can also 'intelligently' distinguish between a normal day out at the office and a longer holiday absence. The heating, ventilating and lighting can then be instructed accordingly to continue running, turn down to a lower setting or switch off altogether.

This is an example of what is commonly referred to as home automation. The popularity of home automation systems is increasing as prices fall and the simplicity of operation through smartphones and tablets becomes commonplace.

5.2.2 Artistic lighting effects and mood music

This is another example of home automation. Sophisticated lighting control can make a home more conducive to multiple uses and can enhance the atmosphere. An open-plan living/ kitchen/ dining space, for example, can benefit from simple scene-setting lighting. A press of a single button might switch off the lights in the kitchen area and illuminate the dining table. Another press might change over to dimmed lights in the living room, or turn off all of the downstairs lights at the end of the evening.

Wearable devices such as smartwatches can inform the home when a specific member of the household has arrived. The home entertainment system can then make that person's playlist accessible via the multi-room music system, and the colours and brightness of the room lighting can be adjusted, either at the user's command or automatically depending on the music genre, time of day, weather, etc.

The vital element is to ensure that all of these devices can communicate with each other using the home network.

5.2.3 Proactive transport applications

With the rise of urban connectivity outside the home, local councils and transport authorities have an opportunity to 'push' information to householders in order to reduce road congestion, increase the use of public transport and generally improve the quality of life. Software applications can assimilate real time traffic information, live parking space availability and predictions of bus, tram or train arrival times to calculate specific travel plans for residents. The resident would state their desired destination and time of arrival, and a PC, laptop or tablet within the home would proactively suggest the optimal mode of transport, route and departure time, keeping the plan constantly updated to reflect the prevailing conditions.

5.2.4 Occupant-sensing security

Security systems which use connected technology can provide reassurance through simple monitoring. They can enable residents to check remotely on the interior and exterior of their property using discreet Internet-connected cameras ('webcams'), via a smartphone app, free of charge. Subscription services can offer higher resolution imagery and recorded historical views. This means that residents could, when on holiday for example, feel comfortable that the doors were locked and that their neighbour had been feeding the pets as arranged.

Connected 'smart lock' technology can enable access to the home only at certain times, or to known individuals using their smartphone or a PIN code. If particular residents are out, the same technology could send messages to their phones when younger members of the family return home, perhaps including an image of them in the hallway for verification purposes.

5.2.5 Advanced telecare

The connected home provides endless possibilities for advanced telecare, or 'telehealth'. Companies that specialise in this area are extending their offerings into wearable devices that monitor heart rate, blood pressure, breathing, etc., and mats which can monitor sleep patterns (see Figure 9). Data from these devices is fed back wirelessly to a centralised server where the information is logged and used by relevant parties to assess the resident's health. Alerts can be automatically flagged, and a real time monitoring service can action the appropriate response. This might range from a call to a family member if an elderly relative has failed to get out of bed, a note to the GP if a symptom has worsened or the despatch of an ambulance if a fall has been detected and the phone not answered.

Figure 9 Advanced telecare sensors

5.2.6 Appliance control based on smart meter data

The ability of a smart meter to receive messages from the energy supplier can enable better control of household appliances. For example, 'cost-reflective messages' can be sent to the meter's display device for customers on flexible time-of-day tariffs, informing them that there is a forthcoming cheap period during which they may wish to turn on higher-powered appliances such as tumble driers.

5.2.7 Low Voltage DC circuits

As described previously, individual USB charging points are now being built into 230V mains outlets. The efficiency of supplying DC devices with power may be improved even further by replacing the multitude of chargers and transformers with a dedicated low-voltage DC circuit, wired around the home alongside the 230V AC circuit. However, the fact that mobile phones and LED lights (for example) require different voltages could complicate matters.

5.2.8 Miscellaneous esoteric applications

There are numerous at-market and near-market technologies which are constrained only by the available budget. At the time of writing, a major manufacturer had just announced a domestic oven which incorporates a built-in camera with which the cook can check from another room that their cake has risen. As long ago as 1998 a demonstration home (Figure 10) built for a BBC Television programme included a bath that could be programmed by each occupant to automatically fill itself to their preferred depth and temperature[15]. The availability of such applications will increase as the price of technology falls.

Figure 10 The BBC 'Dream House'

15. 'Dream House', BBC, broadcast from January 1999

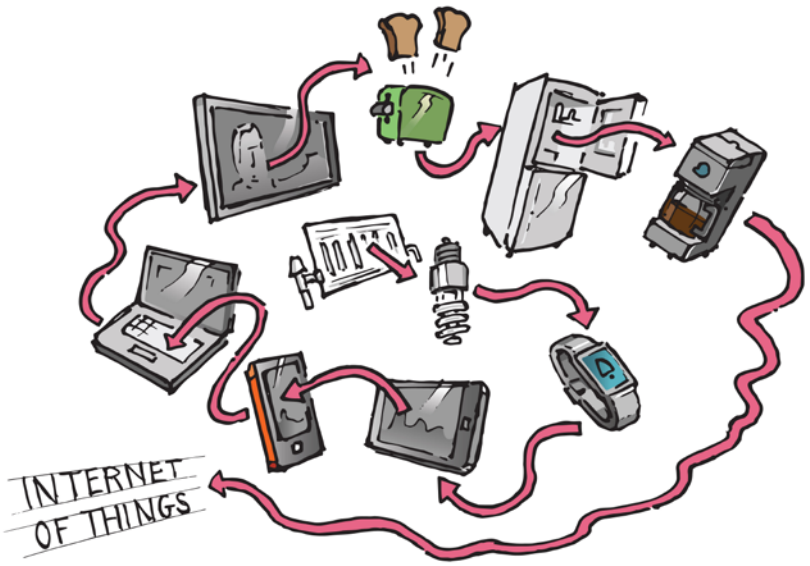
5.3 The emerging 'Internet of Things'

At the far end of the spectrum of connected homes is the Internet of Things (IoT). The phrase simply describes the situation where large numbers of devices are connected to the Internet and are fully 'IP-addressable' (i.e. have their own web address or 'URL'). Every connected device would be able to communicate in both directions with consumers and/or automatic systems, enabling the devices to be monitored and controlled from a distance. The devices would often communicate automatically without consumers requesting information or initiating a 'conversation'.

The IoT can itself be thought of as a spectrum within the spectrum of connected homes, with its own wide range of applications. According to IT consultancy Gartner, there will be 26 billion devices on the Internet of Things by 2020, many of which will be in the home[16]. The extent to which the IoT will change society is difficult to predict. Nevertheless it is important for designers and builders today to understand that while many people are wary of a 'big brother' culture[17], the rise of the IoT has already started. Whatever the extent to which it ultimately develops, house builders should aim to provide the basic infrastructure: a good home network and fast broadband access.

With the IoT, a future can be imagined which includes the following types of application:

- Advanced security systems
- Self-diagnosing and reporting M&E systems
- Automatic electricity load-balancing using grid and smart meter data
- Very advanced telehealth
- 'Future-frivolous' applications.



16. Gartner press release, Dec 2013. http://www.gartner.com/newsroom/id/2636073

17. 'Smart Lives; Making smart smart', Energy Saving Trust, 2015. http://www.energysavingtrust.org.uk/sites/default/files/reports/EST_Smart%20Lives_2015.pdf

5.3.1 Advanced security systems

Connected locks would know when they are locked, and if a connected camera were then to sense motion it could automatically send an alert to the residents if they are away from home. The system could even use facial and walking movement recognition to differentiate between known family members and unknown intruders before triggering the alert. Upon receiving an alert the absent resident could then view the camera images to check on the home. The police could be called either manually or automatically by the system.

5.3.2 Self-diagnosing and reporting M&E systems

Using internal sensors and IoT technology, increasing numbers of mechanical and electrical (M&E) systems such as boilers, heat pumps and mechanical ventilation units will diagnose their own faults, schedule routine maintenance actions (e.g. filter changes) and request appropriate action from a central service company.

5.3.3 Automatic electrical load-balancing using grid and smart meter data

With de-carbonisation of the National Grid as we move away from burning fossil fuels in power stations, and the spread of distributed generation, the task of matching supply and demand becomes more complex for energy generation/ distribution companies. By linking grid performance data with individual homes' demand data, non-essential household appliances could be controlled remotely in order to optimise grid operation at a regional scale. In principle, entire home heating systems could be controlled remotely, providing contracted comfort conditions to the customer but with the energy supplier deciding in real time and at their discretion whether to achieve those conditions using the gas boiler, electric heater or another type of appliance.

5.3.4 Very advanced telehealth

With the expanding IoT, telecare is likely to broaden out from care of the elderly into more everyday health monitoring for all. Toothbrushes might communicate with the dentist to report on the user's oral hygiene routine, and raise an alarm upon detecting specific medical conditions.

Wearable devices, including contact lenses (Figure 11) which analyse the wearer's tears, could monitor and report the blood-sugar level of diabetic residents. Progressive hearing problems could be detected by monitoring trends in the volume level that the viewer has selected on the TV. There is a huge potential for medical advances which utilise the Internet of things.

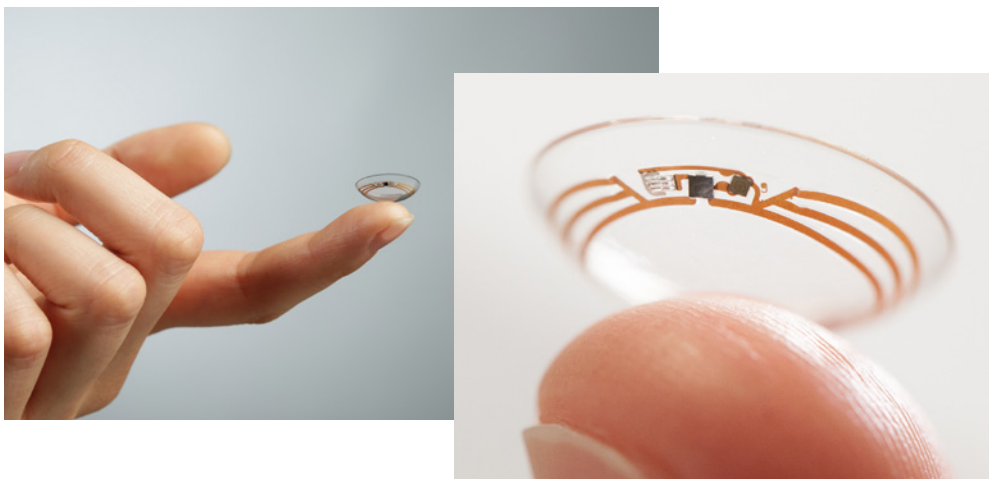


Figure 11 Glucose-monitoring contact lenses

5.3.5 'Future-frivolous' applications

There is frequent talk of fridges which will monitor their stock levels and automatically order more milk at the appropriate moment. Academic institutions are already studying stairs and flooring which track residents' weight and activity levels. These have the potential to lock 'smart' biscuit cupboards accordingly, for everyone or just for selected individuals. There is virtually no limit to the possibilities that will open up if society embraces the potential of the IoT.

6 Considerations for designers and house builders

6.1 The opportunity

The focus on providing services in residential construction has been increasing for many years. Central heating, once considered a luxury, is now a standard feature in almost all new homes. The emergence of the connected home is evolutionary rather than revolutionary, but even the present-day demand for smart devices is turning what were recently considered luxuries into fundamental expectations for many families.

Retrofitting good, reliable smart home technology to an existing home is significantly more costly than including the correct infrastructure in a new home, due to the complications of routing wires and placing sensors in appropriate places. The visual aspects of retrofitted cabling can also detract from the perceived value of the home. There is a tangible opportunity for house builders to address these problems with today's new homes. At the simplest level house builders can enhance the value of their product by incorporating sufficient wiring to provide a basic infrastructure.

6.2 The essential requirements

6.2.1 Ensuring good wireless coverage

Even though wired connections are normally faster and more secure, wireless connections form a key part of a home network. Many older homes can struggle to provide a good wireless signal throughout, but certain modern construction materials, notably steel framing and foil-backed plasterboard, can also limit the transmission of Wi-Fi. With reduced signal strength comes lower bandwidth.

Wireless speed can be affected by the number of devices simultaneously using the home network, and by Wi-Fi from neighbouring properties which can cause broadcast congestion. Also, the size and geometry of a home can mean that good wireless coverage may not extend to all of the rooms. For these reasons, data-intensive services such as ultra-high definition video can fail to deliver consistently.

TIP: To ensure maximum coverage by the wireless signal, the Wi-Fi router/hub should be positioned centrally within the home. Ideally the network terminating equipment (NTE, or 'master phone socket') would also be positioned in the same location rather than in the hall or an under-stairs cupboard, because the router has to connect to it. A switched mains outlet is also required in this location.

6.2.2 Providing some wired connections

Some basic wiring can eliminate many of the Wi-Fi issues described above. Simple network cables can transmit data around the home at up to 1 Gigabit per second (i.e. 1,000 Mbit/s). At the time of writing, this is an order of magnitude faster than either a typical incoming broadband line or an internal wireless connection, and far in excess of what even high-definition video needs.

Wired home data and TV networks can be certified to a specific standard upon completion, and will continue to operate at this standard after the customer moves in; the same cannot be guaranteed with wireless networks.

A wired connected home will include three elements:

- Cables for incoming services (broadband, telephone, digital terrestrial TV, satellite or cable TV)
- A wiring hub (Figure 12) where the incoming services meet[18]
- Cables from the wiring hub to distribute the services around the home.

For a **good standard,** the cables from the wiring hub should include the following to each principal room:

- Two coaxial cables for TV/radio, and
- Two data cables (to 'Cat5e' or 'Cat6/6a'[19]) for digital network services

It is important that mains outlets are positioned adjacent to the coaxial and data outlets in each room.

This simple wiring arrangement is sufficient for most of today's homes, and will provide future-ready cabling for years to come.

18. This hub location is sometimes referred to as the 'extra low voltage headend' or ELVHE.

19. Both types of cable are for data networks; the Cat number relates to their rated speed.

For a **minimum standard,** the wiring from the hub could consist of a single data cable to a central position in the home to ease expansion of the wiring network at a future date.

Consider the inclusion of some wired connections to be business-as-usual. Nothing described above is particularly complicated or expensive. There will be some additional costs for wiring and accessories, but it is straightforward to install. Standard details should be adopted for TV points, the central hub location and incoming services, ideally across all house types.

Wiring guidelines published by professional organisations such as CEDIA and the IET provide useful information[20, 21]. Where more advanced technology (for example a home automation or smart security system) is to be incorporated from day one, a specialist design consultant is recommended.

Figure 12 Wiring hub, which in this example includes the Wi-Fi router

TIP: When providing a wiring hub, its location needs to be determined early in the design process. The incoming services should be terminated in this location, with at least one double switched mains outlet. The Wi-Fi router would typically be part of, or situated adjacent to, the wiring hub.

20. 'Smart Home Recommended Wiring Guidelines', CEDIA, 2015. http://www.cedia.org/recommended-wiring-guidelines

21. 'Code of Practice 1 for Connected Systems Integration in Buildings', IET, 2016.

6.3 Additional considerations

In addition to the essential requirements above, designers and house builders should also consider the following:

- Where a dedicated home office space is provided, ensure that it contains two double power sockets, a telephone point and a wired network point[22]
- Consider installing combined 230V/USB electrical faceplates in a couple of key locations in the home
- Consider using specialist installers such as 'home technology integrators' who are registered under the Electrotechnical Certification Scheme[23]
- If installing IoT technology from day one, provide power and a wired network point where each connected device is likely to be situated (for example, adjacent to every external door with a smart lock security system)
- Ensure that the Home User Guide includes information on the hub and wiring arrangement, with evidence that the installation has been tested and certified; avoid jargon
- Finesse the sales messages: recognise that residents are increasingly focused on broadband speed but may not necessarily be motivated by leading-edge hi-tech or smart features.

22. Good practice also includes a window to provide daylight and adequate ventilation.

23. http://www.ecscard.org.uk

Glossary

4K TV:
See 'UHD'.

App
A software application which runs on a PC, laptop or tablet (for example Instagram, BBC iPlayer, heating control systems, home security).

Bandwidth
The inherent speed at which a network enables devices to communicate. Determined by the physical and electrical characteristics of the wired or wireless links, both within and outside the home.

Cat5e (Category 5 enhanced) cable
A data cable consisting of 4 twisted-pair conductors used for home networks. Can also be deployed for telephone and other low voltage communications.

Cat6/6a (Category 6/6 augmented) cable
As 'Cat5e' but with thicker wire cores and additional physical spacing within the cable to allow faster data speeds and/or longer cable lengths.

Coaxial cable
A cable comprising a central conductor surrounded by an insulator and then a wrap-around braid. Used for radio frequency signals such as conventional television and radio.

ELVHE (extra low voltage head end)
A dedicated central location within the home where network, data and other communication equipment is located alongside cable termination points connected to other rooms. See also 'Hub'.

Fibre broadband
Synonymous with 'superfast broadband'. Internet access provided to the home over optical fibres rather than copper or aluminium telephone wires. Enables the service provider to pass more signals along the same cable and/or offer faster speeds to the end-user.

HD (high definition)
TV pictures with 720 or 1080 horizontal lines of resolution (720p, 1080i, 1080p). 'p' devices produce smoother and more realistic motion than 'i' devices.

Hub
(i) A central network device which typically consists of a router (which directs the data traffic on the network), a number of network ports (for direct connection using wires), a Wi-Fi controller (for wireless connections) and a modem (through which the home network connects to the Internet).

(ii) An arrangement of wiring terminations which enables incoming services to be distributed around the home. See also 'ELVHE'.

IoT (Internet of things)
The situation where large numbers of mundane as well as smart devices are connected to the Internet and are fully 'IP-addressable' (ie. have their own web address or 'URL').

IP (Internet protocol)
A set of conventions by which modern computers and connected devices communicate with each other. Also known as 'TCP/IP'.

LAN (local area network)
A computer network covering a local area such as a home, office or small group of buildings.

NTE (network terminating equipment)
A junction box inside the home, where the incoming telephone and Internet services terminate. Commonly referred to as the 'master phone socket'.

Streamed / streaming
TV, films and music delivered over the Internet rather than over the air.

Superfast broadband
See 'fibre broadband'.

Tablet (or 'tablet computer')
A mobile computer which includes a touchscreen display, cameras, microphone and battery in a single, flat device. Touchscreen finger movements ('gestures') replace the mouse, and an on-screen pop-up virtual keyboard is used for typing.

UHD (ultra-high definition)
TV pictures with 2160 horizontal lines of resolution. Sometimes referred to as 4K. At the time of writing, 8K TV with 4320 lines of resolution is close to market.

VoIP (voice over IP)
Telephone and (increasingly) video calls provided over the Internet rather than via the public telephone network.

Wi-Fi
Synonymous with 'wireless'. Network connectivity using radio rather than physical wires.

The connected home

Designing and building technology into today's new homes

Technology has changed the world beyond recognition, both in the workplace and in our 'connected homes'. Connectivity to the Internet, at ever-faster speeds, is becoming increasingly important. This presents both opportunities and challenges for today's designers and house builders.

This guide describes the spectrum of connected homes, from present technology to future applications. It gives guidance to designers and house builders on what they need to do to make their homes ready for the future as well as fit for today.

The NHBC Foundation, established in 2006, provides high quality research and practical guidance to support the house-building industry as it addresses the challenges of delivering 21st century new homes. Visit www.nhbcfoundation.org to find out more about the NHBC Foundation research programme.

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Published by the NHBC Foundation
ISBN 978-0-9930691-7-8