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New Media and Transformations in Knowledge (II)

Meta-Data

How is the enormity of this challenge to be dealt with in practice? It is generally assumed that meta-data offers a solution. The meta concept is not new. It played a central role in the meta-physics of Aristotle. In the past years with the rise of networked computing, meta has increasingly become a buzzword. There is much discussion of meta-data, meta-databases, and meta-data-dictionaries. There is a Metadata Coalition,[1] Meta Council[2] and even a Meta-data Review.[3] Some now speak of meta-meta-data in ways reminiscent of those who spoke of the meaning of meaning a generation ago.

The shift in attention from data to meta-data[4] and meta-meta-data is part of a more fundamental shift in the locus of learning in our society. In Antiquity, academies were the centres of learning and repositories of human knowledge. In the Latin West, monasteries became the new centres of learning and remained so until the twelfth century, when this locus began to shift towards universities. From the mid-sixteenth to the mid-nineteenth centuries universities believed they had a near monopoly on learning and knowledge. Then came changes. First, there was a gradual shift of technical subjects to polytechnics. New links between professional schools (e.g. law, business) and universities introduced more short-term training goals while also giving universities a new lease on life.

The twentieth century brought corporate universities of which there are now over 1,200. It also brought national research centres (NRC, CNR, GMD), military research laboratories (Lawrence Livermore, Los Alamos, Argonne, Rome), specialized institutes (such as Max Planck and Fraunhofer in Germany) and research institutes funded by large corporations (AT&T, General Motors, IBM, Hitachi, Nortel). Initially the universities saw themselves as doing basic research. They defined and identified the problems the practical consequences of which would then be pursued by business and industry. In the past decades all this has changed. The research staffs of the largest corporations far outnumber those of the greatest universities.

AT&T's Lucent Technologies has 24,000 in its Bell Laboratories alone and some 137,000 in all its branches. Hitachi has over 34,000, i.e. more researchers than the number of students at many universities. Nortel has over 17,000 researchers. The cumulative information produced by all these new institutions means that traditional attempts to gather (a copy of) all known knowledge and information in a single location is no longer feasible. On the other hand a completely distributed framework is also no longer feasible. A new framework is needed and meta-data seems to be *a new holy grail*. To gain some understanding of this topic and the scope of the international efforts already underway will require a detour that entails near lists of information. Those too impatient with details are invited to skip the next twelve pages at which point we shall return to the larger framework and questions.

It is generally accepted that meta-data is data about data,[5] or key information about larger bodies of information. Even so discussions of meta-data are frequently confusing for several reasons. First, they often do not define the scope of information being considered. In Internet circles, for instance, many authors assume that meta-data refers strictly to Internet documents, while others use it more generally to include the efforts of publishers and librarians. Secondly, distinctions need to be made concerning the level of detail entailed by the meta-data. Internet users, for instance, are often concerned only with the most basic information about a given site. In extreme cases, they believe that this can be covered through Generic Top Level Domain Names (GTLD), while publishers are convinced that some kind of unique identifying number will be sufficient for these purposes (see figure 6). Present day search engines such as Altavista, and Lycos also use a minimal approach to these problems, relying only on a title and a simple tag with a few keywords serving as the meta-data.

Others, particularly those in libraries, feel that summary descriptions, full library catalogue descriptions or methods for full text descriptions are required. Meanwhile some are convinced that while full text analysis or at least proper cataloguing methods are very much desirable, it is not feasible that the enormity of materials available on the web can be subjected to rigorous methods requiring considerable professional training. For these the Dublin Core is seen as a pragmatic compromise (figure 7). As can be inferred from the lists above, there are a great number of initiatives with common goals, often working in isolation, sometimes even ignorant of the others' existence. Nonetheless, a number of organizations are working at integrated solutions for meta-data. What follows is by no means comprehensive. Gilliland-Swetland, for instance, has recently identified *five different kinds of meta-data*: administrative, descriptive, preservation, technical and use (Gilliland-Swetland 1998).[6] There are four key players with respect to the Internet: 1) the Internet Engineering Task Force (IETF), which is part of the Internet Society; 2) the World Wide Web Consortium (W3); 3) the Z39.50 group, which was developed by the American National Standards Institute (ANSI); and 4) the Dublin Core Group of the Online Computer Library Center (OCLC).

How will the extraordinary potentials of the technologies outlined above be developed? Any attempt at a comprehensive answer would be out of date before it was finished. For the purposes of this paper it will suffice to draw attention to a few key examples. One of the earliest efforts to apply these new tools is the Harvest Information Discovery and Access System.[7] The Harvest method uses the Summary Object Interchange Format (SOIF),[8] which employs the Resource Description Message Format (RDMF), in turn a combination of IAFA templates and BibTex[9] which is part of the Development of a European Service for Information on Research and Education (DESIRE)[10] project linked with the European Commission's Telematics for Research Programme. It has been applied to Harvest, Netscape, and the Nordisk Web Index (NWI). This includes a series of attributes,[11] a series of template types[12] and other features.[13] While this method is limited to Internet resources, it represents an early working model.

Figure 6: Major trends in meta-data with respect to basic identification

Basic Description: Internet and Computer Software	
Generic Top Level Domain Names	(GTLD)[14]
Hypertext Transfer Protocol	(http)
Multipurpose Internet Mail Exchange	(MIME)
Uniform Resource Name	(URN)
Uniform Resource Locator	(URL)[15]
International	
International Standards Organization	(ISO)
International Standard Book Numbering, ISO 2108:1992	(ISBN)[16]
International Standard Music Number, ISO 10957:1993	(ISMN)[17]
International Standard Technical Report Number	(ISRN)[18]
Formal Public Identifiers	(FPI)[19]
National	
National Information Standards Office	(NISO)
Serial Item and Contribution Identifier	(SICI)
International Standard Serials Number	(ISSN)[20]
Publishers	
Confédération Internationale des Sociétés d'Auteurs et Compositeurs	(CISAC)[21]
Common Information System	(CIS)
International Standard Works Code	(ISWC)
Works Information Database	(WID)
Global and Interested Parties Database	(GIPD)
International Standard Audiovisual Number	(ISAN)[22]
International Federation of the Phonogram Industry	(IFPI)
International Standard Recording Code	(ISRC)[23]
Cf. Other Standard Identifier	(OSI)[24]
Universal Product Code	(UPC)
International Standard Music Number	(ISMN)
International Article Number	(IAN)
Serial Item and Contribution Identifier	(SICI)
Publisher Item Identifier	(PII)[25]
Corporation for National Research Initiatives and International DOI Foundation Digital Object Identifier	(DOI)[26]
Libraries	
Persistent Uniform Resource Locator	(PURL)[27]
Handles	
Universities	
Uniform Object Identifier	(UOI)[28]
Object ID	

Figure 7: Major trends in meta-data with respect to more complete description

Summary Description: Private Internet	
W3 Consortium	
Hyper Text Markup Language: Header	(HTML Header)
META Tag[29]	
Hyper Text Markup Language Appendage	(HTML Appendage)
Resource Description Format	(RDF)
Extensible Markup Language	(XML)
Protocol for Internet Content Selection	(PICS)
Uniform Resource Identifier	(URI)
Uniform Resource Characteristics	(URC)
Universally Unique Identifiers[30]	(UUID)
Globally Unique Identifiers	(GUID)
Whois++ Templates	
Internet Anonymous FTP Archives Templates	(IAFA)[31]
Linux Software Map Templates	(LSM)
Harvest Information Discovery and Access System	
Summary Object Interchange Format	(SOIF)[32]
Netscape	
Meta Content Framework	(MCF)[33]
Microsoft	
Web Collections[34]	
Libraries	
International Federation of Library Associations	(IFLA)[35]
International Standard Bibliographic Description	(ISBD)[36]
Electronic Records	(ER)
Dublin Core	(DC)
Resource Organization and Discovery in	
Subject Based Services	(ROADS)
Social Science Information Gateway	(SOSIG)
Medical Information Gateway	(OMNI)[37]
Art, Design, Architecture, Media	(ADAM)
Full (Library Catalogue Record) Description	
Libraries	
Machine Readable Record[38]	
withmany national variants	(MARC)[39]
Other Catalogue formats summarized in Eversberg	
(Eversberg 1994)[40]	(e.g. PICA, MAB)
Full Text: Libraries and Museums	
Standard Generalized Markup Language	(SGML)[41]
Library of Congress Encoding Archival Description	(LCEAD)[42]
Text Encoding Initiative	(TEI)
Consortium for Interchange of Museum Information	(CIMI)

The challenge remains as to how these tremendously varied resources can be integrated within a single network, in order that one can access both new web sites as well as classic institutions such as the British Library[43] or the Bibliothèque de la France. One possible solution is being explored by Carl Lagoze[44] in the Cornell Digital Library project. Cornell is also working with the University of Michigan on the concept of an Internet Public Library.[45] Another solution is being explored by Renato Iannella[46] at the Distributed Technology Centre (DSTC). This centre in Brisbane, which was one of the hosts of the WWW7 conference in 1998, includes a Resource Discovery Unit. In addition to its Basic URN Service for the Internet (BURNS) and The URN Interoperability Project (TURNIP), mentioned earlier, it has an Open Information Locator Project Framework[47] (OIL). This relies heavily on Uniform Resource Characteristics (including Data,[48] Type, Create Time, Modify Time, Owner). In the Uniform Resource Name (URN), this method distinguishes between a Namespace Identifier (NID) and Namespace Specific String (NSS). This approach is conceptually significant because it foresees an integration of information sources, which have traditionally been distinct if not completely separate, namely, the library world, internet sources and telecoms (figure 8).

Figure 8: Different kinds of information available using the Open Information Locator Project Framework (OIL)

urn:isbn:	publishing	ISBN no.
inet:dstc.edu.au	internet servers	listname
telecom:	telecom	telephone no.

Yet another initiative is being headed by the Open Management Group (OMG).[49] This consortium of 660 corporations has been developing a Common Object Request Broker Architecture (CORBA),[50] which links with an Interoperable Object Reference (IOR). One of its advantages is that it can sidestep some of the problems of interaction between hyper text transfer protocol (http) and Transfer Control Protocol (TCP). It does so by relying on Internet Inter Object Request Broker Protocol (IIOP). It also uses an Interface Repository (IR) and Interface Definition Language (IDL, ISO 14750).[51] CORBA has been adopted as part of the Telecommunications Information Networking Architecture (TINA).[52]

Some glimpse of a growing convergence is the rise of interchange formats designed to share information across systems. The (Defense) Advanced Research projects Agency's (ARPA's) Knowledge Interchange Format (KIF) and Harvester's Summary Object Information Format (SOIF) have already been mentioned. NASA has a Directory Interchange Format (DIF). The Metadata Coalition has a Metadata Interchange Specification[53] (MDIS).

At the university level, Stanford University has a series of Ontology Projects.[54] The California Institute of Technology (Caltech) has a project called Infospheres concerned with Distributed Active Objects.[55] Rensselaer Polytechnic has a Meta-database which includes an Enterprise Integration and Modeling Meta-database[56], a Visual Information Universe Model,[57] a Two Stage Entity Relationship Metaworld (TSER) and an Information Base Modelling System (IBMS).[58]

Meanwhile, companies such as Xerox have produced Metaobject Protocols[59] and Meta Data Dictionaries to Support Heterogeneous Data.[60] Companies such as Data Fusion (San Francisco), the Giga Information Group (Cambridge, Mass.), Infoseek (Sunnyvale, California),[61] Intellidex (cf. Foley 1997)[62] Systems LLC, Pine Cone Systems[63] and NEXOR[64] are all producing new software and tools relevant to meta-data.[65]

Vendors of library services are also beginning to play a role in this convergence. In the past, each firm created its own electronic catalogues with little attention to their compatibility with other systems. In Canada, thanks to recent initiatives of the Ontario Library Association (OLA), there is a move towards a province wide licensing scheme to make such systems available to libraries, a central premise being their compatibility and interoperability.

Global Efforts

Technologists engaged in these developments of meta-data on the Internet are frequently unaware that a number of international organizations have been working on meta-data for traditional sources for the past century. These include the Office Internationale de Bibliographie, Mundaneum,[66] the International Federation on Information and Documentation (FID)[67], the International Union of Associations (UIA)[68], branches of the International Standards Organization (e.g. ISO TC 37, along with Infoterm), as well as the joint efforts of UNESCO and the International Council of Scientific Unions (ICSU) to create a World Science Information System (UNISIST). Indeed, in 1971, the UNISIST committee concluded that:

a world wide network of scientific information services working in voluntary association was feasible based on the evidence submitted to it that an increased level of cooperation is an economic necessity.[69]

In 1977, UNISIST and NATIS, UNESCO's concept of integrated national information concerned with documentation, libraries and archives, were merged into a new Intergovernmental Council for the General Information Programme (PGI).[70] This body continues to work on meta-data.

Some efforts have been at an abstract level. For instance, the ISO has a subcommittee on Open systems interconnection, data management and open distributed processing (ISO/IEC/JTC1/SC21). The Data Documentation Initiative (DDI), has been working on a Standard Generalized Markup Language (SGML) Document Type Definition (DTD) for Data Documentation.[71] However, most work has been with respect to individual disciplines and subjects including art, biology, data, education, electronics, engineering, industry, geospatial and Geographical Information Systems (GIS), government, health and medicine, library, physics and science. Our purpose here is not to furnish a comprehensive list of all projects, but rather to indicate priorities thus far, to name some of the major players and to convey some sense of the enormity of the projects already underway. More details concerning these initiatives are listed alphabetically by subject in Appendix 3.

The most active area for meta-data has been in the field of geospatial and Geographical Information (GIS).[72] At the ISO level there is a Specification for a data descriptive file for geographic interchange (ISO 8211),[73] which is the basis for the International Hydrographic Organization's transfer standard for digital hydrographic data (IHO DX-90).[74] The ISO also has standards for Geographic Information (ISO 15046)[75] and for Standard representation of latitude, longitude and altitude (ISO 6709),[76] as well as a technical committee on Geographic Information and Geomatics[77]

(ISO/IEC/TC 211), with five working groups.[78] At the international level the Fédération Internationale des Géomètres (FIG) has a Commission 3.7 devoted to Spatial Data Infrastructure. The International Astronomical Union (IAU) and the International Union of Geodesy and Geophysics (IUGG) have developed an International Terrestrial Reference Frame (ITRF).[79]

At the European level, geographical information is being pursued by two technical committees, European Norms for Geographical Information (CEN/TC 287)[80] and European Standardisation Organization for Road Transport and Traffic Telematics (CEN/TC 278),[81] notably working group 7, Geographic Data File (GDF).[82] At the national level there are initiatives in countries such as Canada, Germany, and Russia. The United States has a standard for Digital Spatial Metadata[83] a Spatial Data Transfer Standard (SDTS)[84] and a Content Standard Digital Geospatial Metadata[85] (CSDGM).[86]

Meanwhile, major companies are developing their own solutions, notably Lucent Technologies (Potmesil 1997),[87] IBM (Almaden),[88] which is developing spatial data elements[89] as an addition to the Z39.50 standard, Arc/Info, Autodesk and the Environmental Systems Research Institute (ESRI).

Related to these enormous efforts in geospatial and geographical information have been a series of initiatives to develop metadata for the environment. At the world level, the United Nations Environmental Program (UNEP) has been developing Metadata Contributors.[90] In the G8 pilot project dedicated to environment, there is a Metainformation Topic Working Group[91] (MITWG) and Eliot Christian has developed a Global Information Locator Service (GILS).[92] There is a World Conservation Monitoring Centre,[93] a Central European Environmental Data Request Facility (CEDAR). Australia and New Zealand have a Land Information Council Metadata[94] (ANZIC). In the United States, the Environmental Protection Agency (EPA) has an Environmental Data Registry.[95] Efforts at harmonization of environmental measurement have also occurred in the context of G7 and UNEP.[96]

In the field of science, the same Environmental Protection Agency (EPA) has a Scientific Metadata Standards Project.[97] The Institute of Electrical and Electronic Engineers (IEEE)[98] has a committee on (Scientific) Metadata and Data Management.

In the fields of physics and scientific visualisation, the United States has a National Metacenter for Computational Science and Engineering[99] with the Khoros[100] project.

In biology there are initiatives to produce biological meta-data[101] and the IEEE has introduced a Biological Metadata Content Standard. In the United States there is a National Biological Information Infrastructure[102] (NBII) and there are efforts at Herbarium Information Standards.

In industry, the Basic Semantic Repository[103] (BSR), has recently been replaced by BEACON,[104] an open standards infrastructure for business and industrial applications.

In engineering, there is a Global Engineering Network (GEN) and, as was noted above there are a number of consortia aiming at complete interoperability of methods. In the United States, which seems to have some meta-association for almost every field, there is a National Metacenter for Computational Science and Engineering.[105] In the case of electronics, the Electronic Industries Association has produced a CASE Data Interchange Format (CDIF).

In the field of government, Eliot Christian's work in terms of the G7 pilot project on environment has inspired a Government Information Locator Service[106] (GILS). In health, the HL7 group has developed a HL7 Health Core Markup Language (HCML).

In education, there is a Learning Object Metadata Group,[107] a Committee on Technical Standards for Computer Based Learning (IEEE P1484) and Educom has a meta-data Tool as part of its Instructional Management Systems Project. In art, the Visual Resources Association (VRA) has produced Core Categories Metadata.[108]

Not surprisingly, the library world has been quite active in the field of meta-data. At the world level, the International Federation of Library Associations (IFLA) has been involved, as has the Text Entering Initiative (TEI), the Network of Literary Archives (NOLA), and the Oxford Text Archive (OTA). At the level of G8, it is a concern of pilot project 4, *Biblioteca Universalis*.[109] At the European level there is a list of Library Information Interchange Standards (LIIS).[110] In Germany, there is a Metadata Registry concerned with meta-data and interoperability in digital library related fields.[111] In the United States, there is an ALCTS Taskforce on Metadata and a Digital Library Metadata Group (DLMG).

In the United Kingdom, the Arts and Humanities Data Service (AHDS) and the United Kingdom Office for Library and Information Networking (UKOLN)[112] have a Proposal to Identify Shared Metadata Requirements,[113] a section on Metadata[114] and for Mapping between Metadata Formats.[115] They are concerned with Linking Publishers and National Bibliographic Services (BIBLINK) and have been working specifically on Resource Organization and Discovery in Subject Based Services (ROADS)[116] which has thus far produced gateways to Social Science Information (SOSIG), Medical Information (OMNI)[117] and Art, Design, Architecture, Media (ADAM). They have also been active in adopting basic Dublin Core elements. A significant recent by Rust has offered a vision provided by an EC project, Interoperability of Data in E-Commerce Systems (INDECS), which proposes an integrated model for Descriptive and Rights Metadata in E-Commerce (Rust 1998).[118] This concludes the detour announced twelve pages ago.

Standing back from this forest of facts and projects, we can see that there are literally hundreds of projects around the world all moving towards a framework that is immensely larger than anything available in even the greatest physical libraries of the world. Tedious though they may seem, these are the stepping stones for reaching new planes of information, which will enable some of the new scenarios in knowledge explored earlier. They are also proof that the danger of a second flood in terms of information as foreseen by authors such as Pierre Lévy is not being met only with fatalistic, passive, resignation.

Steps have been taken. Most of the projects thus far have focussed on the pipeline side of the problem. How do we make a database in library *A* compatible with that of library *B* such that we can check references in either one, and then, more importantly, compare references found in various libraries joined over a single network? Here the Z39.50 protocol has been crucial. As a result, networks are linking the titles of works in a number of libraries spread across a country, across continents and potentially around the world. Examples include the Online Computer Center (OCLC), the Research Library Information Network (RLIN) based in the United States and PICA based in the Netherlands. The ONE[119] project, in turn, links the PICA records with other collections such as Joanneum Research and the Steiermärkische Landesbibliothek (Graz, Austria), the Library of the Danish National Museum, Helsinki University Library (Finland), the National Library of Norway, LIBRIS (Stockholm, Sweden), Die Deutsche Bibliothek (Frankfurt, Germany), and the British Library. Some of these institutions are also being linked through the Gateway to European National Libraries Project (GABRIEL).[120] The German libraries are also working on a union catalogue of their collections. In the museum world there are similar efforts towards combining resources through the Museums Over States in Virtual Culture (MOSAIC)[121] project and the MEDICI framework of the European Commission. In addition, there are projects such as the Allgemeine Künstler Lexikon (AKL) of Thieme-Becker, and those of the Getty Research Institute: e.g. Union List of Author Names (ULAN) and the Thesaurus of Geographic Names (TGN).[122]

The next steps

What are the next steps? The *Maastricht McLuhan Institute*, a new European Centre for Knowledge Organization, Digital Culture and Learning Technology, will focus on two. First, it will make these existing distributed projects accessible through a common interface using a System for Universal Media Searching (SUMS). The common interface will serve at a European level for the MOSAIC project and at a global level as part of G8, pilot project five: Multimedia access to world cultural heritage.

A second, step will be to use these resources as the basis for a new level of authority lists for names, places and dates. In so doing it will integrate existing efforts at multilingual access to names as under development by G8 pilot project 4, Biblioteca Universalis, and earlier efforts of UNEP, to gain new access to variant names. In the case of terms, it will make use of standard classifications (e.g. Library of Congress, Dewey, Göttingen and Ranganathan[123]), as well as specialized classification systems for art such as Iconclass[124] and the Getty Art and Architectural Thesaurus.[125] As such the research project will in no way be in competition with existing projects. Rather it will integrate their efforts as a first step towards a new kind of digital reference room.[126]

Access to knowledge, which deals with claims about information, requires more than keywords in free text and natural language. Systematic access to knowledge requires a) authority files for names, subjects, places with their variants as outlined above; b) maps of changing terms and categories of knowledge in order to access earlier knowledge collections; c) systematic questions. If one takes basic keywords, translates these into standardized subject terms (what?), and combines these questions with those of space (where?), time (when?) and process (how?), one has a simple way of employing the Personality, Matter, Energy, Space and Time

(PMEST) system of Ranganathan. With some further division these questions also allow a fresh approach to Aristotle's substance-accident system (figure 9). In very simple terms: isolated questions provide access to data and information. Combinations of questions provide access to structured information or knowledge.

Figure 9: Six basic questions related to the five key notions of Ranganathan's PMEST system and the ten basic categories of Aristotle's substance-accident system

Who?	**What?**	**How?**	**Where?**	**When?**
Personality (P)	Matter (M)	Energy (E)	Space (S)	Time (T)
Being	Substance Matter Quantity Quality	Relation	Position Activities[127] Place	Time Dimension

One of the major developments over the past thirty years has been a dramatic increase in different kinds of relations. Perrault (Perrault 1994) in a seminal article introduced a method of integrating these systematically within UDC. The Medical Subject Headings (MESH) has five kinds of relations. Systems such as Dewey are too primitive to allow a full range of relations. Nonetheless, if the Dewey subjects are mapped to the UDC system where these connections have been made, then one can integrate relations within the search strategies.[128] Thus relations such as broader-narrower offer further search stratagems.

In order to ensure that the scope of the project becomes more universal than merely universally daunting, the digital reference room will begin with a subset of the whole, creating the cultural section of a future comprehensive reference room. The research function of the Institute will focus initially on extending the web of co-operation with other cultural institutions in order to prevent duplication of efforts and reinvention of the wheel. On this basis the cultural digital reference room will gradually be expanded to include links to corresponding digital texts from the great institutions. The institute itself will not attempt to replicate physically any of these collections. Rather it will serve as a centralized list of authority names, places and dates linked with a distributed collection of reference sources.

This seemingly narrow focus on art and culture will lead quite naturally to other fields. Paintings typically entail narratives. Hence the reference room must expand to include literature. As was already noted, to study the location of paintings and other museum objects, requires systematic treatments of scale and thus the reference room will expand to include the fields of geo-spatial and geographical information systems. In a subsequent phase, research will turn to expanding the scope of the digital reference room from this focus on culture, from the arts to the sciences, to the full range of human knowledge. As this occurs the common interface will be linked with the digital reference room to produce a System for Universal Multi-Media Access (SUMMA). In the context of the MEDICI framework, the centre at Maastricht will also be the first node of a network of Centres of Excellence in Cultural Heritage.

Horizons of knowledge

These authority lists of names, places and dates will, in the first instance, serve as the basis for a new level of interoperability among collections, at the content level as opposed to the basic pipeline connectivity. This entails considerably more than simple access to titles or even the full contents of materials listed in contemporary author and subject catalogues of libraries. On the one hand, it entails links to dictionaries and encyclopaedias, which will provide searchers with related terms. It also involves cross-references to citation indexes, abstracts and reviews.

Reference rooms, as the collective memory of civilization's search methods, also contain a fundamental historical dimension. To take a concrete example: today a book such as Dürer's *Instruction in Measurement* (*Underweysung der Messung*) is typically classed under perspective. In earlier catalogues this book was sometimes classed under proportion or more generally under geometry. As digital library projects extend to scanning in earlier library and book publishers' catalogues, a new kind of retrospective classification can occur, whereby titles eventually have both their old classes and their modern ones. This will radically transform future historical research, because the catalogues will then lead scholars into the categories relevant for the period, rather than to those that happen to be the fashion at the moment. Links to on-line versions of appropriate historical dictionaries will be a next step in this dimension of the digital reference room. Eventually there can be the equivalents of on-line etymologies on the fly.

There are, of course, many other projects concerning digital libraries. Some, such as the Web Analysis and Visualization Environment (WAVE) specifically attempt to link interoperable metadata with facetted classification (Kent 1998).[129] This project is important because it links methods from traditional library science (e.g. classifications) with those of mathematics (concept analysis). Even so this and other systems are focussed on access to contemporary information. What sets the MMI project apart from these initiatives is that it sets out from a premise of concepts and knowledge as evolving over time, as an historical phenomenon.

It will take decades before the digital library and museum projects have rendered accessible in electronic form all the documents and artifacts now stored in the world's great libraries, museums and galleries. By that time the enormous growth in computing power and memory, will make feasible projects that most would treat as science fiction or madness today. In the past decades we have seen the advent of concordances for all the terms in the Bible, Shakespeare and other classic texts. A next step would be to transform these concordances into thesauri with formally defined terms, such that the relations and hierarchies therein become manifest. This principle can then gradually be extended to the literature of a school, a particular decade, a period or even an empire.

This will allow us to look completely afresh at our past and ask whole new sets of questions. Rather than speaking vaguely of the growth of vernacular languages such as English or Italian, we can begin to trace with some quantitative precision, which were the crucial periods of growth. This will lead to new studies as to why the growth occurred at just that time. We shall have new ways of studying the history of terms and the changing associations of those terms. We shall move effectively to a new kind of global citation index.

It is said that, in the thirteenth century, it took a team of one hundred Dominican monks ten years of full time work to create an index of the writings of St. Thomas Aquinas. With a modern computer that same task can theoretically be accomplished in a few minutes. (Cynics might add that this would be after having spent several months writing an appropriate programme and a few weeks debugging it). In the past, scholars also typically spent days or months tracing the sources of a particular passage or crucial text. Indeed, scholars such as Professor M. A. Screech, who sought to trace the sources of major authors such as Montaigne or Erasmus, discovered that this was a lifetime's work. In the eye's of some this was the kind of consummate learning that epitomized what knowledge in the humanities was all about. For a reference to Aquinas might lead to a reference to Augustine, who alluded to Plotinus, who was drawing on Plato. To understand a quote thus took one into whole webs of cumulative philosophical, religious and cultural contexts, which make contemporary hypertext efforts look primitive indeed.

If we can trace quotes, we should also be able to trace stories and narrative traditions. Ever since the time of Fraser's *Golden Bough*,[130] we have been aware of the power of recurrent themes in poems, epics, legends, novels and other writings. Indeed much of academic studies of literature are based on little else. Trace the theme of x through this author or that period often dominates assignments and exams. If tracing these themes were automated, it would open up new approaches in much more than literature. For instance, if we were standing in front of Botticelli's *Story of Griselda* (London, National Gallery), and were unfamiliar with the story, we could just point our notepad computer and have it show and/or tell us the story.

In the case of direct quotations, machines can theoretically do much of this work today. Often, of course, the references are more indirect than direct or they are allusions that could lead to twenty other passages. It is well known that each of us has their favourite terms, words, which are imbued with special significance, as well as preferred words or sounds that serve as stopgaps in our thought. (Many of us, for instance, have met an individual who bridges every sentence or even phrase with an »um,« or peppers their speech with an »actually,« »indeed« or some other semantically neutral stopgap). An average person often gets by with a vocabulary of only about a thousand words. By contrast there are others in the tradition of Henry Higgins with vocabularies in the tens of thousands of words. Will we some day have the equivalent of fingerprints for our vocabularies, such that we can identify persons by their written and spoken words? Will the complexities of these verbal maps become a new way for considering individual development? Will we begin studying the precise nature of these great verbalizers? Some languages are more substantive (in the sense of noun based) whereas other such as Arabic are more verbal (in the sense of verb based)? Will the new »verbal« maps help us to understand cultural differences in describing the world and life? Will such maps become a basic element of our education?[131]

In the past, famous individuals wrote guidebooks and travelogues, which provided maps of their physical journeys and they wrote autobiographies to offer maps of their mental and emotional journeys. In the past generation, personalities such as Lord Kenneth Clark produced documentaries such as *Civilization* to accomplish this in the medium of film. At the Sony laboratories in Paris, Dr. Chisato Namaoka[132] is engaged in a Personal Experience Repository Project, which aims to record our memories as they occur while we visit a museum or significant tourist site, and to use that captured information for further occasions. Individuals such as Warren Robinett or Steve Mann have gone much further to speculate on the possibility of having a wearable camera that records everything one ever did in one's life: another take on the scenarios presented in the movie *Truman Show* (1998). Such developments could readily transform our conceptions of diaries and other memory devices.

They also introduce possibilities of a new kind of »experience on demand« whereby any visit to a tourist site might be accompanied with the expressions of famous predecessors. In the past, the medium determined where we could have an experience: books tended to take us to a library, films to a cinema, television to the place with a television set. In future, we can mix any experience, anywhere, anytime. How will this change our patterns of learning and our horizons of knowledge?

Emerging scenarios

All this assumes, of course, that computers can do much more than they can today. This is not the place to ponder at length how soon they will be able to process semantic and syntactical subtleties of language to the extent that they can approach deep structure and elusive problems of meaning and understanding. Nor would it be wise to speculate in great detail or to debate about what precisely will be the future role of human intervention in all this.

Rather, our concern is with some more fundamental problems and trends. One of the buzzwords about the Internet is that it is bringing »disintermediation,«[133] which is used particularly in the context of electronic commerce to mean »putting the producer of goods or services directly in touch with the customer.« Some would go further to insist that computers will soon allow us to do everything directly: order books via sites such as Amazon.com without needing to go to bookstores; go shopping on-line without the distractions of shopping-malls. In this scenario, computers will make us more and more active and we shall end up doing everything personally. At the same time, another group claims that computers will effectively become our electronic butlers, increasingly taking over many aspects of everyday life. In this scenario, computers will make us more and more passive and we shall end up doing less and less personally. Indeed, some see this as yet another move in the direction of our becoming complete couch potatoes.

In our view, there is no need to fear that computers will necessarily make us exclusively active or passive. That choice will continue to depend on the individual, just as it does today. Nonetheless, it seems inevitable that computers will increasingly play an inter-mediating role, as they become central to more and more aspects of our lives. In the past decade, the concept of agents has evolved rapidly from a near science fiction concept to an emerging reality. There is now an international Foundation for Intelligent Physical Agents (FIPA).[134] There are emerging fields devoted to user-modelling and user adapted interaction, entailing person-machine interfaces, intelligent help systems, intelligent tutoring systems and natural language dialogues.[135] Leading technologists such as Philippe Quéau, have predicted the advent of tele-virtuality,[136] whereby avatars (Damer 1998) will play an increasing role as our virtual representatives in the Internet. Recently, in Paris, there was a first international conference on Virtual Worlds (July 1998), attended by those at the frontiers of two, hitherto quite separate fields: virtual reality and artificial life. Some predict that self-evolving artificial life forms will soon be integrated into avatars. Some of the early virtual worlds began simply by reconstructing actual cities such as Paris[137] or Helsinki.[138] Others such as Alpha World[139] are creating a new three-dimensional virtual world based on elements familiar from the man-made environment. Potentially these worlds could be synthetic ones, or purely imaginary ones, no longer subject either to the physical laws or even the spatial conditions of planet earth. At Manchester, Professor Adrian West,[140] has begun to explore the interactions of virtual worlds, parts of which are subject to different laws of physics.

In a world where the Internet Society is planning to become interplanetary,[141] assigning addresses for different planets, the solar system and eventually other galaxies, the question of navigation is becoming much more acute and »Where in the world?« is becoming much more than a turn of phrase. We shall need new methods to discern whether the world we have entered is physically based or an imaginary construct; whether our avatar has embarked on a »real« trip or almost literally into some flight of phantasy. In the past generation, children have grown up expecting the realism of video-games to be considerably poorer than that of realistic films or the real world. Within the next generation, such easy boundaries will increasingly blur and then disappear almost entirely. Is it reality? Is it a game? Is it playful reality or realistic playfulness? Such questions will become ever more difficult to discern.

In light of all this, some activities of scholars will certainly remain: reflecting on what sources mean, weighing their significance, using them to gain new insights and to outline new analyses, goals, dreams, visions, even utopias. Meanwhile, it is likely that many of the activities which preoccupied scholars for much of their lives in the past will become automated within the next generations, namely, hunting for texts, tracking down quotes and looking for sources.

At the same time many new activities will emerge. Before the advent of space travel and satellites no one could imagine precisely what it would be like to look at the earth from space. Within a single generation we have developed methods for zooming systematically from such satellite images down to a close up of an object on earth in its original scale, and even how to descend to microscopic levels to reveal biological, molecular and atomic properties. We need to create the equivalents of such zooms for our conceptual worlds, moving systematically from broader terms to narrower terms. We need new ways of visualizing how the horizons of our conceptual worlds grow. At the simplest level this entails demonstrating how we have shifted from a Ptolemaic to a Copernican worldview. Much more elusive and difficult is to find ways of showing how our mental horizons have expanded over time. What impact did major changes in travel such as the crusades, pilgrimages, and the grand tour, have on vocabularies or inventions? Most of the future questions to be asked cannot yet be formulated because we cannot yet see ways of collecting, ordering and making sense of the vast materials that would be required to formulate them.

At present, the frontiers of scientific visualization are focussed on helping us to see phenomena such as the flow of air in a jet at supersonic speeds, the development of storms and tornadoes, the dispersal of waste in Chesapeake Bay, changes in the ozone layer, and many other events that we could not begin to know until we had methods for seeing them. Computers are transforming our knowledge because they are helping us to see more than we knew possible. The physical world opens as we make visible its unseen dimensions (Darius 1981; Pomaranoff 1981). The mental world awaits a similar journey and as with all journeys we must remember that what we see is but a small part of the immensity that is to be known, experienced, sensed or somehow enters our horizons.

Amidst all these developments there are also new problems. In the United States, there is a tendency to reduce cultural heritage to a commodity as merely another aspect of consumerism. This tendency implies the erosion of a long standing distinction between public good versus private interests. The public good, as protected by governments, is a long term investment. Private, business interests are concerned with short term-profits. Culture is more than a series of paintings in museums and books in libraries. In each generation a subset of those paintings and books serve as an informal corpus of works which any given country or group uses for their identity. In the Netherlands, for instance, painters such as Rembrandt, Vermeer and Van Gogh help define not only Dutch painting but what it means to be Netherlandish, just as Shakespeare and Milton, help persons in England define what it means to be English. Private companies may have the resources to buy a given manuscript or painting but they could never afford to buy all the cultural artefacts, by which French, German, Italian or any of the other greater cultures is defined. Needed, therefore, is an ongoing political commitment towards a cumulative cultural memory, whereby the individualities of culture will be fostered, for precisely therein lie the secrets of why tourists are so fascinated by the uniqueness of Italy or the mysterious *je ne sais quoi* of France.[142] While some may predict that corporations could or will rule the world, a deeper challenge lies in assuring that we retain a world that is coherent and self-conscious enough to be worth ruling. An unruly world without cultural identities would not only be much less poorer spiritually but would also be much less attractive from an economic standpoint.

Conclusions

This paper began from the premise that every new medium changes our definitions of, approaches to and views of knowledge. It claimed that networked computers (as enabled by the Internet), cannot be understood as simply yet another medium in a long evolution that began with speech and evolved via cuneiform, parchment, manuscripts to printed books and more recently to radio, film, and video. Computers offer a new method of translating information from one medium to another, wherein lies the deeper meaning of the overworked term multimedia. Hence, computers will never create paperless offices. They will eventually create offices where any form of communication can be transformed into any other form.

In the introduction we raised questions about an excellent article by Classen concerning major trends in new media (Classen 1998). He claimed that while technology was expanding exponentially, the usefulness[143] of that technology was expanding logarithmically and that these different curves tended to balance each other out to produce a linear increase of usefulness with time. In our view, simpler explanations are possible. First, technologists have been so concerned with the pipeline aspects of their profession (ISO layers 1–6 in their language), that they have ignored the vast unexplored realms of applications (ISO layer 7). Second, phrases such as »build it and they will come« may sound rhetorically attractive, but unless what is built actually becomes available, it can neither be used nor useful. Rather than seek elusive limits to usefulness, it is much more effective to make things available. In short, a more effective formulation might be: let it be useable and used and usefulness will follow.

Any attempt at a systematic analysis of future applications would have required at least a book length study. For this reason the scope of the present paper was limited to exploring some of the larger implications posed by the new media. We claimed that there are at least seven ways in which networked computers are transforming our concepts of knowledge. First, they offer new methods for looking at processes, how things are done, which also helps in understanding why things are done in such ways. Second, and more fundamentally, they offer tools for creating numerous views of the same facts, methods for studying knowledge at different levels of abstraction. Third, they allow us to examine the same object or process in terms of different kinds of reality. Fourth, computers introduce more systematic means of dealing with scale. Fifth, they imply a fundamental shift in our methods for dealing with age-old problems of relating universals and particulars. Analysis thereof pointed to basic differences between the arts and sciences and the need for independent historical approaches to reflect these, all the more so because computers, which are only concerned with showing us the latest version of our text or programme, are a direct reflection of this scientific tradition. We need a richer model that also shows us layered, cumulative versions. Sixth, computers transform our potential access to data through the use of meta-data. Seventh and finally, computers introduce new methods for mediated learning and knowledge through agents.

While the main thrust of the paper was focussed on the enormous potentials of networked computers for new approaches to knowledge, some problems were raised. These began with some of the limitations in the technology that is actually available today, with respect to storage capacity, processor speeds, bandwidth and interoperability. The dangers of making normative models, which then affect the future evidence to be considered, as in the case of the human genome project, were touched upon. So too were the dangers underlying some of the rhetorically attractive, but equally misleading assumptions behind come contemporary approaches to complex systems.

At the outset of the paper, mention was also made of the dangers articulated by Pierre Lévy, that we are in danger of a second flood, this time in the form of a surfeit of information, as a result of which we can no longer make sense of the enormity of materials descending upon us. Partly to counter this, a section of the paper entered into considerable detail on worldwide efforts concerning meta-data as a means of regaining a comprehensive overview of both the immense resources that have been collected already and the ever increasing amounts which are being added daily. Sense making tools are an emerging field of software.

A half century ago pioneers such as Havelock, Innis and McLuhan recognized that new media inevitably affect our concepts of what constitutes knowledge. The mass media epitomized this with McLuhan's pithy phrase: *The medium is the message*. Reduced and taken in isolation, it is easy to see, in retrospect, that this obscured almost as much as it revealed. The new media are changing the way we know. They are doing so in fundamental ways and they are inspiring, creating, producing, distorting and even obscuring many messages. New machines make many new things possible. Only humans can ensure that what began as data streams and quests for information highways become paths towards knowledge and wisdom.

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It is planned that a slightly expanded version of this article will be published by the Ontario Library Association as the fourth chapter of a book, *Frontiers in Conceptual Navigation for Cultural Heritage*.

Notes

1 The Metadata Coalition at http://www.metadat.org is a group of 50 software vendors and users including Microsoft with a 7 member council that has voted to support Microsoft Repository Metadata (Coalition) Interchange Specification (MDIS) at http://www.he.net/~metadata/papers/intro97.html.

2 This includes Arbor, Business Objects, Cognos, ETI, Platinum Tech, and Texas Instruments (TI). See http://www.cutech.com/newmeta.html.

3 See http://environment.gov.au/newsletter/n25/metadata.html.

4 For basic articles on meta-data see: Francis Bretherton, »A Reference Model for Metadata« at http://www.hensa.ac.uk/tools/www.iafatools/references/whitepaper/whitepaper.bretherton.html; »WWW meta-indexes« at http://www.dlr.de/search-center-meta.html and Larry Kirschberg, »Meta World: A Quality of Service Based Active Information Repository, Active Data Knowledge Dictionary«, http://isse.gmu.edu/faculty/kersch/Vita-folder/index.html. For books see: Computing and Communications in the Extreme. Research for Crisis Management and Other Applications at http://www.nap.edu/readingroom/books/extreme/chap2.html.

5 For basic definitions of metadata see http://204.254.77.2/bulletinsuk/212e-1a6.htm and the Klamath Metadata Dictionary at http://badger.state.wi.us/agencies/wlib/sco/metatool/kmdd.htm.A basic taxonomy of metadata is available at http://www.1bl.gov/~olken/EPA/Workshop/taxonomy.html. See also the CERA metadata model at http://www.dkrz.de/forschung/reports/reports/CERA.book.html.

6 The author also lists *eight attributes of metadata*: source of metadata, method of metadata creation, nature of metadata, status, structure, semantics and level. Also in this booklet is a useful attempt to map between some of the major metadata standards: Categories for the Description of Works of Art (CDWA), Object ID, the Consortium for the Interchange of Museum Information (CIMI), Foundation for Documents of Architecture/Architectural Drawings Advisory Group (FDA/ADAG), Museum Educational Site Licensing (MESL) project, Visual Resources Sharing Information Online (VISION), Record Export for Art and Cultural Heritage (REACH), United States Machine Readable Cataloging (US MARC) and the Dublin Core. While providing an excellent survey of existing efforts towards standards in the United States, this list does not reflect a comprehensive picture of efforts around the world.

7 See http://harvest.transarc.com.

8 http://www.dbr/~greving/harvest-user-manual/node42.html. This was developed by Michael Schwartz.

9 See http://www.ukoln.ac.uk/metadata/DESIRE/overview/rev-02.

10 See http://www.ukoln.ac.uk/metadata/DESIRE/overview.

11 The Attribute List includes headings such as: Abstract, Author, Description, File Size.

12 Harvest Template Types include: Archive, Audio, FAQ, HTML, Mail, Tcl, Troff, Waissource.

13 Other harvest features include: Identifier, Value, Value Size, Delimiter, URL References.

14 These are defined in the Generic Top Level Domain Memorandum of Understanding at http://www.gtld-mou.org/.

15 The URL began as a simple resource locator for basic internet protocols, such as: file, Gopher, http, news, telnet. A more universal approach to resource location is foreseen in the evolving Uniform Resource Indicators (URI).

16 See http://www.iso.ch/cate/d6898.html.

17 See http://www.iso.ch/cate/d18931.html.

18 See http://www.iso.ch.iso/cate/d18506.html.

19 See http://www.acl.lanl.gov/URN/FPI-URN.html.
20 See http://www.issn.org.
21 See http://www.cisac.org/eng/news/digi/ensymp972.htm.
22 In draft in ISO TC46sc9.
23 This includes specification of ISRC related metadata which is linked with MUSE, an EC funded initiative of the record industry which is due to announce (c. October 1998) a secure means for encoding and protecting identifiers within digital audio.
24 See http://www.tlcdelivers.com/tlc/crs/Bib0670.htm.
25 See http://www.elsevier.nl/inca/homepage/about/pii. On these identifiers from the publishing world see an article by Norman Paskin at http://www.elsevier.co.jp/inca/homepage/about/infoident.
26 See http://www.handle.net/doi/announce.html. Cf. http://pubs.acs.org/journals/pubiden.html and http://www.doi.org. This began in the book and electronic publishing industry but is attracting wider membership.
27 See http://purl.oclc.org.
28 See http://www.cs.princeton.edu/~burchard/gfx/bg.marble.gif.
29 Concerning HTML 3 see: http://vancouver-webpages.com/Vwbot/mk-metas.html.
30 See http://hegel.ittc.ukans.edu/topics/internet/internet-drafts/draft-l/draft-leach-uuids-guids-00.txt. Cf. http://www.icsuci.edu/~ejw/authoring/rd-tri.gif.
31 See http://www.hensa.ac.uk/tools/www.iafatools/slides/01.html. This is being developed by the Internet Anonymous FTP Archives Working Group, whose templates on Internet Data are based on whois++ and include: URI, File System, Contents, Author, Site Administrator, Another Metadata Format. This model is being applied to ROADS.
32 See http://www.dbr/~greving/harvest-user-manual/node42.html.
33 The purposes of MCF are: 1) Describe structure of website or set of channels; 2) Threading E-Mail; 3) Personal Information Management functions (PIM)+; 4) Distributed annotation and authoring; 5) Exchanging commerce related information such as prices, inventories and delivery dates. It will use a Directed Linked Graph which contains: URL, String, E-Mail, Author, Person, Size, Integer. It will also use Distribution and Replication Protocol (DRP) developed by Netscape and Marimba.
The MCF began at Apple Computers. See: Guha 1997 at http://mcf.research.apple.com/mcf.html. Guha then moved to Netscape and developed the Meta Content Framework with Tim Bray of Textuality. See http://www.textuality.com/mcf/NOTE-MCF-XML.html.

34 Web Collections will include: Web Maps, HTML E-Mail Threading, PIM Functions, Scheduling, Content Labelling, Distributed Authoring. It uses XML to provide hierarchical structure for this data. See: http://www.w3.org/TR?NOTE-XML.submit.html.

35 For IFLA metadata See http://www.nlc-bnc.ca/ifla/II/metadata.htm.

36 International Standard Book Description (ISBD) has eight basic features: 1) Title and Statement of Responsibility Area; 2) Edition Area; 3) Place of publication) specific area; 4) Publication Distribution etc. area; 5) Physical Description Area; 6) Series; 7) Note Area; 8) Standard Number (or alternative) and terms of availability. It should be noted that ISBD has a series of other divisions, namely: Antiquarian ISBD A); Monographs ISBD (M); Non Book Materials ISBD (NBM); Printed Music ISBD (PM); Serials ISBD (S).

37 See http://omni.nott.ac.uk.

38 See http://lcweb.loc.gov/marc.

39 The MARC/UNIMARC format uses ISO Z39.50. It is applied to OCLC's Netfirst. There are plans to link this with a URC to create a MARC URC. The MARC record comes in many variants.

40 See http://ubsun01.biblio.etc.tu-bs.de/acwww25/formate/formate.html.

41 The Association for Library Collections and Technical Services (ALCTS: DA) has a Committee on Cataloging Description and Access at http://www.lib.virginia.edu/ccda and is engaged in mapping of SGML to MARC and conversely. See http://darkwing.uoregon. edu/mnwation/ccdapage/index.html.

42 See http://www.loc.gov/rr/ead/eadhome.html. Berkeley is also involved in EAD with a view to creating UEAD URC. See http://sunsite.Berkeley.EDU/ead.

43 For insight into the British Library's efforts see: Carpenter/Shaw/Prescott 1998. Readers are also referred to the library's publication: Initiatives for Access. News.

44 See http://www2.cornell.edu/lagoze/talks/austalk/sld014.htm.

45 See http://www.ipl.org.

46 See http://www.dstc.edu.au/RDU/pres/nat-md/.

47 See http://www.dstc.edu.au/RDU/pres/www5.

48 URC Data includes: Title, Author, Identifier, Relation, Language.

49 See http://ruby.omg.org/index.htm.

50 See http://www.omg.org/corbserver/relation.pdf.

51 This is connected with the Inter-Language Unification (ILU) project of Xerox PARC at http://parcftp.parc.xerox/pub/ilu/ilu.htm,

which is producing an Interface Specification Language (ISL). It is not to be confused with Interactive Data Language (IDL) See http://ftp.avl.umd.edu/pkgs/idl.html.

52 See http://www.omg.org/docs/telecom/97-01-01.txt. Cf. http://www.igd.fhg.de/www/igd-a2/conferences/cfp-tina97.html.

53 See http://www.he.net/~metadata/papers/intro97.html.

54 See http://mnemosyne.itc.it:1024/ontology.html. Cf. http://www.ksl.stanford.edu/kst/wahat-is-an-ontology.html.

55 See http://www.infospheres.caltech.edu.

56 See http://viu.eng.rpi.edu.

57 See http://viu.eng.rpi.edu/viu.html.

58 See http://viu.eng.rpi.edu/IBMS. html.

59 See http://www.parc.xerox.com/spl/projects/mops.

60 See http://dri.cornell.edu/Public/morgenstern/MetaData.html. cf. http://dri.cornell.edu/pub/morgenstern/slides/slides.html

61 See http://www2.infoseek.com/.

62 See http://www.intellidex.com.

63 See http://www.carleton.com/metacnt1.html.

64 See http://localweb.nexor.co.uk.

65 For a further list of software see http://www.ukoln.ac.uk/metadata/software-tools. For a list of tools see: http://badger.state.wi.us/agencies/ulib/sco/metatool/mtools.htm.

66 See http://www.pastel.be/mundaneum/. Cf. Rayward 1975.

67 Based on its French name: Fédération Internationale de la Documentation.

68 Based on its French name: Union Internationale des Associations. See http://www.uia.org.

69 UNISIST. Synopsis of the Feasibility Study on a World Science Information System, Paris: UNESCO, 1971, p. xiii.

70 http://www.unesco.org/webworld/council/council.htm.

71 See http://www.icpsr.umich.edu/DDI. Cf. the Association for Information and Image Management International (AIIMI) which organizes the Document Management Alliance at http://www.aiim.org/dma.

Cf. also the European Computer Manufacturers Association (ECMA) which has produced the Script Language Specification (ECMA 262) at http://www.ecma.ch/index.htm and http://www.ecma.ch/standard.htm.

See http://www.sdsc.edu/SDSC/Metacenter/MetaVis.html which provides electronic addresses for all of the above.

72 See http://www.sdsc.edu/SDSC/Metacenter/MetaVis.html which provides electronic addresses for all of the above.

73 See http://www.ru/gisa/english/cssitr/format/ISO8211.htm.

74 See http://www2.echo.lu/oii/en/gis.html#IHO.

75 See http://www2.echo.lu/oii/en/gis.html#ISO15046.
76 See http://www2.echo.lu/oii/en/gis.html#ISO6709.
77 See http://www.stalk.art.no/isotc211/welcome.html.
78 See http://cesgi1.city.ac.uk/figtree/plan/c3.html. Cf. ISO/IEC/TC 211.
79 See http://www2.echo.lu/oii/en/gis.html#ITRF.
80 See http://ilm425.nlh.no/gis/cen.tc287.
81 See http://www2.echo.lu/impact/oii/gis.html#GDF.
82 See http://www2.echo.lu/vii/en/gis.html#GDF.
83 See file://waisvarsa.er.usgs.gov/wais/docs/ASTMmeta83194.txt.
84 See http://sdts.er.usgs.gov/sdts/mcmcweb.er.usgs.gov/sdb.
85 See http://fgdc.er.usgs.gov/metaover.html.
86 See http://geochange.er.usgs.gov/pub/tools/metadata/standard/metadata.html cf. http://www.geo.ed.ac.uk/~anp/metaindex.htm.
87 See http://www6.nttlabs.com/HyperNews/get/PAPER/30.html.
88 See http://www.research.ibm.com/research/press.
89 See http://ds.internic.net/z3950/z3950.html which provides a list of available implementations.
90 See http://www.grid.unep.no/center.htm.
91 See http://gelos.ceo.org/free/TWG/metainofrmation.html.
92 See http://info.er.usgs.gov/gils. Cf. Eliot Christian, »GILS. Where is it where is it going?« See http://www.dlib.org/dlib/december96/12christian.html.
93 See http://www.wcmc.org.uk/.
94 See http://www.erin.gov.au/general/discussion-groups/ozmeta-l/index.html.
95 See http://www.epa.gov/edu.
96 On Harmonization of Environmental Measurement see: Keune/Murray/Benking 1991, available on line at: http://www.ceptualinstitute.com/genre/benking/harmonization/harmonization.htm. On Access and Assimilation: Pivotal Environmental Information Challenges, see: GeoJournal, vol. 26, no. 3, March 1992, pp. 323-334 at: http://www.ceptualinstitute.com/genre/benking/aa/acc&assim.htm
97 See http://www.lbl.gov/~olken/epa.html.
98 See http://www.llnl.gov/liv-comp/metadata/metadata.html.
99 See http://www.psc.edu/Metacenter/MetacenterHome.html.
100 See http://www.khoral.com/plain/home.html.
101 See http://www.nbs.gov/nbii.
102 See http://www.nbii.gov/.
103 See http://www.cs.mu.oz.au/research/icaris/bsr.html.
104 See http://www.cs.mu.oz.au/research/icaris/beacon.html.
105 See http://www.sdsc.edu/SDSC/Metacenter.
106 See http://www.usgs.gov/gils/prof-v2html#core.

107 See http://jetta.ncsl.nist.gov/metadata.
108 See http://www.oberlin.edu/~art/vra/core.html.
109 See http://www.unesco.org/webworld/telematics/uncstd.htm.
110 See http://www2.echo.lu/oii/en/library.html.
111 See http://www.mpib-berlin.mpg.de/dok/metadata/gmr/gmrwkdel.htm.
112 See http://www.ukoln.ac.uk/metadata/; http://www.ukoln.ac.uk/metadata/interoperability; http://www.ukoln.ac.uk/dlib/dlib/july96/07dempsey.html; http://www.ukoln.ac.uk/ariadne/issue5/metadata-masses/.
113 See http://ahds.ac.uk/manage/proposal.html#summary.
114 See http://www.ukoln.ac/metadata/.
115 See http://www.ukoln.ac.uk/metadata/interoperability.
116 See http://www.roads.lut.ac.uk/Reports/arch/.
117 See http://omni.nott.ac.uk.
118 See http://www.dlib.org/dlib/july98/rust/07rust.html.
119 See http://www.dbc.dk/ONE/oneweb/index.html.
120 See http://portico.bl.uk/gabriel/.
121 See http://www.infobyte.it.
122 See http://www.gii.getty.edu/vocabulary/tgn.html.
123 Cf. the interesting work by Dr. A. Steven Pollitt (Huddersfield University, CeDAR), »Faceted Classification as Pre-coordinated Subject Indexing« at: http://info.rbt.no/nkki/korg98/pollitt.htm. I am very grateful to Dr. Pollitt for making me aware of his work. Some believe that traditional discipline based classifications are outmoded in an increasingly interdisciplinary world. For instance, Professor Clare Beghtol (Beghtol 1994) believes that the distinction between non-fiction and fiction is no longer relevant since both categories entail narrative. Meanwhile, Nancy Williamson (Williamson 1998), although sceptical about replacing disciplines entirely, has explored a series of alternative short-term solutions. Since university and other research departments continue to be discipline based it may be sensible to maintain what has been the starting point for all classification systems for the past two millenia, and work on creating new links between, among these disciplines.
124 See http://iconclass.let.ruu.nl/home.html.
125 See http://www.gii.getty.edu/vocabulary/aat.html.
126 See the author's »Towards a Global Vision of Meta-data: A Digital Reference Room«. Proceedings of the 2nd International Conference. Cultural Heritage Networks Hypermedia, Milan, pp. 1–8.
127 This Aristotle subdivided into active Operation and passive Process.

128 A fundamental problem in the systematic adoption and interoperability of these relations is that different communities and even different members within a community use alternative terms for the same relation. For instance, what some library professionals call »typonomy« is called »broader-narrower terms« by others, »generic« by philosophers, and in computing circles is variously called »is a«, »type instantiation« and »generalization.« Similarly, »hieronomy« is variously called »is part of,« »partitive« by philosophers and »aggregation« by computer scientists. MMI will encourage research at the doctoral level to create a system for bridging these variant terms, using as a point of departure Dahlberg's classification of generic, partitive, oppositional and functional relations.

129 See: http://wave.eecs.wsu.edu.

130 See http://www.philo9.force9.co.uk/books10.htm.

131 This may be closer than we think. Cf. Brin 1998, p. 287, who also reports on trends towards proclivities profiling, p.290.

132 See http://www.csl.sony.co.jp/person/chisato.html.

133 See http://150.108.63.4/ec/organization/disinter/disinter.htm. For a contrary view see: Sarkar, Butler, and Steinfield's paper (JCMC-electronic commerce, Vol.1 No.3).

134 See http://www.cselt.it/ufv/leonardo/fipa/; cf. http://drogo.cselt.stet.it/fipa/.

135 See http://umuai.informatik.uni-essen.de/field-of-UMUAI.html.

136 See http://www.ina.fr/TV/TV.fr.html.

137 See http://www.chez.com/jade/deuxmond.html which represents Paris.

138 See Virtual Helsinki at http://www.hel.fi/infocities/eng/index.

139 See http://idt.net/~jusric19/alphalinks.html.

140 See http://socrates.cs.man.ac.uk/~ajw/.

141 At the Internet Society Summit (Geneva, July 1998), Vint Cerf, the new Chairman, in his keynote, described how the international space agency is working on a new address scheme to be launched with the next voyage to Mars late this year.

142 For a recent call to articulate a European approach to counter the above trends see: Chester (1998)

143 The definition of usefulness could readily detour into a long debate. For the purposes of this article we shall take it in a very broad sense to mean the uses of computers in terms of their various applications.

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