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A Review of Residential Computer Orientated Energy Control Systems

by
Greg North

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DEPARTMENT OF HEAT AND POWER ENGINEERING
LUND INSTITUTE OF TECHNOLOGY
P.O. BOX 118, SE-221 00 LUND
SWEDEN

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FOREWORD

This document is a collection of data obtained from various sources that should give the reader a brief overview of the areas researched during the initial period of the author's doctoral studies, from October 1999 to March 2000. The purpose of the document is to provide a basis for the studies by describing many different aspects of Energy Control Systems.

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Greg North, MSc
greg.north@vok.lth.se

Jurek Pyrko, Assoc. Prof.
Project Leader
jurek.pyrko @vok.lth.se

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1 Introduction

Gone are the days when one can only use electricity to do simple things like switching on a domestic appliance. It is now possible to do advanced things such as communicate and control different devices using energy systems. These systems, if used in a residential situation, can be called Residential Computer Orientated Energy Control Systems.

This review into Residential Computer Orientated Energy Control Systems investigates the numerous ways in which it is possible to manage the energy services within a household. Due to the continuous developments within the electronic and information technology industries, new options and possibilities for such systems are frequently becoming available.

The technical aspects of such a system, as described in this report, extend across many different products and one needs to have a good understanding of each product if the optimal system is to be designed. Generally, none of the products can stand alone so therefore one also needs to know how they will interact together, if the are compatible.

This report provides a review of the basic technical aspects of such systems and many of the individual devices that can be connected.

1.1 Purpose of the Report

The purpose of writing this report was to bring together as much information on Residential Computer Orientated Energy Control Systems as possible within a single document. This report identifies the main elements of the system and is intended to provide many technical options for the design and implementation of various energy related services.

1.2 Report Overview

The two chapters (2 and 3) following this introduction are designed to inform the reader of the direction that energy utilities and their related services will move in the future. It also describes some of the basic aspects of home networking, residential gateways and broadband communication.

Chapters four through seven discuss the various techniques that can be used for the communication on residential energy control systems. This includes new wiring options as well as the possibilities to use the existing residential wiring systems and wireless technologies.

Chapter eight lists many of the organisations that are currently established within the industry. The main role of these organisations is generally to promote or support the specific technology that they are associated with.

The following three chapters (9 to 11) discuss many individual home automation or advanced devices and their respective manufacturer. This also includes advanced metering, home gateway devices and appliance manufacturers that are developing smart appliances.

Chapter twelve concludes the report and gives many examples where actual advanced energy projects have been undertaken.

1.3 Information Gathering

A large proportion of the information included in this report has been sourced from the Internet and their corresponding Website addresses can be found in the Reference List.

This information source was extensively utilised due to the lack of references to this type of information in more typical sources for university based research, ie. within journals and conference proceedings, although some information has been obtained from these sources.

1.4 Information Presentation Method

In many places in this report, especially in the initial chapters, the obtained information, deemed to be very relevant, has simply been edited from its specific source into a form that was considered to be more relevant to this report. This editing generally involved the removal of the less relevant sections of the sourced information and combining the remaining parts into a logical form. Most of the sentences, using this technique, have therefore not actually been written by the author of this report. Where this method has been used, a specific referencing symbol (denoted by a star " * " beside its reference number) can be seen.

This technique, though not typical for an academic report, was used due to the need to find and review the initial background information as fast as possible in the given limited time frame.

2 Looking into the Future of Energy

2.1 Tomorrow's Energy Needs Require Intelligent Networks

With the move towards deregulation, the energy industry has to pay closer attention to energy economics and make increasingly better use of available resources [1*]. This requires a better understanding of customer needs and the resources available to respond to those needs to give more intelligent solutions.

Deregulation is turning energy into a commodity that can be purchased through a free-market economy, with energy being purchased according to the availability of supply and specific demand. Companies that have undergone this industrial and commercial metamorphosis are faced with the new situation of competition and the resultant new commercial imperatives. Deregulation leads to the following effects,

- Energy is a commodity that is easily obtainable at any time, at any place and for any application.
- Increased competition leads to power importation, cost reduction and efficiency improvement.
- There will be new players and new partnerships.
- Development of supplementary decentralised energy generation.
- Development of new business segments, including heat, waste, communication and comprehensive services.

Intelligent networks

The greatest innovative boost to the energy supply sector will however come from better information technology in the form of integrated communications and distributed intelligence. Better protection of relay systems and power system control will help make operational management more effective and increase the level of grid automation. If deregulation is taken to its logical conclusion, we will see the emergence of "energy utilities", suppliers of power and perhaps of other services such as telecommunications.

Integrated communication, which will initially only be necessary to optimise the energy supply system, will pave the way for billing management. This can lead to a more flexible incentive-based tariff structure and at the same time allow the utility to explore new business opportunities.

Building and enhanced domestic services are just two examples of potential opportunity. Once a service connection has been made inside a building or home, the prospects for offering other communication-related services will be enhanced; TV, ISDN telephony, the Internet, home banking, building-services management and security are just a few areas of opportunity. Figures 2.1 and 2.2 shows a way in which these intelligent networks could be arranged.

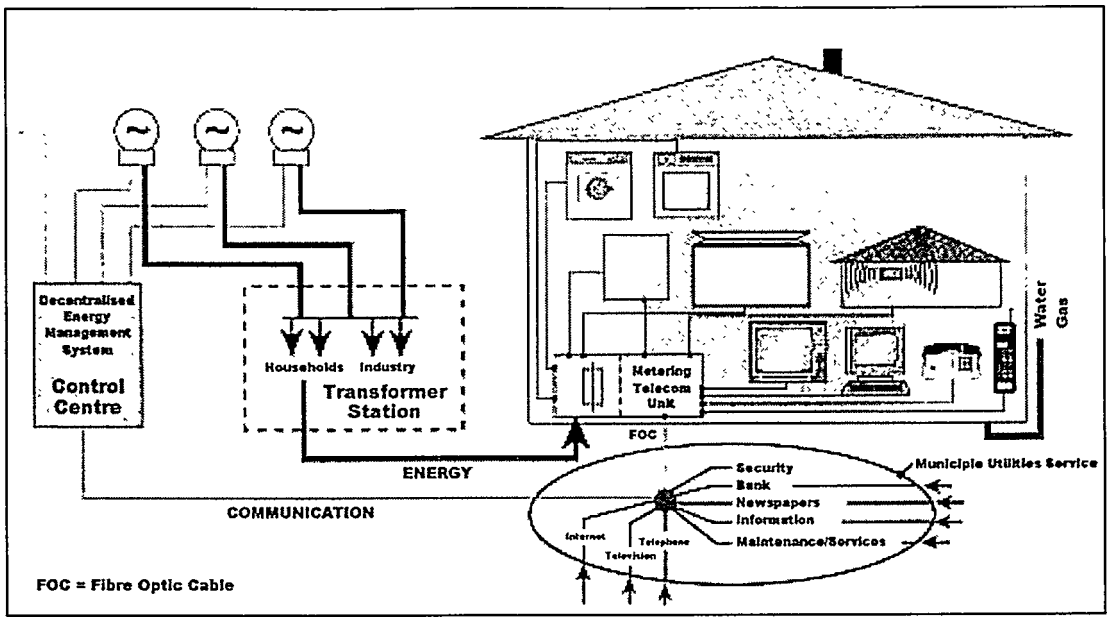

Figure 2.1: Connection of energy, communication and intelligence [1]

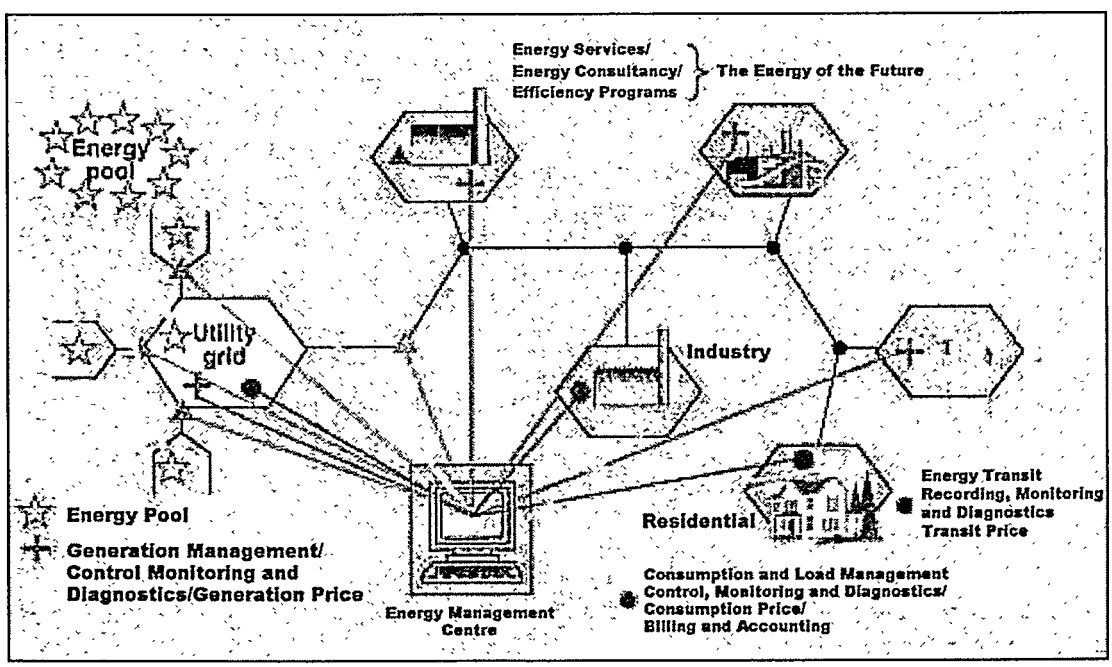

Figure 2.2: Energy and dataflow [1]

2.2 Future Energy Utilities

(Note that the following section has specific references to the USA, notably in terms of monetary information. It is expected that many of the points raised are relevant outside the USA.)

In its bid to respond to evolving business requirements, the energy utility industry is exploring new ways to provide cost effective quality energy to its customers while concurrently reducing the need for additional generation plants, consumption of non-

renewable fuel resources and the generation of pollution [2*]. Their options cover a full spectrum that includes the utilities providing the "last mile" access to its customers for both generic Internet access required for empowering the users as well as supporting the necessary utility applications.

Enhanced control by the consumer over how, how much, when and at what cost energy is consumed is expected to help utilities and the end user. It will help the utility achieve their goals with respect to more efficient energy generation and distribution and will also give the end user more control over their own energy practices and thereby saving them money, although the cost per kilowatt hour (kWh) may increase. All of these changes will require a more capable information and energy infrastructure that supports interactive energy services, automated and online infrastructure maintenance and operation and business style interactions among all of the entities generating, providing and consuming energy.

If the energy utilities were to provide last mile access via fibre to support their energy related services it is estimated that approximately 95% of the fibre optic network capacity will be in excess of the bandwidth required for energy services requirements. This excess capacity could be leased or sold to information service providers.

Both the utility and the consumer can benefit from the use of time of day (TOD) or real time pricing (RTP), whereby the cost of energy is driven by demand and the consumer is given the choice in quasi "real time", eg. every 15 to 60 minutes the price is advertised, to reduce or sustain energy consumption based on their knowledge of the current price of electricity. Real time pricing and the subsequent action of a residence or business to turn off appliances in such times would be accomplished via command-response interactions over various telecommunications media.

In addition to providing more real time driven costing and control of energy consumption via telecommunications based services, the improved management and accountability of its infrastructure is expected to at least partially recoup some of the money lost to energy piracy. This is estimated to be worth 0.5 to 1.0% of the power distributed and in terms of the 1990 figures of $US 177 billion worth of energy distributed in 1990 could well save $US 0.8 to 1.7 billion per year. Manual meter reading has been estimated to cost $US 6 per house hold with a possible savings from automated (infers the need for some sort of telecommunications) of $US 55 billion based on the figure of 92 million occupied households in 1990 in the USA.

One result of the information age is that the utilities will need to not only provide quality energy to its customers, but will also need to give the consumer, both residential and others, more enhanced and easy to use online billing and accounting. In addition, a trend towards more customer control over their own information and energy appliances will require the utilities and third party energy providers, to provide enhanced interactive capabilities for curtailing the use of electricity. This switch to user driven selection will require more information technology to be built into energy appliances to enable energy customers to manage their energy use.

The energy utilities have the choice of either creating and running their own telecommunications infrastructure or utilising the connectivity provided by other telecommunications service providers. Possible synergies between the utility

companies and the cable and telecommunications providers could be exploited such that the utilities could take advantage of the "last mile" infrastructure already in place to address the energy applications currently deployed. However, the future will require more enhanced capabilities for the "last mile", as noted by an Anderson Consulting study. Trends in other industries are moving toward customer interfaces through televisions and personal computers; these interfaces will require broadband. Broadband is required and necessary, not as much for the bandwidth, but more for the speed and real time capabilities it provides.

However, even though the telecommunications industry has made strides in the amount of information it can provide over conventional twisted pair lines, it may make more economical sense for the utilities to provide fibre directly to their customers. This could be funded by such things as the increased revenues from the sale of excess capacity, by overall energy savings to the customer, by the savings from deferred plant construction and also by the provision (at less cost) of the other services to the customer, such as the cable and other Information Services (eg. the Internet).

Some managers in the utility business do not believe that the current Internet or public telecommunications infrastructure (Plain Old Telephone System - POTS oriented) is capable of handling the broadcasts, necessary for real time pricing, rapidly curtailable load requests and other such time critical interactions. Some state that the "Electric utility communications network reliability must meet a higher standard than that for telephone service". This is because the communications network must handle an increasing volume of mission critical functions (ie. real time billing information) requiring complete communications redundancy. Business aspects of real time pricing or time of day pricing, as well as remote control of energy and information appliances, will require business level security and reliability, including authentication and digital signatures, as well as reliable and predictable telecommunications services.

Infrastructure Models for Utilities

Energy Services can be roughly divided into two categories, those services focused on the operation and management of energy services and those focused on customer based services. Many in the energy utility sector now recognise that any communications enabled services, such as the adjustment of energy appliances to an advertised real time price would drastically affect the techniques, protocols, information, concepts and models for providing an enhanced, secure, efficient and component based energy services. The anticipated infrastructural end state will include the residence, industrial, or business customer having a separate local area information and energy appliance network infrastructure (equivalent of a local area network) that interfaces and connects to the energy utilities and information service providers, analogous to the current telephony model of today. From the consumers' perspective the missing link is a cheap (say, $US 100 or less) gateway, router, or equivalent. This link will provide multiple residence/building/campus local area network capabilities, which allow new choices (interfaces such as COAX, twisted pair, X10, CEBus, etc.) on one side and a similar set of choices (interfaces such as radio frequency, ISDN, twisted pair, fibre optics, cable, etc.) on the other side. This building block will spawn new businesses and services providers who will provide

software and hardware systems, as well as services agreements for managing the consumers (homeowners, industry and businesses) information and energy appliances. The end user will now determine what information regarding their energy consumption they allow the utilities or energy appliance producers have access to, as well as maintaining control over when and/or how their own energy (as well as information) appliances are turned off or on. The end user will require a cheap multi-protocol gateway/interface/desk-top-box.

The success of future energy services is dependent upon the creation and deployment of a separated electricity and energy information infrastructure, complete with open access between energy, information and telecommunications service providers as well as the end user.

2.3 The Future of Home & Small Office e-Services and the Open Services Gateway

Few areas are as exposed to the powerful impact of new technology and industry deregulation as the residential services market [3*]. Together, deregulation, new technology and the Internet are rapidly transforming how companies in this market define and manage their business. Significant opportunities are emerging, for both existing and new players to deliver new services.

At the same time devices inside the home are getting more intelligent and increasingly interconnected. The next frontier in the networking industry is without doubt the home and within a few years this market will become a billion dollar industry.

The Internet market has moved from the domain of the technologically literate to a mass market, with many users connecting from their homes. In addition, consumers are increasingly equipping their homes with multiple PC's (over 20% of US households by 2002) and other computer peripherals. As well, the non-PC Internet access market (including Net TV, Web-phones and gaming consoles) is forecasted to grow rapidly. Other household appliances (including white-goods and entertainment equipment) are also starting to have intelligence and networking built in at the point of manufacture.

Open Services Gateway Defined

As residential telecom and datacom services combine and new technologies become available it is expected that homes and small offices will be equipped with service gateways that will function as the platform for many communications based services. The service gateway will enable, consolidate and manage voice, data, Internet and multimedia communications to and from the home and small office. The Services Gateway (SG) will also function as an application server for a range of other high value services such as energy measurement and control, safety and security services, health care monitoring services, device control and maintenance, electronic commerce services and more.

The SG may enable the connectivity and management of an entirely new category of devices eg. JINI and HAVi, but will also be integrated in whole or part in existing

product categories such as (digital and analog) set-top boxes, cable modems, routers, residential gateways, alarm systems, energy management systems, consumer electronics, PC's and more. The SG will accomplish this by adopting existing Java standards, such as JINI, and by integrating with other non-Java standards such as HAVi. The gateway will connect these device standards to the central office and management system as well as provide gateway to Service Providers to facilitate the deployment of services.

Technically, the SG is an embedded server that is inserted into the network to connect the external Internet to internal clients. The SG is inserted between the Service Providers network and the home or SOHO / ROBO LAN and client devices. The SG separates the topology into the external network and the internal network. Services are delivered from trusted Service Providers on the external network and are delivered to the SG or internal clients. The SG is typically a zero-admin device that is secure and functions as a gateway between these internal and external components. The Open Services Gateway Initiative (OSGI) specification includes API's for service cradle-to-grave life cycle management, inter service dependencies, data management, device management, client access, resource management and security. Using these API's clients load network based services on demand from the Service Provider and have the SG manage the installation, versioning and configuration of these services.

Application Examples

Consumers and small business owners will be able to select from a multitude of convenient communications based services. The following paragraphs describe a few of the common usage scenarios for the Services Gateways.

Power companies leveraging the Open Services Gateway Initiative products can deliver not only energy measurement but also energy load management throughout the home. Customers can buy services such as a specific daytime and night-time temperature or the balancing of load (so that, for instance, a HVAC system does not operate at the same time as washers/dryers or other high consumption equipment). This reduces service costs for the consumer and makes load management more intelligent for the utility thus reducing peak loads and investments required to support these.

Home security systems will no longer require proprietary communications systems and the user can buy services that let them know through for example, your cell phone or pager if their kids did not return from school at the normal time. The user can get a message to their cell phone or pager the minute their house is broken into - the same minute the Alarm Company or the police learn about it. Or, the user can get a notification that the temperature in a room has fallen below the freezing point.

Consumers caring for an elderly parent or relative will be able to equip themselves with low cost patient monitoring devices that continuously transmit critical care or emergency information through the Services Gateway to hospitals, physicians, or paramedical services reducing costs and increasing the sense of safety and security.

Traditionally, most of these systems are monitored from remote locations, but maintained through field visits. The OSGI allows providers of these systems to

standardise upon the software gateway used to manage, upgrade and administer these systems, while leveraging the Internet to connect them to the data centre. So when the area code used to call the fire department changes, or when new security policies are implemented, the system can be upgraded via the Internet, without requiring a field visit.

Even traditional home appliances can become intelligent and connected by the Consortium's Open Services Gateway architecture. For example, when a JINI or HAVi enabled washer, dryer, or refrigerator is about to fail, it can send a message over the power line, through the Services Gateway, across the Internet, directly to the manufacturer. Service technicians can call or page the owner and schedule a repair, or access the freezer through the Open Services Gateway and isolate the failed component.

The Business Models/Value Chain

Over the next few years, with the creation of new business models and value chains based on the mergence of the Internet and industry deregulation, new computer communications and consumer devices will allow the creation of opportunities to deliver new services.

Examples of such services might be,

- Voice, Voice-over-IP services
- Shared Internet, data, multimedia services
- Alarm and safety services
- Energy control, measurement and management services
- Health care and safety monitoring services
- House-hold equipment gateway monitoring and control
- Content services
- e-Commerce services

The new e-services value chain will consist of at least four clear elements,

1. Device and product manufacturers. Examples may include computer, communications, consumer electronics and household manufacturers.
2. Infrastructure operators. Examples may be Telecom operators, mobile/cellular operators, Internet Service Providers, cable access providers.
3. E-service Service providers. Energy companies, security companies, health care providers, electronic commerce and content providers, utilities and more.
4. The consumer or small office owner.

We will see independent companies making a business being a marketing function/broker/aggregator of the mentioned services, buying infrastructure services from telecom operators and brokering the value services from eg. alarm companies, energy companies, health care providers etc.

Shortening Time to Market

To shorten the time it takes to move any geographic or vertical market to the new model will include a number of factors,

- Partnerships. A number of companies need to team up to provide the appropriate mix of services applicable to the local market.
- Customisation. No market becomes a volume, infrastructure market from day one. Customer intimacy and customisation for a relatively smaller audience will initially be very important.
- Persistence. Developing this market will take time, money and patience.
- Timing. The Internet has to date shown us that early players are often the winners. They create the systems, processes, brands and awareness that others have to respond and react to and often try to copy.

Consumer Drivers and Challenges

While the computer and communications markets have made great strides in terms of lowering costs and increasing ease-of-use over the past few years, we are reaching a point where changes are required to increase computing and communication penetration. The current one-size-fits all PC model cannot go much further. The market drivers point towards more mission specific devices that are combined with a service business model, namely,

Drivers:

- Lower cost of services
- Improved convenience
- Security

Challenges:

- Technology moves too fast for the average consumer to keep up.
- Technology is still too difficult to the average consumer.

The result may be that unless the market produces more optimised products and solutions, the market will come to a slowdown.

Service Provider Drivers and Discontinuities

The drivers and challenges for the back end service providers will vary even more. Below is a somewhat uniform list that will apply to energy, alarm/safety, health care companies and organisations.

Drivers:

- Enable and acquire new customers and segments.
- Sell more services, add more value per customer.

- Become part of the network economy; new business models, value chains.
- Protect current business while at the same time transitioning the new world economy.

Challenges:

Entrants with less or nothing to protect becomes the pacesetter and rule maker for the new value chain building a much more cost effective service and creating new categories and brand situations.

- Technology knowledge and core competencies required to make good decisions and to move fast.
- Partnership ability and short term "share the wealth" with web partners.

The Technology Implications

The new business models and value chains have very real technological requirements.

The Open Services Gateway specification is a Java based application layer framework that gives service providers, network operators, device makers and appliance manufacturers vendor neutral application and device layer API's and functions.

This strategy enables virtually all emerging home networking platforms, protocols and services to seamlessly inter operate with back end services, using existing residential telephone, cable TV, or electrical wiring.

Because the Open Services Gateway specification focuses exclusively on providing an open application layer and gateway interface for Services Gateways, it complements and enhances virtually all current residential networking standards and initiatives. Some of these include JINI, Bluetooth, CAL, CEBus, HAVi, Home API, HomePNA, HomePnP, HomeRF and VESA.

2.4 Commercial Market Research

There are many companies that are interested in what is happening in the energy industry. One type of these companies are those that are undertaking commercial industry research. The output from these companies generally includes many interesting reports and presentations. The names of such companies include Parks Associates [4], Cahners In-Stat Group [5], Communications Industry Researchers Inc. [6], JP Freeman Co Inc. [7], Forrester Research [8] and Chartwell Inc [9].

On the sixth of January 2000, Parks Associates presented "Defining the Digital Millennium" at the CES 2000 conference. In this presentation they outlined their visions for integrated home systems and Figure 2.3 shows how they perceive the home networking potential [4].

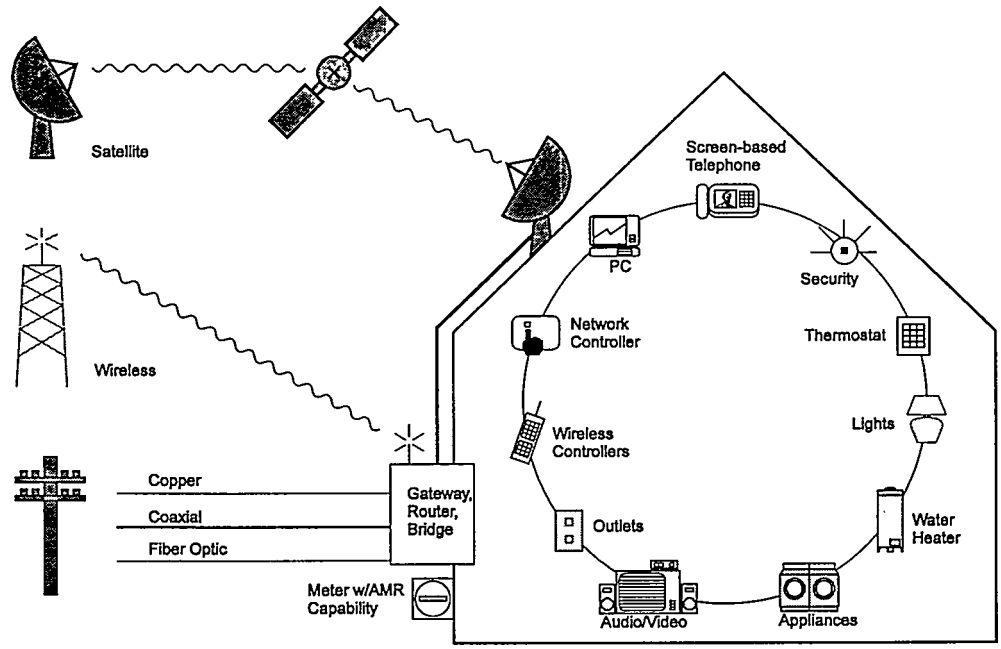

Figure 2.3: Potential for Home Networking [4]

A further study undertaken in 1997 interviewed over 400 commercial customers in five European countries (Italy, France, Germany, Sweden, UK) concluded that providing value-added services offered the greatest opportunity for the utility suppliers to achieve a competitive advantage in an open (deregulated) market place.

An American study, undertaken by the EPRI institute, indicated that it was possible to achieve generation efficiencies of up to 15% by load shifting for an average utility.

Future High-speed Internet Growth

A Yankee Group market study predicts that the market for residential high-speed Internet (HSI) services will grow five-fold in the coming four years [10]. They also say that cable modems, which currently account for 80% of the residential HIS subs at the end of 1999, will have only 42% of the market in 2004. This change is due to the wider deployment, better pricing and more consumer acceptance of DSL.

Broadband Outlook Survey

KMPG Consulting conducted a survey at the American Television Programming Executives conference where its key findings were that companies could gain the broadband advantages by striking alliances with access providers instead of merging with them [10].

2.5 Residential Gateways

Connectivity in the home opens up a world far beyond simple Internet sharing [11]. The home network enables a variety of new and interesting applications for the consumer including home control and automation, distributed entertainment,

multiplayer gaming, IP based security as well as file sharing and shared printing to name a few. Figure 2.4 shows some of the reasons for installing a home network.

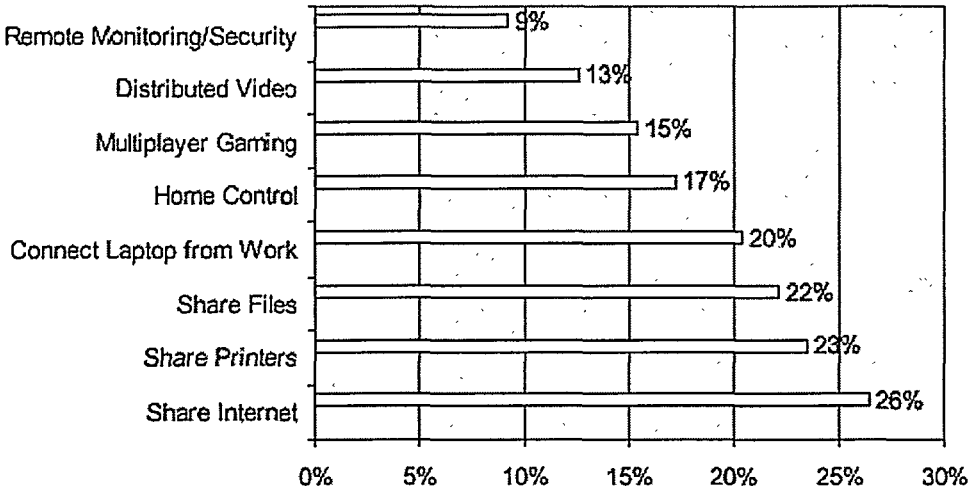

Figure 2.4: Reasons to Install a Home Network [11]

The Residential Gateway, or RG, is a device that connects the external network, or the Internet, with the internal Home Network. While many initial RG's installed have been a high speed Internet access device such as a DSL modem connected to a PC (which acts as a router), a new class of stand-alone, intelligent Gateways are emerging from such companies as 2Wire. These devices will allow consumers to share Internet access as well as perform many of the applications mentioned above without relying on a PC, which is viewed as unreliable by many consumers. A typical set-up for a home network including a Residential Gateway is shown in Figure 2.5.

The Residential Gateway is not a new concept. The idea of connecting the home network to a public network was born out of the utility industry for the purposes of Automated Meter Reading (AMR).

A Residential Gateway must have the following characteristics,

- Non dependent on a Personal Computer. The connection of a high-speed modem to a PC forms a "logical RG", but the emerging class of stand-alone RG's will be able to stand independent of the PC.
- Embedded Intelligence to perform routing or hubbing. The device must be able to distribute the incoming signals from the Wide Area Network and distribute them throughout the residence without the assistance of a PC.
- High Speed Internet Access. While there will be devices that will have lower speed, an always on, high speed connection is necessary [5].
- Durable. A RG must be have a long enough life span to ensure the ability to deliver high speed Internet and services over a long life span.

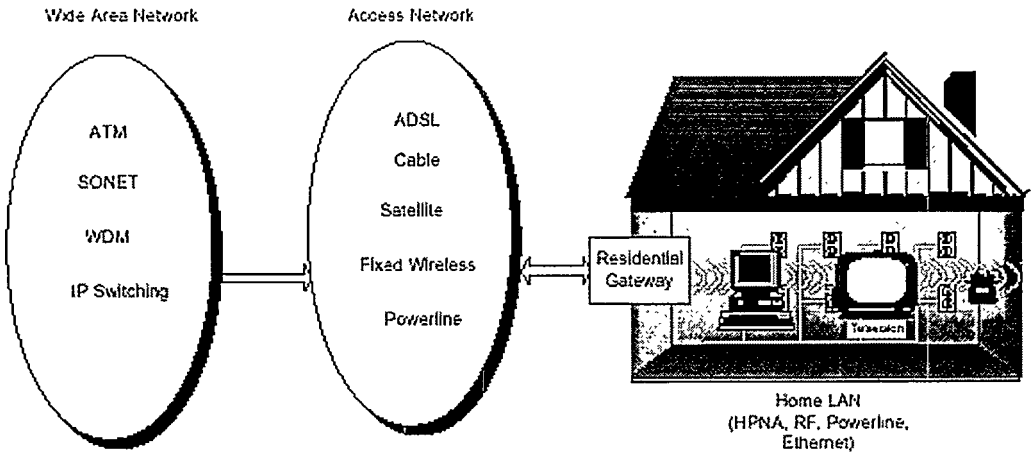

Figure 2.5: Residential Gateway Connects the Internet to the Home LAN [11]

They also noted future characteristics that will be adopted as the Residential Gateway market develops, notably,

- The ability to deliver multiple services throughout the home.
- Security features such as embedded firewall technology.
- Remote management ability.

There will be a variety of devices that will be called a Residential Gateway, but they can be characterised in four basic categories,

1. **Broadband Centric Residential Gateways (BBRG).**
   These are essentially digital modems that have integrated the necessary intelligence to perform routing within the residence independent of a Personal Computer. An example would be a DSL modem with integrated HPNA Phoneline networking ports and some form of IP management from a company such as 2Wire.
2. **Set Top Box Residential Gateways (STRG).**
   These are set top boxes that have high speed access technology as well as integrated routing/IP management. Generally an advanced set top box has a powerful processor, so adding the home networking functionality generally does not require more CPU power. A slightly different incarnation of the STRG will be the gaming console as a Residential Gateway. Sony plans to position its next generation PlayStation2 as a potential Residential Gateway platform. Another possibility of an Entertainment Centre device acting as a RG is a digital video recorder, or DVR, such as those from the likes of TiVo or Replay Networks.
3. **PC Centric Residential Gateways (PCRG).**
   These are scaled down, thin servers such as the e-box from Ericsson. The e-box is a PC with a 486 processor, some DRAM and flash memory and some I/O slots for add in cards. The form factor is that of a small, consumer friendly box. These devices are initially targeted towards more home control and remote services delivery such as security.

4. **Next Generation Residential Gateways (NGRG).**
   The NGRG is a highly flexible, modular Residential Gateway that allows for customisation of different access and Home LAN technologies. The NGRG doesn't exist today but there are vendors who are looking to create these types of devices. The problem with a NGRG is that the more modular a device is, the more costly it is.

Cahners In-Stat Group expects the Residential Gateway market to go from one that is non-existent today to between $US 2.4 and 8.8 billion by 2003. The following drivers will push this market forward,

- As voice over IP technologies mature, service providers such as AT&T will be offering voice, data and entertainment services over the same connection. The Residential Gateway is seen as a way to enable the delivery of these services to the residence.
- The proliferation of high speed Internet access will go hand in hand with Residential Gateway deployment. With the availability of cheap, standards based Home LAN technology, equipment manufacturers will begin to integrate this technology into access devices.
- New and exciting applications and services enabled by the networked home and a high speed Internet connection will eventually create end user demand. The consumer is not in the market to buy a home network, Residential Gateway or other technology for its own sake. The end user will buy new and interesting services.

2.6 Home Networking

It is estimated that, by 2002, 15.3 million households in the United States will have some kind of home networking (Jupiter Communications) [12*].

There are many different applications for home networking. They can be broken into five categories: resource sharing, communications, home controls, home scheduling and entertainment/information.

1. **Resource Sharing**
   Home networking allows all users in the household to access the Internet and applications at the same time. In addition, files (not just data, but also audio and video depending on the speed of the network) can be swapped and peripherals such as printers and scanners can be shared. There is no longer the need to have more than one Internet access point, printer, scanner, or in many cases, software packages.
2. **Communications**
   Home networking allows easier and more efficient communication between users within the household and better communication management with outside communications. Phone, fax and email messages can be routed intelligently. Access to the Internet can be attained at multiple places in the home with the use of terminals and Webpads.

3. **Home Controls**
   Home networking can allow controls within the house such as temperature and lighting to be managed though the network and even remotely through the Internet. The network can also be used for home security monitoring with network cameras.
4. **Home Scheduling**
   A home network would allow families to keep one master schedule that could be updated from different access points within the house and remotely through the Internet.
5. **Entertainment/Information**
   Home networks enable an excess of options for sharing entertainment and information in the home. Networked multi-user games can be played as well as PC-hosted television games. Digital video networking will allow households to route video from DBS and DVD's to different set-top boxes, PC's and other visual display devices in the home. Streaming media such as Internet radio can be sent to home stereos as well as PC's.

The speed of home networks is also important to consider. Most home networking solutions have speeds of at least 1 Mbps, which is enough for most everyday data transmission (but may not be enough for bandwidth-intensive applications such as full-motion video). With the development of high-speed Internet access and digital video and audio comes a need for faster networks. Several kinds of home networks can operate at speeds of 10 Mbps and up. Digital video networking, for example, requires fast data rates. DBS MPEG-2 video requires 3 Mbps and DVD requires between 3 and 8 Mbps. HDTV requires more speed than current home networks have but that should change in the future, as home networks get faster and as technology develops and adapts to new Internet appliances and digital media.

There are currently four major categories of home networking: conventional Ethernet, phoneline, wireless and powerline. More information on these technologies can be found in Chapters 4, 5, 6 and 7.

3 Broadband

3.1 Broadband Fundamentals

By bandwidth, one means the bit-rate or the number of bits per second that can be transmitted through a network [13*]. The International Telecommunications Union (ITU) defines a broadband connection as any rate higher than the standard rate, T-1. Table 3.1 below shows a comparison of the different narrowband and broadband rates.

Table 3.1: Comparison of Narrow and Broadband [13]

Typical Narrowband Rates (typically over copper or coaxial Cables)		**The Optical Carrier (OC) Hierarchy for Broadband Rates (typically over fibre optic cables)**	
PC Modem:	56 kbps	OC-1:	52 Mbps
Telephone Call:	64 kbps	OC-3:	155 Mbps
Basic ISDN Line:	128 kbps	OC-12:	622 Mbps
T-1 Leased Line:	1.5 Mbps	OC-48:	2.5 Gbps
		OC-192:	10 Gbps

Dense Wavelength Division Multiplexing (DWDM)

This technology promises a dramatic increase in the capacity of a fibre line. DWDM technology splits a beam of light into multiple colours, or wavelengths, each of which can operate at 10 Gbps. The technology is rapidly advancing, with the number of possible wavelengths exceeding 100 per fibre.

Network Types - Circuits versus Packets

There are two fundamental types of networks, circuits or packets. The current telephone network is circuit switched, while data networks, such as the Internet, are packet switched.

When a telephone call is made, a live circuit is set-up through the network and a fixed amount of bandwidth, typically 64 kbps, is reserved for the duration of the call.

Packet technology breaks data into small pieces, each containing an address. Sending a packet is much like mailing a letter – many envelopes of data enter the network at the same time, where they travel over the same or different routes. Eventually, most of them arrive at their destination.

Packets are more efficient than circuits because a single line can carry multiple messages simultaneously. The problem is that "real-time" communications, like voice or video, do not work well on packet networks because there is no way to know when the packets will arrive or in what order.

Packet technology is improving, however, and it is only a matter of time before packet switched networks can support telephone calls, with the acceptable level of quality, at a fraction of the cost of a circuit switched call.

The entire global telecom infrastructure is shifting from circuit to packet technologies, a shift even more profound than the shift from analog to digital, because it threatens the survival of the established players. In the regulated world, carriers saw their infrastructure as their key asset. In the deregulated environment, it can be a liability. A carrier that starts two years later can acquire optical technology at half the cost.

What is next for the Net?

We can now be sure that the Net revolution will continue to accelerate based on the three forces of supply, demand and finance coming together to completely change the economics of the Net. Net technology and economics are improving so rapidly that the impact will extend far beyond the Web to transform telephony, PC's and software. Table 3.2 shows that the current Internet demand is growing faster than the current technological improvements.

Table 3.2: Internet Technology versus Demand [13]

	Performance Doubling Time	
	In Months	In Percent per Year
Basic Technology:		
Moore's Law – gates/chip	18	59%
Optical Fibre – bps/fibre	12	100%
Packet Switching	12	100%
Basic Demand:		
Internet Users	12	100%
Data Bits	7.5	300%
Internet Core	4	1,000%

The optical fibre technology shows a 100% improvement, in other words a doubling of the number of bits per second that can be packed on to a fibre every year, by the sending twice as many colours simultaneously. The latest technology promises to send 160 different colours/wavelengths of light simultaneously on a single strand of optical fibre, each running at 10 Gbps, equating to over 1.5 trillion[1] bps, or more than the aggregate total of the long distance telephony in the whole of the world, on a single strand of fibre.

The old phone model was for free local calls and expensive usage charges for long distance. The Net model is a moderate access charge and no usage charges at all.

The Net is the beginning of the end for corporate telecommunications systems because it accelerates the trend to outsourcing as well as the beginning of the end for the telephone system. In the future one will place phone calls via a Web browser

[1] One trillion = 1×10^{12}

interface, allowing mixed media communications. The Net also threatens the entire PC model. Instead of buying and installing software on a PC, one would use Web-resident tools that automatically load the right application into the users browser. Instead of storing files and messages on a "personal" computer they would access them from the Net from various information devices.

3.2 Multimedia Bandwidth Requirements

One of the greatest problems facing networked multimedia is the quantity of bandwidth required for its transmission [14]. Table 3.3 lists some bandwidth requirements for different types of compressed video and audio transmissions.

Table 3.3: Multimedia Bandwidth Requirements [14]

Media	Bandwidth Requirement
Motion JPEG	10 – 240 Mbps
MPEG-2 (Entertainment Quality Video)	6 Mbps
MPEG-1	1.5 Mbps
CD-ROM/VCR Quality Video	1.3 Mbps
Video-Conferencing Applications	128 – 768 kbps
Voice	> 32 kbps

4 Wiring and New Wire Network Communication

4.1 Wire Types

What is Category 5 (CAT 5)?

Category 5 wire consists of four twisted pairs of high quality copper wire enclosed in an outer jacket [15]. It is used for phone, fax, modem and high-speed digital computer transmissions and can support up to four Phonelines with one cable. Category 5 cable exhibits a high immunity to interference.

What is RG-6 Quad Shield?

RG-6 Quad Shield is coaxial cable with insulated centre wire and four layers of shielding [15]. It can support hundreds of channels and digital data and can be used for cable TV, digital satellite, cable modem and high-speed interactive video services. As with Category 5 cable, RG-6 cable also exhibits a high immunity to interference.

Figure 4.1: Category 5 Cable [15]

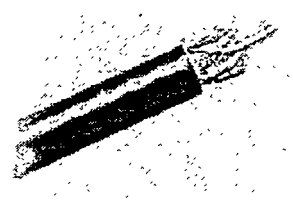

Figure 4.2: RG-6 Quad Shield Cable [15]

4.2 Today's Modern Home Wiring

One can decide to install communication based cables within a residence, thus creating a home wiring system [15*]. Today, modern home wiring systems consist of the three major components, namely,

Three Major Components

1. **Central Hub** (also called Service Centre) - central point accepts incoming services and distributes services throughout the home.
2. **High Performance Cabling** - Category 5 telecommunications cable and RG6 Quad Shield coaxial video cable provide the "highway" for information to travel.

3. **High Quality Outlets** - specifically designed to support advanced information services, outlets are the "off-ramp" to computers, TV's and telephones.

These components form what is known as a Structured Wiring System, which is also called "Star Wiring" as all the cables are run out from a central communication hub.

The "Structured" Wiring System

- **Star-wiring** - instead of daisy-chaining, all cables are "home-run" to the central hub.
- **High-quality cable connections** (also called terminations) ensure a high-performance end-to-end system.
- **Cable management** - services can easily be redirected as the homeowners family grows and their needs change.

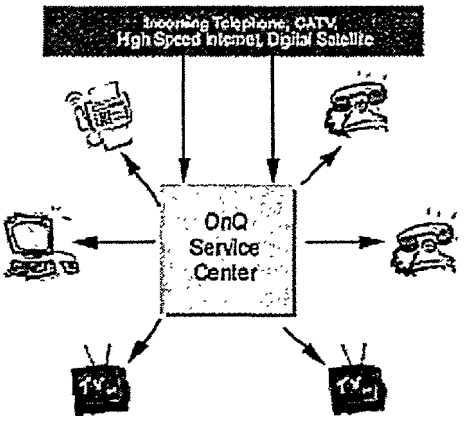

Figure 4.3: Structured Home Wiring [15]

4.3 Future-proofing With the Right Wiring

For only one or two percent of the cost of a new home, it is possible to electronically ready a home office, watch security cameras on every TV in the house, enjoy a home theatre and tap into interactive services like home banking that are quickly coming on line [16*]. Without such "future-proofing", new homes face expensive retrofits.

Upgrading Phone Wire

Old-style Category 1 telephone wire can not handle technologies for video conferencing from the computer and shopping via the TV. Professional home systems installers recommend wiring the home instead with Category 5 four twisted pair data/communications wire.

Each telephone wall plate, TV jack plate and doorbell should receive a separate feed of Category 5 cable, homerun from a central distribution point. In addition, Category 5 cable should be homerun to the outside electrical service for connection to the supplying utility.

Upgrading TV Wire

TV/cable jacks in most homes today are wired with a single RG-59 coaxial cable. RG-6 coaxial cable, however, is better at delivering digitally compressed video, such as programs from DSS, to the home. Again, it's wise to run an RG-6 cable to every possible video location.

For distributing video around the house, two RG-6 cables should be homerun to each TV wall plate. This gives the home one wire on which to receive video, such as a movie playing in a video and a separate wire on which to distribute the picture to other TV's in the house.

Wire Packages

U.S.Tec, IES Technologies, ModTap, Greyfox Systems, AMP Building Systems, Lucent Technologies and Molex offer complete wiring systems that bundle Category 5 data/communications wire and RG-6 TV cable in one convenient package.

4.4 Advanced Home Wiring Systems for New Housing

The speed that one can call up a web site and download has as much to do with the telephone and data wiring as it does the hard drive [17*]. Category 5 twisted pair telephone/data wires strung directly from each outlet to a central hub, called "star wiring", allows homeowners to alter each dedicated line, add new ones and create an in-house network. Advanced (also called "structured") wiring is the basic pipeline providing the service to run security systems, closed-circuit television, intercoms and other electronic and home control devices.

4.5 Access Technology

Quality of service (QoS) technology will become the cornerstone of broadband access [18*]. QoS refers to the ability to guarantee a packet flow through the network is sustained at a maximum throughput and that some types of packets are able to get different levels of treatment based upon header information. QoS has become a hot topic with the introduction of real-time data traffic on the IP (Internet) network.

Hybrid Fibre-Coax (HFC) Systems

Hybrid fibre-coax (HFC) is a tough architecture to beat [18*]. It is economical and has ample bandwidth for the present and future services in demand. The coax cable used in HFC architectures can carry many times the information the telephone company's twisted pair copper plant can transport.

Fibre-to-the-Home (FTTH)

When someone thinks about the best method to get the most bandwidth to the customer's premises, the obvious thought is to run fibre all the way there [18*].

Satellite Systems

Satellite communications offers a natural medium for transporting IP multicast [18*]. With advances in other related areas, it is now possible to carry all content-data, video and audio - in a consistent manner. Furthermore, products exist on the market to support the reliable delivery of data files, high-quality video and even stereo audio in an IP multicast environment.

Conventional Ethernet

Ethernet networks have not been popular because they often require new wiring as well as a hub (a central connection point) and Ethernet add-in cards [12*]. Ethernet does have a high-speed transmission rate from 10 Mbps up to 100 Mbps.

4.6 Current No New Wire Technologies

While those in "the industry" have been loudly promoting the proper pre-wiring of all new homes with ample runs of Category 5 twisted pair and RG-6 coaxial cable, companies like Intel, AMD, Tut Systems and Intelogis, have been working on "no-new-wires" solutions to age-old networking problems [19*].

No wire-free solution will ever be as good as their hard-wired counterparts. However, the latest wireless Radio Frequency (RF) and soft-wired (phoneline and powerline) technologies will soon make it possible for owners of existing homes to enjoy many of the networking and control capabilities as those who have the wires.

Chapters 5, 6, 7 and the Appendix describe in detail some of the specific technology involved in the "No New Wire" solutions to home networking

5 Radio Frequency Communication Systems

If the idea of having a flexible, mobile and cable free home network appeals, then wireless home networking might be the answer [12*]. Three common types of wireless networking services/standards being developed and sold today are IEEE 802.11 (wireless Ethernet), HomeRF and Bluetooth. Each one works a little differently and has its own strengths and weaknesses. All of these services are secure as they use encryption technologies.

Wireless Ethernet, also known as IEEE 802.11, is a wireless networking protocol that is quickly being adopted by the computer industry. Used principally by businesses, medical, manufacturing and academic areas, wireless Ethernet has thus far not been a huge player in home networking. The computer and base can communicate from up to 45 m and at speeds up to 11 Mbps. The AirPort (Apple) system uses 802.11HR, the high-rate wireless Ethernet specification.

HomeRF was developed as an open industry specification for wireless digital communication between PC's and consumer electronic devices. HomeRF uses the Shared Wireless Access Protocol (SWAP) and operates at 2.4 GHz on the ISM band. HomeRF has a range of up to 100 metres. SWAP 1.0 has data transmission rates of 1 Mbps, while SWAP 2.0 can transmit data up to 10 Mbps. HomeRF costs are considerably less than 802.11 and its developers claim that SWAP was designed for voice and data and thus handles voice better than 802.11 which was developed for data only.

The third type of wireless network has a focus on short-range connectivity. Bluetooth was developed for wireless communication and has a range around 10 m. This means that Bluetooth is useful for cable replacement, data and voice access points and ad-hoc networks. Bluetooth can be described as creating point-to-point networks, while HomeRF and Wireless Ethernet are used for an entire home network.

5.1 HomeRF

The HomeRF specification released version 1.0 of the Shared Wireless Access Protocol (SWAP) in early 1999 [19*]. The first HomeRF compliant consumer products were available at the end of 1999. HomeRF marries two RF protocols (IEEE 802.11) and Europe's Digital Enhanced Cordless Telecommunications (DECT). On its own, neither one of the protocols is sufficient to deliver a complete solution for both voice and data networking for the residential market, claims HomeRF with its 75-plus members. "802.11 is good for data but not great for voice. DECT is great for voice, but not efficient for Internet data. We needed a solution that was efficient with data and efficient voice."

5.2 Proxim

Proxim was one of the pioneers of wireless networking, with its 802.11 and OpenAir compliant products for commercial applications [19*]. In 1998, the company introduced the Symphony product family, a lower-cost cordless networking solution catering to the residential market.

5.3 ShareWave

While most of the no-new-wires solutions focus on low-bit-rate PC, printer and modem sharing, ShareWave is at the high end of RF home networking, allowing real-time delivery of full-motion video [19*]. With its 36:1 compression ratio, Sharewave's proprietary "codec" allows a 120 Mbps video stream to be squeezed through a 4 Mbps pipe.

5.4 Alation

Diamond Multimedia was one of the first companies to market no-new-wires PC networking products [19*]. Its HomeFree Wireless devices are based on the 2.4 GHz HomeCast Open Protocol (HOP) from Alation. The technology, which looks like a standard Ethernet card, allows 16 computers to share a wireless network.

5.5 Bluetooth

The Bluetooth wireless technology is intended to revolutionise the personal connectivity market by providing freedom from wired connections [19*, 20*]. It is a specification for a small form-factor, low-cost radio solution providing links between mobile computers, mobile phones and other portable handheld devices and connectivity to the Internet.

The Bluetooth Special Interest Group (SIG), comprised of leaders in the telecommunications, computing and network industries, is driving development of the technology and bringing it to market. The group includes promoter companies of 3Com, Ericsson, IBM, Intel, Lucent, Microsoft, Motorola, Nokia, Toshiba and over 1400 other adopter companies.

Bluetooth technology allows for the replacement of the many proprietary cables that connect one device to another with one universal short-range radio link. Designed to operate in a noisy radio frequency environment, the Bluetooth radio uses a fast acknowledgment and frequency hopping scheme to make the link robust. The Bluetooth radio modules avoid interference from other signals by hopping to a new frequency after transmitting or receiving a packet.

Bluetooth radios operate in the unlicensed ISM band at 2.4 GHz. The gross data rate is 1 Mbps. The baseband protocol used is a combination of circuit and packet switching.

Bluetooth can support an asynchronous data channel, up to three simultaneous synchronous voice channels, or a channel, which simultaneously supports asynchronous data and synchronous voice. Each voice channel supports 64 kbps synchronous (voice) link. The asynchronous channel can support an asymmetric link of maximally 721 kbps in either direction while permitting 57.6 kbps in the return direction, or a 432.6 kbps symmetric link. The full-duplex data rate within a multiple Bluetooth network structure (of up to eight individual devices) with 10 fully-loaded, independent networks is more than 6 Mbps.

It is estimated that, before the year 2002, Bluetooth will be a built-in feature in more than 100 million cellular phones and in several million other communication devices, ranging from headsets and portable PC's to desktop computers and notebooks.

5.6 Infrared Communications (IrDA) versus Bluetooth

At first glance, it may appear that IrDA and Bluetooth technologies compete with each other in the marketplace, but both Bluetooth and IrDA are both critical to the marketplace [21*]. Each technology has advantages and drawbacks and neither can meet all users needs. In fact, together, Bluetooth and IrDA create a powerful short-range wireless story.

5.6.1 Overview of IrDA

What is IrDA?

The Infrared Data Association (IrDA) specifies three infrared communication standards. In general, IrDA is used to provide wireless connectivity technologies for devices that would normally use cables for connectivity. IrDA is a point-to-point, narrow angle (30° cone), ad-hoc data transmission standard designed to operate over a distance of 0 to 1 metre and at speeds of 9.6 kbps to 16 Mbps.

General IrDA characteristics

- Proven worldwide universal cordless connection.
- Installed base of over 50 million units and growing at 40% annually.
- Designed for point-to-point cable replacement.
- High data rates; 4 Mbps currently, 16 Mbps under development.

5.6.2 Overview of Bluetooth

What is Bluetooth?

Bluetooth is a proposed Radio Frequency (RF) specification for short-range, point-to-multipoint voice and data transfer. Bluetooth can transmit through solid, non-metal objects. Its nominal link range is from 10 cm to 10 m, but can be extended to 100 m by increasing the transmit power. It is based on a low-cost, short-range radio link and

facilitates ad-hoc connections for stationary and mobile communication environments.

General Bluetooth Characteristics

- Operates in the 2.4 GHz Industrial-Scientific-Medical (ISM) band.
- Uses Frequency-Hop (FH) spread spectrum, which divides the frequency band into a number of hop channels.
- Supports multiple Bluetooth devices sharing a channel within one network.
- Built-in security.
- Non line-of-sight transmission through walls and briefcases.
- Omni-directional.
- Supports both isochronous and asynchronous services; easy integration of TCP/IP for networking.
- Regulated by governments worldwide.

What is Bluetooth Used For?

It delivers opportunities for rapid, ad-hoc connections and in the future possibly for automatic, unconscious, connections between devices. Bluetooth's power-efficient radio technology can be used in many of the same devices that use IrDA.

5.6.3 Data Exchange

Both IrDA and Bluetooth consider data exchange to be a fundamental function. Both use the same upper layer protocol (OBEX) to implement these applications. By using the same upper level protocol, it is possible for a single application to run over both Bluetooth and IrDA. Fortunately, the very scenarios where IrDA falls short are the ones in which Bluetooth excels and vice versa.

A common data exchange scenario is one in which the exchange will take place in a room containing a number of other devices. This is the situation where IrDA excels but the same situation is a weakness for Bluetooth. Bluetooth has multi-point capabilities and therefore utilises security mechanisms to prevent unauthorised access. The two users attempting to perform a business card exchange using Bluetooth would also need to execute security measures.

In other data exchange situations Bluetooth is the obvious choice. Bluetooth's ability to penetrate solid objects and its capability for maximum mobility within the Bluetooth network allows for data exchange applications that are very difficult or impossible with IrDA.

5.6.4 LAN Access

An important feature of both Bluetooth and IrDA is the ability to wirelessly connect a device to a wired network. Because there are no line-of-sight requirements for Bluetooth devices, it is well suited for this type of application. The one potential area

of weakness for Bluetooth, when compared to IrDA, is performance. Bluetooth's aggregate bandwidth is limited to 1 Mbps, while IrDA supports 4 Mbps, with 16 Mbps under development. Alternatively, IrDA requires line of sight and a maximum distance of one metre as well as a connected device must remain relatively stationary.

5.6.5 Voice Applications

A native feature of the Bluetooth specification is synchronous voice channels. Bluetooth has the ability to reserve bandwidth for carrying digital voice data. Bluetooth can support as many as three simultaneous, full duplex voice conversations within a Bluetooth network. Transmitting full duplex voice data over an IrDA link consumes the full bandwidth of a 115.2 kbps IrDA link so multiplexing other data is not allowed.

5.6.6 Security Issues

IrDA does not provide security capabilities at the link level, as provided by Bluetooth. Instead, IrDA relies on upper level protocols and applications to provide authentication and/or encryption.

5.6.7 Bluetooth and IrDA Implementation Costs

The manufacturers cost of integrating IrDA into a device can be as little as $US 2. Since Bluetooth devices are not yet widely available, implementing Bluetooth into a device is initially projected to cost around $US 20 for first generation devices, with future devices being targeted for around $US 5 within a few years.

5.6.8 IrDA/Bluetooth Comparison Summary

For some devices, having both Bluetooth and IrDA will provide the best short-range wireless solution. For other devices, the choice of adding Bluetooth or IrDA will be based on the applications and intended usage models.

5.7 Wireless Broadband

Fixed broadband wireless technology seems ideal for solving the last-mile access bottleneck [18*]. The various wireless spectrums being developed support almost any kind of access service a customer may need including voice, video, Internet, ATM, frame relay, or traditional T-1 services. Wireless providers can provide service in days rather than the weeks or months it can take traditional wireline carriers to get a service up and running. And the cost comparison with wireline isn't even close. In most cases, a point-to-multipoint wireless connection costs less than one-tenth what it would cost to run wire to the same site.

5.8 Some Wireless Networking Products

PC, Multimedia and Telecom Networking Products [19*],

- Diamond Multimedia: HomeFree Wireless Desktop system with 1 Mbps data rate.
- Innomedia: InfoAccess system with 85 kbps data rates.
- NDC Communications: SOHOWare product line with 2 Mbps data rates.
- Proxim: a Cordless network with 1.6 Mbps data rates.
- WebGear: Aviator Wireless networking system with 1 Mbps data rates.
- Philips Electronics: Ambi PC/TV networking system with 4 Mbps data rates.

Others include,
Axlon, Ericsson, Global Converging Technologies, Home Wireless Networks and Siemens

6 Phoneline Communication Systems

While conventional Ethernet requires special wiring, home networking can use existing phonelines [12*]. Most phoneline communication systems are currently based on the Home Phoneline Networking Alliance (HomePNA), which has standardised two open standard specifications (1.0 and 2.0) for phoneline networking. HPNA 1.0 has a data transmission rate of 1 Mbps. HPNA 2.0 greatly increases that rate to 10 Mbps. HomePNA uses frequency division multiplexing (FDM) to allow the phoneline to carry multiple services without interference. Figure 6.1 below illustrates how a Phoneline can carry these multiple services.

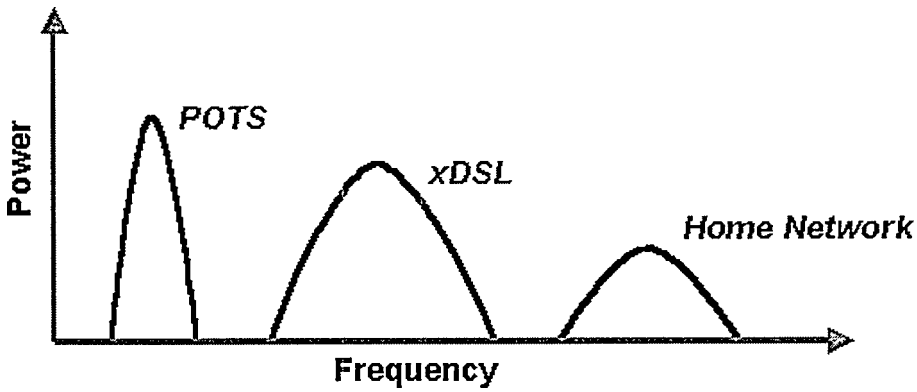

Figure 6.1: Home Phoneline Communication Possibilities [12]

Because HomePNA uses existing phonelines, tests indicate that the service can work in over 99% of the homes and the network can support up to 25 devices up to 150 metres apart in homes up to 930 m^2. Figure 6.2 shows how different devices can be connected in a HomePNA network.

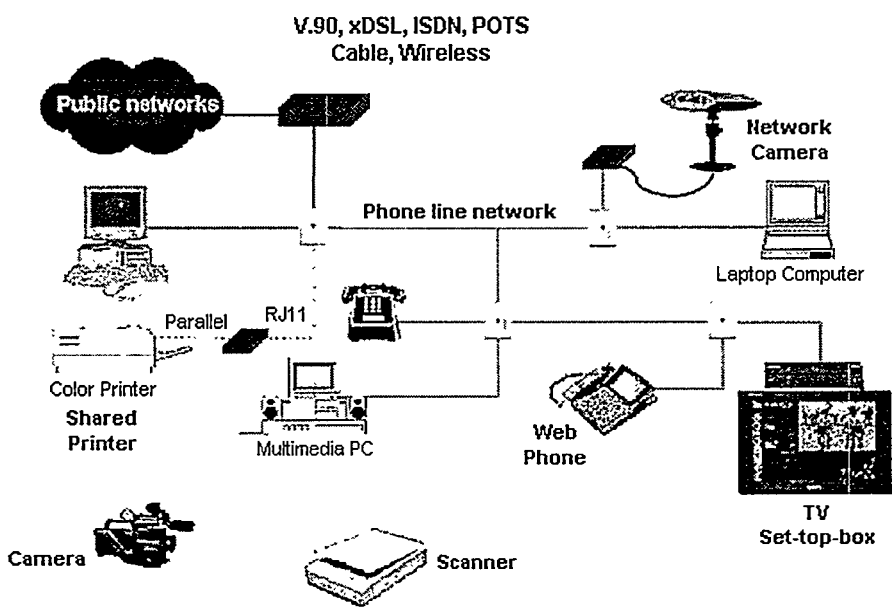

Figure 6.2: Home Devices Connected to a Network [12]

HomePNA is interoperable with other home networking technologies such as Ethernet and HomeRF and is compatible with high-speed Internet access technologies such as cable modems and DSL. Unlike conventional Ethernet, HomePNA does not require hubs or Category 5 wiring, nor termination filters or splitters.

6.1 HomePNA

For years, the no-new wires solutions for data networking and device control have focused on powerline and RF [19*]. From out of nowhere, it seems the phoneline emerged as an important media and the HomePNA is the first initiative to see its technology implemented.

Based on the 1 Mbps HomeRun networking technology from Tut Systems, the HomePNA specification has been embraced by key players in the networking arena. Conexant and Advanced Micro Devices are making HomePNA silicon now; Intel will deliver silicon shortly; and National Semiconductor, 3Com, Lucent and Broadcom have announced intentions to produce chips.

6.2 Tut Systems

So far, the winner in the no-new-wires home networking space is the phoneline, which developed the phoneline networking technology that later became the backbone of HomePNA [19*]. Having cornered the 1 Mbps market for phoneline networking, Tut recently turned its focus to higher-speed solutions, demonstrating recently the 10 Mbps MediaShare technology developed in partnership with Broadcom Corp.

6.3 Epigram

Epigram came to the phoneline party much later than Tut Systems, going straight to the 10 Mbps space with its InsideLine technology and resulting iLine10 chipsets, which are backward compatible with the HomePNA 1 Mbps specification [19*]. The company expected to finalise the design for 100 Mbps networking technology by the end of 1999.

6.4 Avio

Avio provides an 88 Mbps home network via its MediaWire technology over standard Category 3 telephone wiring [19*]. The company claims that a single telephone pair can provide enough bandwidth to simultaneously deliver sixteen 24-bit audio channels, four MPEG2 video channels, eight phone or ISDN lines and over 3 Mbps of serial control or TCP/IP data.

However, the technology is not meant for plug-and-play operability over the home's existing telephone infrastructure. To utilise in-wall phone wiring, users must replace

existing phone jacks from the single-connector type to a multiport faceplate that has one connector for analog telephone and a second connector for MediaWire.

6.5 xDSL

DSL is the generic term for using the installed subscriber loops in place in and above the ground to deliver broadband applications [18*]. This is accomplished by expanding the frequency utilisation of the copper wires. An additional benefit is that unlike the current POTS dial-up analog modems or ISDN, which both continue to burden the telephone switching network, xDSL systems remove the data traffic from the voice switch at the central office. The data is routed to a data network that is more efficient at handling this type information.

It is clear that DSL is seen as a way for telephone service providers to make a quick entry into providing higher rate data services to their customers. Establishing standards for the consumer market will lead to significantly lower equipment costs (approximately halved) and to more rapid acceptance in the consumer market. The standards will also reduce the cost and complexity of customer premises equipment (CPE) and will help eliminate truck rolls for installations.

6.6 Motorola's Digital Living Room of the Future

Motorola and Next Level Communications are working to integrate their interactive client/server software and advanced DSL broadband system over the existing telephone plant [22]. The collaboration will work to deliver interactive video, games and music services, including wireless Internet access on Next Levels Residential Gateway, a single digital set-top terminal connected to a DSL line that provides ATM/IP broadband connections to multiple appliances in the home, including telephone, PC's and TV's.

6.7 Broadcom Corporations High-speed Home Networking Chips

Having produced its 10 Mbps chips for home networking applications, Broadcom is now working on a product that it says will double data throughput in a network to 20 Mbps. The chip – the iline10 – transfers data in an Ethernet fashion between two or more home computers. The device is based on the HomePNA 2.0 specification outlined by the Home Phoneline Networking Alliance.

6.8 ISDN

ISDN stands for Integrated Services Digital Network and is the digital equivalent of standard computer modem transmission [15]. It allows the transmission of high-speed data at rates three times faster than todays standard modems (128 kbps). A telephone company normally provides the service over high-quality copper phone wire.

6.9 DSL

DSL stands for Digital Subscriber Line service that transmits high-speed data anywhere from 50 to 270 times as fast as today's standard modems (1.5 - 9 Mbps) [15]. Again, as with ISDN, the service is normally provided by a Telephone Company over high-quality copper phone wire.

7 Powerline Communication Systems (PLC)

PLC is a technology capable of Home Automation, because it enables the installation of a control-oriented communication network without the need to tear down walls in order to install dedicated wiring [19*]. PLC is usually less expensive than Infrared and Radio Frequency solutions.

Powerline Carrier (PLC) is a communication technique that uses the existing power wiring (120, 230 or 240 Volts etc) to carry information. As a "wireless" means of communication, PLC technology supersedes the installation of dedicated wiring.

PLC can convey analog information (eg. voice in a PLC intercom) or digital information (eg. data or control information in a Home Automation system).

At least in the home control/home automation domain, no media has generated more attention for retrofit applications than the powerline, for two good reasons,

1. AC outlets are common in virtually every existing home.
2. The X-10 protocol showed as early as the 1970's that the powerline infrastructure could be used (somewhat) effectively and very inexpensively at about $US 15-30 per node; today, about half that amount.

While X-10 has taken some criticism over the years for unreliable performance, the technology continues to improve and today no competing device-control technology comes close to the affordability of X-10's.

Reliability and speed, however, are a different story, as the two frontrunners in the standards-race for powerline-carrier control, CEBus and LonWorks, boast faster transmission rates and more robust communications protocols. Although both technologies are "standards" under the EIA, neither has generated momentum anything like what we are seeing today in the phoneline and RF movements.

There are various applications for the use of PLC technology. Here are the three current types,

1. Low Baud rate (sometimes under 0.05 bps), long distance (1 mile or more) PLC systems include such applications as data communication over common 25 kV power distribution grids operated by power utilities.
2. Medium Baud rate (generally in the 0.05 - 50 kbps range), medium distance (typical practical range <100 m) PLC systems include control applications, such as intra-building communications (Home Automation, lighting control, Automatic Meter Reading applications, etc.). The carrier frequency typically lies between 50 - 535 kHz.
3. High Baud rate (100 kbps or more), local area PLC systems include data intensive applications where very low cost is not a critical factor, such as Internet access, printer or file sharing, computer networking,

etc. The typical low-amplitude carrier frequency is high, between 1.7 and 30 MHz.

Powerline networking uses existing power lines within the home [12]. Enikia (10 Mbps), Intellon (1 - 11 Mbps), Itran (7 kbps – 10 Mbps), Media Fusion (2.5 Gbps), Adaptive Networks ("several" Mbps), Ambient (10 Mbps) and Intelogis (350 kbps – 10 Mbps) are some of the companies currently working on powerline networking systems.

The network is relatively secure as the signal is encrypted before transmission. In addition, the signal attenuates quickly, so it will normally not leave the home. However, some powerline technologies are more secure than others; an unencrypted household network may be accessible to neighbours sharing the same transformer.

Powerlines are often called hostile environments for networks because of the flux and change that can occur, such as power surges, lightning and brown outs.

Current powerline home networks support the Ethernet standard, so all software that is network compatible is also compatible with this technology.

Many current technologies for PLC are described in the sections below.

7.1 CEBus

One of these days, something definite will become of CEBus [19*]. Either it will be the universally adopted protocol we have all been waiting for, or it will go away. Alternatively, the language portion of the CEBus spec will stand on its own merits while the communications signalling portion fades away.

The technology is solid and the language robust, but it simply has not approached a critical mass despite years of promises and dozens of utility trials that showed potential for the technology.

Still, the CEBus Industry Council and the two CEBus silicon developers (Intellon and Domosys) continue to make headway in the residential market.

7.2 Intellon

In the late 1980's, when the EIA was looking for an established technology from which to base the emerging Consumer Electronics Bus (CEBus), it was the Spread Spectrum Carrier (SSC) signalling technology from Intellon that won out [19*]. That technology, with the EIA's Common Application Language (CAL), combines to create today's CEBus communications protocol.

While CAL is essentially free to anyone who requests it, developers must license the SSC technology from Intellon. To date, only Domosys and most recently Microsoft have licensed it. In addition, Intellon recently began offering IeOFDM signalling technology, at 10 Mbps, licensed to date only by Microsoft.

7.3 Domosys

No one offers more varieties of CEBus products and tools than Domosys Corporation, whose mission is to propagate CEBus whether by selling its own chips, developing its own consumer products, training product developers or providing any level of developer support requested by potential CEBus advocates [19*].

7.4 Itran

In 1997 Itran demonstrated a "CEBus++" IC that reportedly was CEBus compatible but provided higher transmission rates than those specified by the CEBus specification [19*].

Development work will continue on Itran's powerline products, but focusing more on data networking than on device control for now. A 1.5 Mbps powerline-communications chip and a 10 Mbps powerline IC is available.

7.5 Echelon/LonWorks

Echelon is the developer of LonWorks technology, which defines communications protocols for virtually every media, but is most prominent in residential circles for its success on the powerline [19*]. However, since its protocol is so robust, the company has had little success finding a place for LonWorks in the residential domain, where cost is a key consideration. Today, the technology is popular worldwide for use in factory automation and other commercial/industrial applications (see the SaMBA Technology description in Chapter 11.18).

Still, Echelon has worked hard to deliver LonWorks to consumers and applied in 1998 for the protocol to become an EIA standard. The biggest boost for Echelon lately has come from its close relationship with Internet networking giant Cisco Systems, which has endorsed the use of device-control protocols (specifically LonWorks) for operating appliances and IP protocols for transmitting data. LonWorks is also the standard automation protocol that is used in Finland [24].

7.6 X-10

Still, the only really prevalent control protocol in the home is the venerable X-10, which has been manufacturing powerline-based products since 1978 and claims to have installed 100 million units [19*].

Its relatively slow speed, simple protocol and inconsistent reliability, X-10's protocol nevertheless remains the only protocol to prove successful in the home, with scores of manufacturers building the protocol into their lighting controllers, security systems, touchscreens, remote controls, thermostats and virtually every other type of microprocessor-based device.

7.7 Adaptive Networks

Adaptive Networks was founded in 1984 to develop a technology for transmitting electronic data over building powerlines and the company has been developing powerline-communicating products ever since, almost exclusively for industrial/commercial applications [19*].

Currently ANI offers 100 kbps chipsets, but the company is working on a faster solution with effective (useable) data throughput of 10 Mbps. The company has signed on as a partner of Sun's "Jini" networking initiative.

7.8 Intelogis

Intelogis, the first company to market a powerline-based PC-networking product, is applying for its technology to become an EIA standard [19*]. If it succeeds, the technology would join Echelon's LonWorks and Intellon's CEBus as powerline communications standards.

Currently, Intelogis is in the very early stages of gathering support for its technology, which is now being used only in Intelogis' own line of PC-networking products, namely, "Passport" brand plug-in modules and networking software, with advertised data transmission rates of 350 kbps.

7.9 Metricom Corporation

Metricom PLC-1 products are a type B technology used in cost sensitive, medium Baud rate applications [19*, 25*]. These include Home Automation, lighting control, remote control, etc.

An independent laboratory extensively compared the PLC technologies of Echelon's (PLCA-21), Metricom (PLC-1), Domosys CEBus (CEVal), X-10 with AGC (Leviton) and Standard X-10. The main measurement obtained was the robustness of these systems, facing interference sources and channel impairments found in household environments. The series of tests consisted of transmitting thousands of packets at various settings of channel impairments and then measuring the percentage of successful packet delivery. Table 7.1 is a compiled excerpt from the Lab Report.

Table 7.1: PLC Technology Comparison A [25]

Product	PLCA-21	PLC-1	CEVal	X-10 AGC	X-10
Robustness Rating[1]	95.4%	91.2%	68.8%	52.1%	50.0%

[1] Percentage of successfully delivered packets.

In the characterisation test above, the PLCA-21 would appear a slightly superior product relative to the PLC-1. In fact, this is not the case. One impairment source in

that tests was a PLC intercom with a 6 V.P.P. output at 258.5 kHz and a 17 kHz bandwidth. This frequency is directly within the PLC-1 band and is far away from the PLCA-21 band. To obtain comparable results, the Lab introduced a 6 V.P.P. interference in the 117 to 134 kHz band, i.e., the PLCA-21 band. Table 7.2 shows the compiled results.

Table 7.2: PLC Technology Comparison B [25]

Product	PLC-1	PLCA-21
Robustness Rating	92.0%	85.9%

The only impairment source for the PLC-1 is an in-band PLC intercom. (PLC-1 performs very well alongside out-band PLC intercoms). PLC-1 scores 100% in these lab tests in the absence of an in-band PLC intercom.

7.10 PLC Automation Protocols Summary

The three most common PLC automation protocols can be compared by [26*],

1. X-10:
   Is an inexpensive, universally available and easy to install and offers a rich assortment of add-on products. Because it works by piggybacking on the home's existing powerline circuitry, it can be installed in existing homes without having to tear open walls - an important plus. The major "con" is that it is considered unreliable by many installers.
2. CEBus:
   Is a widely accepted industry standard for home automation running over low-voltage wiring. It is considered very robust, but requires its own network of cabling and CEBus-compliant devices such as light switches remain expensive.
3. LonWorks:
   Is another low-voltage standard that appears to be gaining ground mostly in the commercial and multi-dweller (eg. apartments, hotels) markets.

7.11 Media Fusion

Media Fusion is developing technology that will allow anyone connected to the electric power grid access to low-cost, high-quality voice, video and Internet data with nearly unlimited bandwidth (≈2.5 Gbps) by using a low-cost adaptor that plugs into a home's electrical outlets [27*].

This technology, Advanced Sub-Carrier Communications, would create a "powerline area network" out of a national power grid.

The technology does not use the actual electric wires themselves to transmit voice, video and other data, but instead uses the naturally occurring magnetic field that

surrounds the wires. Utilising proprietary hardware and software, Media Fusion's Advanced Sub-Carrier Modulation process writes data within the electrical magnetic field around the power line. No other company has used or is using this approach. Other powerline communications companies/technologies use either amplitude modulation, frequency modulation, or some variant of the two together.

According to the company, the technology uses power lines in a way that solves problems of line noise, electrical load imbalances and transformer interference that have dogged similar powerline communications attempts in the past.

On the consumer end of the wires, users will hook up an inexpensive adaptor that will allow them to connect telephones, televisions and computers into the grid, through which they will be able to send and receive voice, video and other data.

Media Fusion hopes to begin some sort of formal implementation of the technology by the third quarter of 2000. The total package for an average household is expected to retail for under $US 60.

There are many advantages to employing power line communications, including,

- Coverage:
  The power grid is the most extensive "wire" network in the world.
- Modernity:
  The electric grid in most areas of the world is more modern and better maintained than any other wired communications network.
- Strength:
  Signals over the power grid can be carried more than 3,200 km without regeneration, much farther than fibre optic cable (≈32 km), coaxial cable (≈24 km) or standard copper wire (≈8 km).
- Speed:
  The electric grid propagates information faster than any other wired network, near the speed of light.
- Capacity:
  Analog waves, such as those on the electric grid, have enormous information carrying capacity that is far greater than any digital system which would necessitate analog-to-digital-to-analog conversions, clock pulses and packetisation.
- Simplicity:
  Powerline communications are not burdened by telephony's conventional technologies, including outdated routers, bridges, gateways, legacy switches and software, which slow down traditional telecommunications.

The company had to surmount many hurdles to make power line communications possible. The power grid contains line noise, which degrades signals, load imbalances which disrupt communications and transformers which scrub harmonics and make signals difficult to control. Media Fusion's technology overcomes these obstacles by,

- inscribing data within the natural low-frequency bandwidth of the electric wave to send information.
- identifying all data and frequencies riding within the wave.
- converting those signals into interpretable forms in "real time" by using state-of-the-art signal-processing equipment.

Figures 7.1, 7.2 and 7.3 show how Media Fusion perceive their network to be arranged.

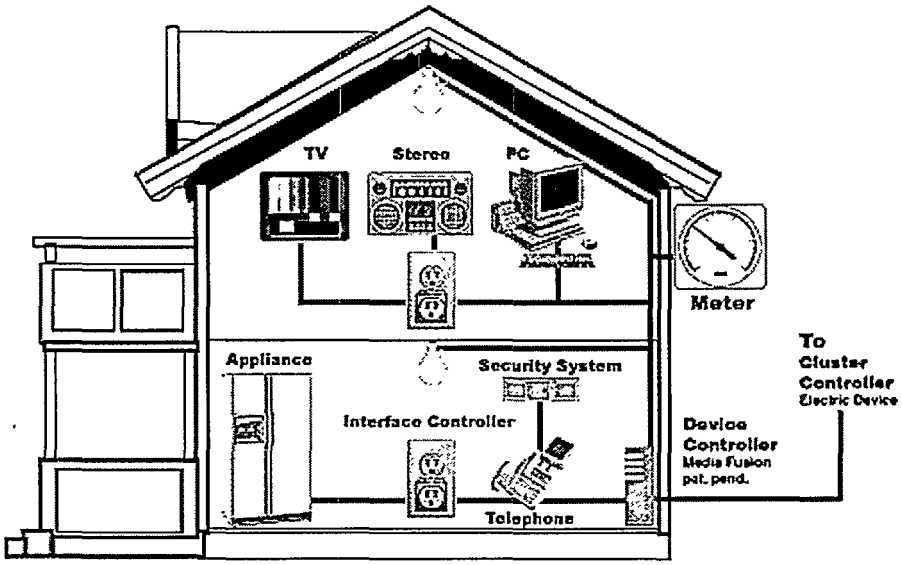

Figure 7.1: Media Fusion's Home LAN Overview [27]

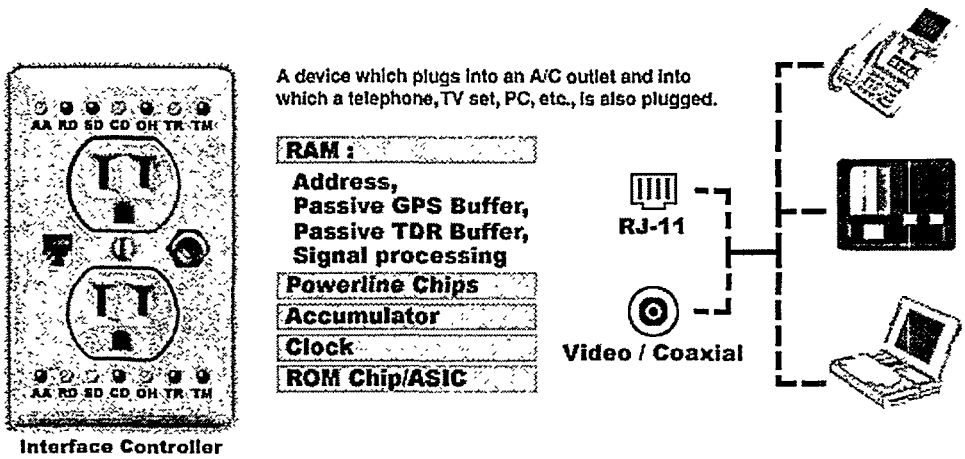

Figure 7.2: Media Fusion's Interface Controller [27]

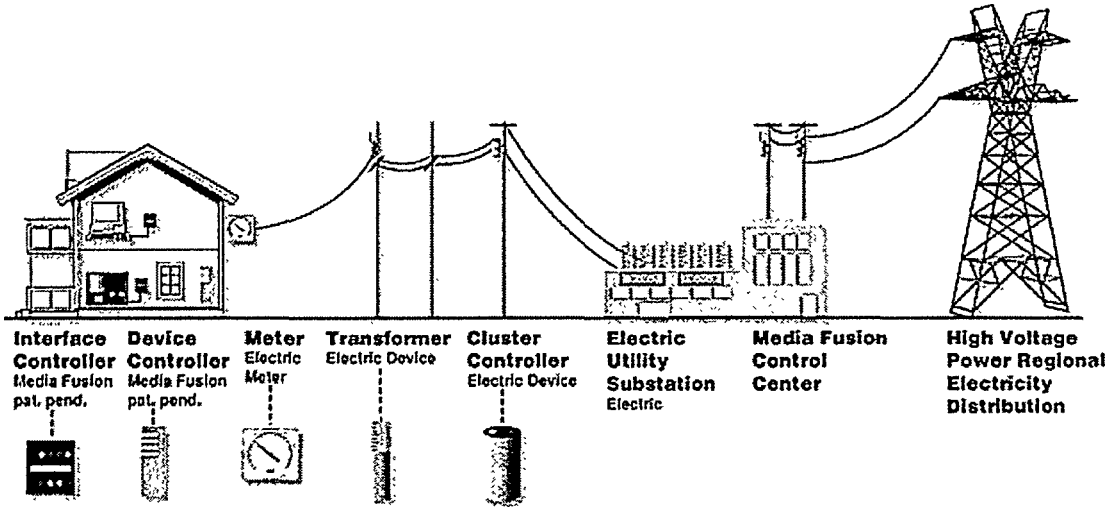

Figure 7.3: Media Fusion's Netwrok Overview [27]

7.12 Phonex Broadband Corporation

The Utah based corporation will be the first to the market in 2000 with 10 Mbps networking over the home power lines [10*]. The product will be developed using integrated circuits, which will provide voice, data and VoIP (Voice over Internet Protocol) over existing home electrical wiring at rates equal to 10 Mbps Ethernet.

8 Organisations

8.1 OSGI

The Open Services Gateway Initiative (OSGI) is an industry group working to define and promote an open standard for connecting the coming generation of smart consumer and small business appliances with commercial Internet services [28].

The Open Services Gateway specification will provide a common foundation for Internet Service Providers, network operators and equipment manufacturers to deliver a wide range of e-services via gateway servers running in the home or remote office.

The following companies are current members of OSGI,

Alcatel, AMD Inc., Cisco Systems Inc., Coactive Networks, Com21 Inc., Compaq, Deutsche Telekom, Domosys Corporation, Echelon Corporation, Electricité de France (EDF), emWare, Enikia Incorporated, Ericsson, France Telecom, GateSpace AB, GTE, Hewlett Packard, IBM Corporation, InfoGear Technology Corp., inSilicon Corporation (Phoenix Technologies, Ltd.), Invensys Controls, Maytag Corporation, Motorola Inc., National Semiconductor GmbH, Nokia Corporation, Oracle Corporation, Philips, ProSyst Software, Schneider Electric SA, Sharp, Siemens AG, SmartMove, Sonera Corporation, Sony Corporation, Sprint Communications Company, L.P., ST Microelectronics, Sun Microsystems, Sybase, Symbol Technologies Inc., Telia, Texas Instruments Inc., Tokyo Electric Power Company, Toshiba Corporation, Whirlpool Corporation, Yello Strom GmbH

8.2 The CEBus Industry Council - CIC

The CEBus Industry Council (CIC) was originally set up in 1994 by the Consumer Electronics Manufacturers Association, a sector of the Electronic Industry Alliance (EIA) and focused exclusively on promotion and use of the CEBus, an open home automation standard developed under EIA's sponsorship [29]. It has been applied to products based on power line and RF media for residential, commercial and utility control applications. As other home networking technologies entered the market in recent years, the need for a common language to ensure interoperability became evident.

In response to this industry need, CIC developed the Common Application Language [CAL] and the Home Plug & Play interoperability guidelines as a potential solution to solve the problem of interoperability. Home Plug & Play also provides uniform interoperability labelling for all home networking products. The CAL and the Home Plug and Play guidelines were developed with the support of several leading industry companies involved in the areas of home automation, home networking, telecom and energy utility applications.

8.3 EHSA

EHSA is an open organisation with an aim to support and promote European industry in the field of Home Systems [30]. Its members include major manufacturers with large research and development facilities. EHSA also includes representatives of the building and installation trade, architects, electrical utilities, connector experts and suppliers of telecommunication systems.

By supporting and promoting European Home Systems (EHS), EHSA reflects the common interests and aims of its members by helping them develop new business.

8.4 Convergence

In early 1999, a new industry association was established for the so called "Convergence" standard. The purpose of this new association is to build upon the competencies, technologies and resources of the three existing industry associations between Batibus Club International (BCI), European Installation Bus Association (EIBA) and European Home Systems Association (EHSA). In order to support a common interworking bus technology standard for homes.

8.5 Home API and The Universal Plug and Play Forum

The Home API Working Group focuses on the problems of getting PC's and home devices connected and reliably controlled in the home [31]. The Universal Plug and Play Forum (UPnP Forum) is an industry initiative designed to enable easy and robust connectivity among stand-alone devices and PC's from many different vendors.

These companies have merged in order to ensure that they do not develop competing specifications that could confuse the industry and consumers. For Interoperation, UPnP includes all essential Home API functionality. UPnP has captured strong industry interest as there were over 150 attendees at the recent UPnP forum meeting representing over 60 member companies.

UPnP Forum has working committees on the following topics,

- Internet gateway
- Audio and Video
- Lighting
- Security
- HVAC
- Energy management

8.6 HomeRF Working Group

The HomeRF Working Group (HRFWG) was formed to provide the foundation for a broad range of interoperable consumer devices by establishing an open industry

specification for wireless digital communication between PC's and consumer electronic devices anywhere in and around the home [32]. The HRFWG, which includes the over 90 leading companies from the personal computer, consumer electronics, peripherals, communications, software and semiconductor industries, has developed a specification for wireless communications in the home called the Shared Wireless Access Protocol (SWAP).

To date, the high cost and impracticality of adding new wires have inhibited the wide spread adoption of home networking technologies. Wired technologies also do not allow users to roam about with portable devices. In addition, multiple, incompatible communication standards have limited acceptance of wireless networks in the home. The HRFWG believes that the open SWAP specification will break through these barriers by (1) enabling interoperability between many different consumer electronic devices available from a large number of manufacturers, and (2) provide the flexibility and mobility of a wireless solution. This flexibility is important to the success of creating a compelling and complete home network solution.

Shared Wireless Access Protocol (SWAP)

The SWAP specification defines a new common interface that supports wireless voice and data networking in the home. Representation from the wide range of member companies, which span diverse industries, ensures that the final specification is complete and robust and that the devices envisioned as part of the home network are interoperable.

Some examples of what users will be able to do with the availability of products that adhere to the SWAP specification include,

- Set up a wireless home network to share voice and data between PC's, peripherals, PC-enhanced cordless phones and new devices such as portable, remote display pads.
- Access the Internet from anywhere in and around the home from portable display devices.
- Share an ISP connection between PC's and other new devices.
- Share files/modems/printers in multi-PC homes.
- Intelligently forward incoming telephone calls to multiple cordless handsets, FAX machines and voice mailboxes.
- Review incoming voice, FAX and e-mail messages from a small PC-enhanced cordless telephone handset.
- Activate other home electronic systems by simply speaking a command into a PC-enhanced cordless handset.
- Multi-player games and/or toys based on PC or Internet resources.

8.7 HomePNA

The Home Phoneline Networking Alliance (HomePNA) is an incorporated, non-profit association of industry-leading companies working together to help ensure adoption

of a single, unified phoneline networking industry standard and rapidly bringing to the market a range of interoperable home networking solutions [33].

Founded in 1998 by 11 companies (3Com, AMD, AT&T, Wireless, Compaq, Conexant, Epigram, Hewlett-Packard Co., IBM, Intel, Lucent Technologies and Tut Systems) the Alliance's membership has grown to include more than 100 companies, spanning the networking, telecommunications, hardware, software and consumer electronics industries.

9 Complete Home Automation Products

Many different products and services are currently available for energy control systems. The purpose of this investigation particular was to find out about these different options and to develop a clearer understanding of the possibilities of the new and emerging technologies.

Many articles looked at how the new technologies could increase the competitiveness of energy utilities. Such technologies could be provided by the utility as Value Added Services, thus hopefully giving the company an increased market share and profit.

9.1 IBM

IBM has three interesting home automation products, namely The Web Point Internet Distribution Centre, The Home Network Controller and The Home Director [34].

1. The Web Point Internet Distribution Centre:
   Web Point is used to set-up a home network for such things as Internet sharing and head-to-head gaming. The system can connect up to seven PC's via an Ethernet hub to Internet access using a single modem and a single ISP account. The system also allows outgoing call bumping, where picking up the telephone drops any current data connections.
2. The Home Network Controller:
   This product delivers home management for homeowners. It links together security, HVAC and lighting systems, allowing them to share information. A built-in infrared transceiver establishes whole-house IR distribution.
3. The Home Director:
   The Home Director builds foundations for home networking for entertainment, education and home office ends. Its TV interface allows control of the home management routines. Three different levels of packages are available, namely the 3000, 2000 and 1000 packages.

9.2 Siemens Home Electronic System (HES)

Stated to be the first comprehensive management system for the private household, HES enables all appliances and systems to be interconnected allowing intra-device communication within the use of a centralised control point [35]. The complete system can be controlled from any point within the home or from the outside. A requirement for the operation and control of domestic appliances with the HES is that they are networked with the Siemens "Instabus", an installation bus where information flows from device to device via separate twisted pair copper cable, via the existing mains wiring or via a wireless connection. HES is standard in the European

Installation Bus Association (EIBA), which ensures compatibility with other products carrying the "EIB" certification. Currently over 5000 products are available with EIB certification from over 100 different producers.

The system is able to control such devices as lighting, blinds, heating, ventilation, air conditioning, alarm system, garage door, telephone, laundry products, kitchen appliances, hot water system, entertainment system and load management. The number of possible devices that can be controlled by the product is constantly being expanded.

The system is operated by a standard multimedia, Windows-based PC on to which the graphical user interface "HomeAssistant" software is installed. By fitting appropriate hardware to the PC, it is possible to connect the system to the Data, Telephone and Television networks. The HomeAssistant software can also be run via a touch-screen or via voice command.

Advantages quoted from Siemens when using the system include convenience, energy savings (of up to 30%), comfort and an improved lifestyle.

9.3 Honeywell

The British manufacturer Honeywell has produced a comprehensive domestic automation system capable of controlling many of the home systems, including the lighting, appliances, security and alarm system, energy management and heating via wireless communication. The system is called the "Hometronic". It is this system that was installed in the "Internet Home" along with Cisco and many other partners.

Its main user interface module, the Hometronic Manager, can monitor up to 16 consumption measuring devices, control 16 different temperature zones and 32 modules for lights, appliances, shutters etc.

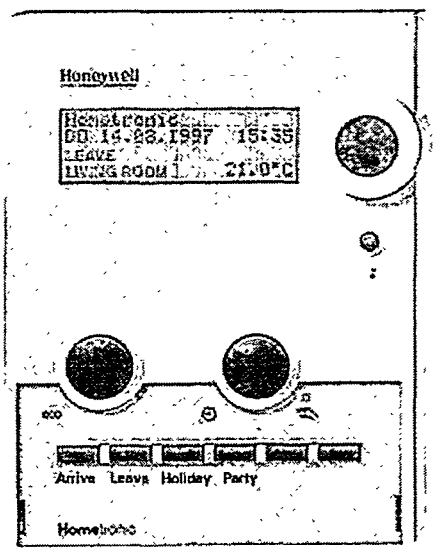

Figure 9.1: Hometronic Controller [36]

9.4 Vantage

With Vantage, one is able to control any system in a home or business – from lighting to security, audio video, heating/cooling, curtains, pumps etc [37]. Remote access to the system as performed by a "Q-Modem". Communication between the "Master Controller" and the other devices attached to the system is possible via both wire and

infrared systems. One programmable Master Controller can coordinate commands from up to 50 "smart stations" (500 buttons) on a single station bus.

The user interfaces with the system via keypads and touch-screens.

9.5 SmartOne

The SmartOne home network system communicates with controllers and devices via CEBus messages over standard powerlines [38]. The programmable "Manager Plus" system controller includes a LCD panel and keypad as a user interface. The main menu of the controller provides a list of functions and subsystems to select from including house macro's, lighting schemes, audio/video macro's, climate control, appliances and lighting/power devices.

The controller is programmed by the SmartOne HomeTool Pro Windows based software. A SmartOne Bridge is also produced. This product is a programmable input/output controller designed to manage multiple non-CEBus compatible home products and integrate the non-CEBus products into the SmartOne system. The SmartOne Bridge includes twelve hardwired inputs and eight relay outputs.

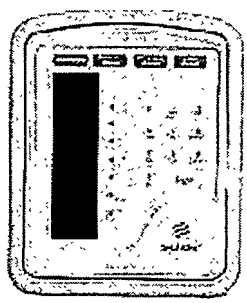

Figure 9.2: SmartOne Controller [38]

9.6 Thinkboxx

The Thinkboxx allows one to activate devices such as home security, heating, cooling, appliances and irrigation via [39],

- Programmable Keypads or Touchpads within the home
- Any Touch-tone or Cellular phone
- Infrared or Radio Frequency programmable remote controls

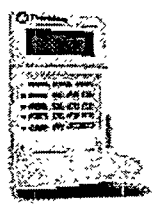

Figure 9.3: Thinkboxx Controller [39]

The system utilises X-10 or CEBus powerline communication and has the capability of controlling up to 256 possible X-10 and 256 possible CEBus device addresses.

9.7 OnQ

OnQtech produces a home wiring, home management system and high performance communication cables [40]. These products provide whole house distribution of,

- Analogue telephone, fax and modem
- Digital telephony for ISDN/xDSL high speed Internet
- In-home Local Area Network (LAN)
- Video from CATV, satellite and security cameras
- Audio for music and sound

And home management of,

- Security
- Lighting
- HVAC
- Appliances
- Energy
- Low voltage devices

The modular design allows the system to be customised into homes of all sizes and application needs. The user interface is possible by home PC, keypad, keyfob, wireless devices, or touch-tone phone (locally or remote). The home management system uses X-10 and wireless communication and also includes a serial interface for future CEBus control. The more demanding communication devices use Category 5 twisted pair and quad shield RG-6 coaxial cables.

OnQ produces its own software packages that allow technicians and homeowners to program the home management system via a PC.

9.8 Arigo

In 1995 the IBM Research Laboratory in Zurich developed a system for the control and monitoring of things such as household electrical appliances [41]. The system, called Arigo, consists of small boxes that simply plug into a normal electrical outlet and can be easily programmed to communicate with each other via the electrical circuit. The purpose of the system is to enhance the security and comfort of homes, offices and industrial premises automatically.

It requires no special installation and no additional wiring and all functions are unified in one modular system that can be expanded as desired. There is an integrated clock to control such time-dependent events as the turning on and off of appliances. Arigo stations can also contain sensors to detect such things as temperature, light, dampness, movement, smoke, etc. The system communicates using LonWork Technology.

The system includes software for programming the desired system functions on a Windows based PC. After the stations have been programmed, they no longer need to be connected to the PC.

By adding an optional modem, a user can check the system and activate switching functions simply over the telephone. Arigo can help utility companies as it could allow electricity companies to determine the exact energy consumption.

The starter set supplied by Arigo was valued at less than 1000 marks ($US 500).

The system is capable of controlling many systems, including,

- Alarm and security systems
- Office
- Greenhouse
- Climate control
- Load management
- Light control
- Photovoltaic management
- Medical care
- Plug in stations
- Easy data transfer
- Load management

9.9 Xantech

With Xantech's products, one can operate all video, cable, satellite and stereo systems by remote control from any room in the house, via a relay network that sends the users infrared commands back to the components [42]. The user carries only a hand-held remote controller from room to room.

Xantech first pioneered and patented the idea of remote control extension systems in 1983 and since then, over 1,000,000 systems have been installed in homes worldwide.

9.10 Unity Systems

Unity Systems provides advanced commercial and residential energy management and temperature control [43]. By using Unity's Universal Controller and remote communications software it is possible to unify the control of temperature, building automation, remote monitoring and the Internet. The Universal Controller is stated to be ideal for national chains, offices, banks, restaurants, churches, schools and larger homes.

The main features of the product are,

- Controls 1 to 16 zones per controller
- Accommodates most combinations of HVAC equipment
- Networking two Universal Controllers for large jobs
- Define up to 20 different schedules
- 1 to 5 Touchpads per installation
- Can accept inputs from security and fire alarm system
- Control of multiple types of HVAC equipment
- Remote upload/download for building control, data acquisition or diagnostics
- X-10 and CEBus cards for power line carrier control

- Advanced HVAC features including improved ventilation control, humidity control and advanced algorithms
- Support general device control such as sprinklers, lights and appliances

The system is able to response to real-time pricing and the future features that are planned to be added include,

- Data logging of energy usage, temperatures, etc
- Internet access for monitoring and control
- Pulse counters for reading and logging gas, water and electricity consumption
- Automated meter reading

Many cases of energy savings have been documented [43] by using the Controller. The cases mentioned give energy saving ranging from 13 to 61%.

Unity Systems products have now shown successfully integration with the products produced by Crestron (See section 9.13). The integration gives products that offer touch-screen technology along with complete zone control of all heating and cooling zones within the house.

9.11 Apex

Apex focuses on providing the security industry using wireless and hardwired products [44]. Apex offers a complete line of control panels and peripheral devices for the security and home control markets. Apex systems incorporate telephone access, two-way voice alarm verification, intercom/paging and automated/manual home control functions.

The components of Apex's Destiny 6100 product includes,

- A 16 zone Control/Communicator Home Management Security System (Expandable to 96 hardwire/wireless zones)
- Keypad User-interface
- 16 and 80 zone wireless receiver
- Temperature sensor
- Fire System control
- Phoneline supervision
- Local and remote phone access
- DOS-based installer programming software
- Home Control of up to 56 lights and appliances
- X-10 powerline communication compatibility

9.12 HAI

HAI provides networking, automation and security solutions for the home and business [45]. Its most advanced product, the OmniPro, is an integrated security and control system designed for commercial and residential applications. The system is able to control the security, fire protection and environmental within the residence, including the management of lighting, HVAC and other mechanical devices. All OmniPro features are accessible by telephone, on or off premises and can be programmed and controlled using the console or personal computer.

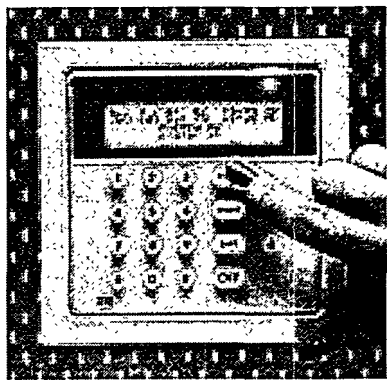

Figure 9.4: HAI's Keypad Controller [45]

Specific features of the system are,

- Home control and Security
- Telephone control
- Voice and Digital dialler
- Computer Interface
- Controls up to 190 loads, plus 64 thermostats
- 128 lighting addresses via X-10 control modules
- Temperature control
- Programmable Energy Saver modules
- Two Way X-10 communication
- Expansion port for future CEBus, Echelon or other interfaces
- LCD keypads
- Wireless Receiver
- Internet control of the system via HAI's Web-Link product

9.13 Crestron

Crestron designs fully integrated home control and automation products that can be controlled by such things as touch-panels and wall-panels [46]. The Crestron system incorporates Internet control of any device connected to the system.

By incorporating a LynX-10 coprocessor in the system, which has is a self-contained X-10 modem designed to connect to any RS-232 device, it is possible to provide complete X-10 interface compatibility. This is mentioned to work especially well with Crestron SmarTouch control systems to provide a gateway for control of X-10 lights and devices. Integration is also possible with the products manufactured by Unity Systems. Crestron's system uses both wireless and wired communication.

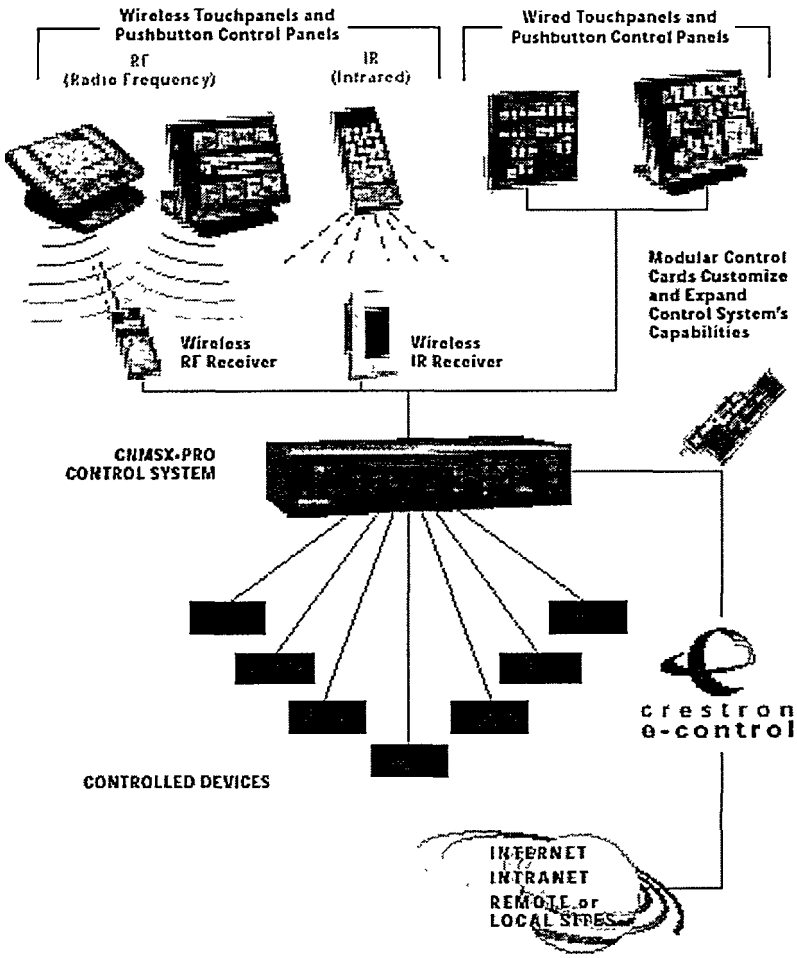

Figure 9.5: Crestron System [46]

9.14 ITI

ITI specialise in security, access control and home automation systems [47]. They produce energy saving modules that can monitor and control the heating and cooling within a residence. The system uses hardwired and wireless communication including X-10.

Their wireless Security Pro 5000 system includes features such as,

- Intrusion detection
- Fire/smoke alarm
- Environmental monitoring
- Energy management
- Lighting control

9.15 Scientific Control Systems

Scientific Control Systems produce devices for the energy management [48]. Their central system, called PC Energy Management, has been primarily designed for

controlling the energy usage in Hotel and Motels, generally by turning off the electrical loads or setting back the thermostats in rooms.

The system uses wireless PLC communication and requires a dedicated PC that is connected to the central transceiver via an RS-232 serial connection.

9.16 Comfort Home Controls

The comfort system provides security, home control and energy savings by the use of a single keypad or touch-tone telephone [49]. The central unit provides personal voice mail for up to eight users.

By adding the home control option to the base system, it is possible to control most appliances within the residence, via the integrated X-10 protocols. The home control menu has eleven sub-menus allowing over 100 possible home control operations.

9.17 Netmedia

Netmedia produces a Totally Automated Building System (TABS) for customised, personal control and security of homes [50]. The programmable system is controlled via keypads, Remote Control or by any touch-tone telephone and communicates through twisted pair wire, coaxial cable and PLC (X-10 and CEBus). TABS can be set up to give the users a visual display of their home via the TABS TV Channel through their television.

The system gives central control of devices such as,

- Security
- Climate Control
- Energy Management
- Lighting
- Audio control and distribution
- Video distribution
- Appliance control
- Voice mail
- Paging and message forwarding
- Personal organiser
- Irrigation

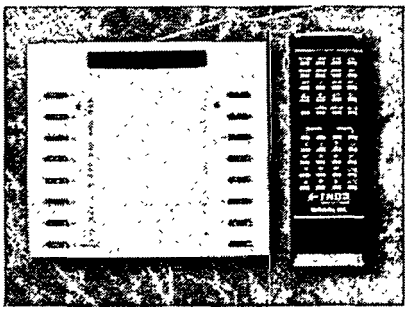

Figure 9.6: TABS Communicator and Remote Control [50]

9.18 PHAST

PHAST (Practical Home Automation Systems Technology) provides complete home automation systems in the form of their PHAST Landmark System [51]. The system can control many things within the home including,

- Audio/video
- HVAC
- Security
- Internet
- Intercom
- Telephone
- Lighting

The heart of the PHAST Landmark System is the Landmark Master Control Unit (MCU), an intelligent, programmable card that resides in the PHAST Card Frame. The MCU communicates with a wide array of available control cards that can be installed in the card frame. Each control card is designed to carry out a specific range of tasks quickly and reliably. This modular approach means that one only purchases control cards that are specific for their needs. This approach allows one to easily update a system.

The Landmark system is compatible with many other home automation systems from other companies. Examples of compatible technologies include,

- AMX AXLink
- Lutron
- LiteTouch
- AudioEase
- Crestron
- X-10
- CEBus
- LonWorks
- LonMark
- Vantage

9.19 JDS Technologies

JDS Technologies manufactures STARGATE, TimeCommander-Plus, TimeCommander and TeleCommand controllers and the Infrared Xpander, for Home Automation and Environmental Control [52].

STARGATE is an Interactive Automation System that integrates control of the different sub-systems throughout a home or business including Lighting, Security, Heating/Cooling, Entertainment (Audio/Video), Communications, Pool/Spa, Irrigation, Appliances etc. The system can be controlled by telephones, computers, X10 controllers, IR remote's (with optional IR-Xpander), wireless (RF) remote's,

keypads, touch screens, digital and analog inputs, ASCII, time/event schedule and remotely via telephone or modem.

TeleCommand System 100 is a telephone-controlled Automation System so that simple touch-tone commands can control lighting, security, heating/air-conditioning, audio/video, irrigation, door and gates, computers and peripherals, office equipment and other applications throughout a home or business for added comfort, convenience, security and energy savings.

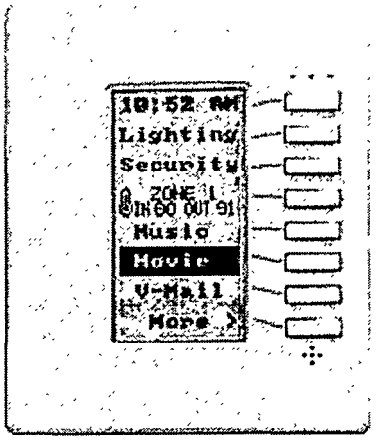

Figure 9.7: A Stargate Keypad [52]

TimeCommander and TimeCommander-Plus is a computer programmable Scheduler/Controller that integrates scheduling and advanced control of X-10 and Infrared devices. The programmable Event Manager software offers many control features that can be customised to suit any residential or commercial application.

Infrared Xpander is a computer programmable 2-way infrared controller for television and audio/video devices. It is programmable by PC and works with the TimeCommander, TimeCommander-Plus or STARGATE in Xpander Mode, or without them in Serial Mode.

9.20 EIB

EIB is an integrated solution for the full range of Home, Office and Building Automation [53]. A internal EIB electrical network may be used for lighting control, just as well as for controlling heating, air conditioning and ventilation, for access control, for controlling household electrical appliances etc.

EIB is an international standard, endorsed by key players from industry. The EIB Association (EIBA) consists of over 85 major companies.

9.21 European Home Systems

European Home Systems (EHS) is a comprehensive home communication system developed by European industries with the help of funding from the European Commission [54]. Its aim is to inter-connect different kinds of electric and electronic products for services used within the home.

The European Home System Association (EHSA) promotes EHS as the future open network technology to be used for home automation applications. The objectives of this technology are to allow integrated communication based on different types of media that is cost effective for the consumer and to provide the means for the type of user friendliness that consumers would expect. Typical benefits include lower energy

costs through home energy management as well as improved security and safety through the use of lighting control, cameras and connection to PSTN to dial out when alarm situations occur.

The system uses a standardised network communication protocol, which links the products in a home. EHS follows the Plug-and-Play concept in that products must be easy to install, use and remove. EHS fully supports the Plug-and-Play concept, a requirement that is not met by other bus solutions. In EHS, this is achieved by dynamic configuration functions that allow the dynamic assignment and exchange of network addresses. The protocol supports several media including powerline, coaxial cable, twisted pair, infrared and radio frequency. Initial efforts have been focused on the powerline medium at 2.4 kbps.

Equivalent buses have been defined in the U.S. resulting in the CEBus specification and in Japan resulting in the HBS specification. They basically provide the same features as EHS. EIBus and Batibus are the two leading European buses for building automation. In Europe, there exists an alliance for convergence between EIBus, Batibus and EHS. An alliance was announced in October 1995 between the CEBus Industry Council (CIC) and the European Home Systems Association (EHSA).

9.22 Batibus

BatiBUS is a single bus enabling intercommunications between all the modules (CPUs, sensors and actuators) in building control systems such as heating, air conditioning, lighting and closure functions [55].

BatiBUS, developed by Merlin Gerin, Airelec, EDF and Landis & Gyr, was the first field bus on the market. These companies that develop products for BatiBUS, were the founding members of BatiBUS club international (Bci) in 1989, whose purpose is to extend applications to other building trades and professions.

9.23 Home Technology Systems

Home Technology Systems provides products and services to integrate today's existing homes with smart technology, thus creating the Smart Home [56]. The products can be installed in existing homes and not just within new constructions.

Products include the advanced control of security, lighting, climate, appliances, pool, audio, video, power centres, home theatres etc. All these products are controllable via in-home keypads, telephone, touch screen and/or computer. The systems are all commercial grade control systems and do not require a computer to operate.

Efficient energy management is provided by SmartPower, which monitors and controls the power usage from the residential load centre or breaker panel. The SmartPower System is Home Plug & Play compatible.

One can monitor and control the electrical usage for the whole house and for individual circuits. Power circuits are remote controllable when integrated with the

SmartOne Home Management System for Lighting and Appliance Control and the SmartSecurity Home Management System for Security and Whole House Control.

The SmartPower system includes the following features,

- Monitors and measures energy consumption at the incoming line.
- Permits remote or programmable control of specified circuits.
- Monitors energy consumption on selected branch circuits.
- Home Surge Protection.
- Electronic module that provides the communication, monitoring and control capabilities.

9.24 Cisco

Cisco Systems is the worldwide leader in networking for the Internet [57*]. Cisco provides end-to-end networking solutions that customers use to build a unified information infrastructure of their own or to connect to someone else's network. An end-to-end networking solution is one that provides a common architecture that delivers consistent network services to all users.

Cisco offers the industry's broadest range of hardware products used to form information networks or give people access to those networks; Cisco IOS® software, which provides network services and enables networked applications; expertise in network design and implementation; and technical support and professional services to maintain and optimise network operations. Cisco is unique in its ability to provide all these elements, either by itself or together with partners.

Cisco serves customers in three target markets,

- **Enterprises** - Large organisation with complex networking needs that usually span multiple locations and types of computer systems. Enterprise customers include corporations, government agencies, utilities and educational institutions.
- **Service Providers** - Companies that provide information services including telecommunication carriers, Internet Service Providers, cable companies and wireless communication providers.
- **Small/Medium Business** - Companies with a need for data networks of their own, as well as connection to the Internet and/or to business partners.

10 Advanced Products

10.1 Meters

10.1.1 muNet.com

muNet.com's develops broad-based solutions including the WebGate Technology, which combines data acquisition, database technologies, embedded computer engineering with two-way secure Internet communication and a graphical interface to the World Wide Web for real-time Automated Meter Reading [58]. Once full two-way Automated Meter Reading is established, Remote Device Control, Integrated Billing, Customer Information Services and a host of other value-added services become available to the Utility and its customers. Figure 10.1 shows the fundamental set-up of the Webgate system.

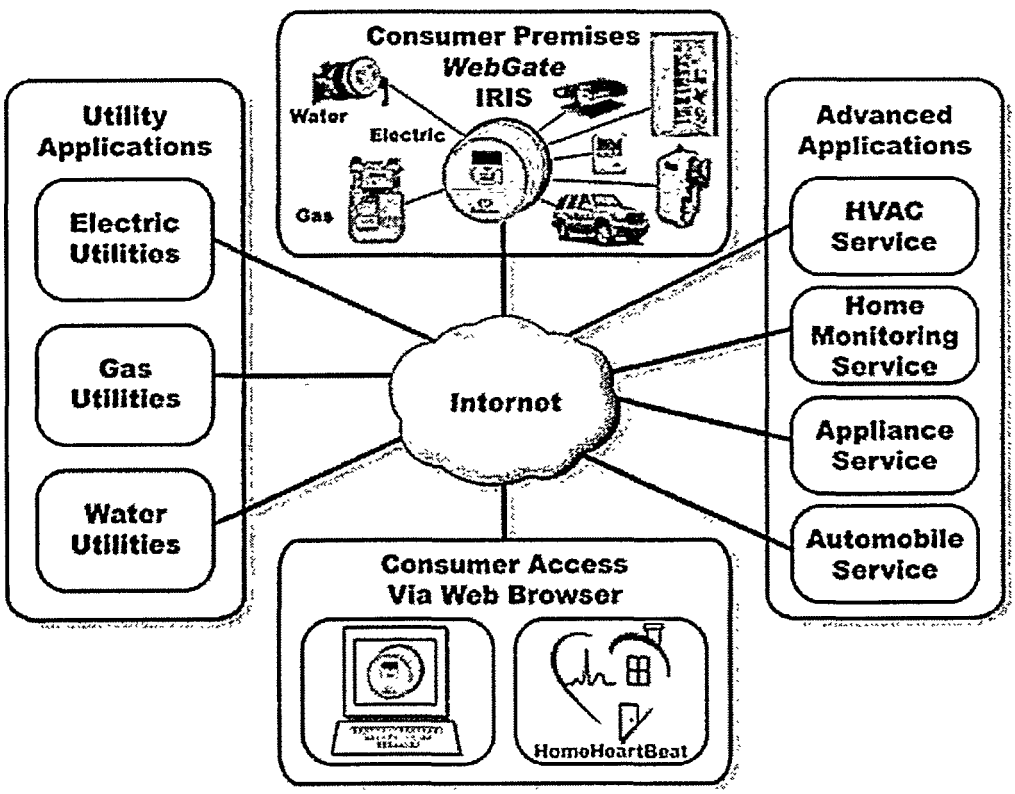

Figure 10.1: muNet's Webgate [58]

10.1.2 Enermet Oy

Enermet is a leading developer and manufacturer of electronic electricity and heat meters as well as metering and load management systems [59].

Enermet Oy has developed the AVALON product concept and a new generation of measurement devices to meet the needs of deregulated electricity market.

The new product concept allows remote reading of metering data, versatile tariff control and collection of hourly energy consumption readings. In addition, the new concept allows communication of energy metering related information between the energy company and its customers, as well as various control services, such as lighting control. Communication can be carried out using telephone network, GSM phones, Distribution Line Carrier, communication cables and in future possibly other communication media. The new terminal units can also be used to remotely read district heating and water metering data.

10.1.3 Daltech

Daltech produces units that can measure and display the energy used within a home [60]. Their products include the Kronometern, the Q2, RE22 and Meterpoint.

These products can tell the user the cost of the energy one uses per hour.

The Kronometern can be used to control other LonWork based items including of alarms and climate control.

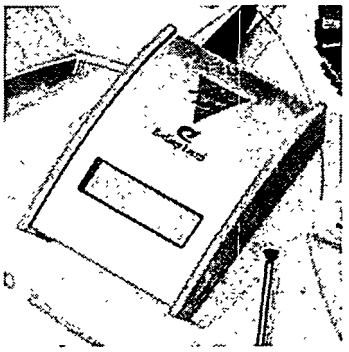

Figure 10.2: Daltech's Kronometern [60]

10.2 Home Gateways

10.2.1 2Wire

Designed for the home, the 2Wire HomePortal 1000 delivers and distributes high speed Internet access [10]. This product combinations a DSL modem, home networking hub, router, web server and value-added software that allows multiple users to simultaneously access a variety of broadband data, voice and entertainment services.

Users can also access other home network features, including printer sharing, file trading and head-to-head game playing. The HomePortal 1000 plugs into any telephone jack inside the home, which activates a home phoneline network (HomePNA 2.0) through all the households' telephone jacks. Phones share the same line with the networked PC's.

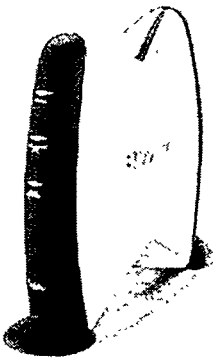

Figure 10.3: HomePortal [10]

Figure 10.4 below shows a typical installation that includes the HomePortal 1000.

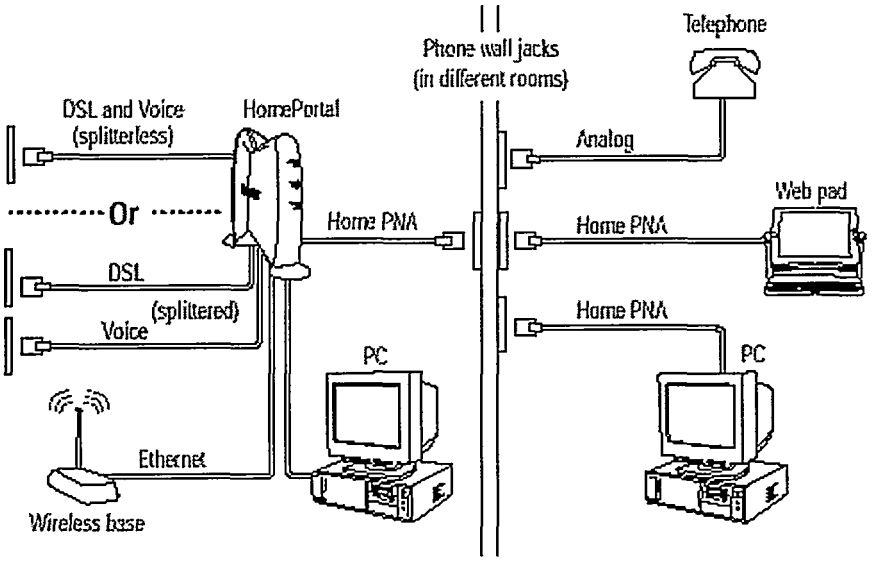

Figure 10.4: Connection of theHomePortal [10]

10.2.2 Coactive Networks

Coactive Networks is a leading provider of solutions for connecting control systems to networks and the Internet [61]. The company produces routers, thin servers and gateways for creating powerful next-generation applications and is the market leader in providing connectivity solutions for the EIA-709 (LonWorks) standard, the leading control technology.

Coactive has supplied Sensel (see section 12.24) with their Coactive Connector. This product and it's related family connects control systems, appliances and other devices to Internet applications enabling access from anywhere on a network.

The Coactive Connector 2000 Series provides a gateway from home control systems to Internet Protocol (IP) wide-area connections including shared phone, cable modem and DSL. The Connector enables multiple services such as AMR, home security, energy management and home automation.

Using Ethernet LAN's, dial-up PPP and the Internet, the Coactive Connector 1000 provides data logging, alarming and real-time remote monitoring and control to Internet-enable systems such as security, energy management and equipment monitoring. The Coactive Connector 1000 allows systems to achieve true integration with the Internet to enable valuable new features and reduce system costs.

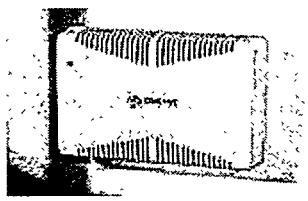

Figure 10.5: The Coactive Connector 2000 [61]

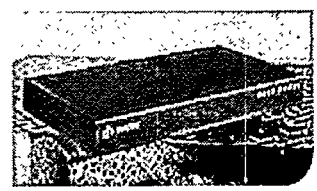

Figure 10.6: The Coactive Connector 1000 [61]

The Coactive Router-LL Multiprotocol LonTalk/IP Router connects multiple LonWorks systems to each other across a building or campus LAN or the Internet. The Coactive Router-LE Remote Access Interface connects LonWorks software to control systems across an Ethernet LAN, enterprise network, or the Internet.

10.2.3 Next Level Communications

Next Level Communications provides a access platform that can provide any combination of voice, high-speed data and/or digital video services to residential or business customers via the existing telephone lines or over fibre optics [62]. Next Level also provides broadband management systems and customer premise equipment (CPE) for both high speed data and video services.

Broadband data and video to the home or business are also delivered over the same copper pair using DSL signals at up to 25 Mbps.

Next Levels N^3 Residential Gateway provides three concurrent MPEG-2 video streams, digital audio and a 10BaseT high speed data port for Internet access.

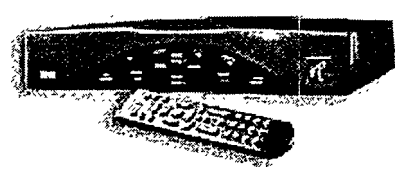

Figure 10.7: N^3 Residential Gateway [62]

10.2.4 Ericsson's e-box

Ericsson has also developed a "smart" home gateway device, called the e-box. This device is designed to deliver electronic services to the customer's home. This device provides an open/common platform that can be used by independent service providers.

The design of the unit focuses on what Ericsson considered to be the most important properties of the system, namely security, robustness and remote-management capability.

The first services likely to emerge using this device was expected to be for the residential market. Such services are expected to include communication, entertainment, security, energy management, home automation and home care.

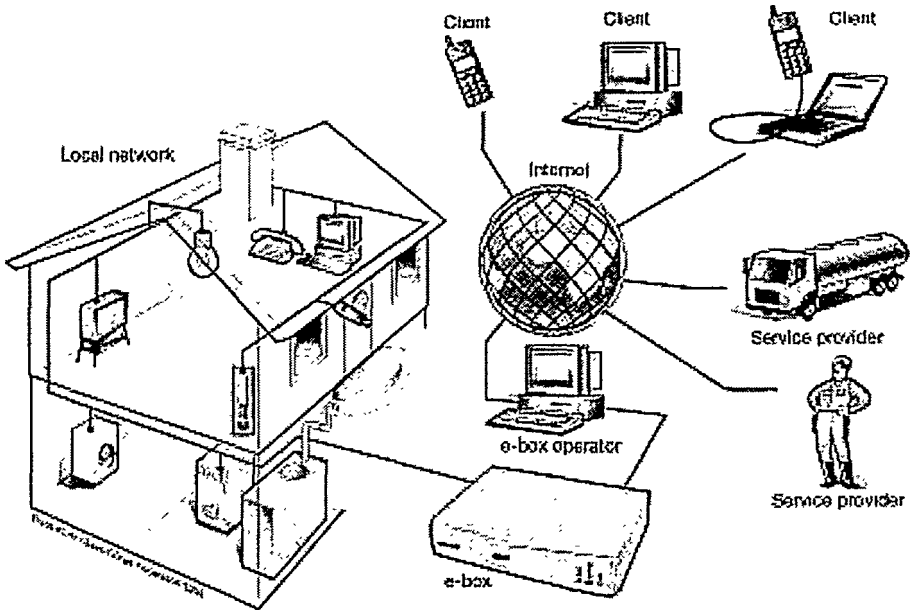

Figure 10.8: An e-box Operated Communication Network [63]

10.2.5 Oneline Corporation

The Oneline Corporation was established in early 2000 for the purpose of providing telecommunication services via the power lines [64]. It has been created by Enikia [65], Oneline AG, PreussenElektra AG and VEBA AG.

The German based companies main product is the "Oneline Box". This box allows communication over the low to mid voltage power network, including the electric wiring within a household. The box is a home controller that provides telephony, the Internet as well as other value added services including energy monitoring and home automation and is mounted within the homes existing meter cabinet.

The box uses Enikia's 10 Mbps Powerline Transceiver chipset that provides a Information Appliance Network (IAN) that supports a Ethernet based broadband communications over a local area Network (LAN).

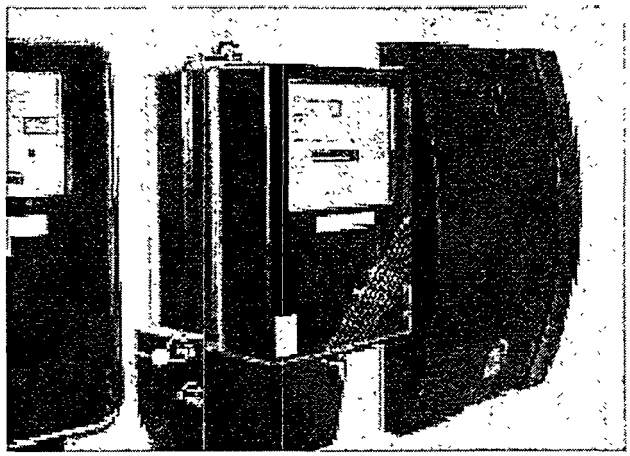

Figure 10.9: Oneline Box and an Electricity Meter [64]

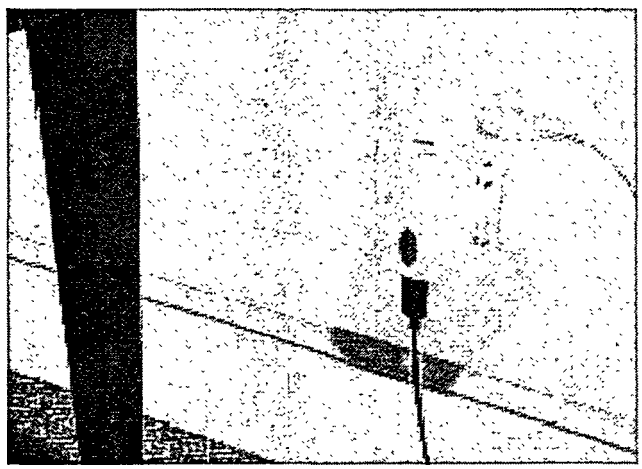

Figure 10.10: Oneline Inhouse Modem [64]

10.2.6 Emerald Gateway International

Emerald Gateway International (EGi) have developed a Energy Service Gateway (ESG) product that is currently used in seven countries, namely Australia, Canada, Korea, Malaysia, New Zealand, Norway and the USA [66].

The ESG system incorporates automated meter reading, energy management, load control as well as other value added energy related services, such as real-time energy displaying and itemised billing. Included in these value added services are also home automation and security devices and community intranet.

The home automation feature of the system uses the CEBus protocol but a converter also allows the use of X-10 technology within the system. Figure 10.11 shows the overview of Emeralds gateway system.

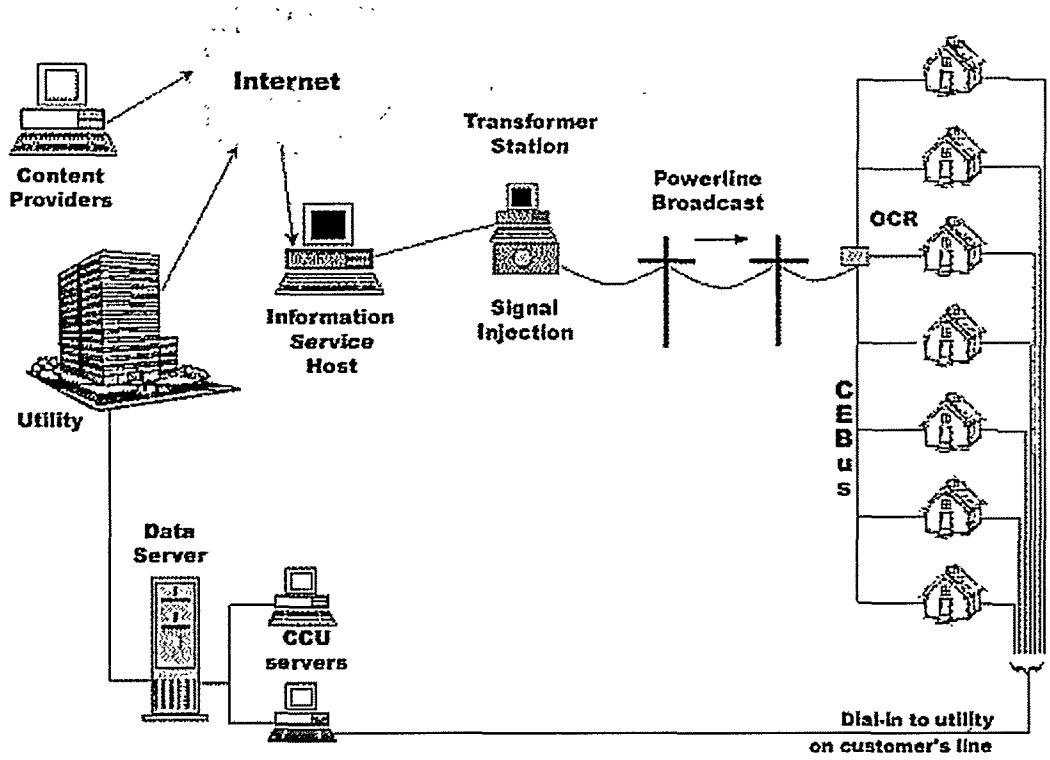

Figure 10.11: Emerald Gateway System Overview [66]

11 "Smart" Appliance Manufacturers

11.1 Electrolux

Electrolux's new "Screenfridge" is a intelligent refrigerator that is designed to help with grocery shopping and dinner ideas, keep track of what is in the fridge and function as a message centre for the whole family [67].

The fridge looks like a normal refrigerator but is equipped with a computer and a touch screen on the door.

This intelligent refrigerator is also connected to the Internet, which allows the user to send e-mails or to surf the Internet and it also includes a built-in library of recipes.

The fridge is equipped with speakers, a microphone and a small video camera, which makes it possible for family members to leave video messages for each other. There is no separate keyboard or mouse as all the functions are available through a touch screen and a virtual keyboard. There is also a television and radio.

The Screenfridge will ultimately include a "reader" that will be able to use the electronic tagging found on all food and liquid packaging in the future. This way, in the future the fridge can keep a food inventory.

Electrolux feels that the fridge is a very natural place for such central functions. "We know from surveys that in most homes the refrigerator is by far the busiest spot in the house. All family members use the fridge and not only for food - it's where you put messages, lists and things to do". The Screenfridge also contains a family calendar.

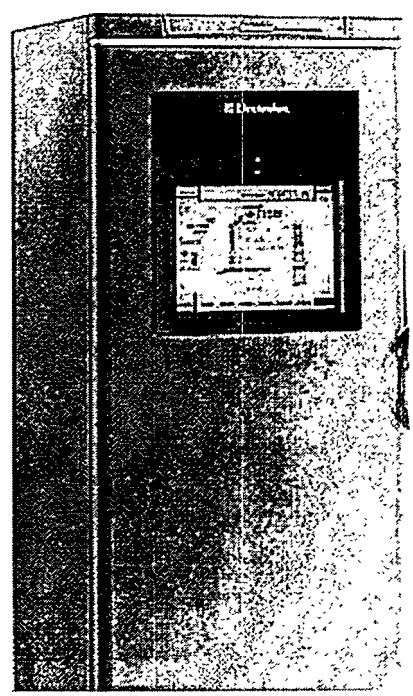

Figure 11.1: Electrolux's Screenfridge [67]

Electrolux does not know when or even if the Screenfridge will be on the market and they do not want to speculate on a feasible price at this time.

Electrolux is the world's largest manufacturer of household products, with a turnover of SEK 117 billion (≈$US 13.6 billion) in 1998 and has approximately 100,000 employees.

11.2 Merloni Elettrodomestici

Merloni Elettrodomestici is a multi-brand pan-European company founded in the mid-seventies and is the youngest of the leading European domestic appliance multinationals in the market today [68]. Merloni has established markets in Southern Europe and more recently in Northern and Eastern Europe.

Merloni has developed the "Ariston Digital" system, after a five-year international research project. This system has produced new household appliances that use the WRAP (Web Ready Appliance Protocol) digital technology partly developed by Merloni that allows them to communicate via a homes powerline, via the standard communication protocol (standard EIA 709).

Ariston Digital's main characteristic is that it is easy to install and use (plug & play). The information travels via the power mains at home so connecting the appliance to the network requires it to only be plugged in. The "intelligence" is distributed in each appliance, thus eliminating the need for a central computer to process the data. The appliances provide three main services, namely; tele-assistance, connection to Internet and power consumption management.

1. **Tele assistance**
   Ariston Digital appliances communicate to the outside network either through the home telephone line or via the GSM networks by means of a "conveyed waves" modem. This type of communication (known as the "conveyed-waves system") represents the worldwide standard of automation for domestic appliances [68*], as it does not require any wiring system in the home, other than the electric mains. This enables each appliance to constantly transmit information to the Assistance Centre on their running conditions, or indicate possible faults, enabling the Assistance Centre to act more rapidly and with a more accurate diagnosis of the problem. For example, in case of a prolonged power cut, the transmission of an alarm can safeguard the food stored in the freezer compartment. Each appliance stores the most important information during its entire running life, (washing or cooking cycles, power consumption, repairs, etc.) allowing the better use of the appliance and a faster and more effective intervention for any possible repairs.

2. **Connection to Internet**
   The Ariston Digital cooker is equipped with cooking cycles for all types of food and it is possible to choose the ideal program, download new recipe ideas from the "Ariston Channel" Website via a computer or directly from the oven and store them on the oven memory.

3. **Power consumption management**
   All "Ariston Digital" appliances communicate with each other and are aware at all times of how much power is being consumed and are able to regulate the consumption accordingly, so as to avoid the risk of a blackout, for example. They are also able to decide should a blackout occur, which appliance should be given priority to restart. At the same time, they can make appliances run more intensely during off-peak,

cheaper rate hours. The communication with other digital domestic appliances allows the regulation of how they work, from consumption of energy, detergent, water, to programming the cooker. Ariston Digital household appliances can communicate in order to administer their energy absorption and remain constantly below an imposed 3 kW threshold.

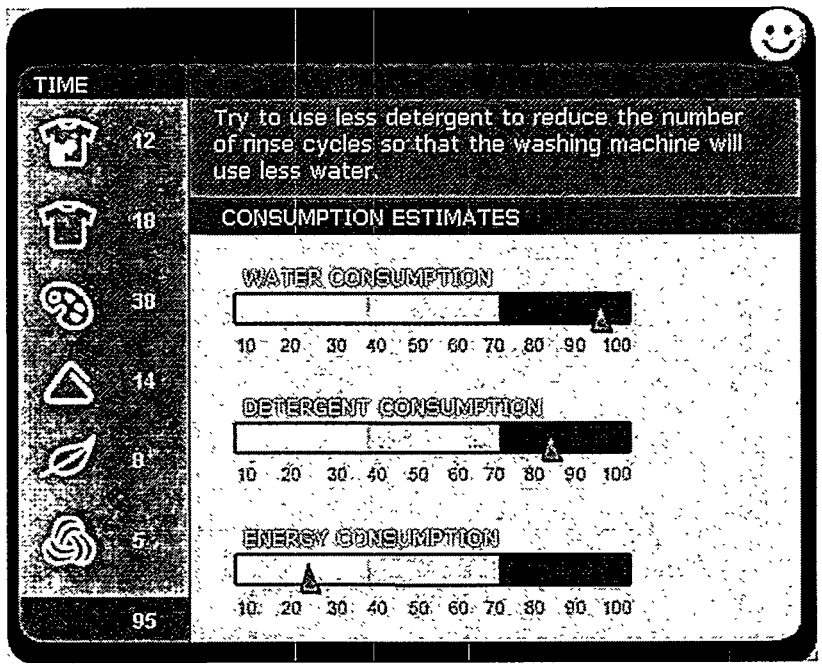

Figure 11.2: Merloni's Displayed Consumption Data [68]

Another device produced by Merloni is the Home Smart Monitor (HSM), a WRAP equipped multimedia, interactive, touch-screen monitor that facilitates access to the Internet from the home. It also offers audio and video services and is able to optimise the performance of all domestic appliances. The Home Smart Monitor, currently given the name of Leon@rdo, is a gateway to the outside world and allows the easy use of,

- Internet
- Ariston Channel interactive services.
- "Intelligent" cooking using the latest recipe ideas from the Internet.
- TV and Radio
- Online Shopping List
- E-mail and Fax
- Agenda and Calendar, a quick and easy reference to remind the user of any appointments.
- Note Pad, a fast and practical way to leave messages and take notes.

The Home Smart Monitor also functions as a home network terminal, allowing the communication with and the monitoring of the functions of tele-assistance, tele-diagnostic, maintenance statistics, consumption management of,

- Refrigerators

- Dishwashers
- Cookers
- Washing Machines
- Other appliances

It can therefore act as the interface for Ariston Digital appliances, although their services could still be activated without the presence of a HSM in the home.

In the Ariston Digital area, it is possible to experiment with the services Leon@rdo offers. It was launched in the Italian market at the end of 1999 and will be commercially launched in Great Britain and France during 2000.

Leon@rdo will soon also be able to download mp3 music files from the Internet, allowing the online listening from within the household.

Figure 11.3: Leon@rdo [68]

HSM is the result of a network of alliances and collaboration that has involved businesses, universities and Italian and foreign research institutes, such as Medialab of the MIT, Boston, Ideo of Palo Alto, California and a consortium of Italian universities and businesses such as Analog Devices, Texas Instruments and Hitachi.

11.3 Sunbeam

The appliance maker Sunbeam Corporation has developed prototypes of several microprocessor-enhanced products that can communicate with each other over existing household electrical wiring or radio waves [69]. The company also announced the launch of a new company, Thalia Products Inc., which will develop its new smart products.

Sunbeam says its approach to the wired home is based on what Thalia has branded Home Linking Technology (HLT), a platform it says will also make it compatible with other device-oriented network protocols, such as Microsoft-backed Universal Plug and Play (UPnP) and Sun Microsystems' Jini.

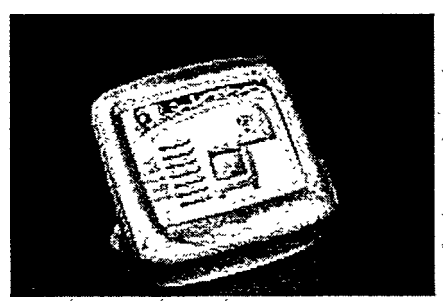

Figure 11.4: HomeHelper console [69]

At the heart of an HLT enabled home, Sunbeam spokesman David Kellis said, "is one of three "gateway" devices through which other appliances may get their marching orders". These devices, the TimeHelper alarm clock, the HomeHelper kitchen console and the HandHelper personal digital assistant can also dial up an Internet

connection via a modem and Phonelines. The touch-screen-driven HomeHelper console also offers Web-surfing capabilities.

The first six HLT appliances (a coffee maker, an electric blanket, a smoke alarm, a stand mixer, bathroom scales and a blood-pressure monitor) are planned to be priced in the same price range as typical higher-end appliances that use traditional technology. More "HLT-Smart" appliances are already planned by Sunbeam to follow the initial launch.

Sundberg-Ferar, a Detroit based product development firm, helped devise the new products, and they mentioned that a key part of the HLT project was the choice of the communications medium. They eliminated infrared as an option because it work through line of sight and would not operate between different floors. A Phoneline interface would have required running additional lines throughout the house to accommodate convenient appliance locations, since most homes have relatively few phone jacks. RF (radio frequency) and PLC (power line carrier) together allow consumers to locate the appliance practically wherever they need it. The main reason for using RF signals was for networking devices that do not plug into the wall, eg. battery-powered devices such as smoke detectors.

11.4 DIBA

Diba Inc designs cheap, single-purpose computers, called "Information Appliances". These devices combine powerful software applications with the convenience and affordability of household appliances [70]. Diba is working with a wide range of customers and partners to bring Information Appliances to the market. Diba has also created a portfolio of Information Appliance concepts that illustrate the broad range of possible appliances with the company's innovative technology. These devices include a financial assistant, a web browser that hooks up to a standard TV, a phone that offers email and fax and a personal travel device.

In 1997, Sun Microsystems Inc., acquired all of the outstanding shares in Diba. Sun and Diba intend to aid consumer electronics manufacturers in developing end-to-end solutions aimed at accelerating the delivery of Java-enabled information appliances into the hands and homes of consumers worldwide. Sun and Diba plan to offer all of the ingredients necessary to create Information Appliance solutions into tightly integrated packages.

11.5 General Electric

Information on General Electric's homepage says that recent studies indicate that within ten years, 98% of appliances will have computer processing capability and be networked and controlled from remote locations - such as the office or cell phone [71]. General Electric has produced prototypes, such as,

- A voice-activated Advantium oven with Speedcook technology that recognises and responds to voice commands.

- A Web-enabled and networked refrigerator with wireless portable Web pad that allows consumers to access the Internet, as well as monitor and control all appliances and home electronics remotely.
- A microwave oven that reads Universal Product Codes (UPC) and then automatically sets the proper cooking cycle, detects ingredients which consumers may be allergic to and displays the calorie content of the dish.

Both the refrigerator and the microwave can self-diagnose problems and alert the GE Answer Centre for parts and service. Just as importantly, they stated that these appliances and others yet to be developed could all be networked as part of a fast, seamless home automation network.

General Electric has announced that it will work to develop standards for connecting smart appliances by joining a industry forum for Universal Plug 'n' Play (UPnP) technology including such companies as Microsoft, Mitsubishi, Honeywell, Sony, Intel and IBM.

11.6 Whirlpool

Whirlpool Corporation's European operations has recently introduced a wide variety of new products under the Whirlpool brand and has displayed prototypes of Internet enabled products from its recently announced Networked Home Solutions Initiative [72].

The prototype networked refrigerator on display included a portable handheld device with a home base on the door. The new device allows consumers to remotely monitor and control the networked appliances and to access a host of other Internet-based products and services for the home. For example, a Whirlpool networked oven will enable consumers to download recipes from an integrated browser and automatically program the oven according to the recipe.

These prototype products are just the first of a complete line that Whirlpool has under development following the announcement of agreements to partner with both Cisco Systems and Sun Microsystems in the development of its Networked Home Solutions Initiative.

These innovative and easy-to-use products attracted consumers with new aesthetics and their time and energy saving features.

12 Advanced Energy Service Related Projects

Another issue described in articles was how "smart" equipment could be utilised to coordinate automated energy control systems. This section summarises many implementations of "smart" devices.

12.1 PCTVnet

In the PCTVnet project, a TV set-top box (called the HomePilot) was developed that was capable of controlling the Internet, e-mail, central heating, lighting and television using a TV interface [73]. PCTVnet stated that such a device must be evaluated as the implementation of a new technology within homes as opposed to simply an energy saving product implementation.

Thirteen HomePilot systems were installed within homes in Norway and evaluated in terms of,

- Technical functionality
- Communication
- Interface
- Users' experiences
- Internet and energy management bundling
- Expectations
- Possible future trends

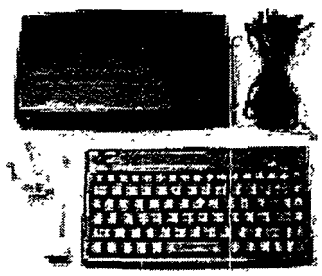

Figure 12.1: The HomePilot System [73]

From this project it was found that the Internet service was of more interest than home automation. The main reason found for implementing home automation functions was to reduce the customer's energy bills as it was estimated that this device could reduced their annual consumption by between 15-20%. The "Plug and Play", ie. simple installation, feature of the HomePilot was also found to be a base condition for acceptance of the product. For this particular product, installation usually took less than one hour.

The home automation and energy metering features of the product were developed using Echelon and X-10 protocols. The power-monitoring feature enabled hourly metering of the household's energy use. Another interesting result was found when investigating the level of satisfaction of the product after a few months use. The customers were generally either very satisfied or dubious about the product. This second feeling was due to the fact that the system did not feature enough functions, especially related to the connection with the energy meter and the possibilities to monitor the consumption.

The project mentioned that as the technology develops, the bundling of the Internet and home automation services will evolve. This service bundling provides value added services to the utility's customers and improves customer loyalty.

12.2 Gotcom

This project aimed to create value-added services through customer communication and to make Vattenfall, the project owner, a more effective electricity grid operator [74, 75]. Communication used in this project is based on the low voltage electricity grid and LonWorks technology placed within the customers' residence. Vattenfall expect that such a project shall be seen as an embryo of a 21st century electricity distribution company.

Features provided introduced by this project include,

- Web interface
- Energy statistics and consumption data on the Internet
- Environmental feedback to customers with changed consumption patterns
- Detailed non-preliminary tariff specification
- Simple invoicing
- Administrative payment options
- Load management and DSM
- Equipment and Climate control
- Alarm functions for establishments
- Movement detector based burglary alarm functions
- Automatic earth fault contact breaker detection

They stated that as the value-added services are introduced, the traditional services of a supplier (energy utility) would become less dominant. This would mean the company's would move from simply selling and metering electricity to that of a service provider, or a Technology Utility. Vattenfall also intend to offer these services to non-electricity customers. It was also mentioned that the future energy market demands a multilateral data exchange, which they called Value Added Data.

12.3 Customer Choice and Control

In 1994 Central South West Corporation (CSW) began a $US 9 million project designed to reduce electricity consumption or to shift the customers' peak electric usage to times when electricity demand was low in Laredo, Texas [76]. The project, called Customer Choice and Control (CCC), uses an experimental set of electric rates as an inducement to actively participate in the project.

The customers were furnished with "smart equipment" to allow them to manage their energy usage by allowing the equipment to make automatic adjustments which lead to savings of around 10% on their electricity bills. This was achieved by monitoring the

peak-time power rate, which when raised above the customers predefined level, reducing the power usage, as per the homeowners programmed instructions.

The whole system uses LonWorks based products from First Pacific Networks, American Innovations and Raytheon Corporation. The set-up of the system is shown in Figure 12.2.

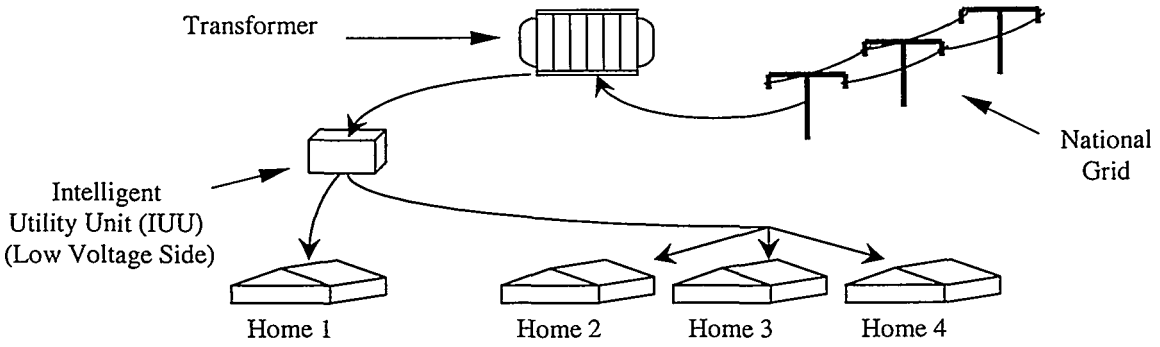

Figure 12.2: CSW Project Set-up

The equipment transmits and receives signals between the Intelligent Utility Unit (IUU) and the customers' homes by using a hybrid fibre/coax network. Each IUU supported up to four homes and preformed numerous functions including serving as an electricity meter for one of the homes (Home 1 in Figure 12.2). The other three homes had standard electricity meters fitted with "Powerlon" power line carrier modules. Installation within the homes usually took less than one hour and typically involved the connection with the central air conditioning system, the electric water heater and one other electrical device.

Control of the system was via a LCD control panel that allowed the customers to program each appliance to respond to the time-of-day and real-time prices that came into the home over the network. The complete in-home system communicated over the power lines using Echelon's PLT-20 power line carrier transceivers.

Since the CCC system can coexist with the telephone service and analog video over the fibre/coax network, they plan to provide their customers with home security, cable television, long distance learning and a telephone service.

CSW state that to modify energy usage patterns, the customers must be educated about the demand for and the cost of energy, which is then backed-up by a financial incentive. The customers also require that the equipment be easy to use, programmable and provide automated control.

12.4 Info-Highway

The electricity utility of Glasgow, Kentucky provides not only electricity but also cable television, telephone services, a computer network, Internet connection and energy management in a project called Info-Highway [77, 78, 79]. The project began

in 1989 and currently has more than 7000 users in a community of only 14000 inhabitants. Some of the initial costs of the project were,

- Initial construction of a Broadband network - $US 1.5 million (approximately 200 km)
- Capital expenditure of the Cable television service - $US 1.3 million (a cable modem is rented to their customers at $US 10 per month)
- Telephone service - $US 500 per line served

The reason for the construction of the network and system was that the utility feared competition in the (then upcoming) deregulated industry environment and they also desired competition in the cable and telephone markets. They also wished to establish a citywide computer network that was not available from either of the cable or telephone companies.

The system currently offers a 4 Mbps citywide computer network, which links all homes, schools, businesses and government agencies. The network is also connected to a high-speed circuit (T-1) providing full-time access to the Internet. The utility even uses the system to synchronise all the traffic signals within the town.

It was mentioned that energy related aspects of the system have been more successful than traditional load management systems. They explain [78] this by stating,

> *"Generally, the programs (load management) in place reward consumers for allowing the utility to control loads...with a $US 3-5 per month credit on the customer's bill. A lack of consumer understanding of the need for the program and the lack of interest in a $US 3 or $US 5 per month savings have rendered these programs less than overwhelmingly successful. ... It also gives the utility new incentive tools. Instead of offering that $US 3-5 per month credit on the electric bill, our project allows us to offer a premium cable television service such as HBO, Showtime, etc., which has a similar cost to the utility, but a much higher perceived value to the consumer. In short, a consumer may not be interested in allowing his hot water heater to be controlled for $US 3-5 a month, but he may very well be interested in allowing the same control in return for the reception of HBO."*

It is mentioned that customer focused services are likely to be the primary method of differentiating energy providers in the future. Within the next five years the utility predicts that their customers will be able to monitor their electric power, gas and water consumption via their computer connected to the system.

12.5 Nor.web

Nor.web has developed a patented technical solution for broadband communication on a low voltage electricity grid [80]. This particular solution is called Digital Power Line (DPL). Nor.web has currently achieved communication of up to 1 Mbps over a range of 300 m. Companies such as Stockholm Energi, Sydkraft, Vatternfall,

Canadian Nortel, United Utilities, Energie Baden-Württemberg AG (ENBW) and Tele2 have used this technology in projects.

United Utilities has already supplied some households within Manchester, England with solutions provided by PDL, namely Internet access. ENBW has also provided some customers with Internet access via the power grid.

This project has now finished.

12.6 West End Networks

This small Canadian is a private telecom equipment manufacturer that has designed high-speed interactive communication over the cableTV network [80*]. The system employed the use of fibre and coaxial cables. The system aimed to give individual customers with a potential bandwidth of up to 2 Mbps.

12.7 Bewag

This German power distribution company collaborated with the University of Paderborn to implement trials of Power Line Telecommunication (PLT) products designed to provide services over a local power distribution network and onto in-house wiring [80*]. The intention was to provide a capability to utilise each power socket also as a communications port. The system is currently at its initial design and testing stage.

12.8 Intelogis

With the aim of developing a product to allow data communications over in-building electricity wiring, this company, based in Ohio, USA, has produced the "Passport" product [80*]. Currently it is restricted to machines using Windows software. When the device is plugged into the electricity mains it produces a communication Local Area Network (LAN) within the building but it does not appear to be able to be used for communications to an external public power distribution system.

12.9 Siemens

The German Siemens company has developed an energy meter data management system called SEMMS [80*]. This system can be implemented for power supply measurements by using its built-in communication using standard protocols. Some advantages are mentioned to be automated meter reading and energy meter maintenance. The system communicates using the DLMS standard protocol via the lower voltage network.

12.10 ABB

The developed "Panorama System" is a platform for distributed automation and demand side management based on power line telecommunications for data transfer [80]. It provides two-way communication for load management, meter reading and further services on the low voltage power grid.

12.11 Electricité de France

Being the biggest electricity supplier in the world, Electricité de France has carried out extensive customer surveys into the possible launching of new applications for various customer segments [80]. The results have shown a very strong customer interest in services such as demand side management and energy management. Also from these results they have been able to construct a residential customer typology and segmentation structure. Another important finding was that even though interest in energy management was high, the residential customers' actual knowledge of their own load and cost profiles was very limited. Improving this lack of knowledge could therefore be seen as a valuable service in itself.

12.12 RWE

Germany's biggest utility has undertaken pilot tests on power line communication applications [80]. It is looking into the technical and economic feasibility of using the low voltage power grid for both telephony (ISDN telecom functionality) and data transmission (value-added energy services).

12.13 ECN, KEMA

The Netherlands nation energy research foundation (ECN) and a commercial consultancy (KEMA) have been working on many studies devoted to the standardisation and integration of PLT communication protocols [80].

12.14 ENEL

ENEL has developed a system (called SITRED) for two-way communication using the distribution power networks as data transmission media [80*]. This system provides a data transmission link in each installation at every point of electricity delivery without requiring any additional physical structures. The SITRED apparatus is used to support the ENEL's Distribution Automation System, which is designed to,

- Remotely control the power distribution network
- Provide MV and LV customer service automation
- Provide new services to ENEL's customers
- Remotely read energy consumption data

12.15 Ontario Hydro

This Canadian utility is currently working on a concept called "Smart Utility Operations" [80*]. This project has the focus of,

- Development of a monitoring and communications system for distribution stations.
- Improving information processing and delivery through an advanced communication system.

12.16 Information Society Energy System - ISES

A three year joint association, beginning in 1996, between Sydkraft, Preussen Electra, Electricité de France, ABB, IBM and IT Blekinge has seen the establishment of a project aimed at providing research results within Information Technology (IT) and energy [80]. The project consisted of nine sub-projects, dealing with numerous issues in areas such as business administration, electrical engineering, communication technology and computer science.

The initial tasks of the project was to study in which way information technology would make energy distribution more efficient and at the same time create synergism with the growing information society by offering the electrical grid as a communication channel.

One example within the program has been the use of "Homebots" technology to develop a large-scale decentralised electric load management system. Within the system, intelligent software agents represent the electrical equipment and appliances and they communicate over the low voltage power grid in order to jointly optimise the energy use efficiency and the cost in a centralised manner.

12.17 The Karlshamn Efficiency Energy System – KEES

By using the knowledge obtained from the ISES project, the KEES project undertook the task of investigating the possibilities of making energy management more efficient, specifically in the municipality of Karlshamn in southern Sweden [80]. This project run during January and September 1999 under the supervision of Enersearch AB as part of its international "IT in Energy R&D" program. The project was made possible by the joint collaboration from several Swedish Universities, namely Lund University, University of Southern California, University of Karlskrona/Ronneby, The Royal Institute of Technology (KTH) and Linköping University (LiTH) as well the use of a steering committee.

The overall project structure was designed to find the answers to the following questions,

1. What are the impacts of the recent market and technology trends upon the energy sector?

- As seen from the perspective of the customer and market interest in energy saving activities and services.
- Investigating the new IT capabilities enabled by "smart home" technology.
- Looking at the associated new possibilities for energy management in buildings.

2. What can be achieved in energy efficiency and savings in the total energy system now and in the future, given these technology and market trends?
3. How should proposed energy efficiency and saving measures be practically implemented in available and emerging IT infrastructures?

The brief conclusions from the KEES projects were,

- Deregulation eventually reduces economic incentives for energy savings and efficiency.
- Energy savings of 10-20% are possible providing the investment cost of the new technology needed is reduced by around 50%. An alternative to this cost reduction would be cost sharing by using the energy saving IT infrastructure for other purposes.
- The information technology for the new home services is mature but how the customer want to interact with it is not well understood – ie. the technology is ahead of the market so real-life field trials focusing on the customer interaction with new forms of information and communication technology is needed.
- In-home networking applications require networks using no new wires.
- Price is the most important consideration in the household market but the customers are also interested in supporting energy saving activities and services.

The two future directions of the KEES project are the investigations into new energy business logistics and electronic energy markets. These investigations make up the new BRIDGE project.

The new energy business logistics project plans to understand the role that energy suppliers can play in their future market where services are bundled together in sometimes completely unrelated and spontaneous ways. Suppliers that survive this change from their traditional market ways must understand the logic of the service development in the shifting "infodigital" economy. The answers are proposed to take the form of specific services offers, service bundles and service models due to the convergence of the telecommunications and electrical energy industries, coupled with increased international deregulated competition.

The second part of the BRIDGE project investigating electronic energy markets will look into ways that a number of industries and the local energy utility can coordinate the energy management in new and more efficient manners by the use of information technology, in particular improving the coordination between production and use of energy.

12.18 The SaMBA Technology Program

This program, coordinated by the Finnish Association of Building Owners and Construction Clients is investigating Smart and Modular Building Automation (SaMBA) [24]. This program, that began in 1995, was set-up with the main objectives to satisfy the increasing and continuously evolving needs of the end user, to support the sustainable development, to open the markets to competition, to support cooperative networking and naturally to create internationally recognised leading edge technological solutions in terms of open building automation systems. The system is based on LonWorks' LonTalk protocol. The main assessment criteria in selecting the LonWorks technology included the actual needs of the building owners and tenants, namely the system performance, availability, open architecture and independence of vendors.

The goals are for lighting, air conditioning, heating, plumbing, security (property and personal) locking and access control to be compatible and easily manageable, therefore allowing the rooms serving the occupants to function in an automated manner. It is stated that smart situation control can reduce the electricity consumption by 20-60%. The modular distributed intelligence increases the systems flexibility and adjustability.

The broadest application of the program has been in the Viikki area in the city of Helsinki. This 1,000,000 m^2 area is designed as an ecology and technology model for the city. The area and all the buildings will have Lon-technology available in the housing, a science park as well as other non-residential premises equating to a total of approximately 13000 inhabitants and 600 jobs.

Through SaMBA, dozens of companies have brought hundreds of new products to the market. The Finnish State Research Centre (VTT) is currently developing an interoperability certification software tool to facilitate the fast and efficient verification of LonMark compliance for individual products. Examples of building projects based on the SaMBA technology include,

- The city of Helsinki's Public Works headquarters (HKR), were Lon-based building automation of the heating, security, fire and lighting system within the building had reduced total energy consumption by 15%.
- The Helsinki Telephone Corporation (HPY) automatically controls its lighting, temperature and ventilation systems.

Other products designed for automation include,

- Protection, control and monitoring devices and local operator interfaces for substation automation. (ABB Transmit Oy, Relays and Network Control Division)
- Lighting control and building automation including control panels, infrared receivers, relay units and dimmers. (Lexel Finland)
- Remote energy metering devices using the existing electrical networks as communication media. (Enermet)

- Fire and burglar alarm integration into automation systems. (Oy Esmi AB)
- Demand based ventilation control. (Halton Oy)
- Daylight-compensating lighting control that automatically adjusts the level of lighting within a room depending on the rooms' occupancy and current natural light conditions. (Oy Helvar)

12.19 The Internet Home

The Internet Home was built by a partnership between Cisco Systems and Laing Homes, completed in early 2000 to show just how far Internet technology is a part of our everyday life [81]. The show-house, built in Watford, London, contains many integrated control and automation devices, including,

- An all-purpose wireless web pad
- Home automation system accessed by the Internet
- Home security and fire protection system
- Automated lighting control
- Automated heating control
- Controllable household appliances
- Monitored electricity and gas meters
- Internet screen-phones

The following sixteen organisations donated equipment for the Internet Home,

> Axis Communications, BT, Business with Government (BwG), Compaq, DVD Plus, First Software, Fujitsu, Honeywell, Iomart, Citizen Connect, Motion Media, Perception Digital Media, Polaris Telemetry, RM, Symbol Technologies and Townpages.

12.20 Intelligent Distribution Automation Management – IDAM

This joint project between Sydkraft and IBM is aimed at obtaining sufficient knowledge for strategic decision making regarding long term IT system extension and management [80*]. The technology developed in this project is limited in respect to the slow speed of communications possible. The system developed has a modular structure with interfaces between different individual components in the system. This system is mainly intended for remote metering, distributed automation and customer services.

12.21 Sydkraft "Spjutspetsprojekt"

Sydkraft initiated this value added service project in 1998 [80]. This project plans to create a technical platform to enable these new services based around the Internet. The television set was chosen as the user interface for these services. It is expected

that all equipment within the customers home would have the required technology to allow for linked communication within the home and with the rest of the world.

12.22 The Diligensen project

Utilator have been involved in the Gävle intelligent home project, called the "Diligensen project", and the first new tenants entered their new apartments in early 2000 [82]. The tenants have the opportunity to control and access a number of different e-services. All the e-services, including the energy and temperature management, energy analyses and an WAP-enabled washing schedule were developed by Utilator.

12.23 cyberManor

This American Internet house, also built in partnership with Cisco Systems is designed to demonstrate the benefits of home networking and "always on" broadband services [83]. The home incorporates value-added services such as entertainment, integrated communications and shared family calendars. Cybermanor is a company that designs and implements home computer networks and broadband Internet access services.

12.24 Vattenfall/Sensel AB

Vattenfall, Sweden's largest energy company with 25% of the electricity sales in the Nordic region, is investing large sums of money into e-commerce that allows its customers to remotely control and monitor household devices and to purchase other value added services [84]. They have formed an independent daughter company named Sensel AB to deliver the technical aspects of these services. They will be the first company in Sweden to offer smart-building services on such a vast scale.

Initially (November 1999) 100,000 Swedish households will receive access to the services and deployment is planned for over 400,000 customers during the next two years.

Vattenfall has also recently built an Internet sales company called Abonnera that will most likely be the important sales gateway for the services.

According to Vattenfall, the Scandinavian market for the "Intelligent House" can be worth around SEK 15 billion (≈$US 1.7 billion) within three years.

The services let customers remotely monitor their refrigerators, ovens, electricity consumption and power status and control their burglar alarms and HVAC systems from afar.

The foundation for Sensel's services is a network integrated with the "Sensel Box", or home gateway, which provides customers with secure access to the service through their choice of a telephone or Web portal. A successful pilot program has been

providing Sensel smart-building services to fifty residential customers and six apartment buildings in Stockholm since mid August 1999.

Once the electricity-wire-to-Web communication network is built, Sensel plan to continue adding new services on top of their current base applications, maybe on a weekly or monthly basis.

The system will be using BEA's Weblogic family of e-commerce transaction servers and Coactive Networks Internet-based home gateways (Coactive Connector). The current supply of the Coactive gateways is valued at $US 22 million.

12.25 Utilator

Utilator is an offspring from a research collaboration project between the Royal Institute of Technology (KTH), Stockholm and Ericsson Radio Systems, Kista [82]. The company addresses the field of information technology in the form of small everyday e-services and develops, markets and operates a number of electronic services aimed at simplifying different aspects of everyday life. They are designed to be able to interact and communicate with each other in the framework not only within intra-home networks but also inter-home networks.

The services offered by Utilator are classified as,

- Energy and control
- Home care
- Media
- Operator
- Consulting
- Logistics
- Commerce and banking

The energy and control services offered are aimed at rationalising the use of energy both for heating as well as general household use, where this is possible to achieve by giving the components of the energy system the capability of communicating and exchanging information. They have been developing energy information systems that enable the inhabitant to visualise and analyse their energy consumption behaviour. The features of the visible and invisible energy systems include,

- Automatic energy metering services
- Measurement and billing systems for utilities for apartments
- Remote home control systems via WAP/PDA's
- Energy analysis systems
- Distributed climate control systems
- Control and surveillance systems for district heating

Utilator was invited as the keynote speaker at the first official Ericsson Third Party Developer conference concerning the e-box in December 1999. They were also

invited speaker at the Linux and Open Software 99 conference during October 1999 where they spoke about the e-box and the Linux environment for the connected home.

Utilator participated in the research project KEES (See section 12.17) were they presented energy services based on the e-box platform.

12.26 Kungsbäck IT Centre (KIT)

The KIT centre is located in Gävle and is the world's first OSGI application platform for IT-services to the home [85]. KIT is affiliated to the Centre for Built Environment at the Royal Institute of Technology (KTH).

Examples of the services offered to the home by KIT include,

- Internet access via the TV
- Video on demand
- Voice over IP
- Energy services
- Home care services
- Smart washing machines
- Remote control of household appliances

The goals of KIT are to,

- Explore the possibilities of using Internet technologies in building research.
- Provide an environment for the development of IT services to the home for the benefit of residents.
- Foster entrepreneurship and the up-start of companies selling IT services to the home.

KIT has a laboratory incorporating fast Internet access (1 Gbps), Linux and NT servers and a home laboratory for the on-site demonstration and testing purposes.

KIT collaborates with or is backed by many European organisations including the following based in Sweden,

- Enersearch AB
- Royal Institute of Technology
- Swedish Council of Building Research
- Gävle Energi AB
- Ericsson Radio Systems
- Sparbanksstiftelsen Nya
- Tel Air Europe
- Hyresbostäder Gävle AB
- County of Gävleborg
- Mitec AB
- Raditex AB

- Sybase AB
- Wireless Solution AB
- Utilator AB

The Energy Barometer was the first application at KIT. This is used to provide energy services to the user, which enables them to follow their energy use in real-time and compare their use to other energy users and to take actions. The services developed by KIT have centred on the use of Ericsson's e-box.

12.27 e2-home

In late 1999, Electrolux and Ericsson announce the establishment of a jointly owned company for the development and marketing of products and services for the Networked Home, which they called e2-home [63, 86]. The company intends to define a complete user-friendly "Plug and Use" infrastructure, making household appliances networked and connected to external providers of information and services over the Internet.

The new joint venture is a result of the strong commitment by both Electrolux and Ericsson to the future of the Networked Home. The business is expected to take off when the industry is able to offer intelligent, easy-to-use appliances with embedded microprocessors and communication modules. In addition, the existence of a Networked Home creates a substantial market for the delivery of new types of electronic services (e-services) to households.

The new company will act as a catalyst for a variety of electronic household services through the establishment of partnerships between the traditional Electrolux retail channels, service providers and network operators. For example, when selling a new freezer the retail channel will also be able to include online supervision of temperature and preventive maintenance.

The Electrolux Screenfridge and the Ericsson E-box service gateway give the new company a start. In addition to the investments already made by Electrolux and Ericsson in the development of the Networked Home, they will together, as a first step, invest SEK 70 million in the new company. The new company will immediately participate in a joint project with TeleDanmark.

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Appendix A: Network Technology Comparison

Table 15.1: Comparison A of Network Technologies [12]

Networking Technology	Advantages	Disadvantages
Conventional Ethernet IEEE 802.3	• Fastest data transmission rate up to 100 Mbps • Reliable and standards-based • Flexible	• Costly • Requires special wiring • Difficult to install • Requires hub, router and server for intelligent networking • Devices must be connected to the network using dedicated wires
HomePNA	• Fast data transmission rate up to 10 Mbps • Reliable and standards- based • Flexible • Uses existing home phone wiring • Easy to install • Low cost • No hub or router needed	• Devices must be wired to the network
Wireless: Ethernet IEEE 802.11	• Fast data transmission rate up to 11 Mbps • Reliable and standards- based • Flexible • No wiring required • No cables or wires • Mobility • Heavily supported by computer industry	• Can be costly • Can have structural setbacks (some walls block wireless signals) • Range problems • Base station required
Wireless HomeRF	• Fast data transmission rate up to 10 Mbps • Reliable and standards- based • Flexible • No wiring required • No cables or wires • Easy to install • Mobile • Low cost	• Range problems • Can have structural setbacks • Not as widely adopted as 802.11 • Base station required
Wireless: Bluetooth	• Reliable • Flexible • No wiring required • No cables or wires • Mobile • Low cost • Embraced by computer industry for handheld devices	• Limited range • Data transmission rate only 1 Mbps currently • Can have structural setbacks • Devices must have Bluetooth chip
Powerline	• Fast data transmission rate • Flexible • Uses existing power line home wiring • Easy to install	• Can have transmission blocks and interference • "Hostile" network environment • Tied to outlets • No standard established

Table 15.2: Comparison B of Network Technologies [12]

	Conventional Ethernet	HomePNA	Wireless: IEEE 802.11	Wireless: HomeRF	Wireless: Bluetooth	Powerline
How it works	Uses Category 5 wiring with a server and hub	Uses existing phone lines and FDM	Uses electromagnetic radio signals to transmit between access point and users	Uses radio frequency at 4.2 GHz	Uses radio frequency at 4.2 GHz	Uses existing power lines in home
Specifications and Standards Organisations	IEEE 802.3 IEEE 802.5	Home Phoneline Networking Association HomePNA 1.0 HomePNA 2.0 IEEE and WTU	IEEE 802.11 HR IEEE 802.11	HomeRF Working Group SWAP protocol	Bluetooth Special Interest Group (SIG)	Proprietary
Speeds	10 Mbps to 100 Mbps	HPNA 1.0: Up to 1 Mbps HPNA 2.0: Up to 10 Mbps	802.11 HR to 11 Mbps 802.11 to 2 Mbps	10 Mbps	1 Mbps	1 Mbps to 10 Mbps
Range	Up to 150 m (??)	Up to 150 m between nodes	30 to 90 m	Up to 30 m	Up to 10 m	Up to 800 m
Applications	RS, C, HC, HS, EI	RS, C, HC, HS, EI	RS, C, HC, HS, EI	RS, C, HS, HC, EI	C, EI	RS, C, HC, HS, EI
Compatibility with hardware, software and high-speed Internet access service	All with network capabilities	All with network capabilities	All with network capabilities	All with network capabilities	All with Bluetooth chip	All with network capabilities
Flexibility	Expansion requires additional wiring and network devices	Adaptors required to connect to some electronic devices	Adaptors required to connect to some electronic devices and in cases of range problems, access points.	Adaptors required to connect to some electronic devices	New products with Bluetooth chips	Adaptors required to connect to some electronic devices
Reliability	High	High	High to moderate	High to moderate	High to moderate	Moderate
Cost	High	Low	Varies	Moderate	Moderate	Low
Privacy	Secure	Secure	Secure	Secure	Secure	Secure

RS = resource sharing
C = communications
HC = home controls
HS = home scheduling
EI = entertainment & information