Home automation, control and security

A myriad of options; one obvious choice

Steven Leussink and René Kohlmann
SiTel Semiconductor B.V.
steven.leussink@sitelsemi.com

The home network market has grown consistently over the last few decades. According to recent research by InStat[1], more than 300 million households worldwide will have a home network installed by 2011.

Perhaps the most familiar home networking application areas are computing and computer accessories. Most home computers these days are connected to wired or wireless networks that link them to other computers, printers, network-attached storage (NAS), internet gateways and the like. Similarly, we are using a growing number of accessories such as mice, headsets and keyboards to expand the functionality of computing or mobile devices, connecting them in an ad hoc fashion as and when we need them.

Now a third category of networked devices is about to enter our homes. Focusing on infrastructure applications such as automation, control, security and energy management, this category aims to make our daily lives more comfortable, safer and more energy efficient.

Each of these categories has different networking requirements. Even within a category different use cases and perspectives on technical parameters such as range, power consumption and data throughput have led to a myriad of networking protocols, each answering specific needs. However, having a single standard is important for wide-scale adoption of an application. It ensures interoperability and increases consumer confidence, leading to more nodes per network and creating value for both the end user and service aggregator.

In the more mature categories (computing and computer accessories), clear winners have emerged: namely Wi-Fi and Ethernet for computing and Bluetooth and USB for accessories. But this shake-out of protocols has yet to start in Home Automation Control and Security (HACS). This area still uses a myriad of networking technologies including: Z-Wave, Zigbee / 802.15.4, Wavenis, Power line, Insteon, X10, M-bus, Lonworks and HomePlug.

Currently, the use of dedicated wired HACS networks is restricted to new buildings. The one exception is power-line technologies, but these are limited by the number and location of power sockets in each room. Wireless technologies are much easier to install in existing homes, so much of the industry's interest is focused here.

[1] Home Network Technology & Connectivity Use: Ethernet, 802.11, Coax, and Powerline; InStat; September 2009

That still leaves a large number of competing technologies. A wireless network protocol has to balance requirements such as range, power consumption, reliability, bandwidth and cost. Each of the current protocols has strengths and weaknesses in particular areas, without demonstrating a compelling *overall* advantage.

However, there is one technology that is often overlooked when discussing HACS networks. It is a technology that, according to a recent MZA report[2], is already installed in 245 million households worldwide and features in around 80 million new systems for the home sold annually. That technology is DECT.

An evolving technology with a strong history

Launched in 1987, Digital Enhanced Cordless Telecommunications (DECT) is a flexible digital radio access standard for cordless communication in residential, business and public environments. It employs several advanced techniques that enable highly efficient use of the radio spectrum. As a result, it delivers high voice quality, raw data rates up to 1 Mb/s, secure communication and a low risk of interference.

Over time DECT has evolved into Cordless Advanced Technology – internet and quality (CAT-iq). This is an enhancement of the DECT standard that offers even better voice quality and enables the integration of cordless telephony and internet services. It allows DECT phones to be used for Voice over Internet Protocol (VoIP) and other internet-based applications such as audio streaming.

Supported by leading telecom operators, DECT technology and its CAT-iq incarnation are already being integrated into many home gateways and Integrated Access Devices (IADs). These devices make home networking simpler for consumers by doing away with the need for separate modem, router and telephone base station. IMS Research predicts DECT / CAT-iq penetration in all kinds of IADs (including cable, xDSL and fiber) will reach 31% by 2013[3].

One reason that DECT has been overlooked for HACS networks until now is the perception that its power consumption is too high for “fix-and-forget” autonomous nodes. However, the latest DECT products include an ultra-low power mode known as DECT ULP. This enables sensor-actuator nodes to operate autonomously for 5-10 years on a standard AAA battery. Fully compatible with previous DECT / CAT-iq generations, DECT ULP offers the same voice quality, reliability, secure communication and plug-and-play installation as the extensive installed base of DECT systems.

With the CAT-iq and DECT ULP developments, DECT exceeds the technical requirements for a HACS network protocol. Factor in its strong consumer acceptance, wide installed base and connectivity to the outside and it is clear that DECT ULP ticks more of the boxes for HACS networks than any of the current networking option (see appendices). Out of the myriad of options proposed, DECT ULP is the obvious choice to bring HACS products and networks widest possible audience.

---

[2] The Global Consumer Cordless Telephony Market; MZA, July 2009

[3] The Worldwide Market for DECT and CAT-iq in Residential Gateways; IMS Research, November 2008

Appendix 1: key characteristics for HACS networks

Range

Any home network technology must be capable of reliably transmitting over distances the size of a typical house. When discussing the range of an RF technology, it's common to think in terms of the link budget (the path loss that can be bridged between transmitter and receiver). To cover most homes from cellar to ceiling, a minimum link budget of around 115 dB is required.

The link budgets for the various HACS options depend on use case choices such as data rate, transmission frequency, transmitter power, etc. Table 1 shows the use case choices and resulting link budgets for various technologies.

Technology	Data rate	Frequency	Sensitivity	Transmitter power	Link budget
Wavenis	19 kb/s	900 MHz	*-107 dBm*	14 dBm	121 dB
Zigbee	250 kb/s	2400 MHz	-98 dBm	8 dBm	106 dB
Bluetooth	1 Mb/s	2400 MHz	-85 dBm	7 dBm	92 dB
Z-Wave	40 kb/s	900 MHz	-101 dBm	up to 0 dBm	101 dB
DECT	1 Mb/s	1900 MHz	-98 dBm	25 dBm	123 dB

With its link budget of 123 dB, DECT clearly meets the range requirements for a home network and gives consumers the freedom to move around and install nodes anywhere in their homes. Some of the other options don't have the required budget, and would need to chop the RF path into smaller segments such as in a mesh network. However, this requires routers to be placed in very specific locations around the home and, if the network traffic is expected to be high, these routers will need to be mains powered. Both of these factors make installation much more complicated for consumers.

Power usage and battery lifetime

Technologies like Zigbee / 802.15.4 are often promoted as having much lower power consumption than other networking technologies. However, physics dictates that sending a given amount of data over a given range with a given probability of reception takes a set amount of energy. So when you take into account the required link budget and the amount of information to be exchanged, the practical power consumption for all proposed HACS systems turns out to be very similar.

Consequently, the largest differentiator in the autonomy (or battery lifetime) of a node actually comes from the sleep / wake ratio which is tied to the specific use case latency requirements. With DECT ULP, a typical sensor application with a 20-second sleep time draws an average of 20 µA, so will run for 10 years on a single AAA battery. For sensors that transmit every 20 seconds the lifetime is still 5 years.

Interference, transmission reliability and data throughput

Interference between radio signals reduces the probability of information reaching its desired destination. Consumers will quickly lose interest in a product if it regularly fails to connect to the network. Even if interference problems don't prevent transmission completely, they could significantly reduce the technology's range and data throughput in the home.

Many proposed home networking technologies operate in the popular 2.4 GHz Industry Science Medicine (ISM) band because it offers unrestricted geographic use. However, this band is now very crowded and is dominated by the large installed base of Wi-Fi and Bluetooth devices.

This represents a big interference challenge to newcomers like Zigbee / 802.15.4 or RF4CE. Service providers using these technologies will need to invest in extra installation support to ensure working systems and quality of service. For IAD manufacturers, the prospect of integrating multiple radio standards operating in the same frequency band is not appealing. Co-existence measures do exist, but deploying them in a crowded frequency space is tough and will stress already-stretched R&D budgets further, pushing up prices.

DECT operates in the 1.9 GHz band. This band is licensed in over 100 countries worldwide, reducing interference issues. Uniquely, although this band is licensed, there are no royalty fees. In addition, DECT's unique Dynamic Channel Selection / Allocation (DCS / DCA) capability ensures each transmission uses the best available radio channel. As a result, a large number of DECT systems can co-exist in the same frequency with high-quality, robust communication.

Network integration

Because HACS covers a wide range of applications from thermostats to home security, energy management and smart metering, different device types have been developed without the ability to interact with other device types.

Mesh networks could in theory enable different devices types to interact via self-organization. However, this will require the various segments to co-evolve in a way to support "cross-segment" interaction, and that level of cooperation seems unlikely. Moreover, as explained previously, mesh networks are difficult for consumers to install themselves, creating a further barrier to adoption. A point-to-multipoint architecture in which nodes communicate via a central WAN / IAD is much more practical for residential use.

With a projected 422 million households having a fixed broadband connection by the end of 2009[4], there is huge potential for a new generation of internet-enabled HACS devices and services. If the HACS network integrates seamlessly with the internet, it would lower the threshold for customer acceptance of these products.

This is why the Session Initiation Protocol (SIP) built into current IADs for VoIP services is gaining growing interest from service aggregators and the HACS market. SIP is an open protocol based on Internet-related standards (RFCs) that provides a secure and flexible way to interface with residential devices.

[4] Next Phase of Growth in World Wide Consumer Fixed Broadband; Gartner; September 2009

DECT is already common in home gateways and IADs, and is routinely used with the SIP to deliver high-quality, reliable VoIP connections. Moreover, adding new nodes to a DECT network is as easy and familiar as placing an extra cordless handset in the bedroom.

Cost

Zigbee, Bluetooth and DECT all have similar hardware and software requirements. For example, the Zigbee software stack is around 100 Kbytes while DECT stacks range from 60-80 Kbytes depending on functionality – so memory costs are similar for both technologies.

This means that the maturity of the technology and the volume of manufacturing are the main cost differentiators for these technologies. DECT's status as a mature, high-volume technology is reflected by current pricing. Today's ZigBee SoCs are priced in the $2-3 range, whereas single-chip DECT SoCs have gone below $1 and often also feature a wide range of sensor interfaces such as voice transmission, data converters, etc.

Overall system costs for the consumer can be reduced even further by sharing the DECT functionality included in existing IADs. Moreover, the 300 million DECT chips sold each year represent a healthy multi-vendor market guaranteeing low component pricing and wide availability.

Voice and security

Although voice applications are not directly linked to HACS segment, there are several security applications where having voice links adds value. DECT was originally designed for cordless telephony, so naturally offers high-quality voice links both inside and outside the home. The DECT ULP mode maintains that same high voice quality as well as the security mechanism for voice transmissions used in the millions of installed DECT systems, offering HACS networks that are as robust against eavesdropping as today's cordless phones.

Appendix 2: comparison of various wireless networking protocols

Technology *Controlling body*	**Frequency**	**Range (min-max)**	**eBoM**	**HACS Pros (+)** **HACS Cons (-)**	**Other remarks**
DECT ULP 2009 *SiTel Semiconductor*	1.9 GHz (Licensed, royalty-free)	100-300 m	$ 1	+ Very good range + No interference + High data rate: 1 Mb/s + Low BoM + Voice enabled + Up to 10 year battery life + Compatible with base of DECT phones and IADs - Not yet mainstream in HACS	Target market: cordless communication and home automation, control and security
Wavenis 2001 *Coronis*	900 Mhz (Unlicensed)	30-100 m	$ 2-3	+ Good range - Low data rate: 19.2 kb/s - Proprietary PHY - Interference issues	Target markets: metering and M2M
Z-Wave 2003 *Zensys Inc.*	sub-1 GHz (Licensed)	30-65 m	$ 2-3	+ Low interference + Medium data rate: 40 kb/s - Medium range - Interoperability - Proprietary PHY	Target market: home automation Products already on the market

Technology *Controlling body*	**Frequency**	**Range (min-max)**	**eBoM**	**HACS Pros (+)** **HACS Cons (-)**	**Other remarks**
Zigbee / 802.15.4 2001 *Zigbee Alliance*	2.4 GHz (Unlicensed)	70 m	$ 2.50	+Low power + 2-way interoperable + Medium data rate: 250 kb/s - Interference issues - Complex network options - Certification body	Target markets: Broad range of low-power networks
RF4CE 2008 *RF4CE Consortium*	2.4 GHz (Unlicensed)	70 m	$ 2	+ Backed by CE market leaders + Point-to-point protocol - Interference issues - Still in development	Target market: Home entertainment Built upon IEEE 802.15.4 PHY
Bluetooth Low Energy 2009 *Nokia (pioneer)*	2.4 GHz (Unlicensed)	10 m	$ 2-4	+ Advanced 2-way communication + High data rate: 1 Mb/s + Compatible with legacy Bluetooth systems - Short range - Ad hoc network - Interference issues	Target market: cellphone-related ad hoc accessories