Tijdschrift van het NERG

Correspondentie-adres: postbus 39, 2260 AA Leidschendam. Internet: www.nerg.nl, secretariaat@nerg.nl
Gironummer 94746 t.n.v. Penningmeester NERG, Leidschendam.

DE VERENIGING NERG

Het NERG is een wetenschappelijke vereniging die zich ten doel stelt de kennis en het wetenschappelijk onderzoek op het gebied van de elektronica, signaalbewerking, communicatie- en informatietechnologie te bevorderen en de verbreiding en toepassing van die kennis te stimuleren.

BESTUUR

LIDMAATSCHAP

Voor het lidmaatschap wende men zich via het correspondentie-adres tot de secretaris of via de NERG website: http://www.nerg.nl. Het lidmaatschap van het NERG staat open voor hen, die aan een universiteit of hogeschool zijn afgestudeerd en die door hun kennis en ervaring bij kunnen dragen aan het NERG. De contributie wordt geheven per kalenderjaar en is inclusief abonnement op het Tijdschrift van het NERG en deelname aan vergaderingen, lezingen en excursies.
De jaarlijkse contributie bedraagt voor gewone leden € 43,- en voor studentleden € 21,50. Bij automatische incasso wordt € 2,- korting verleend. Gevorderde studenten aan een universiteit of hogeschool komen in aanmerking voor het studentlidmaatschap. In bepaalde gevallen kunnen ook andere leden, na overleg met de penningmeester voor een gereduceerde contributie in aanmerking komen.

HET TIJDSCHRIFT

Het tijdschrift verschijnt vijf maal per jaar. Opgenomen worden artikelen op het gebied van de elektronica, signaalbewerking, communicatie- en informatietechnologie. Auteurs, die publicatie van hun onderzoek in het tijdschrift overwegen, wordt verzocht vroegtijdig contact op te nemen met de hoofdredacteur of een lid van de Tijdschriftcommissie.

TIJDSCHRIFTCOMMISSIE

INHOUD

Van de redactie 66
Michel Arts

A Four-Tiered Hierarchy in a Converged Fixed-Mobile Architecture, Enabling Personal Networks 67
Nico Baken, Edgar van Boven, Frank den Hartog, and Ramin Hekmat

In-home Video Distribution for Telecom Operators . . . 77
Bas Hendrix, Frank den Hartog, Harrie van de Vlag and Nico Baken

Virtual Mobility Enabling Multidimensional Life . . . 86
Nico Baken, Edgar van Boven, Ramin Hekmat and Ludmila Menert

Ledenmutaties NERG 96
Proefschriften 97
Persberichten & Aankondigingen 103
PATO Cursusaanbod 2006 103

Deze uitgave van het NERG wordt geheel verzorgd door:
Henk Visscher, Zutphen

Advertenties: Henk Visscher
tel: (0575) 542380
E-mail: : henk.v@wxs.nl
ISSN 03743853

Van de redactie

Michel Arts
E-mail: arts@astron.nl

Dit nummer van het tijdschrift bevat drie Nederlandse bijdragen aan de FITCE conferentie. Deze papers zijn ook gepresenteerd tijdens de themabijeenkomst FITCE 2004 die op 11 november 2004 werd gehouden. De themabijeenkomst werd georganiseerd in samenwerking met de afdeling telecommunicatie van het KIVI. Het paper "In-home Video Distribution for Telecom Operators" verdient een speciale vermelding. Dit paper werd onderscheiden met de Best Paper Award. De redactie feliciteert de auteurs van dit paper met deze prijs.

Verder bevat dit nummer, traditiegetrouw, het overzicht van de promoties aan de technische universiteiten op het gebied van de elektrotechniek. De TU Delft komt in dit overzicht ook weer voor. Dit heb ik in het vorige nummer al vermeld. Het overzicht bevat voor het eerst geen onderverdeling meer in categorieen. Het is in de praktijk erg moeilijk om een bepaald proefschrift in een bepaald hokje te plaatsen.

Verder besteden we aandacht aan een aantal benoemingen. Professor Gert Brussaard is benoemd tot vice-president van de URSI en professor Djan Khoe is benoemd tot fellow van de Optical Society of America (OSA). De redactie feliciteert beide heren met deze benoemingen.

Wat ik over de verschijningsfrequentie van dit tijdschrift in vorige nummers vermeld heb is helaas nog steeds van toepassing. Het is in de praktijk moeilijk om aan kopij te komen. Ondanks inspanningen van de redactie hebben we nu nog materiaal om een nummer te vullen. Dit nummer zal aan het einde van dit jaar of begin volgend jaar uitkomen en is het vierde en laatste nummer van dit jaar.

A Four-Tiered Hierarchy in a Converged Fixed-Mobile Architecture, Enabling Personal Networks

Nico Baken, Edgar van Boven,
Frank den Hartog, and Ramin Hekmat

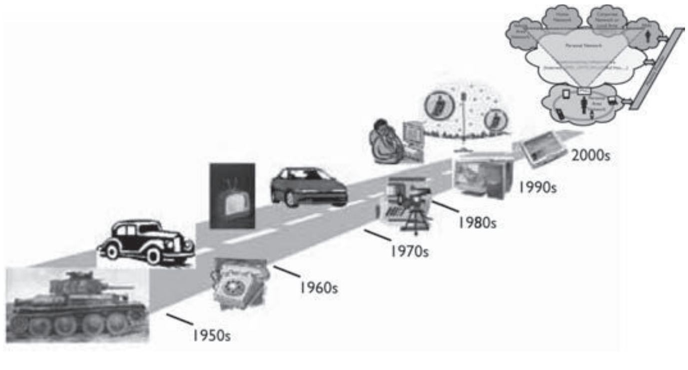
We present a new way of capturing the future technical infrastructure of a converged fixed-mobile infrastructure by means of a four-tiered hierarchy of one fixed and three different mobile and wireless (access) layers. With such a view, the current range of heterogeneous interconnected public and private networks can be easily modelled as a landscape of pockets (the mobile/wireless networks) with various depths and widths, connected by a drainage of high capacity (the fixed network) in which marbles (information) find their way. The metaphor clearly illustrates that higher demand for mobility will increase the need for a densely distributed high-capacity fixed access network. It also shows the high potential of the relatively new concept of personal networking. In the light of this model, we describe crucial technologies for fixed-mobile convergence, such as handover, roaming, and gateways. Summarising, we believe that our contribution in this paper could prove to be a helpful guideline to the telecom industry both from a strategic and operational perspective.

Introduction

Within the realm of the ICT world we can distinguish some clashes of beliefs in different technologies. We witnessed the clash between the 'net-heads' and the 'bellheads'. By the way, is this fight over? Was it a non-issue? Now it looks as though a new non-clash/issue is emerging: the clash between the fixed and mobile believers. Although we do not have the arrogance to prevent this clash by giving some insights into this matter, we embark with this paper on a fundamental endeavour. As an introduction, we have to go back in recent history (Figure 1).

Directly after World War II, the world was 'shaken', and people craved to find new certainties corresponding to the lower Maslow layers: housing, food, security, jobs, and getting the economy restarted. This building phase in the 1950s created the conditions for prosperity. In the 1960s and 1970s, the plain old telephony service became a reality for nearly all families in the Western world, and, in the 1970s and 1980s, the same became true for the automobile, enhancing physical mobility tremendously. Now combining the latter two developments explains retrospectively the unpredicted and vast success of mobile telephony in the 1990s. To technologically realise mobile telephony, operators rolled out, in Europe, the second mobile generation; that is, the GSM networks. In The Netherlands alone, some 5000 GSM masts were erected to cover the whole of the country, creating large radio say macro-cells (with a radius in the order of several kilometres), which can be interpreted as large electromagnetic extensions of a fixed (access) network; this with the aim to cover all those areas, firstly along highways where obviously the fixed access networks were not nearby. Thus the mobile customers, say the 'mobiles', were enabled to make their voice calls 'on the move'. In that same decade of the 1990s, we see the gradual appearance of stand-alone PCs in nearly every home, and, after 1995, the rise of the World Wide

Figure 1 The road towards personal networks.



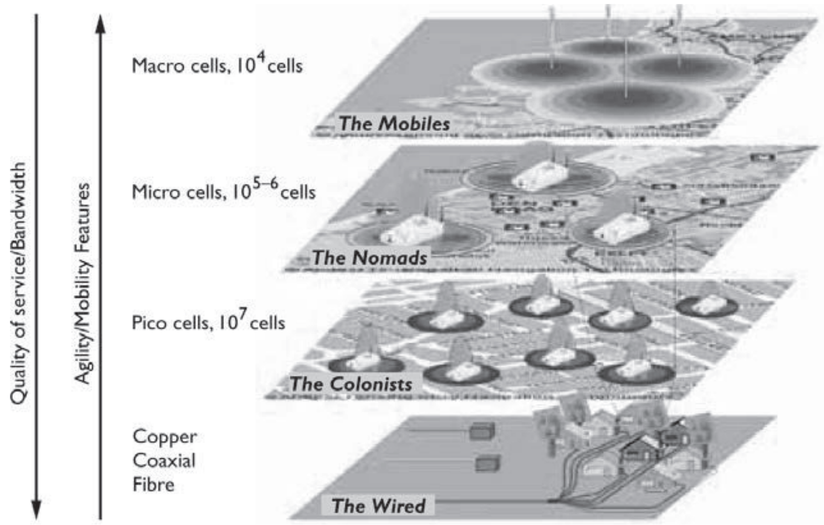


Figure 2 Four-tiered hierarchy of the future network

Web and the phenomenon of getting online all these PCs, and, as a latest trend in our decade, the explosion of broadband services for the residential customer based on DSL- and cable modems.

Add this all together and we will see the inevitable birth of the *personal network* (PN). However, the users of PNs will be most of their time a 'colonist' or 'nomad'[1], and the latter will be topographically often in urban areas where the fixed network is near, this contrary to the early 'mobiles'. This means that the 'electromagnetic extension of the fixed network' can be smaller for the first two categories: the radio cells for them can be smaller, but require more 'bandwidth power'. Thus, we could roughly associate the three user groups with pico, micro and macro radio cells (see also further on) on layer two, three and four in Figure 2, which gives a rough draft of a four-tiered hierarchy of future networks. All three cell types are connected to the fixed network, but the connection differs in terms of bandwidth.

The authors believe that the future technical infrastructure of a converged fixed-mobile infrastructure can be captured in a four-tiered hierarchy of one fixed and three mobile (access) layers. Recognising the subtle interdependency between distance, bandwidth and quality of service (QoS), we conclude that obviously the radio cells need to become smaller with the increasing demands for personal networks and their growing needs for broadband applications. Combine this with the requirements for realtime services and the complementarities of the fixed and mobile networks becomes fully evident: *Mobility is a crucial service feature and the more (broadband) mobility will be required, the smaller the radio cells and the more fixed access network capacity, that is, bandwidth, will be required. In the end we will see therefore ether over fibre!*. The first signs of the latter can be seen in Reference 1.

We distinguish four layers. The bottom layer can be associated with the fixed access network, on top of that three layers with different mobile and wireless access technologies. In the picture of the 4-tiered hierarchy, it is denoted that the QoS will increase for a given service in the downward direction. This may not yet be the case but will be a fact once micro and pico cells are standardised and have levelled their maturity with that of the macro cells.

The end-user, depending on his/her role (employee, member of a community, etc.) plus his/her location, will be able to gain access to his/her personal network, whereby authorisation will be granted on the basis of something the user possesses, knows and is. Continuity of the service can be maintained internationally through seamless vertical and horizontal handover across and in three mobile layers delivered by service provider packagers using again a four-layered business model.

In the first mobile layer we will see, in The Netherlands, some 10 million pico cells, in the heart of

1 The agility/mobility of a user increases from colonist, via nomad to mobile, whereas their need for broadband services decreases.

which we find an integrated access device (IAD) that will be either directly connected to the fixed network or via a host of 100 000 public WiFi cells on layer three. The IADs connect wireless the majority of devices in-house and in-office.

Increases of agility concur with the higher layers. In the top layer we will see the largest mobility at the cost of quality of service (QoS) and bandwidth. This top layer will consist of some 10 000 UMTS cells. Mixing these ideas with the fact that in The Netherlands alone we will, say in 2012, see some 10 billion devices of which the vast majority will be passive RFIDs, some interesting technical challenges will need to be met to cope with all the traffic interlinking business, residential customers and devices. In this paper, we place the different technologies in perspective, highlight the concept of PNs and elucidate the concepts with some metaphors.

Explanation of the 'Marbles and Pockets' Metaphor

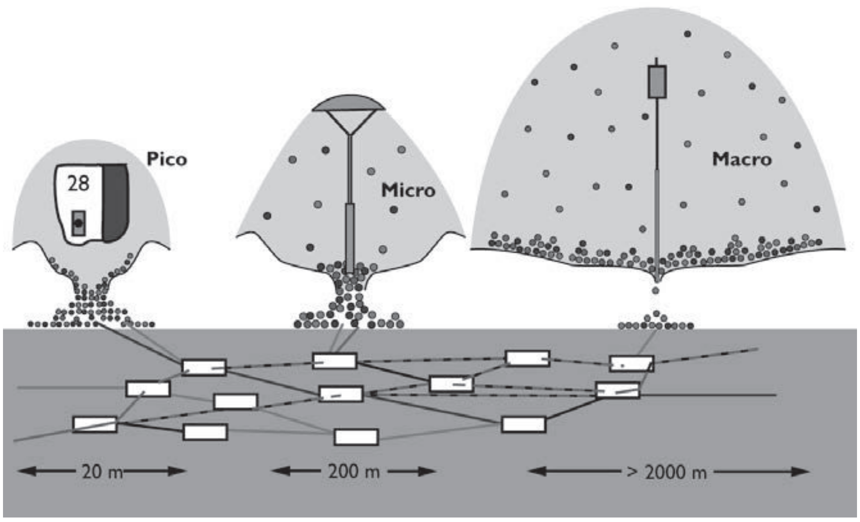
About a decade ago the existence of 'mobile only' operators absolutely made sense. It took only five years to turn mobility features and personalised communication into commodity. Narrowband GSM voice services proved to be an unforeseen gift, fundamentally changing human behaviour. It would not have looked the same if a GSM conversation had required a lot of precious bandwidth (for example, 2 Mbit/s). And here lies the relation with the following statement: 'Mobility is a crucial service feature, the more (broadband) mobility, the smaller the radio cells, the more fixed access network capacity will be required. In the end we will see *ether over fibre*.' This statement's final chord refers to the envisaged future situation in which fibre will be widely deployed in the local loop. On the other hand, future end-user devices will dominantly become wireless. Merging these two leads gives the image of radio bearers (ether) connecting mobile end-users to a fixed local loop outlet (fibre), irrespective of whether this is public or private infrastructure. Transport of bits over radio bearers is, in general, more expensive compared to deployment of fixed bearers, especially when these assets are already in place offering individual end-users abundant transport capacity (for example, twisted pair, FttB or coaxial).

Today, having grown to the startling amount of 1.3 billion subscriber identity modules (SIMs) worldwide, borders between 'fixed and mobile' are blurring due to technical developments and end-user needs. Furthermore, emerging unlicensed wireless techniques like wireless local area network (WLAN) do not make it easier for decision makers 'which horse to bet on'.

Figure 3 is complementary to Figure 2. This model is all about ICT marbles that can disappear in and arise from different types of pockets in the ground (where the fixed network part starts). The marbles represent information particles to be moved between end-users and/or information entities (for example, content servers).

End-users are increasingly free to choose which pockets to use in order to send and receive their marbles. (They are free to choose where and how they want to setup ICT service sessions.) For them it is the game to find the right pocket with the best price-performance ratio customised for each type

Figure 3 Marbles and pockets.



of marble. Telecom operators/service providers make money on transportation of the particles respecting the agreed service level requirements (such as privacy, transfer time and damage control). Their game is to fill their pockets. Therefore it is crucial from an investment and cost perspective to balance the supply of different pocket types. On both sides of the scale we find:

1 **Macro pockets**: Low-declivity pockets featured by a long radio bearer (large operational radius) offering all capabilities for nomadic use in public space for any subscriber. This type of pocket has a public domain character enabling geographic mobility including seamless roaming and handover functionality.
2 **Pico pockets**: Steep slope pockets featured by a short radio bearer (small operational radius) offering high-bandwidth capabilities. When necessary they can be realised in a private domain setting as well for exclusive use by the end-user (or end-user community). They will certainly not always support all functionality for nomadic use mentioned above.

As described in the introduction, in between these types we find micro pockets. These can for instance be public WLAN hot spots.

As depicted in Figure 3, some lightweight marbles, for example, low-bandwidth conversation marbles, first travel a thousand metres via air to reach the closest centralised (public) macro pocket. For an end-user on the move, this absolutely makes sense. Other heavier marbles, for example, high-bandwidth video content marbles, find their way to a closer (private) pico pocket. The integral cost case (based on distance, bandwidth, QoS, the need for seamless roaming and handover) will determine the geographic balance between air and fixed transport. The future end-user device will sniff and detect the optimal pocket. Given that nearly all services in the future will be 'enjoyed' either wireless or mobile, the radio route to the fixed network can be found in different ways. In this situation, the existence/viability of solitary mobile only and fixed only operators is doubtful.

Technologies and Capabilities per 'Pocket' Type

The three wireless pocket types explained in the previous section correspond to network types usually referred to as wireless *personal area network* (PAN), *wireless local area network* (LAN) and *wireless metropolitan area network* (MAN); to which we also refer as pico, micro and macro pockets or cells, respectively. The coverage radius of wireless PAN is roughly in the order of a few metres up to 20 metres. Wireless LAN coverage radius is limited to about 100 metres, while wireless MAN coverage is in the order of a few kilometres. For each network type, various wireless technologies have been proposed. In this section we limit our scope of attention to the following representative technologies:

- wireless PAN: Bluetooth, UWB;
- wireless LAN: IEEE 802.11a, IEEE 802.11b, IEEE 802.11g; and
- wireless MAN: IEEE 802.16e, GPRS, UMTS.

Table 1 gives an overview of some technical characteristics for each of the above-mentioned technologies. We will not zoom into details of each technology. The characteristic features gathered in Table 1 serve for quality and performance comparison between technologies.

Roaming and handover

No single network technology simultaneously provides low latency, high bandwidth, and wide area data service to a large number of users. The concept of wireless pockets presented in this paper provides a solution by allowing flexible connectivity to a large number of mobile users based on their needs and available resources. In this way, the users can always be connected to the network that serves them best. However, for 'always best connectivity' without service interruption, it is required to handover a mobile user between network types and radio cells.

In general, handover is applied when a user moves through the coverage area of various cells in a wireless network and crosses cell boundaries. The handover between wireless cells of the same type is often referred to as *horizontal handover*, and the handover between wireless cells of different network types is called *vertical handover*.[2]. Roaming can be considered as a special case of handover that requires traffic handling agreements between operators and network providers across country borders.

The wireless cellular networks such as GSM/GPRS and UMTS provide dedicated horizontal handover and roaming solutions within their own network

Table 1 Overview of technical characteristics per wireless technology.

	Maximum Data Rate	Frequency Allocation	Channel Bandwidth	Number of therefore Channels	Multiple Access Technology	Typical Range	Mobility Support
Bluetooth	1 Mbit/s	2.4 GHz (ISM)	1 MHz	79	FHSS	10 m	(1)
UWB	110 Mbit/s (at 10 m)	3.1–10.6 GHz	Min. 500 MHz Max. 7.5 GHz	1–15	THSS OFDM (11)	10–15 m	(1)
802.11b	11 Mbit/s	2.4–2.497 GHz (ISM)	25 MHz	3	DSSS	50–80 m (9)	(2)
802.11g	54 Mbit/s	2.4–2.497 GHz (ISM)	(10)	(10)	(10)	50–80 m (9)	(2)
802.11a	54 Mbit/s	various bands in 5 GHz region	20 MHz	US: 12 EU: 8 Japan: 4	OFDM	40–60 m (9)	(2)
802.16e	75 Mbit/s	2–11 GHz 10–66 GHz (3)	1.5–20 MHz (3)	(3)	(15)	30 km (4) 4 km (5)	(6)
GPRS	171 kbit/s (12)	800, 900 and 1800 MHz bands (13)	200 kHz (13)	(13)	TDMA with FDD	1–5 km(14)	Handover possible at high speeds
UMTS (W-CDMA) (8)	2 Mbit/s	1920–1980 MHz 2110–2170 MHz	5 MHz	(7)	DSSS	1–3 km (16)	Handover possible at high speeds

Notes

(1) Technology by itself does not support handover.
(2) Movement within a cell is possible. Technology by itself does not support handover.
(3) EEE 802.16 is designed for a wide range of licensed and licence-exempt frequencies with flexile bandwidth allocation to accommodate easier cell planning throughout the world.
(4) With 'line of sight' condition.
(5) Without 'line of sight' condition.
(6) Mobility is only supported in the 2–6 GHz band without line of sight. At walking speeds handoff between adjacent cells is possible.
(7) Number of frequency bands depends on the operator's licence.
(8) From different variants of UMTS, we consider here only the European W-CDMA.
(9) Lower bound corresponds to 11 Mbit/s data rate, and upper bound corresponds to 2 Mbit/s data rate.
(10) For data rates 1, 2, 5.5 and 11 Mbit/s the same channel spacing, bandwidth and modulation are used as in IEEE 802.11b (for backwards compatibility). Other supported bit rates use OFDM.
(11) UWB can be implemented using several spreading technologies. Most implementations use OFDM or THSS. (12) This is the maximum data rate using eight time-slots and Coding Scheme 4 (CS-4).
(13) Same as in GSM.
(14) With Coding Scheme 1 (CS-1), the coverage radius of GSM voice and GPRS data is the same, with CS-2, CS-3 and CS-4 the coverage radius reduces. Typical range in this table is for urban areas. Theoretically the maximum range could be as much as 30 km.
(15) IEEE 802.16 physical layer supports three access technologies: 1. Singles Carrier Modulation (CS), 2. OFDM in combination with TDMA and 3. OFDMA. OFDM and OFDMA are mainly proposed for none 'line of sight' operation.
(16) Typical range in this table is for urban areas. Theoretically the maximum range could be as much as 20 km.

Acronyms

DSSS	Direct sequence spread spectrum FDD Frequency division duplex
FHSS	Frequency hopping spread spectrum GPRS General packet radio service
ISM	Industrial, scientific and medical (ISM) frequency bands
OFDM	Orthogonal frequency division multiplexing

OFDMA	Orthogonal frequency division multiple access	W-CDMA	Wideband code division multiple access
TDMA	Time division multiple access	Wi-Fi	The 802.11 family is referred to as *Wi-Fi*
THSS	Time hopped spread spectrum	WiMAX	The 802.16 family is referred to as *WiMAX*
UMTS	Universal Mobile Telecommunications System		
UWB	Ultra-wideband		

type. However, these solutions are not applicable in a heterogeneous network environment as described in the previous section. Further, networks that are being optimised for the support of wireless broadband data services tend to be based on the IP protocol suit entirely. Since IP was not designed with mobility in mind, several problems need to be solved before 'all-IP' wireless networks could be deployed. The basic problem to be addressed is that, inside an IP network, an IP address is used to identify both a node[2] and its location. Thus, when a mobile node moves inside the network, its IP address must change. The mobile IP (with two flavours Mobile IPv4 and Mobile IPv6[3]) is a well-known approach for mobility support in 'all-IP' networks and an accepted standard by the IETF community. This offers a pure network layer architectural solution for mobility support and isolates the higher layer from the impact of mobility. However, an inter-domain mobile IP solution for handover can take up to a few seconds to complete. This is certainly an adequate solution for nomadic users, but, for fast and frequent handover of delay-sensitive voice and multimedia applications, better solutions are required. For this purpose, various adjustments and enhancements to mobile IP have been proposed. Examples are hierarchical mobile IP, cellular IP (CIP) and handoff-aware wireless access Internet infrastructure (Hawaii) for local handover control [4]. However, none of these proposals has been implemented and proved to work on a large-scale basis yet.

Comparison of technologies

Looking at Table 1 and considering the handover possibilities and limitations of different technologies we may draw a few rough conclusions:

- Among the mentioned technologies, UMTS and GPRS networks are deployed in the most planned and controlled way. Consequently, interference and capacity estimation are more reliable than other network types. This, in our opinion, is an advantage from the QoS point of view.
- It is evident that wireless PAN, wireless LAN and IEEE802.16e technologies are capable of offering high-bit-rate data services to nomadic users. However, as long as handover and authentication, authorisation and accounting (AAA) problems with these technologies are not solved, UMTS remains the most reliable technology with relatively highbit-rate support for at least fast-moving users.
- Even though wireless LANs support much higher channel bandwidth than 3G networks, their network-layer handoff latency is still too high to be usable for interactive multimedia applications such as voice over IP or video streaming.
- Because of widespread exploitation and standardisation, and partially due to utilisation of licence-exempt frequency bands, Wi-Fi and WiMAX technologies are financially attractive solutions.

From these observations, it is clear that each of the technologies mentioned here has some advantages and some disadvantages. In the wireless pockets scenario described in Chapters 1 and 2, we do not believe in replacement of one technology by another technology. The strength of any fixed and mobile integrated solution should lie in its capability to combine the strength of all these technologies.

The Role of Gateways

Until today not only do different ICT technology generations coexist, but also technologies have their specific functional position, role, strengths

2 A node is any device connected to a computer network. Nodes can be computers, personal digital assistants (PDA's), cell phones, or various other network appliances. On an IP network, a node is any device with an IP address.

3 Mobile IPv6 shares many features with Mobile IPv4, but is integrated into IPv6 and offers some improvements with respect to Mobile IPv4. For an overview see Reference 3.

and weaknesses in both the vertically layered hierarchy and the global multi-domain landscape hosting all ICT end-users. Future expectations show a similar image: a heterogeneous composition in which never one single technology will dominate and where not one worldwide monopolistic domain will connect all endusers and (their) active and passive devices.
Considering these facts, it is obvious that there will always be a role for gateway functionality:

- interconnecting telecom operator domains (marking the borders between legal entities),
- interconnecting the public Internet and telecom operators (offering fixed, wireless or mobile network access to millions of end-users),
- converting packet- and circuit-based information,
- translating network control information between different signalling systems and domains, and
- connecting public telecom operator domains and private domains (residential gateways being an obligatory building block for an in-house network). Personal network gateways (PNG) can eventually be foreseen.

Since different (access) technologies will coexist (see for example Figure 2) and mobile, fixed and converged telecom operators earn most of their money from offering carrier-grade services, the question is raised who will pay for future gateway functionality, enabling various end-to-end service levels. And even more generally: who is going to timely provision new costly network technology with shorter life cycles at high business risk?

Short-term focus, fierce competition, uncertainties concerning regulation, growing complexity and, above all, strict profit and loss targets, will in practice not be beneficial to the realisation of the required technology mentioned above. It has become a multiplayer trans-sectoral investment riddle to be jointly solved.

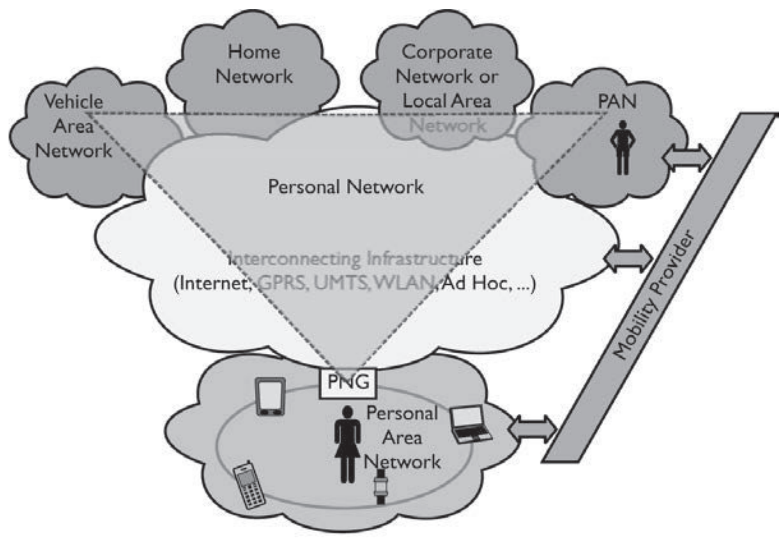
Personal Networks

In a converged fixed-mobile architecture as described above, it becomes possible to deploy new kinds of services, such as personal networking, a concept which has been introduced only recently [5], [6]. A personal network is a distributed personal environment consisting of clusters of geographically dispersed devices that dynamically changes according to the context and needs of the user. It is a personalised overlay over multiple domains that hides the underlying network and business complexity from the user. It offers the user access to his/her personal applications, devices and content wherever he/she is, and wherever the devices are and the content is stored, depending on the role of the user (employee, private person, member of a community, etc.) and his/her location, and grants authorisation on the basis of something the user possesses, knows or is.

A schematic view of a personal network is given in Figure 4. At the heart of the personal network is the core PAN, which is physically associated with the owner of the personal network. The core PAN consists of networked personal devices carried by the user (mobile phone, PDA, watch, digital camera, MP3 players, gaming consoles, etc.). Depending on the user location, the core PAN can interact with devices in its environment or with remote devices to temporarily create a personal network. A key element of the core PAN is the personal network gateway (PNG), which is a new category of mobile devices. The PNG is a personal device, possibly with a large amount of local storage and local intelligence, which can connect to multiple wireless (mobile) access networks. The PNG can be a dedicated device, or added functionality of other devices in the core PAN.

Another important enabling factor for the incorporation of the PAN into a fully functional personal network will be the mobility provider (MP). The MP is not a device or a specific application, but a new business role. It is basically a service provider offering the PN service and providing an operational environment to manage user-, service-, content- and network-related issues. For that purpose, the mobility provider uses a service platform like that described in Reference 7, that communicates with the PNG and offers service control functions that enable endusers to easily gain and maintain access to services, while roaming between different access networks. For other service providers it acts as a one-stop shop for providing their services to the personal network and it hides the changes of access networks and terminals due to roaming.

In terms of the four-tiered hierarchy and the 'marbles and pockets' metaphor, a personal network can be envisaged as follows. The PNG is the personal device that receives a command from the core



A personal network (blue) is a personalised overlay over multiple domains and interacts with multiple devices. The mobility provider offers the PN service. The PNG connects the core PAN (orange) to the rest of the PN.

Figure 4   Personal network..

PAN to send or request content (a marble) to or from another device anywhere in the world. It then sniffs for the optimal pocket, by first sensing the environment for available networks, and then communicating with the mobility provider to negotiate about costs, QoS, bandwidth, agility and mobility. Finally, the PNG sends or receives the desired content via the connection of choice, be it fixed, mobile, hot spot or pico cell. In Figure 4, the pockets are basically represented by the yellow and green clouds, and thus can also include other PANs. The mobility provider takes care of the billing and roaming, depending on the subscriptions with the various network and service providers, and on the authentication of the devices and content as belonging to the personal network.

The wireless network will always be the limiting factor in offering the required range, bandwidth, and quality of service. The personal network though has enough intelligence to 'find the quickest way to the fixed network'. This fits in perfectly with the view on convergence of fixed and mobile networks as presented in this paper. Up to now, the envisioned broadband services to be supported by fixed networks were limited to 'triple play' (TV, Internet, telephony) and peer-to-peer services. Personal networking adds to that all the services that are perceived as mobile services, but can never be enabled and supported by isolated mobile networks. For consumers it means that they are offered optimal quality and optimal mobility, without the need of explicit choosing between fixed and mobile operators.

Conclusions

In this paper we have provided a future-oriented picture of fixed mobile convergence. Although in the telecommunication community there is general consensus that this convergence is just a matter of time, the ideas for the best convergence scenario are diverse. The proposed idea in this paper is based on the 'marbles and pockets' metaphor that clearly distinguishes one fixed infrastructure layer and three wireless layers, each layer with its own set of technologies and capabilities The metaphor shows that higher demand for mobility increase the need for a densely distributed high-capacity fixed access network. Further, as mentioned above, it shows the high potential of the relatively new concept of personal networking in-line with the ongoing trend of personalisation in ICT where the residential gateway tends to be stretched to the human body.

In our convergence scheme, we propose to combine the strength of the described relevant technologies in order to provide the end-user with always-best connectivity. However, we realise that our scenarios could only be feasible if the end-user could be offered the same level of service quality while moving across the layers. In this aspect, it is important to realise the role of the gateways. Finally, for seamless handover between layers, better solutions than the current proposed handover schemes based on mobile IP are required.

References

1 Koonen T et al Novel Signal Multiplexing Methods for Integration of Services in InBuilding Broadband Multimode Fibre Networks. Proceedings ISSLS Conference, 21–24 March 2004, Edinburgh.
2 Mohr, Werner. Further developments beyond third generation mobile communications. Proceedings of International Conference on Communication Technology 2000, WCC - ICCT 2000, 21–25 Aug. 2000, 2, pp. 1001–1008.
3 IETF Mobile IP Working Group. Mobility Support in IPv6, Internet-Draft, 29 Dec. 2003.
4 Campbell, A. T., Gomez, J., Sanghyo, K., Chieh-Yih, W., Turanyi, Z. R., and Valko, A. G. Comparison of IP Micromobility Protocols. *IEEE Wireless Communications*, Feb. 2002, 9(1), pp. 72 –82.
5 Niemegeers, I. G., and Heemstra de Groot, S. M. Research Issues in Ad-Hoc Distributed Personal Networking. Special Issue of the *Journal on Wireless and Personal Communication*, 2003, 26(2-3), pp. 149– 167.
6 Niemegeers I. G., and Heemstra de Groot, S. M. From Personal Area Networks to Personal Networks: A User Oriented Approach. *Journal on Wireless and Personal Communications*, 2003, 22(2), pp. 175–186.
7 Bargh, M. S., Laarhuis, J. H., and Plas, D. J. A structured framework for federation between 4G-service platforms. Proc. PIMRC 2003, Beijing, Sept. 2003.

Acknowledgement

The contribution of TU Delft to this paper is supported by the Towards Freeband Communication Impulse of the technology programme of the Ministry of Economic Affairs in The Netherlands.

Biographies

Nico Baken
KPN

Professor Baken currently holds a part-time chair in the Telecommunications Department at Delft University of Technology alongside his primary position as Chief Architect for The Royal KPN, the Dutch incumbent operator in the Netherlands. His main interest concerns broadband networks and services, dealing with a broad range of aspects such as fibre access infrastructures, fixed-mobile convergence, services, operations, financial strategies such as real option analysis, managerial complexity and regulations. Given this spectrum, he has been asked to advice the Dutch government on the matter of broadband and the roll out of fibre to the home in the national expert group broadband and in the Andriessen committee (former minister of Economic Affairs) to deal with the FTTH for Amsterdam and the Hague. He finished Gymnasium β in 1973 and graduated, cum laude, in mathematics at Eindhoven University of Technology in 1981. He has published over 30 papers, holds several patents and won several prizes for his scientific work; for example, the Dr Neher Laboratory prize (yearly prize for the most outstanding researcher). He received his Ph.D. Thesis from the Delft University of Technology at the department of Electrical Engineering, working with Professor H. Blok and Professor A. T. de Hoop.

N. H. G. Baken, KPN Telecom and Technical University of Delft Regulusweg 1, 2516 AC The Hague, The Netherlands, Email: n.h.g.baken@kpn.com or n.h.g.baken@ewi.tudelft.nl; Tel: +31 70 343 9137

Edgar van Boven
KPN

Edgar van Boven studied electronics and IT at the Technical Highschool in Vlissingen. Though tempted to start an adventurous life as a jazz pianist, he graduated in 1987. After military service as a sergeant in a telecommunications battalion, he entered KPN. Until today public telephony has dominated his career from various viewpoints starting with hardware and software engineering, via operational network planning to architecture and programme management. In the late-1990s, he started to work on the evolution to voice over packet in the former Unisource Business Networks environment within KPN. Since 2001, he has also been guest lecturer at the Delft Technical University. Today he is working in the area of fixed mobile convergence.

Edgar van Boven, KPN, Operator Fixed Network, P.O. Box 30000, 2500 GA Den Haag, The Netherlands, Email: e.f.m.vanboven@kpn.com, Tel: +31 70-3434797

Frank den Hartog
TNO Telecom

Frank den Hartog received an M.Sc. degree in Applied Physics from the Technische Universiteit Eindhoven in 1992. He obtained a Ph.D. in Physics and Mathematics at Leiden University in 1998, after which he joined KPN Research (in 2003, KPN Research became part of TNO Telecom). He specialised in home networking and established an expert group dedicated to the subject. Currently he is leading the Dutch industrial ICT research projects 'Residential Gateway Environment' and 'Personal Network Pilot 2008', collaborating with, a.o., Philips Research, KPN, and Delft University of Technology. He is a guest lecturer at several universities and (co-)authored about 50 papers and contributions. He is a member of IEEE.

Frank T. H. den Hartog, TNO Telecom, Brassersplein 2, P.O. Box 5050, 2600 GB Delft The Netherlands, Email: F.T.H.denHartog@telecom.tno.nl
Tel: +31 15 285 71 19

Ramin Hekmat
TU Delft

Ramin Hekmat received an M.Sc. degree in Electrical Engineering from Delft University of Technology in The Netherlands in 1990. Since then he has worked for several telecommunication companies in The Netherlands and the United States in Research and Development as well as managerial positions. In September 2001, he started his Ph.D. work related to ad-hoc networking at TU Delft. His prime research interest includes multi-user communication systems, wireless communications and peer-to-peer networks.

Ramin Hekmat, Delft University of Technology Electrical Engineering, Mathematics and Computer Science, P.O. Box 5031 2600 GA Delft The Netherlands, Email: r.hekmat@ewi.tudelft.nl Tel: +31 15 278 6272

In-home Video Distribution for Telecom Operators

Bas Hendrix, Frank den Hartog,
Harrie van de Vlag and Nico Baken

We have investigated the various alternatives for in-home video distribution that might be applicable between now and 2010. Among these are wireless and so-called no-new-wires architectures, but also unconventional approaches based on analogue distribution. The latter actually led to a surprisingly attractive and realistic solution. Thereupon we have developed an innovative demonstrator, which is basically a centralised video gateway equipped with analogue modulators that can be connected to the existing in-home coaxial cabling.

Introduction

With the advent of truly broadband access networks, convergence of voice, data and audio/video services is now within reach of telecom operators. But before a mass market can be achieved, many issues should still be solved. A considerable challenge is the userfriendly distribution of video data from the broadband modem to the various television sets in the home. This issue arises from the fact that televisions are usually not placed close to the operator's demarcation point. For digital video offered by telecom operators, current solutions mostly involve wiring the home with unshielded twisted pair (UTP) cables from the modem to dedicated set-top boxes for every television. Having to re-cable the home and to purchase set-top boxes, significantly impedes potential customers to abandon their current service provider and subscribe to television services offered by a telecom operator. We have therefore investigated various alternatives for in-home video distribution that might be applicable between now and 2010.

This paper first describes current developments in the offering of triple-play services, and shows that the use of operatorfriendly as well as user-friendly home networks is unavoidable for creating a profitable proposition. We then analyse several current and future digital home network technologies in terms of properties that are necessary for flawless video distribution: bandwidth, range, quality-of-service (QoS) support and security. For the home network standards that turn out to be suitable, we then compare two different architectures: a decentralised architecture based on Internet protocol (IP) distribution to various set-top boxes, and a centralised architecture based on a single video gateway and analogue video distribution directly to the television sets. The latter led to a quite attractive and realistic solution. We therefore conclude the paper with a description of our video gateway demonstrator.

Recent Developments with Respect to TriplePlay Services

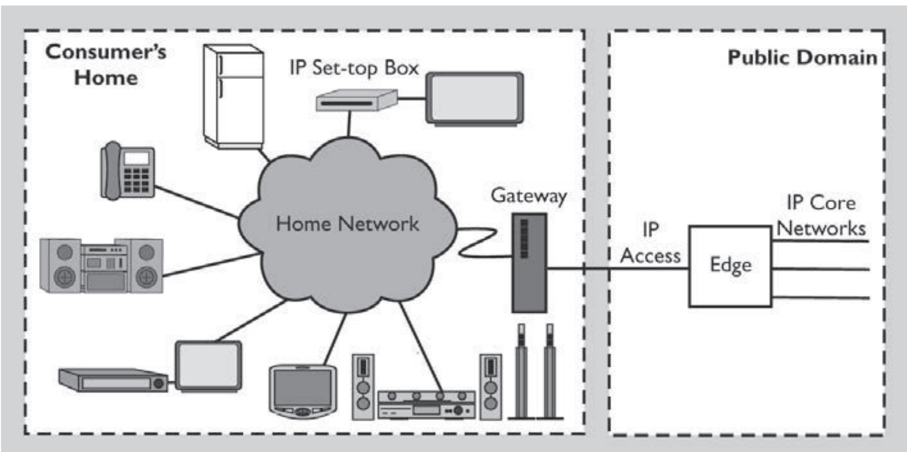
The expression *triple-play* services is open to many interpretations. A consumer might experience triple play when he/she has integrated services digital network (ISDN) telephony, asymmetric digital subscriber line (ADSL) Internet access and satellite TV from a single provider, and receives a monthly invoice covering all subscription fees. However, triple-play offerings in the near future are expected to include also video-on-demand services, personal video recording, electronic programme guides, video telephony, etc.
Recently, the deployment of triple-play services over IP networks has gained much attention, especially in parts of Asia, Europe and North America where the penetration of broadband Internet over cable and ADSL access has reached critical mass. Therefore, this paper narrows the scope of triple-play services as a combination of Internet, voice and video services over a single terrestrial broadband access network based on IP (see Figure 1). For the coming five years, the IP broadband access network can be based on cable, ADSL2+, very-high-rate digital subscriber line (VDSL) or fibre access networks, typically owned

by telecom operators and cable operators. In The Netherlands, about 40% of the households are now connected to such a broadband access network. With that, The Netherlands has one of the highest broadband penetration rates in Europe.

The ruinous competition between cable and telecom operators now extends to the home network. With respect to video services, both cable and DSL operators use set-top boxes (STBs) in order to display digital TV on normal television sets, since the majority of the consumer market does not have televisions sets with built-in digital tuners or IP TV tuners yet. The primary function of digital STBs is to enable an analogue television to receive digital video signals. A typical STB contains one or more microprocessors for running the operating system and for processing and decoding the Moving Pictures Expert Group (MPEG) transport stream. The STB can be connected with the TV using a Scart connector or a coaxial connector. For each television set, a separate decoder is required, assuming that every television should be able to show images independently. This seems to give the cable operators a head start on the telecom operators in the run for digital TV market share, because they can maintain analogue broadcast to every TV set in the home that is not yet provided with a digital STB. Only in the long term, is it expected that TVs might have an integrated decoder. At the moment, integrating a decoder would lead to an unacceptable reduction of the TV's depreciation time, because codecs are still rapidly evolving and are not properly standardised.
There are two different types of digital STBs: IP STBs and digital video broadcast (DVB) STBs. DSL network operators deliver a limited number of parallel video-over-IP channels to IP STBs in the home. The actual switching of the channels when the consumer 'zaps' takes place somewhere in the operator network. Current DVB network operators (cable, satellite, terrestrial, etc.) deliver up to several hundreds of digital channels to the home, and switching between channels takes place in the DVB STB itself. Because DVB does not offer the bidirectional IP infrastructure that is needed for video-on-demand type of services and interactivity, also DVB operators will migrate to IP video in the long term. In this paper, only IP STBs are considered.

Basically, there are no major technological bottlenecks anymore that prevent the introduction of triple-play services over IP. This includes all necessary home-networking technology. The key question is how to make the proposition profitable for all parties involved in the triple-play value chain. In our vision, (at least) two fundamental requirements must be met for such a triple-play proposition. First of all, triple play must be comprehensible for the consumer. It must be easy to install, maintain and operate. Complexity scares people, and can lead to very unhappy customers if not taken care of properly. The whole concept of home networking, connected devices and its possibilities is quite revolutionary to the average consumer and requires a new mindset. Secondly, triple-play service providers must be able to manage at least some of the characteristics of connected devices such as residential gateways, STBs and, ultimately, consumer electronics to guarantee QoS and security to the end-user. Said otherwise, the soft factor 'no hassle for the end-user' is determining the success of triple-play services more than the hard factor 'enabling home-networking technology'. The remainder of this paper therefore focuses on

Figure 1 Schematic architecture for the delivery of triple-play services over an IP network.



finding home network architectures that are user friendly as well as operator friendly. Of particular interest is the support of video services, since video service delivery causes most of the challenges to the home network.

Home-Networking Technologies

In The Netherlands, about 50% of the households with broadband access have their digital devices mutually connected by means of a home network. For the distribution of IP traffic within the home, there are many different standards available. An overview can be found in Reference 1. Ethernet has been the prevailing standard up to the end of the nineties, but because of its inconvenience with respect to installation, many wireless alternatives have been developed in the past decade. The most important wireless technologies currently available are the Institute of Electrical and Electronics Engineers (IEEE) standards 802.11b and g, and the newest version (1.2) of Bluetooth. The IEEE 802.11a standard is not allowed in Europe. An alternative technology that is allowed in Europe is the European Telecommunications Standards Institute (ETSI) standard digital enhanced cordless telecommunications (DECT). Furthermore, a couple of promising so-called no-new-wires industry standards have been developed recently, namely HomePNA (Home Phone line Networking Association) and HomePlug. They use the already installed telephony network and power-line network respectively, without disturbing the legacy telephony and power services. At the moment, about 50%of the home networks in The Netherlands are based on UTP Category (Cat.) 5 cables. About 35% use IEEE 802.11b. The rest uses Bluetooth, HomePNA, DECT, etc.

Table 1 summarises the main properties of these technologies. The bandwidth is specified for the physical layer (the raw data rate) as well as for the application layer based on transport control protocol over IP (TCP/IP) traffic. The latter number is measured in our laboratories or taken from the literature (for example, Reference 1). The coverage is not given as a quantitative distance, because it would not have significant meaning for indoor environments. Instead, we indicate if the technology typically covers the whole house, a couple of rooms, or just a single room. In Europe, HomePNA covers only a couple of rooms, because a typical household has only 1–2 telephone jacks. A standard scores 'yes' on QoS support, if it includes any QoS mechanism, such as prioritisation of service classes.

In Ethernet this can be realized with virtual local area network (VLAN) switching. A technology scores a plus (+) on security, if it supports any user-friendly (!) way of securing the network. Ethernet is inherently secure because it is wired. The security mechanisms of the 802.11 standards are fairly advanced, but not user-friendly. HomePlug is a wired standard, but the wires are so badly shielded, that the signals are also radiated into the air. The main conclusion that can be drawn from Table 1 is that there is only one secure technology with sufficient bandwidth, QoS support and security measures for video distribution within the home. It is Ethernet.

Several new technologies are expected to play an important role in home networking in the future. They are listed in Table 2. IEEE 802.11n is using the recently developed multiple input multiple output (MIMO) technology. Ultra-wideband (UWB) is basically a standard for wireless personal area networks (WPANs) and is partly standardised as IEEE 802.15.3a. HomePlug Audio Video (AV) is the successor of HomePlug 1.0. HomePNA 3.0 can use the existing in-home coaxial network in addition to the in-home two-wire telephone network. From Table 2 it can be concluded that HomePlug AV, HomePNA3.0 and IEEE 802.11n all present good future candidates for user-friendly digital video distribution within the home.

Table 1 Digital home networking technologies that are mature in 2005

Technology	Bandwidth Mbit/s (L1/L7)	Typical Coverage	QoS Support	Security
Ethernet	100/70	whole house	yes	+
IEEE 802.11b	11/5	2 rooms	no	–
IEEE 802.11g	54 /25	2 rooms	no	–
DECT	2/~2	whole house	yes	+
Bluetooth 1.2	0.7/0.4	1 room	yes	0
HomePNA 2.0	10/6	2 rooms	yes	+
HomePlug 1.0	14/5	whole house	no	0

Analysis of Current and Future Architectures for In-home Video Distribution

One of the issues that still have to be settled is how decoding functions should be distributed in the home network. Should the decoding happen centrally, resulting in analogue in-home distribution of the TV signals, or should every TV have its own decoder? Although most of the current home-networking research and development focuses on digital networks, it is not clear if they should also be used for streaming video. Excellent papers have been written on this matter (for example, References 2– 4), but no definite conclusions could be made. We have re-assessed this question by taking into account many more criteria and trying to analyse them in a quantitative fashion. We also considered the influence of timing: in the short term (2005–2006), the ideal home network architecture might be different from the long term (~2010). In the remainder of this paper, the decentralised architecture is also called the STB configuration. The other, centralised solution is called the video gateway configuration.

A video gateway is basically a single device that does the decoding for all the televisions in the home. In this case, two issues have to be solved. First, the decoded (analogue) signal has to be transported to every television set and, secondly, it must be possible to control this video gateway remotely to switch channels and content. Video transport methods such as Scart and high-definition multimedia interface (HDMI) are limited in their maximum range. For the distribution of the decoded video signals, this proves them useless for serving all television sets in the home from one central location. A better solution is found by reusing the in-home coaxial wiring, and broadcasting the video signals from the video gateway to every television via radiofrequency (RF) phase alternating line (PAL) transmission. The gateway then transmits one 'channel' per television in the home, and each television set is permanently tuned to its own, fixed frequency. The video gateway can be controlled remotely by small infrared (IR) receivers located at every television that pick up the IR signal and send it to the video gateway via the coaxial cable.

A typical STB configuration for 2005 is shown in Figure 2, and a typical video gateway solution in Figure 3. The two configurations are assessed on 20 requirements. These requirements follow from many years of user experience research (for example, Reference 5) and market research (for example, References 6 and 7). The requirements are:

Functional requirements:

- A PC should not be required in the home network.
- The home network should have enough bandwidth.
- It should be possible to watch television at any place in the house.
- Besides broadcast channels, also personal content (DVD, PVR, etc.) should be available at each TV.
- The solution should support 4:3 and 16:9 aspect ratios.
- The solution should support high definition television (HDTV) quality.
- The solution should support Dolby surround sound.
- Channel switching ('zapping') should be fast enough.
- The architecture should be modular (easy to extend and personalise).
- A minimum of three televisions and radios can be used simultaneously.
- The solution should have an acceptable user interface.
- The system can be remotely managed.

Table 2 Digital home networking technologies that are expected to be mature in ~2010

Technology	Bandwidth Mbit/s (L1/L7)	Typical Coverage	QoS Support	Security
Gb Ethernet	1000/700	whole house	yes	+
IEEE 802.11n	100/50	2 rooms	yes	?
UWB	200/?	1 room	no	+
Bluetooth 2	3/?	1 room	yes	+
HomePlug AV	140/70	whole house	yes	0
HomePNA 3.0	128/60	whole house	yes	+

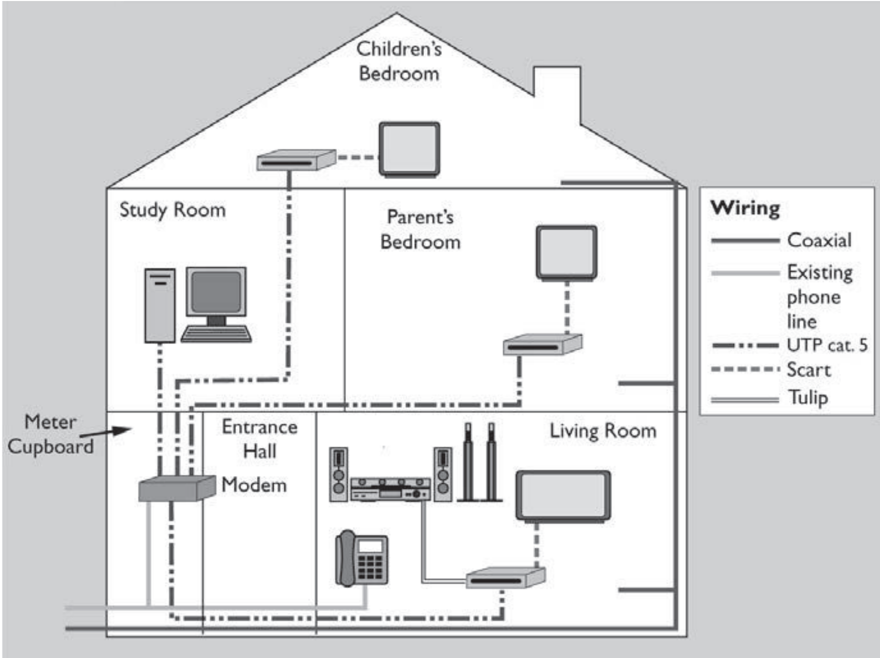


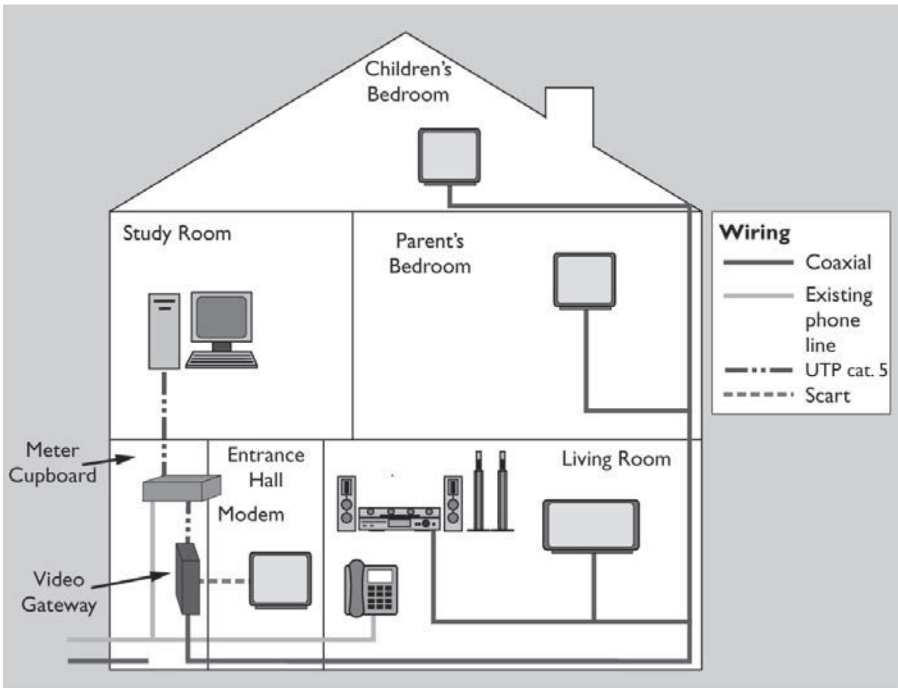
Figure 2 A typical set-top-box configuration ('decentralised'), using current home-networking technologies.

Other requirements (market, usability, operational, regulatory, etc.):

- Service personnel, the helpdesk, and the users need a minimum of training.
- The solution is legal.
- The technologies that are used are standard.
- The solution should have little impact on operational processes of the operator.
- The solution should consist of only a few boxes.
- Installation should take a minimum of time by service personnel and/or users.
- The costs for the user should be less than 100 euros per television.
- The solution should be future-proof.

The configurations can score 0, 1 or 2 on each requirement. On the base of what is known from the literature, each requirement has been assigned a

Figure 3 A typical video gateway configuration ('centralised'), using current home-networking technologies.



Requirement	Weight	Set-Top Box Configuration				Video Gateway Configuration			
		2005		2010		2005		2010	
		Ethernet	Home-PNA 3.0	Home-Plug AV	IEEE 802.11n	Ethernet	Home-PNA 3.0	Home-Plug AV	IEEE 802.11n
HDTV quality possible	3	0	6	6	6	0	0	0	0
Dolby surround sound support	2	4	4	4	4	2	2	2	2
Future-proofness	1	2	1	1	2	0	0	0	0
Modular solution	1	2	2	2	2	1	1	1	1
PVR/DVD at every TV	3	3	3	3	3	6	6	6	6
Few boxes	3	3	3	3	3	6	6	6	6
Easy to install	3	0	3	6	6	6	6	6	6
Bandwidth	3	6	6	6	6	3	3	3	3
Range of network	3	6	6	6	3	6	6	6	6
Total:		**26**	**34**	**37**	**35**	**30**	**30**	**30**	**30**

Note: Only the requirements are given for which the various solutions score differently

Table 3 Assessment of the STB and video gateway configurations, considering four different ways of IP transport between the modem and the STBs or the video gateway, respectively.

weight from 1 to 3. The requirements which score differently for the two configurations are given in Table 3. Both the STB configuration and the video gateway configuration need IP transport between the broadband modem and the STBs or video gateway, respectively. For the short term, only configurations that use Ethernet should be considered. For the long term, also varieties using HomePNA3.0, HomePlug AV, and IEEE 802.11n are addressed.

The scores are rationalised as follows. The PAL standard, which is used with coaxial RF transport, does not support HDTV. Therefore the video gateway solution does not qualify for HDTV services. Since HDTV is going to be deployed by operators after 2005 anyway, only the long-term STB solutions get points here. STBs can support Dolby surround sound. A video gateway can only support it for a single television. The video gateway is a typical short-term solution, compared to IP STBs. Among the various home-networking technologies, HomePNA and HomePlug are future-proof only to a limited extent, because they are just industry standards rather than open standards. A distributed IP-based architecture is easier to upgrade because of its modular architecture. An important advantage of the video gateway configuration is that a single personal video recorder (PVR) and digital video disk (DVD) player can serve every television in the house. Theoretically speaking, this is also possible when the PVR or DVD player is integrated in one of the STBs. However, among other reasons, this is not practical, as the besteffort Ethernet network would have to carry multiple channels simultaneously. It is obvious that the centralised solution involves far fewer boxes than the distributed architecture. A distributed architecture based on Ethernet is also relatively difficult to install, compared to the video gateway solution and the architectures based on the future wireless and power-line networks. HomePNA falls somewhere in between,
Table 3 Assessment of the STB and video gateway configurations, considering four different ways of IP transport between the modem and the STBs or the video gateway, respectively because basically no new wires need to be installed, but there are relatively few connection points for the devices, which might lead to some extra wiring anyway. Because the distance between the video gateway and the modem is probably relatively small, there is no preference for any IP network technology here. In terms of range, the IEEE 802.11 standards are known to have a limited range in a significant number of houses.

When all the scores are added, the STB solutions with HomePlug AV or IEEE 802.11n come out best. However, these technologies are not available in 2005. For the short-term solutions, the video gateway scores slightly higher than the STB solution. But the difference is small, and therefore confirms the qualitative analyses of References 2–4. In the long term, a home network architecture as depicted in Figure 4, based on HomePlug AV, can be viable.

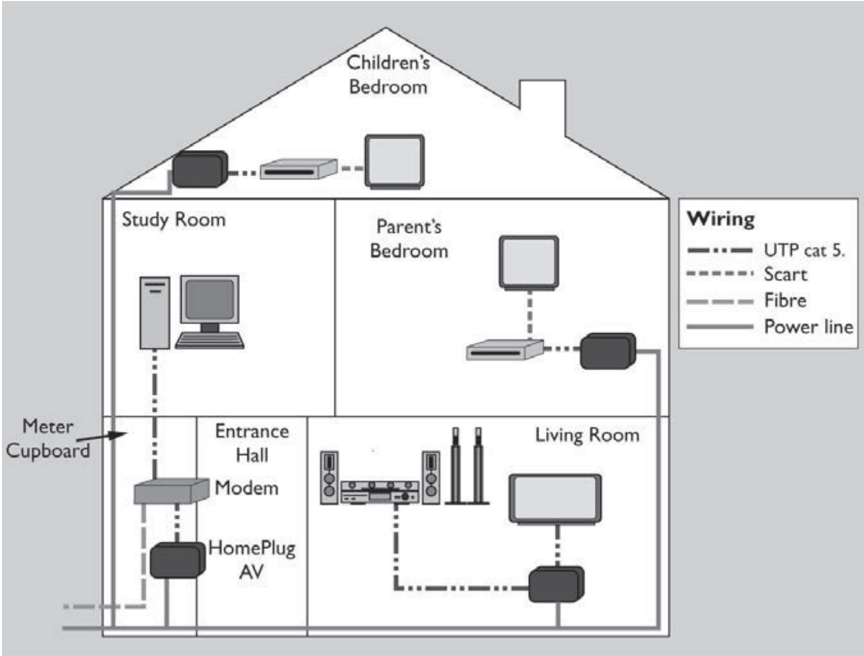


Figure 4 Example of a future home network based on HomePlug AV.

Example of a Video Gateway Architecture

The centralised solution for in-home video distribution has been further elaborated by the implementation of a video gateway demonstrator. The demonstrator consists of a streaming video server, a video gateway, and two television sets. The streaming video server is connected to the video gateway through a multicast network. It encodes and streams two televisions channels, contains video-on-demand content, and provides an HTML-based user interface. The video gateway is controlled remotely by small IRRF converter boxes located at the TVs. They receive the IR signals from the television's remote control and send them to the gateway via the coaxial cable.
The architecture of the video gateway is depicted in Figure 5. The gateway is derived from a PC with a dual-head video card and two sound cards. It runs on a Linux operating system and uses VideoLAN to view and decode the video content. The video and audio outputs are both connected to RF PAL modulators that have coaxial outputs. One output of the video card is also provided to the end-user directly by means of a Scart connector. Also two DVB-T(errestrial) tuners and a DVD player are implemented in the gateway. As a result, the video gateway supports six independent video input channels (the video-on-demand server, two broadcast channels, two DVB-T channels and the local DVD player) and two independent video output channels that can be connected to up to three television sets (two by means of the in-home coaxial network and one by using the Scart output). The gateway contains a hard disc, so the addition of PVR software could easily create a seventh video input. An STB basically contains all the functionality within the white unshaded box ('STB Functionality'). Therefore, it can be readily seen that the centralised architecture is significantly more cost-effective than a decentralised solution with an advanced broadband router modem, a to-be-installed home network, and two or three separate STBs that are able to run software for decoding, DRM, and control.

Experiments with this demonstration set-up show that acceptable user experience is achieved and, therefore, prove that the use of a video gateway can indeed provide a solution for cost-effective and user-friendly in-home video distribution in the short term. The first commercially available video gateways have been introduced to the market very recently [8].

Conclusions

In the short term, there are no in-home IP distribution solutions available that are suitable for video services, except UTP wiring. A good alternative for households with multiple television sets is the use of a central video gateway that broadcasts one analogue channel per television via the coaxial cable.

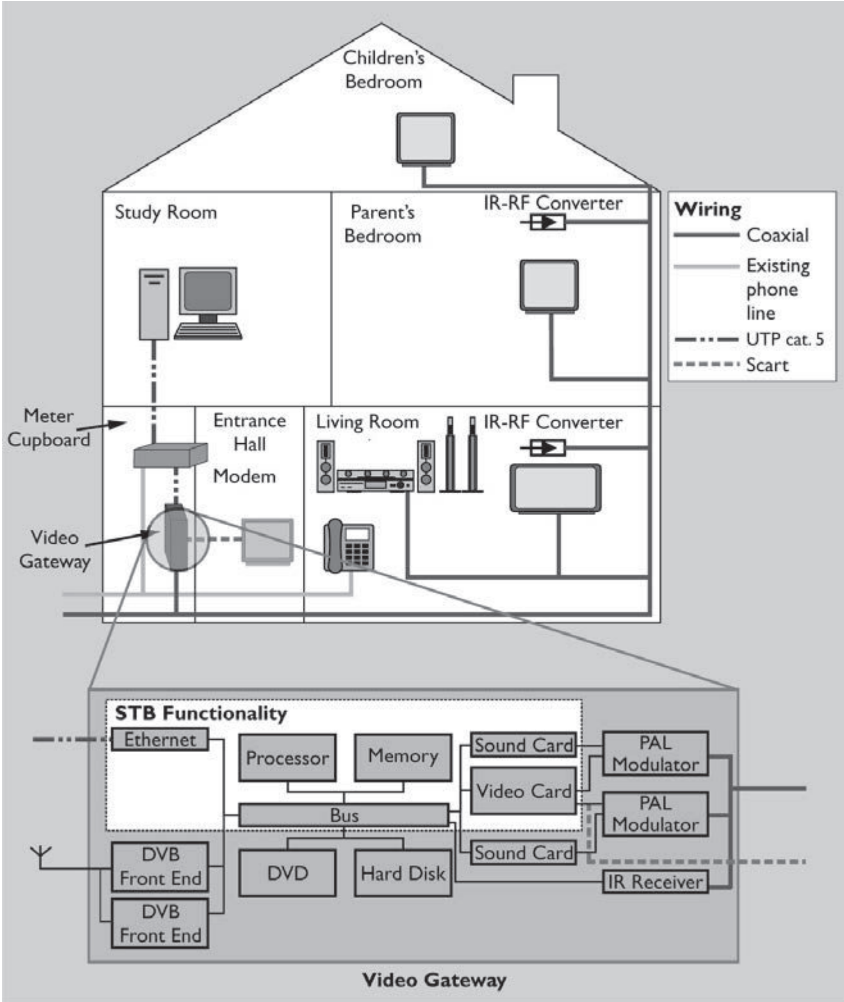


Figure 5 Example of a video gateway architecture.

This solution is attractive to the user because it is easy to install and it does not require new wires. Furthermore, services that run on the gateway, such as a DVD player or a PVR, are available on every television in the home. Finally, the costs of such a centralised solution are probably lower than the aggregated costs of several separate intelligent STBs, a broadband router modem and additional in-home cabling. Therefore telecom operators should consider using a video gateway when they start offering video services.

For 2010 it is expected that technologies such as HomePlug AV and IEEE 802.11n are mature and commercially available. These technologies can then be used for digital inhome video distribution, providing better QoS than analogue transport.
The video gateway can be an important component enabling a first step towards full convergence of telecom and entertainment services. It combines present strengths of both telecom and cable company worlds and can be easily migrated to high-quality, all-digital home-networking solutions.

Acknowledgements

The work presented in this paper is partly carried out in the B@Home project, supported by the Freeband Communication technology program of the Dutch Ministry of Economic Affairs.

References

1 Delphinanto, A., Suarez Rivero, D., den Hartog, F. T. H., Huiszoon, B., van den Boom, H., Kwaaitaal, J. J. B., and van Wijk, P. Home Networking Technologies Overview and Analysis. Deliverable D3.1. of the Residential Gateway Environment project, Dec. 2003., http://www.rge.brabantbreedband.nl/docs/ RGE_D3_1.pdf.
2 Betz, S., and Franken, A. Comparison of Centralized and Distributed Video Service Distribution Architectures for VDSL Customer Premise

Equipment. Contribution FS0077 to the FS-VDSL Committee, FS-VDSL, Geneva, Jan. 2001.
3 Ronai, A. The Home Gateway Architecture Debate. Proc. of the Workshop Broadband and Wireless Services in the Future, Eurescom, Heidelberg, March 2003.
4 DSL Forum (Dowker, M. (ed.)). MultiService Delivery Framework for Home Networks. Technical Report DSL Forum TR-094, Aug. 2004.
5 Aasman, J., van Zeijl, A., Taverne, M. and Steenwinkel, H. The Mobile In-Home User Experience. *Trends in Communications,* 2002, 9, pp. 31–49.
6 Schadler, T. The Battle for the Digital Home. *Market Overview*, Forrester Research, Cambridge MA, Dec. 2004.
7 Jackson, P. A Manifesto for the Digital Home. *Forrester Big Idea*, Forrester Research, Cambridge MA, March 2004.
8 www.entone.com, www.zhone.com.

Biographies

Bas Hendrix
TNO Information and Communication Technology

Bas Hendrix received his Bachelors degree in Electrical Engineering at the faculty of Electrical Engineering, Mathematics and Computer Science, Delft University of Technology. In April 2005, he received his M.Sc. degree in Electrical Engineering after finishing his thesis project on in-home video distribution. Currently, he is working as a technical group leader at the Dutch Royal Navy.

B. S. E. Hendrix, TNO Information and Communication Technology, Brassersplein 2, P.O. Box 5050, 2600 GB Delft The Netherlands

Frank den Hartog
TNO Information and Communication Technology

Frank den Hartog received an M.Sc. degree in Applied Physics from the Technische Universiteit Eindhoven. He obtained a Ph.D. in Physics and Mathematics at Leiden University, after which he joined the R&D department of the Dutch incumbent operator KPN. There he specialised in home networking and established an expert group dedicated to the subject. In 2003, he continued his work at the Netherlands Organization for Applied Scientific Research TNO. He initiates and leads various projects in the field of the digital home. He is a guest lecturer at several universities and has (co-)authored about 50 papers and contributions.

F. T. H. den Hartog, TNO Information and Communication Technology, Brassersplein 2, P.O. Box 5050, 2600 GB Delft The Netherlands, Email: F.T.H.denHartog@telecom.tno.nl, Tel: +31 15 285 71 19

Harrie van de Vlag
TNO Information and Communication Technology

Harrie van de Vlag received his M.Sc. degree in Electrical Engineering at the Delft University of Technology, on the subject of ATM traffic modelling. After his graduation, he worked as a software engineer for the Ministry of Defense. In 1995, he joined KPN Research, starting as a network architect. Since 2003, he has held the position of senior consultant at TNO, working mainly on multiplay service development.

H.A.B. van de Vlag, TNO Information and Communication Technology, Brassersplein 2, P.O. Box 5050, 2600 GB Delft The Netherlands, Email: H.A.B.vandeVlag@telecom.tno.nl, Tel: +31 15 285 73 19

Nico Baken
KPN Telecom and Technical University of Delft

Nico Baken graduated in mathematics at the Technische Universiteit Eindhoven, and received his Ph.D. from Delft University of Technology at the department of Electrical Engineering. He currently holds a part-time professorship in the Telecommunications Department at Delft University of Technology, alongside his primary position as Chief Architect of the Fixed Networks Division within the Strategy and Business Development department of The Royal KPN, the Dutch incumbent telecom operator in The Netherlands. His main interest concerns broadband networks and services. He has published over 30 papers, holds several patents and won several prizes for his scientific work.

N. H. G. Baken, KPN Telecom and Technical University of Delft Maanplein 55, 2516 CK The Hague, The Netherlands, Email: n.h.g.baken@kpn.com or n.h.g.baken@ewi.tudelft.nl; Tel: +31 70 343 9137

Virtual Mobility Enabling Multidimensional Life

Nico Baken, Edgar van Boven,
Ramin Hekmat and Ludmila Menert

Each day, one day is added to our past, and thus one day subtracted from our future. That is why the future ought to be simpler than the past. Why is it then, that we always wrestle with the future? Because the new and changing concepts are increasingly complex.
In this paper, we endeavour to describe some novel and intricate concepts in the ICT world such as presence, virtual mobility and avatars. They will have a crucial impact in our economic and social lives. These themes are positioned and explained as a logical evolution, a concatenation of breakthroughs in man's capabilities, such as speech, counting, writing, and the first steps in (tele)communication. The evolutionary sophistication in (tele)communication can be caught in three main parameters: distance, time and richness. These three entities behave in time as communicating vessels, but the 'ceiling' of the product of the parameter-values increases steadily. Furthermore, an identity matrix is described, highlighting an explosion in telecommunication far beyond human beings.

Historic Overview and Future Image

At the end of the last Ice Age, man, who still lived in small tribes of hunters and collectors, started to establish village communities of farmers and shepherds. They became colonists. With the settling, the registration and reproduction of numbers – say quantities of grain, olive trees, sheep, etc – became a necessity. In short, we had to learn how to count: to symbolise numbers. The need to map these numbers on one or more persons led ultimately to the arithmetic process of division.

The reproduction of symbols for numbers has led to the alphabet. Thus, counting was the basis for writing and knowledge transfer across the barrier of time itself! In writing, in fact, man developed his first primitive time machine. However, the richness of this communication is low, it is asymmetric, text based and therefore poor in 'senses' (compared to the richness of face-to-face communication, where much more information is carried in visual and acoustical cues); nevertheless a skill of tremendous importance contributing in an acceleration of the knowledge build up and progress of mankind. After all: indeed script is what enables us to register our knowledge and part of our experiences and pass them on to next generations. We pay a price for this: the gift of oral transfer over many generations is diminishing. With each innovation, something seems to get lost, and in that sense progress is relative. The power of the time machine of script (and music scores) was exponentially magnified by the arrival of the art of printing in 1450: the basis for decentralisation of knowledge. Here, too, a trade-off took place: knowledge versus insight and memory. In the field of human communication, we see the following major innovations: language as a step from non-verbal to verbal communication, a miracle that took more than a million years; counting and script, THE innovations of the last ten thousand years. But were they sufficient?

No, the need evolved for real-time communication over longer distances, as people themselves became more mobile. The physical distances created a barrier which could not be conquered quickly enough on foot, on horseback, and later by car, train and airplane. Around 1864 Alexander Graham Bell envisaged that his famous patent would be merely used to listen to music from a distance. Apparently, he did not relate his patent with the possibility to realise a commercial public telephony service, because he simply could not imagine that people would be willing to talk to one another without their physical presence and even pay for it.
Bell probably underestimated that for human speech, real-time bridging distance could be more important than the sacrifice of the familiar input for

the human eye. Now we discover the pattern. As with *communicating vessels*, we gain in one parameter but must concede in another one: distance is conquered but we lose in richness. Richness comprises sub-parameters such as symmetry and senses; in the case of telephony, the price is paid by missing the physical presence and all involved senses; that is, sight, smell, etc.

In the 20th century, developments accelerated: a telephony network branched out through the world, in which technical innovations came in rapid succession. We moved from manual switchboards to electromechanical ones and ultimately to computer-operated exchanges with an exponentially increasing number of users[1]. The fixed and mobile telephony network now totals roughly three billion users. Even the most rational of us must experience some emotion at this: an unprecedented accomplishment, because it works and works (nearly) all the time! Applications for new connections, repairs, billing, etc: it has all been taken care of! But is it enough?

No! Despite the arrival of mobile telephony, which has progressed much faster than ever expected in the past 10 years, and despite the unprecedented popularity of the Internet, it is NOT enough. Distance and time barriers have been, as explained, partially overcome. The transfer of sound, text and images in a limited quantity per time unit – that is, narrowband – is possible. High-quality real-time video and large data files require speeds higher than 2 Mbit/s, and this type of broadband information cannot yet be transferred at anytime, from and to anywhere end to end, customised to suit the needs. This must be the next step, and once again it is a giant one because it cannot be made using the existing infrastructure. It will lift the ceiling of the product of the parameter values: time, distance and richness. Until now, we have experienced the following sequence of giant steps in the development of communication:

Non-verbal communication	→	Language
Language	→	Counting
Counting	→	Script
Script	→	Narrowband telecommunication

The predicted subsequent steps will be:

Narrowband telecommunication	→	Broadband telecommunication[2]
Broadband telecommunication	→	Virtual reality and virtual mobility

The innovative steps to broadband telecommunication and virtual reality and virtual mobility appear to be predicted and scheduled for the next 15–20 years. Each step is necessary for the next one and is prepared for by smaller intermediate steps. Thus we discover that natural barriers such as time and distance are partially overcome through script and the first steps in telecommunication. In this process, concessions are made in the 'richness' of the communication session. With increasing bandwidths and computing power this can be relaxed and/or repaired 'virtually'. In this sense, the pitfall of Bell can repeat itself for us. Some of us may not be able to comprehend the presence of the communicating party or parties without them physically being there. And, for the factor time (difference), it is hard to grasp that travelling through time does not actually take place, but communication with deceased living entities or no longer existing non-living entities, will take place by means of systems that represent them. Obviously, the sacrifice in richness is overcome by yet crossing another barrier. The sacrifice is softened or repaired when a major innovation takes place and the ceiling is lifted again.

At the dawn of the 21st century a wellknown future image loses its science fiction character: You can appear anywhere in a digitised representation of yourself or what you want to be associated with. You and your avatars (described in the next section) can have real-time communication sessions without physically transporting your body, when using the right ICT means. We believe a substantial part of mankind will adopt this concept of virtual mobility during the first half of this century. In general, a lot of people wish to enjoy a more efficient and richer multidimensional life and be more

1 The number of telephony connections throughout the world has increased from the earliest times by 6.3% per year. Expressed as a formula: $A_n = A_0(1.063)^n = A_0 e^{0.06\ln}$. A power of e with an extremely small exponent. The doubling period N in years = ln(2)/ln(1+x/100), in which x is the growth percentage per year, renders N = 11.3 years. Our thanks to J. W. Meijer.

2 In terms of services, this is the transition from narrowband telephony and best effort data to carrier grade multimedia.

successful than others. The considered dimensions in 21st century life are:

- the good old physical life;
- life in cyberspace being yourself;
- life in cyberspace being your enhanced self, or even faking to be somebody else;
  and
- life in cyberspace 'meeting' other non human (id)entities

Figure 1 shows an image of physical life in 2014. The yellow beams symbolise information flowing in cyberspace. In Figure 1 people and applications (residing on a plethora of devices) continuously interact. (Nearly) all services are enjoyed wirelessly. Radio ranges will be shorter due to higher bandwidth.

Really new compared to today's situation is the multimedia streetlight on the curb. It not only offers society wireless connectivity for real-time communication, but provides security services, personalised advertising and location-based information services as well. The deployment of intelligent sensors and ICT (id)entities will fundamentally change society.

Figure 1 shows a lady in a wheelchair triggering a sensor that adapts the stairway. A blind man is guided by a multimedia cane, telling him where to go. His health parameters are continuously monitored and sent to his medical account. His doctor asks for an overview of the blood pressure of all his patients on his flat screen. The dog on a leash has an ICT identity, too. It can always be traced when it's lost. The dog's health can optionally be monitored as well.

The man sitting at the sidewalk cafe on the right is playing a multimedia game with the girl sitting on her balcony (on the upper right). The waiter establishes a paying transaction. No banknotes are involved anymore. The car is equipped with an online vehicle area network that can temporarily host every personal area network of all the people who take a ride, not only the owner of the car.

Realising the future image depicted above requires an ICT identity architecture in order to discriminate and service all continuously interacting entities. Our (id)entity matrix, Figure 2, tries to grasp all thinkable future information flows in cyberspace, by means of typical examples of interactions between (id)entities.

An important development is the rise of (wireless) communication devices (D). Many different types of devices will be able to (autonomously) communicate. They will outnumber people before 2010 and generate and process more information than people. In the (id)entity matrix in Figure 2 devices (D) are discriminated from all other nonliving entities (E) because of their communication function. All (id)entities (A–F) depicted in Figure 2 are expected to be equipped with:

- sensors being their (additional) eyes and ears; and
- applications and actuators being their (additional) brains, mouths and limbs (for example, cat door (E) opens when an authorised cat (A) approaches).

Passive devices (like sensors and electronic tags) will outnumber active devices (D).

Figure 1 Future image [7].

to / from	A Animal	B Business	C Consumer	D Device	E Entities (non-living & non-D)	F Flora
A		Show their condition	The cat's location	This cow is hungry	Not applicable	Not applicable
B	Remote tag info	We could be partners	Buy our Product !	Install software	Archive search	Guarding rare trees
C	Come and get it !	Your product doesn't work	Bla bla bla	I'd like to download	What is your price?	Looking at a rare plant
D	Dinner Time !	Somebody stole me !	Your car needs oil	Which codec?	Search query	Checking humidity
E	Door opens	Camera images	Camera images	Water temperature		Not applicable
F	Not applicable	Help, I'm cut down	I'm at the Hortus Botanicus	I could use some water	Not applicable	

Figure 2 Information will flow among all (id)entities in this (id)entity matrix (panta rhei).

Two different long-term images exist:

1 *Autonomous devices gaining importance*, being smarter, faster and far more efficient then average people for specific tasks. In 5 years time, devices and (their) applications will be able to take simple decisions; in 10 years time they will take more complex decisions (helping their owner) without asking direct permission. Being connected to vast information databases, devices/applications can be consulted real time if you can afford it.

2 *People remaining in the lead*, physically enhancing themselves with technological extensions and brain-controlled user interfaces. People start to engineer themselves (in order to be more successful than others who don't use these features).

No matter which of these two images will dominate, the simplicity of user interfaces will be crucial.

(Id)entity matrix example:
In 10 years time, water (E) will be more expensive than today. In 2015, a group of apple trees (F) is thirsty. Due to hot and dry weather going on for days, the trees' humidity sensor (F) tries to trigger the irrigation system (E) requesting for some precious water. The communication application of the irrigation system (E) queries the weather report domain (B). Weather satellites forecast rain in five hours. The irrigation control system decides to wait. Somewhat later the trees finally enjoy the welcome rain, and the farmer (B) a lower water bill.

Virtual Mobility and Avatars

Today's real-time presence information comprises the 'MSN pawns' and maybe a few other icons on communicator applications. Most instant messaging (IM) users today only share with their community of interest whether they are online or not, typing additional status information themselves.
It is technically feasible in the midterm to distribute real-time status information revealing the actual state of all used ICT means and in the long-term even physical events. Figure 3 shows a schematic presentation of this concept.

The main three messages of the presence concept shown in Figure 3 are:

- There will arise a gigantic new traffic flow caused by people continuously sending their real-time status information to their communities.
- People will continuously define and redefine their communities (your tribes of virtual nomads)
- It will bring telcos and service providers a new revenue-generating feature in their packages.

Status information of all ICT means will/can be aggregated:

- your geographic location (Global Positioning System);
- being active in a telephony session (fixed and wireless telephony (video or sound only));

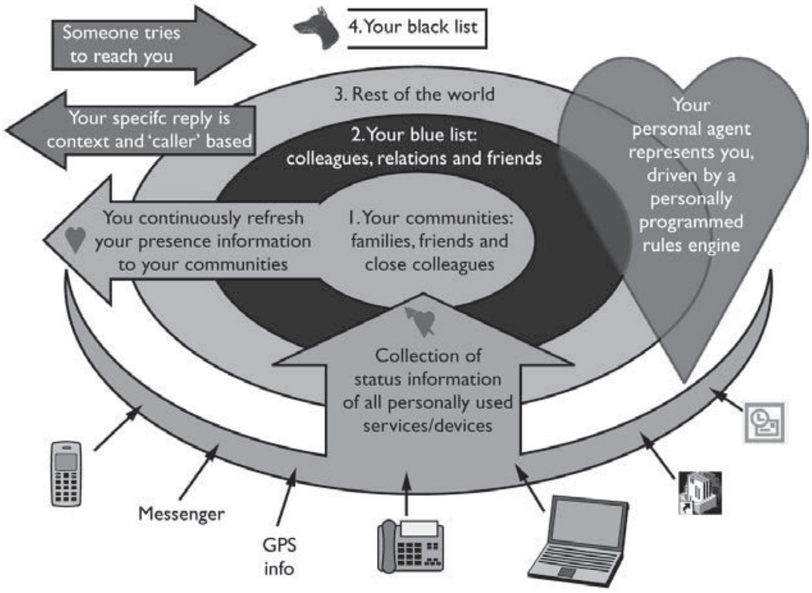


Figure 3 Next-generation presence concept.

- being active in 'don't disturb mode' (for example, reading a document, writing towards a deadline);
- IM or email sessions (messenger); and
- Outlook (your schedule).

Future presence information will be spread to your communities in a context and preference based way, depending on:

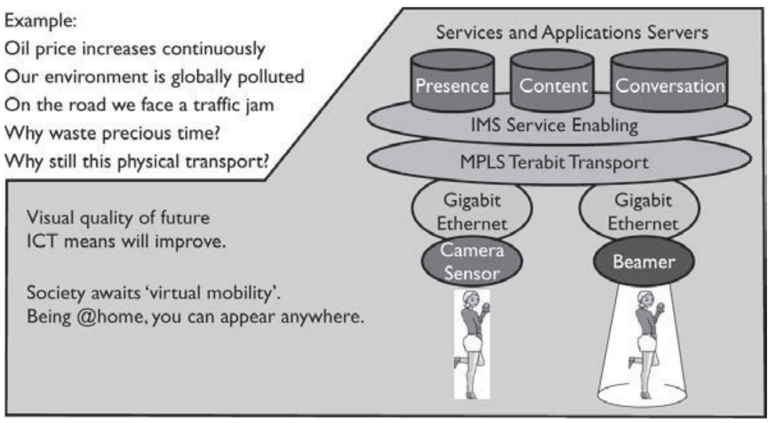
- time of day;
- your current activity (working, enjoying holiday, sleeping, eating, shopping, etc.); and
- your current indicated mood, health and energy level (sometimes you will be in 'leave me alone mode').

When you adopt this next-generation presence technology you will have to accept the continuous monitoring and spreading of your status, and to learn to program your rules engine. Today people have got used to filling their schedule in Outlook. For market acceptance of this new presence concept, simplicity, privacy, and user friendliness of rules engines will be crucial.

Probably your communities only comprise a minority of all people/entities interacting with you. Depending on who or what is trying to reach you, your actual preferences, context and your status, they will receive your tailormade reply. It could look like:

1 Members of your communities (continuously receiving your presence informa tion) will be met as soon as possible and/ or even directly and above all warmly and with your personal touch dedicated for this special person.
2 Your blue list will consist of precious relations, colleagues and friends to be contacted as soon as possible, friendly and with a personal touch.

Figure 4 Example stage 3 virtual mobility benefits.



3 All unknown 'callers' probably receive a standard, polite, friendly, open answer (comparable to your current voicemail greeting).
4 People on your blacklist receive a neutral voice or video mail. Don't call us we call you!

In general the service evolution could likely follow these stages:

1 Today's interactive multimedia and presence (mainly Microsoft messenger based).
2 Today's presence concept transforms into 'virtual mobility' in a parallel cyber world.
3 Virtual mobility concept will be enhanced with 3D projections (being at X you can appear at Y) (see, for example, Figure 4).

It means a paradigm shift: virtual mobile people and their representatives in cyberspace (avatars) will generate an enormous new traffic flow. It will consist of:

- traffic among avatars,
- traffic among people and avatars,
- availability information (presence information to your communities),
- two- and three-dimensional images and projections of people communicating realtime, and
- traffic caused by meeting non-human (id)entities (A, D, E and F).

The evolutionary path to ergonomically feasible avatars is not trivial. Below we elaborate on the technological implications of user-friendly avatar design. A personal assistant should help instead of irritate people.

Avatar types and designs

Avatars are used in virtual environments to act on behalf of *all* (id)entities (see (id)entity matrix Figure 2), as their virtual, mostly personified, representation. The avatar interface should offer comfort, convenience and efficiency, being unobtrusive and yet effective. This implies use of sensors in order to provide information about the entity itself (humidity/food/ drink/health monitoring), but also to function as the ears and eyes of such devices in their interaction with humans in the physical world. So-called attentive appliances are able to assess whether or not to alert the owner (for example, to an incoming message) not only on the basis of the user's presence status, but also by monitoring the user's current activity, level of attention and even information load2. To be able to do this, the avatar's skills need to include reasoning: the value of a message is weighted against the cost of the disruption and the appropriate action is taken. Also, the appropriate channel should be chosen depending on the information type and the situation. Voice-only interfaces should be deployed either when voice access is the only possibility (car, hands/eyes needed for something else, etc.) or when talking is faster then typing and the content is fit for being listened to (long texts, complex instructions, overviews, lists or tables are unsuited for auditive presentation due to sequential processing and the limited shortterm memory in case of auditive input).

A personal agent is designed and customised by the owner in order to reflect his or her actual or assumed persona. This enables you to improve your representation, by enhancing or adjusting your image. You can even choose to be represented by an image or persona that is totally dissimilar to yourself. As using such a *mask avatar* can bring the avatar owner psychological and emotional (though possibly addictive) satisfaction, we can expect growing demand for this type of fully customisable personal agents. However, the attraction of this aspect of avatars and cyber life in general is also a danger. Avatar adoption might cause tendencies towards withdrawal from physical society.
The appearance and behaviour of agents will always be designed with the main functions of the interface in mind: lively anthropomorphic agents may enhance the perceived presence, creating a favourable attitude towards advertisements, and the willingness to revisit a site. An anthropomorphic agent with some carefully crafted 'social' behaviour can have a positive effect on the user experience; for example, in interaction with patients. For specific tasks, users may prefer a machine to a human when the machine provides at least the same level of service and certainly when the machine can help quicker than a human (automated attendant, online banking), or better than a human (for example, Google).

Avatars powered by speech technology and artificial intelligence

As explained earlier, we expect even nonliving entities from the identity matrix in Figure 2 will be interacting. For any interaction, the schematic representation shown in Figure 5 can be used.

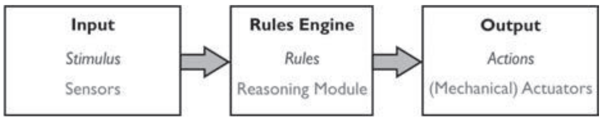


Figure 5 Schematic representation of human-machine or machine-machine interactions.

Figure 6 Schematic representation of human-avatar conversational interactions.

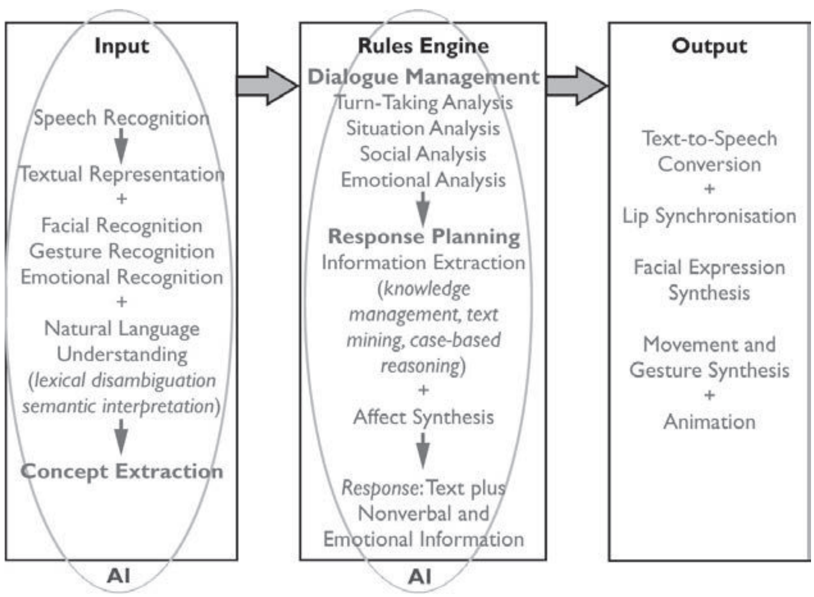
In our earlier example of the thirsty trees, the stimulus (triggered by a particular value of the sensor indicator) is sent to the irrigation system, which then follows its rules (here carefully defined so as to take water shortage into account) and takes action by first sending a query to the weather satellite. (Simpler rules would just send a request to the irrigation system directly.)
When an avatar communicates with humans, it needs to emulate human communicative behaviour. This has some far-reaching technological consequences.

When we extend Figure 5 to describe such a conversational session, the input will be natural speech of a human and the output human-like speech of the avatar (Figure 6). However, speech is not all: in human face-to-face conversation, the verbal content of speech is supplemented by nonverbal information in the form of acoustical cues like stress, loudness, pitch, rhythm, and in the form of gestures and facial expressions, signalling topic-comment distribution (what are we talking about and what is being said about it), relevance, deictic reference (pointing) and attitude.

The most challenging module, though, is the *rules engine*: combinations of computational linguistics, artificial intelligence (Al) and knowledge management are needed for the application to do its work: first, to carry out its task (for example, provide information), and, second, to maintain a humanlike dialogue with the user.

Figure 7 shows the different technologies that need to be combined for a conversational session between a human and a human-like avatar.
Correct input interpretation and response planning require context analysis on various levels: linguistic, situational, social and psychological (emotional). For example, correct recognition of the user utterance that sounds like ‘seventy four’ as ‘seven to four’ and its consecutive interpretation as ‘15:53 [time]’ is facilitated by intelligent use of relevant contextual information. The same applies for interpretation on a more abstract level, for example substituting ‘John’ for ‘he’ in the sequence ‘Reschedule the meeting with John. He can not come today’, or, on yet another level, substituting ‘Tom’ for ‘my son’ in ‘I want to call my son’. Information from previous sessions is needed to correctly interpret the emotional message expressed by above-average loudness and pitch values accompanying the phrase ‘Not again!’ The same levels can be distinguished in system output, where responses need to be generated in stylistically appropriate language,

Figure 7 Integration of different technologies required for human-like conversation.



syntactically and semantically correct utterances (resolving pronunciation of words with identical spelling which are pronounced differently depending on their meaning) and naturally sounding speech.
Allowing for so-called 'free speech' input means not only that the speech recognition engine can interpret natural language utterances[3] (which in itself already implies quite advanced Al), hut when the input can be anything, the engine has verg little to base its decisions on to resolve ambiguities on different levels, as illustrated above.

Understanding the typically short, often incomplete and grammatically incorrect, utterances in free speech depends heavily on knowing the context of the conversation. The system needs the support of pragmatics. The approach taken in most current implementations is to use relatively simple pattern matching, based on domain knowledge. This artificial intelligence is still far from 'human': inserting words or whole parts of sentences from the user's comment in the responses, which are often randomly chosen from a set of arbitrary sentence templates, or responding with a predefined answer when a specific word in the question is recognised makes such a so-called *intelligent agent* just more or less an extensive pattern-matching case-statement. Complex discussions about complicated subjects are beyond the state of the art of AI.
Such systems can be improved semiautomatically by so-called *ripple down rules*, which provide a form of teacher-guided incremental learning method. Another possibility is so-called *batch learning* by induction over examples: logs of user interactions are stored and collected and machine learning programs seek common patterns and construct sets of rules (or decision trees) that describe the preferred behaviour of the system.
A further step will be when avatars themselves will be able to access knowledge stored in different locations on the Internet. Information about the user (past interactions, preferences, etc) could be delivered to the avatars by the personal assistant of the user. Such integration would help to create a self-learning intelligent environment where information gathered about the user will become available to other users[4].

Information flows

This means information exchange and information flows between avatars: in addition to communication with people, avatars will increasingly communicate with each other to improve themselves. In the future, the self-learning ability of avatars will outgrow the probabilistic machine learning; avatars will become more autonomous and able to take more complex decisions and eventually organise themselves in hierarchical layers.
In effect, human–machine and machine– machine communication will dwarf the traffic volume of inter-human communication.

Proof of traffic increase caused by virtual mobility

Figure 8 shows a simple scheme proving the increase in incoming as well as outgoing traffic when avatars are used to enhance the presence as well as the (id)entity of a person. Here we explain the idea behind this picture. Our calculation method here is somewhat crude. However it serves well our purpose of rough estimation of the traffic increase due to virtual mobility and the presence of avatars.
Assume the incoming traffic arrival rate for the person depicted above is λ (in units of traffic arrival, for example calls per day or hits per hour) and each call or session duration is 1. Symbol p is the probability of the avatar owner being present to receive the call. The total incoming traffic load is then simply $\lambda\, p$. When avatars are used, there are three steps in communication:

1 There will be a communication with an avatar first (in our case we assume avatars take all incoming traffic first before forwarding the call or informing the person). This communication is of duration α. This communication will probably be shorter in comparison to the length of the communication if the owner would have been present.

3 *Natural Language Processing* (NLP) uses a syntactic, semantic and pragmatic analysis of textual or speech input in order to allow for a free and flexible exchange in written or spoken natura) language. Modes for semantic equivalence and entailment are deployed for the correct interpretation of overtly distinct lexica) content. Pragmatic knowledge, that is 'knowledge of the wond' or knowledge of the domain of the discourne, is used to resolve ambiguities and make correct deductions from the available informiation.

4 Sergey Shumsky [5] proposes an interesting self-organising semantic network, in which personal agents act on behalf of their users, thereby forming a distributed search engine, where each node, though possesing only limited amount of local information, can handle global queries.

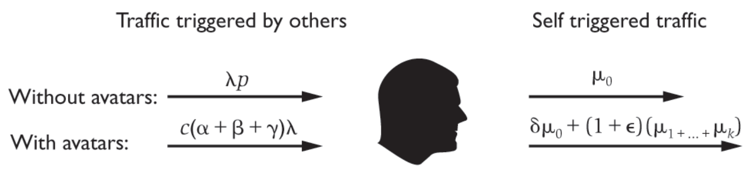


Figure 8 Traffic increase formulae.

2 The avatar informs the person directly or in due time that there is (or there was) incoming traffic for him. We represent the duration of this communication with β.
3 The owner may decide to get in touch with the generator of incoming traffic. The duration of this communication session is represented by γ.

The total traffic generated till now is then $(\alpha + \beta + \gamma)\lambda$. Generally $\alpha + \beta + \gamma > 1$. Further we may assume that due to better reachability (popularity) of the person above, there will be an additional factor of traffic increase (factor c here).

Concerning the traffic triggered by the owner himself, assume that under normal conditions without avatars there is a traffic load of μ_0. When k avatars are used, each generates a traffic amount by itself: μ_1 to μ_k. Further, each avatar will probably communicate briefly to the owner the summary or results of its mission. For simplicity we have assumed here that this is a fraction ϵ of the traffic for all avatars. Finally, because avatars take over a part of activities from the owner, the owner himself would probably reduce his own traffic generation with factor $\delta > 1$. It is realistic to assume that the sum of the traffic generated in the case of avatars presence is (much) higher than μ_0.

A numeric example is given here with the following conservative assumptions:
$p = 80\%$, $\alpha = 0.1$, $\beta = 0.1$, $\gamma = 0.9$, $c = 2.0$, $\delta = 0.2$, $\epsilon = 0.1$, $k = 3$, $\mu_1 = \mu_2 = \mu_3 = \mu_0$. With these values there will be 2.75 times increase in traffic triggered by others and 3.5 times traffic increase triggered by the owner. Please notice that this conservative estimation of traffic increase could in the future be multiplied by an order of magnitude proportional to the possible communication combinations shown in the (id)entity matrix of Figure 2.

Conclusions

Virtual mobility will:

- cause a landslide in society comparable with the shift from nomadic to colonist life – the pervasiveness of cyber life will dramatically change society and human behaviour this century;
- enable multidimensional life – people will travel and appear anywhere without carrying their atoms with them;
- be facilitated by human-like avatars;
- endanger the mental health of people who already struggle with their personality and identity. Future 'multimedia masks' will be far more sophisticated compared to today's text-based instant messaging hide and seek. Using mask avatars and the possibility to submerge oneself in cyber life will impoverish some people's real physical life.

Full-blown virtual mobility will cause an enormous new traffic flow:

- which is a new revenue generator for telcos and service providers;
- consisting of presence status information being sent to different groups of entities being people, avatars, applications running on several devices.

Market introduction of virtual mobility and avatars will be driven by:

- efficiency needs in general;
- the increasing value of time;
- cost and irritations concerning physical transport;
- higher oil price, saving energy and reducing global pollution (Kyoto).
- vanity or being uncertain about one's looks.

Avatars will:

- develop into an enormous diversity, some acting on behalf of people as their personal agents, others as agents representing organisations, animals, flora, precious objects – in cyberspace information will flow in a 6×6 identity matrix;
- communicate with people and with each other;
- be powered with artificial intelligence (Still simple in the short term, the ability to learn will arise. Human intuitive orientation skills are

hard to learn and probably can not be matched so avatars will not become replicas of people, but will communicate in a human-like way with people and their appearance and behaviour will in some cases be anthropomorphic.);
- become more autonomous in the long term, take more complex decisions for their owner;
- organise themselves in hierarchical layers in the long term;
- not only be used for work, study or organisational purposes, but also for entertainment and psychological and emotional satisfaction;
- use sensors being their eyes and ears in cyberspace;
- require an *ergonomic* user interface/rules engine for the avatar owner. Note the 'rest of the world' is user of this avatar as well.

Avatars/active devices will outnumber people and dwarf the traffic volume between people.

References

1 Adams, W. H., Iyengar, G., Lin, C-Y., Naphade, M. R., Neti, C., Nock, H. J., and Smith, J. R. Semantic Indexing of Multimedia Content Using Visual, Audio and Text Cues. *Eurasip Journal on Applied Signal Processing*, Feb. 2003, 2003(2).
2 Wayt Gibbs, W. Considerate Computing. *Scientific American*, Jan. 2005. pp. 40–46.
3 Gorniak, Peter and Roy, Deb. Speaking with your Sidekick: Understanding Situated Speech in Computer Role Playing Games. To appear in Proceedings of Artificial Intelligence and Digital Entertainment, 2005.
4 Moore, Gerhard. R., and Hobbs, D. J. An Experimental Study of the Effect of presence in Collaborative Virtual Environments. Proceedings of the British Computer Society Conference on Intelligent Agents, Mobile Media, and Internet Applications, 2001, Bradford, UK.
5 Shumsky, Sergey. Self-organizing Internet Semantic Network. White paper, by NeurOK, LLC, 2001.
6 Thrun, et al. Probabilistic Algorithms and the Interactive Museum Tour-Guide Robot Minerva. *The International Journal of Robotics Research*, 2000, 19, pp. 972–999.
7 We thank Siemens for providing the basis for Figure 1 – Future image.

Biographies

Nico Baken
Delft University of Technology and KPN

Professor Baken currently holds a part-time chair in the Telecommunications Department at Delft University of Technology alongside his primary position as Chief Architect for The Royal KPN, the Dutch incumbent operator in the Netherlands. His main interest concerns broadband networks and services, dealing with a broad range of aspects such as fibre access infrastructures, fixed-mobile convergence, services, operations, financial strategies such as the real option analysis, managerial complexity and regulations. Given this spectrum, he has been asked to advice the Dutch government on the matter of broadband and the roll out of fibre to the home in the national expert group broadband and in the Andriessen committee (former minister of Economic Affairs) to deal with the FTTH for Amsterdam and the Hague.
He finished Gymnasium β in 1973 and graduated, cum laude, in mathematics at Eindhoven University of Technology in 1981. He has published over 30 papers, holds several patents and won several prizes for his scientific work; for example, the Dr Neher Laboratory prize (yearly prize for the most outstanding researcher). He received his Ph.D. Thesis from the Delft University of Technology at the department of Electrical Engineering, working with Professor H. Blok and Professor A.T. de Hoop.

Nico Baken, Delft University of Technology and KPN Oosteinde 187, 2271 EE Voorburg The Netherlands, Tel: +31 70 3876378, Email: n.h.g.baken@kpn.com

Edgar van Boven
KPN

Edgar van Boven studied electronics and IT at the Technical Highschool in Vlissingen. Though tempted to start an adventurous life as a jazz pianist, he graduated in 1987. After military service as a sergeant in a telecommunications battalion, he entered KPN. Until today, public telephony dominated his career from various viewpoints starting with hardware and software engineering, via operational network planning to architecture and programme management. In the late 1990's, he started to work on the evolution to voice over packet in the former Unisource Business Networks environment within KPN. Since 2001, he has also been guest lecturer at the Delft University of Technology. Currently, Edgar is working in the area of fixed mobile convergence and service architecture.

Edgar van Boven, KPN, Email: e.f.m.vanboven @kpn.com

Ramin Hekmat
Delft University of Technology

Ramin Hekmat received his M.Sc. degree in electrical engineering from Delft University of Technology in The Netherlands in 1990. Since then he has worked for several telecommunication companies in The Netherlands and the United States in research and development as well as managerial positions. In September 2001, he started his Ph.D. work related to ad-hoc networking at TU Delft. His prime research interest includes multi-user communication systems, wireless communications and peerto-peer networks.

Ramin Hekmat, Delft University of Technology Email: r.hekmat@ewi.tudelft.nl

Ludmila Menert
Consultant

Ludmila Menert graduated in General Linguistics and Phonetics at Leiden University, and in 1994 received her Ph.D. in Phonology and Phonetics from Utrecht University. After three years of teaching at the phonetics department of Utrecht University she made a career switch by cofounding Fluency Speech Technology. Within this company she co-authored Fluency, the best text-to-speech software for Dutch at that time. When the company was sold to Van Dale Lexicografie (Dutch dictionaries publisher), she joined Van Dale as a speech technology expert. Due to her involvement during the past years in a whole range of projects in the field of man–machine communication for her last employer, Comsys BV, her expertise now covers the broad area of deployment of language and speech technology in automated systems as well as usability of speech applications. Currently she works as an independent consultant.

Ludmila Menert, Consultant, Email: ludmila.menert@fluency.nl

Ledenmutaties NERG

Nieuwe leden:

Op den Kamp, ir. N.A.A
Koenraadlaan 70,
5651 EX EINDHOVEN

Winands, Dipl. Ing. E.H.M.
Bostrop 45,
6462 GT KERKRADE

Nieuwe adressen:

Koelemeij, D.
de Wingerd 25,
3823 CT AMERSFOORT

Koole, ir. C.Th.
Annadal 43,
5551 BM VALKENSWAARD

Sinttruyen, ir. J.S. van
Vredehoflaan 816,
4382 CK VLISSINGEN

Smulders, ir. P.F.M.
Strijpsestraat 152,
5616 GT EINDHOVEN

Proefschriften

Hieronder treft u, traditiegetrouw het overzicht aan van de proefschriften behorende bij de promoties in het academisch jaar 2004/2005 aan de Technische Universiteit Delft, de Technische Universiteit Eindhoven en de Universiteit Twente. Voor detailinformatie verwijzen wij u graag door naar de bibliotheek van de universiteit waar de promotie heeft plaatsgevonden. Onderstaand vindt u de adressen:

Bibliotheek TU Delft	Centrale Bibliotheek TUE	Bureau Universiteit Twente
Postbus 98	Postbus 513	Potbus 217
2600 MG Delft	5600 MB Eindhoven	7500 AE Enschede

Technische Universiteit Delft

Quality of service routing in the internet: Theory, Complexity and Algorithms
F.A. Kuipers
14 september 2004
Promotor: prof.dr.ir. P. Van Mieghem

Archived film analysis and restoration
A. Rares
27 september 2004
Promotor: prof.dr.ir. J. Biemond
Copromotor: dr.ir. J.T. Reinders

Simulation of single-electron tunnelling circuits using SPICE
R. van de Haar
15 oktober 2004
Promotor: prof.dr. J.R. Long
Copromotor: dr. J. Hoekstra

Electrothermal behaviour of high-frequency silicon-on-glass transistors
N. Nenadovic
1 november 2004
Promotors: prof.dr. L.K. Nanver
prof.dr.ir. J.W. Slotboom

Sparse matrix vector processing formats
P.T. Stathis
19 november 2004
Promotor: prof.dr. S. Vassiliadis

Democratic processing
H.W. van Dijk
22 november 2004
Promotors: prof.dr.ir. H.J. Sips
prof.dr.ir. R.L. Lagendijk

Single electron tunneling based arithmetic computation
C.R. Lageweg
24 november 2004
Promotor: prof.dr. S. Vassiliadis
Copromotor: dr. S.D. Cotofana

Antennas for multi-band RF front end modules
K.R. Boyle
29 november 2004
Promotor: prof.dr.ir. L.P. Ligthart

Calibration and testing of integrated thermal airflow sensors
S.P. Matova
1 december 2004
Promotor: prof.dr.ir. J.H. Huijsing

PECVD silicon carbide - a structural material for surface micromachined devices
H.T.M. Pham
7 december 2004
Promotor: prof.dr. P.M. Sarro

The Molen polymorphic media processor
G.K. Kuzmanov
13 december 2004
Promotor: prof.dr. S. Vassiliadis

A probabilistic approach to symbolic performance modeling of parallel systems
H. Gautama
16 december 2004
Promotor: prof.dr.ir. H.J. Sips
Copromotor: dr.ir. A.J.C. van Gemund

Condition assessment of power cables using partial discharge diagnosis at damped AC voltages
F.J. Wester
20 december 2004
Promotor: prof.dr. J.J. Smit

Nano-liter sensor arrays for biochemical analysis
V.P. Iordanov
21 december 2004
Promotors: prof.dr. M.J. Vellekoop
prof.dr. P.J. French
Copromotor: dr.ir. A. Bossche

CMOS bandgap references and temperature sensors and their applications
G. Wang
11 januari 2005
Promotors: prof.dr.ir. G.C.M. Meijer
prof.dr.ir. A.H.M. van Roermund

Convolutional models for landmine identification with ground penetrating radar
F. Roth
21 januari 2005
Promotors: prof.ir. P. van Genderen
prof.dr.ir. M.H.G. Verhaegen

Bio-inspired local learning neural nets using nanoelectronics
E. Rouw
28 februari 2005
Promotor: prof.dr.ir. P. Dewilde
Copromotor: dr. J. Hoekstra

Bipolar transistors with self-aligned emitter-base metallization and back-wafer-aligned collector contacts
H.W. van Zeijl
19 april 2005
Promotors: prof.dr.ir. J.W. Slotboom
prof.dr. L.K. Nanver

Adaptive RF front-end circuits
A. Tasic
25 april 2005
Promotor: prof.dr. J.R. Long
Copromoter: dr.ir. W.A. Serdijn

Development of an airborne Ka-band FM-CW Synthetic Aperture Radar
J.J.M. de Wit
9 mei 2005
Promotors: prof.ir. P. Hoogeboom
prof.dr.ir. L.P. Ligthart

Adaptive OFDM and CDMA algorithms in SISO and MIMO channels
H. Che
23 mei 2005
Promotors: prof.dr.ir. L.P. Ligthart
prof. R. Prasad

RF amplifier design techniques for linearity and dynamic range
M.P. van der Heijden
3 juni 2005
Promotor: prof.dr.-ing. J.N. Burghartz
Copromotor: dr.ing. L.C.N. de Vreede

Radio resource management for orthogonal frequency division multiple access systems
S.A. Pietrzyk
6 juni 2005
Promotor: prof.dr.ir. I.G.M.M. Niemegeers
Copromotor: dr.ir. E.J.M. Janssen

Radio frequency interference mitigation in radio astronomy
A.-J. Boonstra
14 juni 2005
Promotor: prof.dr.ir. A.J. van der Veen

DRAN fault analysis and test generation
Z.E. Al-Ars
27 juni 2005
Promotor: prof.dr.ir. A.J. van de Goor

Trade-offs in buffer planning
G.S. Garcea
27 juni 2005
Promotor: prof.dr.ir. R.H.J.M. Otten
Copromotor: dr.ir. N.P. van der Meijs

Enhanced techniques for the design and characterization of RF power amplifiers
M. Spirito
30 juni 2005
Promotor: prof.dr. J.N. Burghartz
Copromotor: dr.ing. L.C.N. de Vreede

Technische Universiteit Eindhoven

High-speed D/A converters : from analysis and synthesis concepts to IC implementation
K. Doris
14 september 2004
Promotors: prof.dr.ir. A.H.M. van Roermund
prof.dr.ir . W.M.G. van Bokhoven

Minimum power design of RF front ends
P.G.M. Baltus
16 september 2004
Promotors: prof.dr.ir. A.H.M. van Roermund
prof. ir. A.M.J. Koonen

Contrast echocardiography for cardiac quantifications
M. Mischi
4 oktober 2004
Promotors: prof.dr. A.A.C.M. Kalker
prof.dr. H.H.M. Korsten

All-optical buffering based on nonlinear optical processing with semiconductor optical amplifiers
Y. Liu
18 oktober 2004
Promotors: prof.ir. G.D. Khoe
prof.dr. D. Lenstra
Copromotor: dr. H.J.S. Dorren

Corona plasma for tar removal
S. A. Nair
26 oktober 2004
Promotors: prof.dr.ir. J.H. Blom
prof.dr.ir. A.A.H. Drinkenburg
Copromotor: dr.ing. A.J.M. Pemen

Observer design and identification methods for hybrid systems : theory and experiments
A. L. Juloski
9 november 2004
Promotors: prof.dr.ir. P.P.J. van den Bosch
prof.dr. H. Nijmeijer
Copromotor: dr.ir. W.P.M.H. Heemels

Integration of multiwavelength lasers with fast electro-optical modulators
J.H. den Besten
18 november 2004
Promotors: prof.dr.ir. M.K. Smit
prof.dr. J.H. Wolter
Copromotor: dr. X.J.M. Leijtens

Performance modelling for system-level design
B. D. Theelen
25 november 2004
Promotors: prof.ir. M.P.J. Stevens
prof.dr.ir. R.H.J.M. Otten
prof.dr. H. Corporaal
Copromotor: dr.ir. J.P.M. Voeten

Reduction of process simulation models : a proper orthogonal decomposition approach
P. Astrid
30 november 2004
Promotors: prof.dr.ir. A.C.P.M. Backx
prof.dr.ir. R.G.C. Beerkens
Copromotor: dr. S. Weiland

Finite antenna arrays : an eigencurrent approach
D.J. Bekers
13 december 2004
Promotors: prof.dr. A.G. Tijhuis
prof.dr.ir. C.J. van Duijn
Copromotor: dr.ir. S.J.L. van Eijndhoven

System-level design decision-making for real-time embedded systems
S.-A. Ong
14 december 2004
Promotors: prof.ir. M.P.J. Stevens
prof.dr.ir. R.H.J.M. Otten
Copromotor: dr.ir. L. Józwiak

Decomposition and encoding of finite state machines for FPGA implementation
A. S. Slusarczyk
15 december 2004
Promotors: prof.ir. M.P.J. Stevens
prof.dr.ir. R.H.J.M. Otten
Copromotor: dr.ir. L. Józwiak

Effective and efficient circuit synthesis for LUT FPGAs : based on functional decomposition and information relationship measures
A. Chojnacki
16 december 2004
Promotors: prof.ir. M.P.J. Stevens
prof.dr.ir. R.H.J.M. Otten
Copromotor: dr.ir. L. Józwiak

On-line signal analysis of partial discharges in medium-voltage power cables
J. Veen
7 april 2005
Promotors: prof.dr.ir. J.W.M. Bergmans
prof.dr.ir. E.F. Steennis
Copromotor: dr. P.A.A.F. Wouters

On-line detection and location of partial discharges in medium-voltage power cables
P.C.J.M. van der Wielen
7 april 2005
Promotors: prof.dr.ir. E.F. Steennis
prof.dr.ir. J.W.M. Bergmans
Copromotor: dr. P.A.A.F. Wouters

Parameter tuning and cooperative control for automated guided vehicles
B. Stouten
26 mei 2005
Promotor: prof.dr.ir. P.P.J. van den Bosch
Copromotors: dr.ir. A.J. de Graaf
dr.ir. A.A.H. Damen

Sigma Delta A/D conversion for signal conditioning
K. J.P. Philips
2 juni 2005
Promotors: prof. dr. ir. A.H.M. van Roermund
prof.dr.ir. P.G.M. Baltus

Frequency selective surfaces integrated with phased array antennas : analysis and design using multimode equivalent networks
S. Monni
27 juni 2005
Promotor: prof.dr. A.G. Tijhuis
Copromotor: dr. G. Gerini

Radio-over-fibre technology for broadband wireless communication systems
A. Ng'oma
28 juni 2005
Promotor: prof.ir. A.M.J. Koonen
Copromotor: prof.dr.ir. E.R. Fledderus

Universiteit Twente

Dielectric engineering. Characterization, development and process damage minimization of various silicon oxides
J.G.G. Ackaert
8 september 2004
Promotor: prof.dr.ir. F.G. Kuper

Software-defined radio for wireless local-area networks
R. Schiphorst
10 september 2004
Promotor: prof.dr.ir. C.H. Slump

Detection of and protection against plasma charging damage in modern IC Technologie
Z. Wang
17 september 2004
Promotor: prof.dr.ir. F.G. Kuper

Coarse-grained reconfigurable processors - Reflexibility meets efficiency
P.M. Heysters
24 september 2004
Promotors: prof.dr.ir. C.H. Slump
prof.dr.ir. Th. Krol
Copromotor: dr.ir. G.J.M. Smit

Deuterium in the gate dielectric of CMOS devices
A.J. Hof
29 oktober 2004
Promotor: prof.dr. J. Schmitz

Using generative probabilistic models for multimedia retrieval
T.H.W. Westerveld
25 november 2004
Promotor: prof.dr. F.M.G. de Jong

Diffusion barriers for Cu Metallisation in Si integrated circuits: depostion and related thin film properties
S. Bystrova
1 december 2004
Promotor: prof.dr.ir. R.A.M. Wolters
Copromotor: dr. J. Holleman

High speed photodiodes in standard cmos technology
S. Radovanovic
1 december 2004
Promotor: prof.dr.ir. B. Nauta
Copromotor: dr.ir. A.J. Annema

Silicon-Technology based mircroreactors for high temperatur heterogeneous partial oxidation reactions
R.M. Tiggelaar
2 december 2004
Promotors: prof.dr. M.C. Elwenspoek
prof.dr.ir. J.C. Schouten
Copromotor: dr. J.G.E. Gardeniers

Micromachined capacitive long-range displacement sensor for nano-positioning of microactuator systems
A.A. Kuijpers
8 december 2004
Promotor: prof.dr. M.C. Elwenspoek
Copromotor: dr. G.J.M. Krijnen

Mobile internet traffic measurement and modeling based on data from commercial GPRS networks
R.A. Kalden
8 december 2004
Promotor: prof.dr.ir. B.R.H.M. Haverkort

Interative learning conrol - A Critical review -
M.H.A. Verwoerd
13 januari 2005
Promotor: prof.dr.ir. J. van Amerongen

State-Dependent Factors and Attention in Whiplash Associated Disorder
M.G.B.G. Blokhorst
21 januari 2005
Promotor: prof.dr. G. Zilvold

Steady-state and cyclostationary RTS Noise in Mosfets
J. S. Kolhatkar
27 januari 2005
Promotor: prof.dr. H. Wallinga

Test-Access planning and test scheduling for embedded core-based system chips
S.K. Goel
2 februari 2005
Promotor: prof.dr.ir. T. Krol

Novel Integrated Optical sensing platforms for chemical and immuno-sensing
J. van Lith
4 februari 2005
Promotors: prof.dr. P. Lambeck
prof.dr. Th.J.A. Popma

Experiments in rights control expression and enforcement
C.N. Chong
4 februari 2005
Promotor: prof.dr. P.H. Hartel

Towards database support for moving object data
N. Meratnia
23 februari 2005
Promotor: prof.dr. P.M.G. Apers

Walking after stroke co-ordination patterns & functional recovery
J. H. Buurke
24 februari 2005
Promotors: prof.dr.ir. H.J. Hermens
prof.dr. G. Zilvold

Ion selective gates active device component for 3D microfluidic architecture
R. Schmuhl
25 februari 2005
Promotors: prof.dr.ing. D.H.A. Blank
prof.dr.ir. A. van den Berg

Design and fabrication of Quasi-2D Photonic Crystal Integrated optical components based on silicon-on-insulator technology
C. G. Bostan
25 februari 2005
Promotor: prof.dr. A. Driessen

MEMS generated and AFM-Based surface modification
S. Deladi
4 maart 2005
Promotor: prof.dr. M.C. Elwenspoek
Copromotor: dr. G.J.M. Krijnen

Edge effects and submicron tracks in magnetic tape recording
A. Hozoi
17 maart 2005
Promotor: prof.dr. J.C. Lodder

Calibration Techniques in two-step A/D converters
H. van der Ploeg
24 maart 2005
Promotor: prof.dr.ir. B. Nauta

Quantative microchip capillary electrophoresis for inorganic ion analysis at the point of care
E. X. Vrouwe
15 april 2005
Promotor: prof.dr.ir. A. van den Berg
Copromotor: dr. R. Luttge

Mosfet LF noise under large signal excitation measurement, modeling and application
A. P. van der Wel
15 april 2005
Promotor: prof.dr.ir. B. Nauta
Copromotor: dr.ing. E.A.M Klumperink

Analog-Digital codesign using coarse quantization
A. B. J. Kokkeler
28 april 2005
Promotors: prof.dr.ir. Th. Krol
prof.dr.ir. C.H. Slump

Development of a hydorgel-based carbon dioxide sensor. A tool for diagnosing gastrointestinal ischemia
S. Herber
13 mei 2005
Promotor: prof.dr.ir. P. Bergveld
Copromotors: prof.dr.ir. A. van den Berg
dr.ir. W. Olthuis

Electrostatic microactuators fabricated by vertical trench isolation technology
E. Sarajlic
13 mei 2005
Promotor: prof.dr. M.C. Elwenspoek
Copromotor: dr. G.J.M. Krijnen

Managing Complexity of Control Software through Concurrency
G.H. Hilderink
19 mei 2005
Promotor: prof.dr.ir. J. van Amerongen

Adaptability of model transformations
I. K. Ivanov
19 mei 2005
Promotor: prof.dr.ir. M. Aksit

Distribution of multimedia streams to mobile internet users
C. E. W. Hesselman
20 mei 2005
Promotor: prof.dr.ir. E. Huizer

Polymeric microring resonator based electro-optic modulator
A. Leinse
27 mei 2005
Promotor: prof.dr.ir. A. Driessen

Full chip modelling ICs under CDM test
M. S. B. Sowariraj
9 juni 2005
Promotor: prof.dr.ir. F.G. Kuper

The Gyracc, An integrated sensor for 3D rate of turn and acceleration
B.J. Kooi
23 juni 2005
Promotors: prof.dr.ir. P. Bergveld
prof.dr.ir. P.H. Veltink

Integration of analysis Techniques in security and fault-tolerance
G. Lenzini
30 juni 2005
Promotors: prof.dr. P.H. Hartel
prof.dr. E. Brinksma

Epitaxial oxide spintronic structures ferromagnets and semiconductors
F.M. Postma
1 juli 2005
Promotor: prof.dr. J.C. Lodder

Persberichten & Aankondigingen

Professor Gert Brussaard benoemd tot vice-president van URSI

Emeritus-hoogleraar Gert Brussaard is door de Raad van de Wereldunie voor Radiowetenschappen (URSI) benoemd tot lid van de Raad van Bestuur van de Unie in de functie van vice-president. Prof. dr. ir. G. Brussaard was 15 jaar hoogleraar telecommunicatie bij de faculteit Elektrotechniek en nam in oktober 2003 afscheid van de TU/e.

URSI is één van de wetenschappelijke unies van de ICSU, de Raad voor Wetenschap van de Verenigde Naties. De Raad van URSI wordt gevormd door vertegenwoordigers van haar 44 lidstaten, die op de Algemene Vergadering de leden van de Raad van Bestuur kiezen. Nederland wordt vertegenwoordigd door een nationaal comité dat ressorteert onder de Koninklijke Nederlandse Academie van Wetenschappen (KNAW). URSI coördineert het wetenschappelijk onderzoek in de wereld in alle aspecten van elektromagnetische velden en radiogolven.

Gert Brussaard verkreeg internationale bekendheid door zijn voortrekkersrol in Europese samenwerkingsprogramma's in het onderzoek van elektromagnetische golfvoortplanting en satellietcommunicatie. Hij bekleedt leidinggevende functies in de Internationale Telecommunicatie Unie (ITU) en in het Europese programma voor technisch-wetenschappelijke samenwerking COST. Hij is lid van de commissie voor elektromagnetische velden van de Nederlandse Gezondheidsraad. Nederland is aktief in verschillende taken van radiowetenschap. De TU/e concentreert zich daarbij op onderzoek voor geavanceerde systemen voor mobiele communicatie en de modellering van complexe elektromagnetische structuren.

Bron: Technische Universiteit Eindhoven.

Professor Djan Khoe benoemd tot Fellow van OSA

Professor Djan Khoe is benoemd tot Fellow van de Optical Society of America "for sustained pioneering in optical fiber communication technologies, starting as an industrial innovator and maturing as an academic leader". Professor Khoe was reeds IEEE Fellow sinds 1991, "for contributions in single mode lightwave devices and systems". Met deze OSA award is hij de eerste in Nederland die beide prestigieuze onderscheidingen op zijn naam heeft staan.

Bron: Technische Universiteit Eindhoven.

PATO Cursusaanbod 2006

Hoogspanning II: Beproeving, meten en diagnostiek (college)

Verschillende aspecten van beproeving van hoogspanningsmaterieel en de waarde van de resultaten van deze testen

data/plaats:	de maandagen 6, 13, 20, 27 februari, 6, 13, 20 maart, 10 en 24 april 2006 van 10.45 - 12.30 uur in Delft
cursusleiding:	prof.dr. J.J. Smit (TU Delft)

Telecommunicatie- en datanetwerken

Theorie, concepten en praktijk van netwerken voor multimedia

data/plaats: 8-9-10 maart 2006 in Delft
cursusleiding: Prof.dr.ir. P. Van Mieghem (TU Delft)

Beveiliging van elektriciteitsnetten

Basisprincipes en aspecten die van invloed zijn op de juiste werking van beveiligingssystemen

data/plaats: 16-17 maart 2006 in Delft
cursusleiding: prof.ir. L. van der Sluis (TU Delft)

Hoogspanning III: hoge gelijkspanning (college)

Verschillende aspecten bij gebruik van hoge gelijkspanning

data/plaats: 13, 20, 27 april, 11, 18 mei, 1 en 8 juni 2006 van 13:45 - 15:30 uur in Delft.
cursusleiding: prof.dr. J.J. Smit (TU Delft)

Blootstelling aan elektromagnetische velden

Effecten op gezondheid, veilig werken, veilige producten, risico-inschattingen en metingen

data/plaats: 26-27-28 april 2006 in Eindhoven
cursusleiding: dr.ir. P.A. Beeckman (Philips Applied Technologies)

Asset management van elektrische infrastructuren

Technische en economische processen bij onderhoud en vervanging van hoog- en middenspanningscomponenten

data/plaats: 8, 15, 22 en 29 mei 2006 (10.45 - 12.30 uur) in Delft
cursusleiding: prof.dr. J.J. Smit (TU Delft)

Schakelen in energienetten

Techniek, gevolgen en beheersaspecten

data/plaats: 22-23 juni 2006 in Arnhem
cursusleiding: prof.dr.ir. R.P.P. Smeets (TU Eindhoven/KEMA)

Decentrale energievoorziening

Inpassing in het elektriciteitsnet

data/plaats: 2 dagen in het voorjaar van 2006 in Eindhoven
cursusleiding: mw. dr.ir. J.M.A. Myrzik (TU Eindhoven)

Vermogenselektronica (college)

Moderne componenten van de vermogenselektronica en hun toepassingen

data/plaats: 9 dagdelen in het voorjaar van 2006 in Eindhoven
cursusleiding: dr. J.L. Duarte (TU Eindhoven)

Antennetechniek

Theoretische grondslagen, ontwerpmethodieken en experimentele verificatie van een antennestructuur

data/plaats: 6 dagen in het voorjaar van 2006
cursusleiding: ir. M. Hajian (TU Delft) en prof.dr.ir. A.P.M. Zwamborn (TU Eindhoven/TNO)

Mini-vermogenselektronica (college)

Principes van vermogenselektronische toepassingen bij voedingsbronnen

data/plaats: 8 dagdelen in het najaar van 2006 in Eindhoven.
cursusleiding: ir. M.A.M. Hendrix (TU Eindhoven)

Digitale modulatie

Theorie en toepassingen van digitale modulatie en demodulatie

data/plaats: 5 dagen in het najaar van 2006 in Eindhoven
cursusleiding: ir. C.R. de Graaf (Catena Radio Design)

Hardware specificatie en ontwerpen m.b.v. VHDL

Mogelijkheden en toepassingen van VHDL voor specificatie, modellering, simulatie en synthese van digitale hardware

data/plaats: 3 dagen in het najaar van 2006 in Enschede
cursusleiding: ir. E. Molenkamp (Universiteit Twente)