STAND-ALONE ELECTRONIC PRODUCTS ARE BECOMING INCREASINGLY LESS COMMON IN OUR HOMES. TV SETS ARE CONNECTED TO VIDEO RECORDERS AND SET-TOP BOXES, SPEAKERS TO AUDIO SETS, PRINTERS AND CAMERAS TO COMPUTERS. THE MOST DESIRABLE NEXT STEP WOULD BE TO CONNECT ALL PRODUCTS INTO A SINGLE NETWORK. **In an ideal situation, you would bring a new product into the home, put it where you want it, plug it in and it will not only do what you want, but it will also link to other products and prepare for their joint operation. A home network can not only do just that for you, it can also control your children's access to certain TV programmes, detect when a product is defective or disconnected, maintain your personal preference profile and make it available throughout the house.**

Vision

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COMMUNICATION

This situation has not yet been realized, but Consumer Electronics (CE) companies throughout the world are working hard to fulfil this dream. There is a real need for inter-company cooperation, because consumers do not want to exchange all their products for new ones of just a single brand. The CE companies have joined forces and created a standard that is more advanced in user friendliness and completeness than that of the ambitious PC and telecom industries striving to expand into the living room. Apart from policy arguments, technical features play a role in this proces and thus research organizations are heavily involved in this, sometimes chaotic and hectic, process.

Changing rules

Digitization of content, driven by Moore's law, changes the rules of the game in the home: not only is the performance of semiconductors growing exponentially, the price for the same performance is also decreasing dramatically. New applications are becoming possible with a speed new to the home (entertainment) environment: radio and TV broadcast via the Internet, stopping and starting live TV broadcasts without missing a thing, taking a look at who is at the door without leaving your chair, … (see Password 3, pp 10-13).

Digitization of content, implies storing, processing and transferring it in the digital domain, broadcasting it to the home and from box to box in the home. Overall this promises better quality, more flexibility, and new applications. Music and movies can be handled similarly to other kind of digital data, which drives the convergence of the previously separate domains of entertainment, communication and information. There are endless possibilities, hype is created to promote competing technologies. Fear of missing opportun-

The struggle to get the right communication architecture

"In order to realize our vision of bringing new devices into our homes, putting them where we want them, and enabling them to work together with the equipment already in place, means taking risks and making choices now. Even though we cannot completely foresee the consequences which lie far ahead of us. The explosive growth of markets for such new products demands a flexible organization with short decision lines," says Tobias Helbig, department head of Philips Research. "Every box will need a communication interface to make an 'operating system' on a network possible, and although there is no immediate profit, eventually it will sell more boxes and applications running on them."

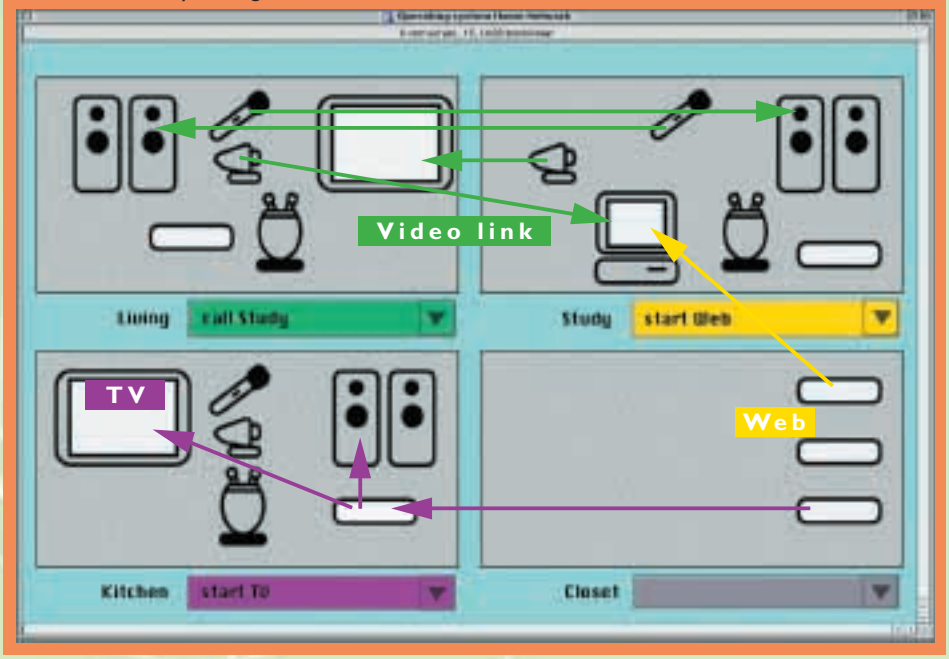
ities and uncertainty is widespread, since it is so hard to predict the changes that will materialize, and which of those are likely to prove to be the winning bets.
In short: welcome to the new world of home networking …

Three layers

Basically, a home network consists of the boxes in our home –TV, video recorder, DVD player, PC, printer, cameras, portable screens– linked by wired or wireless connections. New applications make use of these boxes, separately or in combination, to offer useful features to the consumer. In a simplified approach, three layers can be distinguished in the communication architecture: the networking layer that enables interconnectivity, the middleware layer that enables interoperability, and the applications which ultimately bring value to the consumer. A standardized way of achieving interconnectivity

Advanced management system

An IHDN is a distributed and heterogeneous network built in incremental steps, which, with a limited amount of memory, must react quickly to non-technical, inexperienced users. It must be absolutely reliable and support automatic management applications. A model for such a system is now being developed that offers the user the required level of automatic control and functional diagnosis, and at the same time offers the technician who installs or maintains it, detailed technical system control and information for problem analysis. It has to provide for commands such as 'Call study', 'Start TV in kitchen' and 'Start web in Study' occurring simultaneously and communication between the different devices in the network has to be handled in a consistent way, see figure.



and interoperability is needed. Companies form consortiums and have to be flexible, to be able to switch from one body to another if prospects for success change.

Interconnectivity

Connections between devices can be wireless (see Password 2, pp 16-19) or wired. Existing cabling such as phone networks or power cabling or new cabling can be used. The communication links transfer information (bits) from device to device without knowing what they represent: video, audio or data.

In the traditional mobile networks, as operated by telecommunications companies, communication between terminals practically always occurs through the base station. This is logical enough, because the telecommunications companies, in addition to getting their revenues from selling terminals, also earn from the data traffic. However, in a wireless home network you would not want a pre-defined base station to be included in each link between two terminals. At Philips Research a set-up was defined in which there is a dynamic selection of the terminal playing the role of the base station. In addition to this, terminals can talk to each other directly and the base station only manages the bandwidth required. You do not have to switch on your set-top box if you just want to look at a video from your VCR and you get more bandwidth since streams go directly and not via the set-top box. Due to concerted action of the CE industry this approach is now part of the ETSI/BRAN Hiperlan/2 standard for wireless communication in the 5-GHz frequency range, which is the only one that can be used worldwide for true broadband applications in this range. Prototypes that comply with this standard are now in the making and will be shown soon. Along with Philips Semiconductors, chips are being designed that will realize this functionality in CE products.

Interoperability

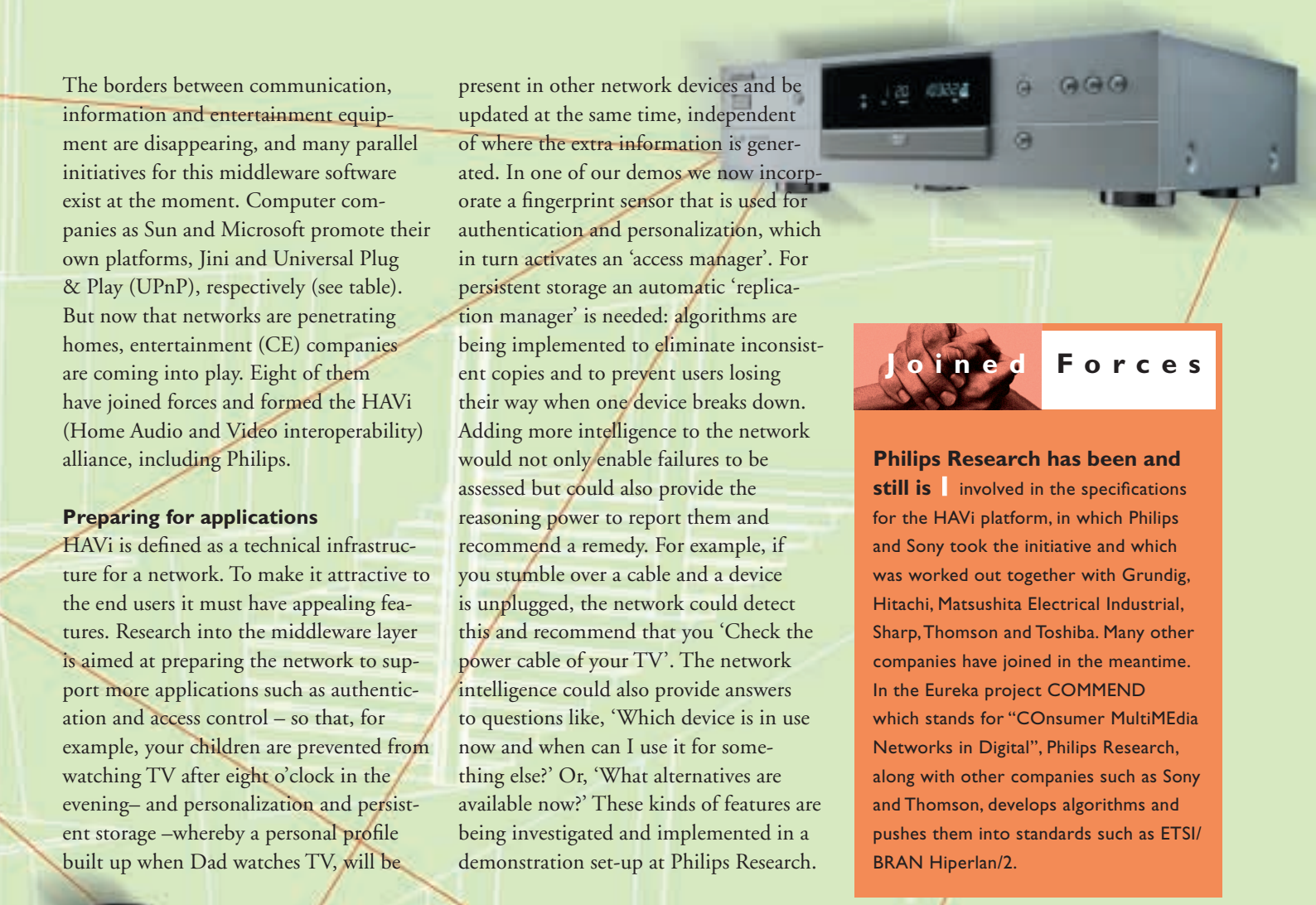
The challenge is to provide for the interoperability in a way that is as flexible and unobtrusive as possible. Interoperability is made possible by the second layer of the communication architecture, which interfaces with both the network and the applications layer, and consists mainly of software called middleware. This is the glue that makes the concept of cooperating equipment work. If a display is required, for instance, for displaying information from a security camera, the middleware detects which display is available for that function and how to address it. Middleware resembles an operating system in a computer, but in this case it is distributed over the constituent devices making up the network. In this layer, links are configured, communication protocols are set up and bandwidth is allocated according to the application. Middleware prepares the network optimally so that applications can run smoothly. Moreover, certain features that are independent of a specific device or application can be accounted for in this intelligent part of the network. For example, your personal preference tor certain TV channels is available on all of the TV sets in the house.

initiative	main companies	based on	focus on
Jini	Sun Microsystems	Java technology	service discovery and interoperability
UPnP	Microsoft	Internet protocols	PCs and peripherals
HAVi	Sony, Philips, Toshiba, Matsushita, Sharp, Grundig, Thomson, Hitachi	IEEE 1394 (FireWire or iLink)	audio/video devices and streaming

The borders between communication, information and entertainment equipment are disappearing, and many parallel initiatives for this middleware software exist at the moment. Computer companies as Sun and Microsoft promote their own platforms, Jini and Universal Plug & Play (UPnP), respectively (see table). But now that networks are penetrating homes, entertainment (CE) companies are coming into play. Eight of them have joined forces and formed the HAVi (Home Audio and Video interoperability) alliance, including Philips.

Preparing for applications

HAVi is defined as a technical infrastructure for a network. To make it attractive to the end users it must have appealing features. Research into the middleware layer is aimed at preparing the network to support more applications such as authentication and access control – so that, for example, your children are prevented from watching TV after eight o'clock in the evening– and personalization and persistent storage –whereby a personal profile built up when Dad watches TV, will be present in other network devices and be updated at the same time, independent of where the extra information is generated. In one of our demos we now incorporate a fingerprint sensor that is used for authentication and personalization, which in turn activates an 'access manager'. For persistent storage an automatic 'replication manager' is needed: algorithms are being implemented to eliminate inconsistent copies and to prevent users losing their way when one device breaks down. Adding more intelligence to the network would not only enable failures to be assessed but could also provide the reasoning power to report them and recommend a remedy. For example, if you stumble over a cable and a device is unplugged, the network could detect this and recommend that you 'Check the power cable of your TV'. The network intelligence could also provide answers to questions like, 'Which device is in use now and when can I use it for something else?' Or, 'What alternatives are available now?' These kinds of features are being investigated and implemented in a demonstration set-up at Philips Research.



Joined Forces

Philips Research has been and still is involved in the specifications for the HAVi platform, in which Philips and Sony took the initiative and which was worked out together with Grundig, Hitachi, Matsushita Electrical Industrial, Sharp, Thomson and Toshiba. Many other companies have joined in the meantime. In the Eureka project COMMEND which stands for "COnsumer MultiMEdia Networks in Digital", Philips Research, along with other companies such as Sony and Thomson, develops algorithms and pushes them into standards such as ETSI/BRAN Hiperlan/2.