This month, the Davis Langdon Mott Green Wall cost research department reviews the latest available wireless technology for building management systems, together with its current and potential ranges of application, benefits and costs

Wireless networks for building automation

Wireless control has been around for decdades and, despite some initial concerns about its application for building automation, it looks set to become the de facto solution in the next 10 to 20 years.

A host of technology options are available with a range of different characteristics, depending on the needs of the application. The main ones are:

- Infrared (IR). This is the lowest cost, but has the shortest range, and it requires line-of-sight to work successfully. It offers data rates up to 16 Mbits/s
- Industrial, Scientific and Medical (ISM) wireless. Low-cost chips and modules, operating in the ranges 315 MHz to 433 MHz and 902 MHz to 928 MHz. Good for simple applications, but no standard protocols
- Bluetooth. Highly developed, with many profiles, offering data rates up to 3 Mbits/s and distance ranges of 10 m to 100 m. Offers networking capability
- Wi-Fi. Relatively expensive and power-hungry, but with high data rates (to 54 Mbits/s) and, at 100 m, the longest range
- Ultra-wideband (UWB). Available as chips and modules with very high data rates (to 480 Mbits/s), but with a range under 10 m, and generally applied only to consumer products
- ZigBee. The latest technology, with low data rates (up to 250 kbits/s), but with very low power consumption and inherent mesh networking. It has good potential for many applications, leading to high-volume and low-cost production.

Standards

There are many different proprietary wireless systems, but there is a clear move towards global standards for buildings leading to improved inter-operability. The ZigBee Alliance for example describes itself as "a global ecosystem of companies creating wireless solutions for use in home, commercial and industrial applications". It has recently announced a new collaboration with BACnet, a leading protocol for wired commercial building automation, establishing interoperability between the two technologies.

ZigBee-ready sensors and controller adapters are available from BMS manufacturers so that existing wired networks can be extended, refurbished or remodelled to provide new functionality.

Power requirements

Wireless room sensors are typically battery powered, with an estimated battery life of five years, whereas controllers derive their power from the same mains supply as their associated actuators.

Controllers are generally mounted out of sight of the building's occupants. This is often in the open space of a false ceiling plenum, and with controllers relatively close to each other. Mesh technologies range from 15 to 45 m, and most controllers have many neighbours located within this range, guaranteeing multiple redundant paths of communication. The overall effect is that controller nodes are easily able to establish and maintain communication with many other nodes, and the typical controller environment is conducive to a wireless mesh topology.

Room sensors, on the other hand, are typically located further apart, possibly with more obstructions between them and in a more uncertain environment. The movement of occupants, furniture, cabinets and other obstructions, for example, along with mobile phones and wireless LANs, creates a more challenging environment for room sensors.

Health concerns

There is anecdotal evidence to suggest that a small proportion of people react badly to wireless networks, reporting symptoms such as

headaches, fatigue, irritability and lack of concentration. Mobile phones and Wi-Fi networks have been implicated in these complaints, but it is interesting to note that the mesh network nodes proposed for BMS applications operate at much lower power levels (typically 100 mW or less), and that they are normally located maybe 2-3 m from building occupants.

It therefore seems unlikely that similar problems will arise. In fact, one leading scientist who reviewed a 2005 Health Protection Agency report on "electrosensitivity" with regard to Wi-Fi was quoted as saying, "This is yet another example of the modern disease of Compulsive Risk Assessment Psychosis – otherwise known as CRAP." It seems there is no evidence for precautionary action.

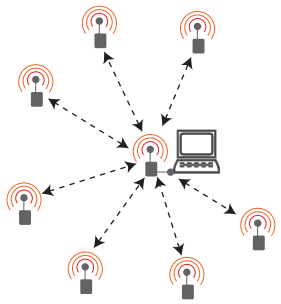
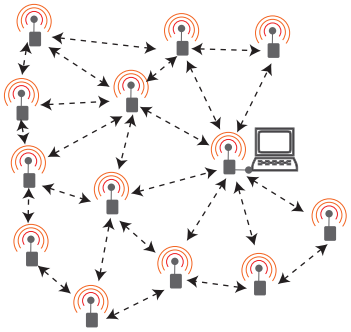
Wireless advantages

Many industry pundits consider that within 10 to 20 years wireless building control mesh networks will be the low-cost infrastructure of choice, as power requirements continue to decrease and sensors and controllers become smarter yet smaller. In the meantime, the main advantages of wireless controls are:

- The ability to deploy them in difficult situations, especially in existing buildings or remote locations
- Mobility and rapid deployment – effectively eliminating one trade and enabling shorter project programmes
- Easy and quick to expand or modify the network
- Self-configuring and self-healing mesh networks
- Sensors may be placed more accurately, leading to better control resolution and possibly energy savings
- Enables staged migration from wired legacy systems to suit budgets and programmes
- The emergence of low-power, low-cost ZigBee chips and modules means that a wireless mesh network can be implemented at the same cost or even at lower cost than a wired network.

Wireless mesh networks for BMS applications may offer first-cost and lifecycle cost savings in a wide range of settings and should be considered for:

- Refurbishment – retrofits and upgrades of legacy wired systems to provide new capabilities such as enhanced environmental control for improved energy efficiency
- Retail – hard-to-wire spaces, with layouts subject to frequent change
- Commercial offices – system flexibility should yield savings and less disruption to tenants subject to high "churn"
- Hotels and hospitality - minimal disruption

Network type	Features
Point to point 	The point to point set up uses direct connection from one device to another. In practice, one controller may be linked to a nearby network hub, or signals can be relayed over a long distance, from a single device to the next.
Point to multi-point 	The point to multi-point set up relies on a hub-and-spoke arrangement, with a central controller for all of the other wireless nodes. Area covered is restricted by signal strength. Interference between hub and any node will disrupt traffic. It is commonly used for Wi-Fi, Global System for Mobile Communications (GSM) and Bluetooth.
Mesh network 	The mesh approach uses distributed intelligence for communication with all devices within range. Nodes can send and receive messages, and they can function as routers, relaying messages for their neighbours. By this process, packets of wireless data can reach their destination by passing through whatever intermediate nodes are necessary. Signal range can be extended as required by using simple and low-cost repeaters. The result is full RF redundancy, with self-configuring and self-healing multiple data paths.

A mesh network installation

■ Museums and historic buildings – minimum damage to special or fragile building elements

The cost model building

The detailed costs for the 'traditional installation' in table 1 are based on tender costs for an office development in London. For the wireless model, the on-floor LAN wiring has been replaced by ZigBee-type mesh networks, with the controllers and routers replaced by wireless versions. The building has a gross internal area (gia) of 7,403 m², arranged over 10 floors, with a net lettable floor area (nla) of 5,234 m².

The development is served by a single roof-mounted package boiler plant room and external roof mounted air cooled chillers. Primary fresh air is distributed to the floors via one supply and extract air handling unit.

Local temperature control on the floors is achieved via a series of ceiling mounted two pipe fan coil units with electric reheat.

A single PC drives the building management system installation via a dedicated Ethernet network. In addition to controlling the environmental plant, the system also monitors the fire dampers and sprinkler status, and the main gas and water meter. ■

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Table 1 : Detailed installation costs

Shell and core installation	Traditional wired LAN installation	Wireless mesh networks
Main plant controls; two controllers in the two main motor control panel with 141 points connected; front end and PC peripherals.	£13,000 £1.75/m² (gia) £2.48/m² (nla)	£13,000 £1.75/m² (gia) £2.48/m² (nla)
Site preliminaries	£13,600 £1.83/m² (gia) £2.59/m² (nla)	£13,600 £1.83/m² (gia) £2.59/m² (nla)
Two single Form 2, wardrobe-type motor control panels MCC1 and MCC2, with feeds and drives for three boilers, one supply fan, eight extract fans, lthw and chw primary and secondary pumps, lthw and chw pressurisation units. Also includes a mimic sprinkler and fire damper monitoring panel	£24,000 £3.24/m² (gia) £4.58/m² (nla)	£24,000 £3.24/m² (gia) £4.58/m² (nla)
Associated sensors, valves and actuators, inverters and meters for the main plant items	£7,200 £0.97/m² (gia) £1.37/m² (nla)	£7,200 £0.97/m² (gia) £1.37/m² (nla)
System programming; graphical interface to represent the points connected to the system; building main menu items, excludes CAT A fit out.	£4,600 £0.62/m² (gia) £0.88/m² (nla)	£4,600 £0.62/m² (gia) £0.88/m² (nla)
Project management, strategy design, commissioning, documentation and two days on site training item, excludes CAT A fit out.	£18,000 £2.43/m² (gia) £3.44/m² (nla)	£18,000 £2.43/m² (gia) £3.44/m² (nla)
Installation of controls and power wiring from MCC1 and MCC2 to main plant; containment; controls backbone terminated in risers on each floor	£56,400 £7.61/m² (gia) £10.77/m² (nla)	£55,400 £7.48/m² (gia) £10.58/m² (nla)
Total shell and core cost	**£136,800** **£18.46/m² (gia)** **£26.11/m² (nla)**	**£135,800** **£18.34/m² (gia)** **£25.94/m² (nla)**
Category A fit-out		
Riser controllers on floors ground to eight	£12,600 £1.70/m² (gia) £2.41/m² (nla)	£13,300 £1.80/m² (gia) £2.54/m² (nla)
Fan coil unit controllers, valves, actuators and return air sensors for 203 FCUs	£23,350 £3.15/m² (gia) £4.46/m² (nla)	£38,600 £5.21/m² (gia) £7.37/m² (nla)
System programming, graphical interface to represent points connected to the system	£2,800 £0.38/m² (gia) £0.54/m² (nla)	£2,800 £0.38/m² (gia) £0.54/m² (nla)
Project management and commissioning	£18,000 £2.43/m² (gia) £3.44/m² (nla)	£18,000 £2.43/m² (gia) £3.44/m² (nla)
Electrical & IT network installation associated with the fan coil unit controllers, connection to a local fused connection unit (mains supply to unit by others); dedicated on floor network	£19,800 £2.67/m² (gia) £3.78/m² (nla)	£2,200 £0.30/m² (gia) £0.43/m² (nla)
Total category A fit-out cost	**£76,600** **£10.35/m² (gia)** **£14.64/m² (nla)**	**£74,900** **£10.12/m² (gia)** **£14.31/m² (nla)**
Total BMS cost, shell & core plus Cat A fit-out	**£213,400** **£28.81/m² (gia)** **£40.75/m² (nla)**	**£210,700** **£28.46/m² (gia)** **£40.26/m² (nla)**
Category B fit-out The following element is one of the more common category B items, but they will vary according to particular tenant requirements: **Local control to cellular offices - upgrading return air sensor on fan coil unit to space sensor with set point adjustment**	**Add £122 per sensor**	**Add £73 per sensor**

Exclusions:
■ Power supply wiring to main motor control panels ■ Pulsed output energy meters ■ Installation of valves and pipework pockets ■ Builders work in connection with BMS
■ Site organisation and management costs other than specialist contractor's allowances ■ Contingency/design reserve ■ Main contractor's overhead and profit or management fee
■ Professional fees ■ Tax allowances ■ Value Added Tax ■ Inflation beyond fourth quarter 2006