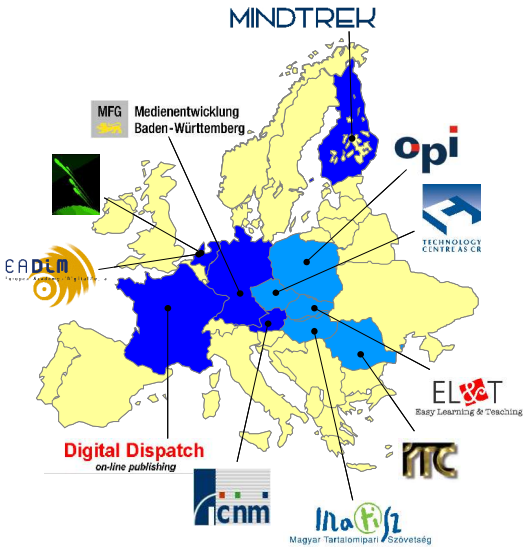
Experience machines: capturing and retrieving personal content

E-Content Report 9

an integrating report by

ACTeN
Anticipating Content Technology Needs



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About this report

This report is an E-Content Report delivered in the context of the EU-funded project **ACTeN** (Anticipating Content Technology Needs).

ACTeN aims at stimulating the development of a European e-content industry by **monitoring the digital media market** and by **transferring know-how in Europe**. As such, ACTeN detects new developments in e-content research and industry and disseminates them to interested parties working in the e-content industry or in related research.

ACTeN disposes of four "instruments" allowing for this transfer:

- continuously monitoring market innovations and publishing them in a **monthly newsletter**,
- facilitating expert discussions in **18 business roundtables** Europe-wide,
- demonstrating best practices in **10 scouting workshops** Europe-wide and
- looking into the future in **2 international scholars network conferences**.

As a result of these activities and together with the help of a number of experts ACTeN provides with its E-Content Reports an overview and analysis of several e-content areas which emerged to be of significance for the e-content industry across Europe. Among them are Paid Content, E-Learning, Mobile Content, Cross Media and the Internationalisation of the content industry.

If you want to stay abreast of EU-wide trends in the e-content industry then subscribe to ACTeN's newsletter at **www.acten.net** which informs you about the upcoming E-Content Reports. They are available in printed form as well as electronically from the ACTeN website as downloadable texts. For your convenience, the electronic versions of the E-Content Reports are also linked up with relevant other information sources on the ACTeN site, thus providing an as broad coverage of the area at stake as possible.

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by ACTeN-Anticipating Content Technology Needs
Author of this report: **Peter Werkhoven**

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Introduction

Fundamental to human existence is the ability to capture, memorize and retrieve personal experiences and to share them with others. Can systems help us to capture and retrieve experiences? After motors have supplemented our *muscles* and sensors have supplemented our *senses*, emerging computer systems are on the verge of becoming intimate supplements to our *memory*. New generations of sensor technology, interaction methods and semantic computers enable the capturing and interpretation of a person's daily activities and the pro-active assistance of these activities. Semantic computers are the engines of rich digital autobiographic archives that are intuitively accessible for retrieval of *personal content*. New interaction methods turn computers into *experience machines* that allow a new and deeper sensory awareness of environmental, bodily and cognitive processes. We will see entirely new ways of experiencing information through combinations of sensory modalities (multimedia) and translations between sensory modalities (syntaesthetic media).

This paper describes the value and exponential growth of personal content, the urgent need of consumer applications to manage and utilize this content and challenging dilemmas related to capturing and sharing personal content.

History

Early visionaries

The visionary road towards experience machines was laid out by Dr Vannevar Bush in 1945. Bush was head of the US Office of Scientific Research and Development and coordinated the activities of some six thousand leading American scientists in the application of science to warfare (Nyce and Kahn 1991). He wrote down his vision in an essay "As we may think" for the Atlantic Monthly in 1945. Bush foresaw the development of the Memex. The Memex was to serve as an aid to memory. Like the brain, Memex would file material by association and could be consulted with exceeding speed and flexibility. With a keypress it would run through a "trail of thoughts". Obviously his ideas of "associative indexing of information" are closely related to the concept of "hyperlinks" on the internet as we know today. Further, Bush foresaw Cyclop cameras that are worn on the forehead and can photograph anything you see and want to record. To record all this he

foresaw the microfilm that could reduce the Encyclopaedia Britannica to the volume of a matchbox. He based his visions on electro-mechanical devices, which is not surprising because the world's first electronic calculator (the ENIAC) was yet to be built and the transistor had yet to be invented.

According to Bush the Memex would lead to a total experience of observations, opinions and decisions of ourselves, friends and authorities. The Memex would be an intimate supplement to our *memory*. It lasted until 1966 when Douglas Engelbart realised the first step of Bush's vision on man-machine interaction by demonstrating a desk-top personal computer with innovative interaction tools (basically the current PC, including videoconferencing) and entirely new ways of organising information (basically hypertext).

Why would we want a Memex?

Our natural human memory enables us to store, retrieve and associate information in a miraculous way. Memory access is direct, without the interference of interfaces that characterize digital memories such as keyboards, spoken commands or gestures.

However, the very brain mechanisms that make us so good at creativity and aesthetics seem to result in a poor capability for the memory of details. In the course of time information becomes "inaccessible". First, this may be due to the blending of pieces of old and new information into more general and abstract schemes. Second, our association methods may change when we grow older. Memory is at the service of expectations. In fact people record experiences for the person they will be in the future, a customer with the same name but whose wishes are yet unknown. Third, fatigue, stress and emotions can hinder the access to our memory.

This is where an intimate supplement to our memory would come in to support us in accurately retrieving information. It could illustrate topics discussed with others, structure and order information for us in time, or recognize patterns and people. In such a way personal digital archives would naturally become interwoven with our daily activities and communication.

The growth of digital personal content

Nowadays we see that sensors and computing devices are miniaturized, that text, sound and images are represented digitally and that people are connected through wired and wireless networks. We are gradually embedded in Body Area Networks consisting of sensor, actuator and communication devices that form extensions of our

natural sensing and motor systems.We have started using personal digital assistants (PDAs) to manage address books, calendars and "things to do" while we are on the move. Nowadays, PDAs are organisers and storage devices for sound, music, images and personal notes and connect us to the information world on internet and form communication channels to colleagues and friends.

To bridge the traditional world and the digital world consumers have started to digitize experiences captured on traditional media such as paper, plastic en magnetic media. Until now our autobiographic archives consist of drawings, photos, videos, notes, tapes, financial and medical files, stored in various corners of our houses and offices. These archives are often incomplete, inaccessible, without labels and fragmented. Some of them even gradually decay. In the digital era all these media are digitized and stored in electronic networks, which are accessible through hand-held devices. Digitization may save our memories. New experiences are directly captured with digital photo and video cameras, with mobile phones, body sensors for heart rate and blood pressure, etc.

Collections of personal content on PCs grow exponentially because people share their collections. When we experience an event, we rely on the aggregations of other experiences and experiences of others to shape the experience.

The digital archive of even one person in 2020 is likely to consist of Peta-bytes of linked images, documents and audio; the potential for extracting useful knowledge from this archive is stupendous, and only limited by our imagination.

Management of personal content?

Interestingly, tools for managing personal content have not come much further than media players, image browsers and calendars. Even digital information about an activity or about a person lives in many different information worlds such as email folders, document folders, address books, calendars, audio-visual databases, web-sites, and phone conversations. All too often, these worlds have unrelated structures and varying or non-existing indexing rules. Moreover, the storage systems have no semantic understanding of their content and interconnections. It is therefore impossible to integrate these information worlds into a sufficiently complete "story" or "experience".

There is a great need for tools to analyse a filter personal content at a semantic level and tools for organizing personal content conform to the mental representations of their users. Last but not least, we are

desperate for tools that help us integrate, organize, retrieve and experience previously captured content. Nowadays, Virtual Reality is commonly used to experience computer generated synthetic worlds for the purpose of design, training and entertainment. However, tools for experiencing our own personal content or "real reality" are scarcely out of the egg and often limited to only a few scientific frontiers. The average consumer is left with an intimate but *inaccessible* digital supplement to his autobiographic memory.

Companies such as Microsoft do recognize this problem. The software in the MyLifeBits project is designed to support people with the annotation, clustering and rating of personal content and with quickly retrieving the right information at the right time. Although these efforts are presented under names like "surrogate brain" the focus is more on storage and retrieval than on cognition and experience.

Remarkable progress with respect to experiencing "real reality" has been made by Steve Mann (University of Toronto) who, for the last thirty years, has worn a headset (wearable wireless webcam) as if it were a part of his own body. This vision system not only records daily experiences, but also provides intelligent feedback based on these recordings. It acts as a personal visual assistant and allows him to record, interpret and "augment" his everyday experiences.

Towards experience machines

Combining these two developments we may expect to witness the evolution of wearable digital autobiographic archives. Nowadays personal digital assistants help us with planning, address information, communication and making notes. Soon they will be able to capture our environment audio-visually and store our perceptual experiences. They turn into personal content managers. Personal content managers will be able to capture, filter, store, analyze and retrieve continuous streams of audio and video. They will be able to understand sensory information at a semantic level and proactively support us in our navigation and conversation by presenting personal content at the right time and the right place. They will help us recognize people and places. In the end personal content managers will turn into *experience machines* and will provide experience on demand.

Experience machines will let us share multimedia experiences across networks, pass experiences on to others and to next generations. This development is in line with Waterworth's observation that most computer artifacts that are currently in interactive use function not as 'cognitive' tools (tools that help the user process information better) but as sensual enhancers, as essentially perceptual artifacts (URL: Waterworth).

Virtual reality techniques make it possible to experience synthetic worlds based on computer models of geometric objects and visualizations of abstract data. This gives us the opportunity to experience working on the bridge of a ship before it is built. If computers were able to analyze and model the structure of the real world fast enough we would be able to remotely experience real world scenes in real time. This would allow tele-presence. For example, this would upgrade watching the world cup finals on television to experiencing running around between the players - real time - without really being there. The next step is not to model the actual real world, but to model the past based on a person's digital memory of autobiographic multimedia data. We will then be able to re-experience the first time we kissed a girlfriend, including multimodal feedback about what we saw, heard and said, and various forms of bodily and contextual information.

Further we can share and integrate archived personal experiences from many persons into a "collective experience" yielding fascinating applications in the field crisis management and rescue teams.
Confidence in the further realization of Bush's vision is reinforced by recent advances in areas such as search technology, computer vision and graphics, natural language processing. Real world modeling techniques are being developed in the robot vision world. Recent successes in machine analysis and machine learning have indicated that many of the problems that were previously considered hard enough to require cognition are in fact solvable in a purely data-driven manner.

The Market

Experience machines are fed by the personal content of their users. Users or consumers become producers and distributors of their personal content and experiences. The amount of personal content stored on hard disks is already huge and will grow exponentially because also information flows such as telephone calls and email are expected to be systematically archived in the near future. The market for adequate tools to adequately manage, share and experience this content is huge.

How much content is there world wide?

The School of Information Management and Systems at the University of California at Berkeley (URL: How Much Information) analyzed information storage and information flows world wide for the year

2002. They estimated the annual size of new information recorded in storage media, and heard or seen each year in information flows. The following conclusions were drawn:

Recorded information (print, film, magnetic, and optical storage media):

- Print, film, magnetic, and optical storage media produced about 5 Exa-bytes of new information in 2002 (1 Exa-byte = 10^9 Giga-bytes = 10^{18} bytes). 5 Exa-bytes are equivalent to 37000 the content of the Library of Congress collection. It should be noted that the lower bound of this estimation is 3.4 Exa-bytes after correction for compression and duplication of content.
- The category "magnetic" (representing 92% of the total) includes videotape, audiotape, digital tape, miniDV, floppy disk, zip, audio MD, flash and hard disk. After correction for compression and duplication videotapes make up for 39% of this category, MiniDV for 37% and hard disks for 12%.
- The category "film" (representing 7% of the total) includes photographs, cinema, films made for TV, TV series, direct to video, X-rays. Photographs make up for more than 50% of this category.
- The category "paper" represents only 0.01% of the total.
- New stored information grew about 30% a year between 1999 and 2002.

Non-recorded information (information flow such as telephone, radio, TV and internet):

- Information flows contained almost 18 Exa-btes of new information in 2002.
- Telephone calls make up 97% of the total information flow, including both voice and data on both fixed lines and wireless. Most of the calls are person-to-person. Only 13% of the calls are wireless.
- The second largest component of information flows is the Internet (3% of the total information flow). Email is good for 83% of this component. Email generates 400.000 Tera-bytes of new information each year with 31 billion emails sent daily. One third of email traffic is personal.
- The World Wide Web contains about 170 Tera-bytes of information with 2.1 billion static web pages.
- These information flows are expected to be systematically archived in the near future.

How much personal content is produced per person per year?

Based on a world population of 6.3 10^9 almost 800 Mega-bytes of recorded information is produced per person per year. Videotapes and miniDV are dominant magnetic media, mostly containing personal content. The storage on hard disks is expected to grow due the use of digital cameras. In 2002 about 28 million digital still cameras were purchased world wide, compared to 63 million analogue cameras. Consequently, the total number of digital images created annually in the US is expected to rise from about 14 billion in 2000 to 47 billion in 2004. Interestingly, owners of digital cameras take three times as many pictures (700 a year, see PMA meeting 2000) as owners of traditional cameras.

The most dominant information flow is telephony which accounts for three times as much digital information per person per year than recorded information. With the advance of Voice over IP (VoIP) and the integration of VoIP with PC applications we may expect most of the digital information flow to be stored, adding to a total growth of 2900 Mega-bytes of content per person per year.

Expected "personal content management" products

Already digital personal content surpasses professional content by far and is expected to be ever-increasing. It started with multimedia documents, digital communication (internet), the digital acquisition of photos, video and music and the use of PDAs for basic office applications. In the next decade we will see a more systematic and automated acquisition and storage of sensory data and information flows, feeding into what may be called our "prosthetic memories". During this evolutionary process we will see a need for products like:

- *Personal archive manager*: This manager relates the structures and metadata of digital information from various sources into a coherently accessible personal archive. It integrates sources at a semantic level, e.g. email folders, document folders, address books, calendars, audio-visual databases, web-sites, and telephone conversations.
- *Briefing assistant*: automatic updates/ briefing before going into a meeting or conversation. Mental workload of a person is usually determined by three factors: the level of knowledge based working, the time left to finish a task and the frequency of task switching. The last factor causes the person to switch between mental models and task context which are "expensive" operations. The briefing assistant could reduce work load by bringing us back to the status, context and actions points of a task as captured at the moment of switching to another task. First prototypes of wearable briefing assistants have been

produced at MIT and named Remembrance Agent (Rhodes, 1997). It displays one-line summaries of notes-files, old email, papers, and other text information that might be relevant to the user's current context. These summaries are listed in the bottom few lines of a wearable head-up display, so the wearer can read the information with a quick glance. Briefing assistants can also improve conversational skills for patients with Alzheimer's disease as showed clinically by Bourgeois (Bourgeois, 1990).

- *Intelligent illustrator*: Nowadays, people are slavishly dictated by their Powerpoint presentations or photo-albums. In the near future we will see forerunners of experience machines in the form of content management systems that support us during conversations or presentations by providing the right illustration at the right time based on dialog based topic detection and agenda based context extraction.
- *Prosthetic memory:* a real time visual recognizer based on a camera built in your sun glasses. It recognizes people, traffic signs and buildings based on personal experiences and external databases. First prototypes of visual prosthetic memories have been constructed and used by Steve Mann, including wearable face recognition and "déjà vu" functions (URL: Wearcam).
- *Collective experiential system*: a synthesized global perspective of multiple ongoing and archived personal experiences. First prototypes have been developed and tested for rescue workers and crisis managers in the Informedia project "Experience on demand" by Wactler et al. (URL: Informedia).
- *Knowledge extractor*: extracting useful patterns and knowledge from unlimited personal archives with application areas such as medical informatics and criminal investigation.

The Business mode and work flow

Open standard, open research

Certainly there is commercial interest in better ways of organizing, integrating, searching and interactive presentation of personal content. Many commercial enterprises are built around search technology, and have an interest in extending the types of data which can be searched. However, most commercial R&D is focused on short-term incremental improvements. Long term research is necessary to develop robust and trusted management tools for safeguarding your digital memories. Privacy and trust will become extremely important issues when

personal content is concerned, let alone secure accessibility at any place and any time. The successful development of universally trusted protocols may require that no central authority controls privacy, and may depend on open standards and open research.

Sharing personal content

Basically the sharing of multimedia personal content is a consumer-to-consumer economy. Experiences can be shared for free (P2P) or can be commercialised for entertainment or educational purposes, resonating with the concept of the "experience society" described by Pine and Gilmore (1999) and the "dream society" analyzed by Jensen (1999). In fact the TV "reality soaps" in which we share the experiences of well known personalities are first examples of personal content sharing. Broadcasting your activities or even your aquarium on the web are first examples of P2P "content sharing".

Service providers facilitate this process by providing storage and transport networks, retrieval tools, and perhaps, by acting as experience brokers.

Multiple business models

Business models for internet commerce can be defined and categorized in the following basic categories:

- *Brokerage model*: bringing buyers and sellers together. A broker charges a fee for each transaction facilitated and usually operates in the B2C, B2B and C2C markets. Example: eBay.
- *Advertising model*: an extension of the traditional media broadcast model in which content and services are provided mixed with advertising messages which may be the sole sources of revenue. This model works when viewer traffic is voluminous or highly specialized. Example: Google.
- *Infomediary model*: collecting, analyzing and selling data about either consumer behavior (for marketing campaigns) or about producers and products (for buyer assistance). Example: Nielsen.
- *Merchant model*: wholesalers and retailers sell manufacturer goods and services based on list prices or through auctions. Example: Amazon.
- *Manufacturer model*: companies sell their products directly and compress the distribution channel. Success is based on efficiency, improved customer service and a better understanding of customer preferences. Example: Dell Computer.
- *Affiliate model*: affiliates provide user click-through to merchants. Merchants pay per click or offer a percent-of-sale. Example: Barnes & Noble.

- *Community model*: voluntary contributions and open sharing of content, software and knowledge by community members. Revenue is generated from related services like systems integration, product support, tutorials and user documentation. Example: Red Hat.
- *Subscription model*: users are charged a periodic fee to subscribe to a service, independent of actual usage rates. Example: America Online.
- *Utility model*: this "on demand" model is based on actual usage rates like traditional metered services such as electricity and water. Example: Telephony companies.

The business models for commercialising tools and services for managing personal archives, for mobile access and for experience and sharing of personal content fall into different categories. In particular: the Manufacturer model (direct sales of management tools and services), Utility model (mobile access and experience) and Community model (sharing experiences). The analysis of personal archives and knowledge extraction for medical or financial purposes may fall into a variant of the Infomediary model in which the results are sold to the user himself. A sort of Infomediary model for content management is seen in the UK where companies commercially exploit services such as content management and access of medical records.

Challenges ahead

The evolution of experience machines is driven by tremendous scientific and engineering challenges in the area of non-intrusive multimedia event capturing, real-time storage and semantic analysis, intuitive interaction techniques with wearable devices. Further, we have to tackle numerous questions related to the protection and sharing of digital experiences.

Experience capturing
Multiple sensor and multiple perspective acquisition techniques for capturing the environment, actions and context of an event are needed.

Capturing techniques include traditional sensors for 3D sound and 3D sight that are well developed and even surpass human capabilities and sensors for touch, taste and smell that will be developed relatively soon. And not to forget the registration of bodily information such as body movement (including gestures), heart rate, blood pressure, transpiration as indices of emotional behaviour. Capturing techniques also include the registration of environmental parameters such as

position and height (GPS), temperature, humidity, wind force and sun power. Wearable sensors are part of the personal area network and can be embedded in hand-held devices (PDAs, phones), in head-mounted devices (eye glasses, ear pieces) or in clothes (smart clothes). For first prototypes of visual capturing devices see Mann and Niedzviecki (2002) and Sawahata & Aizawa (2003).

Moreover, event capturing can make use of fixed sensors in the environment that give you a different perspective and / or public information sources such as radio, TV and internet . Finally, it should integrate the information of wearable sensors of other persons that are actors in the scene captured.

Real time storage and semantic analysis of experiences

Sensor information must be analysed at a semantic level, filtered, combined and stored in a multimedia system.

- *Database systems*: Storage should be for a lifetime and longer, adaptable to new hardware and software, allowing new types of questions to be asked such as age, context and society changes.
- *Storage*: How can we store high volume multimedia data streams in combinations of local and remote and distributed storage devices. To what extent do users trust the usage of remote storage devices for their valuable personal memories?
- *Operating systems*: a person's memory will contain Peta-bytes of data and last for decades. How should these data be stored in a way that maximises accessibility and reliability?
- *Artificial intelligence*: How can we interpret audio and visual data at a useful semantic level, with a minimal amount of annotation and guidance from the person? For example, the automatic recognition of relevant persons, objects, signs etc. How do we transcode semantics across different type of information channels? How do we classify, relate and summarize events and activities, learn useful generalisations from the interpreted data and generate ontologies? What are the relevant data dimensions for future retrieval?

Intuitive interaction techniques for remembering

A proactive natural interaction environment that lets users experience specific content at the right time.

- *User models*: How can we use personal archives to create *personal profiles* that represent people's knowledge, experiences, intents, abilities in a coherent and useful way? How can we adapt interfaces, web pages and documentation so that they are well matched to a person's profile and cognitive maps (Newby, 2001)?
- *Experiential systems*: How can we use different types of sources of information and knowledge about a person's

experience to build a coherent and consistent *multimodal Virtual Reality model* of that experience? What are useful generative models of an experience? We need formal models for *interactivity* and immersion in such experiential systems (multimedia grammars, feedback). We need formal mechanisms of *evaluation* of experiential systems (models, user study methodologies).

- *Display technology*: We need innovative wearable *display techniques* for non-intrusive mobile experience feedback (miniature head-mounted audiovisual displays, foldable displays, retinal projections, etc). For first products in this field see DeVaul et al. (URL: Memory Glasses). How can we use environmental displays for feedback on personal experiences (*ambient intelligence*)?
- *Augmented experiences*: How can we map senses that people lack naturally (e.g. ultrasound, infrared) to our natural senses with the purpose of *augmenting experiences*? How can we map sensory information of one modality to another (e.g. sound to vision or vice versa) for the purpose of adaptation of presentation modes to communication context or sensory disabilities. For developments in this field see (URL: Sensory substitution; URL: Synaesthetic media).
- *Proactive recall*: How can we use a user's speech (subject), location, time, company and context to support him *proactively* in his activities based on previous experiences? Human memory does not naturally operate in a vacuum of query-response pairs. On the contrary, the context of a captured event - such as the physical location, who was there, what happened simultaneously, before and after – provides valuable cues for recall and association with past experiences (Rhodes, 1997; Tulving, 1983).

Privacy and security: Protection and sharing of experiences.

- *Privacy*: Personal digital archives generally contain information about other people (correspondence, pictures). How can we protect people's privacy? Should other people have control over information in other people's memories and how can this b realised? To what extent do we want to share digital experiences with friends or inherit the memories from our parents?
- *Security*: How can we prove both to the scientific community and to the general public that memories are secure from attackers? (see also Fitzgibbon & Reiter, 2003)
- *Lossless memory*: What are the psychological and social impact of lossless personal memories that people inherit from their parents and pass on to their children?

Recent programs and projects

Informedia program (Carnegie Mellon)

The Informedia program at Carnegie Mellon started in 1994 under the supervision of Howard Wactler and is sponsored by the National Science Foundation (NSF) and the Defense Advanced Research Projects Agency (DARPA). The research projects focused on integrated speech, image and language understanding for creating digital video libraries (Informedia I project). In 1999 it was followed by the Informedia II project which concentrated on video information summarization and visualization.

The subject of this paper came into focus in 1997 when a project was started with the name “Experience on Demand” which developed tools, techniques and systems allowing people to capture a record of their experiences unobtrusively, and share them in collaborative settings spanning both time and space. Personal EoD units recorded audio, video, position (GPS) and other sensory data, which could be annotated by human participants. The EoD system synthesized data from many EoD units into a “collective experience” - a global perspective of ongoing and archived personal experiences. The technology could be applied for remote crisis management teams.

Building upon the technology developed under Informedia the project CCRHE was started in 2001. CCRHE (capturing, coordinating & remembering human experience) developed systems enabling people to query and communicate synthesized records of human experience derived from individual perspectives. These records were transformed into meaningful resources available retrospectively. The technology is applied in ongoing projects such as CareMedia in the domain of geriatric care and clinical studies. Through activity and environmental monitoring in a skilled nursing facility audiovisual records are captured and analyzed, thus empowering specialists with greater insights into patient behavior.

MyLifeBits project (Microsoft)

MyLifeBits is a project of the Media Presence Group of Microsoft's Bay Area Research Center (BARC) in San Francisco. The project is both an experiment in lifetime storage and a software research effort aimed at building multimedia databases that chronicle people's life events and make them searchable.

MyLifeBits uses Microsofts enterprise data management platform SQL Server 2000 with Index Server supplying a full-text search (SQL = Structured Query Language). The database scheme is very simple: there is one table for resources, one table for annotation links and one table for collection links. MyLifeBits makes stories easy with Interactive Story by Query (ISBQ). ISBQ enables users to make queries, then drag and drop selections from the query into a story. There are two story types: a slide show and a time sheet. The slide show allows images to be dragged and dropped into a sequence with captions added, an audio clip to be spoken for each image, and audio clips for background music. The time sheet is a composition of multiple time lines. Resources are dragged and dropped into each timeline. It is stored using XML.

The lifetime storage experiment is carried out by Gordon Bell who "has captured a lifetime's worth of articles, books, cards, CDs, letters, memos, papers, photos, pictures, presentations, home movies, videotaped lectures and voice recordings and stored them digitally. He is now paperless, and is beginning to capture phone calls, television, and radio." The MyLifeBits software has been designed to support him with the annotation, clustering and rating of this information and with quickly retrieving the right information at the right time. Articles appear with the titles "Logged on for life", "My life in a Terabyte", "Saving your bits for posterity", "back-up brain", "virtual brain" and "surrogate brain". The focus of these activities, however, is more on storage and retrieval than on experience.

WearComp project (U. of Toronto)

Steve Mann is a professor of engineering at the University of Toronto and calls himself the first Cyborg (Mann and Niedzviecki, 2002). His focus is on wearable computing, capturing and experiencing. For the last thirty years he worn a headset (wearable wireless webcam) as if it were a part of his own body. His glasses actually act as a very compact electronic studio since they contain several lasers, diminutive video-cameras and half-a dozen tiny computers strapped to his body. This vision system not only records daily experiences, but also provides analyses and intelligent feedback based on these recordings. It acts as a personal visual assistant and allows him to record, interpret and "augment" his everyday experiences.

Examples are freeze-frames (enhanced learning), annotated computer induced flash backs (déjà vu's), an agent for remembering places and people, way finding (based on stacks of key frames in video recordings). Further, the system learns from information access patterns.

LifeLog program (DARPA)

In February 2004 the Pentagon canceled its so-called LifeLog project, an ambitious effort to build a database tracking a person's entire existence. Run by Defense Advanced Research Projects Agency (DARPA), the Defense Department's research arm, LifeLog aimed to gather in a single place just about everything an individual says, sees or does: the phone calls made, the TV shows watched, the magazines read, the plane tickets bought, the e-mail sent and received. Out of this seemingly endless ocean of information, computer scientists would plot distinctive routes in the data, mapping relationships, memories, events and experiences LifeLog is not a program to track terrorists, but analysts believe its research may continue on the classified side of the Pentagon.

Shadow (U. of California at Berkeley)

An experience capture system proposed by Landay and colleagues at the computer science department of U. of California at Berkeley in 2001 (URL: Shadow). Shadow is an experience capture system that will enhance our capabilities to recall, find, explore, create, manage, and share information. The basic concept underlying the Shadow is to have a long-lived, roaming, personalized process follow a user wherever he goes and "know" everything he does. The motivation for this is based on a simple premise: events, experiences, and information from our past are useful in the present. Through multimedia capture, inference, and filtering, the Shadow will help augment personal and group experience, memory, and knowledge.

Lifestreams (Yale University)

In their Lifestreams project (1996-2000) Freeman and Gelernter developed a file management system based on time-ordered streams of documents (life-streams) that you created or that other people send you. The stream starts with your electronic birth certificate and contains person centered pictures, correspondence, bills, movies, email, voice mail. Moving beyond the present and into the future, the stream contains documents you will need: reminders, calendar items, to-do lists. Lifestreams provides contextual cues for managing information and allows to label future events, such as meeting times that trigger alarms shortly before they occur. (URL: Lifestreams; Freeman and Gelernter, 1996).

ACM Workshop CARPE 2004

Finally, the research community has organized the first ACM Workshop on Continuous Archival and Retrieval of Personal Experiences (CARPE 2004, October 15th in New York). This workshop will bring together researchers from around the world to share their findings and insights into this burgeoning field.

Outlook

Memory overload?

With digital memory "*the past is always here and always perfect; everything can be represented, no moment be lost. Moreover, all of it is as good as new, and every copy identical to the original. What's missing is a cadence, a play of values, or a respect for the way loss informs our experience of time. Like the map that's as big as the world itself, it's useless precisely because it's too good*" (Lewis, 2003).

Obviously people worry about the dilemma that if you record 24 hours a day, seven days a week you'll never have time to "watch". And indeed, you cannot watch *everything*. Recordings should be presented at the right time in a form that is optimally attuned to the task and context of the "owner" of the digital memory. The fact that everything is recorded does not mean that everything has to be watched or remembered. It is recorded all because the owner does not now a priori which selection will be of value in the future.

More generally, perception and introspection (remembrance) should be in balance. Norman (1992) says that normal brain functioning requires the right balance between two modes of functioning. The first mode is driven by our sensory data and externally controlled by signals from outside, including the signals from external forms of memory. The second mode, called conceptually driven processing, the mind drives itself and develops and invents new concepts and thoughts. Excesses of the sensory driven mode may cause solitary thinking to disappear, along, perhaps, with creativity and invention.

Organisational content and personal content

Not surprisingly individuals usually organize their stored information in a way that differs strongly from organisations. The effectiveness of dealing with personal content is optimal when its organisation is *ego centred*. That is, when its structure and presentation optimally serve the owner's skill, task and context. From a person's perspective personal content serves a lifetime and its value is in feelings, lifelong learning, social activities, privacy and entertaining. Professional organisations, however, are more and more *project centred* and aim for knowledge based value creation. High priority issues are validation, consolidation, knowledge sharing within the organisation, intellectual property rights, security and protection.

Ego centred and project centred organisation of content conflict in many ways. In a project centred organisation, documents and correspondence is usually organised in projects with inflexible formats, quality standards and limited lifetime. Bilateral communication is often facilitated by non-recorded information channels. Consolidated knowledge is "published" to the organisation and its accessibility by colleagues depends on their role in the organisation and the classification of documents. For security reasons content is usually "imprisoned" in enterprise information systems and strictly separated from personal content.

Personal content is much more oriented to keeping memories alive and share them with friends. Experiences are best with audiovisual representations, not documents. And, in contrast to project centred information, personal information is extremely fragmented and stored in many formats. Additionally, the value of company information usually decreases with time, the value of personal content increases with age. And most of all, it is all about the person's life which has a time span far beyond the duration of a project.

A person's work, however, is part of his life and part of his experiences and thus should be integrated into his personal archive. An interesting challenge is to relate organisational content and personal content such that security and property rights are respected.

EC funding opportunities

The subject of personal content has received only fragmented and incomplete attention of the European Commission in 4th and 5th Framework Program (FP). Projects were aimed at related topics such as semantic web and immersive presentation systems. For example, in the FP4 we saw projects such as ECRAN (Extraction of content: Research at Near-Market, 1995-1997) and BAKE (Bayesian Knowledge Extractor, 1998-2000) aimed at the automated extraction of structured and reusable knowledge from databases. In FP5 projects were launched in Future and Emerging Technologies aiming at semantic web technology and ontology generation (IBROW, Intelligent Knowledge Broker for the www). Although knowledge extractors and briefing assistants can exploit these results, an integral approach of experience machines for personal content was missing.

The development of personal assistants is addressed in the SPECTER project funded by the German federal Ministry for Education and Research (www.dfki.de/spectre). This project aims at monitoring

user's actions and affective states and at generating context appropriate recommendations.

In preparation of the 7th Framework Programme, the European Commission asked the IST Working Group on Grand Challenges to assess the future of IST technologies and their influence on European society. The Working Group identified concrete visionary projects, focusing 8-10 years in the future, focussed at application domains of particular promise for growth in Europe. Interestingly, two projects are strongly related to personal content and the experience machine:

- The Augmented Personal Memory: create, preserve, sort and retrieve your own personal archive of the past, in the form of a personalised digital life diary and augmented memory assistant.
- The Personal Everywhere Visualiser: convenient personal and mobile visualisation systems that will work anywhere with great comfort.

Obviously the integration of technology for the purpose of managing personal content is most pronounced in the USA. A strong vehicle for this seems the notion of large volume of 'Man on the moon' programs to direct research efforts towards appealing and high impact applications in combination with a passionate "marketing" of these programs. Research programs in Europe seem more focused on scientific results in sub-fields, less on the integration of technology and seem to put less efforts in the marketing of applications.

Future funding should be allocated in a *European Experience Machine program* comprising the integration and application of multimedia acquisition and analysis techniques, user and real world modelling techniques, multimodal display technology in combination with knowledge about user behaviour and business models. The program will yield various spin-offs in the field of personal content management applications as described in section "Major Market and technological developments".

Further Information

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About the author

Peter Werkhoven obtained his Master of Science in physics (with a minor in computer science) in 1986 (cum laude). He received his PhD degree in Physics from Utrecht University in 1990 on research in

image processing and human visual motion perception. At that time he moved to New York where he held a position as Associate Research Scientist at the Psychology Department and Center for Neural Science, New York University. At NYU he carried out research on the mathematical modelling of human motion and texture perception.

In 1992 (back at Utrecht University) he carried out research on human perception of 3D spatial structures and he coached various PhD students.

As of 1994 he held various positions at the TNO Human Factors Institute: group leader Ergonomics (1994-1998), group leader Steering & Control Tasks (1998-1999) and head of the Department of Information Processing (1999-2000, 25 researchers). During that time he was in charge of many research programs in the areas of Virtual Reality, mediated communication and man-machine interfaces. He has published over 40 scientific papers and over 30 scientific TNO-reports on contract research.

In November 2000 he was appointed director of the TNO-business centre Multimedia and Telecommunications where he was responsible for the development of public-private research programs and contract research in the area of ICT. He is co-founder of the ambitious research consortium MultimediaN.

September 2001 he became full professor in “multimedia interaction” (part time) at the University of Amsterdam. Currently he is the director of the Information Office at TNO (corporate ICT staff, 40 employees) managing the change process of making TNO a leading organization in the area of information and knowledge management.

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