Acknowledgements

This guide has been funded through the Housing Corporation’s Innovation and Good Practice Grants Programme. Further information can be found on the Housing Corporation website www.housingcorp.gov.uk

BRE would like to thank HellermannTyton Data for permission to use Figures 3 to 8.

Copies of this document can be downloaded from the following website www.bre.co.uk/pdf/smarthomesbriefing.pdf

Contact details

Keith Ross, BRE, Garston, Watford, Herts WD25 9XX

The Housing Corporation, Maple House
149 Tottenham Court Road, London W1T 7BN
Tel 020 7393 2000

© copyright the Housing Corporation and BRE 2003
Smart Homes
A briefing guide for housing associations

Produced by
Ken Bromley
Mike Perry
Graham Webb
and Keith Ross
for the Housing Corporation

March 2003
This briefing guide has been prepared to help housing associations plan for the future in providing smart home systems and services. It covers:

- smart home technologies for internet access, telephone networks, PC networks, home entertainment, security, safety, environmental control and special needs
- the external and internal ‘connectivity’ infrastructure (both cabled and wireless) needed to support smart home systems
- internet (web-based) services
- the benefits and costs of smart homes for landlords and tenants

The guide has been funded through the Housing Corporation’s Innovation and Good Practice Grants Programme to raise awareness among housing associations of recent advances in residential electronic systems and services. The aim is to help housing associations formulate robust new-build and planned maintenance programmes that will cater for electronic systems and services that tenants may demand in the future.

The guide will help housing associations support the government’s e-agenda of making access to online services available to all social groups, thereby overcoming ‘digital exclusion’.

New technologies for housing association tenants can lead to substantial improvements in services and quality of life. In particular there is great potential for provision of new care services that could allow tenants to live independently in their own homes for longer.

The guide is divided into the following sections:

Section 2 – What is a smart home?

begins with an introduction to what is meant by the term ‘smart home’.

Section 3 – Internet services

covers new and emerging electronic services available over the internet, and how these interact with smart homes.

Section 4 – Smart home systems and connectivity infrastructure

introduces electronic systems for smart homes – eg for internet access and home automation – and the wired and wireless infrastructure both outside and inside the home needed to support them.

Section 5 – Design and installation – components, practices and standards

is a technical section that covers components, practices and standards for designing smart homes and installing cables and systems.

Section 6 – Conclusions and recommendations

contains conclusions and recommendations, covering a range of smart home scenarios, costs and steps that housing associations can take to future-proof homes.

Further information

contains a list of publications and websites.

Glossary

a comprehensive list of terms located at the end of the guide for easy reference.

---

3 Housing association is used as a generic term for the organisations regulated by the Housing Corporation, legally known as Registered Social Landlords.
What is a smart home?

There is no one fixed definition of a smart home, but a smart home could be defined as a home where technology has been introduced with the aim of enhancing lifestyle or quality of life.

A key element of a smart home is likely to be a connection to the internet, since this not only gives occupants access to new and emerging internet (web-based) services (eg online shopping and banking), but it also opens up the possibility of remote monitoring and control of home systems. For example, while away from home it becomes possible to use a personal computer (PC) or a mobile telephone to check the security system and CCTV cameras, or to adjust the central heating settings. New home appliances such as washing machines and boilers are being developed that have an internet connection. One day the service engineer will call to repair an appliance before the owner knows there is a fault.

In a smart home, services such as lighting and heating can be computer controlled to optimise comfort and minimise energy consumption. User interaction with the systems – for example to select a lighting ‘scene’ for watching television or to change the set point temperature – could be through an easy to use display panel. Remote control will also be possible using infrared handsets or ‘pocket PCs’ linked by radio to the home PC network.

Home automation services and assistive technologies like this can be of great benefit to the elderly and disabled, enabling them to be more independent and to live in their homes for longer. Occupants will be more secure and also safer – for example systems are being developed that can detect if occupants have had a fall or other accident. The health of occupants can also be monitored – for example blood pressure and heart rate can be measured and sent over the internet to the doctor’s surgery. Other health and social care web-based services will be developed that improve support for the elderly and disabled while reducing support costs.

A smart home will include a cabling infrastructure to distribute the various electronic services around the home. So in every room – alongside standard 13A power socket outlets – there will be additional socket outlets for making connections to the home PC network and the internet, to the home telephone system, and to the home’s audio and video entertainment system.

The benefits of smart homes for landlords and tenants

- ‘digital inclusion’ – access for all to e-services and digital information
- improved and lower cost social care, medical care and property care
- extended independent living
- improved personal safety, security and ‘peace of mind’
- reduced energy consumption
- flexible control of electrical devices

Smart home technologies

Many homeowners and tenants already have access to the following:
- wired and cordless telephones
- digital TV (terrestrial, satellite or cable)
- one or more PCs
- dial-up or broadband internet access – but usually from only one PC
- a security system
- smoke detectors

Newer smart home technologies can add the following:
- shared broadband internet access from a home PC network
- distributed networks for telephone, audio and video
- access control and security combined with CCTV
- automated lighting and heating control
- remote monitoring and control of home systems and appliances:
  - within the home from an infrared handset, or from a laptop PC or pocket PC connected by radio to the home PC network
  - outside the home from a mobile telephone or PC connected over the internet or telephone network to a home PC network
- safety systems that generate local and remote alarms in case of fire or other hazards
- assistive devices for the elderly and disabled, along with access to web-based social and medical services

2

3
The website of the government’s Office of the e-Envoy\(^2\) reports that the number of households with internet access grew from 27% in the 2nd quarter of 2000 to 45% (or 11.1 million households) by the 2nd quarter of 2002. An estimated 57% of adults in Great Britain have now accessed the internet at some time.

Access to the internet can be through a range of devices, or ‘channels’, including:

- PCs
- digital TVs
- telephones
- mobile telephones
- games consoles
- public kiosks

This growth in internet use, and the wide availability of devices for accessing the internet, is introducing opportunities for new ways of delivering services and doing business electronically. Internet access is becoming a key feature of a smart home.

The internet as the foundation for electronic business (e-business or e-commerce) in the UK is already firmly established. For example, internet trading exceeded £1 billion in November 2002, and amounted to another £1 billion in the two weeks before Christmas.

Beyond economic and commercial opportunities, the growth in internet use presents housing associations, health carers and others with substantial opportunities for delivering enhanced and more cost-effective services to their tenants and the wider community.

The Government through the Office of the e-Envoy has acknowledged the substantial economic and social opportunities that the internet can offer. The government’s goals include:

- confident people – people who have the access they need to information and communication technologies, along with the trust, skills and motivation to use them
- modern markets – a market framework which both empowers consumers (individuals, in business and in government) and encourages competition and innovation from the industries which serve them.

The government is particularly committed to ensuring that electronic services are accessible to all, and that disadvantaged groups should not experience inferior electronic access to public services compared to other groups. To quote from an Office of

---

\(^2\) www.e-envoy.gov.uk
Organisations should promote social inclusion, so that cost, skill and lack of confidence are not impediments to channel use.

Statistics suggest that there is currently a social divide in the ability of people to access internet services (see Figure 1 taken from the Office of the e-Envoy's website). There is therefore a clear role, underlined by government policy, for housing associations to contribute to making internet access socially inclusive.

Establishing acceptance of the need for electronic services by tenant groups can be challenging, but once the mechanisms for accessing the internet are in place, use of electronic services can grow very quickly. A recent news item underlines this point: ‘Until you have it the benefits are hard to appreciate. But once you use it the advantages are immediately and constantly apparent.’

Without reservation, the future will see continued growth in the demand for electronic services.

---

Section 3 – Internet services

Existing and emerging electronic services

The wide range of electronic online services made available by the internet include:

- email
- general information access
- shopping
- learning
- government services (eg filing tax returns)
- local government services (eg paying community tax)
- local community services (eg [http://www.improveline.co.uk](http://www.improveline.co.uk) provides access to local contractors)
- health monitoring, health care and social care
- utility metering and diagnostics
- ‘smart communities’

---

A contract for £168m has been announced between BT and the NHS to install broadband services as part of the NHS modernisation programme, with the objective of improving healthcare delivery to patients.

---

The e-Envoy report: ‘Organisations should ... promote social inclusion, so that cost, skill and lack of confidence are not impediments to channel [ie internet] use’.
The term connectivity in relation to smart homes and the internet encompasses all types of communications media – including copper wiring, optical fibre, radio and infrared – that are needed to support the transmission of signals and data to and from the smart home systems that provide internet access, telephony, personal computing, home entertainment (audio and video) and home automation.

The connectivity infrastructure broadly divides into two parts:

- connectivity external to the dwelling
- connectivity internal to the dwelling

The external and internal circuits are linked by a wiring hub or ‘electronic consumer unit’ (see Figure 2). The electronic consumer unit may simply be a junction box for cables entering the home and from which computer, telephone, video and audio cables are distributed to the various rooms around the home. It may also contain electronic devices such as aerial amplifiers, a modem for internet access, and a ‘router’ for linking the modem to a PC network.

A ‘patch panel’ is an integral part of the electronic consumer unit. Using ‘patch leads’, incoming cables can be directed to the desired wall socket outlets.

**External infrastructure**

The existing external infrastructure can provide homes with:
- a telephone line
- analogue TV and radio through an aerial
- digital TV through an aerial (‘free-to-air’) or via cable or satellite
- dial-up and broadband internet access

Not all of these will be available in all areas or to all households. Where they are available, there will usually be only a single connection point for each service.

The government intends to phase out analogue TV transmissions between 2005 and 2010, so that by 2010 at the latest all TVs will need to have a digital rather than an analogue tuner.

**Internet access**

Many electronic services depend on or are enhanced by a fast broadband internet connection.

Until recently, the most common way of connecting to the internet has been from a PC through a dial-up telephone modem. Such connections are inexpensive, but they are slow and inconvenient. In contrast, broadband connections are permanent (‘always on’) and typically 10 to 40 times faster (see Table 1). For consumer markets, the main benefit of broadband is convenience. The expectation for services to be available 24 hours a day, 7 days a week can be met by the internet over a broadband infrastructure. **Contention ratio and security** of data are two aspects of broadband connections that may need to be addressed by housing associations – see opposite.

Substantial elements of the external infrastructure for broadband are already in place, but utilities will often not extend coverage further until it can be shown to be commercially worthwhile. Housing associations may find that they are able to exert some influence over utilities in persuading them to extend coverage.
Alternatively, housing associations could consider arranging to provide tenants with their own private, estate-wide broadband infrastructure linked to the external infrastructure. Such an arrangement is being explored by South Liverpool Housing Trust in Speke. Some services could be public, but others would be password protected.

Contention ratio
Most broadband technologies share bandwidth between users so that the speed available to individuals will vary with the number of users and the amount of data traffic. The ‘contention ratio’ is a measure of the degree of sharing allowed by the internet service provider. A ratio of 50:1 means that the maximum number of users sharing the bandwidth allotted to each user is 50 times the available bandwidth. Typical ADSL services in the UK (mainly using the BT network) have a contention ratio of 50:1, while more expensive, mainly business, packages may have a ratio of 20:1. As broadband becomes more popular, increased sharing and the resulting deterioration in connection speed and service may become more of an issue, particularly when sending video or if alarm messages have to be delivered quickly and reliably.

Internal infrastructure
The introduction of a cabled network infrastructure into homes enables services such as the telephone, TV viewing and internet access to be distributed to a number of different rooms around the home. Wall plates with socket outlets for telephone, PC and TV can be installed alongside 13A socket outlets. Audio and environmental control may also be distributed in a similar way.

Several wireless options are available for implementing the home network – including powerline and radio – which can supplement, although not entirely replace, the use of cables.

Smart home functionality
Current home network infrastructures focus mainly on service distribution (eg TV) and improving control flexibility (eg remote control of lighting). However, smart home functionality can include all of the following:

- TV distribution – terrestrial, satellite and cable TV, viewed and optionally controlled from selected rooms.
- Audio distribution – speakers and a control panel in every room, optional central CD jukebox allowing selection from selected rooms.
- Telephone distribution – multiple telephone points, multiple cordless telephones, or both.
- Networked PCs with internet access – every computer on the network can simultaneously access the internet
- Security and access control – breakage detection, presence detection, pressure pads, occupancy simulation, CCTV, central locking and remote control and monitoring.

**Table 1 Types of Internet connection**

<table>
<thead>
<tr>
<th>Connection Type</th>
<th>Speed/Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dial-up through a telephone modem</td>
<td>Slow (56 kbps), not permanent</td>
</tr>
<tr>
<td>Dial-up through a mobile telephone</td>
<td>Very slow (9600 bps), not permanent</td>
</tr>
<tr>
<td>GPRS mobile telephone</td>
<td>Medium speed (115 kbps), permanent</td>
</tr>
<tr>
<td>ISDN broadband</td>
<td>Medium speed (128 kbps), permanent</td>
</tr>
<tr>
<td>ADSL broadband</td>
<td>Fast (0.5 to 2 Mbps), permanent</td>
</tr>
<tr>
<td>Cable modem</td>
<td>Fast (0.5 to 2 Mbps), permanent</td>
</tr>
<tr>
<td>Satellite</td>
<td>Receiving fast, but sending slow (by telephone)</td>
</tr>
</tbody>
</table>

Security
Security is a primary issue. It embraces:
- security of financial transactions such as payment by credit card
- privacy and security of personal information – a particular concern when considering healthcare issues
- protection against viruses and ‘hacking’

Permanent broadband internet connections should be protected by a ‘firewall’. A firewall is a combination of hardware and software that acts as a buffer between the internal network and the internet. It protects the internal network from being broken into by intruders or hackers.
● Safety systems – for detecting fire, smoke, gas (eg carbon monoxide), water leakage, flood, voltage drop, door and window closure; baby and medical condition monitors.

● Heating and ventilation control – in individual rooms, ensuring that each room reaches the desired temperature at the appropriate time; control of curtains and blinds to control solar gain, minimise heat loss, and to simulate occupancy.

● Lighting control – remote control by infrared or radio; scene setting (adjusting the brightness of a group of lamps to suit particular tasks or moods); and to simulate occupancy.

● Electricity, gas and water consumption monitoring and feedback to promote conservation.

● Remote control and monitoring – of the above services, wirelessly from anywhere within the home and from remote locations via the telephone or internet.

Implementing smart home systems

Figures 3 to 9 show examples of how smart home functionality can be implemented in practice. The cables of each system are routed back to the electronic consumer unit.

Figure 3 shows the wiring for a home PC network with a broadband internet connection. Each RJ45 socket outlet is connected by a Category 5e cable through a patch panel on the electronic consumer unit to a 4-way hub. The hub can connect up to 4 computers together over an Ethernet network. The patch panel is used to...
select the 4 socket outlets to which computers are to be connected. (Hubs are available with more than 4 ways if required.) The PC network is connected through a ‘router’ to the ISDN, ADSL or cable modem connection point in the electronic consumer unit. All four PCs can access the internet simultaneously, sharing the available bandwidth.

Figure 4 shows a home PC network with an internet connection linked by cable and radio to household appliances and systems. The connections are made through a 4-way wired hub with an additional radio interface for wireless connections. Again, all the PCs and devices can access the internet simultaneously, sharing the available bandwidth. The home appliance could be a washing machine or gas boiler that is able to report its service status over the internet to the company responsible for its maintenance.

The desktop PCs are shown linked by Category 5e cable to the internal network. The personal digital assistant (PDA) and laptop PC are linked to the network by a wireless IEEE 802.11b connection. The PDA could be used here as a remote control device to operate home appliances or lighting. A mobile telephone with its own internet connection could also be used for this purpose.

Figure 5 shows the arrangement for distributing telephone points around the home with a structured telephone network. The telephone network uses the same Category 5e cables as the PC network. The telephone network
and the PC network share a patch panel so that a socket outlet can be used as a telephone point or a PC point. The diagram shows a single BT telephone line coming in from the Public Switched Telephone Network (PSTN). The patch panel allows up to four telephone socket outlets to be connected to the one line (ie three extensions). Additional PSTN telephone lines could if required be brought in through the patch panel and distributed around the home.

Figure 6 shows the arrangement for **radio and TV distribution** around the home using coaxial cables. An RF (radio frequency) patch panel with coaxial connectors is used to link incoming cables to the socket outlet points. In any room it is possible to listen to or view the incoming broadcast services, or to view a tape playing on the video cassette player located in the main viewing room.

The patch panel also accepts signals from CCTV (closed circuit television) cameras for viewing on TV (see Figure 7). An infrared controller is available to control the radio and TV sources.

It is possible to route audio signals around the home in a similar fashion to radio and TV signals. The central audio system may include a CD jukebox so that any one of several hundred CDs could be selected remotely and played in the chosen room. Figure 8 shows one arrangement for **audio distribution** to four separate locations in the home from a central audio player. Category 5e cables are here used to carry low level audio signals to amplified speakers.
The volume can be controlled locally and an infrared controller is available to control the audio source.

The newest audio-visual (AV) home entertainment systems may incorporate a cable/satellite decoder, a DVD player, video cassette recorder, radio tuner, 6 channel (or more) surround sound amplifier and speakers, and a large plasma, flat screen display which also serves as the display for a PC and CCTVs.

This calls for a variety of cable types to connect the different components together and to route the signals around the home. Connection standards include, for example, composite video, S-video, RGB, component video, VGA, and 5.1, 6.1 and 7.1 surround sound audio.

In the future, connections will be simplified by digitising all the audio and video home entertainment signals so that they can be routed around the home on the home PC network and controlled from a device such as a tablet PC or a personal digital assistant connected wirelessly to the network.

Figure 7 shows the wiring for a CCTV security system. The CCTV panel is also linked to the TV distribution panel in the electronic consumer unit so that CCTV images can be viewed on a TV.

Finally Figure 9 shows an example of an ‘integrated environmental control system’ based on a standardised control network (which is separate from the PC network) known as the European Installation Bus (EIB). The system can provide flexible control of heating and lighting, as well as security and safety functions. Conventionally heating, lighting and security systems are separate and unable to communicate with each other and share information.

The arrangement in Figure 9 allows a passive infrared detector (for example) to signal the presence of an intruder when the house is locked, and to turn on the heating when the house is unlocked and someone enters a room. In a similar way, a window contact can be used to detect a break-in and to turn off the air conditioning if someone opens a window for fresh air.
Section 4 of this guide has presented an overview of the connectivity infrastructure required to support smart home services. This section takes a more detailed look at components of the infrastructure (e.g., types of cabling and connector), installation requirements, and relevant design and installation standards.

Smart homes will invariably feature a cabling infrastructure, supported to a lesser or greater degree by wireless links. Current research into the use of wireless devices such as mobile phones and infrared controllers in smart homes is not aimed at replacing cable, but rather at supplementing the cabling infrastructure so that ‘no more wiring’ will be needed as more functionality is introduced.

Cable has the advantage over wireless media of being more robust (e.g., less likely to be affected by electrical interference), more secure (radio transmissions can be picked up even outside a building), and generally able to offer a higher level of performance (e.g., the speed of current residential wireless computer networks is typically 11 Mbps compared with 100 Mbps for a wired network). Cable is also likely to be more cost effective, particularly for new installations.

**Cable infrastructure**

**Structured wiring**

A ‘structured’ wiring system is a standardised, vendor-independent cabling system for all the electronic and computer systems in a building. Structured wiring is installed during the construction of a building or during a major refurbishment, taking account of future requirements and the need for flexibility. Structured wiring contrasts with unplanned, ‘ad hoc’ wiring which is installed as and when needed.

Structured wiring systems can comprise a selection of different types of cable, but generally two types will cover most non-power requirements:

- unscreened twisted pair (UTP) cable for carrying data for telephone, computer, home automation, fire and security systems
- coaxial cable for carrying radio frequency signals for TV, radio and CCTV

Power cabling is kept separate from the structured wiring.

All incoming signals to the home are routed through a central wiring hub and distributed to wall outlets which provide a convenient means of making connections in any part of a building to the desired system. Horizontal paths are used to run cables to the majority of rooms, and vertical paths to run cables between floors.

The current European standard for structured wiring is BS EN 50173, ‘Information technology: Generic cabling systems’. Its international equivalent is ISO/IEC 11801. The standard is well established but it covers only voice and data communications.

A structured wiring standard specifically for residential buildings that covers a wider range of cabling systems is currently in draft form. ISO/IEC 15018, ‘Integrated cabling for residential and SOHO and light commercial environments’ covers the following three types of application:

- Information and communications technologies (voice and data communications)
- Home entertainment and multimedia (audio and video)
- Control/command communications for buildings (lighting and heating control, fire and security, etc)

Structured wiring systems that comply with BS EN 50173 are becoming standard in commercial buildings because they can reduce the initial construction costs by up to 30%. They also give the building the ability to adapt and respond quickly and easily to the changing requirements of building users, cutting the cabling related costs of ‘churn’ by up to 60%. For homes, although initial wiring costs may be higher, structured wiring provides a convenient and inexpensive way of accommodating future smart systems.

**BT telephone cable**

Standard BT telephone cable, as used for interior telephone wiring, is relatively low grade and designed to support data rates of no more than 10 Mbps. BT telephone cable connectors are of the RJ11 type.

BT telephone cable is not suitable for use in computer networks since these operate at data rates of 10 to 1000 Mbps.

BS EN 50173 specifies the use of computer grade cable for both the telephone and computer wiring (see next section), which helps to simplify the wiring, lower costs and increase flexibility (since the telephone and computer cables are interchangeable).
Computer cable
Computer (and telephone) cable used in IT systems that comply with BS EN 50173 is unscreened twisted pair cable (UTP). Twisting the cable pairs extends the bandwidth and minimises the effect of radiated interference.

The current market standard is Category 5e consisting of four cable pairs within an overall sheath. Each pair can support data rates of over 100 Mbps (more than adequate to support domestic internet broadband data rates of 128 kbps to 2 Mbps). Category 5e cables use standard RJ45 connectors.

‘Trunk’ Category 5e cable has solid copper conductors suited to ‘punching down’ in insulation displacement-type connection blocks (where the insulated cable is squeezed between two knife edges to achieve a contact, doing away with the need for terminal screws). ‘Patch’ cable, which comes ready fitted with RJ45 connectors and is used in wiring hubs to link two circuits together, is stranded (made from a number of fine wires rather than a single, solid wire) to give it flexibility.

Category 5e cable can support computer (Ethernet) network speeds of up to 1000 Mbps (1 Gigabit per second) if all four twisted pairs are used at the same time (to the 1000 Base-T IEEE 802.3ab standard). Because this protocol requires a transceiver at both ends of each pair, the electronics are more costly.

An alternative Gigabit Ethernet protocol is to the 1000 Base-TX (TIA-854) standard. This requires the use of a higher grade Category 6 cable which is nearly twice the price of Category 5e cable, although the electronics are less costly.

The Category 6 standard was approved in June 2002. The 1000 Base-TX protocol will not work over Category 5e cable so that if the need for a 1000 Mbps network is anticipated, then it would be wise to install Category 6 equipment. However, users will probably find that, until the Category 6 standard becomes better established, they will be locked in to buying products from just the one vendor.

It is unlikely in the near future that Gigabit Ethernet will be cost-effective in residential premises. Furthermore, apart from the extra cost of the cable, Gigabit networks must be installed more carefully. The performance of high data rate networks can be adversely affected by kinks in cables, sharp bends, over-tight cable ties, and poor quality connections. The standards specify installation practices very precisely.

Optical fibre
Although fibre-optic cable may form part of the future home network infrastructure, there are currently very few devices for the residential market that would integrate with this technology and costs are prohibitive.

Cable installation
Electronic consumer unit
A central feature of a smart home network is a wiring hub or electronic consumer unit to which all external and internal cables are connected. The wiring hub may simply be a junction box, or it may contain electronics such as aerial amplifiers. A ‘patch panel’ allows signals to be routed only to the required socket outlets (since some socket outlets may not be needed once a house is occupied).

Wiring topology
Two types of wiring topology are commonly used with electronic systems (figure 10):

- Star wiring – for computer networks and audio and TV distribution
- Bus wiring – for lighting, heating and other control networks

A third topology, loop wiring, is also sometimes used with control systems.

TV and radio cable
Coaxial cables (coax) are used to carry radio frequency signals for TV, radio and some CCTV cameras. Coax has a circular cross-section, and consists of a central conductor separated by insulation from a surrounding conducting braid or foil screen, all within an outer insulating jacket.

Two types of coaxial cable are commonly in use:

- ‘Standard’ TV cable, suitable only for terrestrial analogue TV and FM radio
- CT100/CT125 cable, a higher grade (double screened) cable intended for digital satellite and cable TV, and terminated with a special ‘F-type’ connector

Cable ducting and routing
If a decision is taken not to install cabling at new build or major refurbishment, then providing ducting to allow retrofitting would at least avoid the major disruption and cost of rewiring. At the present there are no dedicated product standards or codes of practice covering the installation of ducting for smart cabling. However, ducting should be installed in such
a way that the eventual cabling installation will comply with all relevant standards for electrical safety and electromagnetic compatibility.

In particular, installations must comply with BS 7671:2001 ‘Requirements for electrical installations’ (IEE Wiring Regulations Sixteenth Edition). This calls for a separation of 50 mm to be maintained between telecommunications (Band I) circuits and electric power and lighting (Band II) circuits in order to prevent mains voltage from appearing on the telecommunications circuits. If this separation cannot be maintained, then the Band I cables must be insulated for the highest voltage present, or a non-conducting divider must be inserted between the Band I and Band II cables. (The 50 mm separation need not be maintained if the Band II cables are enclosed in separate plastic or metal conduit or trunking, or they are of the mineral insulated type or of earthed armoured construction.)

The following BS 7671 requirements for cable routing may also be relevant as a means of providing protection against accidental damage. Where cables are to be installed under floors and over ceilings, the cables should be run at least 50 mm away from the top or bottom of a joist, or in steel conduit, or be provided with mechanical protection to prevent nail penetration. Where cables are to be concealed in walls, the cables should be run horizontally or vertically to a connection point or accessory, or horizontally within 150 mm of the top of a wall, or vertically within 150 mm of the angle formed by two walls. Outside these zones, cables should be run at least 50 mm beneath the surface of the plaster, or in metal conduit.

ISO/IEC 15018 will contain recommendations for segregating data cables to prevent electrical interference in residential buildings. In the meantime, EN50174-2:2000, ‘Information technology – Cabling Installation’, Part 2, ‘Installation planning and practices inside buildings’ provides guidance for commercial buildings. The recommended separations in this standard vary with the type and length of cable used, and depend on the presence of metallic or plastic dividers or partitions.

With a view to simplifying internet access, the government’s Building Regulations Division has prepared a draft Approved Document (AD Q) specifying ducting requirements for new homes. The proposed internal requirement is for a 50 mm by 50 mm duct, with a minimum separation of 75 mm from mains cabling. A consultation document is due to be published in the Spring. If adopted, the proposed requirement would apply to all buildings, not just dwellings, although the AD itself contains guidance only for dwellings.

Alternatives to data cable
Data transmission in a smart home can be implemented with wireless (radio or infrared) links. Wireless links are not so secure as cable, they are generally more expensive and have lower data transmission speeds. However, wireless links can add flexibility and convenience, and are easier to retrofit.

Another alternative to data cabling is the mains power wiring system, which can also be used to carry data signals. ‘Powerline’ links avoid the need for a dedicated data wiring system, but communication over mains wiring is slow, insecure and can be unreliable.

Wireless
Bluetooth. Bluetooth could be regarded as a wireless version of the USB connection standard for
computers. It is a low power radio technology that allows wireless connection between electronic devices. Voice and data can be exchanged at a range of up to 10 m.  

**IEEE 802.11b.** The 802.11b standard is used to make wireless links to computer Ethernet networks. It is used to link portable devices such as personal digital assistants (PDAs) and tablet PCs to networks, including for the purposes of remote control. The standard was introduced in 1999 and has become established as the most popular wireless standard. The ‘raw’ data rate is 11 Mbps, and the range is up to 100 m depending on the environment and obstacles such as walls. The range for ‘roaming’ can be extended by introducing additional wireless access points to the wired network. The transmission is encoded and the key to coding is known only to the sending and receiving devices. A more recent version of the standard, 802.11a, supports data rates of 54 Mbps over typically shorter distances.  

**Mobile telephones.** Mobile telephones can also be used as an interface to home PC networks. The link with the network is made over the internet using WAP (the Wireless Application Protocol). GPRS (General Packet Radio Service) phones have an ‘always on’ connection and can communicate at speeds of up to 115 kbps. Third generation (3G) mobile phone technology will emerge within the next 12 months, bringing video communications and correspondingly high data transmission rates. Further into the future, fourth generation (4G) phones will exploit satellite links so that, for example, it will become possible to use mobile phones on aircraft.  

**Powerline**  
Powerline devices transmit information, such as control signals, over standard mains electrical power wiring. This effectively transforms each electrical outlet into a potential network connection, and fixed or plug-in sensors and actuators can be used to control appliances and devices, such as switching and dimming lights. In Europe mains powerline communication installations have to adhere to the EN 50065-1 standard. EN 50065-1 defines the frequency and voltage range of the superimposed signal. Mains power lines can be subjected to high levels of electrical noise from electrical appliances such as electric drills, vacuum cleaners, light dimmers and TV sets. For this reason powerline communication is generally not used for safety related applications.

**List of standards and codes of practice**

| Information technology – Generic cabling systems | EN 50173 |
| Information technology – Cabling installation | EN 50174 |
| Specification and quality assurance | EN 50174-1 |
| Installation planning and practices inside buildings | EN 50174-2 |
| Installation planning and practices outside buildings | EN 50174-3 |
| Testing of installed cabling | EN 50346 |
| Integrated cabling for residential, SOHO and light commercial environments | ISO/IEC 15018 |
| Home and building electronic systems (HBES). | BS EN 50090 |
| System overview. Architecture | BS EN 50090-2-1:1996 |
| System overview. General technical requirements | BS EN 50090-2-2:1997 |
| Aspects of application. Introduction to the application structure | BS EN 50090-3-1:1996 |
| Aspects of application. User process | BS EN 50090-3-2:1996 |
| Conformity assessment of products | BS EN 50090-8:2001 |
| Part 9-1. Installation requirements. Generic cabling for HBES class 1 twisted pair | prEN 50090-9-1. |
| Home electronic system, HES. Part 1. Standardisation structure | ISO/IEC 10192-1 (prEN 50090-1) |
| Signalling on low voltage electrical installations in the frequency range 3 kHz to 148.5 kHz | EN 50065 |
| Application of equipotential bonding and earthing in buildings with information technology equipment | EN 50310 |
6 Conclusions and recommendations

Smart home features
We have defined a smart home as a home where technology has been introduced with the aim of enhancing lifestyle or quality of life. A key element is likely to be a connection to the internet, both to gain access to new and emerging web-based services – such as online shopping, online banking, and online community care services – but also for the purposes of remote monitoring and control of home systems. In a smart home, services such as lighting and heating can be computer controlled to optimise comfort and minimise energy consumption. Home automation services and assistive technologies in particular can be of great benefit to the elderly and disabled, enabling them to be more independent and to live in their homes for longer, and to be safer and more secure. A smart home will include a cabling infrastructure to distribute the various electronic services around the home. Socket outlets will be provided in every room for making convenient connections to the home PC network and the internet, to the home telephone system, and to the home’s audio and video entertainment system. ‘Peace of mind’ services – such as being able to check the security system while away from home – along with home entertainment are two of the most appreciated features of a smart home.

Benefits for landlords and tenants
Smart homes present housing associations with substantial opportunities for delivering enhanced and more cost-effective web-based and technology-based services to their tenants. The benefits to landlords and tenants include:
- ‘digital inclusion’ – access for all to e-services and digital information
- improved and lower cost social care and medical care
- maintenance reporting
- extended independent living
- improved personal safety, security and ‘peace of mind’
- reduced energy consumption
- flexible control of electrical devices

Smart home scenarios and costs
The cost of installing smart home systems can vary enormously. A typical entry level system – providing computer, audio and TV signal distribution via a small home network – can cost between £600 and £700 when installed in a new building using the same methods that are applied to mains wiring (ie routing cables under floors, through joists and within plaster, without any special ducting).

Systems for an ‘executive’ smart home – with a large PC network, home theatre, audio and TV distribution (with remote channel/source selection and control), a security network (including CCTV), lighting and heating control, etc could cost £10,000 or more.

Indicative costs for a range of new-build smart home scenarios are shown in Table 2.

Table 2 Installation costs for new 3-bedroom house

<table>
<thead>
<tr>
<th>Action</th>
<th>Cost (£)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Satellite/ cable interactive digital TV connection</td>
<td>50</td>
</tr>
<tr>
<td>2nd telephone line for dial-up internet access</td>
<td>50</td>
</tr>
<tr>
<td>Broadband internet access</td>
<td>50</td>
</tr>
<tr>
<td>Ducting for structured cabling</td>
<td>500</td>
</tr>
<tr>
<td>Structured cabling infrastructure based on Category 5e UTP cable and CT100 coaxial cable for PC networking, TV distribution and future services</td>
<td>&gt;1000</td>
</tr>
<tr>
<td>Smart systems for heating control, lighting control, security, safety, etc</td>
<td>&gt;5,000</td>
</tr>
</tbody>
</table>

Table 3 Internet running costs

<table>
<thead>
<tr>
<th>Type of internet connection</th>
<th>Cost (£)/month</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dial-up (56 kbps)</td>
<td>10</td>
</tr>
<tr>
<td>Slow broadband (128 kbps)</td>
<td>15</td>
</tr>
<tr>
<td>Medium speed broadband (600 kbps)</td>
<td>25</td>
</tr>
<tr>
<td>Fast broadband (1 Mbps)</td>
<td>35</td>
</tr>
<tr>
<td>Business broadband (&gt;2Mbps)</td>
<td>&gt;45</td>
</tr>
</tbody>
</table>

Typical running costs for an internet connection are shown in Table 3. Costs vary with the speed of connection – for domestic users from £10 per month for a slow dial-up connection over a telephone line, to £35 per month for a permanent, fast broadband connection over cable (for example). Installation is often free.
The cost of broadband is falling all the time and will soon be little more than that of a dial-up connection.

Future-proofing
Housing associations can go a long way towards future-proofing new homes by providing suitable ducting to accommodate cables. The Building Regulations Division will shortly begin a public consultation on proposals for new regulations covering ducting provision in new homes for broadband internet access. A draft Approved Document contains technical guidance that housing associations will be able to follow.

The installation in new homes of a structured wiring system that conforms with ISO/IEC 15018 is an additional, but more expensive, step that could be taken to future-proof new homes. The system would comprise Category 5e (or possibly Category 6) cables for telephones and data, and CT100 (satellite grade) coaxial cables for audio and video, with socket outlets suitably distributed around the home.

Meeting user needs
There is a danger that smart home solutions will be over specified. It is important to have a clear understanding of end-user needs and to accommodate those needs within the budgetary framework (Figure 11). Smart home technology offers a ‘toolbox’ of options which need to be applied selectively to optimise the costs and benefits.

Target group needs may include:
- information access
- support for daily living
- emergency support
- working from home
- health and social care
- greater security and safety
- tenant interaction
- digital inclusion
- lifestyle benefits

Collaboration
Housing associations and local authorities can save money by collaborating on:
- the provision of web services and content management (eg Lincolnshire County Council have developed an internet portal that it hopes to sell to other local authorities)
- interactive TV content for local communities

Further savings can be made by negotiating with cable and satellite TV providers to make digital TV available to tenants at more affordable rates, and by working with charities and large companies on providing tenants with PCs.

---

**Figure 11 Meeting user needs**

- Identify needs of target group
- Select appropriate technology
- Implement
- Support, maintain and enhance
Further reading


[http://www.housingnet.co.uk](http://www.housingnet.co.uk). A UK housing information resource, Housingnet is a ‘not for profit’ site.

[http://www.housit.org.uk](http://www.housit.org.uk). housIT is a virtual community of people interested or involved in housing to share knowledge and skills about best practice and innovation relating to housing and IT.

[http://www.rethinkinghousebuilding.org/default.asp](http://www.rethinkinghousebuilding.org/default.asp). JRF & SPRU. The Housing Innovations Site provides a resource for all those interested in innovation in housing. Its development was prompted by an increase in innovation in the UK housing sector following new pressures for change in the sector and the launch of The Housing Forum in 1998.

[http://www.thehousingforum.org.uk](http://www.thehousingforum.org.uk)

[http://www.homesonthenet.co.uk](http://www.homesonthenet.co.uk). This national industry and government initiative promotes and encourages improvements in housing quality and production processes, drawing lessons from housing in other countries as well as from other industries.

[http://www.sxfps.com/pls/sxfps/fronddoor](http://www.sxfps.com/pls/sxfps/fronddoor). First Housing is a comprehensive housing management solution for all types of housing organisations world-wide.

[http://www.renfrewhshire.gov.uk/interfinder/contents.html](http://www.renfrewhshire.gov.uk/interfinder/contents.html). Renfrewshire Council has set up an online service for tenants to report repairs to their homes.

[http://www.lincolnshire.gov.uk](http://www.lincolnshire.gov.uk). Lincolnshire County Council has set up its own website to provide information and support to citizens. It has developed internet portals that it hopes to sell to other local authorities.
Glossary of terms

**ADSL (Asymmetric Digital Subscriber Line)** – A method of making a broadband connection to the internet using a standard BT telephone line.

**Band I circuit** – A low voltage telecommunications, computer or similar circuit.

**Band II circuit** – A mains voltage circuit.

**Bandwidth** – An indication of the speed at which information can be transmitted over a computer network or over the internet.

**Bits per second (bps)** – A unit of measurement for the speed or rate at which digital information can be transmitted. A kilobit per second (kbps) is 1000 bps; a megabit per second (Mbps) is 1 million bps; and a gigabit per second (Gbps) is 1 billion bps.

**Bluetooth** – A low power radio technology that allows wireless connection between electronic devices. Voice and data can be exchanged at a range of up to 10 m.

**Broadband** – Description applied to a high speed internet connection that can transmit data at speeds from 128 kbps to 2 Mbps or more.

**Bus wiring** – A wiring system in which devices are connected to a single cable line.

**Category 5e** – The current ratified standard for computer network wiring employing a cable consisting of four unscreened twisted pair (UTP) wires. Category 5e can support data rates of up to 1 Gigabit per second (1 billion bits per second) using all four pairs. Home computer networks typically support 100 Mbits per second (100 million bits per second) using two pairs.

**Category 6** – An enhanced computer network wiring standard that employs cables with a higher bandwidth than Category 5e cables.

**Churn** – Changes of personnel or their desk positions. Churn rate is the frequency of change, usually expressed as a percentage of turnover of total staff per annum.

**Connection speed** – The speed in bits per second (bps) at which digital information can be transmitted over an internet connection.

**Connectivity infrastructure** – Encompasses all types of communications media – including copper wiring, optical fibres, radio and infrared – needed to support the transmission of signals and data for internet access, telephony, personal computing, home entertainment (audio and video) and home automation.

**Contention ratio** – A measure of the number of users allowed by an Internet Service Provider (ISP) to share an internet connection.

**CT100/CT125** – Standards covering coaxial cables and connectors for digital TV.

**Data transmission speed** – The speed in bits per second (bps) at which digital information can be transmitted over a computer network or internet connection.
Downloading – Receiving data over a computer network

e-business (e-commerce) – Electronic business carried out over the internet

Electronic consumer unit – A central box from which TV, internet, telephone and computer cables, etc, are distributed throughout the home

Ethernet – A type of network commonly used to connect PCs together. Data can be transmitted over an Ethernet network at speeds of between 10 Mbps and 1 Gbps

Extranet – An extension of an organisation’s intranet to make it available to selected outsiders

Firewall – A combination of hardware and software that acts as a buffer between the internal network and the internet. It protects the internal network from being broken into by intruders or hackers

Gigabit Ethernet – A very high performance Ethernet network with a data transmission speed of 1 Gbps

GPRS General Packet Radio Service – An extension of the standard GSM digital mobile phone network that can provide an ‘always-on’ connection to the internet at data transmission speeds of up to 115 kbps

GSM Global System for Mobile Communications – The current wireless digital technology for mobile phone communications

Integrated control system – A system in which the lighting control, heating control, security and fire protection services, etc, use the same home communications network to transmit, receive and share data

Internet – A world-wide network of computers connected by the TCP/IP communications protocol

Intranet – A private internal internet network

ISDN (Integrated Services Digital Network) – An international telecommunications standard for providing a digital service from the dial-up telephone network. A line can be used for both voice and data communications at speeds of up to 128 kbps

Kiosk – An internet access point outside the home

Loop wiring – A wiring system in which devices are connected together in a loop

Narrowband – Description applied to a low speed internet connection (for example through a dial-up telephone modem) that transmits data at speeds of less than 128 kbps

Networked PC – A PC connected to other PCs by a computer network, usually an Ethernet network

Patch cable – A flexible data cable made from stranded wires for use on patch panels. Patch cables generally come in fixed lengths ready fitted with RJ45 connectors.
**Patch panel** – A wiring panel – part of the electronic consumer unit – that uses patch leads to connect incoming cables to the desired wall socket outlets.

**Powerline communications** – A communications system in which data are transmitted over the mains wiring.

**PSTN (Public Switched Telephone Network)** – The established international telephone system for carrying voice data over circuit switched connections.

**Radio communications** – A communications system in which data are transmitted using radio waves.

**RJ11** – A plug and socket standard for telephone connections.

**RJ45** – A plug and socket standard for computer network connections.

**Smart home** – A home where technology has been introduced with the aim of enhancing lifestyle or quality of life.

**SOHO** – Small Office Home Office.

**Star wiring** – A wiring system in which each device is connected to a separate cable emanating from a hub. This is the system used in smart homes for telephone, computer and home entertainment wiring.

**Structured wiring system** – A standardised, vendor-independent cabling system for all the electronic and computer systems in a building. The current European standard for structured IT wiring (covering telephone and computer wiring) is BS EN 50173, ‘Information technology: Generic cabling systems’. A draft standard for residential buildings covering structured wiring for telephone, computer and home entertainment is ISO/IEC 15018, ‘Integrated cabling for residential and SOHO and light commercial environments’.

**TCP/IP (Transmission control protocol/ internet protocol)** – A communications protocol for sending data over the internet.

**Transceiver** – An electronic circuit that can both transmit and receive data.

**Trunk cable** – Generally hidden cable that runs, for example, from a socket outlet back to the electronic consumer unit. It has solid copper conductors suited to ‘punching down’ in insulation displacement-type connection blocks (where the insulated cable is squeezed between two knife edges to achieve a contact, doing away with the need for terminal screws).

**Unscreened twisted pair (UTP) cable** – A two core cable in which the two wires are twisted together along their length to improve performance. Screened twisted pair (STP) cable features an outer conducting foil or braid screen.

**Uploading** – Sending data over a computer network.

**WAP (Wireless Application Protocol)** – A communications protocol for connecting mobile phones to the internet.

**www (World Wide Web)** – A network of computers on the internet that store information in the form of pages that can be viewed with ‘web browser’ software such as Internet Explorer or Netscape Navigator.