

# Vision for the Home

*ZigBee Wireless Home Automation*



**ZigBee™**  
**Alliance**

Wireless Control That Simply Works



# ZigBee™ Vision for the Home

## Introduction — ZigBee Wireless Home Automation

In 1995, the media revealed how Microsoft founder Bill Gates built his \$125 million high-tech dream estate on Lake Washington. In fact, the description of Gates' revolutionary estate became so famous, online encyclopedia Wikipedia contains a definition. "The Gates home is a modern design in the 'Pacific lodge' style, with classic features such as a large private library with laser sensors on the floor to kill small insects and pests..." Media typically describes this kind of home in a *Lifestyles of the Rich and Famous* manner that says only the very rich can afford "sensors in the floor" and other high-tech amenities.

Today, these user perceptions about home automation have begun changing because of an influential wireless standard developed by a consortium called the ZigBee Alliance. ZigBee is a group comprised of international technology companies that work together to enable reliable, cost-effective, low-power, wirelessly networked, monitoring and control products based on an open global standard. The Alliance's membership grows every day as international technology companies adopt and embed ZigBee technology in a wide range of products and applications.

As a result, ZigBee and its member companies have become a global market catalyst for wireless home automation. These companies' collective efforts to develop flexible, mobile and easy-to-use solutions

build wireless intelligence capabilities into everyday devices, drive down prices, and increase demand from residential, commercial and industrial markets.

Using ZigBee-enabled digital devices and products, average home owners once left to dream about ideas depicted in the pages of *Popular Science* can enjoy the same luxuries as the wealthy. The net affect of ZigBee technology results in the average consumer home — whether new or established homes — being respectively built or retrofitted to deliver smart, wireless capabilities that use various control devices to perform a number of high-tech functions. Companies use a standards-based wireless platform optimized for the unique needs of remote monitoring and control applications that addresses simplicity, reliability, low power and low cost. ZigBee defines the network, security and application software layers, provides interoperability and conformance testing specifications, and manages the evolution of the technology.

In fact, industry experts believe ZigBee will change the way the average person thinks of controlling elements in the home. A ZigBee-enabled house provides home automation capabilities, from the living room to the kitchen, from the home entertainment or home theater room to the bedroom, and from the garage to the bathroom. ZigBee products deliver whole home automation that creates "smart" home surfaces that allow you to customize your environment and create a seam-

less, interoperable experience where all devices "talk" to each other and can even connect to the Internet to enable remote access and control.

## Envision the Home Driven by ZigBee Wireless Technology

So what does it feel like to live in a wirelessly automated home? *CE@Home*, an online magazine, describes the wireless home automation experience like this: "You arrive home from a long day at work. As soon as you use your digital key to unlock the door, your house adjusts the lighting, heat, and window blinds to your liking and puts on your favorite CD in the kitchen. While you were at work, the house fed the cat, turned off the space heater your kids accidentally left on in the basement, and recorded motion-triggered video from security cameras around the property. Your refrigerator detected an almost empty milk carton and added a gallon of two percent to the shopping list that it will e-mail to you on Friday. Your house was ready to detect water or gas leaks, freezing pipes, and fire and could have called you, the fire department or a plumber."<sup>2</sup>

The ZigBee digital home would look and act much the same as the futuristic description above. A ZigBee-enabled digital home creates a kind of "robotic household [to produce] an entirely new paradigm for home construction."<sup>3</sup> When a consumer's home contains ZigBee-enabled digital devices, the very essence of

<sup>1</sup> Wikipedia, "Bill Gates' House," [http://en.wikipedia.org/wiki/Bill\\_Gates'\\_house](http://en.wikipedia.org/wiki/Bill_Gates'_house).

<sup>2</sup> CE@Home, "First Glimpse, Home Awareness Systems," June 1, 2005, <http://www.firstglimpsemag.com/Editorial/article.asp?article=articles/2005/y0205/51y05/51y05.asp&guid=>

<sup>3</sup> Popular Science, 2005, "Home of the Future," "Our High-Tech Dream House," <http://www.popsoci.com/popsoci/flat/hotf/index.htm>.



the living experience begins at the person's work, travel location or upon arrival at the house. ZigBee wireless devices remove barriers and boundaries to deliver a fully automated home of the future today. ZigBee products offer wireless solutions using hand-held remote controllers, security and lighting systems, keypads, climate control, audio-video capabilities via the computer or standard (SDTV) or high-definition (HDTV), and more.

Wireless, Internet-based security can be pre-programmed or remotely activated to turn on/off a security system, release door locks or open or close windows. Users can use a hand-held remote to identify security breaches and safety issues described above. Upon entering the living room, a ZigBee-enabled sensor network detects an occupant's presence and turns on the light to a pre-set lighting level for the time of day. Walk up to the main control panel and find information about the house including temperature, safe CO2 levels; reminders to open or close windows; temperature readings; appliance monitoring (e.g., temperature of food in the refrigerator or freezer); current price of energy from the utility company.

The energy component of the ZigBee-enabled home provides a number of advanced two-way network connections between the home and the utility company, creating enhanced services through the customer's ability to leverage the system to control energy consumption and

cost. Automatic meter-reading capabilities provide "wireless network-agnostic advanced metering-reading platform, comprising hardware, flexible communications, meter management software"<sup>4</sup> and more. Networked meters create customer convenience through real-time access to usage, price alert information on the meter, third-party on-premise displays or information displayed on a Web site. Utility providers can, in turn, tailor programs to meet the needs of customers whose homes use a combination of critical and non-critical peak load devices.

## ZigBee and its member companies have become a global market catalyst for wireless home automation.

Home entertainment enthusiasts will enjoy capabilities created through ZigBee's application in the home theater. Now users can turn their homes into a personal multiplex, as the ZigBee-driven home theater provides multiple levels of data, video and voice-over IP (VoIP) through high-speed broadband Internet access and audio-video (AV). The television watcher clicks through 100,000 channels of content using standard or HDTV programming that also provides a control menu for the rest of the house.

The bedroom provides the same temperature and light control, but takes it a step further by using home health monitoring that scans each person's body

while in bed, watches healthy levels, and signals the person to consult with his or her doctor. Finally, the garage becomes a central powerhouse to heat or cool the rest of the house, and more.

ZigBee-enabled homes add the extra benefit of providing safety and protection for occupants and their assets through remote monitoring devices such as smoke detectors that trigger safety scenarios. When the wireless smoke detectors detect fire, the HVAC system immediately turns off to prevent smoke circulation and avoid a flow of fresh oxygen to feed the

fire. Lights come up to a dimmed level — not too bright to blind the people it awakens — to help people find their way through the dark and out of the house. Motorized blinds and the garage door open automatically to provide quick escape. The home intercom system even tells the tenants the best escape route. The exterior lights also flash to make the house easier for the fire fighters to locate.

### ZigBee's Role in Emerging Wireless Technologies

New wireless home automation technologies continue to launch using ZigBee capabilities. Many companies intend to release ZigBee-enabled digital devices over

<sup>4</sup> AMRON Technologies, Press Release, AMRON Technologies Powered by the Chipcon CC2420/Figure 8 Wireless ZigBee Compliant Platform, <http://www.prnewswire.com/cgi-bin/stories.pl?ACCT=104&STORY=/www/story/05-09-2005/0003589950&EDATE=>



the coming months. Emerging ZigBee products and devices include enhanced audio and video controls for MP3s and DVD movie selection via a ZigBee wireless remote and TV interface, media management, audio servers, audio distribution, user interface devices, protocol bridges, advanced AV control, lighting control and thermostats.

ZigBee overcomes speed limitations found in other wireless home automation technologies and opens greater possibilities to use more devices on a single network. ZigBee uses the 2.4GHz band to provide low data rate wireless applications. IEEE 802.15.4 defines a robust radio PHY (physical layer) and MAC (medium access control) layer. ZigBee defines the network, security and application framework for an IEEE 802.15.4-based system. These capabilities facilitate speeds to enable a network to have over 65,000 devices on a single wireless network.

ZigBee networks support star, mesh and cluster-tree topologies. Many of these emerging technologies have been around for a decade or longer, but can now leverage advanced features through these wireless, mesh network features. Wireless mesh networks mean all devices have communication capabilities to "talk to one another," and act as repeaters transferring data to other radios that might be out of communication range of a particular device. Mesh networking means ZigBee networks do not require a central control point. New products ex-

pected for release that take advantage of mesh network capabilities include cellular phones that remotely control elements in the house and sensing networks to provide remote monitoring.

ZigBee also leverages emerging wireless solutions through its use of open specifications (IEEE 802.15.4). ZigBee offers a "published specification set of high level

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communication protocols designed to use small, low-power digital radios based on the IEEE 802.15.4 standard for wireless personal area networks (WPANs)."<sup>5</sup> A personal area network (PAN) is a computer network used for communication among computer devices (including telephones and personal digital assistants) close to one person. The reach of a PAN is typically a few meters. PANs can be used for communication among the personal devices themselves (intrapersonal communication), or for connecting to a higher level network and the Internet (an uplink).<sup>6</sup>

### ZigBee's Role in the Market

While no direct correlation can be drawn that ZigBee technology drives up adoption and market value, analysts ex-

pect ZigBee-related technologies to experience a surge in market adoption over the next several years. Wireless home automation figures demonstrate significant growth in 2006. "The market is huge already. Peter King, director of the Connected Home Devices service in Strategy Analytics' Digital Consumer Practice, recently wrote the research firm's global market

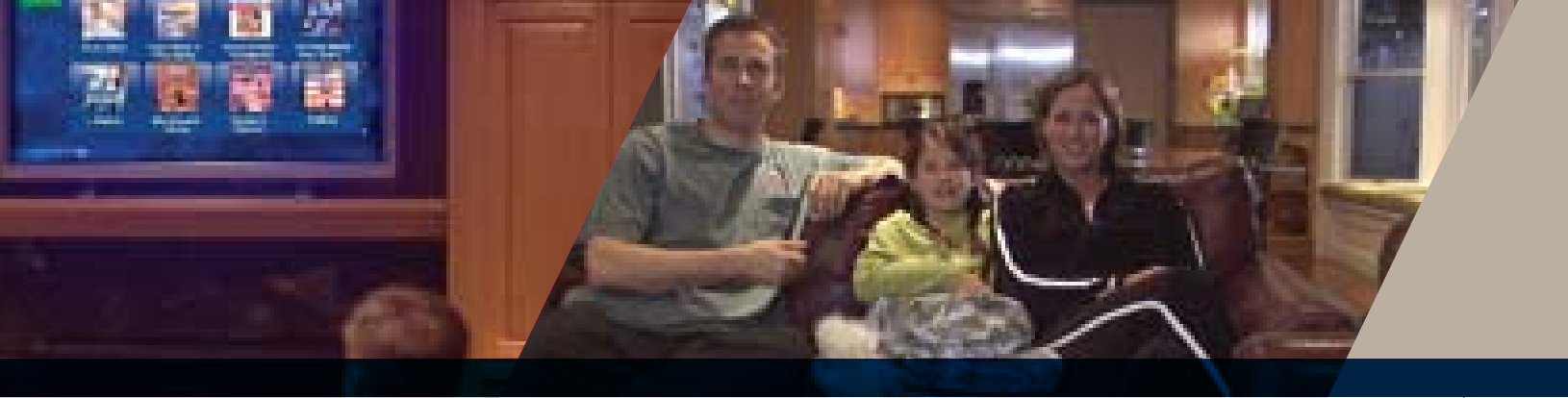
forecast for the period 2005 to 2010. In "Quantifying The Digital Home Opportunity," King estimates that consumers around the world spent U.S. \$118 billion on digital home devices in 2005, for an annual growth rate of 25 percent. That pace will continue in 2006. By 2010, the report says, 700 million connected home devices will be installed worldwide.<sup>7</sup>

The adoption rate figures of general wireless usage in the private sector also provide positive economic indicators for the future of wireless home automation. Most technology adoption tends to start in the business sector. One could theorize that general wireless technology adoption by businesses will also likely act as a catalyst in the wireless home automation market.

<sup>5</sup> Wikipedia.org, Definition of IEEE 802.15.4 on the Web, [http://en.wikipedia.org/wiki/IEEE\\_802.15.4](http://en.wikipedia.org/wiki/IEEE_802.15.4).

<sup>6</sup> Wikipedia.org, Definition of Personal Area Network on the Web, [http://en.wikipedia.org/wiki/Wireless\\_PAN](http://en.wikipedia.org/wiki/Wireless_PAN).

<sup>7</sup> Appliance Magazine, "Appliance Line: Cautiously Connecting," Tim Somheil, February 2006, <http://www.appliancemagazine.com/editorial.php?article=1308>.



“Enterprises and small- and medium-size businesses (SMBs) ranked setting wireless policy and centralizing management of mobile devices as the top two telecom initiatives for 2006. Budgets reflect these priorities: In 2006, SMBs plan to spend closer to one-third more on both mobile voice and mobile data services than in 2005. Fifty-six percent of enterprises expect spending on mobile voice to increase, and 63 percent expect mobile data spending to increase, according to Forrester Research.”<sup>8</sup>

Overall wireless adoption rates will help attract more companies that intend to enter this market via home automation to become members of the Alliance. As more companies join the Alliance and leverage the benefits of ZigBee, more wireless home automation products will continue to emerge. Already in fall 2006

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and throughout 2007, major companies expect to release new products and services with tremendous end user benefits made possible by a foundation built on ZigBee capabilities.

### The ZigBee Advantage

ZigBee’s technical capabilities also bridge the gap between wealthy home owners having wireless home automa-

tion and average consumers having access to simple, inexpensive wireless network solutions. Products based on “ZigBee should start showing up at home improvement and electronics stores later this year, all starting at around \$20.”<sup>9</sup> For example starting at an affordable price range of \$600 to \$1,000, an owner of a new or older home can install and use a wireless lighting and temperature control system in a 3,500 square foot house.

Industry analysts suggest ZigBee will likely emerge as the de-facto standard based on these price points and capabilities. Experts also expect prices to drop further as user adoption rates continue to make it economically feasible for ZigBee Alliance members to leverage economies of scale. One expert compared the price of electronic automotive door windows to manual window levers. He noted that

while automotive electronic door windows used to come at a premium price, the demand increased, volume went up, and prices came down. Many such analysts expect a similar economic effect as ZigBee standard specification adoption increases and pushes prices down.

Other ZigBee advantages and benefits include easy installation, short transmission rates, low power consumption, real-

time execution, seamless device interoperability and more. The following case studies describe how companies develop wireless home automation products and devices to deliver these advantages to the end user to enhance their lifestyles.

### Control4

Control4, a rapidly growing leader in affordable and easy-to-use home control and entertainment systems, brings high-quality home automation to average consumers in new and existing homes. Its home control products use ZigBee mesh networking standard to provide wireless networking for communication between devices in the home.

Control4 products provide automatic discovery of IP-based control devices, as well as auto creation of programming and user interface for integration of new products. Interoperability between devices currently in the home combined with new devices added to the network when consumers can afford them overcomes barriers to adoption. For example, the cost of entry for proprietary networks provided by luxury dealers used to be in the \$20,000 range. Control4 technology provides lower price points with some products costing under \$1,000. A Control4 Home Theatre Controller that leverages ZigBee technology costs \$595 suggested retail price and provides much more than a universal remote at the same price. It does lighting, security, HVAC control, media management and more.

<sup>8</sup> Forrester Research, Press Release, Mobility Management, Tighter Security, and Migration to IP Dominate 2006 Plans, According to Forrester’s Telecom & Networks Survey; Telecom and Network Adoption Trends by North American Enterprises and SMBs, June 27, 2006, <http://phx.corporate-ir.net/phoenix.zhtml?c=60569&p=irol-newsArticle&ID=876624&highlight=>

<sup>9</sup> CNET, “Take Control of Your Digital Home,” [http://www.cnet.com/4520-10839\\_1-6224211-1.html](http://www.cnet.com/4520-10839_1-6224211-1.html).



Control4 chose ZigBee based on the idea of using a wireless control that simply works and contains costs to open up the consumer market channel. Control4 uses ZigBee to build interoperable products to enable communication on all technical levels including ultra wide band. These products range from a significant number of digital control devices for interior and exterior lighting systems to remote touch screens to play audio and video, and from remote control devices for temperature and climate control to universal remote controls.

Major advantages of using ZigBee's mesh network and an 8-bit microprocessor allows Control4 to keep development and retail costs low while not compromising capabilities. Easy installation doesn't require any new wires and authorized dealers can readily install systems after only a day's training. ZigBee also enables real-time product activation

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and reaction times, which improves performance and enhances the overall consumer quality of experience.

As a member of the ZigBee Alliance, Control4 influenced the current version of the ZigBee standard to meet its home

automation needs. The value of the open standard exists in its collaborative development environment, which fosters an ecosystem of interoperable devices. Control4 expects this "ecosystem" of other ZigBee Alliance members to propel the company toward continued success in its respective markets.

### Eaton — Home Heartbeat

Eaton, a worldwide leader in power distribution, power protection and power equipment maintenance, advances a new segment in the home automation market called home awareness. Eaton's Home Heartbeat leverages the ZigBee wireless standard and provides consumers with anytime knowledge of their home. The "plug-and-use" system monitors activity and remotely alerts homeowners if a window or door opens, a washing machine leaks, or a coffee machine is left on while the owner is away.

Heartbeat — designed for anyone who owns a home — because it offers a number of advantages over competitive technologies. Eaton's choice of wireless protocol played a crucial role in its development and success. Eaton chose ZigBee based on its robust open standard mesh network.

Comprised of a Base Station, Home Key™ and wireless sensors, the system allows consumers to plug in the Base Station power adapter and phone cord and use the Home Key™ to "find" and quickly program the sensors the user mounts throughout the home. Home owners typically install the system in less than 15 minutes. Home Heartbeat combined with the ZigBee capabilities create easy installation, standard serial interfaces, IEEE approval, and mesh network capabilities.

Two significant factors guided Eaton to choose ZigBee. The mesh network's short transmissions consume little power, allowing Home Heartbeat sensors to have an extended battery life to three years. With the internationally accepted radio frequency of ZigBee, Home Heartbeat opens up to a potential global market.

Home owners reduce costs by narrowing their selection of sensors to meet specific needs. Sensors use ZigBee wireless technology to help Home Heartbeat detect water leaks and shut off water lines to control flooding; monitor power status of appliances like coffee pots or irons; remind homeowners to change batteries in devices like smoke detectors; and alert homeowners to open/closed doors and



## Motorola Remote Location Sensors

windows. The system reports home activity to the Home Key, carried by the homeowner, or sends e-mails or text messages to the homeowner's cell phone.

Eaton actively participated in the development of the ZigBee standard. Using the open ZigBee standard increases the value of Home Heartbeat and Eaton's other wireless sensor applications because it fosters development of interoperable third-party sensors and devices to keep the market niche vibrant and interesting to consumers. Widespread ZigBee adoption will also reduce costs for common components like radios and the overall development of interoperable products.

### AMX

AMX®, a worldwide leader in advanced control system technology, incorporates ZigBee wireless technology for its ability to enable AMX wireless products to control anything within the home. AMX selected ZigBee wireless technology based on the premise that it offers better performance than 802.11 to enable easy implementation for handheld remote devices.

ZigBee advantages allow for desirable

power-save mode and wake-up device capabilities (working through 802.11 could have five-to 10-second delays, which the average consumer will not accept). ZigBee's 802.15.4 specification overcomes those delays and extends the battery life to provide prolonged power-saving capabilities.

Leveraging these benefits, AMX last September launched two new handheld remotes powered by ZigBee wireless technology. AMX introduced its new Mio Modero® R-3 and R-4 Handheld Remotes and NetLinx® ZigBee Gateway and Repeater as the first products in their new line of ZigBee-enabled devices. AMX incorporated ZigBee into its Mio Modero R-4 (Mio R-4) to provide a solution for consumers wishing to have touch-panel functionality in a small handheld form factor.

The remote features a 2.4-inch color LCD touch display with an AMX G4 graphics engine, enabling the R-4 to support animated and/or static icons, as well

Motorola is one of the earliest developers of cellular phones and has embraced ZigBee from the beginning. Considering itself one of the technology's "founding fathers," Motorola is developing end-to-end X-Internet technologies based on ZigBee and 802.15.4 wireless standards which enable the forthcoming "T2T" (things-to-things) applications. Location technology embedded in ZigBee-enabled devices can help individuals find lost digital devices in the home. For example, if your brother steals your ZigBee enabled MP3 player, you can go to the Internet, perform a search on the house, and discover the device hidden under his mattress. More value will come from public safety applications, such as ZigBee-enabled smoke detectors telling incident command the location of rescue personnel, their vital signs or even the specific location and temperature of the fire or other alarm.

as dynamic lists and scrolling marquee text for long words and phrases. Using AMX's TPDesign 4 design tool, system integrators can customize each screen to unique customer preferences — from lighting and climate control presets for entertaining and watching movies to device usage options for TVs and DVRs.

The Mio R-4 also includes 28 pushbuttons for operating specific device functions, as well as three remote navigation buttons. The Mio Modero R-3 (Mio R-3) leverages the same features and form factor as the Mio Modero R-2. It offers a monochrome LCD display that indicates the current device being controlled and 45 backlit laser-engraved buttons that can be customized to meet the needs of

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individual users and unique applications. Three buttons' designs activate macros or pre-determined sequences of events. The device designates six for accessing individual devices and the remaining 36 represent specific operating functions for each device.

The Mio R-3 and R-4 both support two-way communication on the ZigBee network, enabling the handheld remotes to control a virtually unlimited number of devices. With its large display, the Mio R-4 is also able to receive feedback on device

status — from current room temperature and lighting levels to the song title and artist being played by the AMX MAX Multimedia Server. AMX ZigBee mesh network always connects the Mio R-E and R-R, which allows them to instantly wake up through touch, tilt or push button.<sup>10</sup>

### ZigBee Coming to Your Neighborhood

ZigBee wireless technology has already become a leader in wireless home automation. With so many major companies

recognizing it as the clear choice to build the foundation for wireless home automation, it seems clear that the road has been paved to create a ZigBee-enabled neighborhood full of automated homes that could be owned by everyone. Thus, ZigBee appears to be the key to unlock the wireless automated home of the future.



### About ZigBee

The ZigBee Alliance is an association of companies working together to enable reliable, cost-effective, low-power, wirelessly networked, monitoring and control products based on an open global standard. The goal of the ZigBee Alliance is to provide the consumer with ultimate flexibility, mobility, and ease of use by building wireless intelligence and capabilities into everyday devices. ZigBee technology will be embedded in a wide range of products and applications across consumer, commercial, industrial and government markets worldwide. For the first time, companies will have a standards-based wireless platform optimized for the unique needs of remote monitoring and control applications, including simplicity, reliability, low-cost and low-power.

<sup>10</sup> AMX, Press Release, AMX Adds ZigBee Products to Control System Line, Unveils First ZigBee Handheld Remote with Touch Panel Functionality, <http://www.amx.com/newsroom/pressrelease-file.asp?release=2006.09.14.a>.