



Enabling the “Interconnected Home”: a European vision

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Overview

Complex challenges stand between the vision and reality of a “interconnected home” where people can access any services they like from any device and in any room they choose. The heterogeneous nature of the solutions for implementing wired and wireless networks (i.e., each built from various sub-networks and with their own protocol stack and physical transport medium) in the interconnected-home and service-platform environments stands in the way of both interoperability and the ability to access services and information.

In a Europe-wide effort to seamlessly integrate the different network segments and therefore close the gap between the interconnected-home vision and reality, a two-year research project called HomeNet2Run was started in 2001 under the auspices of the ITEA (Information Technology for European Advancement) program within the EUREKA framework. This huge collaborative effort focuses on broadband access networks, residential gateways, high-speed wireless in-home networks and bridges in a heterogeneous network environment. Participating in it is a consortium of distinguished European companies and research institutes.

Targeting the development of end-to-end network architecture, as well as standards and technologies that enable access throughout the “broadband home” to information, communication and entertainment (ICE) services over any network, to any device and at any time, HomeNet2Run has now been concluded on schedule. This white paper summarizes the project’s vision and achievements, the practical results of which can now be demonstrated.

The HomeNet2Run Consortium

Participants in the HomeNet2Run project include leading names in the worlds of electronics and research: Philips, STMicroelectronics, dZine, IMEC, PIMC, Jabil



(Belgium), ATLINKS, Canon, Thomson (France), CEFRIEL, CiaoLAB Technologies (Italy), Thomson, Sony, Grundig, Deutsche Telekom, Fraunhofer IIS (Germany), Philips and the Technical University of Eindhoven (Netherlands).

The future market for networked homes

The major change expected in the way that people will satisfy their future needs regarding information, communication and entertainment is being driven by the deregulation of telecommunications markets, together with the rapid digitalization of audio-visual entertainment functions and the spectacular progress in information processing and storage technology (especially in price / performance).

New and more interactive forms of video infotainment are emerging and digital TV broadcasting and audio-video streaming based on the Internet Protocol (IP) are now becoming a reality. Meanwhile, Internet access via cable-TV and telephone networks is growing rapidly and digital pipes will eventually extend into the home. Together with cheap mass-storage devices that gain functionality from public networks and enable them to be used both outside and inside the home, these developments will mean that the interconnected home will offer many opportunities for a wide range of new and personalized digital services. With around 150 million households in European Community member states alone, the opportunity for electronic equipment manufacturers, network operators and service providers is vast.

Challenges on the way to the networked home

If we take a look inside today's home, we will find network connections for televisions, phones, audio/video equipment, and personal computers. Yet all of these networks are different in terms of the technologies and bit rates they use. They remain distinct clusters or "islands" that are unable to interact with each other.

Despite this current situation, the interconnected home is widely recognized as being the next large step in the networking revolution, a domain where our lives will be strongly influenced by the benefits of the merger between consumer technology and the full range of services available via Internet. Although such a scenario is dependent on consumer products working seamlessly together, many technical challenges remain to be overcome.

Seamless interoperability between appliances from different vendors, as well as their ease of use and installation is only part of the challenge. Secure access and delivery to networked ICE services, interoperability across the different networks and between home networks and service platforms, not to mention shielding users from the heterogeneous nature of networks and platforms, are all challenges that must be addressed.

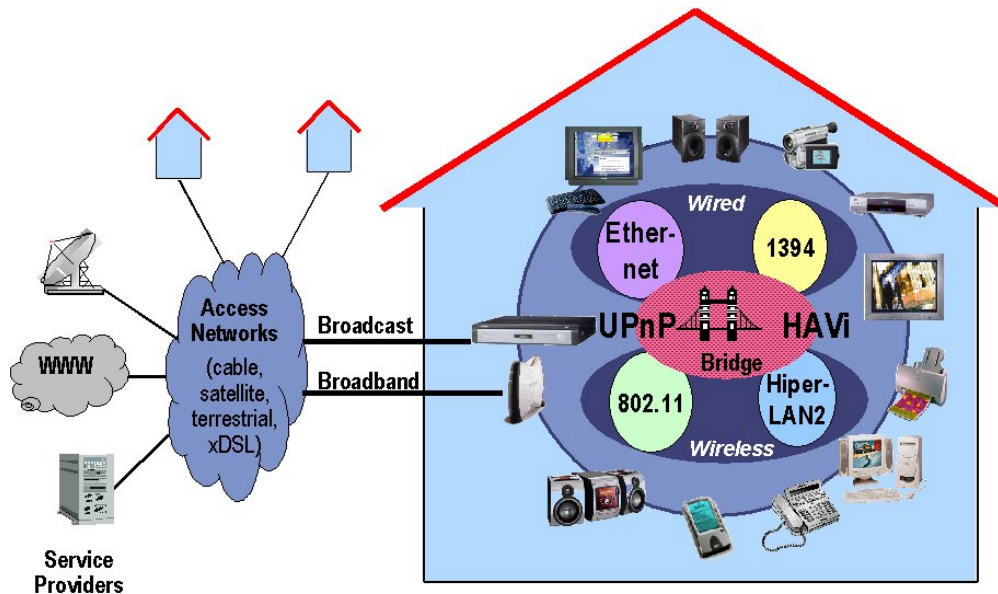


Figure 1: HomeNet2Run reference diagram

There are currently no overall homogenous solutions for the implementation of either wired or wireless networks because of the variety of solutions and devices that exists, mainly as the legacy of consumer equipment stemming from the separate audio/video and PC domains. Neither is this heterogeneous picture likely to change.

The big challenge, therefore, is the physical and seamless integration or “bridging” of the various “islands” of existing heterogeneous networks. This must take into account the different standards for the computing, consumer, and communication industry segments representing the multiplicity of outside-home technologies providing services. So, bridging is necessary at the control and media levels, as well as the physical network and transport level. The keyword in providing communication across heterogeneous platforms is control middleware.

Moreover, solutions must not undermine the underlying and differing business models of the respective worlds providing services. And content must remain identifiable and be protected as it travels from one world to the other.

Crucial elements for the networked home

The HomeNet2Run project identified 7 crucial elements for achieving the networked-home vision:

- Content packaging and routing
- Residential gateways
- Quality of service



- Wireless in-home networks
- Middleware
- Content coding
- Digital rights management (DRM).

- Content Packaging and Routing

IP packaging and routing, which offers the possibility to separate applications from the underlying distribution / transport mechanism, will form the basis for communication in global and local networks, although in some cases the transition period to an all-IP solution could be as long as a decade. There is also a trend that IP will grow in importance for local in-home networks, especially those specified in the future, but it will not be the only solution.

Non-IP protocols will be terminated in so-called residential gateways, unless compelling reasons, e.g., system costs, prevail. IP-packaging and routing is a consequence of there being no homogenous networks - neither wired or wireless – and does not mandate any physical layer or accept any lack in Quality of Service, the responsibility for which is delegated to the lower system layers.

- Residential Gateways

The residential gateway acts as a firewall between the in-home networks and public networks, filtering content to leverage the traffic capacity difference between them. Services to the interconnected home (via digital-subscriber loops, wireless and satellite, as well as cable TV networks) will arrive at the home's residential gateway where the various networks will be terminated and the respective protocols converted to the in-home network protocols. Evolving towards a "home server", which has mass-storage capability, multi-modal user interface functionality, and serves as a navigator to find network services and functions.

As multiple-standard access networks evolve during the transition phase to IP-based service delivery, the use of residential gateways will enable a new category of customer premises equipment that will also evolve. Two scenarios are envisaged: 1) multiple access networks (dedicated service networks), and 2) one access network comprising a variety of available full-service networks (DSL, broadband cable, satellite, and terrestrial). As inter-gateway communication plays a minor role in both scenarios, HomeNet2Run has not specified protocols for these, but has focused on the provision of residential gateways for connecting the home network to various access networks.

- Quality of Service

Guaranteeing quality of service (QoS) is a major challenge due to a multiplicity of QoS requirements that will vary according to the underlying business models, and as technological developments take place on a continuous basis. HomeNet2Run uses the



most appropriate QoS mechanisms and standards that cater for different business models and enable the establishment of an optimum network path. Mechanisms have been developed to signal QoS requests and to ensure use of the most appropriate transmission channel, for example, RTP (Real-time Transport Protocol) transmission via asynchronous IP-over-1394, bandwidth reservation within the UPnP framework or mechanisms studied in 802.11e networks for basic service functionality, and isochronous channels or HiperLAN2 error-protected direct links for audio/video transmission.

- Wireless In-Home Networks

Although audio /video networks are likely to start with wired interconnection of IEEE-1394 devices in the same room, wireless interconnection is an important driver and room-to-room connections will be both wired and wireless. The QoS framework enables the most appropriate network path and transmission scheme to be selected.

HomeNet2Run has enabled research and interoperability testing of audio/video-capable wireless in-home networks based on the HiperLAN2 and the 802.11a standards. However, these and other competing home-communication technology options need to be brought up to the capacity levels necessary for the transport of audio/video. The consortium foresees a unique opportunity to use the WLAN frequencies allocated in the 5-6 GHz frequency band for high-quality, high-data-rate audio/video distribution in the home, for which a common view is required by the IT and consumer electronics industries.

- Middleware

Essential to the implementation of home networks is an appropriate middleware-enabling device and service registry and detection, as well as proper network management. Two existing and alternative middleware concepts are currently available (HAVi and UPnP), but these do not provide a comprehensive solution. HomeNet2Run provides bridges between the two and provides an efficient and acceptable middleware solution that fits the long-term vision. The concept of a global service discovery / registry that is universal for all types of broadcast and Internet services still has to be specified and the design of such a service is a possible future project. Beyond this, the Open Services Gateway Initiative (OSGi) has been fully studied as part of the solution for service distribution

- Content Coding

In the digital era, content is not expected to be as harmonized as in the analog era, with CVBS and stereo FM dominating future coding for video and audio, respectively. The transmission of MPEG-2 encoded signals will be mandatory in any future home audio / video network, as mass-market products will feature dedicated silicon relying on that coding scheme. However, more advanced coding schemes will evolve that must be adapted to regardless of the hardware or software being used, and MPEG-2 distribution



will be complemented by schemes like MPEG-4, which will feature in powerful new consumer devices.

- Digital Rights Management

Digital Rights Management (DRM) will be a key enabler (and disabler) in digital in-home networks, and HomeNet2Run participates in standardization groups like DVB-CPT. The consortium favours a network independent DRM / Conditional Access solution. This would enable consistent delivery of content over a variety of different physical network segments and avoid restriction of transmission to certain network segments or point-to-point connections.

The achievements of HomeNet2Run

At the transition between the analog and digital worlds, HomeNet2Run set out to prove that heterogeneity in digital home networks (which we will live with for some time to come) need not necessarily lead to complex system behaviour and handling, but that this heterogeneity can be masked from consumers by the appropriate system management and bridging technologies. In the process of successfully developing an interconnected-home architecture that supports innovative user scenarios, the project looked critically at various European standards, e.g., HiperLAN2, DVB, and MHP (Multimedia Home Platform), and contributed to their improvement. Other standards, e.g., IEEE 1394, HAVi and UPnP, have been extended appropriately, while the next-generation Internet Protocol Version 6 (IPv6) has been taken into consideration. This work has resulted in working prototypes that prove these standards can easily be applied in consumer products.

- Residential-gateways

The interoperability of HAVi has been combined with the interactivity of MHP. Furthermore, IEEE 1394, HAVi and MHP technologies have been integrated into a stable platform (called N-MHP) for which new APIs and enhanced functionalities have been created. The N-MHP/HAVi architecture provides network-device access to broadcast-interactive applications through an extension of the MHP API.

Residential gateway architectures have been created for:

- IP-based telephony: between various devices in one home, and between devices in different homes. UPnP/VoIP phones have been provided with extended functionality.
- Audio/video-over-IP streaming, supporting IP transparent streaming, protocol conversion (IP/IEC61883 proxy), stream control functionality (HAVi/RTSP and RTSP proxy), and bit-rate transcoding.
- Control functionality for Video-on-Demand (VoD) and multicast services (RTSP proxy), and for streaming services (using a HAVi / RTSP proxy).
- Bandwidth reservation: UPnP IGD with bandwidth-management functionality.



- Remote access/control of home networks based on DNS_ALG and OSGi service-provision framework, respectively.

Other achievements include: designing a bandwidth reservation scheme for deployment in a UPnP-based home network; describing conditional-access/copy-protection mechanisms for distribution of data or audio/video over a home network, and creating a CA/CP framework for home networks

- Bridging

The "Heterogeneous Network" group of the project worked on the architecture of different concepts for bridges and gateways. The work resulted in a comprehensive system specification for several bridging architectures: IEEE1394 over IP bridge, HAVi-HAVi bridge based on IEEE1394.1, proxy-based HAVi-UPnP gateways, HAViML gateway, voice-over-IP application. In addition to the bridges and gateway specification work, the project invested considerable effort to develop the aforementioned concepts in functional real-time modules. The modules have been implemented and tested, and their functionality has been validated within an interconnected environment. For the very first time, real-time streaming of AV content crossing two different physical networks has been demonstrated.

- Wireless interoperability

A major achievement has been the establishment of an interoperability-test organisation in partnership with ETSI, which has a much broader and long-term impact than the project itself. As a result, the wireless interoperability activity is continuing in the ETSI framework and with new partners and takes on a new and broader dimension. Plans are afoot for extension to other organisations dealing with video transmission. Beyond this, 5Ghz prototypes validating the principles and specifications of wireless technologies have been created, as well as a complete 'transparent bridge' specification that is ready for standardization.

User benefits

The HomeNet2Run consortium has built a demonstrator to show key aspects of the interconnected-home architecture, including: HiperLAN2-based wireless connectivity, MHP-based interactivity in in-home networks, broadcast and on-demand video over IP, bridging across Ethernet and 1394 networks, and vendor interoperability.

- Room-to-room audio / video communication

The first demonstration shows how "bridges" enable content (in this case, music) to be moved around the home without being limited to the device in any particular room (e.g. currently you can only listen to sound from your CD-player or watch video on your



recorder in the same room). It shows that home devices need not limit people's freedom to roam around their homes.

- Room-to-room audio / video control

Increased access to content requires increased control on behalf of the user. This demonstration shows how the distributed control in a home network lets people control devices (e.g. TVs, recorders and web pads) from anywhere in the home through bridging audio / video and PC applications by linking devices governed by HAVi and UPnP standards.

- Content access at any time and on any device

Accessing the content you want (e.g. Internet, broadcast or stored), when and where you want and on any device is the subject of a demonstration that highlights the flexibility and freedom offered by home networking. Watch TV in one room and continue watching the same program in another room on a different device.

- Bridging the PC and consumer-device worlds

In the not-too-distant future, as broadcast-quality TV becomes deliverable to homes over broadband IP networks, the functionality currently located in end terminals will shift into the access network. This demonstration shows how the Networked Personal Video Recorder receives live content from multiple TV stations and caches it on large video servers (located in the access network) in compressed digital format. This enables people to watch TV programs at anytime without having to record on their VCRs, and interrupt (pause and resume) a live TV broadcast (e.g. to take a phone call) without having to miss anything. They can also get assistance in selecting favourite TV programs and other content from the past, present or future, as well as being able to access the content from either a PC or other consumer device.

- Home-to-home synchronized video-stream sharing

In the final demonstration, examples are given of how audio and video content can be shared simultaneously in different homes using interconnected-home devices (e.g. TV sets and IP phones) in combination with a high-speed Internet connection. Also within the interconnected home, audio/video streams can be transferred via wireless links to portable devices such as web pads and personal digital assistants.

Summary

By focusing strongly on digital home interconnections for consumer appliances and providing an interconnected-home architecture, the HomeNet2Run project has demonstrated that the interconnected home offers many opportunities for a wide range of new combinations of broadcast, Internet and telecommunications services – areas that were previously distinct from each other.



The collaboration between HomeNet2Run consortium partners, who are all representatives of the European consumer, telecommunications and IT electronics industries, has helped European industry to maintain a competitive position in a domain with high growth potential. This was achieved by contributing to the development of a shared and consistent long-term vision, to standardisation effort, to improvement in European cooperation (HomeNet2Run has stimulated strategic partnering between manufacturers of electronic equipment, network operators and service providers), and to the creation of new product opportunities that will boost the position of the European electronics industry and related digital services and content industries at the start of the digital era.

For more information about HomeNet2Run, please see our website at <http://www.homenet2run.org>.

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