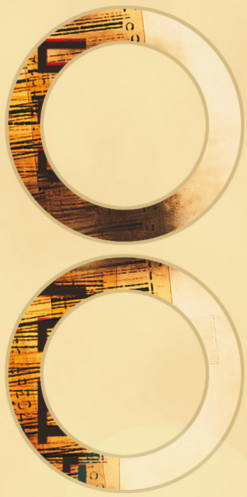
EP2010 – THE FUTURE OF ELECTRONIC PUBLISHING TOWARDS 2010

A strategic study on the future of research into publishing, content and knowledge technologies

http://ep2010.salzburgresearch.at/

DOSSIER on Smart Content as proposed vision for future RTD



September 2003

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Content

1 Acknowledgements

The strategic study *EP2010 - The Future of Electronic Publishing Towards 2010*, was conducted by Salzburg Research on behalf of the European Commission, Information Society DG – E2, Knowledge Management and Content Creation.

We especially like to thank the EP2010 Steering Committee for its insightful critiques and constructive recommendations:

Brian Blunden, International Electronic Publishing Research Centre IEPRC, UK

Pascal Jacques, European Commission, DG Information Society, Unit E2, LU

Roberto Minio, KnowledgeViews Ltd., UK

Erich J. Neuhold, Fraunhofer IPSI, DE

Steven R. Newcomb, Coolheads Consulting, USA

Philippe Wacker, European Multimedia Forum, BE

Further, we would like to express our appreciation to all the experts who participated in the study at various points:

Anne Bergmann-Tahon, Federation of European Publishers, BE

Henrik I. Christensen, Centre for Autonomous Systems, Royal Institute of Technology, SWE

Arnoud De Kemp, Springer Verlag, DE

Kurt Englmeier, Deutsches Institut für Wirtschaftsforschung, DE

Nils Enlund, Royal Institute of Technology, SWE

Brian Green, PA / BIC / EDItEUR, UK

Aphra Kerr, Centre for Society, Technology and Media (STeM), Dublin City University, IRE

Wolfgang Maass, =mcm Institut, Universität St. Gallen, CH

Mark Maddocks, Reed Elsevier, UK

Frank Nack, National Research Institute for Mathematics and Computer Sciences CWI, NL

Jason Rutter, ESRC Centre for Research on Innovation and Computation CRIC, UK

Roger Seaton, Independent Consultant, UK

Ralph Traphöner, empolis GmbH, DE

Cornelia Waldenmaier, Börsenverein des Deutschen Buchhandels, DE

Thanks also to the reviewers:

Jan Bierhoff, European Centre for Digital Communication EC/DC Infonomics, NL

Mark Maddocks, Reed Elsevier, UK

David Worlock, Electronic Publishing Services Ltd, UK

We also would particularly like to thank the European Commission, Information Society DG – E2 Knowledge Management and Content Creation, for the opportunity to perform this study:

Roberto Cencioni, Head of Unit

Pascal Jacques, Head of Sector

2 Introduction

2.1 Background to the EP2010 study

In October 2002, the former Information Society DG's Unit D1, Electronic Publishing, commissioned a strategic study entitled "The Future of Electronic Publishing towards 2010" (EP2010). The focus of this study was to draw up a road map for relevant technology research and development for the interactive electronic publishing industry. Since then however, triggered by internal restructuring of two units, Electronic Publishing and Knowledge Management, to form Knowledge Management and Content Creation (KMCC), the EP2010 study has had an "interesting career" shifting its focus towards the research issues surrounding Knowledge and Content Technologies for a prospective Knowledge Based Economy in 2010. The shift occurred by consensus of all stakeholders including those representing interactive electronic publishing, which is also reflected in the new title of the study, "The Future of Research into Publishing, Content and Knowledge Technologies for the Knowledge-Based Economy".

Despite the changed focus, the original objectives have proven a good choice that still sits comfortably with the ground covered in the work.

2.2 Objectives

The primary objective of EP2010 is to provide key orientations for policy makers and input to concrete implementation measures. In particular, the study aims at ...

Providing information for policy makers in Information Society DG – Unit E2, Knowledge Management and Content Creation

The remit of the Information Society DG's Unit E2, Knowledge Management and Content Creation is very wide – policy makers need a roadmap of major research strands, technologies and possible emerging markets in order to assess the effectiveness of funding measures that can only be springboards for private sector investments. This kind of "governance" through strategically placed funding requires an undistorted picture of the RTD landscape.

Fostering dialogue between industrial and public sector stakeholders

Fulfilling the vision of Europe as a leading knowledge based economy will require, both regulatory and funding support for technology research and development. Policy makers need a thorough understanding of the interplay between the potential shortcomings of regulatory frameworks, and the effectiveness of RTD in markets where such regulatory inhibitors exist. The knowledge management and content creation area needs to identify the major fault lines that exist within its field. Examples for such fault lines are differences between US and EU law with respect to software patents and different approaches (and commercial interests) with respect to copyright legislation in the digital domain which may affect the roll out of research results. Although aware of those issues, it was decided to not cover regulatory and legal issues within this study as they clearly lie outside the remit of Unit E2.

Giving input towards the evolution of RTD work programmes

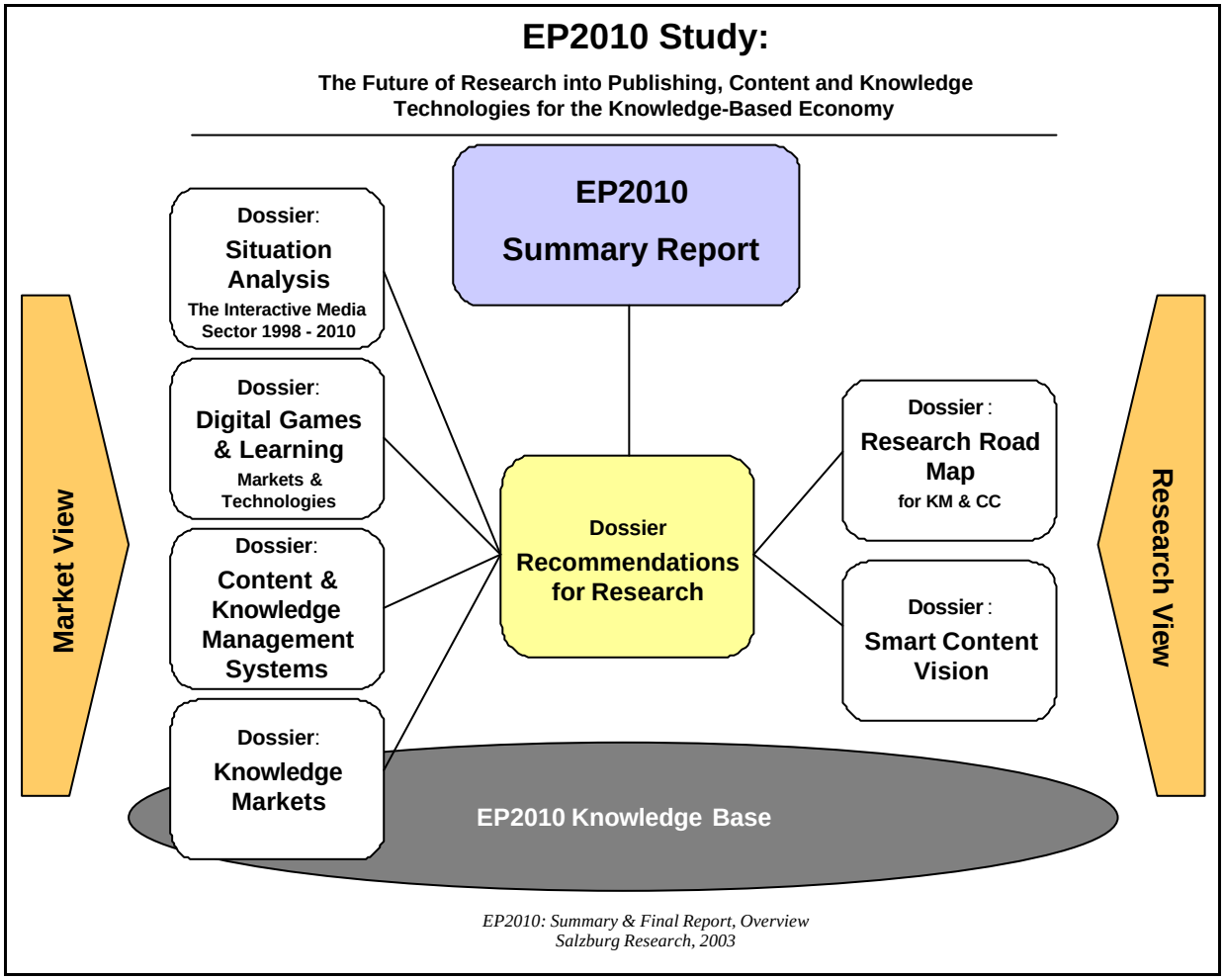
The actual success of the RTD programme rests on the willingness of researchers to take up the challenges, and on the willingness of the private sector to invest in the proposed RTD programme. One major traditional industrial constituency of the Knowledge Management and Content Creation unit (KMCC) has in the past been the publishing sector. For the Sixth Framework Programme, researchers and industrials in knowledge technologies are entering into the frame. The key concepts of a knowledge based economy need to be defined in more detail before investors buy into its vision. Major shifts in research agenda may be required to address some of the challenges. For example, natural language *generation* may be more interesting and have larger industrial uptake than natural language *recognition*. As knowledge and content technologies converge there is a need for infrastructures that are able to support both the creation of knowledge and its packaging as content.

Therefore, based on a thorough analysis of current technologies, markets and trends, the intended contribution of the EP2010 study is threefold:

- Firstly, develop a *Research Map* of those themes of investigation that impinge on KMCC;
- Secondly, derive from the larger visions of Semantic Web, Ambient Intelligence, and new forms of Content Generation and Distribution a set of *Recommendations* that implement the *Research Road Map;* and
- Thirdly, investigate the buzz word concept of "Smart Content" to test whether it could provide a coherent vision for longer term research lines in KMCC.

2.3 Structure of the EP2010 study

The EP2010 study consists of seven thematically focused dossiers that create the argumentative basis for this Summary Report. These dossiers are: Recommendations for Research, Research Road Map, Smart Content Vision, Situation Analysis of the Interactive Media Sector, Digital Games and Learning, Content and Knowledge Management Systems, and finally, Knowledge Markets.



The entry point to the study is this *Summary Report*, which presents – in response to the primary objectives of the study – key technology research challenges and a set of selected, top level recommendations that address these challenges. In addition, the Summary Report outlines the concept of Smart Content as a vision that could direct and drive future RTD in the area of publishing, content and knowledge technologies.

In the dossier on *Recommendations for Research*, we outline the research recommendations in more detail by providing the reasoning behind our arguments as well as assessment, following a matrix that evaluates recommendations with regards to their leverage effect for the commissioning Unit, their timeliness and contribution to EU competitiveness as well as their impact on becoming the most competitive knowledge-based economy. Furthermore, the dossier provides additional recommendations on various issues that we consider important and worth keeping on the radar, yet, which did not "pass the threshold" to be included into the Summary Report.

The research recommendations are closely related to the *Road Map for Research*, which on the one hand highlights the future research fields in the area of knowledge management and content creation and on the other hand suggests how to tackle those research challenges by implementing three research strands:

- *foundational* research addressing "grand challenges" such as human-like systems behaviour,
- *application-oriented* research in content-driven domains such as broadcasting, and
- *co-operative systems* research addressing the systems integration aspects and interoperation of across systems platforms at a semantic level.

The last dossier that takes a strictly technology-driven research perspective is entitled "Smart Content". With the smart content concept we intend to introduce a unifying vision for knowledge management and content technologies and any activities pertaining to digital content value chains. Making a first step towards a hype-free definition of smart content, the dossier outlines desirable features (and behaviours) of smart content for users, tries to identify the technical requirements and the architectural characteristics of a "smart content system", and finally, presents an abstract technical view on the core properties that would support most of the above.

In contrast to the strict RTD perspective that we have adopted for the first three dossiers, the last four dossiers try to underpin the suggested research road map from a market perspective.

In the *Situation Analysis*, we first set the scene by describing the development of the interactive media sector, outlining the situation from 1998 until today, and then providing a hypothetical preview for 2010. In the situation analysis we take a closer look at the factors that influence future development, the general economic, legal and political framework, the demand as well as the supply side, and finally point out the major trends that will influence development towards a knowledge based economy.

Digital Games & Learning investigates one of the most promising application areas for future publishing, content and knowledge technologies, highlighting the fact that there is much to learn from the games industry when it comes to developing engaging learning products and environments. The RTD challenge for game-based e-learning environments lies in the careful match of pedagogy and technology in high-end environments, which demands a systematic analysis and exploration of the interdependencies of knowledge structures (e.g. ontologies), learning processes (e.g. single vs. multi-learner settings in collaborative problem solving), and presentation (e.g. dynamic, 3D and real-time forms of presentation).

The dossier on *Content and Knowledge Management Systems* takes a closer look at the current providers of knowledge and content management technologies, who are also potential carriers and partners for future RTD in the field. However, despite knowledge and content technologies still being on the business agenda, the market is clearly dominated by US companies. This situation led us to the conclusion that European RTD effort should be planned and targeted at the next generation of these technologies, instead of trying to win the current technology round.

Finally, *Knowledge Markets* examines a more recent trend, the emergence of electronic knowledge market places on the web. As knowledge management means a considerable investment for companies, organisations today are increasingly looking for opportunities to capitalise on their knowledge assets by trading them in knowledge market places. Yet, success for those marketplaces is not a foregone conclusion. The dossier looks at the five key challenges that influence the success of electronic knowledge trading and analyses a range of current knowledge markets, which allows to draw conclusions and make recommendations with regards to future research.

In addition to the dossiers, the EP2010 study also provides access to a *Knowledge Base* which comprises a selection of primary research papers and studies that underpin the arguments made within this study, and link to external resources for further reading. All these resources can be found on the EP2010 web site at http://ep2010.salzburgresearch.at/ as well as the EP2010 CD-ROM.

3 Executive summary

The buzz word "Smart Content" was agreed as a term to describe a unifying vision for knowledge management technologies and any activities pertaining to digital content value chains. The study makes a first step towards a hype-free definition of smart content in order for the term to serve this purpose. It will be the task of research and development projects to demonstrate how their results will add value to the common vision, in the interest of making Europe one of the leading societies in the emerging knowledge economy. We focus on defining a small set of key properties for Smart Content.

We envision it to be self-describing; smart content systems to be interoperable with all other content systems, and all smart content to be semantically compatible with other smart content while keeping its original identity, thus enabling content aggregation without piracy. The purpose of this vision is to lay a technological foundation for the emerging knowledge economy.

In this dossier, we approach the notion of smart content from four angles:

- Smart content **user** perspective: a set of desirable features exhibited by smart content in an appropriate environment, as perceived by people in different roles.
- Smart content **requirements** perspective: a set of technical requirements as perceived by players in the value chain, i.e. producers, providers and end users, based on analysing the desirable features.
- Smart content **system architecture** perspective: a general architecture indicating a possible division of labour between pre-defined data structures and sets of functionality making use of the structures.
- Smart content **key properties** perspective: an abstract technical view on core properties that would support most of the above.

Firstly, there is an overview that takes us from proprietary single-use (canned) content to open, re-usable (smart) content: we define a set of initial user requirements for smart content, depending on whether the "user" is in the role of the content producer or consumer. Secondly, we attempt a ranking of such requirements by asking pertinent questions, such as "what goes missing if we do not provide functionality for this requirement"? Thirdly, we look at smart content in terms of a potential system architecture, for a grouping of functionality. Fourthly, we take up the proposal by Steven R. Newcomb[1], of asking for the necessary and sufficient properties that Smart Content needs to have in order for the user requirements to be fulfilled.

[1] Steven R. Newcomb is an independent consultant, a co-chair of the annual Extreme Markup Languages Conferences, and a co-editor of the Topic Maps (ISO/IEC 13250:2000) and HyTime (ISO/IEC 10744:1997) standards. He was a member of the EP2010 Steering Committee.

4 From "traditional" to knowledge based publishing

The knowledge economy will bring new business opportunities for those players in the publishing sector, who are able to address key differences between "traditional" and "knowledge-based" publishing, as indicated in the table below.

Traditional publishing	**Knowledge based publishing**
Canned one-off content in single proprietary formats, each requiring a specific production process	Non-canned, i.e. structured content in open formats with cross-media production process (i.e. one process for different "renditions" of the content)
Editions in multi-annual revision cycles	Evolvable content with on-line updates, revision tracing, etc.
Author "Fanclub": Authors belong to schools of thought; publishers choose "gurus" as lead authors	Knowledge managers leverage the distributed knowledge of communities of practice, and organise around shared concepts e.g. regular updates, bringing in expert opinion, buying in / trading new related knowledge
Closed universe of professional discourses, because of the limitations imposed by "canned content"	"Cross section" publishing: While in "canned content" lines of discursive threads, in particular, inter- and trans-disciplinary ones, need to be cut off at certain points, K-managers can mine and offer these intersections as special "knowledge units" (and thereby maybe also act as innovation agents)
Mode of interaction is READ and make NOTES (if it is your own copy of the book)	Value adding services for the "Reader/User": - e.g. feedback template (e.g. "add your own case study to this book") – from expert reader to author / publisher - tools for knowledge workers (bibliography service, knowledge based search) - annotations/changes/improvements to "texts" (e.g. on a reward basis) - tradable (small) units – e.g. visualisation of a concept, by downloading (plug-in) the publisher's visualisation tool, using the corporate/brand specific layout scheme

4.1 Scenario – "Smart Content Work Plan Editing"

The following scenario is intended to demonstrate that at present (2003), knowledge workers are poorly served in terms of integrated tools that support them in their tasks. One fundamental reason is that while there are *specialised* tools (e.g. for project planning), *generic* tools (e.g. spreadsheets) and *any-purpose* tools (e.g. word processors), the inputs and outputs of these tools simply do not match up. As a result, it is not possible today, to move a work plan from a work plan tool to a spreadsheet or into a word processing document at a descriptive level, i.e through the use of meta data or knowledge representation

mechanisms. The scenario tries to illustrate what a tool of the nearer future may be able to do, *without* having to solve fundamental "Grand challenges of artificial intelligence" beforehand.

J-P has been requested to change the work plan of his latest project. The reviewers suggested that more effort should go into testing, and they request that an indication of the test plan should also be part of the description.

J-P loads the project proposal into his OmniProcessor and selects the workplan diagram from the visual content map. He then selects the testing work package and extends the time-by-effort bar by two weeks, then he changes the work-package effort profile to medium/high/medium and makes some manual adaptations.

At this point, Paperclip the proposal avatar knocks …

J-P lets Paperclip enter the screen - Paperclip points out the following:

"You have three dependencies between this item and the rest of the proposal:

- *the work package description [do it now?] or [do it later?]*
- *the effort profile description [do it now?] or [do it later?]*
- *the overall scheduling of milestones [do it now?] or [do it later?]"*

J-P wants to revise the work package description and the overall schedule. The effort profile is only used for internal planning and has no effect on the proposal. J-P just wanted to put it into the plan so he would not forget it when they got on to dividing up the work between partners.

The work package description window for the Testing Module pops up. Duration and effort figures have already been dynamically updated because they are dependent on the work plan bar. J-P suddenly realises that he should have extended testing by three weeks. So he now changes this in the textual description after acknowledging the overall effort figure. The work package diagram uses a default logic to determine that J-P only wants to change the duration so it adapts the effort profile to spread effort in medium/high/medium over the three weeks, keeping the overall figure fixed because it was acknowledged by J-P.

The avatar logs the changes because at the end of the session, the avatar will update the revision history of the proposal document by summarising what changes have been made and what dependencies are not resolved yet. The avatar will also set warnings where conflicts may arise from unresolved dependencies or from the user overriding functional dependencies.

Changing the work plan, writing a few paragraphs and issuing the new version to the reviewers has taken approximately 10 minutes.

Historical Aside

The work plan ontology underlying this mode of the Omniprocessor had been supplied two years back, by a generous project manager who made it publicly available. Its publication had a tremendous effect on European proposal procedures leading also to improved quality management in the subsequent projects. The current version of Propos-ont is 7.1 which was issued in 2006 and has since become a de facto standard for IT R&D projects. It reduced the cost of proposal development for SMEs to 20% of the cost in 2003, with average project quality levels rising to level three of the Software Capability Maturity Model.

It is our belief that the above system could exist very soon using open standards and shared ontologies. At the core of this and many other systems is the (expandable) notion of smart content. Smart content has defined ways of accessing its fundamental components and has defined ways in which it can be manipulated. By carrying its "user manual" with it, smart content can be explored without damage and smart content enabled systems may be able to learn "new tricks" from content that they encounter.

5 Smart Content as a Unifying Vision for KMCC

The Sixth Framework Programme acknowledges the convergence of technologies as a prerequisite for novel types of information systems. The combination of Knowledge and Content Technologies under the roof of KMCC is a good example for this new, integrative approach to RTD.

EP2010 has undertaken an initial exploration into the issue of "Smart Content" which was felt to have potential for acting as a common underlying theme for both Knowledge and Content Technologies.

"Smart Content" must be distinguished from the notion of "content that contains knowledge". The "smartness" refers to the ease with which the content can be manipulated and re-purposed in different environments, irrespective of how much knowledge is contained in it. The Smart Content Vision derives from the following reasoning:

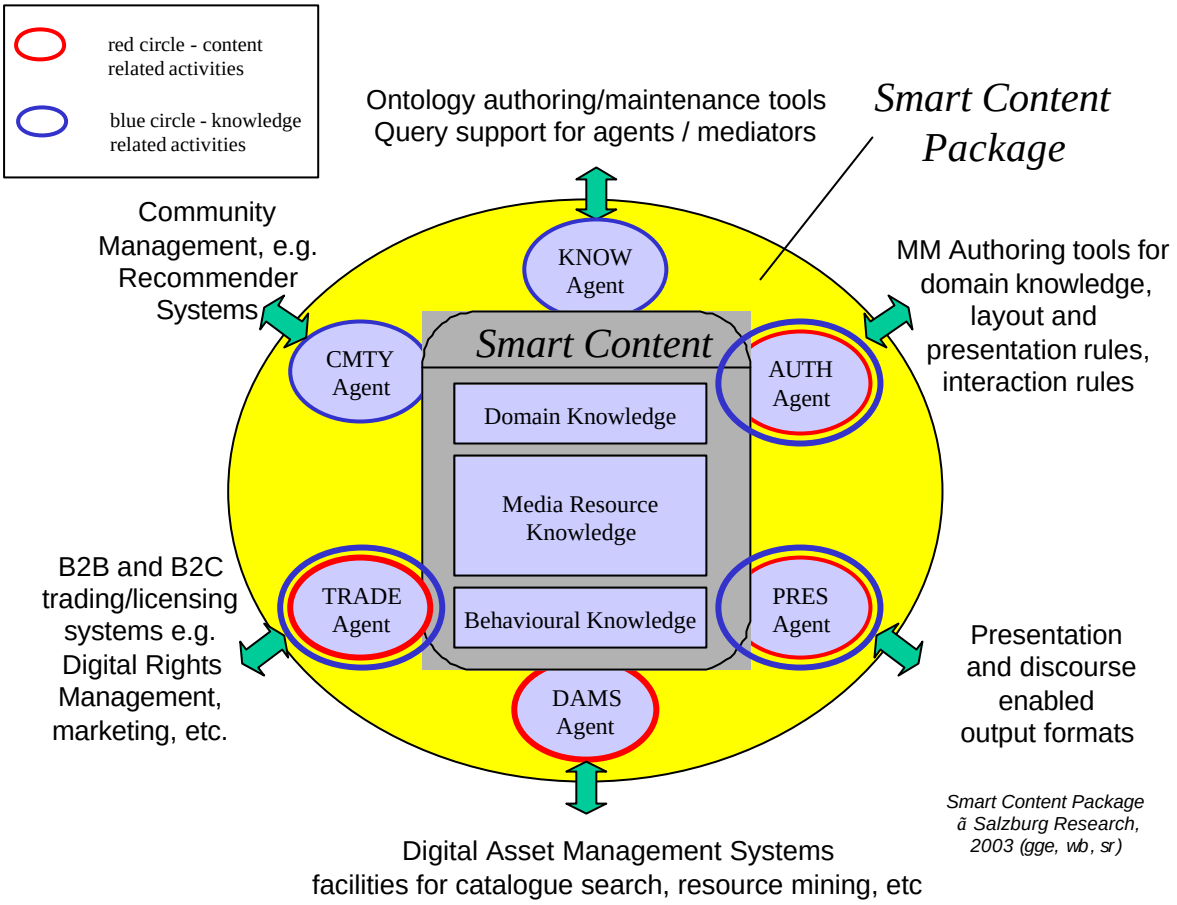
Current content technologies have several problems

- acquiring raw content leads to much data with little knowledge about the nature of the content associated with the data (e.g. places, people, activities, themes shown or referred to in a video).
- creation of usable content is labour intensive and typically geared towards "use once"
- once created, content tends to be canned, because it has tool-specific encoding and is therefore often not re-usable.
- traditionally, there is no easy way of knowing about the existence of some content and there is also no easy way of making its existence known to the world, except for indexing it via a Web Search engine.

There is a possible solution - Smart Content could consist of self descriptive units of knowledge that can be aggregated through standardised interfaces. The structure of these units should adhere to open standards to allow their processing by different tools. Furthermore, the different sets of metadata associated to content (e.g. library-type cataloguing, adherence to learning object standards, multimedia format encodings) should be accessible in a ubiquitous fashion within a single environment.

The figure below emphasises that for future e-publishing we foresee a significant shift from publishing products based on static "document models" towards new forms of content that are commonly described as "software". In this line of thinking, e.g. interactive content means "content + behavioural knowledge", where behaviour - computationally - means software programs, acting on data. We propose that agreement between the knowledge/content communities can only come from a process of convergent thinking. At present, these communities think partly in terms of (digital) content structure, and partly in terms of functionality acting on content. As long as the communities do not agree on what features should usefully be modelled as (static) structure and what features should be modelled as algorithms (e.g. as methods or functions) there will always be an "impedance mismatch" between systems whose ontological assumptions diverge significantly.

There is a number of research problems that need to be addressed, towards an architectural framework for Smart Content. This architectural framework could be the focal point of work shared between knowledge based and content-related research. One of the challenges will be to streamline description languages for content and knowledge so that both angles can be served by a single standard or, at least relevant standards "connect" with each other. The figure illustrates a number of functional groups that need to be addressed by a complementary set of standards.

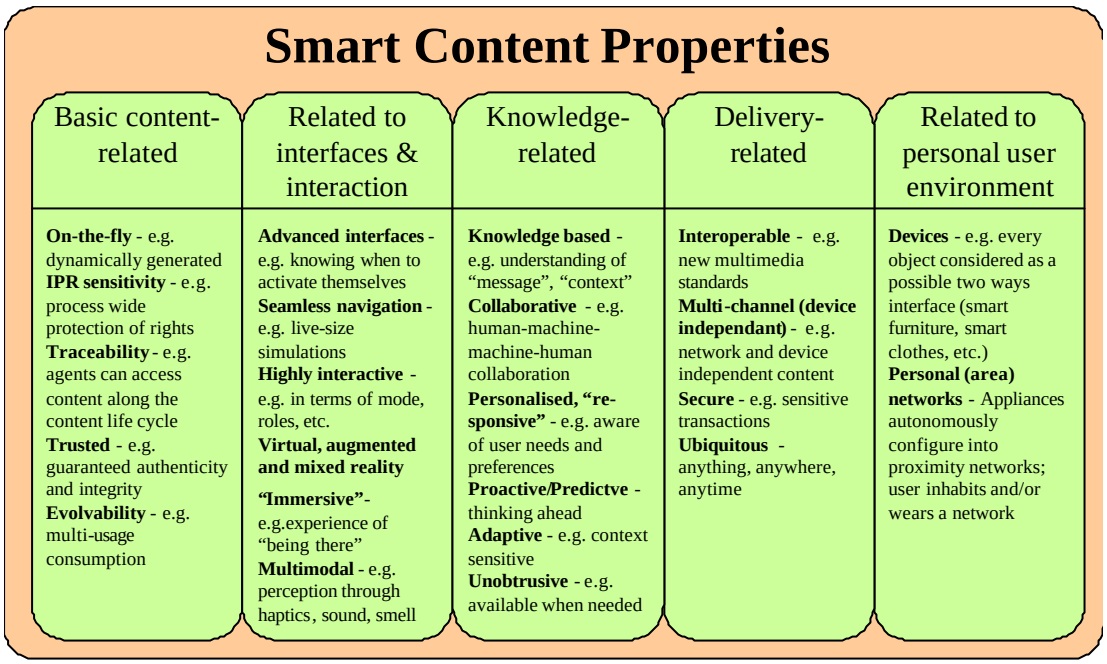


In the diagram, the functional groups are presented in the form of agent based services which is a matter of implementational preference. What should be stressed is that the functional groups should exhibit a good deal of "eternal truth" in the sense of being reasonably complete (no functional holes!) and orthogonal (no functional overlap!). Once this is the case we would have a good basis for objects that can be stored, used and maintained over long periods.

These future explorations should strengthen the vision so that

- researchers can use it as a tool for systematic formulation of research objectives,
- technologists can use it as a high-level architectural metaphor for future information systems, and
- content providers can use Smart Content Objects as a unit of value when they think of new knowledge/information services and products.

One initial route was to build clusters of desirable properties for Smart Content, which would be the basis for specifying user and system requirements. This is summarised below:



ã Salzburg Research, 2003

Ideally, the properties of Smart Content are such that the consumer begins to associate tangible qualities and benefits with "smart" as opposed to "dumb" content.

The vision is to focus the research activities in a way that fosters standardisation to gain *direction* and technological innovation to gain economic *momentum*.

The major function of the "Smart Content" concept is to stimulate and support the discussion of novel digital content technologies or solutions and - if applicable - of associated novel value chains.

5.1 Smart content properties from a user perspective

Generally, the smart content concept should allow for variants of knowledge-enhanced e-content products and knowledge services with different characteristics to be developed, by making use of subsets of the relevant features and associated technologies.

These subsets we term "property". From the user's point of view, we distinguish five sets of properties: content-related properties, properties related to interfaces and interaction, knowledge-related properties, delivery-related properties, and finally, properties related to the personal user environment.

In the tables below, we provide a preliminary compilation of such properties and give for each property a short description as well as examples of related technologies. For the grouping we have used common categories and have arranged each property only in one of the categories, while some of them might span two or more categories.[2]

[2] The classification scheme can perhaps be further refined by reasoning over the complexity involved in obtaining desired properties, and by creating rankings e.g. mandatory, desirable, optional. A suggestion for this could be; mandatory: sine qua non; desirable: at least 80/20 pay off in benefit/effort; optional: at least 60/40 pay off in benefit/effort.

BASIC CONTENT-RELATED PROPERTIES

Smart Content Property	Short description	Examples of related technologies
"On the fly"	Content automatic and dynamically generated in real time (in several formats)	Digital Asset Management Systems (DAMS) supporting advanced storage, tagging, compression etc. Knowledge-based/controlled assets Multi-format and multi-channel presentation Agents for searching, selecting, generating, manipulating content Real time rendering of content
IPR sensitive	Protection of the rights of the entire value added publishing process	Digital rights management technologies (agents), e.g. support in reliable DRM reconciling
Traceability	Search agent can trace content along the content life cycle	Automatic metadata creation and embedding in content "Intelligent watermarking" Content search engines Tracing of intellectual ownership
Trust	Guaranteed authenticity and integrity of content	Agent/human can demand from content to authenticate itself", e.g. show authenticity profile Standardisation of "Trusted digital repositories" (e.g. in areas as public sector, cultural heritage, science);
Evolvability	e.g. multi-usage consumption: content can be used passive, interactive, creative...	Highly re-purposable content Advanced versioning tools Longevity of format support

PROPERTIES RELATED TO INTERFACES & INTERACTION/NAVIGATION

Smart Content Property	Short description	Examples of related technologies
User-friendliness	e.g. interfaces that "know" when to activate themselves, can adapt to the user, e.g. user personality, emotions	Intuitive interfaces (usable with little additional learning) Voice controlled interface (voice recognition), natural language interaction Technologies for emotive feedback loops
"Seamless" navigation	e.g. navigation through life-size simulations or heterogeneous sources / environments	Non-text-led navigation, more "playful" animated, highly graphical or audio-visual interfaces/displays
Interactivity	e.g. in terms of mode, roles, number of players etc.	Applications for user controlled rapid switching between tasks, e.g. from "lean back" to "lean forward" Multi-user games with highly flexible repertoire of behaviours Technologies for capturing emotions and creating emotive feedback (loops)
Virtual, augmented and mixed reality	e.g. 3D simulation of work, leisure, educational environments	High-level languages for VR description; Advanced methods and tools for scene composition;

"Immersive"	Experience of "being there", in the centre / real flow of action...	Advanced 3D, animated user environments and interfaces, mixed reality
Multimodal	Perception and control through vision, sound, haptic....	Natural language recognition (because it is still not solved as a problem, but desirable as a communication medium!, ed) Rapid changing between modalities Haptic computing Gesture-based interfaces

KNOWLEDGE-RELATED PROPERTIES

Smart Content Property	Short description	Examples of related technologies
"Knowledge based"	e.g. understanding of "message", "situation", "context", "interpretation"	Breakthrough in forms of inference applied to tacit, implicit information Fundamental research into the richness of human language vs. Knowledge representation languages Web Ontology Language Standard
Collaborative	human-machine-machine-human collaboration	Advanced Computer Supported Collaborative Work tools/systems Collaborative distributed authoring Agents that support users in achieving goal in various environment, e.g. work, learning, conflict management...
Personalised, "responsive"	e.g. aware of user needs and preferences;	Capability to capture and process fine-grained user data (profiling) Tracing of small shifts in user preferences Process-based (coherent and flexible) model of user interest and their access to media at the time of interaction (e.g. bandwidth, equipment, etc.)
"Proactive"/"Predictive"	e.g. "thinking" steps / necessary activities ahead	Causal reasoning systems; Understanding of purpose and progress of activities Content may be "surrounded" by proactive agents
"Adaptive"	e.g. context-sensitive, understanding of momentary "information culture" of users, e.g. business, educational, leisure...	Encoding of spatial and temporal information; Understanding thematic relationships Understanding kinds and levels of activities
Unobtrusive	e.g. available when needed, unobtrusive when used	Privacy assurance mechanisms The user is surrounded by an "information bubble". Parts of the bubble turn into "content" when needed. This may be triggered by the user or his agents.

DELIVERY-RELATED PROPERTIES

Smart Content Property	Short description	Examples of related technologies
Interoperable	e.g. new multimedia standards:	MPEG-7, MPEG-21, SMIL 2.0...
Multi-channel (device independent)	e.g. network & device independent content	Use of emerging metadata standards to promote consistency of publishing across multiple consumer devices Encoding, to allow streaming, scaling and transfer across different networks and devices; e.g. highly efficient media coding methods for optimal use of bandwith Compression tools that can react in a dynamic way to network congestion Efficient seamless heterogeneous networks; continuity / quality of service; cross media and cross-modality capability Self-adapting to capabilities of platform
Secure	secure e.g. sensitive transactions	Authentication methods, e.g. biometrics based access to devices and services (note: dichotomy of high security versus ease of use); Encryption techniques Safeguards to ensure protection of personal and sensitive data (e.g. in profiling, mobile/location based services...) Safeguards for privacy in "emotive" profiling
Ubiquitous	"anything, anywhere, anytime"	Wide distribution of ambient intelligence infrastructure Distributed storage management

PROPERTIES RELATED TO PERSONAL USER ENVIRONMENT

Smart Content Property	Short description	Examples of related technologies
Device-adaptivity	e.g. every object considered as a possible two ways communication interface	Solutions for smart furniture, smart clothes... Advanced media interaction and authoring tools
Personal (area) networks	Appliances autonomously configure into proximity networks User "inhabits" and/or "wears" a network (clothes, shoes, etc. as devices)	Short-range wireless communication Dynamic self-configuring networks; Highly user-friendly tools to generate, update, manage, and disseminate content Modular devices Ubiquitous remote control(s)

5.2 Requirements Perspective – Towards a Ranking of Smart Content Requirements

In order to get a better handle on the technical implications of the properties of Smart Content, we take the above *user-perceived* properties and interpret them as *requirements*. We then reason about the consequences of content systems *failing* to address the requirements and about the benefits envisaged for systems *succeeding* in addressing the requirements. Given a proposed separation of functionality for a knowledge and content infrastructure, we also indicate where the requirements need to be addressed, and indicate likely dependencies with other enabling technologies.

Smart content property	Short description	Weaknesses resulting from NOT having this property	Strengths expected from introducing this property	Relationships with other enabling technologies
"On the fly"	Certain content may primarily exist as knowledge structure, its media might be interchangeable	Construction of static content for each consumer group is more expensive because of content maintenance costs	Content can be created as the result of a communication process between a user (agent) and a provider (agent)	Multivalent documents and fundamental research into the nature of knowledge content vs "media content"
IPR sensitive	Content elements carry IPR knowledge that can be used by content delivering agents or processes	It is difficult to develop internet-based business models without the ability to tag content	IPR sensitivity does not mean IPR has to be enforced - laissez-faire models are still possible	IPR sensitivity may be coupled with presentation mechanisms that enforce or do not enforce IPR
Traceability	The origin of content should be traceable The right of creating anonymous content may also be a requirement	When traceability is neither defined in the positive nor in the negative, then this is likely to be an inhibitor for future markets	When traceability is clearly defined and its rules are understood, providers and consumers can make choices based on trust	Traceability is coupled with compositionality of content
Trusted	Trust means that users, service providers and content providers are able to weigh up personal, economic and other perceived risks (e.g. legal risks) when entering the digital world	Lack of trust will remain a major inhibitor for the future of digital markets	Trust appears to be an aggregate property that will be ascribed to the whole content infrastructure	The major dependency is probably with legal issues (what is allowed / not allowed in the digital world?) Is the digital world a medium and therefore, freedom of expression holds, or is it an extension of society and therefore, relevant rules and laws of society hold for different social spaces within the digital world

Smart content property	Short description	Weaknesses resulting from NOT having this property	Strengths expected from introducing this property	Relationships with other enabling technologies
Evolvability	Digital content may be changed, added to, and may even be manipulated in ways unintended by the originator	Society has developed an economic and legal infrastructure in which traditional content can be accumulated, aggregated and accessed (broad-casting, publishing, libraries, etc) Lack of equivalent digital infrastructure will inhibit future markets When content becomes outdated then its "truths" die together with its "falsehoods"	Evolvability leads to better preservation of knowledge for further reuse	There appears to be a close relationship with the property of traceability
Userfriendliness	Smart content should be adaptable to different interfaces In particular, the smart content infrastructure should enable content and (new) interfaces to link up with little "glueing" effort	Lack of adaptability to new interfaces will lead to content having to be re-planted, or with content dying out because it is no longer accessible or presentable in a user accepted fashion	Being able to integrate quickly, with novel interfaces will keep the value of content longer	All research into advanced interfaces is likely to be relevant
"Seamless" navigation	Smart content should enable different interaction or navigation mechanisms to exist in parallel	Lack of seamless navigation makes interaction less intuitive and therefore, decreases user acceptance of content and technology	Seamless navigation allows the user to interact more intuitively with digital content, leading to higher acceptance and faster technology uptake	The dependencies between the structure of a knowledge space, the constraints of a presentation environment and the constraints of a chosen interaction model need to be investigated
Highly interactive	In a knowledge economy, content may be administrated by agents. "Hooks" are needed to indicate how specific types of content can be interacted with (e.g. how does one query a CAD model?)	Lack of generalised support for interaction will lead to mass re-invention of the wheel, as content technologists re-create interaction engines for known kinds of content	Development of "interaction patterns" that can be applied to classes of content are likely to reduce the effort for creating useful and appealing forms of interactive content	Navigation, presentation, knowledge and interaction are interdependent - see above

Smart content property	Short description	Weaknesses resulting from NOT having this property	Strengths expected from introducing this property	Relationships with other enabling technologies
Virtual, augmented and mixed reality	Virtual realities require a complete model; augmented reality adds further sensorial information to the natural information intake; mixed reality manipulates perceived reality, e.g. for artistic purposes	Anthropologically, one could argue that VR, AR, and MR are extensions of the brain in the same way as hammers or screwdrivers are extensions of our hands. Lack of tools for the brain will impede progress towards a leading knowledge society	Development of "brain tools" may accelerate the move towards a knowledge economy, because the productivity of knowledge workers may be dramatically increased	To be identified. Note that the research communities may be more fragmented than our grouping suggests - e.g. augmented reality in medical informatics vs virtual reality in cultural heritage applications
"Immersive"	See virtual, augmented and mixed realities	*(we are not sure whether immersive is different from VR/AR/MR, above, ed)*	*(we are not sure whether immersive is different from VR/AR/MR, above, ed)*	*(we are not sure whether immersive is different from VR/AR/MR, above, ed)*
Multimodal	As content becomes more abstract (knowledge) it will be possible to "render" it in different modalities Environments must be capable of handling these different renditions	Lack of multi-modality means that content is bound to a specific medium - e.g. to a screen for audio-visual content	Support for multi-modality will advance the idea of ambient intelligence: e.g. we can listen to our emails being spoken to us, over wireless LAN digital headphones	Low-tech approaches to multi-modal systems and infrastructures already exist Advances will require progress in various "language technologies", i.e. language understanding (as opposed to recognition) and language generation
"Knowledge based"	In the knowledge economy multimedia content will become increasingly, media-supported knowledge content	Lack of knowledge structures will mean manual semantic annotation of content that is otherwise not understandable by machines (i.e. machines cannot act upon content, in a rational fashion)	Presence of knowledge based content will enable composition of new services and added value from existing building blocks This is likely to become a motor for innovation	There is an ontological research question of what content is, what knowledge is, and what smart content should be, technically. Today's starting point is textual or multimedia content with added meta data. One could consider all content as primarily knowledge, with media added as "illustration". This way, a film would be a narrative supplemented by moving pictures.

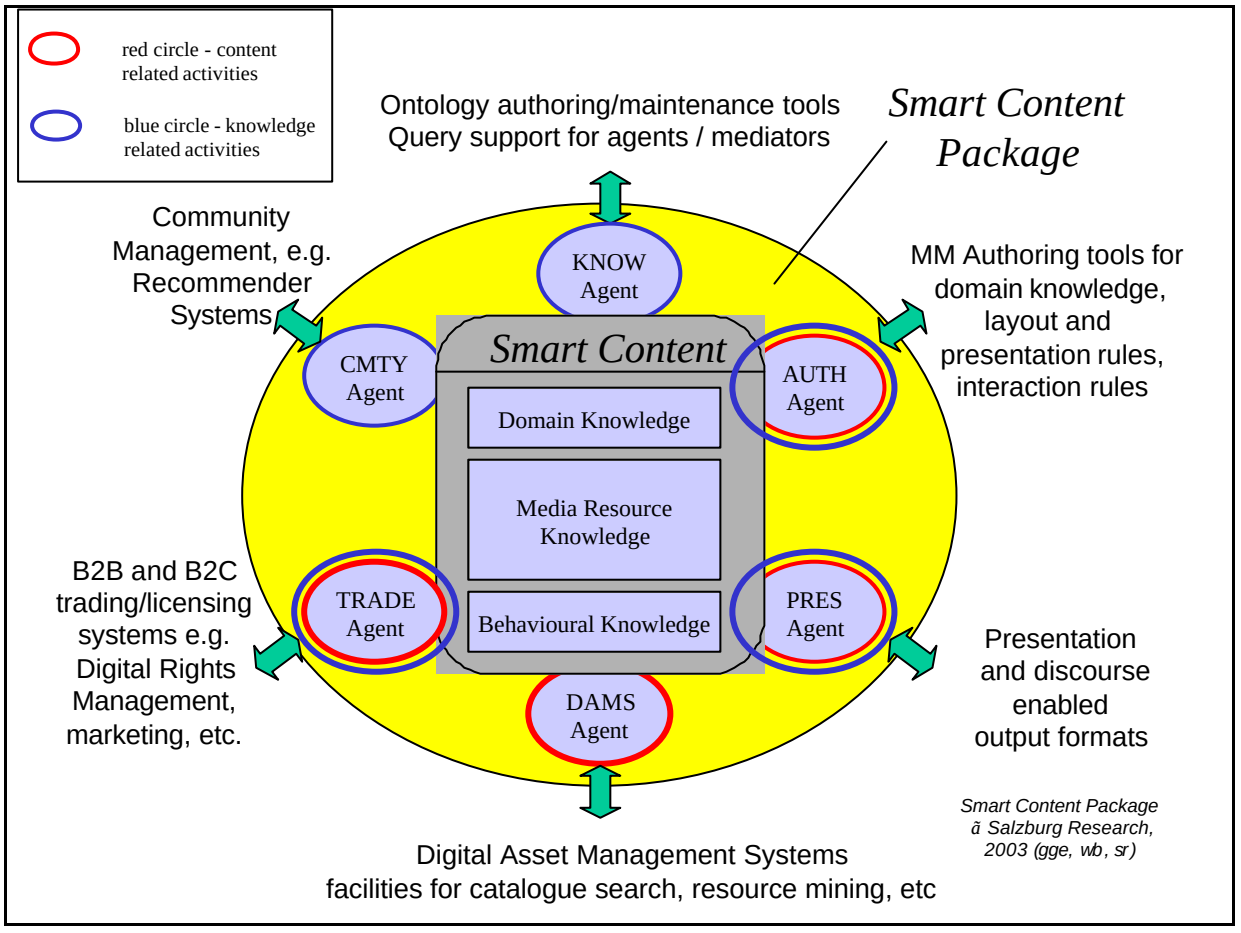
Smart content property	Short description	Weaknesses resulting from NOT having this property	Strengths expected from introducing this property	Relationships with other enabling technologies
Collaborative	One aspect of collaboration is when it is aimed at content creation, the other is when content is used as an instrument for some other collaboration e.g. learning in a virtual group, or engineering	Lack of support for collaborative interaction with content (either for creation of that content, or for creation of other artefacts) will inhibit the use of AmISpace as a sphere in which the knowledge economy could otherwise prosper	Good support for collaborative interaction may lead to fast uptake of AmISpace infrastructure. This may result in Ambient Intelligence really becoming a driver for the knowledge economy	Computer supported collaborative work (CSCW) has a long research tradition that is relevant here
Personalised, "responsive"	Content should be adaptable to user needs, preferences, interests	"one-size-fits-all" syndrome"	More opportunities for good products in niche markets (favouring European SMEs)	Personalisation could be seen as a sub-area of context related research The notion of spatio-temporal and thematic "Context" would be a more general research issue which may inform work on personalisation
"Proactive"/ "Predictive"	Interactive content should enable e.g. "thinking" steps / necessary activities ahead	Lack of timely system intervention	Depending on application, benefits can range from user satisfaction to improved safety and risk management	This requirement should sit firmly with agents. Content related issues should come from the agent's user model
"Adaptive"	E.g. context-sensitive, understanding of momentary "information culture" of users, e.g. business, educational, leisure...	Inflexible, "brittle" systems	"ambient" systems	Fuzzy matching, partial matching
Unobtrusive **(Note: unclear whether adaptive and unobtrusive are fundamentally different)**	E.g. available when needed, unobtrusive when used In ambient intelligence scenarios, systems will be required to take the initiative when communicating with humans.	Obtrusive, "loud" systems will not be considered helpful by users. Potentially, AmISpace will contribute to the notion of the "attention economy": systems that waste human attention will become inhibitors to business based on such systems	Unobtrusive, "tactful" systems will be regarded as adding to the quality of life, be it in the work sphere or in the private sphere of people	The role of "intelligent" systems in the attention economy poses a challenge to an inter-disciplinary research community: psychology, marketing, cognitive science, linguistics, AI, HCI

Smart content property	Short description	Weaknesses resulting from NOT having this property	Strengths expected from introducing this property	Relationships with other enabling technologies
Interoperable	With respect to: knowledge (ontologies); content structure; content systems	Lack of knowledge-level interoperation leads directly to information islands and a legacy problem Lack of structural equivalence complicates content processing without adding any value Lack of system-level interoperation hinders seamless movement in information spaces	If ontologies are based on sound representation formalisms and have been built using sound modelling guidelines then integration and interoperation become emergent properties If systems are built to process soundly engineered knowledge content then standardisation may "come for free"	Foundational research on sound ontological modelling; Both foundational and experimental research on (smart) content structure Open platform-based integrative research on interoperation of content creation management and delivery systems
Multi-channel (device independent)	Future devices may benefit from the availability of a general, knowledge based content model. However, the content model needs to be designed in such a way as to allow useful abstraction/ generalisation over the content processing characteristics of various types of devices	A content model that lacks understanding of the nature of devices (e.g. input, interaction, presentation) will contribute to an impedance mismatch between content creation and content use	A content model that has a good abstraction layer will enable new devices to be more easily introduced in the market place because adaptation to the content delivery platforms will be better supported	Interdisciplinary analysis of semiotic relationships between observable real-world things, their conceptualisations and their medial representations is likely to be needed Based on this, a technical analysis of the relationship between content (medial representation) and content rendering (medial performance) can be done. From the analysis, insights into rendering-effective content modelling can be gained
Secure	Authentication methods, e.g. biometrics based access to devices and services Encryption techniques Safeguards for privacy in "emotive" profiling	Lack of security may lead to privacy problems as happened with service providers' databases in the past	Privacy-sensitive content would benefit from strong security (e.g. knowledge about patient records, etc)	Authentication may not be the most prominent factor. Security in the sense of safeguarding privacy may be a more burning issue. Note: there may be a dichotomy of high security versus ease of use

Smart content property	Short description	Weaknesses resulting from NOT having this property	Strengths expected from introducing this property	Relationships with other enabling technologies
Device-adaptivity	E.g. every object is considered as a possible two ways communication interface (based on an idea put forward by Motorola UK at one of the consultation meetings)	To be discussed by experts in advanced interfaces	To be discussed by experts in advanced interfaces	May require significant technology breakthroughs in materials science
Ubiquitous	"anything", "anywhere", "anytime"	People get used to / rely on systems - sudden breakdowns can happen where there are "holes"	The system becomes "part of the furniture"	This may be viewed as a smart content requirement, but there does not appear to be any structural feature associated with it. E.g. whether the transmission of some content is admissible at a given time for a given purpose will have to be decided by agents but is unlikely to be encoded in the content itself
Personal (area) networks	Appliances autonomously configure into proximity networks User "inhabits" and/or "wears" a network (clothes, shoes, etc. as devices)	To be discussed between ubiquitous computing and (smart) content research community	To be discussed between ubiquitous computing and (smart) content research community	Spontaneous networking appears to be a level below smart content applications and therefore, we do not expect structural features of smart content to be related to spontaneous networking

5.3 Architectural Perspective of Smart Content Environments

The diagram below emphasises that for future e-publishing we foresee a significant shift from publishing products based on static "document models" towards new forms of content that are commonly described as "software". In this line of thinking, e.g. interactive content means "content + behavioural knowledge", where behaviour - computationally - means software programs, acting on data. We propose that agreement between the knowledge/content communities can only come from a process of convergent thinking. At present, these communities think partly in terms of (digital) content structure, and partly in terms of functionality acting on content. As long as the communities do not agree on what features should usefully be modelled as (static) structure and what features should be modelled as algorithms (e.g. as methods or functions) there will always be an "impedance mismatch" between systems whose ontological assumptions are - more or less - fundamentally (or at least significantly) opposed.



Smart Content Service Architecture
ã Salzburg Research, 2003 (gge, wb, sr)

The above diagram illustrates a smart content "package" in which active components (engines or agents) mediate between outside applications and the core content. The current picture may not be exhaustive, but does already indicate "points of contact" between (smart) content and some ambient environment, in which the main external actors are themselves geared towards "understanding" smart content objects.

Assumption – Smart Content units may be packaged together with agents
There is a fundamental architectural question concerning the technical nature of Smart Content: we propose to distinguish between a "Smart Content **Unit**" which contains knowledge hooks for active components such as agents. In order to maintain the (technical) boundary between content and content manipulation, the smart content unit is assumed to be static. However, a "Smart Content **Package**" may contain several Units and may be managed by one or more "Smart **Content-Aware** Agents". Value added businesses would probably act at this level of content trading.

The smart concept can be used to conceive of different e-publishing products or knowledge services. In this one has to distinguish between properties that are mandatory in every smart content product/service, and properties that are specific for certain types of smart content product.

5.4 Key Properties Perspective for Smart Content

Steven Newcomb starts by relating Smart Content to the ISTAG vision as proposed in the Draft Interim Report: *"Smartness" is "ability to participate fully, at the semantic level, in the ambient intelligence space".*

He then argues that *"the essence of the smartness of smart content is its readiness to be semantically integrated with all other smart content"*. From this postulate, he derives two key properties for Smart Content:

- Comprehensively and rigorously self-describing, e.g. through the use of ontologies
- Support for comprehensive and deterministic indexing, i.e. in any given integrated body of smart content, there is exactly one "location" (analogous to an index entry) per subject, from the perspective of which users (including computers) can find everything relevant to that subject

Newcomb then argues that the various properties originally defined for Smart Content can be derived from (are subsumed by) the above two key properties. The critique and insight is extremely useful, because it points out that the original "properties" consisted in part, of *requirements* that different user groups would *view* as tangible and valuable properties, irrespective of how they are realised in a computational environment. The two key properties are also instrumental in communicating the research challenge in a concise way. However, for a diverse set of research communities to communicate and specialise in aspects of smart content, the key properties must be elaborated on, in order to reduce the conceptual gap between the two all-encompassing properties and the many detailed research questions that are related to or possibly even solvable through, application of the "key property"-question.

Newcomb's proposed approach raises another research question. His principal argument is *"It's all knowledge, including the knowledge about the use and presentation of content".* He argues that several of the properties "*are expressible as specific knowledge within one or more specific knowledge domains, in terms of one or more specific ontologies*". Thus the implication of Newcomb's proposal means bringing the notion of smart content into the focus of ontological investigation. In other words, we should treat "knowledge about content *rendition*" in the same way as we treat "knowledge about *any other* domain". Once we do this, programs can interpret the "smart part" of knowledge and media content as knowledge about the intended rendition and act on it accordingly. Since it is not in the scope of EP2010 to develop an ontologically sound model of smart content, we outline some of the issues, by synthesising in the table below, the original EP2010 model with Newcomb's proposed smart content key properties:

Smart content property	Justification	Interpretation according to Newcomb (abbreviated SRN)	Proposed synthesis (EP2010)
Proposed Key Property KP1 **Self describing**	**When content is described using a meta model, then inferences about the content are possible (at the level of the meta model)**	**For example, smart content explicitly invokes each component of each ontology wherever it depends on that component**	**Leads to a research question: Is it necessary for a given smart content, to know about the ontologies whose components it depends on? If it is necessary, is it then also possible to know about all the ontologies?**
Proposed Key Property KP2 **Deterministic indexing of subject fields**	**When knowledge can be uniquely identified then its terms will span a universe of discourse relating content to terms**	**In any given integrated body of smart content, there is exactly one "location" (analogous to an index entry) per subject, from the perspective of which users (including computers) can find everything relevant to that subject**	**Leads to a research question: Is it possible for smart content to get reduced into a canonical form where each knowledge component exists exactly once (in the index)?**
Evolvable content	Evolvable addresses a structural and a social aspect: structural compositionality of content is needed for traceability, and it is also a prerequisite for group collaboration. One aspect of collaboration is when it is aimed at content creation, the other is when content is used as an instrument for some other collaboration e.g. learning in a virtual group, or engineering	Semantic (de-/re-) composition SRN: derivable from KP1	Accepted in principle, but requires strict bi-directional (one-to-one) mapping functions for the aggregation of content User requirement: collaborative construction and de-construction of content (Can I retract content that others have already used for their content?)
"On the fly"	Certain content may primarily exist as knowledge structure, and at least some of its media might be interchangeable	The "on the fly" and "highly interactive" properties appear to be about rendition. If they are about the tools, they should not be considered properties of the content	EP2010 also argues that the smartness of content should be encoded in a static attribute structure. However, for the purpose of rendition, processes or methods need to interpret these attributes, and some of the attributes are only features of smart content because we *want* to use them for rendition, interactivity, etc.

Smart content property	Justification	Interpretation according to Newcomb (abbreviated SRN)	Proposed synthesis (EP2010)
IPR sensitive	A given body of smart content enables the user's environment to check which usage rights are needed to use the content legally, in a given user environment	Interpreting SRN: self-describing, deterministically indexed and compositional would be the pre-requisites for IPR-sensitivity	Smart content should enable different business models ranging from "inhibitive" (content can only be used when all rights are obtained) to "laissez-faire" (content can be used with temporary rights or even illegally). This is analogous to speed limits: the user decides whether to act legally or not. The penalty is not automatic, but only in the case of detection, and within a range commensurate with the infringement.
Reward (NEW proposed property)	Knowledge workers may want to be associated with knowledge content	SRN: in conjunction with knowledge economy and knowledge technology, we need to take into account that there are at present, only rudimentary social or economic reward systems in place for sharing knowledge	A stronger notion of social or economic reward mechanisms in the knowledge economy should be added to the requirements for smart content
Traceability and the right of non-traceability of content creation and content use	The origin of content should be traceable The question remains whether a creator of content should also have the right to create anonymous content.	Same as "evolvable"	Every operation on a smart content object must have an inverse operation. Every operation on smart content has to be logged so that roll-backs are possible Every content creator should have the right to remain anonymous The counterpart of traceable creation is traceable use. Does the user have a right of non-traceabiliy?
Trusted	Whether the content is medial (image/text) or whether it is a knowledge structure according to some ontology: The user must be able to trust that incoming content will not do any damage, e.g. by infringing copyright.		

Smart content property	Justification	Interpretation according to Newcomb (abbreviated SRN)	Proposed synthesis (EP2010)
Advanced interfaces	Smart content should be adaptable to different interfaces In particular, the smart content infrastructure should enable content and (new) interfaces to link up with little "glueing" effort	SRN: "If an ontology permits an advanced interface to be defined, and if such a definition exists, then the moral equivalent of a stylesheet can be used to integrate that knowledge with any other kind of knowledge. The content's readiness to be integrated with an interface description is what makes it 'smart'; not the fact that it has already been integrated with it."	A distinction between knowledge input and knowledge presentation interfaces should be made. Each type of interface may also be interactive. In order for smart content to support any of these types of interfaces, a set of ontological features (in Newcomb's terms) will have to be defined. An interface (advanced ot not) will use the values for exactly those ontological features that are specified for the kind of interface in question.
"Seamless" navigation	Future interfaces may include 3D, haptics, augmented reality, etc. How can we ensure that the user does not have to switch between computational / software environments in order to consume knowledge and media content?	SRN: "Seamlessness of navigation (and seamlessness with respect to many other things) is simply the inevitable result of achieving a situation in which every subject has a unique 'location'. In other words, semantic integration is seamlessness."	Ontological uniqueness is agreed to be at least a very desirable property from which to develop seamless navigation. However, ontological uniqueness would appear to be a necessary but not a sufficient precondition for seamless navigation in a content space that was built with different presentation environments in mind.
Highly interactive	See "on the fly"		
Virtual, augmented and mixed reality	Human social spheres will increasingly include parts of the digital world. VR/AR/MR are means of merging real and digital spaces.	SRN: this is about rendition	VR/AR/MR is not only about rendition, it is also about interaction models and multi-modality, each time constrained (or enabled by) advanced types of interfaces
"Immersive"	The distinction between immersive, highly interactive, and V/A/M reality may be unnecessary	SRN: this is about rendition	See virtual, augmented, mixed reality, above.

Smart content property	Justification	Interpretation according to Newcomb (abbreviated SRN)	Proposed synthesis (EP2010)
Multimodal	Channelling input through a QWERTY keyboard and being limited to (on average) half an A4 page of screen (even worse for mobile communications) is a severe inhibitor for productivity in a knowledge economy. Multimodality promises a significant improvement of human-machine interaction	SRN: this is about rendition	See virtual, augmented, mixed reality, above.
"Knowledge based"	In the knowledge economy multimedia content will become increasingly, media-supported knowledge content	Interpreting SRN: "knowledge based" seems to capture some of the intended benefits of SRN's key properties Key property 1 ("self describing") is in essence, a meta-property that by its definition must have all other properties as its object Key property 2 ("deterministic indexing of subject fields") is a plea for a unique ontological namespace to which all content can be related.	We suggest that the underlying knowledge structure of media content should be a major research objective, with the promise of technology breakthroughs enabled by a better understanding of the nature of media content.

It should be noted that while the focus on just two key properties has its merits, particularly in generating some fundamental research questions, it does not get researchers and technologists out of the dilemma that for experimental and real "smart content systems", they have to decide how much of the complexity of dealing with smart content should be put in the static structure of the content and how much of the complexity should rest with the surrounding software.[3]

[3] Note that the distinction between smart content and its surrounding software is analogous to Dijkstra's view of "computing = data structure + algorithms".

6 Relevant Standards and Technologies for Smart Content

There is a number of technologies and standards that have a bearing on the concept. The first attempt at smart content was probably SGML and the prize for the most ambitious attempt should probably be given to HyTime. In between, there have been many document models that addressed issues of synchronising and presenting of multimedia information. The following is a list of relevant technologies and a short assessment of their strengths and weaknesses.

Technology or Standard	Intended area of application	Strengths	Weaknesses
OWL	Ontology description language	Knowledge representation language with first order logic and description logic as basis	Purely descriptive, no reasoning engines available, not sufficiently elaborated for systems architectures
RDF/S	Resource description on the WWW	Widely accepted as a new standard for description of access to web based information sources	Does not address system-level architectural structuring of content
MPEG-7 and MPEG-21	Multimedia meta data	Increasingly used in digital broadcasting	Unclear relationship with ontological models, media centred
SMIL - Synchronised Multimedia Integration Language	Web based multimedia presentation	Synchronisation, multimedia	Not intended as being interactive; divergent implementations (e.g. RealPlayer)
Topic Maps	Web based structuring of large information spaces	Relatively simple model	Not sufficiently rich for knowledge representation, no synchronisation of presentation (structuring only)
LOM/SCORM	Learning objects interoperation standards	Attempt at standardisation for learning software objects	No knowledge level semantics, creating modules is "knitting" of file dependencies
HyTime	Description language standard for multimedia time based, space-aware synchronisation	Ambitious attempt at describing process-based multimedia in physical and virtual space	Never implemented to a sufficient degree, some parts are not solved in research

Candidate Technologies for Smart Content

There is, of course a long tradition of research in the areas of databases, knowledge bases, hypermedia, multimedia, and document models, all of which has led to useful technologies such as SQL, OWL/RDF, HTML, Web Services, MPEG, HyTime and XML. Much of these can be usefully applied to the emerging challenges such as a Grid-Computing based Semantic Web.

One of the weaknesses of current research is that the work tends to focus on new description languages and that few projects tackle the tricky parts of the semantics that are hidden in each of the standards. This goes hand in hand with our earlier observation that in general, there is too much invention of notation and not enough focus on processes that *do things* - the ultimate objective of any semantics!

The above list is only a small subset of content related standards. see http://www.diffuse.org/meta.html for a list of at least 26 Metadata standards.

Our initial investigation into Smart Content must be seen as a first meeting point from which different explorations can and should be made to assess possible routes to the summit. The next meeting place should be somewhere higher up that mountain. Some of us may have to return to base and follow somebody else's route. Subscribing to a smart content vision means we are at least, at shouting distance from each other!

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