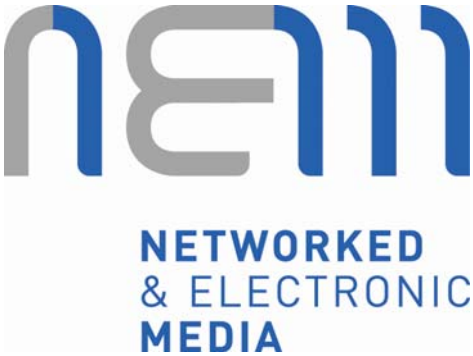
Strategic Research Agenda

"Networked and Electronic Media"
European Technology Platform

www.nem-initiative.org



September 2008

Foreword

This is the 2008 version of the Strategic Agenda of the European Technology Platform NEM (Networked and Electronic Media).

This SRA document reflects a comprehensive compiled collection of active and upcoming developments in the research world of Networked Media while clearly aiming towards the realisation of the NEM Vision. The main focus is to provide a well structured publication which reflects and covers the broad set of NEM aspects. The document is updated with regard to new developments and evolutions of research topics addressed by the NEM world. The aim was to identify future trends on the horizon before they have become buzzword mainstream in order to help the European ICT community to gain a position ahead of the market.

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Executive Summary

Joint evolution of media and networks

The European Technology Platform on Networked Electronic Media, the NEM Initiative, foresees a future when all will be able to generate, manipulate, use, and enjoy any kind of electronic media content – wherever they are. Electronic media content will include not only the audiovisual services of today such as telephony and television but also a wide range of interactive services across all realms of information, education, and entertainment, offering a wide range of new business opportunities.

This future is elaborated in the NEM Initiative's Vision 2020 document, which looks forward to:

- An infrastructure of effective, ubiquitous, and seamless social networks that is people-centric, giving interesting and motivating immersive and sensory experiences.
- A service oriented society in which ambient and context-sensitive services are created and provided, personalised and customised to people's individual and social needs, available to communities of users and including ALL citizens.
- Open very flexible business models and revenue generating models derived from radically changed value chains, a loose network of niche markets and fast operating small enterprises governed by 'soft' regulation.

The NEM Initiative follows a unique path into the future because it deals with 'content' from both the users' point of view and the technical perspective. Both views are essential if new services, with new commercial opportunities, are to work well and to be attractive to a wide range of users from different backgrounds and with different applications.

To make this vision a reality requires the development of a seamless, pervasive network and easy-to-use tools for generating, searching, accessing, transforming and delivering media content – the future internet in the widest sense. This Strategic Research Agenda outlines the technical work needed to achieve the vision, concentrating on what needs to be done rather than the form of technology required to achieve it. It aims to inform the workplans of the seventh Framework programme, other international programmes such as Eureka and the programmes of the Joint Technology Initiatives, and the national programmes of the Member States – and to inspire wider international collaborations.

State-of-the-art and apparent trends

The media industry consists of a value chain creating, storing, adapting, aggregating, delivering, and consuming 'content' – understandable information made available to a user at any stage of the value chain. Content includes both the 'essence' – the data representing text, audiovisual services, games programs etc. that is the object of the value chain – as well as the metadata that describes the essence and allows it to be searched, routed, processed, selected, and consumed. The value 'chain' is increasingly becoming a 'mesh' as consumers are increasingly becoming originators of content and stored content is increasingly reused and repurposed.

At present, much content is produced by a craft process, for broadcast services or for recorded retail distribution. Europe is now accelerating the transition from analogue broadcasting standards

to new all-digital standards. Broadcast services continue to be available, but using all-digital standards, with additional data services and interactivity. The digital transition gives better spectral efficiency, enabling an expanding range of services.

A vast amount of content is becoming available on demand, both through storage in the home and on request over many different networks from content producers and aggregators as well as from broadcasters. There is an explosion in social networking internet sites, where content is a form of communication in its own right, reflecting the fundamental human drive to communicate. These new services will need new internet structures and intelligent universal terminals, together with new object-based methods of representing real or imagined worlds and manipulating those representations.

There is a wide variety of distinct technologies in use, each adapted for a different application. There is little compatibility between devices, making seamless usage impossible.. This leads to clearly separated usage scenarios: combining a telephone and a radio in one handset offers nothing extra in terms of services. Moreover, a new generation of improved sound and picture formats is appearing which will enrich the variety of services and terminals available to the consumer.

Increasingly, networks will be used for communication between inanimate devices – the 'internet of things' – as well as for carrying content for use by humans. Only telephone, broadcast and mobile phone networks are currently close to ubiquitous. New technology is far from being easy to use. This reinforces the 'digital divide' between those who are technologically literate and those who are excluded from the benefits the technology could bring.

Although technology can be – and is – used to create barriers, it more often creates new opportunities, new applications, new services that can transform people's lives and create wealth for all. It is those applications of technology that the NEM Initiative would like to encourage to fulfil its vision for 2020.

The changes needed

The media revolution is in full progress. The NEM Initiative hopes that electronic media will finally appear as a ubiquitous service, easily and simply available to all users for professional and recreational purposes. Of course, this apparent simplicity may mask many layers of complexity – the point is that the user should not need to care about underlying technologies.

The implications for the NEM SRA can be exemplified as:

- The distinction between today's basic routing technologies – such as unicast, multicast and broadcast – must become invisible, not only to the user but also the media application itself;
- Media must become networkable, an integral part of any kind of network rather than just something to be transmitted from A to B;
- Media must become ubiquitous; content will come from any user, with highly sophisticated and user-friendly indexing engines to generate the accompanying metadata;
- The infrastructure must become context-aware, recognising users to know their needs, and adapting itself to the environment;
- Intuitive and multi-modal interfaces must offer a more natural way to interact with and within media environments;
- Any kind of media should be known by its content and not by the technology used, to make networked media communication inclusively available to all, using or consuming;

- Media retrieval must become effective and sensible;
- Networked media should allow new groups to form, for social or business purposes, defined by their media interests;
- Networked media should contribute to sustainability, bringing new ways to create contact, to travel virtually round the world, to meet together;
- Video must be represented in such a way that it entices and offers exciting new creative possibilities;
- Seamless and intuitive service handover between devices and environments must be accomplished to allow users to access services anywhere, on any terminal;
- 'Federated' services – complex services built up from multiple elements from different originators – must be enabled, offering valuable commercial opportunities;
- Services must engage users' trust and protect their privacy;
- Service providers must address, in a way that is fair to all, the security and rights issues involved when handling audio-visual material in networked and electronic media.

Market perspectives

Impact

Technology is always a means to create and shape markets and technological developments will influence the business world, offering new opportunities and developing new industries. At the same time, the business world, and the markets it creates, must enable the deployment of new technologies to promote new product concepts. At the core are the users – who are willing to pay only if they see a clear and understandable advantage.

The NEM Initiative's members are mainly from the wide business segment of the content production and distribution industries – network operators, games producers, broadcasters, and equipment manufacturers. Therefore this Strategic Research Agenda is written mainly in terms of those industries' products. However, the NEM Initiative is well aware that the realisation of its vision will have profound effects on other aspects of industry and society, facilitating social interaction without travel, building communities, closing the 'digital divide', revolutionising healthcare, bringing real inclusion to the elderly and handicapped, enabling a wide range of e-government services, and offering European citizens real participation.

Regulation and standards

Because of their large perceived influence and their important role in democracy, the media industries have always been carefully regulated. In order to accommodate technological and market developments, and new customer usages resulting from convergence, modernised and flexible regulation covering all media services is required. The NEM Initiative will continue to discuss how it can best contribute to regulatory matters and, where possible, it will offer views and recommendations for better regulation.

Successful European standards like GSM and DVB show how powerful a single standard can be. The NEM Initiative encourages standardisation, and prefers open standards where possible.

However, sometimes the opportunity for standardisation may be lost. If agreement cannot be achieved on a single standard, it may be possible to ensure that different standards can gracefully coexist to ensure seamless delivery of services through interworking: technology can help to deal with the complexity of multiple standards.

Training

The education and training of researchers in NEM technologies and knowledge gaining is key for the progress of NEM communities to improve the skills of researchers. Cooperation with other academic initiatives, such as the long term research Networked Media Task Force, the exchange of knowledge regarding the ongoing research with other areas in the world, and new pan-European qualifications will help the achievement of the NEM Initiative's main objectives.

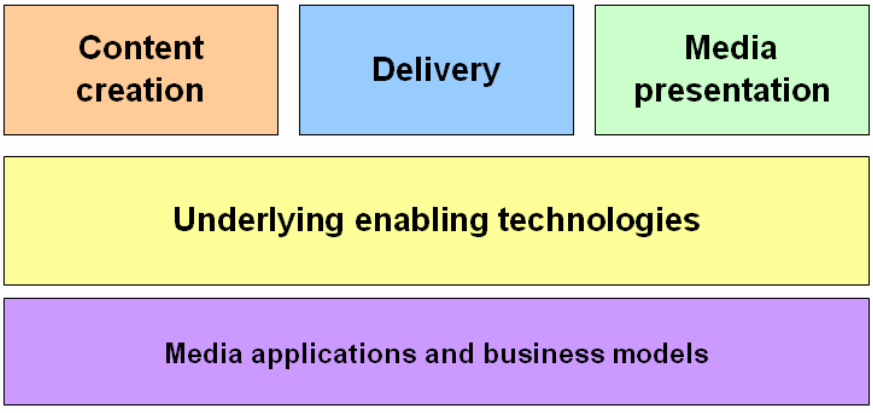
International cooperation

Many of the research challenges described in this Strategic Research Agenda can best be achieved, –and can have greater market impact – if faced from an international perspective, involving researchers from countries beyond Europe. A clear European strategy is needed. This SRA should also help other countries around the world, to define their own strategic research agendas, perhaps as a subset of or complement to the NEM SRA.

Most important research topics

This chapter gives detailed descriptions of the research aspects needed to fulfil the NEM Initiative's vision for 2015. The topics are addressed according to the following diagram.

Figure 1 - Structure of described research fields



Content creation

Work on content creation will help to ensure the availability of innovative new services. Areas of work are:

- New forms of content – to drive take-up of new services and to adapt networked media technologies to wider purposes, for example through 'serious' games.
- Representation of content – file formats for the audio, video and data that are the active constituents of services, plus the metadata that describes them and allows them to be

processed; modelling formats for avatars are included, with auralisation formats to represent realistic sound fields; video coding will be based on the objects in the scene; new tools must be developed to classify metadata;

- Tools for content creation and manipulation – including transducers for capturing content (not just audio and video, but other human senses as well); manipulation of audiovisual content must be easier than using today's word processors, and content once created must be easily and automatically adaptable to the changing circumstances of users on the move; metadata must be automatically captured;
- Automated semantic annotation – to generate metadata automatically from new or existing content using semantic techniques.
- Human language technologies – to provide language transparency to allow all citizens to become e-included in the information society.

Networking and delivery infrastructure

Work on networking and delivery infrastructure will deliver services to users wherever they are. Areas of work are:

- Intelligent delivery – to allow users to access interactive services of all kinds, regardless of the underlying network infrastructure and enabling dynamic handover of services;
- Quality of service – to guarantee quality of service appropriate to the content being carried and expressed in terms users can understand, across heterogeneous networks;
- Network architecture – to devise new network architectures appropriate to multi-provisioning of services based on wired and wireless hybrid heterogeneous networks for broadband, broadcast and mobile; they must be scalable to cope with the enormous increases in traffic that are expected;
- Home and extended home networks – to ensure that new network technologies extend into this specialised domain.

Media presentation and content access

There will be new ways of presenting services to users, and new ways for users to interact with services. Areas of work are:

- Authentic, true-to-original media reproduction – displays to offer realistic and immersive video reproduction, including energy-efficient and wearable displays, and new methods of immersive sound reproduction;
- Virtual reality – interactive technology for business applications such as remote action and entertainment applications including games;
- Dynamic federation of distributed interface devices – ad hoc federations of devices self-assemble on demand on the basis of essential components distributed in the near environment; 'mobile augmented reality' is a possible early application;
- User-system interaction – multimodal user interfaces aiming at mimicking human communication skills that use several modes of communication could offer a natural and transparent way to deal with the complexities of interaction while hiding them from the user.

Enabling technologies

A set of horizontal technologies will act as a foundation for the functionality of the entire end-to-end chain. Areas of work are:

- Security, privacy, and trust – to provide services and their content securely between all users, guaranteeing the privacy of each participant in a media transaction and securing networks against breakdown and malicious attack;
- Rights management – technology to offer appropriate and fair protection to those who wish to retain a degree of control over content they have created or acquired (including the right to remuneration) when it is distributed over heterogeneous networks;
- Federated services – services built up from multiple components from different originators; enabling such services to mobile users with different terminals will require networks and terminals to be aware of users' context, including identity management, location, and personalisation; new methods of guaranteeing and partitioning small payments will be needed;
- Middleware – to develop an open middleware framework providing a stable architecture and application programming interface (API) dedicated to multimedia for a wide variety of services and applications;
- User number measurement and behaviour logging – to allow service providers to measure audiences and how they are using the service;
- Effective recommendation systems – to help people to find content they might want to access, from the vast amount available;
- Power management and energy saving – so that networked media technology can contribute to energy saving in all sectors of the economy;
- Spectrum economy – to make best use of a limited resource.

Media-related applications and business models

If new technology is to be adopted, advances are needed in understanding applications and how they create value. Areas of work are:

Value chains – to understand how value is created, and how can it be protected;

Social networking and media sharing – to see how social networking can have a positive impact on the content industry;

User satisfaction and quality of experience – to develop methods of measuring quality of experience which could replace quality of service metrics.

Conclusions

The research and development work described in this Strategic Research Agenda can be fulfilled through the seventh Framework programme, other international programmes such as Eureka and the programmes of the Joint Technology Initiatives, and the national programmes of the Member States. Some areas will also benefit from cooperation with third countries. It will serve to fulfil the NEM Initiative's vision, achievement of which will not only maximise economic growth in Europe; it will improve the quality of life for all Europe's citizens – the users of networked electronic media services – whose importance has been stressed throughout.

1 Joint evolution of media and networks

The European Technology Platform on Networked Electronic Media, the NEM Initiative, foresees a future when all will be able to generate, manipulate, use, and enjoy any kind of electronic media content – wherever they are. Electronic media content will include not only the audiovisual services of today such as telephony and television but also a wide range of interactive services across all realms of information, education, and entertainment, offering a wide range of new business opportunities.

This future is elaborated in the NEM Initiative's Vision 2020 document, which looks forward to:

- An infrastructure of effective, ubiquitous, and seamless social networks that is people-centric. These networks are easy and efficient to use, accessible when needed, effective and trustworthy. They give people interesting and motivating immersive and sensory experiences. Voice, video and data convergence are handled in a transparent fashion and, when appropriate, in an understandable way for users. Users have access to services whenever they want, anywhere and anyhow.
- A service oriented society in which ambient and context-sensitive services are created and provided, personalised and customised to people's individual and social needs, available to communities of users and including ALL citizens.
- Open business models and revenue generating models that anticipate and exploit disruptive innovation patterns that are very flexible and derived from radically changed value chains. A loose network of niche markets – particularly those exploiting the opportunities offered by the 'long tail' of the Zipf curve – and a multitude of fast operating small enterprises governed by 'soft' regulation and general principles and by specific rights and obligations.

To make this vision a reality requires the development of a seamless, pervasive network and easy-to-use tools for generating, searching, accessing, transforming and delivering media content – the future internet in the widest sense. This Strategic Research Agenda (SRA) outlines the technical work needed to achieve the vision. It concentrates on what needs to be done rather than the form of technology required to achieve it.

The NEM Initiative follows a unique path into the future because it deals with 'content' from both the users' point of view and the technical perspective. Both views are essential if new services, with new commercial opportunities, are to work well and to be attractive to a wide range of users from different backgrounds and with different applications. For the first time, media and content will be tightly linked to the network and the infrastructure. The only interface visible to the user will be the networked media itself in such a way that technical aspects are entirely hidden from the user.

The realization of the NEM vision requires big changes in the handling of media compared to today's methods. This Strategic Research Agenda sets out the technology changes that will enable today's network infrastructures to evolve towards the vision. But research on disruptive solutions

should also be fostered: tackling old problems from an unexpected point of view has always produced the most innovative solutions which have really advanced the technology.

The NEM Initiative's Strategic Research Agenda aims to inform the workplans of the seventh Framework programme, other European programmes such as Eureka and the programmes of the Joint Technology Initiatives, and the national programmes of the Member States. The NEM Initiative hopes that its SRA will also inspire wider international collaborations.

1.1 State-of-the-art and apparent trends

First, a snapshot is presented which illustrates the currently scattered environment of mixed communication infrastructures, different service concepts, and inconsistent or incompatible media content formats.

The media industry consists of a value chain creating, storing, adapting, aggregating, delivering, and consuming 'content'. The NEM Initiative considers content to be understandable information made available to a user at any stage of the value chain. This definition of content includes both the 'essence' – the data representing text, audiovisual services, games programs etc. that is the object of the value chain – as well as the metadata that describes the essence and allows it to be searched, routed, processed, selected, and consumed. The value 'chain' is turning into a 'mesh' as consumers are increasingly becoming originators of content and stored content is increasingly reused and repurposed.

At present, much content is produced by a craft process, for broadcast services or for recorded retail distribution. Normally, the user either has to make an appointment (through a broadcast schedule) to consume content or has to buy the physical medium supporting the content, for replay on specific equipment (DVD player, portable media player etc.). Download of content over networks is making progress, but is still beset by problems of rights management, format conversion, and incompatibility of devices and software. Increasingly, short segments of content are produced or repurposed by individuals and made available via sharing websites

Broadcasting is normally over-air, using spectral bands reserved for this purpose. Broadcasting of audiovisual content over cable networks is almost ubiquitous in a few countries, but little developed in others. Distribution over telecommunications networks is developing, although telecommunications networks are still mainly used for person-to-person communication. The use of wired telecoms networks for data services to the general public is generally treated as an 'add-on', using ADSL over copper twisted pairs for the final connection to the user, though experiments are at last starting on 'fibre to the home'. Wireless telecommunications networks are almost entirely digital, with content distribution services available in some countries, although they have not yet made much impact on the overall market.

Europe is accelerating the transition from analogue broadcasting standards to new all-digital standards. Digital broadcasting offers a wider range of interactive services offering the possibility of much wider innovation in content formats. Technically, it gives better spectral efficiency, enabling broadcasters to offer a much wider choice in the same bandwidth, or to reuse spectrum by introducing new media formats such as HDTV, expanding the range of services. Broadcast services continue to be available, but using all-digital standards, with additional data services and interactivity.

Increasingly, content is becoming available on demand, both through storage in the home and on request over many different networks from content producers and aggregators as well as from

broadcasters. On-demand content comes not only from professional producers but increasingly from individual users. The industry is moving to a seamless integration of broadcast content with on-demand content chosen by the user with the help of intelligent agents using descriptive metadata distributed as part of broadcast content and via metadata aggregators. Here, we will see a close relation between the creation of content, service provision, and the capabilities emerging inside the terminals. An example, currently changing broadcast dramatically, is the personal video recorder (PVR).

Regulatory systems are changing: the internet allows content providers and consumers to interact directly on open networks and exchange platforms. Because these are 'on-demand' services, the regulatory system can allow much more freedom than is allowed for broadcasting services which, because of their ubiquity have traditionally been heavily regulated.

The centre of competition in the market is also changing. In the past, revenues have been derived mainly from provision of networks, but the competitive advantage is moving from network owners towards provision of content and value added services.

A marked trend is the explosion in social networking internet sites which combine person-to-person communication with audiovisual content. In these sites, content is becoming a form of communication in its own right, reflecting the fundamental human drive to communicate and interact – and to find and exploit new ways of doing so. It will be an important aim of future developments to make these new forms of communication more readily available to all.

Access to content is also made difficult by the difficulty of finding it – because of the tremendous amount of data online. Search engines, as a mediation unit between the users and the network(s) need to develop dramatically.

New concepts of multicast distribution are necessary to realise a mass market for IP oriented audiovisual services. For the voice and video streams it is not acceptable to need a personal computer as a receiver. Both network and service architectures have to improve further to make it possible to have terminals with reasonable cost structures.

Networked electronic media have been enabled by data compression. However, most video compression algorithms are pixel based; object recognition could revolutionise video coding. Video coding generally treats pictures as 'flat', whereas surround-sound audio coding can localise sound in three dimensions.

There is a wide variety of distinct technologies in use, each adapted for a different application. Audio CDs use different standards from digital radio and from voice telephony; present-day wireless data networks are not optimised for delivering continuous services such as video. There is little compatibility between devices, making seamless usage impossible. A games console will not receive broadcast TV, for example. There is generally no communication between applications: different devices are unaware of each other (unless they cause each other physical interference). A technology defines a service, often to the point where the name of the technology becomes the name of the service (for instance, the ubiquitous "mp3 players" although the actual audio coding format is irrelevant). This leads, by and large, to clearly separated usage scenarios: a telephone is a telephone and a radio is a radio – combining them in one handset offers nothing extra in terms of services.

A new generation of formats for representing 'reality' with increased resolution, spatial sound and even 3D, is now appearing. Those technologies will add to the already available set of services (and terminals!) available to the consumers.

For service delivery, only telephone, broadcast and mobile phone networks are close to ubiquitous. Wireless IP networks are confined to 'hot spots' in dwellings, hotels, airports etc. Each wireless

network has its own access control – and even when access is achieved there is no guarantee of compatibility at the application level.

Increasingly, networks will be used for communication between inanimate devices, such as sensors and monitoring devices – the 'internet of things' – as well as for carrying content for use by humans. This SRA deals mainly with networks for human communication, the very large numbers of inanimate devices that will be connected will have an effect on network architecture.

Apart from some well-established services like basic telephony and broadcast reception, electronic media technology is far from being easy to use. Many applications are difficult to install and configure, and often will not work at all until configured. User interfaces are counter-intuitive and clumsy, producing incomprehensible error messages without apparently being misused. This reinforces the 'digital divide' between a (usually) young technologically literate class and a (usually) older class of people who have no access to new technology, or who are afraid of technology they do not understand; these people are excluded from the benefits the technology could bring.

The digital divide is exacerbated by some market participants who use proprietary technology as a means for creating vertically integrated closed markets to lock users in. An example (though far from the only one) is rights management technology, which may be invisible to users until they find that it prevents them from enjoying content they have acquired legally, in the way they want to use it. Such technology barriers may be used in an attempt to prolong the life of a business model that would otherwise have been rendered obsolete by technological developments.

Although technology can be used to create barriers, it more often creates new opportunities, new applications, new services that can transform people's lives and create wealth for all. It is those applications of technology that the NEM Initiative would like to encourage to fulfil its vision for 2020.

1.2 The changes needed

Changing demographics, changing lifestyles, demanding, educated consumers and media-literate producer-consumers, and trends in globalization, while keeping development sustainable, are driving forces for the exploitation of technological developments. They dramatically affect the context for R&D in the networked electronic media domain. Networked devices and flexible service platforms have emerged as new R&D drivers. The media revolution is in full progress. Integrated complex systems are becoming business, social and growth enablers instead of just single technologies. This convergence and the ICT business strategies that are being developed induce more complexity at all levels in the media ecosystems.

The power of our technology users should not be underestimated. They provide the ultimate NEM challenges and induce fundamentally different views on future NEM R&D.

The NEM Initiative hopes that electronic media will appear as a ubiquitous service, easily and simply available to all users for professional and recreational purposes. Of course, this apparent simplicity may mask many layers of complexity – the point is that the user should not need to care about underlying technologies.

For this to happen, fundamental changes will have to take place in the in the course of the next ten years. These fundamental steps are analysed in the following sections individually for each affected domain.

1.2.1 Fusion of transmission technologies

The distinction between today's basic routing technologies – such as unicast, multicast and broadcast – must become invisible, not only to the user but also the media application itself. The user's needs - remembering that users may be creators, distributors and final users of content – will be the key to an automated selection, from the possible network infrastructures, of the best infrastructure to provide the service required with the terminal available to the user. This also includes the efficient and flexible hidden selection of an appropriate feedback channel if needed.

1.2.2 Media becomes *networkable*

In this process media transforms into an integral part of any kind of network rather than being understood as the transmission of a certain type of content from A to B. Somebody communicating or someone creating media content (privately or professionally) will not need to care anymore about how recipients are going to access it. The creator or the rights owner will be able to set fair usage conditions in a flexible manner, if it is necessary to do so.

1.2.3 Media becomes ubiquitous

Although professional content production will remain an important industry, the traditional distinction between the creator or producer and the end-user or consumer will change radically: content will come from any user. To take some examples from today's applications, a 'user' might be a private individual sharing photos, a recreational music producer, an originator of a semi-professional video, or a specialised branch news agency. Of course, more flexible networks will generate many new applications.

For each of these users, the only interface will be *media* itself. The entire technology behind the application is completely hidden. To make it hidden, metadata is needed to describe both the content and the application. In order to generate metadata for rich-media content, highly sophisticated and user-friendly indexing engines will be required.

1.2.4 Context-aware environment

Context-awareness allows systems to take action autonomously by using sensors that detect and respond to features of the surroundings. The ability to detect and recognize the context and determine the appropriate action requires considerable intelligence. Lurking problems that are imperative to address and to prevent are, for example, intruding into social situations at inauspicious moments and violating people's privacy. To provide such ubiquitous user services, the infrastructure will need to be able to detect and interpret user activities, and understand the meaning and context (for instance, what kind of media communication the user's application needs, what language does the user prefer to use, does the user have any disabilities?). Similarly, the user's terminal will need to be able to recognise its environment (where is it, what services are available to it?) and configure itself to adapt to its environment. Such context-awareness implies concerns over privacy: access by others to data the user considers private must be under control of the user.

1.2.5 Intuitive and multimodal human-machine interfaces

The human-machine interface is the key to inclusive use of new technology by all: it hides complexity from the user. Intuitive and multi-modal new generation interfaces will offer a more natural way to interact with and within media environments. Such interfaces might use avatars, and could include, for instance:

- Voice control;
- Pointing gestures;
- Control by eye movements (e.g. for handicapped people);
- Smell;
- Human type of interactions (virtual hands, arms, etc.).

1.2.6 Switch mindset from technical terms to media terms

To make networked media communication inclusively available to all, terminology will also have to change from being technology oriented ('FM', 'MP3', 'DVB' etc.) to being application oriented: using or consuming any kind of media should be known by its content and not by the technology used. Even formerly obvious terms like 'TV' will be inappropriate when sharp limits between watching a live TV programme and a video stream on the internet have disappeared.

1.2.7 Affective media retrieval

People consume media primarily to get emotional needs satisfied, not just to get information. Nowadays 'channels' may represent linear programme sequences and 'brands' may represent a certain media offering, from which the consumer can choose. In the future there may be genre-based playlists representing moods and degrees of user involvement, such as:

- Entertain - lean back, e.g. game shows;
- Entertain – lean forward, e.g. gaming;
- Inform – lean back (e.g. news programme);
- Inform – lean forward (interactive services).

These playlists may reference both 'push' (pre-scheduled) and 'pull' (on-demand) content.

The means and mechanisms by which content is marked up by what could be described as emotional metadata and often generated by users (how did this content make me *feel*) will need investigation. Some metadata will be derivable from the media itself, some may be explicitly added, and other metadata my come from peer and community sources ('When I watched this I felt ….'). How we can categorise this information and create taxonomies to make it relevant is another question that will have to be answered.

1.2.8 Creation of media communities

Although boundaries between formerly distinguishable forms of media consumption and content provision are dissolving, users still want to experience collective events – scheduled events such as the broadcast of a specific TV programme or real events such as a football match or a state occasion. Talking about the same programme people have seen on TV the night before is an important part of the spirit of togetherness amongst peers.

Networked electronic media will continue to offer this kind of shared experience to existing groups such as the nation, the workplace, the club, the village, or the family. It will enhance the experience by making it independent of physical presence: no longer will a business trip be a reason for failing to contribute to the school parents' evening or a local concert!

Networked media will also allow new groups to form, defined by their media interests. They will be able to create their own scheduled events – created by an individual member of the group, or collaboratively – and to interact as a group to participate in them and to discuss them, wherever the members are. In such groups, interaction and communication generally will melt together as an integral part of media.

Community building makes novel services more attractive. Hence novel services may become more valuable in a world where delivery systems compete both for content and for users' attention.

1.2.9 Networked media contribution to sustainable development

Globalisation requires more and more communication between people, over longer distances. New telepresence technologies based on faster networks, better video compression algorithms, more realistic and immersive viewing experience, are needed to answer to those requirements at lower cost, avoiding physical transportation and thereby reducing energy consumption.

1.2.10 Multi-modal models to describe our environments

In the audio world, spatial representation has been integrated for many years – first with stereo, then with surround-sound. Most other media components lack such realistic rendering: at present: video is just a series of two-dimensional pictures reproduced on a flat surface. To offer exciting new creative possibilities, video must be represented in a much more human way, by realistically modelling entire media environments on an object-by-object basis. This will allow multi-modal and three-dimensional presentations of media content that the user can step or almost "dive" into. It will be possible to 'capture' entire objects for re-use in new applications.

1.2.11 Seamless and intuitive service handover between devices and environments

Users should be able to access services wherever they are, whatever terminal they are using, with seamless handover as they change from one terminal to another. Users cannot expect the same experience, for example, from viewing a football match on a handheld screen as on a fixed HD display, but they should be able to access the service. This will require appropriate coding of

content, perhaps hierarchically, so that it can be reproduced appropriately on a wide range of devices, allowing the content creator to offer the same content to a wide range of terminal equipment without further adaptation. Terminals will need middleware – the software that turns a terminal into a platform that can support multiple applications – that can extract the appropriate elements of the signal.

1.2.12 'Federated' services

Seamless handover between devices and environments will allow users to move around, maintaining sessions across devices and networks, from a fixed terminal at home to a handheld to a terminal in a train, for instance. It will also allow service operators to offer complex services built up from multiple elements from different originators, offering valuable commercial opportunities for service differentiation.

1.2.13 Trust and privacy

If new networks and services are to be used, they must engage users' trust. And they must - to the extent allowed by law – protect users' privacy. Sensitive details that affect the user's rights must always be handled in a clearly understandable way to create a broad viable trust environment.

1.2.14 Rights management

European and national law recognises the right of content creators to be identified, and to have fair control over the re-use of the content they have created. And some business models require that the delivery chain include rights management technology to enforce these rights to ensure payment for services provided. Such technology is often given the abbreviation DRM (for digital rights management – although 'DRM' is actually registered by the Digital Radio Mondiale consortium.

There are alternatives to managing rights through technical means. Levies, taxes, or fees can be imposed; and content can be marked by technologies such as watermarking so that ownership can be established and appropriate payment can be enforced by judicial process. However, such actions are effective only at national level; in a global market they are more difficult to implement than rights management technologies. Levies are unpopular, and attempts at usage restriction have generally failed. A new approach is needed that guarantees fair remuneration for rights holders and protects the rights and privacy of consumer. New services will be needed for interoperable content identification and authentication. Where technologies for rights management are used, they should be considered as a business tool enabling any user to flexibly provide and market content while retaining influence on possible future use of the content. Rights management systems for the future should permit rights holders and content owners to exchange audio-visual material (whether for financial reward or not) with associated rights documentation. Such systems will have to interact with electronic commerce systems for controlling payment schemes and royalty chains.

In this view, rights management can be seen as an aspect of media communication like any other, and thus subject to all the requirements discussed above: technologies for the future must be ubiquitous, and interoperable across different vendors, networks, and systems, so as not to create unreasonable barriers to use of content. For the consumer, rights management technologies should not unreasonably prevent access to content. And when users do not have the right to access a piece of content, they should be informed why the content is unavailable and what they can do to gain access.

In addition, rights management technologies for the future must be trusted by all participants in the value chain, from content originators to consumers. To gain that trust, technologies must address,

in a way that is fair to all, the rights issues involved when handling audio-visual material in networked and electronic media.

2 Market perspectives

More detail is given on the relevant research issues in Chapter 3. Before addressing these technological aspects, the SRA touches on market issues, as technology is always a means to create and shape markets and the described scenario will influence the business world. At the same time, the business world, and the markets it creates, must enable the deployment of new technologies to promote new product concepts. At the core are the users – who are willing to pay only if they see a clear and understandable advantage.

2.1 Business impact

Some of the technology changes needed to bring about the NEM vision will bring fundamental changes to business models, offering new business opportunities. Other changes may lie within existing business models and enter the market just because there is a substantial benefit for consumers.

2.1.1 Example applications

- There is a vast market for specialised services revealed by the phenomenon of the 'Zipf tail' – there is a very large number of customers who want to access (different) items of content that would appeal to only a few people. This market can be served economically only by a pervasive broadband infrastructure;
- A reliable universal rights management system could hugely increase the value of audiovisual archives; it could stimulate new applications using archive material.
- Advertising that is targeted and more naturally integrated, and thus more acceptable to the consumer. When media scenes are object-based, specific elements can be modified or replaced on a user-by-user basis. If the infrastructure can recognise users, to know their individual needs, then consumers can be addressed with advertising for products they are likely to need.

2.2 Further socio-cultural impact

The NEM Initiative's members are mainly from the wide business segment of the content production and distribution industries – network operators, games producers, broadcasters, and equipment manufacturers. Therefore this Strategic Research Agenda is written mainly in terms of those industries' products. However, the NEM Initiative is well aware that the realisation of its vision will have profound effects on other aspects of industry and society.

In particular, electronically delivered services (eServices – social networks, e-Government, e-Health, e-Inclusion, e-Tourism, e-Finance, e-Transport, e-Education, e-Energy management, e-Entertainment, e-Banking, e-Commerce…) will have a great impact on society, as will the opportunities for communication between inanimate objects offered by the 'internet of things'. Ubiquitous media access that has intelligence built in so as to be readily usable to all can, for example:

- Facilitate business (and social) interactions and potentially can be used as a tool to reduce physical travel whilst increasing collaboration and redefining communities across geographical boundaries;
- Close the 'digital divide' between those who are at ease with new technology and those who have no access or fear it;
- Revolutionise healthcare with remote diagnostics;
- Bring real inclusion to the elderly and handicapped;
- Enable a wide range of e-government services;
- Offer European citizens real participation: the mass media, which have a critical role in democracies, must make good use of new technology to maintain their level of social influence and relevance.

2.3 Regulation aspects

2.3.1 The role of the NEM Initiative

Because of their large perceived influence and their important role in democracy, the media industries have always been carefully regulated. The content delivery industries (telecoms and broadcasting) have been 'deregulated' over the last few years, turning them from being seen as historical monopolies towards an open and competitive framework. However, these deregulated markets seem to need adapted regulation to keep them working as intended. The regulatory regimes applied to the content industries such as broadcasting and to the delivery industries such as telecoms are inevitably different in kind

Regulation and technological research and development need to keep in close touch. Over-regulation may limit the opportunities for exploiting the benefits of new technologies; and technological development can find ways of circumventing existing regulation, or may require new forms of regulation. In order to accommodate technological and market developments, and new customer usages resulting from convergence, modernised and flexible regulation covering all media services is required.

Different regulatory regimes at the national level cause problems. The market for networked media is a global one, yet there is no enforceable global regulation. This limits the free movement of networked media and also presents security challenges: the global market is open to threats like 'spam' and denial-of-service attacks, as international broadcasting has always been open to jamming.

Regulation is essentially a political process, since for its success it requires the consent of those regulated. However, regulation does raise technical questions as well as political ones, for example:

- Will a regulatory proposal still be realistic when viewed against the technological progress that is likely by the time it is implemented?
- Is a new technology likely to come to commercial maturity in a given time-frame?

So Technology Platforms like the NEM Initiative may be able to provide recommendations to plan and arrange better regulation. It may be on specific technical aspects of regulation that a Technology Platform can best advise the regulators. The NEM Initiative will continue to discuss how it can best contribute to regulatory matters and, where possible, it will offer views and recommendations for better regulation.

2.3.2 The opportunities for standardisation

Successful European standards like GSM and DVB show how powerful a single standard can be. The NEM Initiative encourages standardisation, and prefers open standards where possible.[1]

What are the conditions for successful standardisation of a new technology? In the early stages of development, the technology itself, and its commercial possibilities, are not well enough understood for standardisation to have a high chance of success. Standardisation discussions are worthwhile to clarify the directions for future research, but generally this is the 'Too early' phase.

Another phase is reached when commercial services start. At this stage, organisations have made significant investments in the market, and will need to protect those investments: they will strongly oppose the imposition of any standard other than the one they are using. This is the 'Too late' phase for standardisation.

With luck, the 'Too early' phase will end, with the technology and its capabilities reasonably well understood, before commercial services start. This leaves a 'window' during which attempts at standardisation may well be successful. Organisations announcing that they intend to start services in a given time frame give a useful impetus to the process.

But it can happen that the 'Too late' phase of commercial services starts before the 'Too early' phase has ended. Services may start in one country for particular commercial reasons, or to serve a niche market – for which the fact that the technology is not fully understood may not be so significant. When that happens, the opportunity for standardisation may have been lost: competition law makes it difficult to impose standards by regulation, and the market may take so long to decide between competing standards that the commercial opportunity of the new technology is lost.

Adoption of standards should not be uniquely determined by adoption in the private sector alone: it can be supported through implementation by the public sector through the provision of badly needed common services. This may be achieved through collaboration between the public and private sectors.

2.3.3 Interworking: a necessary complement to standardisation

If agreement cannot be achieved on a single standard, it may be possible to ensure that different standards can gracefully coexist to ensure seamless delivery of services through interworking.

[1] It is important to note that in some contexts 'open' implies a standard accessible to all but with conditions (which may include royalties) on its application. In other contexts, 'open' implies 'open source', with or without conditions of usage attached, or even freely usable in all applications. However, no standard can be considered 'open' unless any associated intellectual property and its conditions of use are equally accessible to all.

This approach is certainly more complex, since terminals may have to be designed to deal with several different standards. However, technology can help to deal with complexity. The increase in processing power and the fall in the cost of storage through the seemingly inexorable application of Moore's Law can make it perfectly practical to design multi-standard terminals at little extra cost, and sophisticated software can hide the complexity from the user.

Interworking may have to be enforced by regulation, to ensure that all technologies have an equal chance. Regulation may also be needed to impose fair and reasonable terms on owners of patents and other intellectual property rights, if their demands for royalties threaten fair competition.

2.4 Training

The education and training of researchers in NEM technologies and knowledge gaining is key for the progress of NEM communities to improve the skills of researchers, workers and managers thus enhancing the NEM-related technology created. For this reason the cooperation with other academic initiatives, such as the long term research Networked Media Task Force supported by the European Commission, and the exchange of knowledge regarding the ongoing research with other areas in the world, will help the achievement of the NEM Initiative's main objectives.

Cooperation of industry and academia will be able to devise and promote new pan-European qualifications, from higher degree level down to operational training.

2.5 International cooperation

Many of the research challenges described in this Strategic Research Agenda can best be achieved – and can have greater market impact – if faced from an international perspective, involving researchers from countries beyond Europe. A clear European strategy for international cooperation in the area of networked electronic media is needed.

The first step should be to achieve the highest cooperation at the European level (Framework Programme, Eureka/Celtic, Eureka/Eurostar), in all the regions including coordination with national initiatives. This overall goal has three main objectives:

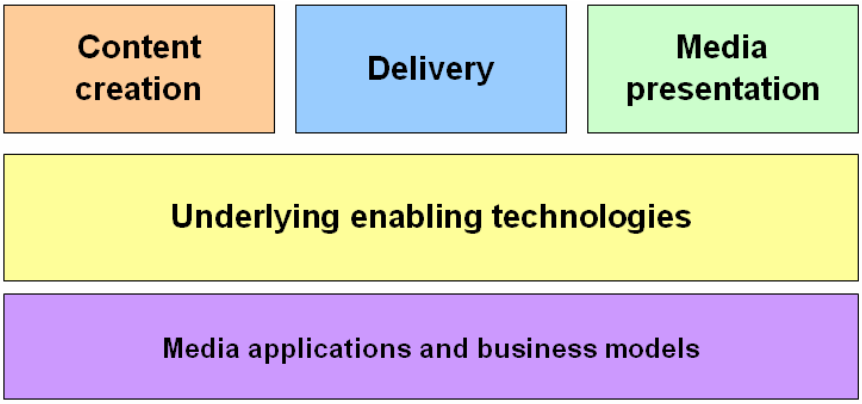
- To identify consistent strategic objectives at European level;
- To harmonize national programmes aiding R&D efforts, and make them more efficient by exploiting synergies;.
- To extend this European cooperation to the worldwide level, aiming at enlarging the markets where R&D results could be exploited.

One aim of the NEM Initiative's SRA is to help other countries around the world, to define their own strategic research agendas, perhaps as a subset of or a complement to the NEM SRA. The NEM Initiative has set up a GlobalNEM Activity as a channel to identify requirements from third countries.

3 Most important research topics

This chapter gives descriptions of the research aspects needed to fulfil the NEM Initiative's vision for 2015. The topics are addressed according to the following diagram.

Figure 2 - Structure of described research fields



3.1 Content creation

'Content' was defined above as 'understandable information made available to a user at any stage of the value chain', including both the 'essence' – the data representing text, audiovisual services, games programs etc. that is the object of the value chain – as well as the metadata that describes the essence and allows it to be searched, routed, processed, selected, and consumed. The NEM Initiative's understanding of 'content' thus goes well beyond the products of the traditional media industries such as broadcasting and computer games. The information exchanged between inanimate devices in the 'internet of things' might be considered to fit this definition, if the devices are thought of as 'users'; however, this section concentrates on content creation for human users.

Content may also be considered as intellectual property of different forms such as 'original work' or 'adaptation'. The intellectual property status of the content must be clearly accessible to users as it is captured, manipulated, and delivered if disputes and conflicts are to be avoided.

Until recently, content creation was the preserve of professionals, and was very much a craft process. In future, content will be much more widely produced, and the production industry will have to evolve to reflect this change.

3.1.1 New forms of content

Recent experience has shown that take-up of new digital platforms is strongly driven by the availability of new services. Users will not buy into a new platform just because it is new or digital. A key objective of technological development should be to make possible new forms of content that will help to drive take-up; and the new forms of content will shape and orient the technological development. Only by producing strong content is it possible to sell strong technology.

A worthwhile area for development of new forms of content is 'serious' computer games. Computer game technologies are primarily developed for entertainment purposes; however in principle there is no limit to the field of application for those technologies. Computer games that are not developed for entertainment purposes using specific computer game technologies are

called serious games. They are not really more serious than entertainment games: they are merely developed for a non-entertainment purpose.

The term 'serious games' was coined to show the utility of games for other purposes, as different as recruiting tools and real time simulation in health care technology The underlying technology is in general the same; there is very rarely something like a specific serious game technology. From the content creators' point of view this additional market is different from the hit-driven mass consumer market and can be an element of stability. However, they will always be a peripheral approach – the core technology is and will be developed for mass-market-driven entertainment and cultural products.

R&D in new forms of content needs to reflect the necessary interplay between technology and creative content production, including synergies between different delivery platforms, and synergies between media forms such as interactive and linear content. To enable this process:

- R&D work plans must include creativity in the ideas behind audiovisual content (sometimes called programme or game formats);
- Cross-disciplinary, practice-based research involving real production teams and real audiences must be encouraged; creative talent must be brought to the NEM arena;
- 'Serious' games need to be taken seriously as tools for education and healthcare;
- Proposal evaluation guidelines must ensure that evolving new forms of content is equally rewarded with technological creativity;
- Widespread demonstration is needed to show the people who originate compelling and successful audiovisual content – not just script writers, producers, journalists, graphical designers, but also managers in the whole audiovisual media industry – the importance of embracing new media.
- With a potentially significant increase in new formats, more clarity will be needed around the protection of intellectual property relating to these programme formats, and how (and if) copyright rules can be applied.

3.1.2 Representation of content

Content consists of dynamic or static data, the components used to render these data, the interactions between the components, and the mechanisms to adapt the rendering of the content across various networks, devices and user contexts. All these components can be represented in a file format for content including video, audio, data (such as subtitles), and metadata (note that this content file 'format' is quite different from the programme format referred to above, and from the line/frame format of the video, which will be described by metadata).

Content will normally be compressed for storage and transmission. In the area of compression coding theoretical limits (rate-distortion boundaries) have been approached well, for video by H.264 in its various forms including scalable coding, for audio by AAC and its derivatives for high efficiency and low delay, and for metadata by BiM coding. These can still be improved, but major breakthroughs can only be expected if the content representation drastically changes.

The NEM Initiative would like to see a content format relying on open (and, if possible, open-source) standards that are widely used and shared between large communities of the whole content publication chain. The format should allow dynamic adaptation and scalability through a multi publishing platform and should be common to the widest range of public and professional production tools. Standards must be interoperable, for instance by standard software plug-ins. The aim is that manipulating multimedia content should be as simple as – or if possible, simpler than – editing text with a word processor.

A new content format should be based on the following principles:

- It must allow content to be rendered in different ways appropriate to different terminals – from HD displays to handheld screens, or from multi-speaker setups to a single earpiece. This could be done hierarchically. In the context of MPEG-2, hierarchical coding was shown to be less efficient than simulcasting for distributing content in different resolutions; however, this conclusion might not apply to other compression algorithms.
- It should be a new generation open format to replace or subsume all the current formats, and able to manage synchronised contents such as audiovisual streams, whether the publication chain is based on a rich client or on a thin client.
- It should embed as much of the semantics of the content as possible and be human readable, following the approach that was a key to the success of XML and HTML.
- It should use more efficient compression techniques: 3D video, fully defined sound-wave-fields, augmented reality or – even more radical – reality augmented modelling (where the scene is described by 3D models and accompanied by the difference data between the scene and the reality) are areas where changes in content representation can lead to major changes in coding efficiency.
- The open-source approach should be encouraged because it is more flexible, but it needs a new business model. Open-source standards must be maintained and improved continuously just as proprietary ones must be.

Modelling formats

More and more, in production of linear video content – as well as in producing interactive content such as games – reality will be augmented, refined or even substituted by synthetic models. Some video coding standards already incorporate elements from real and virtual worlds. VRML elements or animated human characters are examples. While AR (augmented reality) describes the augmentation of real scenes by synthetic data, a more radical approach augments synthetic models by reality.

Multi-view video is a key technology that will serve a wide variety of applications, including free-viewpoint and 3D video applications for the home entertainment and surveillance business fields. Multi-view video coding and transmission systems will probably form the basis for next generation of TV broadcasting applications and facilities. Multi-view video will greatly improve the efficiency of current video coding solutions performing simulcast of independent views. HDTV multi-view video will probably reshape consumer behaviour significantly.

Believable virtual characters or avatars are key elements of future virtual reality, telepresence, and Interpersonal applications. They can be used as assistants or companions, with dialogue and non-verbal behaviour capabilities; they can be used to represent humans for inter-personal, collaborative applications (from professional applications to games). In any case they must convey information and be believable in the human-machine multimodal interaction and in their relation

with other virtual characters. Their use in interactive networked environments will increase, and a trade-off must be found between quality of animation and real-time interaction.

Some interactive avatars exist; but they lack realism and credibility in co-articulation and gestures when they have to be rendered in real time, as is necessary for interaction with humans. We need to go further in believable, expressive rendering, better co-articulation rendering and synchronization of audio and body language to make avatars acceptable in multicultural contexts. "Intelligent", context-aware and semantic-based control of avatars needs more investigation. Scalable rendering depending on the context (human interaction, network, display), including mobile and immersive display (holographic display) should also be addressed. A standardised control language for avatar characters should be developed.

Content formats must include sound. Auralisation is the realistic creation and rendering of a 3D sound scene: sound source position, orientation and size, reverberation, occlusion, obstruction over different means of reproduction such as stereo headphones or a loudspeaker setup. Auralisation technologies will be more and more used in games. The game market will help auralisation to enter the multimedia content market (music, video, TV, and rich media contents). Specific authoring tools and players will be developed for the multimedia content market.

In summary, the main topics for research are:

- Multi-view 3-D video modelling formats;
- Believable avatars capable of real-time interaction with humans, with a standardised control language;
- Auralisation technologies to create sounds that are indistinguishable from real sounds coming from real objects from a precise position in space.

Scene-based content description

A scene is a combination of different audio and video objects – or a composition of scenes itself. The scene can be described by describing the most important elements of it and how they should be rendered to generate the presentation. This description is then independent of any specific output device that might be used to reproduce the scene, and of any scenario for using it. The content creator or assembler can prioritise specific elements (objects or scenes) and can thereby influence the rendering process. Simple alternative elements, objects and scenes can be provided that can replace more complex low-priority content if necessary.

When the scene is to be reproduced, the reproducing terminal interprets the scene description for rendering, depending on the terminal capabilities, location and user preferences.

The challenges are:

- To find the balance between device interpretation tactics and customised content creator specifications or concepts;
- How to prioritise the rendering;
- How to render less important parts.

Metadata (including indexing and search engines for rich-media content)

Metadata (data about data) can be classified as ‘descriptive metadata’, describing the structure and meaning of the different components of audiovisual content, ‘functional metadata’, specifying, at a high level of abstraction, the processing operations that can be performed on the content depending on system conditions, and ‘semantic metadata’ providing descriptions that can be understood and processed not only by human users, but also by machines.

Among the different possible types of metadata, 'profiles' and 'policies' are considered of increasing interest and are already widely exploited in open and dynamic distributed systems. Profiles represent characteristics, capabilities, and requirements of users, devices, and service components. Policies express the choices ruling system behaviour, in terms of the operations that can be performed upon service components. Policy metadata enables the flexible management of complex systems: policies can dynamically regulate the behaviour of system components without changing application or system code, and without requiring the explicit cooperation of the components being governed. By changing policies, a system can be continuously adjusted to accommodate variations in externally imposed constraints and environmental conditions. Policies are maintained completely separated from system implementation details and are expressed at a high level of abstraction to simplify specification by system administrators, service managers, and even final users. Application of policy metadata will allow context-aware applications – applications that are able to adapt their behaviour to changing situational conditions.

There are many different metadata standards (or metadata models), such as Dublin Core, MPEG-7, LOM (Learning Object Metadata), OWL (Ontology Web Language); these standards are specialised in different knowledge areas, but it is difficult to match meanings of metadata expressed in different standards in a general search process.

Important areas for research are:

- Collaborative definition of ontology for audiovisual content to add more semantics and enrich the description of audiovisual content;
- Automatic generation of metadata; this is much easier to do when the content is being created, but automatic or machine-assisted generation of metadata from existing content would enormously enhance the value of archives;
- Harmonisation and integration of different metadata models, to facilitate translation and interoperability between different metadata standards;
- Metadata for rights representation and content identification;
- Collaborative generation of metadata, where users are invited to contribute semantic metadata by 'tagging' content;
- Semantic search of audiovisual content;
- Realisation of useful context-aware services.

3.1.3 Tools for content creation and manipulation

Content capture

Transducers for capturing content include sensors and actuators for human senses: audio, video, taste, smell, touch, and for other parameters (temperature, position, motion, force …). Today the only transducers that can be considered relatively mature and massively deployed are the audio and video ones together with certain very specialised applications – keyboards, mouse, joystick. Metadata parameters such as time and position can be captured through satellite services such as GPS.

The main objectives are:

- Significantly enlarge the set of human parameters and "senses" that can be detected, digitally manipulated and rendered by consumer transducers;

- Evolve transducers and device/resource management architectures to support the evolution from mono-device (few senses) service experience to a rich multimedia experience achieved by coordination of multiple transducers.

Content manipulation

A new generation of authoring tools is needed, taking into account the increasing relevance of user-generated and community-generated content. The production of interactive content will become the most important element of content production. Content produced by organizations for public consumption will ask for contributions from individuals; and individuals will wish to personalise and adapt content produced by others and to make it available to third parties. This includes metadata creation and adaptation for the interactive content, by means of both automated and collaborative methods: content becomes useless without metadata. Collaborative tools for metadata production, in particular for video (social segmentation and tagging of video material) is necessary.

The main requirement is the realisation of more economical and more easily usable tools for content production. One example emerges in the gaming industry, where there are barriers to market entry similar to those of early film or television. The costs of creating new products and prototypes are much higher than in other media sectors. It is therefore crucial that content developers have better access to technology that enables them to create content and implicitly opens the way to distribution channels.

Next- generation game consoles and PCs are going to be even more massively-parallel and have many more cores. The game industry is currently struggling to maximise the power of six cores on current machines. Will another paradigm be required when we have 32, 64 or 128 cores? Massively parallel algorithms will be needed and small-memory or small-data-set algorithms. It is important that they can do everything in real-time so that, for example, occlusions can be rendered naturally.

Procedural content creation is the creation of content via a process or algorithm. Examples are the generation of texture, or the pseudorandom variation of an element to create a population. The creation of automated tools for the development of specific content elements is a high priority for game developers in Europe. Automated processes allow cost-cutting business strategies - especially in an environment where the demand for content creation rises considerably and the personnel costs are higher than in other parts of the world. Procedural authoring tools for generation of content are key to 3D asset production of tomorrow's games. Their flexibility and adaptability to the environment make them the perfect candidate for the different playing platforms and the challenges game developers are facing for massive world creation. Their very thin storage footprint makes them ideal for new world of digital distribution and user-generated content.

Auralisation authoring tools already exist for game developers but they are still far from having the maturity of graphic authoring tools. For music, video, TV or rich media content there are hardly any authoring tools using auralisation features.

In the future, home / personal content production will play an important role on the market – and will be important as a means for citizens to make their views available as freely as organisations do now. The focus will be on making the residential user a major player in content production, thus

enabling a potential growth in content market together with European society cultural enrichment. The usage context needs to be taken into account: TV scripts and their guides of style, for example, will not be the same for traditional TV as for video content products shaped for 3G phones. Crucial topics to be covered are the following:

- Content manipulation tools running on domestic equipments that can easily support the capturing and assembling of content relating to family life and specific genres such as sports, culture, entertainment;
- Procedural authoring tools for creating effects such as such as texturing, animation, sound, terrain, cities;
- Auralisation tools adapted to the type of content to be created (game, music, video, TV, rich media, etc.) and that allow content creators to produce content that takes into account the features provided by auralisation technologies (interactivity, realism, immersion, customization, adaptation to the terminal).
- Publication and delivery systems with a suitable mix of centralised and de-centralised topologies, dynamically adapting according to the size of content audience;
- A whole new set of context-aware metadata must be developed for interactive content;
- Metadata must include intellectual property entities such as 'original work', 'adaptation' and make clear the intellectual property status of the content;
- Above all, such tools must be intuitively usable - this will require trials with wide user groups in several stages to refine tool requirements and measure the benefits;
- Content production tools should include monetization solutions – simple and reliable means for content producers (including individuals) to sell their own content.

Content adaptation

Content adaptation is the ability to tailor content to the current circumstances of the user. The adaptation required is determined by the capabilities of the terminal(s) and equipment available at the user's current location, the capabilities (such as bandwidth) of the communication networks at the user's disposal, and the physical circumstances of the user - who may, for instance, be visually impaired. Such adaptation must be transparent to end users, so that they do not need to know all the technical parameters that may be of influence. Content adaptation is related to content personalization, which is concerned with tailoring content semantically to the user's requirements.

Several different forms of content adaptation may be identified:

- Selection of the most appropriate content version among a set of statically pre-prepared versions;
- Scalable formats, where higher quality or more complete versions are built up by adding to lower quality versions and the components relating to the appropriate quality level can be selected;
- On-the-fly production of new content versions (dynamic downscaling, format transcoding, merging of different media channels, …);
- Dynamic binding to the resources and service components that best fit the currently applicable context;
- Content management function able to support changes in the user's context such as automatic suspension and service recovery.

All of these require appropriate context-sensitive metadata as part of the content being delivered. The research needed is in the generation and application of this metadata.

3.1.4 Automated semantic annotation

This topic is concerned with automatic generation of metadata. Simple descriptive metadata such as time and place, camera and microphone settings can in principle be captured when content is produced. Semantic metadata can be entered by the producer, perhaps prompted by the capturing device. However, vast amounts of content already exist in archives for which no metadata is available beyond, perhaps, a pencilled note on a can of film. Without metadata this content is almost valueless. Can semantic metadata be generated from the content itself?

The main aim is to develop advanced automatic analysis and recognition tools and systems for audiovisual content capable of generating highly semantic metadata in a very fast and reliable way. Only a few indexing techniques can be considered as mature and effectively deployed: audio and video segmentation, image and music identification, detection of recurrent shots (e.g. newscaster) and speech-to-text transcription in very favourable conditions. Currently the analysis consists of the automatic determination of a set of low-level parameters forming feature vectors that are subsequently classified into meaningful categories. All other recognition techniques must progress a lot in order to achieve the minimum level allowing their use in operational services.

For almost all recognition techniques (vocal, person, object, event), stress must be put on relative independence of content type and recording/capturing conditions, essential for reliable and effective use. Knowledge-assisted complex scene understanding is an ambitious but natural goal for more advanced functionalities. One-pass recognition of multiple entities is also a fundamental topic to address to maintain acceptable processing complexity.

Within object recognition there are two basic levels. The first is physical recognition that separates objects to allow object based coding, improvement of coding efficiency (by applying parameter models to the moving objects) and for adapting the focal point (e.g. in foreground/background separation). The second, more demanding, level is the semantic object recognition that not only extracts an object but also deduces its meaning (e.g. the 'Renault of Fernando Alonso' or 'the British Prime Minister'). Object recognition can be supported by fusion of data from several sources (video, audio, pre-existing metadata).

Semantic techniques have recently started to be applied within multi-agent systems to provide software agents with reasoning capabilities that allow them to exhibit intelligent behaviours, especially when involved in mutual interactions. In fact, semantic languages make it possible to assign to a generic resource a well-defined meaning, expressible in a format that can be acquired and subsequently processed by a machine, possibly to draw new conclusions from the existing facts. To support such machine-understandable modelling of semantics, ontologies – explicit conceptualizations of a knowledge domain – and automated reasoning tools are used.

Once objects are extracted, coding can be adapted and semantic information can be generated. Automated indexing, multimodal fusion (e.g. overlaying a politician's speech with its original script) and object-based data retrieval/search engines are typical examples.

For restricted application scenarios (monitoring, political talks/Parliament debates) demonstrators have been built that show the viability of object recognition and data fusion. The integration into an overall framework for automated parameter and metadata extraction, however, is missing.

The most promising topics for further research are

- 3D-object recognition on a physical level (extracting the object itself and applying a complex motion parameter model);
- 3D-object recognition on a semantic level (identifying the object);
- Definition of ontologies for restricted application scenarios;
- Automated indexing;
- Data fusion (video, data services, audio, metadata). Early, late and recursive fusion must be elaborated.

The semantic level of object recognition is a field that needs a variety of technologies that are only implementable in collaborative RTD efforts. Ontologies that bring together the physical parameters of objects with potential semantics (at least in restricted application scenarios) form the baseline. Object databases (e.g. all national politicians in a database supporting indexing and fusion for debates in a legislature) have to be generated and standardised query and modelling languages have to be developed.

An extension of semantic annotation is content summarising: generating a condensed version of a given audio-visual document, programme or full channel broadcasting providing an overview of the most relevant information or events of interest present in the content. Summarization possibilities strongly depend on the nature of the content itself: news, sport, musical programmes, etc. Moreover it is important to consider the interaction between humans and machines in order to ensure correct perception of the summarised content. Technologies capable of generating adaptive summaries will enable video summary distribution in diverse contexts: fixed & mobile TV and VoD, video conferencing, video surveillance.

3.1.5 Human language technologies

With the rapid advances in the information society, language transparency is becoming vital. Human language technology provides the most elegant way to seamlessly overcome language barriers.

For all citizens to become e-included in the information society, the products and services of that society must be accessible in their languages. Language transparency, in which products and services are offered cross-lingual and in a localised manner, is one of the major prerequisites for the successful establishment of a common European market for content and services; the final goal is to smooth communication across languages, just as EU has made it easier to move across borders.

The extent to which the languages spoken in Europe have been researched systematically varies widely from language to language, with a minority (such as English, French and German) being well investigated within dedicated EU and national programmes and some of them hardly being addressed at all.

If we want the contents and products to reach a broad variety of potential users, high-quality human language technology resources and products need to be developed for the less researched language groups, including:

- Affective or 'emotion-oriented' user interfaces;

- Work towards user- and application- and environment- independence of human language technologies;
- Develop missing language resources for less investigated EU languages;
- Improve machine translation techniques for rapid content localisation and develop machine translation techniques for a large number of EU language pairs;
- Systems and applications with natural and easy-to-use man-machine interfaces, able to register, model and influence human emotional and emotion-related states and processes - 'emotion-oriented systems';
- Search for alternatives to current data-driven speech technology approaches in order to improve speech recognition performance.

3.2 Networking and delivery infrastructure

Networks underlie all the services and applications described in this Strategic Research Agenda. But in normal operating conditions the user should not have to configure the network to suit an application; the operation of the network should be invisible to the user. To achieve that goal, current network technologies need much improvement. The size and complexity of the internet is growing very fast, both in terms of volume of traffic and the numbers of users (not only human users but also inanimate devices). Human users increasingly demand services that are real-time, simple, secure and personalised. Accommodating these requirements presents the main challenge for the future internet.

Specific trends that will govern the development of networks include the following:

- **Nomadic access becomes the norm:** Users are increasingly mobile and require wire-free and nomadic access via a growing number of diversified communications devices and appliances. Moreover, they demand services in ever-changing personal contexts, often on impulse. Users are able to discover and select services and deliver them easily to the most applicable device connected to any access network.
- **From ad-hoc usage to an always-on experience:** The user is active on the internet with multiple devices and appliances at any given point. Each device may have specific capabilities, which may overlap. The system is scalable, making it possible to extend the number and type of connected users, federated services and networks without interrupting the correct operation of the platform.
- **From static information access to dynamic and time-critical services:** Current caching and search mechanisms are aimed at static information access. They do nothing to facilitate the growing number of real-time internet services – such as audiovisual services, messaging, communities, and gaming. This poses a threat to the effectiveness and accessibility of the internet. Future networks must deliver services with *predictable end-to-end quality of service*, regardless of the access technology or device utilised by the end-user. Novel mechanisms are needed to cope with traffic growth while ensuring quality of service levels and accurate service discovery.

- **From free-of-charge access to value-based transactions:** More and more collaborative services emerge; the distinction between producers and consumers becomes blurred and the distinction between 'business' and 'domestic' customers disappears. There is an increased demand for specialised business, legal, financial and fiscal models, applicable frameworks and infrastructure to help individuals and small enterprises create collaborative Internet services. *New collaborative business models* emerge and boost service convergence.**Security and trust:** The establishment of trust is essential for future success. Users must have the confidence that all their online communications and transactions are safe, and will want to navigate the internet via multiple certifiable identities. End users must be able to initiate end-to-end secure communication channels, combining authentication and encryption, independently of the initiating device (secure associations shall be independent of the device identifier. To ensure integrity and confidentiality of the transactions and exchanges over these channels, application-specific and device-independent security mechanisms may be required.
- **Simplification of the user interface:** The user expects the service to provide an intuitive, easy-to-access and easy-to-navigate user interface across a wide range of devices. The system should be *open*, with users able to combine services offered from several domains to compose new personalised ad-hoc services. This requires novel human interaction models and methods as well as advances in service development and runtime environments.
- **Increased machine-to-machine (M2M) interaction:** Man-machine and machine-machine interactions constitute a significant part of the growth of internet usage (in personal, home, business as well as community domains). Future systems will be *intelligent*, with machines able to understand the user in a natural way. Thus, there is a need for standard low-cost, always-on ubiquitous network access and secure, efficient (i.e. low-bandwidth) and time-sensitive protocols for remote control and monitoring of machines (systems), appliances and applications.

Research challenges

There are a number of broad challenges in meeting these requirements:

- **Security and trust:** Creating trusted environments for the new service world will require mechanisms to facilitate initiation of secure communication channels by end-users themselves, as well as secure channels provided as a network service. t will be necessary to provide means for proof of the integrity of data (by providing the necessary verification information), origin of data and authentication. It may be necessary to research the nature of trust and to find technical and legal mechanisms to bring about changes in attitudes.
- **Interoperability:** This applies at many different levels: i) service interoperability to provide the ability to integrate largely stand-alone services with similar ones and with other services, for instance from the business domain; and ii) semantic interoperability, so as to provide the (automated) understanding of the information exchanged and ensure quality of service[2].
- **User centricity:** Users will be at the centre of the future internet. To achieve this, we have to develop service models, concepts and tools that are so intuitive that it is easy for end-

[2] Semantic interoperability is important from a quality of service perspective in order to facilitate composition and middleware support

users to develop and/or customise service behaviours (not just *content*). New approaches for personalisation and personalised delivery of services are also needed.

- **Complexity:** The internet is expanding, with ever-more users, devices and service nodes. Reference architectures and implementations are proposed as solutions in the short term. This expansion, and the extra functionality expected from future networks, will result in additional complexity. How can we minimise complexity of networks and devices that are increasingly dynamic and adaptable, and where machine-to-machine is the dominant form of service interaction?
- **Scalability:** The increasing scale of the internet brings new challenges in a number of areas. Examples include: modelling, validation and verification of business processes composed on SOA; flexible evolution and execution of business processes; data, process and service mediation; reliable management of composed services; and brokering, aggregation and data management. Quality of software is an important factor in all of these and will become essential to the smooth working of the 'service universe'.
- **Information sharing:** Information sharing on the internet is currently based on messaging approaches (such as email) or on providing access to a central repository (perhaps mirrored at several sites). More dynamic forms of information sharing and exchange between end-users will be needed to support users who both *contribute and access* information, and who may be working in mobile environments where connectivity may be unreliable. Developments here must reflect convergence, moving towards standardised approaches to sharing information between the internet and telco worlds.
- **Quality of service and optimisation:** QoS is central to convergence. Combining the reliability and predictability of the telecoms world with the flexibility and openness of the internet world will involve: i) ways to determine, assess and describe quality parameters appropriate to a particular service; and ii) network mechanisms to request and measure levels of service. Combining availability (under various load conditions) with accessibility, flexibility, and openness should result in new congestion control mechanisms that do not impeded performance and scalability.

More detail of some of these challenges is given in the following sections.

3.2.1 Intelligent delivery

Intelligent delivery means that users are able to access services of all kinds, regardless of the underlying network infrastructure. All services must be expected to be interactive, so that a return channel must always be available – whether through the network used for delivery or a complementary one. Moreover, there must be no significant service interruption when network access changes, perhaps because the user has moved: the services should be provided seamlessly. The necessary support functionality – so-called enabling services – may be part of the network infrastructure itself or part of the terminal.

There are two approaches to achieving this aim: intelligence may be built into the network and content may be generated to be capable of adaptation to the network resources available at a particular place and time.

Network intelligence

Services must be created and delivered to end-users much faster, and constituents of an application (the service components) may come from a larger community of providers in partnership. Service logic will be highly geographically distributed. The end-user experience will be highly individualised based on user context, role, preference, behaviour.

Networks may soon all be multi-provider and multi-service. In this scenario the network provider will sell connectivity to service providers in fair competition with other network providers. The user will no longer buy connectivity but services, and new business roles like "service brokers" will appear in the market.

The key concepts of 'Next Generation Network' architectures to support this vision are control of services independently of the bearer resources, and open and standardised interfaces between the services control and the resources control. These new architectures will provide more flexibility regarding support of new services and will optimise the use of network resources. They will support high-quality basic services with multi-usage components as building blocks (such as identity management and access control) with improved diagnostics to allow guaranteed quality of service.

Further research is needed on:

- Design of an open, standard and scalable architecture enabling multi-operator service trading and a fair value-added chain offering advantages for operators and users;
- Handover and roaming mechanisms to seamlessly operate services for users on the move;
- Mechanisms for collecting and processing information from heterogeneous networks and terminals;
- Handover triggering solutions capable of selecting networks optimally by taking into account the requirements of the application and of the user;
- Application of user profiles and user contexts to enable personalisation of services for all users, while protecting the users' privacy;
- Dynamic composition of services from a large number of finer grained services of which the behaviour and characteristics depend on context, proximity, time;
- Service middleware for highly distributed environments where interaction between loosely-coupled fine-grained services is triggered through advanced messaging mechanisms;
- Provision of an extensive multi-access test network to ensure interoperability of different network technologies and applications.

3.2.2 Quality of Service

The network infrastructure must allow all kinds of services to be offered to users, wherever they are. It must offer control and monitoring of such services end-to-end, including the control of 'quality of service', QoS. Operators currently measure QoS in network terms such as bit-error ratio and maximum throughput. In future, QoS must be presented in terms appropriate to the application. Operators will need to use techniques such as behavioural modelling and channel prediction to provide feedback so that hosts can make their applications work with the network that is actually available. This requires elaborate technologies, as sessions and services must be monitored, adapted, seamlessly rerouted, billed, and so on – and such intelligence may be distributed across the entire network or across hybrid networks.

In order to operate in heterogeneous networks where the underlying network connection may be transferred from one access technology to another (e.g. from WLAN to optical to 3G), applications need to include mechanisms to adapt their operation to tracking and changing network conditions. This will require mechanisms for collecting network status information from the transport stream and from the network interfaces to make fast adaptation decisions. These decisions will be application-sensitive, because different applications have different QoS requirements – for instance, file transfer requires error free delivery but is tolerant of delay, whereas many audiovisual services require very low latency but can tolerate occasional errors.

What is needed, therefore, is a service-centric network (which could be interpreted as integrating a 'service plane' in the network architecture) with user-centric interfaces. The challenges include:

- Migration of higher-layer intelligence in the access network closer to the end-user so that network operators can interact with the delivered multimedia services;
- Advanced service-aware QoS strategies to inform the network traffic engineering capabilities;
- End-to-end solutions in which users are also content broadcasters and service providers (unicast and broadcast);
- Constructs that complement the management and control planes, to create and maintain high-level knowledge of the network, its usage, and its behaviour, and to integrate, reflect on and draw interferences from that knowledge. In particular, dynamic reconfiguration capability is included to achieve optimal resource exploitation, while enabling multi-layer traffic engineering, which combines functions in the various layers to optimise performance and QoS;
- Monitoring tools to determine the characteristics of the subscriber's access, which may be wired or wireless and provide for the possibility of balancing traffic over multiple access links;
- Admission control techniques for use when the network is overloaded taking account of the requirements of different applications, and users' preferences; such techniques should preferably be pre-admission control, i.e. the decisions – based on sophisticated infrastructure and user models – are made before the network access is granted.
- Techniques for managing and configuring user devices remotely: most users do not have technical skills to configure future networks devices, so terminals have to configure themselves, or they have to be configurable remotely by a service provider.

3.2.3 Network architecture

Network architecture is about the organisation and structure of networks and their connections. In the context of NEM, the scope spans from the core network to body area networks. As a network does not consist only of connected wires, the understanding is that physical connections, interfaces, medium access controls, and protocols are included as well as operational aspects such as resilience and reliability.

Network architectures need to evolve from the concept of isolated infrastructures of service providers and customer premises networks to a multi-provisioning of services based on wired and wireless hybrid heterogeneous networks for

broadband, broadcast and mobile. The requirements of the users have to be covered without the users needing detailed knowledge of the networks across which the content is conveyed. Network providers must improve handover between networks so that it becomes more nearly seamless. The fundamental requirement is to keep the network infrastructure as simple, as flexible, and as generic as possible while providing the minimum feedback the user may need to ensure the success of the application.

Networks are still being viewed as connectivity pipes independent of what flows through them. Such a view was sufficient when the traffic flowing was not diverse. But with increasing diversity in network traffic and the explosion in the location and number of end-points for these pipes, that traditional view does not fully meet the needs of networked multi-media.

Different services have different QoS requirements. Also, if an end-user wants to interact with a particular multi-media content, it should not be necessary for the user first to have separate negotiations with the first/last mile provider, internet access provider or broadcast TV provider, etc.

The ideal network is the network that is invisible to the end-user and that regulates itself dynamically to meet the needs of the end-user, of course within the cost constraints chosen by the end-user and the technical constraints of the providers such as scalability and stability.

Such adaptive multi-purpose networks will generate enormous increases in traffic. So it is important that they can be scaled to cope with increased traffic at much lower costs to the user.

The main features of the new networks are:

- They have the capability to organise themselves dynamically to suit the needs of the multi-media content that has to be transported between any end-points continuously.
- They have the capability to tell the user what services are available, when they are available, and what other actions (e.g. remote user profiling) they entail.
- They have the capability to prove that the service provided is what was requested (using monitoring techniques).

To provide these features, some kind of functional plane will be needed that can be thought of as a loosely coupled distributed system, made up of components running on hosts and within the network. It will augment the network control paradigm of low-level data collection and decision making with higher-level processes and expert systems to learn about its own behaviour over time. Thus it will be better able to analyse problems, tune its operation, and generally increase its security, reliability and robustness. It will collect and filter network conditions and route the resulting information to where it is needed, ensuring successful operation even when the information available is limited or even imperfect.

The result will be a network capable of driving its configuration, diagnosing its own problems, and making decisions about how to resolve them. Given the different types of networks involved, the number of persons, machines and sensors that will be connected, and the amount of data that will be generated, new control paradigms will be required to efficiently diagnose network state and running conditions and derive suitable decisions from these observations without human intervention.

In addition to the above abilities of the future networks, the future of media services will require strong capabilities for deployment of repositories and cached content, aiming at optimising the networked search and access to the relevant multimedia information.

In summary, the research topics are:

- Novel residential, access and edge network elements and network architectures implementing new paradigms so as to cope with the increasing operational complexity,

terminal diversity, widely differing transfer volumes, and evolving business relations – and seamless session handover;

- Layer-spanning network planning and optimization for more modular and flexible networks including automation of network management operations;
- Dynamic mechanisms to allocate the network resources with a maximum of efficiency and prevent congestion or service denial;
- Network architecture and solutions designed with multimedia applications and related traffic in mind;
- Common or interoperable operational and management network protocols to allow the convergence of networks.
- Networked search and retrieval of content for more efficient access to content.

3.2.4 Home and extended home networks

Customer premises networks – and particularly home and extended home networks, individual and collective – are something of a special case. The networked home is the domain where the impact of the conversion between computing, consumer electronics and communication platforms culminates.

Home networks are governed by the same requirements as outlined above, but they are owned by the users or the building owners although in many cases with operation controlled by the network provider. It can therefore be expected that a much wider range of equipments will be installed, and core and access networks will have to take account of that fact. Old customer premises networks were specialised by service: twisted pair for telephones, coaxial cable for broadcast services, and wireless or powerline networks for data file transfer. Some progress has been made towards integrating services in home networks. However, there has been little progress so far in integrating telecom and broadcast networks with other networks and devices (automation, safety, security, etc.). Extended home networks will include networks in vehicles and networks extending the services available in the main home to other buildings such as summerhouses, as well as collective networks such as those in apartment blocks.

Home networks should be pervasive, enabling the creation and delivery of multimedia services for entertainment, education, communications, security, healthcare, remote control, etc. Home appliances will be inherently connected to at least one very high capacity local network and increasingly to a global broadband network. Both types of platforms will evolve to systems with more and more embedded intelligence. The home will have the beginnings of autonomous control over many of its functions ranging from intelligent environmental controls and energy management to sophisticated security and safety systems. Many of the devices that today plug into the wall and are programmed manually will become intelligent to their particular function and collaborate with other related devices. Increasing energy costs will encourage the deployment of intelligent systems in the home to optimise efficiency.

It must be possible to install a home network with minimal alteration to existing homes. This requirement, along with the need to work outside the house, practically requires the use of wireless or powerline networks, both of which have interference implications if they are widely installed: wireless networks may interfere with each other, and emissions from powerline networks may interfere with licensed users of the radio spectrum. The complexity of converged home networks must be hidden from the user: users have to be able to set up devices and services as easily as possible.

Collective networks such as those in apartment blocks are a particular case, a hybrid between the public network and individual home networks. They often include means for receiving broadcast signals collectively and adapting them for distribution, often by changing frequency and modulation method. A new generation of standards (e.g. DVB-T2, DVB-C2) is emerging, and collective networks must evolve to accommodate these new standards.

In summary, research should ensure that the future home and extended home networks are:

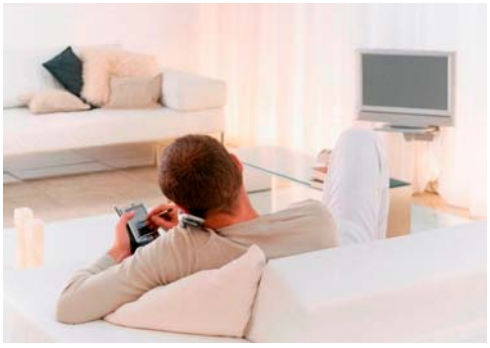
- Technology-independent;
- Able to interwork with each other and with the public networks and services;
- Able to integrate economically the handling of a wide range of signals from low-bandwidth home automation to HDTV;
- Easy to install without disturbance to the dwelling structure;
- Able to give connectivity between the central home premises and the wider extended home;
- Easy to set up by the user, with the complexity of network configuration and device compatibility hidden from the user.

In addition, collective networks for multi-occupier buildings must:

- Combine all available audiovisual applications with the new telecom services (wired and wireless);
- Be adaptable to include new standards as they emerge;
- Maintain the regulatory principle of fair and equal access to all neighbours connected to the same network in a converged scenario of services and applications.

3.3 Media presentation and content access

3.3.1 Authentic, true-to-original media reproduction



The rendered media output should appear as similar as possible to the original or to the intended scene. The emphasis should be on video reproduction devices ('displays') although new forms of immersive sound reproduction are now considered by research. Reproduction technologies have always played a vital role as key enablers for services. Any new display technology will enable new usage models for audio-visual content.

The improvements might come in better 2D resolution, in integration of 3D, or in the development of wearable devices that might enhance reproduction of content for users on the move, in a better adaptation to home environments with multiple displays and other reproduction devices.

Mobile display – even of text – has always been seriously limited by the technology available. Consequently there should be a special emphasis on innovative display concepts like holographic eyeglasses, wearable organic light-emitting diodes (OLEDs) and similar.

Users may wish to view multiple media sources at the same time, replacing many existing forms of communication and media, such as telephoning, broadcasting, e-mail, and paper mail. The result is that there will be a growing need to have a federated system of distributed high resolution, large displays with integrated common interface capability to allow multiple media sources to be reproduced at the same time.

Display technologies have to evolve up to a level where displays can replace paper in terms of visual quality. This will foster the wide adaptation of even higher resolution content (2-4 times HDTV resolution and up) to visualise maps, radar, high resolution pictures and applications which will be used for sharing and collaboration. These displays will grow from standard computer display size to wall size, depending on the number of users. These displays have not only to support multimodal interfaces but also concurrent multi-user interfaces.

Research should concentrate on:

- Innovative displays in very high resolution stationary (volumetric and autostereoscopic 3D displays, living room caves) and mobile form (OLED or holographic displays integrated in eyeglasses); high density (>100 dpi) large area displays (>1 sq.m.) for paper replacement;
- Energy-efficient displays, particularly for mobile applications;
- Secure digital interfaces for the interoperable connection of displays to any rendering device;
- New methods for immersive sound reproduction.

3.3.2 Virtual reality

Virtual reality uses immersive 3-D ‘displays’ (including transducers for audio, and for other senses as they become available) to create the illusion of presence in a virtual or distant world as an immersive and integrated experience for users. Telepresence services provide a virtual environment for humans to control devices, robots, etc., in a hostile or remote real environment through body-operated remote actuators.

Experiencing virtual reality and telepresence does not depend so much on the faithfulness of the reproduction of the physical aspects of external reality as on the capacity of simulation to produce a context in which users may communicate, interact, and cooperate.

Two main targets may be pursued:

- Business applications such as pipeline video inspection for maintenance and repair, distance learning, subsea work in deep waters, hazardous situations, remote surgery, virtual healthcare, experiencing virtual products prior to production;
- Entertainment applications, including interactive applications such as games, walkthrough environments.

Multimodal interactivity with remote environments is a great challenge in respect to the growing needs in efficient remote collaboration within multi-site companies. For an efficient remote interactivity, among numerous topics to be addressed are:

- 3D capture and manipulation of multimodal stimuli;
- Network latency: Multimodal interactivity needs to have an immediate and secure feedback;
- Mutual awareness: new devices and software (audio, video, tactile) reproducing for the users a natural peripheral awareness of a remote or imaginary site;
- Displays: few haptic and tactile devices are available.

3.3.3 Dynamic federation of distributed interface devices

In this vision, ad hoc federations of devices self-assemble on demand on the basis of essential components distributed in the near environment, for instance interface devices available in a home or office environment, or worn by the user as accessories and clothing. The corresponding device assemblies might be called "virtual distributed interface devices".

As intelligence moves into the infrastructure of our daily life and even eyeglasses may be equipped with some processing power, such "virtual devices" could create themselves based on the components available in a certain range. In combination with intelligence and processing power woven into clothes and body area networks, a multimedia device could consist of the display integrated into glasses, earphones, wrist input device etc. As one gets close to a large screen, that screen is immediately integrated into the device and all content (provided the user had enabled it) is presented there. Once the consumer leaves the range of one component the device disassembles or creates itself anew on the basis of what is available. Services are automatically adapted to the current device capabilities.

Mobile augmented reality is a possible early application. As an example, it allows a user to view route indications (arrows, virtual guide, etc.) directly in the field of view by means of a hand-held camera coupled with see-through glasses. Spatially distributed hypermedia is also an interesting concept to explore. Multimedia documents can be geo-localised and are viewed as the user navigates in a city or a building. The user may be allowed to modify the documents or add new ones allowing a sort of spatially distributed blogging.

Nothing comparable exists today. Some early work is going on in labs, for instance with intelligent devices woven into clothes, or mobile augmented reality with a regular camera phone. Further research should address architectures and interfaces for such classes of devices. In particular:

- Representation of component interface devices by functional entities;
- Specification of interfaces between functional entities, preferably in a dynamic manner, so that new functionalities can be learned and automatically be integrated in future applications;
- Global context awareness of functional entities;
- Seamless composition and configuration, which requires extremely flexible networking interfaces
- Suitable security mechanisms.

3.3.4 User-system interaction

Multimodal user interfaces aim at mimicking the human communication skills that use several modes of communication (such as voice, handwriting, gesture, gaze, possibly simultaneously) in order to communicate and exchange information and control. By providing users with such a multimodal approach for interacting with media and for communicating, a natural and transparent way is offered for dealing with the complexities of the interaction while hiding them from the user. The multimodal approach should be more fun to use, encouraging users to take up new devices and services.

Multimodal communication has to deal with multiple styles of interaction – use of one or more of the possible modes. The modes chosen may depend on the context (while driving a car, voice may the principal mode used, whereas at home gestures could also be used) and on the type of application. Different users, consciously or unconsciously, will show different usage approaches, or preferences, with respect to the preferred communication mode.

The NEM vision foresees a multimodal future where terminals will recognise different styles of communication in order to offer to users more efficient interactions, allowing a better adaptation to individual differences (modality preferences, degree of expertise, handicaps...) and to the context (reduction of global error rates at the input thanks to the possibility of switching from one modality to the other, or by combining information from several modalities). Multimodal communication will be more efficient and will give a more powerful experience to users.

While for the operation of NEM devices all input modes are relevant, a special interest in the NEM Initiative is the fusion (on the input side) and fission (on the output / rendering side) of audiovisual modes: Augmentation of visual scenes by acoustic descriptions when important details are off-screen (e. g. due to a user initiated zoom), speech controlled devices where the result of the speech analysis depends on the visual focus are intuitive examples for multimodality in media environments.

Research questions focus on two main fields. The first one deals with interpretation of information at signal, semiotic or semantic levels in order to understand and interpret multimodal inputs from users and furnish the required information in the best way, taking into account the context of usage. Several technologies such as speech recognition, handwriting recognition, gesture recognition, speech synthesis, haptic feedback need to become mature. The second research field deals with ergonomic and usage studies on how users appropriate themselves multimodal systems, what is the learning curve, how they tend to specialise themselves with time.

3.4 Enabling technologies

A set of horizontal technologies will act as a foundation for the functionality of the entire end-to-end chain. These are described in the following.

3.4.1 Security privacy and trust

Services and their content must be provided securely between all users. The infrastructure components must be secured against hacks, intrusion and misuse. The privacy of each actor in this environment must be guaranteed; but, under some conditions established by law, the network must provide the possibility to trace illegal behaviours of connected individuals or service providers. The consumer (in particular the business customer) trusts a business partner to maintain confidentiality and to handle the business issues – in particular payments – correctly. Without trust, no viable business is possible.

The universal adoption of on-line digital services and contents is highly dependant on the ability to provide consistent solutions for the security of networks and services, and the protection of privacy. The objectives are:

- Trust of all users in networks and the services they provide;
- Users should gain secure access to public networks and services;
- Users should have the capability to gain secure access to devices/services in their private networks from the outside;
- Networks should be protected from malicious users, hackers, denial of service attacks, spam without constraining the usability of networks and services too much;

- For ease of use, authentication of users must become easier and more natural;
- The users must be allowed to keep control on the authority they have delegated to machines;
- The privacy of the user has to be protected.

The research topics to meet these objectives include:

- Security policies and architectures, scalability, interoperability, secure processing, and lawful basis;
- A definition of trust, and models and parameters for measuring it;
- Cryptography;
- New, more natural methods of user authentication;
- Early discovery of new types and occurrences of attacks on the network and its users – particularly to nomadic terminal users, now seen as easy and attractive targets as the number and complexity of applications increase;
- Making the network resilient to exceptional peaks of network traffic caused by a malicious behaviour of some users or by a bad configuration or poor design of some network components;
- Effective concepts for infrastructure protection by traffic analysis and intrusion prevention employing a modular design in order to rapidly integrate new security aspects.

Privacy and trust will always be important factors in security systems. All work will involve finding a trade-off between privacy, security and non-repudiation. The following points should always be kept in mind:

- Simplicity: the user should always be able to understand what is happening;
- Visibility: users must be kept aware of the choices they have made – and the consequences of those choices;
- Transparency: the user must be aware of who has access to what part of his authentication profile;
- Revocability: for all parties, the business partners (on either side) and the trust platform, there must be a clear set of rules how and when to revoke all or parts of a user's authentication profile;
- Privacy: there should be no leaking of privacy information other than as required by law.

3.4.2 Rights management

Most content is subject to copyright, and most rights owners want to be able to keep control over the future use of their content. Many of them want to be able to receive payment for making their content available. Rights management systems are designed to protect copyrighted material from being copied or accessed without permission. Rights management therefore is much broader than is often implied. It comprises both the contractual and the infrastructural framework by binding the content to a specific licence and by securing the content in a way that breaking this licence cannot be done unintentionally. Currently there are many non-interoperable rights management systems. A "Single European Information Space", however, calls for interoperable solutions that enable free choice of content and content provider for any customer. Although a single technological solution might not satisfy all business and social goals and models, technologies to facilitate interoperability of solutions should be a major target.

Rights regulations must recognise that the media industry moves towards networked solutions, thus helping create a true market for networked content. Technologies for rights management should bear in mind the needs of end users and satisfy their expectations regarding normal fair use of content for private use on different devices. They must also generate legitimate trust through impartial common basic services accessible to all users

Internet experience tells us that users often wish to distribute their value added contents between them. The phenomenon of massive distribution of multimedia content will bring new business opportunities and enormous benefits to users

Nevertheless, this will only be possible if there are effective rights management solutions on the distributed multimedia contents to guarantee that all participants in the value chain (end users, suppliers of contents, authors, operators, etc) can benefit. A rights management system for the future requires interoperable components over all the delivery chain:

- The service provisioning must take into account which rights are assigned to content;
- The network must ensure integrity;
- The terminals must make sure that the consumer has the rights to access a certain piece of content in a specific way; a “personal identification module” might play an important role in separating the rights from the terminal.

The problems associated with rights management are more to do with business models and regulation than technology; nevertheless, there are some areas for further work where technology could help to solve the problems:

- Means to guarantee a trusted environment between the terminal and the rights management platform;
- Technologies and standards for protection of continuous content (streaming of audio, video);
- Means to facilitate innovative concepts like portable licences or licences for communities of users;
- Means to ensure interoperability between different rights management technologies;
- Metadata for rights representation, content identification;
- Means to verify that the content delivered is what was asked for, and that it has not been tampered with or damaged in delivery.

3.4.3 Technologies for federated services

Federated services are services built up from multiple components from different originators.

Creating services for different terminals, networks and media formats is becoming more complex all the time. At the same time the range of services and service providers is increasing. Intelligent service creation helps service creators in creating services for different platforms. Automating the service creation allows more people to create (e.g. community-based) services - even without technical knowledge. The best case would be that the service provider only needs to create a certain service for one terminal by using automated "bricks" and the service would be automatically adapted to suit different platforms. As far as possible, the same services and content have to be available for users regardless of time, location

or equipment. Also the service creation should be able to automatically recognise the context where the service will be used.

Federation ensures that highly dispersed content can be searched, organized and consumed from any type of end-device, irrespective of where the information source resides.

Contextual awareness

Context is defined as “any information that can be used to characterise the situation of an entity, for example, a person, place, or object that is considered relevant to the interaction between a user and an application, including the user and application themselves”. Context awareness is an enabling technology for creation and deployment of context aware services. Context awareness middleware collects information from different context sources (networks, servers, devices, platforms, etc.) in order to have a better indication of the user needs. It will also provide a reasoning engine that will understand (semantically), compose and will provide the application or service layer with a fully fledged context representation. All context sources must technically share the same context ontology, which will be used by the context data consumer and by the context broker.

The objective is to define and develop an open, modular architecture to support the easy creation and deployment of context aware services. Such services may include personalised content distribution and proactive services that can adapt dynamically according to particular situations (context) that may occur to the user (e.g. location, availability, end user devices, access network, available bandwidth, mood, …).

Future research should take into account the various elements that are required to derive context:

- Multi-modal context capturing (e.g. through sensory inputs);
- Context Interpretation, i.e. deriving more abstract, higher-level conceptual context information from the low-level context information;
- Adaptation inference, i.e. deducing potentially useful service adaptations from the higher-level context information obtained from the interpretation process;
- Semantic methods enabling the representation and manipulation of context information through machine-interpretable ontologies;
- Context reasoning paradigms and methods, enabling the context interpretation and adaptation inference process. Candidate paradigms include:
    - logic reasoning, e.g. ontology-based inference,
    - rule-based reasoning, e.g. rule-based inference engines,
    - probabilistic reasoning, e.g. statistical inference models,
    - machine–learning by model-based reasoning, e.g. models for the automatic classification and/or prediction of context patterns;
- Context-based tagging of content;
- Metadata annotation of (user generated) content to created context (by means of tags or other mechanisms).

Identity management

The first piece of contextual information needed is the user’s identity – a token for gaining access to all of the media services and terminals.

Personal identification can be established in many ways. It can be pure hardware (e.g. smart card with memory), it can be pure software (e.g. secured storage on one or on distributed servers) and it can be used in combination with personal knowledge (e.g. pin-codes) or biometrics.

Three lines of research can be identified:

- Physical methods of identification such as biometrics, RFID chips;
- Ensuring interoperability of identity management among different services and applications;
- Ensuring an appropriate level of privacy.

Personalization/Profiling

Personalisation is about adapting to the needs of individual users. However individual users can have a range of different needs at different times and places: they may be acting only for themselves, or they may be acting for one of several groups they belong to (family, an association, a firm …). The aim is to enable individuals and consumers to organise, compose, and manage basic media and communication functionalities, possibly from different suppliers, in the way that best fits their current needs. Personalization allows services and content to be tailored automatically to the end-user's preferences (e.g. content consumption in the past) as well as the user's context (location, current connectivity, mood, etc…). The idea is to personalise the set of services available according to the context (when you leave your home, you just get the relevant set of services active).

Users perceive personalization to be effective when they are receiving highly relevant content available exactly when they want it - any type of media available at anytime and in the most efficient way. Personalization is not just limited to on-demand TV, video or music, but equally relevant for life experiences like education, self-awareness, community, immersive reality, multi-player games, and shopping. Advanced content delivery systems need to exploit information about the environment in which they are working.

This 'context awareness' is much more than location awareness alone, or merely the immediate situation. The vision is to have a middleware infrastructure capable of collecting all context metadata from clients, servers, involved resources and the environment in general, and of transparently deciding the most appropriate content customization operations, with no impact at all on the design and implementation of multimedia clients/servers. Such a middleware infrastructure must be capable of integrating data and resources from delivery networks, sensor networks and content metadata.

In order to speed up service creation a service framework should be made available to the customer. It should act as a toolbox where basic services from different suppliers can be selected and integrated in order to create a new personalised service.

In a competitive world with many providers, consumers will not have a single repository of their needs and preferences. Thus, powerful mechanisms are needed to synchronise data and exchange information. In effect, a common repository description is needed. The seamless update of the repositories is key for seamless service provisioning for a consumer on the move. The real challenge comes in acquiring the user preferences automatically.

Objectives of the research work would be to demonstrate:

- A platform independent approach encompassing all types of services;
- A support infrastructure that is aware of the user's situation (location-based information, mood). Such a system will interpret the contextual information in the light of preferences previously declared by the user or choices previously made; it will include means for signalling the automatic update of the user profile;
- The description of a user profile that could be used to filter services in order to provide to the user the right set of services according to the context and to the user rights;
- A support infrastructure with an integrated programming interface for both retrieving current context and commanding service customization;
- The long term objective should be the automatic learning of people's behaviour in order to update automatically the user profile and to provide a corresponding service filtering.

Particular research topics might include:

- Definition of an abstract language that allows new services to send objects between them without any operation made by the service integrator. Thus, all of these interchanges could be executing at the client side, minimizing all data traffic due to delivering data to the server, enabling a new generation of user interfaces where the communications between client and server will be greatly reduced. This method of working allows the release of network resources for other applications;
- "Personal/home" service controllers able to execute flows of communication actions, media rendering and delivery;
- Multimodal simple service definition interfaces through which users can describe the expected service behaviour;
- User profile description: which are the relevant data, what about privacy and data storage
- Automatic user behaviour analysis and user profile update;
- Service filtering according to user profile, context and rights;
- User behaviour recorder and analyzer, able to automatically support the service definition.

One important support aspect to be addressed is the availability of automated testing in order to extensively test a newly created service. This testing tool must support the service creator to check all service features to avoid malfunctioning components and/or wrong data management.

Beyond the technological issues, collection, storage and use of the data needed for personalization involves challenges in the field of personal privacy. If early personalised services are perceived as not useful, or as an invasion of privacy, public reaction could prevent this area of work from achieving its promise.

Location

Location and context-aware applications are closely related concepts: many of context –aware applications could not be envisaged without certain location information. But what does location mean? Depending on the application, location information can be the coordinates of the specific target, the position with respect to a known reference, proximity information, and so forth. Accuracy is another aspect related to positioning. While some applications require high accuracy (centimetres even millimetres), others require only proximity information, that is, "target A is near target B", without specific and stringent requirements. High accuracy usually needs specific and more expensive hardware, and as the accuracy requirements decrease, the devices needed

become cheaper and more generic. The scenario and the required accuracy will decide the technology and the technique to be used.

Outdoor tracking can be successfully solved with location technologies such as GPS (very precise) or mobile phones. However, indoor applications with tracking requirements are still an open research topic since GPS cannot work indoors, and radio communication technologies, mainly based on distance estimations, are prone to high errors because of the complexity of the indoor radio channel. Most popular methods to locate people indoors are based on measurements of radio signals, such as Time of Arrival (ToA), Angle of Arrival (AoA), Time Difference of Arrival (TDoA) and Received Signal Strength (RSS). The first three measurements need costly customized hardware and obtain more accurate results while RSS is the most attractive technique (but not so accurate) because of the variety of personal radio communication devices that cheaply and by default implement it.

This inability to model accurately the radio channel indoors is probably the most challenging issue in the location research field, still needing alternative clever approaches.

Billing/payment

Federated services will require a complex structure for collecting many levels of billing data for services and content. In many cases, the payments will be very small – micropayments. Micropayments are small, usually one off, payments made for a given piece of content or service. They allow for billing for small amounts collected centrally and then distributed to the appropriate content/service provider.

Rules to control how micropayments are applied can be complex, particularly in the case of acquiring rights to a complicated set of content, which may be dynamically reconfigurable. However, the micropayments system must be easy to use, secure and trusted by users, auditable and low cost to run. When an individual payment may be only a few cents the overhead of processing that payment needs to be an order of magnitude smaller. Important issues are how to make the micropayments easy to use, secure and trusted.

3.4.4 Middleware

Multimedia middleware is a software layer providing a stable architecture and application programming interface (API) dedicated to multimedia and accessible by service developers and providers. A middleware layer is used to allow application software to execute multimedia functions with a minimum knowledge of the inner workings of the multimedia terminal – which may be used for generating content or for reproducing it. Middleware enables technological complexity to be hidden from the user, and is particularly important when it is necessary to facilitate interworking between different, perhaps proprietary, applications. It could make different terminals appear as common platforms that can exploit the potential of, for example, content interactivity or 3D visualisation, so that content can be generated for use in various media terminals from set-top boxes to cell phones and game consoles

There are two types of software solutions for complex consumer devices: a completely proprietary, closed-source solution, and an open-source solution. Current middleware solutions are proprietary, are not interoperable and are not available to all on fair and reasonable terms. This leads to increased costs for development and maintenance of applications, increased time-to-market for

innovative services and huge efforts to ensure interoperability of services over different platforms. Effectively utilising all of the software that is available to a user is an almost impossible task because of the lack of commonality.

An open middleware framework is needed that can be used to develop a wide variety of services and applications. It must be intelligent and adaptable and will need to be supported by suitable tools for authoring applications that will run on a wide range of devices. A suitable middleware platform to make the creation of content and user navigation transparent across different technologies, such as broadcast and internet, will simultaneously stimulate both markets

A multimedia middleware should provide an API providing the basic functions allowing each service application to adapt to the executing platform; in addition, it must address:

- The life-cycle management of the software components that provide the functionalities wrapped by the middleware layer (e.g. identification, download, etc…);
- Intelligent inference mechanisms for dynamic composition, negotiation, adaptation, replacement, and recovering of components, supported by suitable tools for the effective and smart deployment of components according to the device status, final user needs, and component profiles;
- The issues related to the integration in complex service contexts such as rich media personal communication;
- Specific extensions able to manage signalling protocol mechanisms and QoS in all delivery networks.

3.4.5 User number measurement and user behaviour logging

Many content providers will want to measure the numbers of users that access the content they offer and get an idea of users' reaction to it. This may be, for example, to satisfy advertisers or other stakeholders, to gauge popularity of content as a tool for planning new services, or to apportion payment to rights holders.

Interactive sources such as websites can count numbers of hits and requests to access content. Measurement is more difficult for unidirectional content providers such as broadcasters or public-view advertisers. At present, measurement is done by interviewing samples of the audience, by samples keeping diaries, or by special hardware in sample households that records the time for which TV channels are on.

Measurement of numbers in the vicinity of content is only the first step. Are the people who see a poster merely walking past, or are they reading it? Are the people in the room where a TV programme is on watching it, engaging in other activities, or merely asleep?

Some audiovisual content includes extra components (for instance recipes for a TV cooking programme, programme notes for music, or the words of a song). How can the usage - and hence the utility to the user – of such content be measured?

Research topics would include:

- Accurate automatic measurement of audiences, for instance by RF or infrared detection or personal recognition;
- Attention measurement, for instance by detecting gaze direction;
- Methods for measurement of usage of extra components.

In all work in this area, particular care must be taken to respect users' privacy.

3.4.6 Effective recommendation systems

The networked media domain enables users to access an increasing amount of contents that educate, inform and entertain. The challenge is to access easily those content items that the users may appreciate, that suit their information needs, their entertainment wants and their personal tastes.

Recommendation systems produce suggestions of content items a user may prefer, generating a list of recommendations. The list may be based on knowledge about user preferences and/or content characteristics (content based filtering), or based on community recommendations (collaborative filtering). Content-based systems depend on content characteristics and possibly on single user profiles. Collaborative-based systems with no content analysis match the group of users that have requested or rated the same set of contents, and use that knowledge for suggestions.

Effective recommendation systems require the combination of both approaches trying to achieve the best mix for different situations: recommendations suitable for well-known users but also for unknown or new users and for well described content but also for content without relevant structured or unstructured descriptions (metadata and ratings). Moreover, effective recommendation systems must discover and choose an appropriate set of content among the huge choice on offer, but should also propose unexpected contents (serendipity) and those beyond blockbusters (content in the long tail of the Zipf curve). Business and other rules may influence content selection, but recommender systems have to be effective from a user perspective in order to make the recommender not only accurate and helpful, but also a pleasure to use.

There exist challenges in the perception of suggestions produced by recommendation systems beyond the technological issues, collection, storage and use of the user data (preferences, explicit and implicit feedback, ratings…). Whenever the recommendations are perceived as not useful, as an invasion of privacy, or as advertising, this area of work will not achieve its final objective.

Important topics for research are:

- Recommendation based on ratings**:** recommendations that approximate the real taste of the users, giving a relation between items or between items and users. The results will depend on the number and accuracy of ratings;
- Recommendation based on metadata: this approach establishes relations between items and the results depend on the availability and quality of metadata;
- Recommendation based on content analysis. This field of research is very challenging, as it relies on algorithms capable of automatically capturing meaningful aspects from the content itself. This approach aims at overcoming the frequent scarcity of metadata and ratings;
- Metrics for evaluating the quality of recommendations. At the moment there are no commonly accepted methods for evaluating the accuracy of the recommendations, except in the case of algorithms that use ratings;
- Improvement of the acceptability. In this field of work, one must study trustworthiness, pleasantness and usefulness, which are aspects that go beyond the pure precision of the recommendations.

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3.4.7 Power management technologies - energy saving

"ICT has the biggest carbon footprint of all industries" versus "ICT offers the biggest savings in carbon emission"; these are only few of the headlines that ICT faces when it comes to energy consumption.

Energy-efficiency of networked electronic media

ICT research has always included efficiency in its design targets. Originally this was more for the sake of bigger coverage areas and higher spectral efficiency (in broadcasting and telecommunications). It led to transport schemes that approach the Shannon limit within 10ths of a dB and audiovisual codecs that eliminate redundancy and irrelevancy to a large extent.

Streaming applications require real time delivery and therefore new concepts of media transport and error resilience to remain as near to the Shannon bound as we are today while offering a higher adaptivity and shorter delivery times. Mixed worlds (synthetically augmented realities or reality augmented virtual environments) should enable great improvements in audiovisual coding.

The demand for portability has been a driver in reducing the energy demand of electronic circuitry, in order to conserve battery power. However, these improvements are not always reflected in the performance of fixed equipment.

The advent of completely new networked electronic media applications, however, such as data distribution and replication, but also distributed processing has greatly increased the energy demand of the sector.

Energy efficiency, while often self-motivated to increase coverage areas, spectral efficiencies, battery lifetimes etc., should become a general underlying design principle for NEM-related research.

Influence of networked media R&D on energy efficiency of other sectors

It is often claimed that only 2% of the overall energy savings made possible by application of ICT can be accomplished by improving the efficiency of content distribution. 98% of the energy saving is due to savings in other areas:

- Audio/visual surveillance minimizes the efforts for human control (transport, adequate supply);
- ICT-based management of lighting and heating / air conditioning systems can significantly reduce the energy costs,
- Networking of micro-generation schemes can tell the power distribution authorities what capacity is available and make small payments possible, hence making micro-generation viable;
- Audiovisual communications can significantly reduce travel needed for face-to-face meetings;
- ICT-based remote work can significantly reduce commutes (if only one day per week would be allowed, commutes would already be reduced be 20%);

- Electronic delivery of digitized goods (music, films) significantly reduces energy, not only eliminating the physical transport of media but eliminating also the energy costs of warehousing.

The list can be extended infinitely. Potential energy savings must be sought from all R&D in networked media, and should be part of the rating of R&D proposals in the same way as other 'ethical' issues of concern to society.

3.4.8 Spectrum economy

Many of the services and applications described in this Strategic Research Agenda make use of the radio spectrum. Wireless delivery is particularly appropriate for one-to-many applications and for temporary links and is the only solution for mobile applications.

The radio spectrum is a finite resource. Its applications become part of the communications infrastructure and can last for many years. It must be allocated wisely and economically. Some applications already approach the Shannon limit, but others could be improved. There may also be potential for sharing spectrum between different applications.

Research topics include:

- Improved methods of modulation and channel coding;
- Studies on interference and spectrum sharing;
- Methods of reducing unintended interference.

3.5 Media-related applications and business models

Applications are fundamental to the networked media industries and a good business model is essential to a successful application. New technologies will make new applications possible and change business models, making some obsolete and enabling new ones. Applications and business models are therefore proper subjects for an R&D programme in networked media.

3.5.1 Value chain

The value chain is the combination of actors from the industry that together create value. Each part plays a unique role; sometimes roles are subject to regulation. Co-operation between actors is essential for successful business.

There could be new business opportunities linking a never-reached user experience to the creation of realistic immersive and more and more interactive content. However in the present business conditions, the extra cost generated by the production and the transmission of such content must be balanced by new revenues. The R&D challenges in this domain are governance of value webs, and revenue models for content

The questions related to the governance of value webs are:

- To understand the field of forces in the value webs with interdependent actors from the network, application, device and content sectors;
- To understand how new services linked to new forms of content may change the value webs;

- Will individual content items or channels/brands dominate in the new networked media area?
- Where will money be generated? Who pays whom, and how?

The revenue models for content and rights management systems are an important R&D challenge. There are rival rights management systems and standards, and rival content distribution platforms. For each content distribution system content owners have to enter into a separate set of negotiations. Content consumers are often unwilling to pay the price demanded by rights owners; the result has been a substantial black market in free downloading and cheap physical copies (CDs, DVDs etc.). Attitudes vary from 'All copyright violation is theft and should be severely punished' to 'The content industry has grossly overcharged and is now getting what it deserves'.

The Creative Commons licensing system is one initiative towards an alternative system for making content available for creative purposes.

The research questions are:

- Rights management and royalty systems are broken: can they be mended by technological means?
- What other business models are possible that are acceptable to consumers and give fair rewards to content creators and distributors?

3.5.2 Social networking and media sharing

Social networking encourages people to collaborate in media sharing, commenting, content mixing and new content creation. The actions are open and mainly transparent, but copyright issues are difficult to define. The sharing often includes remixing or associated commentary – that is, user generated content – and the copyright is shared between users. The distribution of the content is based on a viral model and involves media that might not have mass distribution value without social media sharing.

Social networking and media sharing could be as much an opportunity as a threat to content industry. On the negative side, the sharing raises difficult copyright issues, and potentially the social media can lead to market disruption, especially from traditional content creation perspective. On the positive side, the social media trend is very powerful marketing channel, a way to increase consumer involvement, and an opening for disruptive business models. Social networking has quickly become one of the major communication channels and it is already an integral part of internet culture. Research should focus on identifying of the positive impacts of social media for the European content industry.

3.5.3 User satisfaction and quality of experience

The common wisdom is that the future holds a multitude of new networked services. However, the continuous introduction of these services is not always as fast or as successful as predicted. The process is not limited by creativity or need, but by technical and economic obstacles. There are architectural and security difficulties that need to be addressed, but also user-oriented obstacles. As an example, the operators are very hesitant of introducing new services as it could lead to a disproportional increase of the amount of calls to customer support lines. A wave of customer complaints overloading the support functions lead to increased costs and a damaged brand name. There are many examples of this, for instance the halting of many launches of IP-TV service.

Network operators measure quality of service (QoS) in terms such as bit error ratio, errored seconds, and service availability. Although these parameters are easily measured, they have little

meaning for the user. Quality of experience (QoE) is what is perceived by the user and is obviously key for emerging and future services. New content distribution services will first need to equal the QoE of their existing counterparts (for IPT-TV examples would be artefact-free, no picture freezing, fast zapping times) and offer new features often using interactivity (Time-shifted TV, access to more content, 3DTV with feeling of presence).

The huge variety of communications alternatives will lead to different requirements per customer, whose needs will also be dependent on parameters like time, place, and mood. To introduce new services successfully, the networks of the future should learn from the way the users are communicating, what services they are using, where, when, and how, and adapt accordingly.

The research question is, how can quality of experience be measured, to give results that are helpful in service development?

4 Conclusion

The research and development work described in this Strategic Research Agenda can be fulfilled through the seventh Framework programme, other international programmes such as Eureka and the programmes of the Joint Technology Initiatives, and the national programmes of the Member States. Some areas will also benefit from cooperation with third countries.

This R&D work will serve to fulfil the NEM Initiative's vision of a leading networked and electronic media industry in Europe, competitive with other business regions, with a regulatory environment favouring the deployment of NEM technologies and open business models and novel revenue generating models. Achievement of this vision will not only maximise economic growth in Europe; it will improve the quality of life for all Europe's citizens, the users of networked electronic media services whose importance has been stressed throughout.

Annex 1: Table of research priorities

The following table gives an careful estimate of the expected significance of different research topics in the domain of networked and electronic media as it was assessed by the NEM community. The forecast has been limited to the year 2013, because it was agreed that any prediction beyond 2013 would be too speculative.

Explanation of the columns

Priority: Estimation of the actual priority of each of the mentioned research topics for NEM

Effort intensity: Educated guess on volume of research necessary and the necessary amount of effort which will need to be spent over the respective time frames

NEM SRA 6 (Version 2008) *List of most important research topics*		Priority + low ++ medium +++ high	Timeline, effort intensity (low, medium, high) 2009 - 2011	 2011 - 2013
3.1 - Content creation				
3.1.1	**New forms of content**	++		
3.1.2	**Representation of content**	+++		
	Modelling formats	++		
	Scene-based content description	+		
	Metadata	+++		
3.1.3	**Tools for content creation and manipulation**	+++		
	Content capture	++		
	Content manipulation	+++		
	Content adaptation	+++		
3.1.4	**Automated semantic annotation**	+++		
3.1.5	**Human language technologies**	++		
3.2 - Networking and delivery infrastructure				
3.2.1	**Intelligent delivery**	+++		
	Network intelligence	+++		
3.2.2	**Quality of service**	+++		
3.2.3	**Network architecture**	+++		
3.2.4	**Home and extended-home networks**	++		
3.3 - Media presentation and content access				
3.3.1	**Authentic, true-to-original media reproduction**	++		
3.3.2	**Virtual reality**	++		
3.3.3	**Dynamic federation of distributed interface devices**	++		
3.3.4	**User-system interaction**	+++		

NEM SRA 6 (Version 2008) *List of most important research topics*		Priority + low ++ medium +++ high	Timeline, effort intensity (low, medium, high) 2009 - 2011	 2011 - 2013
3.4 - Enabling technologies				
3.4.1	**Security privacy and trust**	+++		
3.4.2	**Rights management**	+++		
3.4.3	**Federated services**	++		
	Contextual awareness	++		
	Identity management	+++		
	Personalisation/profiling	++		
	Location	++		
	Billing and payment	++		
3.4.4	**Middleware**	++		
3.4.5	**User number measurement and user behaviour**	++		
3.4.6	**Effective recommendation systems**	++		
3.4.7	**Power management technologies - energy saving**	+		
	Energy efficiency of networked electronic media	+		
3.4.8	**Spectrum economy**	++		
3.5 - Media-related applications and business models				
3.5.1	**Value chain**	++		
3.5.2	**Social networking and media sharing**	++		
3.5.3	**User satisfaction and quality of experience**	++		