

Tijdschrift van het NERG

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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.

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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.

Voor toestemming tot overnemen van (delen van) artikelen dient men zich te wenden tot de tijdschriftcommissie. Alle rechten berusten bij de auteur tenzij anders vermeld.

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ISSN 03743853

Van de redactie

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Voor u ligt het eerste nummer van het Tijdschrift van 2008. Dit jaar zal begonnen worden met de elektronische variant van ons tijdschrift. Het tijdschrift zal via de vernieuwde website beschikbaar worden gesteld in het gedeelte dat alleen voor leden toegankelijk is. Daarvoor is het noodzakelijk dat u een account aanvraagt bij het secretariaat. Nadat is vastgesteld dat u daadwerkelijk lid bent krijgt u de inloggegevens per e-mail toege-

stuurd. Het is de bedoeling om ook oudere jaargangen beschikbaar te stellen. Hoe en wanneer dit gerealiseerd gaat worden is echter nog niet duidelijk. Meer over de nieuwe website vindt u elders in dit nummer.

In dit nummer vindt u naast twee nederlandse bijdragen aan de FITCE-conferentie een artikel over de perceptie van webbrowsing kwaliteit zoals die ervaren wordt door eindgebruikers. Dit

artikel is geschreven door twee medewerkers van Alcatel-Lucent en twee medewerkers van TNO Telecom. Het traditionele proefschriftenoverzicht zal worden gepubliceerd in het volgende nummer.



Roadmap to Personalised Liquid Bandwidth

Nico Baken, Edgar van Boven, John Hoffmans,
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Abstract

This paper addresses a roadmap to a personalised liquid bandwidth future. It covers the sequential steps and corresponding measures to be taken. As wireless personal area networks will support different radio technologies, we believe deployment of short range mini cells is a first step towards this future liquid bandwidth stage. Generally, the higher the offered bandwidth, the shorter the radio ranges will be. Mini cells could provide offload possibilities and wireless indoor access to the end user at higher speeds than today's 3G outdoor solutions. Bitrates comparable to xDSL or cable come within reach. Operators could initially benefit by offloading large amounts of non real-time data traffic via these mini cells, thus avoiding scaling up their macro radio networks. A second step lies in redefining the radio planning and provisioning process. Automated and balanced deployment of mobile, wireless and fixed access capacity requires a novel integrated complementary access planning framework. As a next step we foresee additional real time sniffing functionality to be put in place. This, in the long term, will enable a next societal stage in which end users' supply and demand can instantaneously be matched. The enabling infrastructure could be featured by personalised services over optical circuit-switched networks.

Keywords: liquid bandwidth, complementary access, access planning tool, roadmap, transsectoral innovation.

Introduction

Currently three major trends in telecommunications are commonly recognised:

- increasing demand for personalised high QoS services,

- the tendency to enjoy these services wirelessly,
- ongoing growth of bandwidth need.

These trends force us to redefine the capabilities and properties of a future personalised liquid bandwidth infrastructure. Particularly its access part will change substantially. Currently at the fixed access plane consumer market requirements are met by deploying coax cable or ADSL technology. Considering xDSL, during this decade copper and its capabilities will be pushed to its very limits. As the next incremental step (VDSL/Fiber to the Curb) would imply thousands of street cabinets, we envisage another future infrastructure. It should be based on a combination of macro and mini radio cells, being interconnected by fixed end-to-end optical switched capacity [1]. This future image is summarized in Fig. 1, metaphorically showing a complementary wireless and wired access structure.

Water in this picture symbolises information flowing in two directions: raining down into sinks and spraying up via fountains. Water travelling via air represents the wireless part. Water condenses and rains down from the customer clouds. The size of the water drops represents the required bandwidth. The rain is collected into sinks with differently sized surfaces (radio cells). The water generally flows to the nearest sink at the border of the fixed drainage system. Underground the collected streams of water are multiplexed, aggregated and directed across the transport network, via huge optically switched rivers in many colours of light. As the availability of clean water is increasingly precious, so is the reliability of a liquid bandwidth infrastructure enabling high QoS services. Customer needs will dominantly influence the next generation infrastructure properties. The convergence of fixed, wireless and mobile features in the

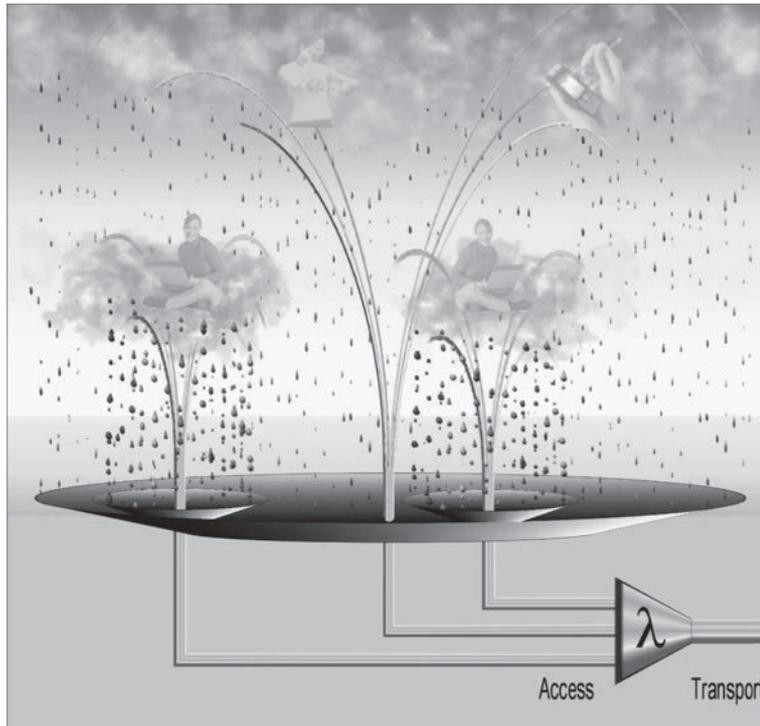
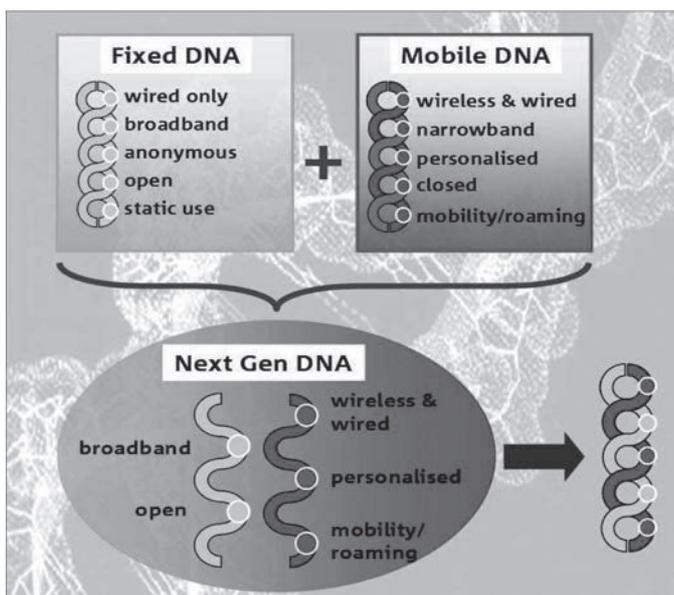


Fig.1: A colorful personal liquid bandwidth metaphor.

telco's portfolio is ongoing. The enabling technology is likely to follow. Figure 2 describes the fundamental differences in the Fixed DNA and the Mobile DNA. Today's Wireless DNA can be considered to be somewhere in between, i.e. having radio capabilities on the one hand, but lacking mobile handover capabilities on the other hand. The Next Gen DNA obviously is an optimized combination, in which attractive properties are selected and obsolete properties will be rejected.

Fig.2: Customer needs drive the Next general DNA selection.



In general today's fixed connections are not personalised and do not support mobility.

Their static and anonymous DNA properties no longer seem to be futureproof. Here mobile network technology and for instance its robust personalised SIM functionality, proves to be superior. The end user can enjoy the offered services any place, at any time.

On the other hand today's mobile networks tend to be less open than fixed networks for business reasons. Closed business models are likely to disappear. As one single operator or service provider cannot meet all customer desires, it has to open its walled garden to welcome partners. From this perspective a wholesale enabled infrastructure requires openness.

After the Internet boom mobile operators have been acting more carefully, balancing their profitability and total cost of ownership. This status quo is slowing down the mobile broadband innovation process. Compared to fixed data speeds, mobile data speeds can be considered to be narrowband. As mobile data usage is growing worldwide, in this perspective the bandwidth provisioning process needs to be enforced with complementary options, in order to meet future bandwidth needs.

Taking the above into account the Next Gen infrastructure DNA selection below is the most likely set for survival in an extremely competitive landscape.

Explanation Complementary Access

We expect the telecommunications infrastructure (2010-2015) to become a Fixed Mobile converged infrastructure, stimulating bandwidth consumption.

Radio bandwidth usage strongly varies in a geographic sense. Current 3G networks are over-dimensioned due to traffic uncertainty and initial coverage reasons. Knowing that bandwidth needs will increase this over-dimensioned inefficient reality cannot be perpetuated. A requirement for shorter radio ranges will arise, leading to the conclusion that complementary access is a future necessity. Macro outdoor radio cells will be combined with various mini radio cells which can be deployed both indoor and outdoor. In this paper we define complementary access as all functions, together providing end user equipment (personal area networks, handhelds, devices, terminals, etc.) access to a set of service platforms via two or more different access networks.

A generic transport plane will bridge the access plane and the service plane. Figure 3 shows an example of a TV service that can be reached using multiinterface devices handling streaming sessions over various access technologies. Similar examples could be depicted where the end user can reach (and supply) data/Internet, voice or gaming services via the same transport and complementary access layer. Note the (graphic) presentation of the services can be diverse, depending on the type of end user equipment.

When establishing a complementary access network, integrated network planning and provisioning has to be performed over all involved access technologies both at the customer side and the transport side. Examples of involved technologies are: UMTS/ HPSA, GPRS, GSM, WiFi (IEEE 802.11 family), WiMAX (IEEE 802.16 family), Ethernet (9802.1D/Q), ATM, xDSL and FttX. Another boundary condition for an operational complementary access network, is the availability of QoS management mechanisms on all involved layers.

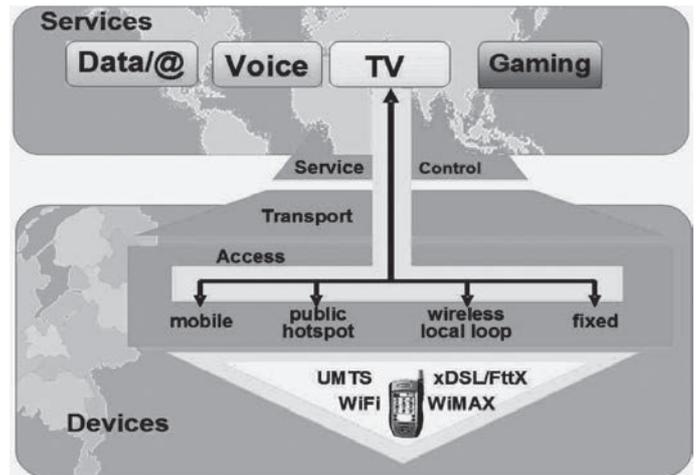


Fig. 3: Example complementary access to a TV service.

Complementary Access Hierarchy

Each technology has its typical range, varying from a satellite able to cover almost half the earth's surface, to several meters covered by a Bluetooth device. As standardisation proceeds towards 4G the functional capabilities of the different technology families increasingly converge. Thus a hierarchical classification of these (access) technologies based on the way they are deployed, seems more appropriate.

Especially concerning mini radio cells, several terms are in use today e.g., "femto cells", "pico cells", and "micro cells". Many types of solutions are announced or have been introduced recently, often combining different radio technologies (e.g., WiFi/GSM).

In a four-tiered hierarchy model [2] the majority of the radio implementation solutions can be captured. One fixed and three different mobile and wireless access planes together form a converged fixed-mobile infrastructure. From a top-down perspective it consists of:

A **macro plane** consisting of outdoor radio cells, having a cell radius in the order of magnitude of *several km's*, which can be deployed on top of a tower or tall building for wide area coverage, serving a great many users on the way.

A **micro plane**, generally consisting of outdoor radio cells, having a cell radius in the order of magnitude of *several hundreds of metres*, can be deployed on rooftops or streetlights. They are to be used for hightraffic hot zones and can serve tens of users

simultaneously. For business market purposes tailor-made indoor solutions can be envisaged too.

A **pico/femto plan**, consisting of indoor or outdoor radio cells, having a cell radius in the order of magnitude up to a hundred metres, can be deployed under the rooftop. Less than 10 (broadband) users can be served simultaneously.

A **fixed plane**, consisting of a densely distributed high-capacity wired access network.

Technologies and their Properties

This decade a large scale transition from “narrow-band circuit technology to broadband packet technology” is ongoing in the fixed plane. Due to increasing bandwidth need, optical technology is emerging in the fixed access plane (replacing copper). Thus, circuits are likely to come back, because an optical connection (i.e., wavelength, colour or Lambda) can be considered as a circuit. A revolutionary approach is to revert to circuit switching in casu to all optical switching and routing in

order to obtain highly efficient routing and fast transmission [1].

We now limit our scope of attention to (expected) capabilities and properties of the following technologies: WiFi, WiMAX, EDGE, UMTS, HSPA and new LTE technology currently being standardised. Table 1 gives an overview of some technical characteristics for each of these technologies¹. The characteristic features gathered in Table 1 serve for a functionality and performance comparison between technologies.

Today concerning mobility support, only GSM, GPRS, EDGE, UMTS, HSPA and Mobile WiMAX are designed to perform seamless handovers and roaming, a requirement originating from the voice business. Services like TV, video streaming, and Internet are mainly used in a nomadic way. As today these (broadband) services do not necessarily require full mobility, mini cells can already be deployed in the short term providing improved performance and macro network off-load.

Table 1. Overview of wireless technologies

	Peak downlink	Typical download data rate	Frequency allocation	Channel bandwidth	Number of RF Channels	Radio Technology	Typical range outdoor/indoor	Mobility support
802.11a	54 Mbit/s	25 Mbit/s	various bands around 5 GHz	20 MHz	8	OFDM	40-60 m (8) /25 m	No, (12)
802.11b	11 Mbit/s	6,5 Mbit/s	2,4-2,497 GHz (ISM)	23 MHz	13	DSSS	50-80 m (9) /35 m	No, (12)
802.11g	54 Mbit/s	25 Mbit/s	2.4 and 5 GHz	(3)	(3)	(3)	50-80 m (8) /25 m	No, (12)
802.11n	600 Mbit/s	100-200 Mbit/s	2.4 and 5 GHz	40 MHz	13	OFDM	75-125 m /25 m	No, (12)
802.16d	75 Mbit/s	30 Mbit/s	2-11 GHz 10-66 GHz	1,25-20 MHz (4)	(4)	(7)	1-30 km /50 m	No, (12)
802.16e	75 Mbit/s	10 Mbit/s	2-11 GHz 10-66 GHz	1,25-20 MHz (4)	(4)	(7)	1-5 km /50 m	(13)
EDGE	0,5 Mbit/s (2)	0,1-0,2 Mbit/s	900 and 1800 MHz	200 kHz	(5)	TDMA with FDD	1-5 km (10) /100 m	yes
Enhanced EDGE	1,3 Mbit/s (2)	0,3-0,4 Mbit/s	900 and 1800 MHz	200 kHz	(5)	TDMA with FDD	1-5 km (10) /100 m	yes
UMTS (1)	2 Mbit/s	0,4 Mbit/s	1920-1980 MHz 2110-2170 MHz	5 MHz	(6)	W-CDMA with FDD	300 m-5 km (11) 50m	yes
HSDPA	14,4 Mbit/s	3-4 Mbit/s	1920-1980 MHz 2110-2170 MHz	5 MHz	(6)	W-CDMA with FDD	300 m-5 km (11) /50m	yes
HSPA+	28,8 Mbit/s	10-14 Mbit/s	1920-1980 MHz 2110-2170 MHz	5 MHz	(6)	W-CDMA/MIMO/FDD	300 m-5 km 50m	yes
LTE (HSOPA)	100 Mbit/s	30-40 Mbit/s	2,6 GHz	1,25-20 MHz	(6)	OFDMA/SG-FDMA MIMO/FDD and TDD	300 m-5 km /50 m	yes

1 Please note that the figures provided in Table 1 are indicative for the performance of the mentioned radio technologies.

Notes

- (1) From different variants of UMTS and its successors, here only the European versions are considered.
- (2) This is the maximum data rate using eight time-slots and Coding Scheme 4 (CS-4).
- (3) For data rates 1, 2, 5.5 and 11 Mbit/s the same channel spacing, bandwidth and modulation is used as in IEEE 802.11b (for backwards compatibility). Other supported bit rates use OFDM.
- (4) IEEE 802.16 is designed for a wide range of licensed and license-exempt frequencies with a flexible bandwidth allocation to accommodate easier cell planning throughout the world.
- (5) Same as in GSM.
- (6) Number of frequency bands depends on operator's licence.
- (7) IEEE 802.16 physical layer supports three access technologies: 1. Single Carrier Modulation (CS), 2. OFDM in combination with TDMA, and 3. OFDMA. OFDM and OFDMA are mainly purposed for none 'line of sight' operation.
- (8) Lower bound corresponds to 54 Mbit/s data rate, and upper bound corresponds to 11 Mbit/s data rate.
- (9) Lower bound corresponds to 11 Mbit/s data rate, and upper bound corresponds to 2 Mbit/s data rate.
- (10) With Coding Scheme 1 (CS-1), the coverage radius of GSM voice and GPRS/EDGE 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 20 km.
- (11) Typical range in this table is for urban areas. Theoretically the maximum range could be as much as 30 km.
- (12) Movement within a cell is possible. Technology itself does not support handover.
- (13) Technology itself does not support handover. Mobile WiMAX implementations should include mobility.

Complementary Access Planning Framework

This section covers a framework for a complementary access planning tool. As all access means (electricity, water, gas, telecom) are to be regularly

Acronyms

DSSS	Direct Sequence Spread Spectrum
EDGE	Enhanced Data rates for GSM Evolution
FDD	Frequency Division Duplex
HS PA	High-Speed Packet Access
HS DPA	High-Speed Downlink Packet Access
HS OPA	High-Speed OFDM Packet Access
ISM	Industrial, Scientific and Medical bands
LTE	Long Term Evolution
MIMO	Multiple-Input Multiple-Output
OFDM	Orthogonal Frequency Division Multiplexing
OFDMA	Orthogonal Frequency Division Multiple Access
SC-FDMA	Single Carrier Frequency Division Multiple Access
TDD	Time Division Duplex
TDMA	Time Division Multiple Access
UMTS	Universal Mobile Telecommunications System
W-CDMA	Wideband Code Division Multiple Access
Wi-Fi	Wireless-Fidelity
WiMAX	Worldwide Inter operability for Microwave Access

renewed, an integral planning tool (e.g., for digging activities) could be envisaged on a trans-sectoral level [3].

The tool described below enables the telco's planning personnel to perform the provisioning process of fixed, mobile and wireless technologies, leading to an optimally balanced complementary access network. Figure 4 shows the framework's building blocks.

1. The *blue technology part* on the left is technology related and discriminates outdoor, indoor and fixed deployment. The green modules inside specify and detail the technological properties depending on their deployment. Modules can easily be added, changed or left unused.
2. The *orange operator part* comprises the operator's specific input, being the current installed base, the current traffic, the forecast and the (negotiated) equipment costs.
3. The *yellow geographic information system part* provides the demographic and geographic data maps.

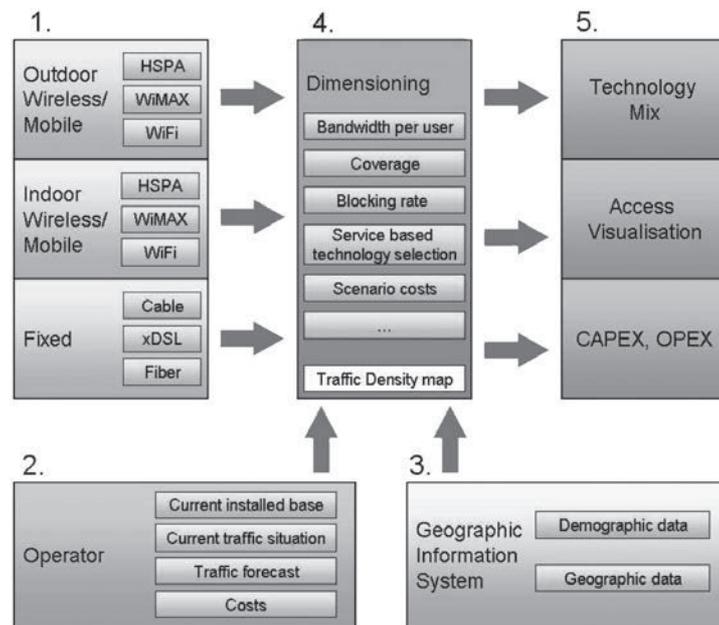


Fig. 4: Framework for a complementary access planning tool.

4. The *pink dimensioning part* processes the input from 1–3. Inside the dimensioning part of the planning tool a traffic density map is created where every pixel geographically represents the local traffic intensity. The green modules represent the constraints given by the operator, being bandwidth per end user, coverage, blocking rates and the operator’s technology selection.
5. The *purple output part* represents the calculated technology mix and a derived geographic visualisation of the position and capacity of the sites. Completed with the calculated investments (CAPEX) and recurring costs (OPEX), a complementary access scenario for a selected area is established. Thus, several scenarios can be simulated, varying the operator’s preferences and constraints. The outcome of each scenario with different mixes of radio and fixed technologies can be compared. Doing so, the tool can give a more in-depth financial and operational insight.

HSDPA Offload Case Study

Currently, the Netherlands host 16.4 million inhabitants, living in 7.2 million households on a surface of only 28.000 km². An overview of the population density distribution [4] is given in Fig. 5. It clearly shows the demographic status quo. e.g., 94% of the inhabitants occupy 19% of the national area². Ten million people live within the so called

“Randstad”, an urban area demarcated by Amsterdam, Utrecht, Rotterdam and The Hague.

As average distances are small and the regulatory climate is friendly towards new entrants, the attractiveness of the Dutch playing field resulted in a prime position for this country on the global telecom ranking list of competitiveness and broadband market penetration. Summarizing some facts, in early 2007 broadband access was installed in 69% of all households [5]. In 2006, the number of mobile subscriptions (SIM cards) exceeded the number of people. Increasing WiFi deployment and its use of unmanaged spectrum could lead to interference problems in urban areas in the mid term. In The Hague, for example, an area exists where 27.000 people live in one km².

Given the trend of increasing mobile and wireless bandwidth use, macro network capacity provisioning should closely follow at the same pace and moreover, seems to evoke a necessity for radio offload. A uniform macro network could locally be heavily stressed or have to be largely over-dimensioned. A balanced solution seems to be more appropriate. Unused and new fixed broadband access capacity could be increasingly deployed for transferring both mobile and wireless traffic. In the Netherlands the cable, xDSL and FttH installed base is expected to grow steadily (2009 forecast

2 CBS Demographics 2006.

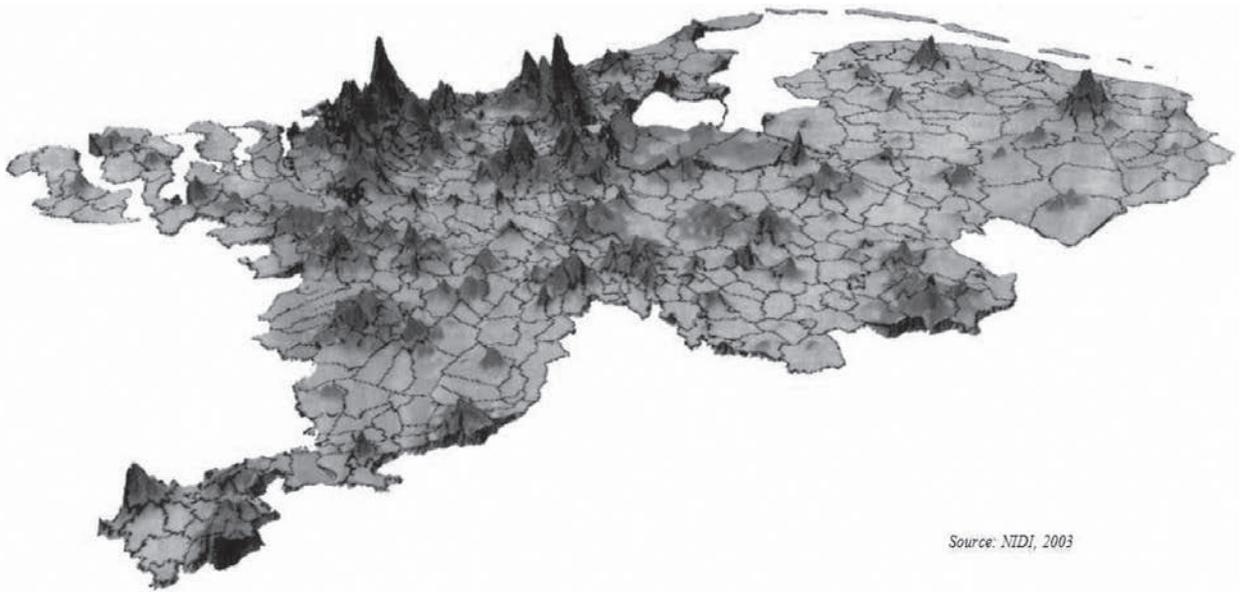


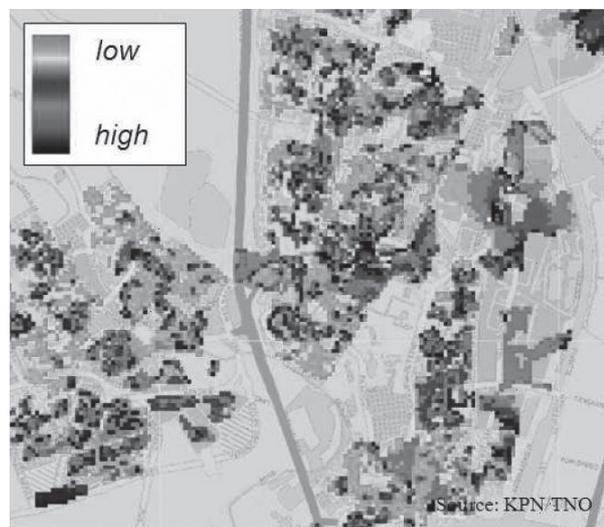
Fig. 5: Population density distribution 2003.

indicates the FttH penetration is to exceed 15%). This is where micro, pico and femto cells come into play, being attached to fibre, xDSL and cable access means. In this perspective an offload case study was performed.

The ongoing growth of wireless/mobile bandwidth use demands a similar increase in capacity of the network. A couple of methods are available to increase the capacity for the existing macro network. For the radio planning the methods in preferable order are: increase the number of carriers per site, if the operator spectrum license allows for this. The second way is to increase the number of sectors on the site. Nowadays three sectors are standard, but four or six sectors and even more are available

in the near future. If both methods are fully exploited, one can turn to building extra sites to increase the capacity. However, this brings up two issues: cost efficiency and above all regulation. In the Netherlands for example, already 70 out of 500 municipalities strongly discourage deployment of new UMTS outdoor sites. Keeping these constraints in mind, three future HSDPA scenarios were simulated. Figure 6a shows the geographical map of a representative suburban area. To predict the traffic volume for this area in 2009, a novel traffic grid was developed, depicted in Fig. 6b. A traffic grid is a geographical map showing the local traffic intensity averaged over a certain period of time. The data is gathered from traffic analysis of the current macro network in operation. While

Fig. 6: (a) Map of simulated area. (b) Traffic grid.



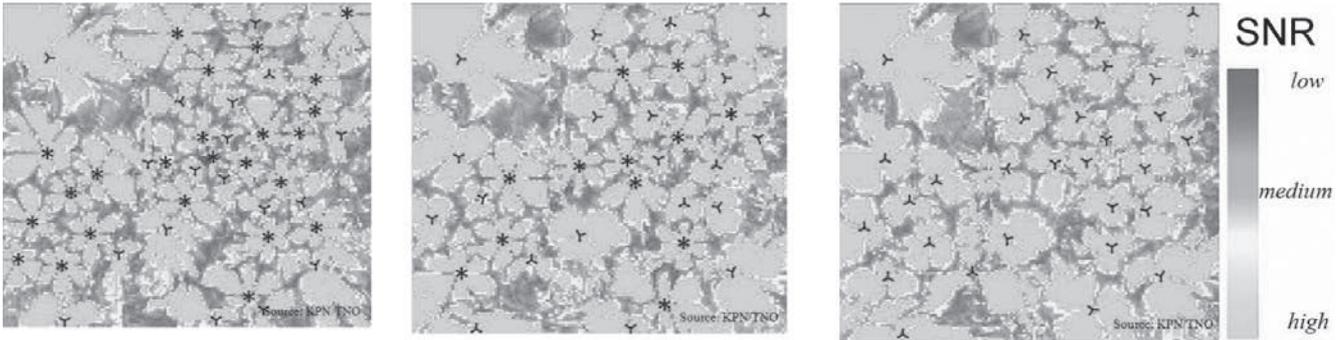


Fig.7: (a) No offload. (b) 40% static offload. (c) 40% static + 40% nomadic offload.

today UMTS and HSDPA are not yet widely used, a GSM traffic grid was scaled up following a traffic forecast for 2009. The GSM grid was modified for a next generation situation by subtracting the traffic generated at highways, because it is possible to call hands free, but it is certainly less easy to use broadband services while driving. Three scenarios have been simulated aiming to have full coverage of the selected area offering a minimal user throughput guarantee.

1. Scenario A (Fig. 7a) is a scenario where the macro network scales up to meet the forecast, resulting in the need of the deployment of more than twice as many sites. Most of the sites have 6-sector antennas and use the maximum number of available carriers.
2. In scenario B (Fig. 7b) we assume a 40% static traffic offload (inside and around the user's home). Compared to scenario A not only fewer sites are required in general but the number of six-sector sites is reduced significantly as well. The net present value of the cost reduction compared to scenario A is about 20%.

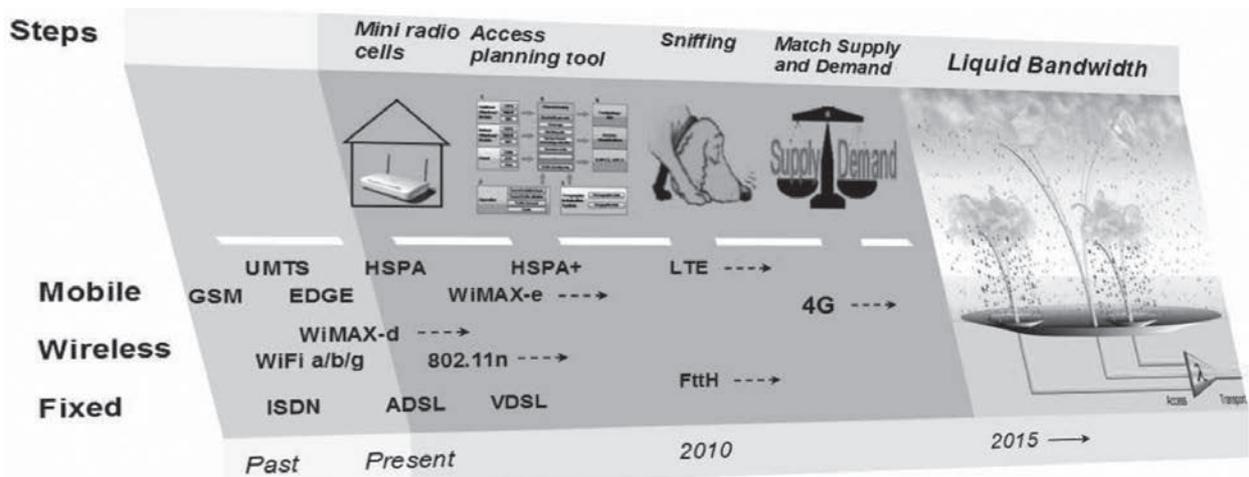
3. In scenario C (Fig. 7c) we assumed an extra 40% offload (total 80%), when users open their mini cells to allow nomadic use. Three-sector sites suffice and again much less sites need to be deployed, resulting in a cost reduction of approximately 40% (NPV) compared to scenario A.

We conclude from the case study that when no off-load solution is available an unfavourable dense macro network is required. Next to the high costs of such a network are considerations that the high bit-rate areas at the centre of a radio cell are smaller, due to a larger surface with lower Signal to Noise Ratio (SNR). Indoor mini cells could off-load macro cells and improve user bitrates indoor, as well as outdoor. However, a dense macro network may still be required for capacity reasons in the long term.

Roadmap

Departing from today's fragmented infrastructure situation, the first milestone on the roadmap towards personalised liquid bandwidth is the mini cell, as illustrated in Fig. 8. Being regularly

Fig. 8: Roadmap to personalised liquid bandwidth.



upgraded, mini cell capability sets could gradually incorporate functionality like: SIM, Node-B, RNC, GGSN, and SGSN. After adding mini cells to the macro plane, and having gained some initial footprint, a necessary second milestone ought to be reached: the set up of a complementary access planning and provisioning process. Imagine having established this process, the operational and commercial portfolio is ready for a next stage in real time service offering.

Communication devices inside the customer's personal area network can continuously interact via the complementary access network with the service plane and even commercial outlets, recognising the identity of the device and its owner. Handovers can be performed during communication sessions. When moving, connectivity offers can reach these devices. As many providers and operators are trying to survive in our current Anglo-saxon climate, commercial interests and tariff issues will initially slow down this general breakthrough of real time access sniffing.

Later on as the market adopts these novel telecom oriented concepts, the transactional functionality could be extended to sniffing the right offer. Negotiating and real-time bridging supply and demand without the use of banknotes and coins can be performed instantaneously using trusted personal ICT means. Thus, sniffing [6] might evolve from: 1) sniffing the right access, to 2) sniffing the right offer, to 3) sniffing the right people for any potential transaction or fruitful contact [7]. In this still imaginary stage where optical connectivity will be deeply integrated into our networks, society will have reached a personal liquid bandwidth stage.

Conclusions

The telecom infrastructure will face fundamental change due to three major trends: firstly increasing demand for personalised high QoS services, secondly the tendency to enjoy services wirelessly, and thirdly an ever growing bandwidth need.

Next Generation telecom properties derived from these trends comprise personalisation, openness, mobility support, broadband capacity and complementary fix/wireless access.

We conclude that the rise of the mini cell is inevitable, combining these future properties with the following facts:

- mini cells can realise macro cell functionality indoor as well, improving total coverage and improving bit rates indoor, as well as outdoor;
- fixed indoor capacity can transfer additional mobile/wireless traffic at lower integral cost;
- lower energy consumption and lower electromagnetic radiation are generally encouraged;
- municipalities actively discourage deploying new outdoor macro site radio antennas.

Bandwidth represents value, irrespective of the business model. Generally wireless bandwidth is more expensive than fixed bandwidth. From an operator perspective mini cells (within a complementary access context), improve the overall infrastructure performance, because mini cells can offload the macro network without loss of perceived quality.

Complementary access planning gives (financial) insight and geographically optimizes cost efficiency combining heterogeneous wired and wireless access technologies.

As ICT services, devices and broadband networks are to become personal, reliable and trusted, these new requirements have to be met. Doing so, a new societal stage lies within reach. Personal networks could become the prime transaction instruments, and not just for finding the appropriate access. In mini cell environments SIM technology again seems the best in class authentication technology to meet trust and security requirements for any type of communication service.

The expected mechanism offering the end-user the possibility to sniff the right access, could evolve into functionality sniffing the right offer, and even sniffing the right B-party for any transaction over any distance, almost instantaneously matching supply and demand.

Assuming average bandwidth need keeps on increasing according to Moore's law from today's 4 Mb/s fixed lines, towards a 100 Mb/s in 2015, a future image starts to unfold where a Lambda per end user becomes feasible. Still hidden, far ahead in time a Lambda per session might be the case. Anyway, we believe these kind of connections and sessions require optical circuit-switched networks.

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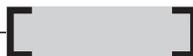
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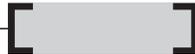
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Using Advanced Integration Concepts for Trans-sector Innovation – View and Status

H.J.M. (Harrie) Bastiaansen and N.H.G. Baken



Abstract

Through history, society has evolved from self-sustaining groups into a set of independent sectors. Today, ICT is pervasive in all sectors. Combine this with the trend that these sectors can no longer exist and innovate independently and we realize that a trans-sector approach is required. Information technology has an important role to play in trans-sector innovation. It literally and virtually connects the sectors, makes them interact and enables a wide spectrum of innovative trans-sector opportunities. But the decomposed society also raises a tremendous integration challenge in bringing together the different IT-environments of the various sectors. This puts a severe restriction on the trans-sector innovation power. Minimization of the integration complexity and effort becomes a key to success in trans-sector innovation. In this paper, we present a view on coping with the trans-sector integration complexity. This view builds upon deploying recent, state-of-the-art, developments in integration technology. As such, developments in model driven architectures, service oriented architectures, semantic web services and ontologies are considered. Along with the view, we identify various short-comings in the current status of these new integration technologies and present the challenges for bridging the gap between the view and reality.

Keywords: trans-sector integration, model driven architectures, service oriented architectures, semantic web services, ontologies.

Introduction - the Historic Perspective

Nomadic families started to settle down during the aftermath of the last iceage and became colonists. The first villages emerged, hosting several families. During the tremendously long period before colo-

nization, nomadic tribes were entirely self responsible, almost completely self sustaining cohesive clusters performing all necessary tasks in order to survive as a group. One may consider a tribe to have a collective nerve system guarding and controlling the prosperity and well-being of this relatively small "network".

The early colonist era was characterized by the introduction of agriculture and cattle breeding laying the foundation for the first wave [1], the agricultural revolution. People commenced, for sake of efficiency, to divide tasks among each other. They learned to specialize in a set of gradually and logically expanding specific tasks, such as farming, construction (houses, roads), mining, warfare, etc. Each requiring a rather unique knowledge and skill set.

The outsourcing of the tasks is based on a trust relation and supported by transactions, where people allowed other people to take over vital tasks they used to perform themselves. This transition initialized an important trend: progressing *functional decomposition* in economy and society. This enlarged efficiency and thereby the scale of economy and society, growing from local all the way to global. Direct implications are increasing complexity of economic and societal processes accompanied by a strong growth of the vocabulary of our language and the discovery of counting and abstract numbers providing the basis for the skill of writing.

This progress naturally invoked the secondary and tertiary wave (Fig. 1), i.e., the industrial and information (technology) revolution or rather the ICT-revolution, respectively. During all phases the functional decomposition progressed, and new

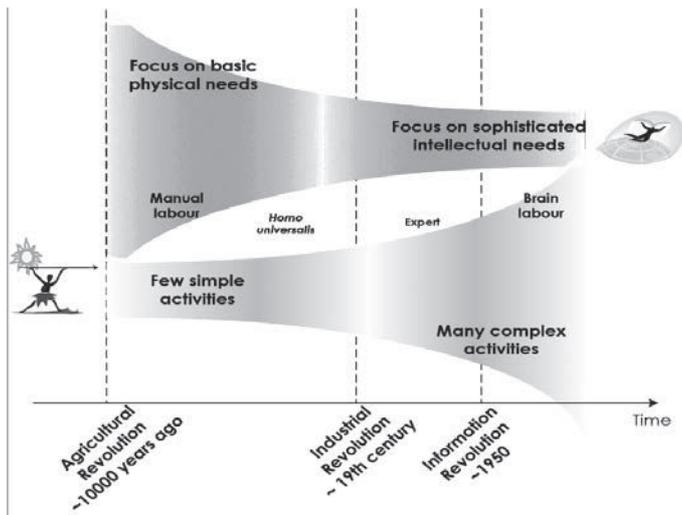


Fig. 1.: The global revolutions so far.

entities, sectors, branches and companies emerged, having their own “partial rationale”, e.g. healthcare, energy, construction, telecommunications, finance, industry, education, etc.

Summarizing, economic values gained importance and herewith the former tribal holistic nerve system gradually started to fade or even disappear to make place for partial rationalities of the emerging functional entities, such as sectors. The tight small-scale network of the tribe transformed in steps into a large scale network, comprising a set of sectors that in turn have become internationally organized [2]. Too strongly, they navigate on their own partial rationale for short term benefits. Presently, they resemble more the collection of opportunistically interacting isolated nodes instead of a strongly interactive network.

Have the individual sectors evolved too far? Is trans-sector innovation still feasible without excessive amount of effort? The answer to these questions contains organizational, commercial, cultural and technological aspects. In this paper we focus on the latter. We present a view on how integration technology may help in a distributed society and play a vital role as enabler for trans-sector innovation. It shows how integration complexity and efforts may be minimized in building bridges between the sectors.

Approach to Transsector Integration

From the above, we found a diverging trend through time, the functional decomposition of tasks, leading to a set of loosely coupled sectors. Re-unification of the sectors under a single autho-

rity is a utopian dream. Integration approaches will have to be deployed supporting efficient innovation in a distributed world with many sectors without central authority to impose a preferred information architecture onto all sectors. A distributed architecture for transsector integration is required with collaboration based on choreography rather than orchestration. Hence, the view as presented in this paper builds upon two basic assumptions:

- *Top-down development of transsector innovations while preserving autonomy of individual sectors.* The functionality to be realized must be leading in the development process for traps-sector innovations. Hence, its business requirements must be topdown translated into traps-sector processes and implementations. Such a top-down approach however must be able to cope with the autonomy of the individual sectors in which individual sectors keep their own (governance of) functionality, internal working, IT architecture and solutions.
- *Dynamic discovery and integration of a sector’s functions.* Trans-sector processes require the integration of the functions provided by the individual sectors. Such integration currently takes much effort and is slow. An important cause is that the functions provided are usually only described on a syntactic basis. This leads to intense interaction to find out whether the function’s details meet the requirements (discovery), realize datamappings and agree upon service levels before interconnections can be made. Using richer and unambiguous semantic description of the functions can make the integration process a lot quicker, perhaps even fully automated. The following sections describe a view on how both basic assumptions can be met. This will reduce the traps-sector integration effort considerably. The next section describes a top-down approach for the development of traps-sector processes with preservation of the sector’s autonomy. The subsequent section considers the dynamic discovery and integration of the sector’s functions.

Top-down Development of Trans-sector Processes Using MDA and SOA

The enormous advent of ICT in all sectors of society over the last decades has led to an urgent need for structural approaches for overcoming the integration challenge. Therefore, various new integration

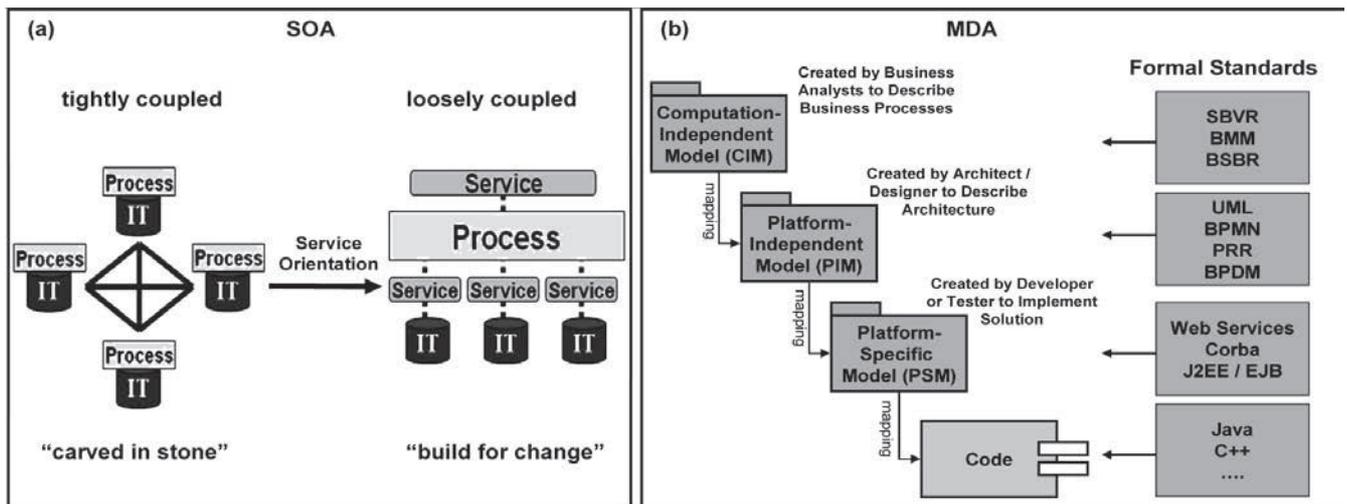


Fig. 2.: SOA-approach (a) and MDA-approach (b).

solutions, technologies, protocols and standards have been developed over the recent years, of which the concepts of Service Oriented Architecture (SOA) and Model Driven Architecture (MDA) have gained enormous momentum. They form the basis of the view on the top-down development of traps-sector processes as described in this paper. Both architectural concepts are briefly described. A concise overview on integration patterns can be found at [3].

Service Oriented Architecture

In the world of distributed IT-environments the concept of Service Oriented Architectures (SOA) has widely been adopted as means to realize an agile architecture. The essence of service orientation is about (re)designing the infrastructure around providing and consuming services, as opposed to the more traditional approach of interconnecting applications and their embedded processes. Service orientation reflects the everyday service oriented world. The goal is to design services as stable factors, while realizing agility through dynamic business processes that re-use the individual services. A clear separation in (stable) service-logic and (dynamical) process logic is envisioned, Fig. 2a.

SOA uses the principles of a distributed, interface-oriented architecture. These principles are not new. However, the emergence of web services (WS) technology has spurred the SOA-concept. Currently, a rich suite of WS-protocols and -standards has been developed by the OASIS organization and the W3 C-consortium.

Model Driven Architecture

As said, the business requirements for the traps-sector innovations must lead the development of processes and implementations. The objective of MDA (an initiative of the Object Management Group - OMG) is to automate and provide consistency in the development process from business requirements to implementation. To this end, MDA uses formal description models at different levels of abstraction (Fig. 2b) with well-defined mappings and transformations for automatic translation between the formal description models of the various levels. This way, the top level business requirements (formally described,) can be automatically and consistently converted into implementations.

Figure 2b illustrates the layered MDA approach. It shows the four levels of MDA. At each level a different formal model is used to describe the architecture at a different level of abstraction. The figure also enumerates some formal standards used in each level. In top-down direction, the models used at the various levels are:

- the Computational Independent Model (CIM) formally describing the business requirements, e.g., in common understandable language
- the Platform Independent Model (PIM) describing the architecture in a manner that is independent of implementation technology;
- the Platform Specific Model (PSM), tailored to a specific implementation technology;
- the Code providing the actual implementation of the functionality.

In our view, both SOA and MDA have their own merits and role to play for transsector innovation. MDA provides the topdown approach that allows the trans-sector business requirements to be defined and to be translated into processes and implementations. SOA abstracts the functions and data of the individual sectors into re-usable (web) services to be used by the transsector processes while keeping the autonomy of the individual sectors.

However, it is to be noted that the MDA and SOA concepts can not readily be combined. SOA reflects a bottom-up reverse engineering approach abstracting available functionality and data in a sector. MDA on the other hand, provides a topdown approach deriving functionality for lower-level implementations. Hence, exploiting the merits of both approaches requires a unification method for the bottom-up SOA approach and the top-down MDA approach.

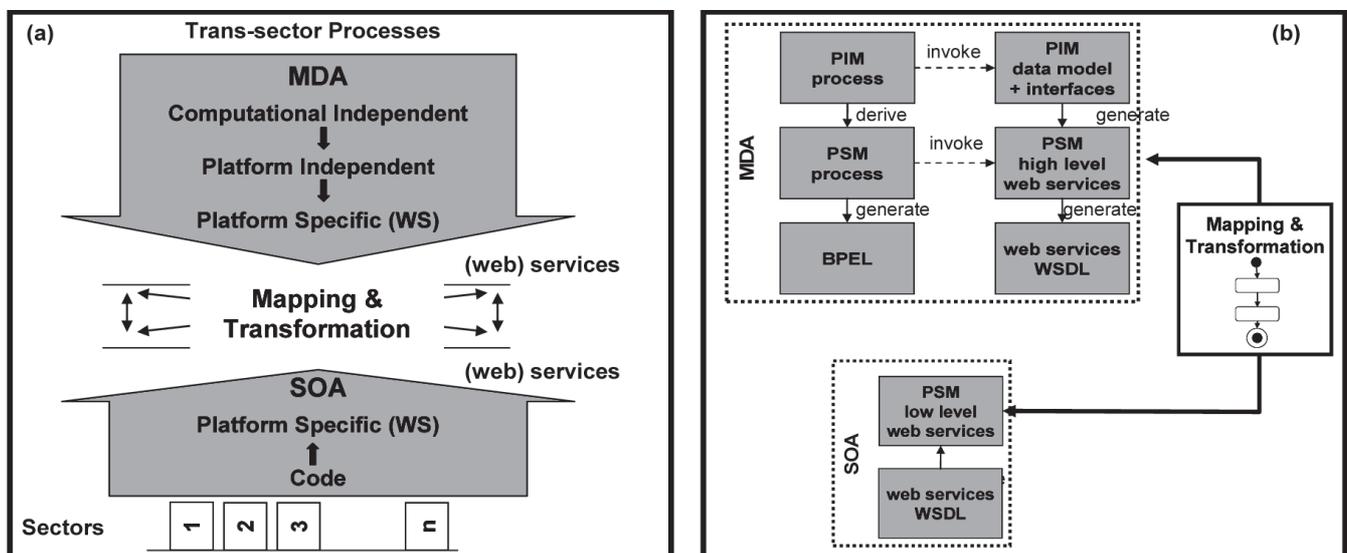
Several methods to unify the bottomup SOA and the top-down MDA approach have been presented in literature. As such, the extensive work of British Telecom (BT) deserves special attention [4]. BT has elaborated a method using MDA in conjunction with component (service) based OSS standards to be deployed in a telco environment. They use (bottom-up) reverse engineering of the SOA-compliant standardized TMF NGOSS and OSS through Java (OSS/J) services into reusable PSM's and PIM's. By exposing the component capabilities in model form, they can be used in new PSM's and PIM's through (top-down) forward engineering. They

demonstrate the method for the case of a network inventory application with graphical interface for which the code has 100% automatically been generated. Their methods and the relation with the TMF NGOSS life cycle has further been demonstrated in various TMF Catalyst demonstration projects.

An alternative method is presented in [5]. It describes an intermediate layer for coupling the top-down MDA-approach and the bottom-up SOA-approach. The top-down MDA approach is used to generate a PIM and a SOA-specific PSM down to the lowest implementation part of the PSM that is represented by BPEL and WSDL files for the executable business processes and web services that can be invoked. Both a process-model and a datamodel are included. Such an MDA approach is supported by the various initiatives for generating UML profiles for web services [6], [7] and the current OMG-initiative (as owner of the UML standards) for formal standardization hereof. Also in this method, SOA is used for bottom-up reverse engineering and abstracting available functionality and data in a sector. The intermediate layer maps and transforms functions between on one hand the web services created by the top-down MDA-approach and on the other hand the web services created by the bottom-up SOA-approach, Fig. 3. As part of its coupling, mapping and transformation function, the intermediate layer can:

- absorb unwanted changes from bottom-up to top-down, e.g., changing a data-base or application in a sector (resulting in a change of a low-

Fig 3.: Mapping and transformation at the web service level for MDA-SOA unification.



level webservice) doesn't affect the highlevel processes;

- hide semantic differences;
- integrate (results) of various lowlevel sector services into a single high-level trans-sector service.

Both the described methods for unifying the bottom-up SOA and the top-down MDA approach will have their own pro's and con's in the context of trans-sector integration as discussed in this paper. The former method seems to provide better opportunities for re-usability of PIM's and PSM's. But it also assumes relative stable and standardized low level services that are generated. Within a single sector with a strong standardization effort (such as for the telco case) this may be true and may therefore lead to less integration tax. In a trans-sector situation with many different sectors, non-standardized services and many alternative service suppliers this will probably be less the case. In that case the latter method may prove to be more advantageous, although it results in (manual) mapping and transformation steps between top-down MDA-generated and bottom-up SOA-generated web services.

Dynamic Service Discovery and Integration Using Semantic Web Services

As discussed thus far, trans-sector innovation requires the integration of the (web) services that are provided by the sectors into trans-sector business processes. Dynamic discovery and integration of these services may contribute significantly in minimization of the trans-sector integration effort. Mere syntactic description of the services is therefore insufficient¹. The unambiguous semantic description of the web services that are exposed is required for dynamic discovery and integration. In scientific literature various semantic web services methods have been presented. Reference [8] describes a telecommunications case study. It describes how semantic web service technology can be used so that service providers can dynamically integrate with a wholesale business-to-business gateway of an incumbent operator to allow them to integrate their operational support systems. Without such a system, a large amount of manual integration effort would be required. But such methods good enough to enable dynamic discovery and integration in the broader context of

trans-sector innovation as described in this paper? What is (currently) feasible? Literature doesn't provide a direct answer. Hence, this section describes the state-of-the-art in semantic web services by considering the various (structure and process) components that together unambiguously define a service. Formal and unambiguous semantic description of all these components is necessary to facilitate the dynamic discovery and integration of such services.

The structure components of a service

The structure components describe what a service is. There are three structure components that are required and sufficient to unambiguously describe a service:

- The effect of a service. This describes the results of the processes and activities that a service performs.
- The message exchange on the service interface. This describes the messages that are sent and received over its interface when calling the service.
- The service level agreement. This describes a list of criteria which is used to measure performance of the service. It contains a consequences clause that determines what happens when the performance agreed upon is not realized.

An ontology provides the means to unambiguously define terminology. Therefore an ontology forms the basis of a semantic web service method. When an ontology unambiguously specifies knowledge with mathematical (logical) constructs it becomes possible (for machines) to reason about the contents of a service. A service can then be interpreted by a computer. If the three structure components of a service can be expressed by such an ontology, the service is unambiguously described.

The process components of a service

The process components describe the activities that are required for dynamic discovery and integration of a service, i.e.:

- *The discovery of a service.* A (potential) consumer formulates the service he wants to use. Subsequently, it is determined which suppliers can

1 With special thanks to Bart Vrijkorte for his work on the assessment of semantic web services as presented in this section.

provide the requested service. The consumer receives a list of potential suppliers and selects one of them. In current, non-semantic, web service architectures mostly a relatively primitive method using key words attributed at service publication is used to search for services, e.g., by means of an UDDI directory. However, this is insufficient. Ontological service descriptions of semantic web services are more precise.

- *The parameter refinement for a service.* This determines specific values for state-parameters and additional details for providing the service after the service has already been discovered. Parameter refinement is required when provisioning the service depends on the state of the consumer. This can be illustrated by means of a parcel delivery service. State information such as “Is the parcel delivery address within the servicing area?”, “What is the timeslot for retrieving and delivering the parcel?”, “What is the volume of the parcel?” and “What is the price?” will not be available after the discovery process. Parameter refinement must result in specific parameter values that are satisfactory for both the consumer and the supplier of the service.

Currently, various methods for semantic web services are in development. The three most well-known and advanced methods are OWL-S, WSMO and SWSF. Table 1 shows how these methods are evaluated against the structure and process components as introduced in this section. The table indicates that the methods do not fulfill all requirements (yet).

As the table shows, none of the methods provides a sufficient solution on how to negotiate and enforce service level agreements in a service-oriented architecture, although this aspect is rapidly becoming of increasing importance.

Secondly, each method has a limited solution for service discovery as these methods do not take into account the state changes (the effect) that a service will realize. Instead, a service is formulated as if it were an object in the world. This is not very precise. Again, this can be illustrated for the parcel delivery service. With the object-centric methods for discovery, the parcel delivery service is described as the object transport with attributes for the parcel-retrieving address, the parcel-delivery address and the price. In no way it can be derived what the essence of the service is, i.e., that the parcel changes

location. It will be better to find a parcel delivery service by describing the object parcel and to search for a service that can change the current location of a parcel to the delivery address. This will make it possible to split this effect into several partial effects in which different parties will transport the parcel a part of the route. This advanced manner of searching is impossible with current object-centric methods.

Finally, there is no answer to the complex issue of parameter refinement. Often, a consumer wants to define specific pre and post-conditions for a service (e.g. the parcel should change locations between specific addresses), whereas suppliers will use more generic pre- and post-conditions (a parcel delivery service in Europe). Checking whether these different views on pre- and post-conditions are in agreement is a difficult (logical) problem. Moreover, a service may require additional pre and post-conditions with which the consumer may not be able or willing to comply (e.g., the parcel should weigh less than 1 kilogram or the receiver of the parcel should also pay an amount of money). Hence, a parameter refinement procedure is often inevitable, including negotiating the price of the service (which is currently not possible). This poses a major challenge on semantic web services.

But, although these considerations indicate that fully dynamic discovery and integration of services is not yet feasible, it is already feasible to speed up the integration process by using semantic information. This is under the condition that the organizations within the same sector develop a shared ontology for their sector. On the basis of this model, they should develop and describe their services. These descriptions can initially be informal (in a natural language). At a later stage, they can be formalized. In the telecommunications sector, the TMF's Shared Information Data model (SID) provides a good basis for this purpose.

Conclusions - Bridging the Gap

In this article, we have described a view on how MDA, SOA and semantic web service technology can be used in trans-sector innovation for minimizing integration efforts. Although, these technologies are good steps forward towards the ultimate goal of highly-automated trans-sector process development and integration, still some gaps have to be bridged before manual efforts can completely be banished, especially on:

Criterion	OWL-S	WSMO	SWSF
Representation of business process/effects	yes, non-composite services through pre- and postconditions, composite services through a process model	yes, services are described through pre- and postconditions	yes, non-composite services through pre- and postconditions, composite services through a process model
Message exchange on service interfaces	yes, but only one single input- and output message per service	yes, every interaction pattern is feasible	yes, with process-model for composite services
Representation of service level agreements	not in method	not in method	not in method
Service discovery	discovery based on objectcentric approach	various proposals but not yet decided upon, not on the basis of state-changes	limited, based on the centrally defined objectives for a service
Parameter refinement	not in method	not in method	not in method

Table 1.: Evaluation of semantic web service methods.

- unification of the top-down MDA-approach for the development of trans-sector business processes with the bottom-up SOA-approach for exposing sector-specific services.
- dynamic discovery and integration of services using semantic web service technology.

But although the ultimate goal may appear to be far away, it is to be noted that the current state of technology can already help considerably in minimizing the transsector process development and integration effort. With the view described in this paper, trans-sector integration can be reduced to mainly service discovery and mapping/ transformation of semantic (web) services exposing each sector's functionality. Having to interconnect (by manual effort) deeply into the IT-systems of the individual sectors will no longer be necessary. Furthermore, additional steps can be taken to further combine the concepts of MDA and semantic web service discovery into a unified development process. To this end, it should be possible to embed semantic web service discovery processes as part of the MDA development methodology. The first ideas on how to realize this have already been published [9].

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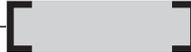
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Quantification and prediction of end-user perceived web-browsing quality

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Abstract

Web browsing is one of the most popular data services. To evaluate the perceived web-browsing quality, a new model is formulated that relates response and download times to end-user perceived quality. To this end, three experiments were set up based on a novel approach. In each of these experiments, a subject repeatedly retrieved the same two web pages: a search page and a results page. The response and download times of the pages are manipulated in the three experiments, representing slow, medium and fast Internet access. Major results are that the perceived quality is inversely proportional with the logarithm of the (weighted) session time and that the last download time dominates the perceived quality. This effect is stronger for fast Internet access. With the optimal weighting of the response and download times, the correlation between objective timing measurements and perceived quality is above 0.93 for all three experiments. Without weighting, the correlation for fast Internet access dropped to a value as low as 0.72.

1. Introduction

The number of users having access to the World Wide Web increased over the past decade and is still increasing. Web browsing is one of the most popular data services over both fixed and mobile networks, and its end-user perceived quality is an important issue for service providers, network providers, and end-users. E.g. if end-users cannot access a particular site quickly enough, they will become impatient and start focusing their attention on other tasks or simply leave the site in which case business revenues will be lost. The end-user perceived quality of web browsing depends on the entire end-to-end chain: network performance (server load, number of servers, link capacity, etc.), user equipment, and application performance (the

browser itself). Due to the complexity of this chain, the end-user perceived web-browsing quality has received very limited focus from both academia and industry up to now.

If the user perceived web-browsing quality could be quantified, application developers can optimize a web browser's performance [1], and network operators and service providers can:

- Optimize their network/service using for instance load-balancing techniques (e.g. where to deploy proxy-servers, where to realize network-based caching [2], and whether to apply network-based transcoding of web content) or upgrade the network capacity.
- Apply performance monitoring and fault analysis.
- Validate Service Level Agreements.

The perception of web-browsing quality is dominated by the response time, the download time, and the variations in these quantities [3]-[7]. To determine the influence of these parameters on the perceived browsing quality, a novel experiment was carried out in which several video recordings are made of the download progress of a web site. The web site consists of a search page and a results page, which are then interactively played back in a real browser and presented to the test subjects.

The set-up that is used allows to manipulate the response and download times exactly and to find their impact on the subjectively perceived browsing quality. It is obvious that the *expected* maximal session time will dominate the perceived quality. If one expects a session time of 100 seconds, the perceived quality of a 10-second session will be much higher than if one expects a session time of 1 second. Therefore, the experiment takes a context

dependent approach by using three different time scales, 6, 15, and 60 seconds, corresponding to fast, medium, and slow contexts, respectively. The goal of the current experiment is to find a mapping between objective time-related parameters and subjective quality results.

In general, quality perception related to response time can be classified according to the following three perceptual regions [8]:

1. **Instantaneous experience:** 0.1 second is about the limit for having the feel that the system is reacting instantaneously, an important limit for conversational services (e.g. chatting).
2. **Uninterrupted experience:** 1.0 second is about the limit for the user's flow of thought to stay uninterrupted, even though the user does lose the feeling that the service is operating directly, an important limit for interactive services (e.g. gaming).
3. **Loss of attention:** 10 seconds is about the limit for keeping the user's attention focused on the dialogue. For longer delays, users want to perform other tasks while waiting for the computer to finish, so they should be given feedback indicating when the computer expects to be done. Feedback during the delay is especially important if the response time is likely to be highly variable, since users will then not know what to expect.

Regarding download times, subjects tend to adapt their quality judgment towards the expected download time [9]. When subjects are informed about the expected download time, they are willing to accept large download times. A large movie can alternatively be downloaded overnight leaving the quality issue dependent on the expected download time only. Similar to [8], in [9], it was shown that leaving test subjects ignorant of waiting time (e.g. no duration information and/or countdown of web objects remaining) results in significantly lower evaluation of the web site. For web browsing without large downloads during the session, subjects show the same behavior as for response times.

This paper pursues a model that quantifies the relation between the end-user perceived quality of web browsing sessions and performance parameters such as response and download times. First, Section 2 describes the approach towards finding such a model. Section 3 is about the subjective experi-

ments to obtain data from end-users. Then, Section 4 presents the experimental results, and Section 5 discusses the derived model. Section 6 concerns application of the model in an existing network. Finally, Section 7 ends with conclusions and recommendations. Initial results of this work [10] were submitted to ITU-T Study Group 12, and models based on the experiments described in this paper are included in ITU-T G.1030 [11]. This paper elaborates on the approach, experimental set-up, and model application.

2. Approach

The model that is aimed for in this contribution should ideally describe the relation between the different response and download times within web browsing sessions and the corresponding perceived web-browsing quality for a given *maximum* session time within a certain network and system configuration. The model should be applicable to a wide range of network and system configurations, as well as to web browsing services for a wide variety of users. The subjective experiments should mimic a real-life experience as close as possible. And in order to determine the effect of different maximum session times, corresponding for example to different access network technologies, experiments with different time scales should be carried out. The time scale is defined as the maximum session time that actually occurs in the experiment.

It was decided to set up three subjective experiments with time scales of around 6, 15, and 60 seconds, representing fast, moderate, and slow network contexts, respectively. A single experiment consists of 49 sessions using the same two web pages. In each session, a subject first retrieves a search page and then a page that shows the search results. In Figure 1, the timeline of such a session is shown. The first two time intervals, T_1 and T_2 , represent the non-interactive response and download time of the search page. The second two time intervals, T_3 and T_4 , represent the interactive response and download time of the result page. T_1 and T_3 were manipulated using Java scripting, and T_2 and T_4 were manipulated using a network manipulator.

In real life the search page will show little variation in response and download time because the search engine needs no interaction with other Internet addresses. The results page will show larger varia-

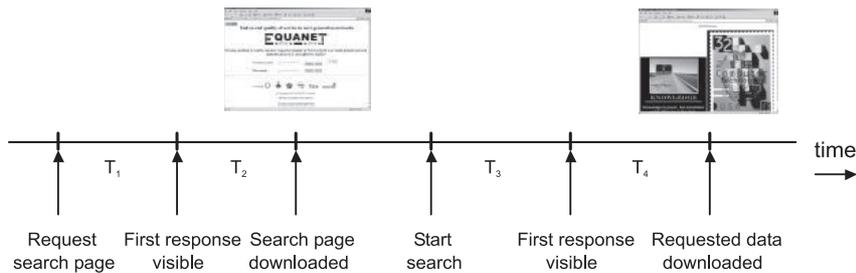


Figure 1. Experiment timers T_1 thru T_4 . The sum $T_1+T_2+T_3+T_4$ represents the session time.

tion because it has to be retrieved from a huge amount of possible information sources. In the experiments, all four timings are manipulated with the same variance. Between two sessions in an experiment, the subjects are told that the network settings are changed and that a new response is required. The sum of the download and response times of an experiment is varied between zero and the maximum for that time scale.

To be able to reproduce the configuration exactly, in the preparation of the experiment, video recordings were made of the download progress of the four parts of the web browsing session using the different timings in each of the three experiments. They were played back in the actual experiment on a stand-alone PC in reaction to the mouse clicks of the subject, giving the impression of a normal web browsing session. This set-up allows collecting large amounts of data in an easy, reproducible manner.

Due to the known difference in behavior between trained experts and untrained, so-called naïve users, a distinction is made between these groups in the development of the model. Separating these two groups allows us to develop a model that predicts the quality of web browsing for a large population of users.

3. Subjective Experiments

The experimental set-up used audio video interlaced (AVI) files of web browser content "recorded" using the NIST Net emulator [12] to realize different network conditions. The actual experiments were carried out on a stand-alone PC using a standard Internet browser and locally stored HTML, AVI and JavaScript files, simulating the request, retrieval, and display of a limited set of web pages. In fact, each AVI file is a movie of the retrieval of a particular web page under specific network conditions. These movies simulate how a web page is build up in time, and are played in a

browser window. The test subjects were not made aware of the fact that the web pages were stored locally and that AVI files were used instead of real web pages.

The time values for the response times were controlled using JavaScript timers and page "build-up" times were controlled using a predefined set of AVI files. As a result, the experimental set-up provided all subjects with exactly the same experiment and still gave the impression of a normal browsing session. The order of the 49 sessions within an experiment is randomized [13] for each subject, thus minimizing a potential effect of a specific order.

When a subject carries out an experiment, all events of the browsing sessions are logged, i.e. the response and download times of the search page, the time to fill in a text-box on the search page, and the response and download times of the results page. For each session, consisting of the retrieval of both the search page and the results page, these times are accompanied by the subject's assessment of the browsing quality, expressed in an Opinion Score (OS) value. In the actual experiment some realizations were slightly longer (up to 25%) than the actual settings. In the analysis, these timing values were averaged.

The OS values of the ITU-T Absolute Category Rating scale [13] were used, which evaluate the perceived quality of a service on a five-point scale with 5: excellent, 4: good, 3: fair, 2: poor, 1: bad. For each session, the obtained OS values for all subjects were averaged to obtain the Mean Opinion Score (MOS) value for this session.

In our approach, a subject is provided with a small training prior to the actual experiment [13]. In this training, the best and worst qualities (shortest and longest session time in the experiment) are shown and subjects can adapt their rating scale to the experimental context, thus minimizing differences

between them. The complete experiment consists of the following steps:

1. First the subject is presented a welcome page, after which he or she is presented with instructions based on the instructions used for voice experiments in [13]. The text explains that the subject will be presented 49 sessions, each consisting of:
 - Requesting, retrieving, and displaying of a search page, which consists of text, small pictures, and a search form field in which the subject can type in a search term.
 - Typing and submitting a search term on this page.
 - Retrieving and displaying of the results page, which mainly consists of two large pictures.
2. After reading the introduction text, three examples are shown to the subject including an example of "excellent" web browsing (instantaneous appearance of all results), an example of "bad" web browsing (session time equal to time scale and all four timings the same), and an example of intermediate quality (something in between "bad" and "excellent") for the time scale of the experiment.
3. A randomized set of 49 sessions, each with different combinations of T_1 thru T_4 , is presented to the subject. After each session, an OS is asked from the subject. Between two sessions, a page is shown with the text: "This ends the session. Network settings are now changed for the next session."
4. After all sessions are completed, the subject is presented an end page on which the subject is thanked for participation in the experiment.

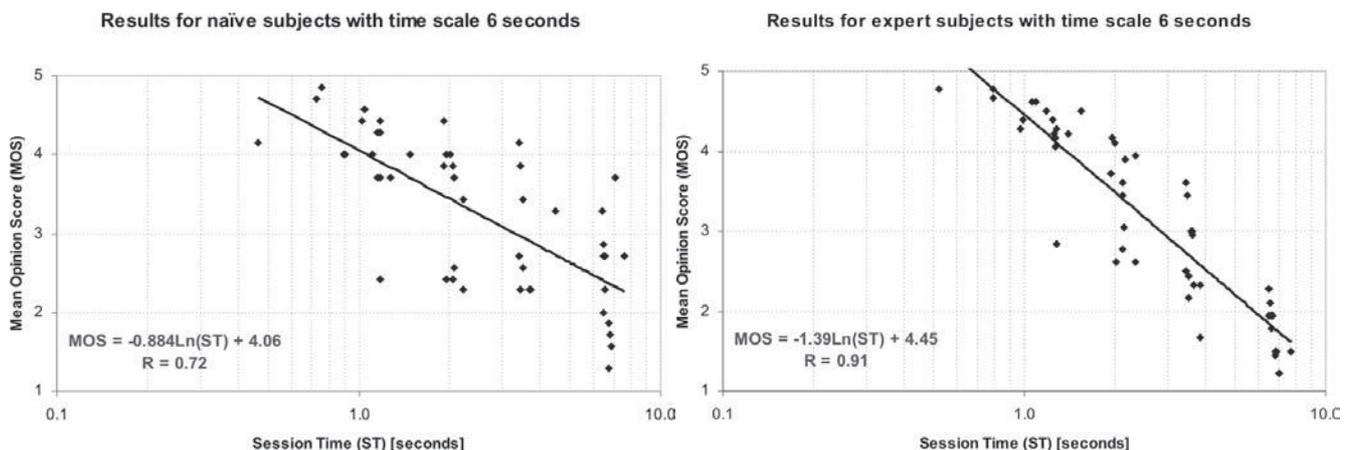
To get consistent data, each session used exactly the same search and result pages irrespective of the search term entered by the subject. This is a compromise between realism versus reproducibility. However, the subjects are unaware of this fact, since they are asked to type in the same search query in every session. In this way, it is obvious to the subjects that the same results page will appear in each session, albeit under different circumstances. In the perspective of the subjects, the search engine first has to find the result page, which then has to be downloaded.

For each of the 49 sessions, different combinations of T_1 thru T_4 are configured using JavaScript timers and pre-recorded movies of the web browser content, varying each of T_1 thru T_4 from 0 to the time scale for this set of experiments such that the sum $T_1+T_2+T_3+T_4$, i.e. the session time, varies between 0 and the time scale.

4. Experimental Results

Experiments were done for the time scales 6, 15, and 60 seconds with 25, 29, and 29 different subjects, respectively. It seems obvious that the perceived browsing quality decreases as the session time increases. Indeed, this behavior is confirmed and clearly demonstrated in Figures 2-4 where the session time (i.e. $T_1+T_2+T_3+T_4$) is plotted versus the MOS value for all three experiments. For the long duration context, see Figure 4, the results for naïve and expert subjects were about the same and MOS values were calculated over the whole population. For the two shorter duration contexts, see Figures 2 and 3, naïve and expert subjects behaved differently, and the correlations between session times and perceived quality are significantly different and are thus given separately. All results show the

Figure 2. Results for (7) naïve and (18) expert subjects with time scale 6 seconds.



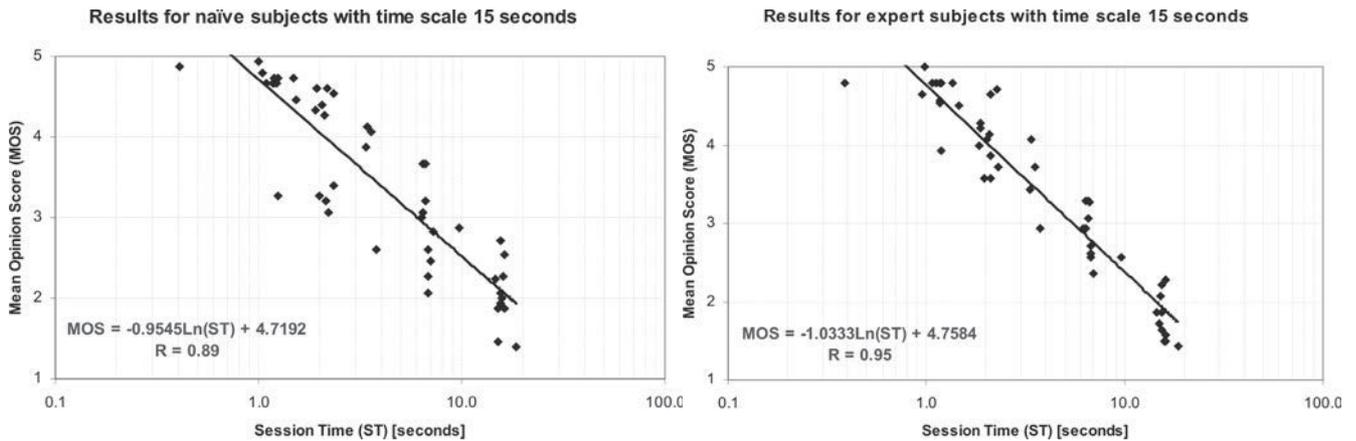


Figure 3. Results for (15) naive and (14) expert subjects with time scale 15 seconds.

same behavior, the perceived quality goes down linearly with the logarithm of the session time. The correlation in the long duration experimental context is high enough (>0.9) to make reliable quality predictions. In general, correlations above 0.9 are aimed for in psychophysical modeling of quality perception [14].

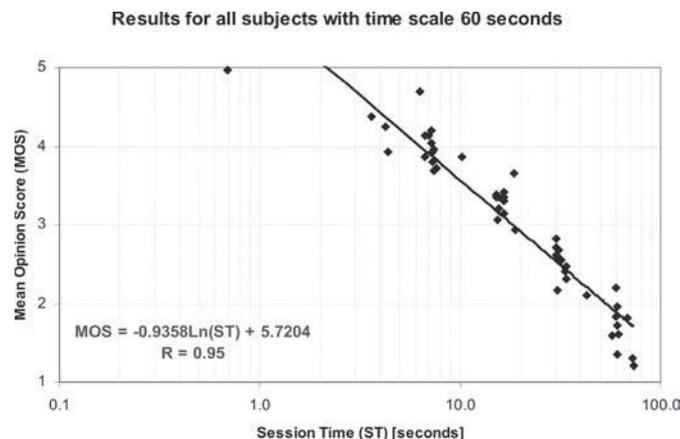
Two effects cause the difference in correlation between expert and naive subjects. The first one being the larger variance in the subjective scores for the naive subjects that could be observed from the calculated 95% confidence intervals for the MOS values. The second underlying cause for the lower correlation is a difference in behavior when comparing the results for naive and expert subjects. This will be discussed further in Section 5.

The results also show that for the 6-second experiment with naive subjects the correlation between session time and perceived quality is far too low (0.72) to make reliable quality predictions.

5. Model Derivation

For the 60-second context, the correlations between session time and subjective quality are very good (0.95) for both naive and expert subjects. In the trend line for this context (see Figure 4), we can also see that session times below about 2 seconds lead to the maximum MOS value of 5, while the minimum MOS value of 1 is obtained for a session time above 100 seconds. In other words, the minimum score of 1 in the trend line is obtained for session times that are larger than the longest session time in the actual experiment (73 seconds). The main cause for this is the fact that subjects have difficulty estimating the longest session time. In addition, the maximum score of 5 is also obtained for session times that are larger than the shortest session time in the actual experiment. The main cause for this is most probably that subjects have difficulty in discriminating short session times in the presence of long session times. Support for this can be found in Figures 2 and 3 that show that the MOS value of 5 is obtained for shorter session times when the maximum session time in an experimental context gets shorter.

Figure 4. Results for all (12+17=29) subjects with time scale 60 seconds.



A general mapping from session time to web browsing quality for the long duration context can be constructed by defining a minimum (*Min*) and a maximum (*Max*) session time and using a logarithmic interpolation between these extreme session times. If we write $MOS = a - b \cdot \ln(\text{SessionTime})$ fill in $MOS = 5$ for $\text{SessionTime} = \text{Min}$ and $MOS = 1$ for $\text{SessionTime} = \text{Max}$, we obtain for session times between *Min* and *Max*:

$$MOS = \frac{4}{\ln(\text{Min} / \text{Max})} \cdot (\ln(\text{SessionTime}) - \ln(\text{Min})) + 5. \quad (1)$$

From the regression for the long duration experiment in Figure 4, $MOS = 5.720 - 0.936 \cdot \ln(\text{SessionTime})$ we find minimum and maximum session times of 2.16 and 155 seconds, respectively.

For the 6 and 15-second experimental contexts, the correlations between session time and subjective quality are much lower than for the 60-second context, and better models for the prediction of the subjective quality for naïve and expert users have to be constructed. Nevertheless, the idea of using a logarithmic interpolation between minimum and maximum session times will also be pursued in the construction of these models.

The main additional idea behind the development of the web browsing quality models for shorter duration session times is that the last download time (T_4 in our experiment) has a more severe impact on the final perceived web browsing quality than the other response and download times (T_1, T_2, T_3 in our experiment). Optimized models have been developed that use a weighted sum over all response and download times (T_1, T_2, T_3 and T_4 in Figure 1) to predict the perceived browsing quality. In fact, the correlation is maximized as a function of the weights under applicable boundary conditions. Table 1 gives an overview of the optimal weights, i.e. the factors with which T_1 thru T_4 have to be weighted in order to get a quantity that has the highest correlation with the subjectively determined MOS values. This quantity, the weighted session time,

$$\text{WeightedST} = WT_1 \cdot T_1 + WT_2 \cdot T_2 + WT_3 \cdot T_3 + WT_4 \cdot T_4$$

can be mapped to the MOS value using the same logarithmic interpolation between minimum and maximum session times as used in (1):

$$MOS = \frac{4}{\ln(\text{Min} / \text{Max})} \cdot (\ln(\text{WeightedST}) - \ln(\text{Min})) + 5. \quad (2)$$

Note that in Table 1 the sum of the weighting coefficients is normalized to 4 in order to be able to compare normal session times ($T_1+T_2+T_3+T_4$) with weighted session times. The table shows that for the shortest duration context, the impact of the last download time is more than twice as large as the impact of the other download and response times. It also shows a significantly different behavior for naïve and expert subjects, the optimal weighting for naïve subjects shows a larger impact of the last download time than the optimal weights for the expert subjects. For the naïve subjects, the impact of the large download time is more than four times as large as the impact of the other download and response times. For expert subjects, it is about a factor of two, while the overall best weight shows an impact that is about three times as large.

Table 1 also shows that for the medium duration context, the weight factors for naïve and expert subjects as well as the overall weight factors are in between the weight factors for the short and long duration context experiments. This shows the vali-

Table 1. Optimal model weighting for T_1, T_2, T_3 and T_4 with the associated model correlations between objective timing and subjective MOS results.

	WT1	WT2	WT3	WT4	Corr.
6s expert	0.56	0.84	0.80	1.80	0.97
6s naïve	0.37	0.40	0.60	2.63	0.93
6s overall	0.47	0.60	0.71	2.22	0.95
15s expert	0.63	0.77	1.11	1.49	0.98
15s naïve	0.48	0.70	0.88	1.95	0.96
15s overall	0.54	0.72	0.98	1.76	0.97
60s expert	0.84	0.77	1.22	1.18	0.99
60s naïve	0.64	1.01	1.12	1.24	0.98
60s overall	0.73	0.90	1.16	1.22	0.98
60s overall, no weighting, see Figure 4	1.00	1.00	1.00	1.00	0.95

Model versus data for all subjects with time scale 6 seconds

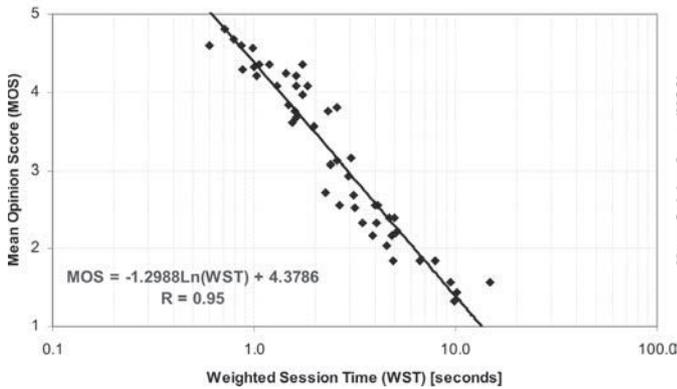


Figure 5. Model versus data for all subjects with time scale 6 seconds.

Model versus data for all subjects with time scale 15 seconds

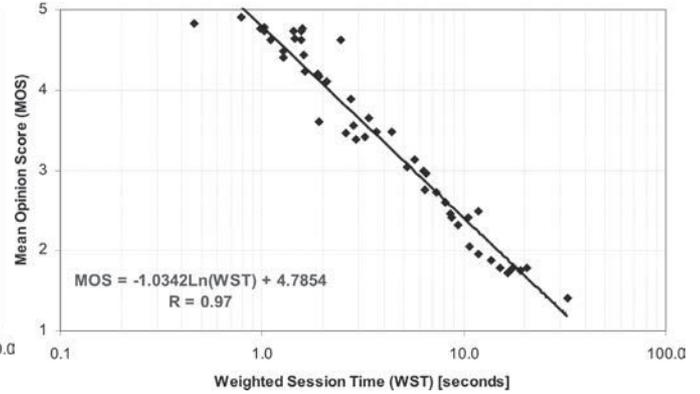


Figure 6. Model versus data for all subjects with time scale 15 seconds.

dity of the approach thus allowing for an interpolation between the different *session context times* (i.e. the time scales 6, 15, and 60 seconds) in order to obtain weightings for other context times.

Although there is a significant difference between naïve and expert subjects, the overall best weights provide high enough correlations (>0.95) to allow the formulation of a single, overall averaged, mapping, for both the 6 and 15-second experiment. This keeps the final modeling as simple as possible and one only needs to provide a single session context time in order to be able to predict the perceived quality of a certain web browsing session from the individual response and download times. The results for this processing are given in Figures 5-7.

The relation between the session context time, the overall weight factors WT1 thru WT4, and the minimum and maximum session times for use in the perceptual model as defined in (2) are given in Figures 8 and 9. This allows direct mapping of the response and download times of a web browsing

Model versus data for all subjects with time scale 60 seconds

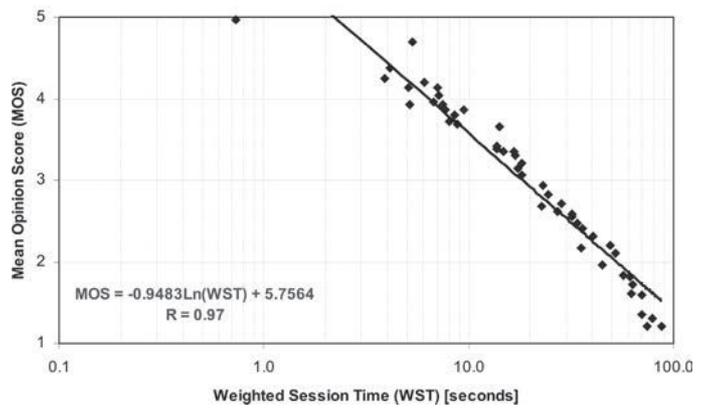


Figure 7. Model versus data for all subjects with time scale 60 seconds.

session that is composed of a search page request followed by a search page result into an expected MOS value when the session context time is determined. This will be further addressed in Section 6. To conclude this section, similar results are expected for other types of web browsing sessions that are composed of more web requests.

Figure 8. Relation between session context time and weight factors for the perceptual model.

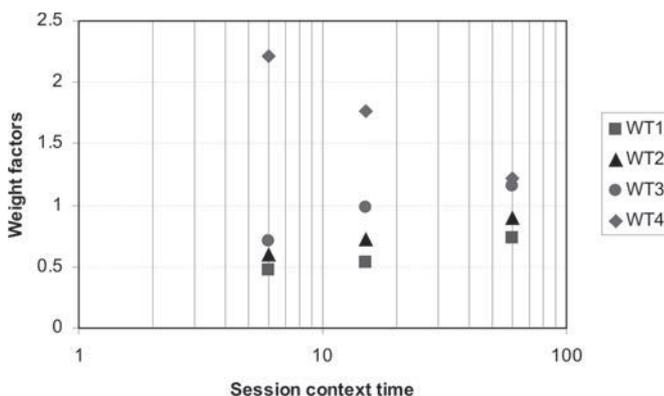
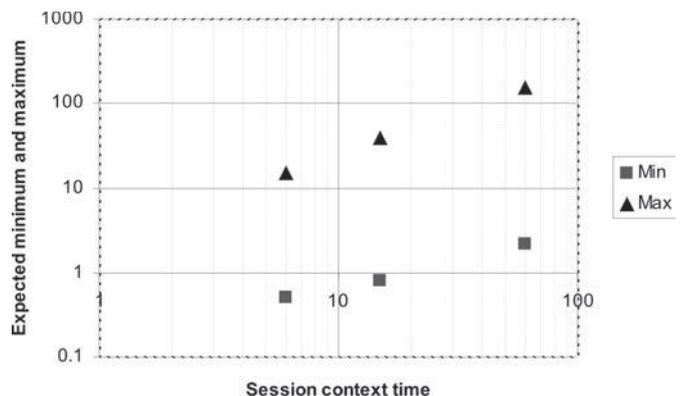


Figure 9. Relation between session context time and expected minimum and maximum session times for the perceptual model.



6. Model Application

When monitoring the quality of networks, service providers are generally not interested in the prediction of a single MOS value, but need a statistical quality measure. Well-accepted measures [15] are the percentage poor or worse (%PoW) and the percentage good or better (%GoB). These values give an indication of what percentage of web browsing sessions will respectively be rated as "poor" or "bad" (MOS value 1 or 2), or as "Good" or "Excellent" (MOS value 4 or 5) by end-users. First, service providers need to formulate a requirement by setting the boundaries for both values, for instance $\%PoW \leq 5\%$ or $\%GoB \geq 90\%$. Then, the following steps can be carried out:

1. **Find the session context time in specific situation.** Traffic monitoring tools can be applied to trace the web browsing traffic on a particular network for a particular period. Use the output to estimate the session context time in a specific situation.
2. **Tune the model.** Determine the overall weight factors WT_1 thru WT_4 , and the minimum and maximum session times for use in the perceptual model as defined in (2).
3. **Determine the probability distribution function (PDF) of the weighted session time in a specific situation.** Use the traffic monitoring tools to estimate the PDF of the weighted session time in the specific situation. Note that this estimation does not take into account the effect of caching and only partly incorporates effects by end-user applications and equipment (including possible delays by for instance Wireless LAN).
4. **Determine the PDF of the MOS.** Use the model tuned to the specific situation and the PDF of the weighted session time to determine the PDF of the MOS, see Figure 10. Now it is possible to compute:

$$\%PoW = 100 \cdot \Pr \{MOS \leq 2\}, \text{ and}$$

$$\%GoB = 100 \cdot \Pr \{MOS \geq 4\}.$$

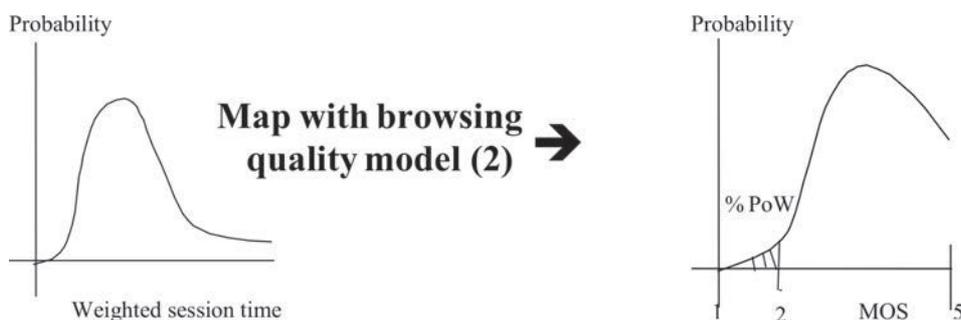
Finally, it can be validated whether this network satisfies the requirements set on %PoW and %GoB.

7. Conclusions and Recommendations

A major result is that the perceived quality of a web browsing session is inversely proportional with the logarithm of the (weighted) session time. Furthermore, the results show that the perceived quality of a web browsing session is dominated by the last download time of a page. This effect is stronger as the maximum expected session time decreases and thus of vital importance for fast Internet browsing. This is in contrast with what would be expected if the effect would be caused by human memory constraints only. In general, memory constraints cause the last stimuli to dominate perception. In addition, the effect of the last downloading time on perception also points out that caching can be an advantageous technique to optimize web browsing servers. In fact, caching can be used to decrease the last download time (T_4 in our experiment) by increasing the last response time (T_3 in our experiment), leading to an improved quality perception, while the total session time remains the same.

A model is presented that derives a minimum and maximum session time from the experimentally determined session context time. From this session context time, a weighting can be determined that puts an increasingly higher weight on the more recent parts of the web browsing session. For large duration contexts, i.e. web browsing sessions that take more than 1 minute, the logarithm of the *total* session time correlates very well with the perceived browsing quality. In this case, an equal weight to all parts of the web browsing session provides results that are accurate enough for the prediction of the quality.

Figure 10. Determine the PDF of the MOS.



As the model is derived from an experiment that only uses a four-step web browsing session, further validations are needed for other types of web browsing sessions to make the results applicable in a wide range of situations.

Acknowledgement

This work was carried out within the EQUANET project, an "ICT breakthrough project" supported by the Dutch Ministry of Economic Affairs via its agency SenterNovem.

The authors would like to thank the more than 80 subjects for their participation in the web-browsing quality experiments described in this paper.

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De vernieuwde Nerg website

Duncan van Meeteren

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Misschien is het u al opgevallen dat sinds januari 2008 de Nerg website is veranderd.

De vorige website was qua layout en structuur sterk toe aan een opknopbeurt. Tevens was het beheer van de website alleen mogelijk via de webmaster die d.m.v. een zgn. html-editor een nieuw artikel aanmaakte en door middel van een ftp-programma dit artikel online zette.

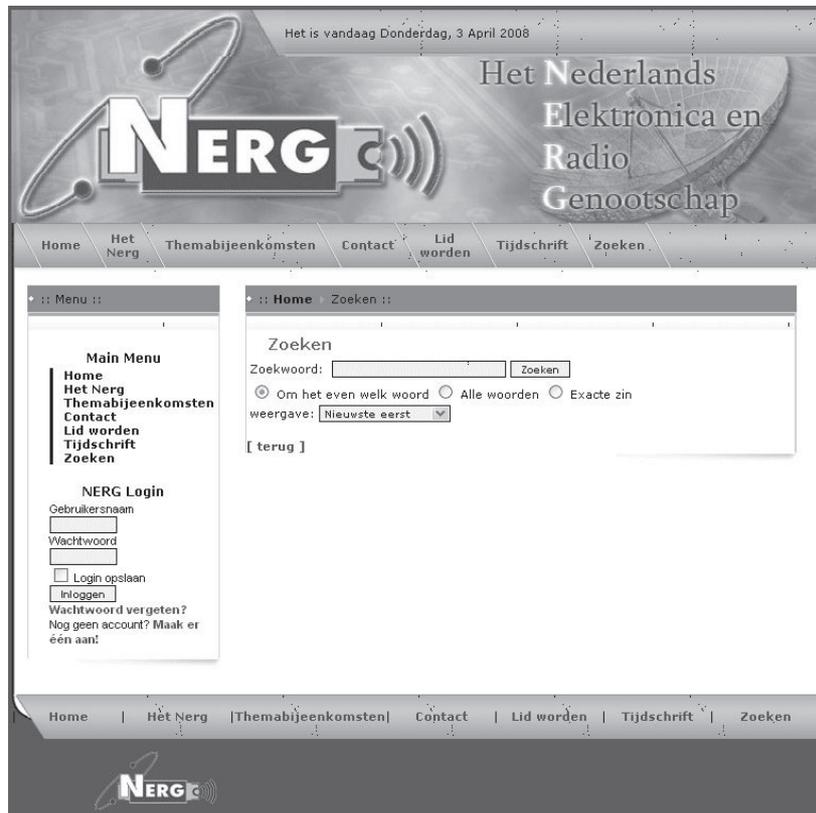
Layout

Voor het layout is gekozen voor een duidelijk zichtbare en identificeerbare banner aan de bovenkant van de website, met daaronder gelijk het menu. Op elke webpagina verschijnt steeds duidelijk het NERG logo en tevens de uitleg over de afkorting. Voor de achtergrond van de banner is gekozen voor een printspoor (link naar Elektronica) en een schotelantenne (link naar Radio).

CMS

De nieuwe website maakt gebruik van het 'open source' Content Management Systeem (CMS), Joomla. Joomla is geschreven in PHP en werkt met een MySQL-database. Door dit systeem te gebruiken is het mogelijk geworden om online content toe te voegen of te verwijderen op de website, zonder tussenkomst van een webmaster/webbeheerder. Dit heeft als voordeel dat de website snel aan te passen is en dat er hier geen additionele software voor nodig is.

screenshot van de vernieuwde website



De voorpagina

Op de voorpagina zal steeds het laatste nieuws, d.w.z. hoofdzakelijk de themabijeenkomsten worden geplaatst. Om direct op de hoogte te worden gehouden van het laatste nieuws is een RSS-feed opgenomen (activeren door de 'Syndicate' button aan te klikken, links onderaan het menu).

Inloggen

Om bij het afgeschermd gedeelte van de website te komen is het nodig om u eenmalig te laten registreren. Dit kunt u doen door onder het linker menu 'NERG Login' te klikken en op de link 'Nog geen account? Maak er één aan!'. Nadat u alle velden heeft ingevuld (graag bij gebruikersnaam

uw Nerg lidmaatschap nummer opgeven) en op 'verzend registratie' is geklikt, wordt er eerst een bevestigingsmail naar u verstuurd met daarin een URL. Pas wanneer het URL is bevestigd (aangeklikt) wordt er een bericht gestuurd naar de secretaris om het Nerg lidmaatschap te controleren. Indien alles correct is, autoriseert de secretaris het Nerg lid om bij het afgeschermd gedeelte van de website te komen.

Bij dit gedeelte kunt u de digitale versie van het Nerg tijdschrift vinden (in pdf-formaat), alsook presentaties van themabijeen-

komsten en Nerg documenten (zoals het Regelement en het Jaarplan).

Themabijeenkomsten

De meest actuele themabijeenkomsten wordt op de voorpagina geplaatst en de vooraankondigen zijn te vinden onder het menu 'Themabijeenkomsten'. De bedoeling is dat van elke themabijeenkomst een korte samenvatting wordt gemaakt met daarbij enkele foto's. Zo krijgen de bezoekers (hopelijk ook potentiële Nerg leden) meer inzicht in de bijeenkomsten.

Slotwoord

Hopelijk kan de vernieuwde website bijdrage aan werving van nieuwe Nerg leden en dat het een toegevoegde waarde kan zijn voor Nerg leden. In de toekomst kan er nog gedacht worden om bijvoorbeeld een Forum, Gastenboek of Enquête toe te voegen aan de website. Joomla leent zich er namelijk uitstekend voor om deze 'Extensions' te integreren.



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Mini-vermogenslektronica (college)

Principes van vermogenslektronische toepassingen bij voedingsbronnen

data/plaats: jaarlijks 9 colleges in de maanden augustus t/m november in Eindhoven

cursusleiding: ir. M.A.M. Hendrix (TU Eindhoven)

Hoogspanning I: velden en constructies (college)

De aard van elektrische velden, de inwerking op isolatiemateriaal en de daarvan afgeleide constructieprincipes

data/plaats: jaarlijks 10 colleges in de maanden september t/m december 2008 in Delft

cursusleiding: prof.dr. J.J. Smit (TU Delft)

Decentrale energievoorziening

Inpassing in het elektriciteitsnet

data/plaats: najaar 2008 in Eindhoven

cursusleiding: mw.dr.ir. J.M.A. Myrzik (TU Eindhoven)

Power quality

Netkwaliteit: spanningsdips en harmonische vervorming; bepaling, gevolgen en oplossingen

data/plaats: voorjaar 2009 in Eindhoven

cursusleiding: mw.dr.ir. J.M.A. Myrzik (TU Eindhoven)

Industriële netten en installaties

Een actueel overzicht van de inrichting van moderne elektrische installaties bij eindgebruikers

data/plaats: 2 dagen nader te bepalen in Eindhoven

Voor meer info: Stichting PATO, tel. 071-5282535, e-mail: info@pato.nl

