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ON-LINE ENERGY SERVICES FOR SMART HOMES

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ABSTRACT

The EC funded 'SmartHomes' project commenced in 2001 as a 3 year programme. The primary objective is to establish Internet-based energy services and test these within field trials in Sweden, Greece, the Czech Republic and the UK. The tasks include the prototyping and testing of energy services for citizens and professionals, and the establishment of cable and wireless approaches to Internet connection. The implementations are based on residential gateway, or `e-box', technology. Users, for example utilities, citizens, local authority energy managers and health care providers, can access the information through standard Web browsers and, depending on the particular energy service, may transmit information or control requests back to the originating homes. This paper sets out the overall structure of the SmartHomes system and reports on progress to date.

KEYWORDS

Energy services, smart homes, broadband.

INTRODUCTION

Broadband connection to homes has commenced in many countries and, although the timescale is uncertain, is expected to become commonplace within the EU. The market drivers for this are communications, home security, multimedia and healthcare access. Such home connections offer the opportunity to develop a range of new Internet-based, energy services.

The EC funded 'SmartHomes' project set out to identify possible energy services for citizens and professionals and test the more promising candidates within field trials established in Sweden, Greece, the Czech Republic and the UK. The delivery architecture (Figure 1) is based on Ericsson's residential gateway, or 'e-box', technology (Lindfors *et al* 1998). These e-boxes, which are essentially small computers with a Linux operating system, are placed in homes and connected to both the Internet (via cable or wireless) and local sensors/actuators (via radio-frequency (RF) or cable connections). Appropriate environmental and energy use data may then be transferred via the e-box to an e-Service Centre (eSC) from where it may be analysed by a designated energy service provider (ESP), e.g. a utility, local authority or health care provider. These ESPs may then act on the data (e.g. raise an alarm) or transmit information or appliance control instructions back to the originating homes via the e-boxes.
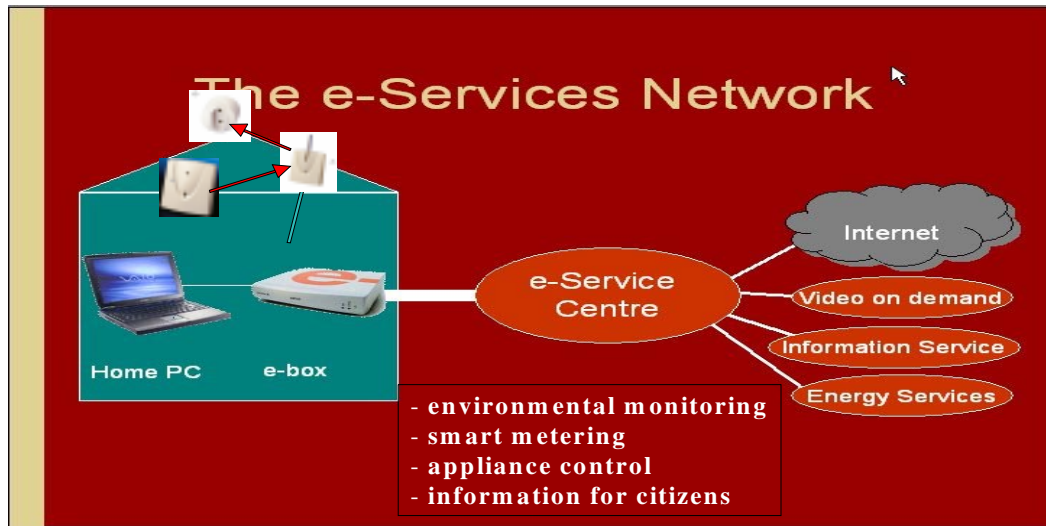
Figure 1: SmartHomes concept

For each energy service, the project is developing data acquisition, management and distribution protocols. In addition, the industrial partners are undertaking market studies and economic evaluations for future technology deployment.

The e-boxes, or e-service gateways, that will be placed in homes are designed for always-on operation with high availability. They offer local IP and non-IP network support, internal fault management, and remote configuration. The current version of the e-boxes has 32 Mbyte DRAM and 24 Mbyte flash memory with 10 Mbit TP Ethernet for both the access and local networks. They also have an RS232 serial port for connection to wire or wireless sensor/control networks. Both the eSc and the e-service gateway provide an OSGi compliant application environment (Open Services Gateway Initiative 2002), enabling secure and transparent communcation between them. For security, all HTTP connections, via the eSC, are based on two-way authenticated SSL-connections.

STATE-OF-THE-ART

Many companies in Europe, the USA, Japan and Korea are developing capabilities for providing home services using broadband connections, mostly focused on the telecommunications, home entertainment and security markets. Much of this effort is fragmented and proprietary. The SmartHomes project stemmed from the realisation that there is a need to promote integrated projects so that standard protocols can be adopted and new energy/environment/health services established and proved in relation to citizen derived value. The project builds on previous pilot projects, most notably the Swedish Energy Barometer project (Westergren *et al* 1998), which addressed the provision of actual and projected energy consumption data to home owners/occupiers.

A state-of-the-art review identified several options for home network communication including wireless LAN, phoneline, powerline and ethernet technologies. Short range radio-frequency (RF) communication (e.g. using the Bluetooth protocol) are recognised to have the best potential for home applications. However, further development is required to provide sensors and actuators at acceptable cost: a range of sensors/actuators will be required to

implement the possible energy services, e.g. for temperature, CO, CO_2, humidity, power consumption and load switching.

Several options are also available for access network communication to link homes to an eSC. Two such options are ADSL on twisted pair lines and GPRS over mobile networks.

POTENTIAL ENERGY SERVICES

The initial tasks were to elaborate the possible energy services and identify the stakeholder groups that could deliver or benefit from such services: home occupiers, property owners/operators, energy suppliers, service providers, local and national authorities and telecommunications providers/operators. An important consideration for the new services is that decision-making is simultaneously supported at the local and large scale (through the aggregating of many residences). Thus, a given service may be of value to the occupant of an individual home and to a housing association charged with the management of a large estate. The identified energy services are categorised as shown in Table 1 along with specific service examples. Within the project special attention has been given to the remote monitoring of environmental conditions/energy use and the remote control of appliances.

Table 1: Example energy services.

Service Categories:

Information, e.g. authorities inform potential customer about the energy labelling of domestic appliances and about the benefits of particular purchases.
Monitoring with alerts or alarms, e.g. CO monitoring in a care for the elderly context or community gas leakage detection.
Monitoring with feedback information, e.g. simultaneous reporting of metered energy consumptions to occupants and energy suppliers.
Monitoring with actuation, e.g. for supply-level network load management.

Service	Example
environmental monitoring	detection of gas, smoke, temperature and humidity
metering	gas, electricity and water consumption
weather related	heating control, night cooling, use of rainwater
performance evaluation	city energy consumption by fuel type and emissions
appliance control	heating, lighting and small power
aggregate control	district load manipulation and HVAC operation
building-integrated renewable energy systems control	renewable energy trading as a function of electricity prices and demand

Each of the four countries involved in the project are responsible for field trials involving

those services that reflect local concerns and conditions as follows.

Czech Republic - Individual metering of energy use and thermal comfort in multi-family buildings with remote actuation of set-point temperatures of heating systems for entire housing blocks. Data is being reported to occupants, the energy supplier and authorities.

Greece - Cooling load predictions based on real time data input to neural networks, and information to occupants on how to effectively reduce space-cooling demand.

Scotland - The services target the public housing sector and comprise cold condition alarms, CO-level monitoring, fuel use metering and reporting to energy suppliers, health care agencies and local authorities.

Sweden - Metering of space and domestic water heating and electricity in multi-family buildings. The coupling of metered values to a simulation program allows estimates of the heat exchange between neighbouring apartments, thereby providing information for energy consumption debiting models. The data is reported to occupants, the energy supplier and the local authorities.
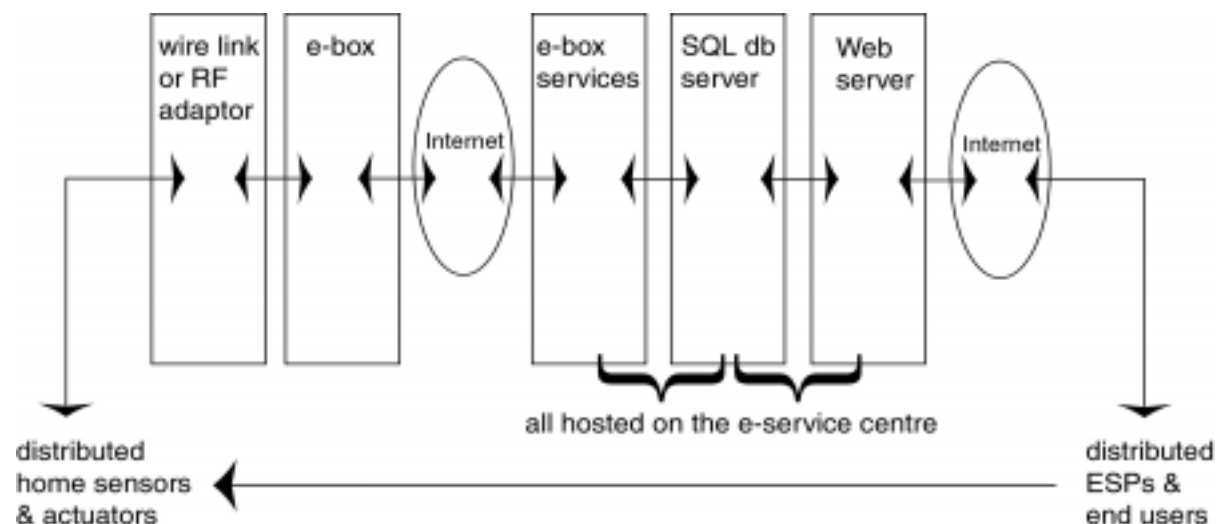
SYSTEM OVERVIEW

Figure 2: Architecture of the SmartHomes system

Figure 2 shows the main elements of the SmartHomes system. These include:

1. Sets of related sensors and actuators exist to support the needs of a particular energy service. While these devices are typically wireless and based on radio frequency (RF) technology, they may also correspond to conventional wire-based installations.

2. An electronic gateway device exists to receive/send information from/to the sensors/actuators and send/receive data to/from an eSC located elsewhere on the Internet. Within the project Ericsson's e-box is being employed as the electronic gateway. This is a low cost device utilising the Linux operating system within a solid-state architecture.

3. The eSC has software to receive and organise the returns from registered e-boxes and energy service providers (ESP). These data are held within an SQL server database.

4. Software agents closely associated with this database act to extract the aspect data-sets corresponding to the particular energy services being supported at any time. These data-sets are either aggregate e-box data, for onward transmission to an ESP, or actuation requests from an ESP for transmission back to the e-boxes.

5. Finally, distributed Web sites, one for each energy service, are maintained up-to-date as a function of the outcomes from the data processing at the eSC. It is envisaged that some ESPs will establish secondary Web sites to transmit their service back to homes or elsewhere (e.g. to a local authority or an emergency service).

LABORATORY PROTOTYPES

Prototypes of the system shown in Figure 2 have been constructed and subjected to initial testing by the academic project partners. This work required the development of e-box resident software to decipher the data exchanges with a range of sensors and actuators according to their specific protocols. Software has also been developed to receive and store the e-box data returns at the eSC, and arrange for the dispatch of information to the ESPs via dedicated Web sites. All system software is based on Web-enabled Java technology operating on a central SQL database server.

CONCLUSIONS

The SmartHomes project has proceeded to plan and has established an operational system that is capable of delivering a range of new energy services. Some of these services, as appropriate to the 4 partner states, are being field trialled in order to test their value and prove the robustness of their delivery. Several benefits are expected to arise from the deployment of such services in relation to running cost reductions, the management of demand in real time, the provision of added value services to customers, optimised operation of supply systems, and better management of service quality according to customer requirements.

The potential of advanced home communication systems to impact on the quality of life is significant: the services targeted within this project relate to home energy use, environmental quality and health & safety.

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