



DSP Group – Home automation Whitepaper

DECT Home Networking – The Next Step in Home Automation

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Introduction

Traditionally, DECT-based products have been limited to cordless phones packaged with PSTN-connected base units and IP-connected home gateways (HGWs) providing voice services. DECT technology, however, is ideally suited to support a broad array of applications. In fact, DECT audio/video baby and home monitors have been introduced in recent years, while the technology is deployed in a wide variety of products ranging from wireless microphones to home care pendants.

DECT is also evolving as a residential wireless networking technology for home automation (HA). Designed to provide greater convenience, comfort, energy efficiency, and security to consumers, home automation systems include myriad applications such as lighting control; heating, ventilation and air conditioning (HVAC) control; and security (e.g. intrusion alarm devices, smoke/gas leak detectors). Other home automation applications on the rise include plant watering, pet feeding and pool pumps. Nearly any home device can be automatically or remotely monitored and controlled, making the potential for new home automation product development virtually unlimited.

The home automation market is expected to grow significantly in the near future and total hundreds of millions of units, according to multiple research studies ([1], [2], [3]). Figure 1 illustrates this market take-off, which is predicted to reach 38 million units in 2013. The general consensus is that the home automation market is close to an inflection point, beyond which it will grow even faster.

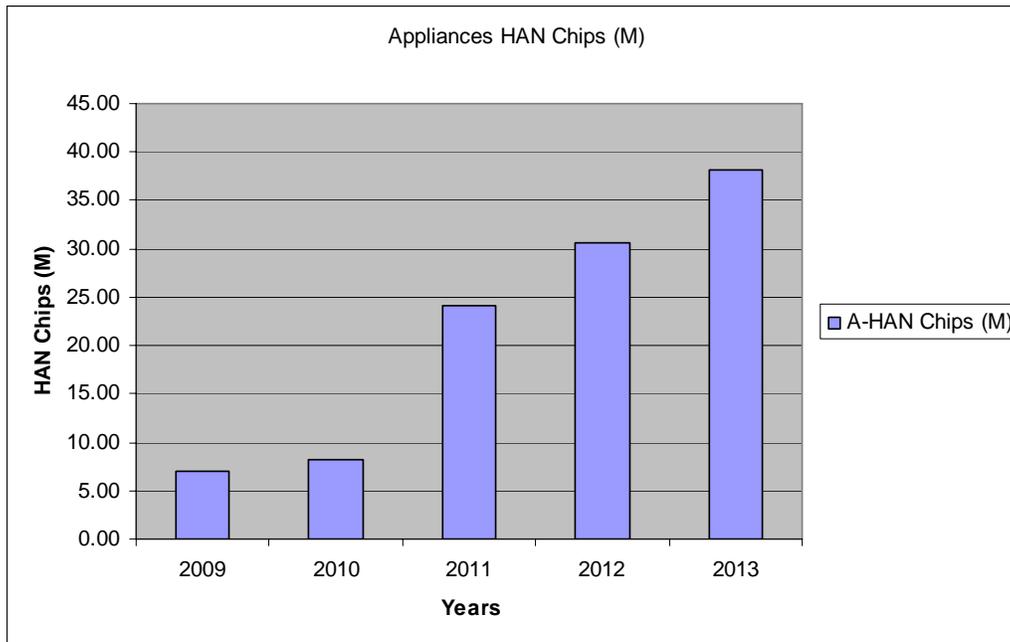


Figure 1: Digital chipset growth WW (forecast); Source: DSP Group internal analysis

In this paper, we show why DECT is an excellent technology for meeting home automation market challenges. In addition, we explain how DECT is well positioned to address this market from a technological, economic and market perspective.

Home Automation Applications

Home automation applications cover myriad areas including:

- **Lighting Control Systems**
 - presence-based automated on/off light switching (e.g. motion/volume sensors)
 - light dimming according to ambient light level
- **Smart Energy/Smart Grid Management**
 - home smart appliance/smart switch control
 - heating, ventilation and air conditioning (HVAC) control
- **Security Systems**
 - intrusion detection: movement detection, glass breaking, magnetic door/window contact, other sensors
 - safety: smoke detectors, gas/water leak detectors
 - medical alert and tele-assistance services for elderly and disabled individuals
- **Intercom:** multi-room communications, automatic door camera viewing
- **Other Applications:** automated garage door, pet feeding and watering, plant watering, pool pumps and heaters, sump pumps

Home Automation Architecture

Home automation typically includes the following architectural elements:

- **Home Gateway:** The HGW connects the home premises to the PSTN/IP network, enabling the user or operator to remotely monitor and control equipment via the Internet or a PSTN network for simple use cases.
- **Home Area Network:** The network enables access to home equipment being monitored.
- **In-home Monitoring Devices:** These devices enable local monitoring and control of home equipment (e.g. mobile/mounted pad, multimedia phone handset, control unit).
- **Home Equipment:** This equipment (e.g. security sensors, smart appliances) is being monitored and controlled.
- **Remote Monitoring and Control:** This involves remote equipment monitoring by residents (e.g. air conditioning units), or remote service monitoring by service providers (e.g. intrusion sensor monitoring by security companies, smart-grid control provisioning by utility service providers).

Figure 2 illustrates DECT-based home automation network architecture. Given that major telecom service providers are increasingly integrating DECT into home gateway equipment, HGW hardware is ready for such architecture *even today*.

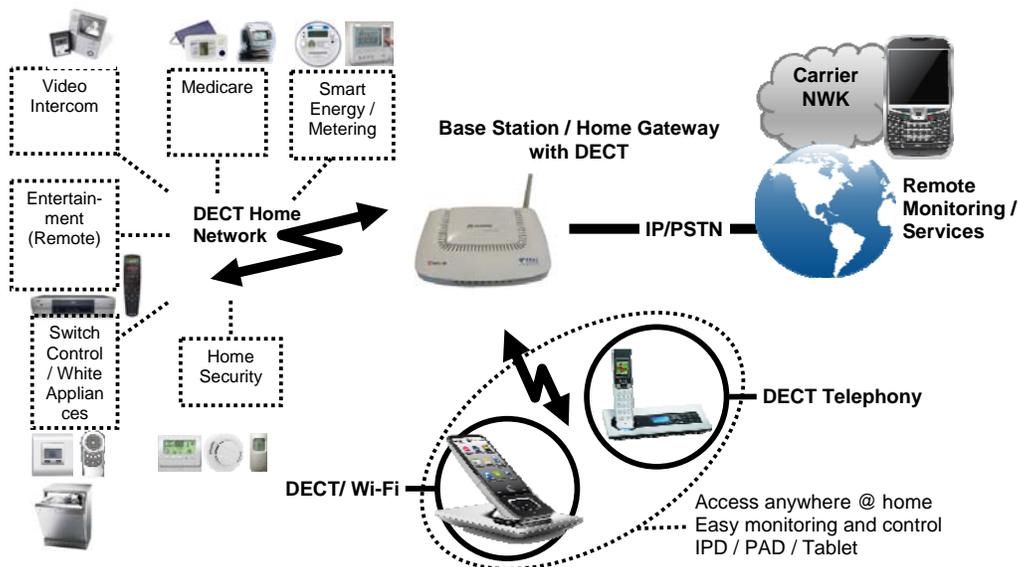


Figure 2: DECT-based home automation architecture

Home Automation Driving Forces

In addition to the rising demand for enhanced convenience and comfort for end users, several other forces are driving home automation technology forward. Here are a few of these drivers.

Regulatory and Insurance Implications

Security systems featuring monitored smoke detectors and fire alarms hasten the response time of emergency services. Since faster response time saves lives and lowers the amount of damaged property, insurance companies are offering discounts of up to 20% to customers who install such systems ([8], [9]).

Beyond the requirements of insurance firms, monitored fire alarm systems are becoming mandatory in public places such as "clubs, theaters, auditoriums, conference venues and other places of assembly" ([10], [11]). Imposition of these regulations by governments and insurance companies is further driving home automation for safety and security applications.

Insurance companies also offer generous discounts for installing intrusion sensors against burglary and home invasion ([12], [13]). The introduction of these alarm systems can be carried out via a basic DECT base station connected to a PSTN network. When a fire alarm, smoke detector or intrusion alarm is triggered, it automatically calls either a fire emergency service/security company (whereby the caller's location is retrievable via Caller ID) or the property owner, who can then call emergency services.

Remote Healthcare and Tele-Assistance

With the rise in life expectancy among modern societies driving health care costs to unprecedented heights, reducing the cost of caring for elderly and disabled individuals is becoming increasingly important. HA services such as remote health monitoring (e.g. blood pressure, sugar level, regular drug intake) and tele-assistance (e.g. emergency call support, drug reminders) can lower these costs. Therefore, medical insurance companies and service providers are expected to push for further home automation for these applications.

For many of these use cases, connecting a DECT base to a PSTN network is sufficient. In fact, DECT-based personal emergency response systems are now quite popular ([14], [15]). More sophisticated systems for monitoring ECG, blood pressure, drug intake, and other health-related areas are either available ([16], [17]) or in advanced development stages ([18]).

Broadband Internet and Triple-Play Service Providers – New Revenue-Generation Opportunity

With the proliferation of broadband Internet services, broadband average revenue per user (ARPU) has been steadily declining, while overall growth of these services has slowed down ([6]). ARPU has fallen by 30% from an

annual average of \$31.70 in 2004 to \$22.30 in 2010. During that same period, the annual growth rate of broadband services has decreased from 150% to 30%. While 30% still represents robust growth, the market is becoming increasingly competitive: over 80% of all broadband service in 2004 was supplied by phone operators via ADSL; in 2010, their market share fell to under 40%. Cable operators' broadband market share has also plummeted nearly in half, from 13% to 7%. Part of that share has been grabbed by wireless service providers including cellular operators that primarily provide 3G services and fiber-to-the-home (FTTH) operators ([7]).

Given these market developments, broadband operators are looking for new ways to provide value-added services (VAS) in order to keep customer attrition down and ARPU up. As a result, they view home automation services – including security, medical alert and tele-assistance services – as an integral part of their offering.

Smart Grid and Green Energy

Electrical power efficiency is one of the major challenges of the current era. And with emerging markets further increasing their demand for oil and gas, the cost of most energy sources is expected to rise, thereby making operational efficiency of existing facilities even more critical. Given these developments, smart grid management, including the utilization of tools for peak curtailment and leveling as well as time-of-use pricing, is becoming increasingly important.

A recent study conducted by the US Department of Energy calculated that internal modernization of US grids with smart-grid capabilities would save between \$46 billion and \$117 billion over the next 20 years ([4], [5]). For smart grids to implement advanced features such as load adjustment and demand response support (i.e. automatic equipment shutdown for reducing power demand spikes and preempting power shortage failure), they require home automation capabilities.

Why DECT?

Multiple technologies target the transport layer of the home area network in order to carry out home automation. These include wireless technologies such as Zigbee, Z-wave, Wi-Fi and Wavenis, as well as non-wireless technologies such as power-line transport (e.g. HomePlug, UPA, HD-PLC) and coax-based (e.g. Moca, HPNA) technologies.

It is safe to assume that there will be room for more than one technology for this market. For example, while wired solutions boast impressive performance numbers, the available infrastructure and its related costs limit their usage. In addition, wired solutions are quite expensive, and often must be coupled with wireless technologies in order to offer a full solution.

The fact that so many wired and wireless technologies are targeting home automation indicates that this market is just scratching the surface in terms of potential, and there are no clear "winners" as of yet. As such, DECT is well positioned to serve this market.

A proven and highly proliferated solution, DECT is ideally suited for home automation. In addition to providing data rates and ranges on a dedicated spectrum, the technology offers secure communications, local mobility, voice, and low-resolution video capabilities. Implementing standby and sleep functionality, DECT reduces emissions and consumes little power. And by supporting remote software update over the air (SUOTA), DECT enables remote maintenance, making it highly desirable among operators and service providers seeking to minimize capital expenditures (CapEx) and operating expenditures (OpEx).

DECT vs. Other Technologies

Table 1 summarizes several RF technologies being used for home automation.

Standard	Medium	Target Application	Standard	Maximum Data Rate	Max. Range	Comments
DECT	1.7GHz 1.8GHz 1.9GHz Licensed	Cordless phone & data	ETSI	1Mbps	300m	Large install base (600 millions homes); low cost; dedicated spectrum; integration with complementary standards (Wi-Fi & Bluetooth)
Zigbee	2.4GHz Unlicensed	Wireless personal area networks	ZigBee Alliance	0.25Mbps	100m	- Technology adapted by a few vendors yet still only a small install base - Complex system architecture: mesh network required
Bluetooth Low Energy	2.4GHz Unlicensed	Accessories, mostly for cell phones	Bluetooth Spec.	1Mbps	10m	Low cost; short range that limits home automation applicability
ONE NET	868MHz 915MHz Unlicensed	Wireless personal area networks	Open standard	0.23Mbps	100m	Small install base
Wavenis	900MHz Unlicensed	Metering	Proprietary technology (Coronis Systems)	0.02Mbps	100m	Low data rate limits home automation applicability
Z-Wave	900MHz Licensed	Home automation	Proprietary protocol (Zensys, owned by Sigma Designs)	0.04Mbps	65m	- Short range and low data rate limit home automation applicability - Problematic frequency band (cellular interference)
Wi-Fi	2.4GHz, 3.6GHz, 5GHz License is country-dependent	Home networking	IEEE standard	56Mbps (a/b/g) 300Mbps (n)	>100m	Less suitable for many home automation applications due to high cost and power consumption
UWB	3.1Ghz to 10.6GHz Unlicensed	PC peripherals, etc.	WiMedia Alliance UWB Standard (basis for Wireless USB)	480Mbps 110Mbps	3m 10m	Short-range indoor high bandwidth

Table 1: Comparison of DECT to other RF technologies

When evaluating home automation solutions, the most important factors to consider include:

- **Cost:** end unit, entire network, installation complexity
- **Performance:** throughput, link quality, range, coverage
- **Interoperability:** complementary standards and applications
- **Outer connectivity:** simplicity, available means of communication with the outside world
- **Power consumption:** battery life (for applications not connected to main power such as fire alarms, security intrusion sensors)
- **Video/audio enabled:** for a variety of applications including alarms and other security devices

DECT has shown that it can adequately address all of these factors.

Cost: As a highly proliferated technology supported by several silicon vendors, DECT enjoys economies of scale advantages, and enables the development of highly competitive, cost-effective solutions.

Performance: The technology utilizes a licensed, royalty-free spectral band (1.9GHz), and employs dynamic channel selection and allocation, which allows multiple DECT systems to coexist with multiple Wi-Fi and Bluetooth devices. Unlike other RF technologies such as Zigbee and Bluetooth, DECT is not affected by Wi-Fi interference in the 2.4GHz band. DECT also enjoys a combination of high sensitivity (-99dBm) and transmission-power flexibility (up to 24dBm), thereby providing the best link budget among wireless technologies competing for the home automation market. As a result, DECT offers superior range (300m) and complete home coverage without the complexity and high power consumption of mesh networks.

Interoperability: The recently adopted CAT-iq standard is specifically designed for data and voice service interoperability. The DECT Forum is in the process of extending CAT-iq to home automation, and is reviewing the adaptations required to enable interoperability with existing home automation and smart grid protocols (e.g. SEP 2.0).

Outer connectivity: DECT maintains connectivity to the outside world, whether over a PSTN or IP network, which, in turn, enables remote monitoring, automation and control.

Power consumption: Similar to other low-power home networking standards, DECT supports a variable active-to-sleep duty cycle, while the end unit remains synchronized with the gateway/base station. As a result, it draws an average current of just a few microamperes. As will be shown in Figure 4, DECT is also very competitive in terms of power consumption, an issue that is being addressed by the DECT ULE WG within the DECT Forum.

Video/audio enabled: DECT offers voice capabilities, enabling voice communications with home area network elements when required. In addition, the technology provides low-to-medium bit-rate video capabilities, thereby enabling cutting-edge security and monitoring systems to receive real-time images from within the home for incidents such as break-ins.

Common Misconceptions about DECT and Home Automation

Despite the apparent perfect fit between DECT and home automation, there are several misconceptions regarding previous use cases and future opportunities. Here we will attempt to defuse these misconceptions.

#1: Does wireless technology for home automation require ultra-low energy?

Over 80% of all home automation use cases do not require ultra-low energy. For example, home automation devices used for controlling lighting, smart appliances or air conditioning units are connected to main power sources. As such, while ultra-low energy operation may be "nice to have," it is far from being a "must." For intercom, baby monitor, medical alert, and tele-assistance applications, power consumption is indeed important. However, DECT offers a reasonable battery life, enabling the technology to adequately handle these and other power-sensitive applications.

#2: Is there a limit to the number of devices DECT can support?

While there is a limit to the number of DECT handsets that can operate **concurrently** in the air, there is virtually no limit to the number of DECT handsets that can be **registered** to a specific base. The number of registered handsets, in fact, can easily reach hundreds or even thousands. Since home automation data exchanges are short, the same slots can be rapidly reused by multiple DECT devices, making the number of DECT-supported devices virtually unlimited on a practical level.

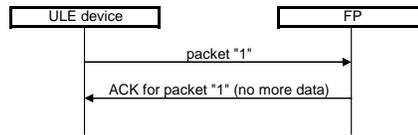
Packet Mode Communication

To facilitate the serving of many DECT home automation devices, a new approach – packet mode communication – has been proposed recently. With this mode, a separate slot, or set of slots, is reserved in a DECT frame for home automation devices, whereby the reserved/allocated slots are not used by regular DECT handsets. The mode's sequence of events is as follows:

- The home automation device uses the dedicated slot or slots to send a packet to the base station with a short message.
- The base station sends back an "ACK," which might contain a request for further data exchange.
- When the data exchange has been completed, the home automation device can relinquish use of the same slot to other home automation devices.

Figure 3 shows how this scheme works for single transaction cases and cases when retransmission is required.

Simple packet exchange:



Packet exchange with re-tries:

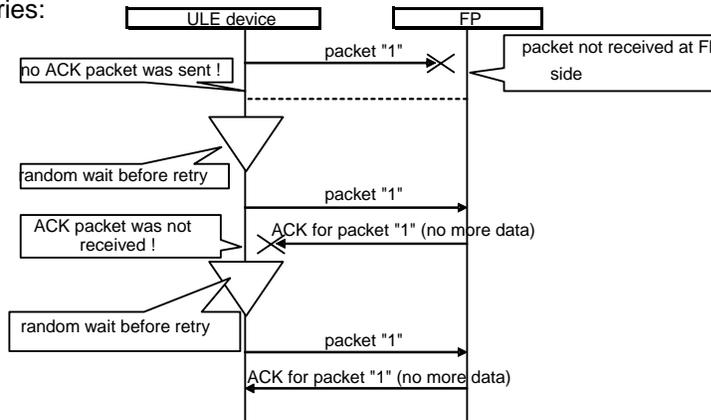


Figure 3: DECT packet mode operation

#3: Does DECT operate at a sufficiently low energy level?

This question comes up since DECT is primarily used for voice operations, and all devices on the market are optimized for such an operation mode. DECT provides superior battery life for voice communications compared to other technologies such as Wi-Fi and GSM. With ULE, DECT is standardized for small packet communications at an ultra-low energy level. This is achieved by moving from circuit-switched to packet-oriented communications on the one hand (as described in the previous section), and by introducing deep sleep and fast sync methods to the standard on the other.

Ultra-Low Energy Operation Developed in DECT ULE

Low-power operation is required for battery-powered devices such as fire alarms and security sensors. To meet this requirement, each DECT power-sensitive device remains in sleep mode except during short wake-up periods when it needs to communicate with the base. The duty cycle of these wake-up periods may be a few hours or more for certain applications. The operation's principle is very simple:

- The ULE device will gain sync with the base station very quickly.
- Communication between the ULE device and base station will remain very short.

The ULE device's fast sync operates as follows:

- The base station will have an extended dummy bearer
 - Regular dummy bearer A-Field for normal DECT handsets
 - The base station will have a “preferred carrier” mechanism (i.e. the ULE device does not have to scan all 10 carriers most of the time)
 - Extended information in the B-Field to allow quick sync
 - This contains a “sync subfield” that enables the ULE device to lock into it very quickly (i.e. no need to wait and collect Qt/Pt information from several frames)

The details of this ULE approach are now being defined within the DECT ULE WG and ETSI, with ULE interoperability testing targeted for Q3 2011.

Figure 4 shows the potential battery (1500mA) life of a ULE DECT device based on wake-up event frequency.

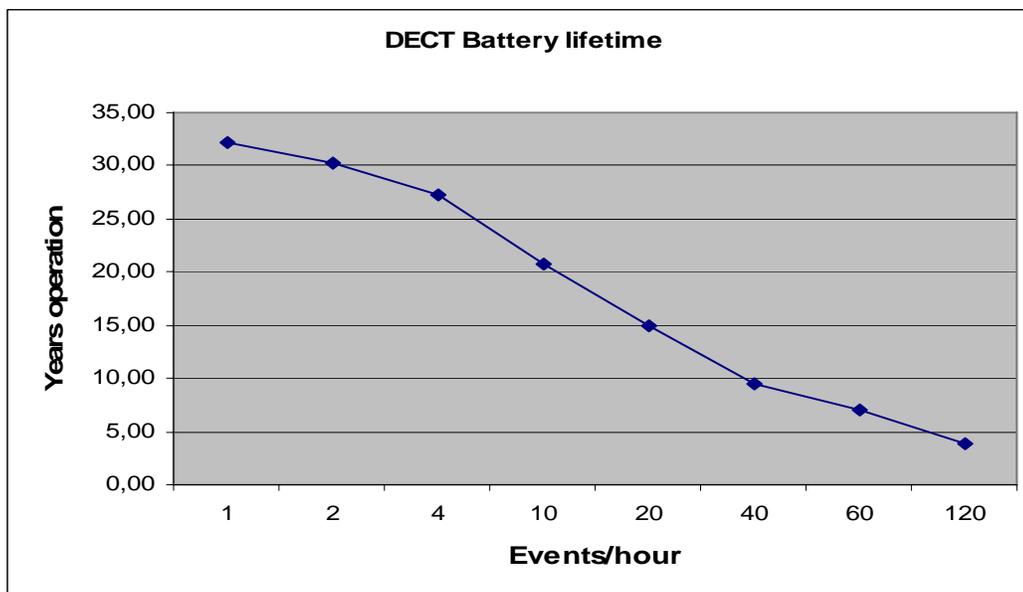


Figure 4: Operating time (battery life) of ULE DECT device

Non-Frequently Triggered Devices

As shown in Figure 4, DECT's influence on battery life is negligible for non-frequent wake-up events. For example, in the case of a wake-up event every 6 minutes (i.e. 10 times/hr.), battery life expectancy for a DECT device is 20 years or more. As such, DECT is well equipped to provide low-power solutions in the case of non-frequently triggered devices.

Frequently Triggered Devices

Figure 4 also shows that for wake-up events occurring every 2 minutes (e.g. for security sensors applications), battery life expectancy is still over 4 years. Even for such power-sensitive applications DECT is a good solution.

After-Market: Reusing the DECT Install Base

Although a growing number of DECT base stations are now connected to a home gateway and therefore to the IP network, the majority of DECT stations are connected to the PSTN network. To make use of this vast install base for home automation, the following approaches can be utilized:

1. **No Modifications:** No HW/SW modifications are made to the DECT base. Devices such as smoke alarm/motion detectors are paired with the base and pre-programmed to call a specific number (e.g. emergency services, user's mobile phone) when triggered. Such an approach is feasible for a variety of uses including security services, certain health and remote-assistance services, fire alarms, and smoke detectors. The maximum number of registered devices is limited for each specific DECT-base implementation.
2. **System Extension**
 - No HW/SW modifications are made to the DECT base
 - An HA DECT Extender is added to the existing DECT telephony system, and is available in various forms such as:
 - i. USB dongle connected to a PC or USB dongle connected to a HGW
 - ii. DECT-enabled tablet with Wi-Fi connection or multimedia handset with Wi-Fi, thereby enabling a connection to the main home gateway
 - The HA DECT Extender can be used with any typical DECT base station (GAP or CAT-iq)
 - The HA DECT Extender enables monitoring, control and configuration of HA devices (e.g. smoke detector threshold, number to call in case of alert). This can be carried out in two ways:
 - i. Locally via a LAN connection and PC application
 - ii. Remotely via the Internet
 - The DECT-enabled control unit is registered to the existing DECT base, while other DECT HA devices are registered to the control unit (i.e. HA DECT Extender)

- The control unit can be implemented on a tablet or multimedia handset – with the option of Wi-Fi connectivity – to create a better user experience

3. System Upgrade

When the DECT base is integrated with a home gateway, SW update via the network can be performed in order to upgrade the base to full ULE functionality. This process is transparent to the end user.

DECT for Home Automation: What's Next?

Within the framework of the DECT Forum and ETSI, DECT leaders are finalizing certain technical, marketing and commercial aspects so that the technology can become the preferred vehicle for home automation. This includes the following developments:

- DECT Forum is working on ULE interoperability testing during Q2 and Q3 2011
- DECT Forum is considering adaptation layer for IPv6
- DECT ULE standard, which is backward compatible to standard (GAP) DECT, is being addressed by the DECT Forum and ETSI as its own standard
- DECT is being promoted as home automation technology in various forums such as:
 - Home Gateway Initiative (HGI)
 - ETSI
 - ITU

Beyond Home Automation

Personal automation does not stop at the home. Expanding the technology to develop enhanced control and monitoring for residential buildings, commercial offices and industrial plants is a natural extension to current usages, and enables: information gathering, monitoring and control by building/hotel supervisors, monitoring and control of motors and assembly lines by factory floor supervisors. Wireless and cordless technologies used in residential environments already go beyond home automation, and are expected to serve these markets in the not-so-distant future. As with home automation, the combining of local area networks with landline (e.g. PSTN, IP) and cellular networks will enable remote monitoring and control of these automated devices.

DECT also supports the commercial and industrial arena, offering low- and mid-data rates (e.g. for control and information data) as well as voice capabilities, while bringing a mature, proven and standardized technology to a fragmented market. Furthermore, the same cordless technologies can also be used in healthcare applications such as automatic blood pressure monitors and medical pendants (e.g. alarms).

As is the case with many innovative technologies, new use cases that are difficult to imagine today will emerge and enrich the lives of those using them in the future.

Summary: DECT Home Networking – The Right Technology at the Right Time

As we have shown in this paper, DECT not only addresses the challenges presented by home automation, but also is the ideal technology for HA applications. Given its vast install base, support among multiple silicon vendors, and maturity, DECT is highly cost effective and appears to be the most competitive solution for home automation.

The technology's dedicated RF spectrum (i.e. non-overlapping with heavily occupied 2.4 GHz band), high sensitivity, and output power enable superior range and home coverage. As a result, DECT-based home area networks are simple and reliable, while offering full home coverage – a very important and reassuring feature for home automation.

DECT is also being integrated in home gateways as defined by the HGI Initiative ([19]), while products implementing this approach already are being offered by leading operators. DECT also supports an unlimited number of devices, and consumes little power even for the most power-sensitive applications.

All told, DECT home networking is the right technology at the right time.

DSP Group provides a full spectrum of robust, feature-rich DECT-based solutions for home automation. These include low-power, low-cost chipsets for operating sensors, chipsets with Wi-Fi, USB and Ethernet connectivity for implementing home automation networks, and a high-end chipset that supports multimedia handset and tablet functionality for implementing HA gateways, monitoring and control.

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