Wireless standards for home automation, energy, care and security devices

Why DECT enables the creation of low-power, long-range, interoperable devices that operate on scalable and interference-free plug-and-play networks

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Exceptional changes are underway in the home networking market and a wide range of home systems – from thermostats and light switches to door locks and smoke detectors – will become networked. Born from a collective desire to better control our environment and cut our consumption, this shift is widely predicted to bring exceptional market growth opportunities that are open to a diverse array of technology companies.

In the US alone, over 140 million home energy management devices are forecast to ship in the next five years (GBI). And a similar picture can be seen in other markets, with the UK, for example, expected to spend over £2.4 billion on such devices (IMS).

However, such devices will have to work with existing home networks and interoperability between devices from many manufacturers is essential for sustained commercial success.

Over 600-million households worldwide have home networks installed (IMS prediction), with computers, media players and smart TV's joining printers, network-attached storage (NAS), internet gateways and a growing number of accessories such as mice, headsets and keyboards.

Like the home computing networks they join, which standardised on WiFi, Ethernet and USB, these new home-automation, energy management, care and security (Haecs) networks must standardise to adopt an interoperable technology that gives whole home coverage and long battery life, furthermore this standard must be reliable, secure, scalable and be simple to set up.

This standard is DECT.

DECT as a de facto standard

Building upon a standard is imperative for wide-scale adoption. It ensures interoperability and increases consumer confidence, leading to a greater number of nodes per network, and creating value for both the end user and service aggregator.

Many of today's solutions are not driven by a standard but, instead, through special interest groups.

Conversely, the DECT standard, whilst often overlooked is already installed in 580 million households worldwide (MZA) and features in around 120 million new systems for the home sold annually.

An evolving technology with a strong history

Launched in 1987, DECT (Digital Enhanced Cordless Telecommunications) is an open ETSI standard for flexible digital radio access in 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 Mbps, secure communication and a very low risk of interference.

Over time DECT has evolved, with the CAT-iq (Cordless Advanced Technology – internet and quality) enhancement of the DECT standard offering wideband voice quality and enabling the integration of cordless telephony and internet services; allowing DECT phones to be used for VoIP (voice over internet) and other internet-based applications such as audio streaming as well as guaranteeing interoperability between vendors of gateway and handset devices.

Supported by leading telecom operators, DECT technology and its CAT-iq incarnation have already been integrated into many home gateways and integrated access devices (IADs), which do away with the need for separate modem, router and telephone base station and enable triple play service offerings. IMS Research predicts DECT / CAT-iq IADs (including cable, xDSL and fiber) will reach 35% worldwide penetration, leading to 25M devices by 2015[1].

One reason that DECT has been overlooked for HAECS applications until now is the perception that its power consumption is too high for “fix-and-forget” nodes. However, the latest DECT products include an ultra-low energy mode, a new development ratified by the ETSI and known as DECT ULE.

This enables sensor-actuator nodes to operate autonomously for 5-10 years on a standard AAA battery pack. Fully compatible with both previous DECT and CAT-iq generations, DECT ULE 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 ULE developments, DECT is a perfect match with HAECS applications. Factor in its strong consumer acceptance, wide installed base and connectivity to the Internet and it is clear why DECT ULE ticks more of the boxes than any of the current networking options (see appendices).

[1] The Worldwide Market for DECT and CAT-iq in Residential Gateways; IMS Research, March 2012

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 HAECS options depend on use case choices such as data rate, transmission frequency, transmitter power, etc. Table 1 shows the use case choices and best case 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

Figure 1: DECT has a link budget high enough to cover a normal home and is able to transmit data at high rates

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 even in non-ideal places like cellar or wall-sockets. Some of the alternatives don't have the required budget, and would need to chop the RF path into smaller segments such as in a mesh type networks. This requires routers to be placed in specific locations around the home and will need to be mains powered. All of these factors make installation more complicated for consumers.

Power consumption and latency

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 HAECS systems turns out to be very similar.

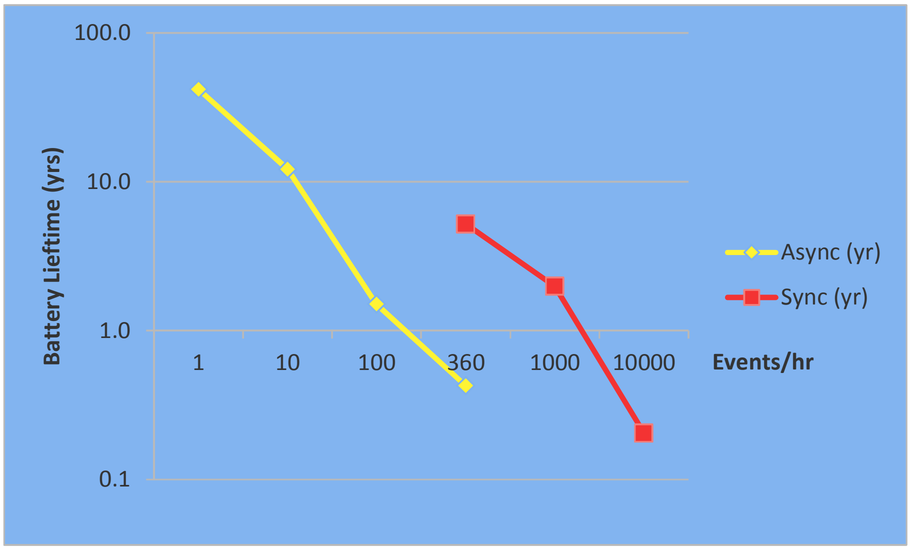

Figure 2: Battery life depends on the sleep / wake ratio, enabling 10 years from a AAA battery pack for several applications

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. Sensor autonomy mostly depends on the number of events as they sleep during their non-activity. For actuators, the autonomy is generally determined by the required latency and typically actuators require less than a second latency.

With DECT ULE, a typical sensor application with a 10 events per hour will run for more than 10 years on a single AAA battery pack (yellow curve), for actuator devices with latencies below 2 sec the autonomy is still 2 years (red curve).

Interference, transmission reliability and data throughput

Interference between radio signals reduces the probability of information reaching its desired destination. Consumers will lose interest in products which regularly fail.

Even if interference problems don't prevent transmission, they significantly reduce the technology's range and autonomy in the home.

Many home networking technologies operate in the popular sub-GHz or 2.4 GHz Industry / Science / Medicine (ISM) band because it offers unrestricted geographic use. However, these bands are very crowded and are dominated by a large installed base of Wi-Fi, Bluetooth and a long string of proprietary devices.

Without agreement on coexistence in these bands even in the less populated sub-GHz band there is no guarantee that competing devices can co-exist.

It represents a big challenge to newcomers in the 2.4 GHz band, like Zigbee / 802.15.4 or RF4CE but also to the many proprietary sub GHz band solutions. Service providers using these bands 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 solutions operating in the same frequency band is not appealing. Co-existence measures exist, but deploying them successfully without a certification body remains very challenging.

DECT on the other hand operates in a 20 MHz wide band centered around 1.9 GHz. This band is licensed in over 100 countries worldwide, reducing interference issues from other sources. Uniquely, although this band is licensed and reserved there are no royalty fees. In addition, DECT's proven Dynamic Channel Selection / Allocation (DCS / DCA) capability ensures each transmission uses the best available radio channel. DECT DCA can be considered a preliminary implementation of what today is called cognitive radio. As a result, a very large number of DECT systems can co-exist in the same band sustaining high-quality and robust communication.

Interoperability

The HAECS market is a very fragmented one, with many individual players each supporting few elements of the HAECS residential network. Interoperability is essential to reach critical mass and also to offer value to the consumer.
From its conception, the DECT standard supports Generic Access Profile (GAP) to guarantee interoperability between manufacturers of base stations and handsets.

This has evolved with CAT-iq to support further interoperability, such as wideband codec negotiation.

To help maintain this key benefit, the DECT Forum, an interest group of service providers, manufacturers, and chip vendors, hold interoperability test events for ULE devices, - with the second such event which took place in Switzerland earlier this year. Additionally, ETSI is finishing the ULE amendment to the DECT standard.

These activities safeguard the integration of ULE devices into legacy DECT systems and also guarantee interoperability between manufacturers of ULE devices.

Network scalability

The wide range of applications from heating systems to home security, energy management and home care, resulted in incompatible subnets, often operating as island solutions, and not part of a larger network like the internet.

Separating the application protocols from the transport protocols (UDP/TCP) has been essential to the scalability of the internet. For this reason the DECT/ULE roadmap foresees the integration of IPv6, realising complete application transparency from the 'cloud' to the end nodes. The combination of successful internet standards (IETF) with the DECT/ULE standard is a unique opportunity in realizing a scalable network of wireless devices (Internet of Things).

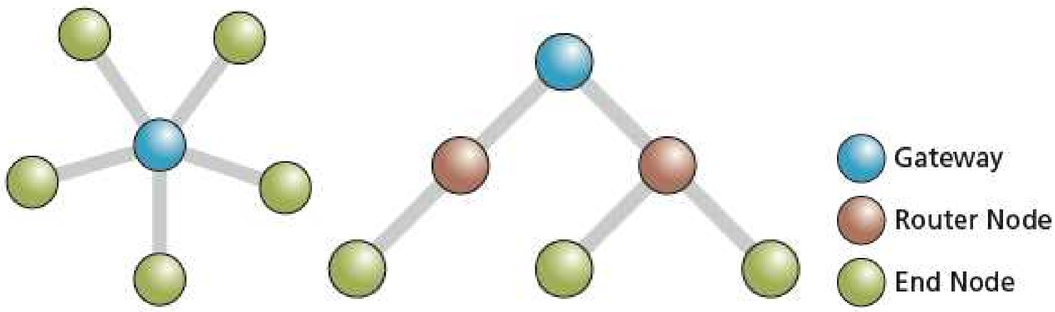

Figure 3: Basic star (left) and tree networks

Multihop networks like Mesh and Tree topologies are easy to scale in size. Though within the context of residential applications their usage is limited and creates additional complexity to install. Meshed Zigbee networks are notorious for their complexity, whereas consumers have implemented self-installed DECT repeaters (Tree) very successfully over the past decade(s).

Next to the size of the network, the density (number of nodes per m^2) is of importance. Where sub GHz based networks soon run out of capacity due to available bandwidth (2MHz) and 2.4 GHz solutions fall short due to interference of legacy products, DECT ULE with its 20 MHz system bandwidth supports very high densities of nodes.

With 540 million households having a fixed broadband connection in 1Q 2011[2] (Point Topic) and growing at a rate of 12% year on year, there is a huge potential for a new generation of internet-enabled HAECS devices and services.

These DECT/ULE enabled gateways integrate HAECS devices seamlessly with the internet, creating a ready to go ecosystem enabling service operators to develop new offerings, and raising the Average Revenue Per Unit (ARPU).

[2] Q1 2011 World Broadband Statistics, Point Topic March 2011

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 price differentiators. The 300 million DECT chips sold each year represent a healthy multi-vendor market guaranteeing low component pricing and wide availability.

Today's single-chip DECT SoCs are priced well below the ZigBee SoCs $2-3 range, and often feature a wide range of HW & SW resources such as voice coding and data converters to differentiate applications.

Overall sharing the DECT functionality can reduce system costs for the consumer further, this includes existing IADs too.

Voice and security

Although voice applications are not directly linked to HAECS segment, there are several security and home-care applications where voice links are paramount. DECT was originally designed for cordless telephony, so naturally offers high-quality voice links both inside and outside the home. DECT nowadays supports AES-128 encrypted links, including authentication algorithms and has a proven track record with respect to its link integrity. DECT ULE maintains that same high voice quality as well as the security mechanisms for voice transmissions used in the millions of installed DECT systems, offering HAECS networks that are as robust against eavesdropping as today's cordless phones.

Install, configure, run and maintain

DECT ULE is as easy to install, configure and run as its ancestor the cordless phone.

Automatic frequency planning based on a distributed algorithm (dynamic channel allocation) executed by all devices, allows all sensors/actuators to access the complete DECT spectrum simplifying the configuration compared to other solutions. Its star topology reduces network configuration to a proven consumer task.

Furthermore, updating firmware over the air (via the ETSI DECT standard Software Upgrade Over The Air (SUOTA)) makes ULE networks future proof and gives service providers further leverage to deploy new products within existing configurations.

Appendix: comparison of wireless networking protocols

Technology	Freq	Range (min-max)	HAECS Pros (+) HAECS Cons (-)	Other remarks
DECT ULE	1.9 GHz (Licensed, royalty-free)	100-300 m	+ Very good range, No interference + High data rate: 1 Mb/s + Simple network configuration + Lowest BoM + Voice enabled + Up to 10 year battery life + Compatible with DECT phones and IADs - Not yet mainstream in HAECS	Target market: cordless communication and home automation, control, care and security
Wavenis	900 MHz (Unlicensed)	30-100 m	+ Good range - Low data rate: 19.2 kb/s - Proprietary PHY - Interference issues	Target markets: metering and M2M
Z-Wave .	sub-1 GHz (Licensed)	30-65 m	+ Low interference + Medium data rate: 40 kb/s - Medium range - Interoperability - Proprietary PHY	Target market: home automation Products already on the market

Technology	Freq	Range (min-max)	HAECS Pros (+) HAECS Cons (-)	Other remarks
Zigbee / 802.15.4	2.4 GHz (Unlicensed)	70 m	+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	2.4 GHz (Unlicensed)	70 m	+ 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	2.4 GHz (Unlicensed)	10 m	+ 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