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Culture and Knowledge in the Digital Age

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Kultur und Wissen im Digitaler Zeitalter

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[This essay summarizes some of the key insights of the author's book *Augmented Knowledge and Culture*, 2000.]

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1. Introduction

It is difficult to keep up with and to understand the magnitude of the revolution in Information and Communication Technologies (ICT). Two examples make the point. In 1995 the G7 demos at Midrand used a Silicon Graphics (SGI) machine with a gigabyte of Random Access Memory (RAM) valued at \$1,000,000. In 2002, the same power is available on a home computer at a cost of \$2,600. A second example: In the year 2000, the ASCI Red computer at Sandia Labs, the size of 5 basketball fields with 11.5 trillion instructions (or teraflops) per second, was the largest computer in the world. In November 2002, that same computer was at position 15 in the list of the world's fastest supercomputers.¹ In November 2002, the top computer was Japanese, at least three times as fast as ASCI Red and we are told that by the end of 2003 there will be a new computer, which will have 1000 trillion instructions per second:² i.e. the fastest computer will soon be 15 times more powerful than the combined power of all the 500 top computers in 2000 and it will only be the size of only two refrigerators.

1987	10,000
1989	100,000
1992	1,000,000
1995	4,900,000
2000	230,000,000
2002	560,000,000
2003	650,000,000
2004	940,000,000

Figure 1. The growth of the Internet.³

Technological	Invisibility
Material	Virtuality
Organisational	Systemicity
Intellectual	Contextuality
Philosophical	Spirituality

Figure 2. Five possible consequences of the new media.

Similarly, it is difficult to appreciate the growth of the Internet. In 1987, there were only some 10,000 users. By the beginning of 2000, there were some 230 million. Notwithstanding the so-called dot-com bust and the IT woes, the number of users doubled in the next 24 months (figure 1). By September 2003, the figure was 680 million, approximately 10% of the world population. By the end of 2004, we are told the figure will be 940 million.

During this period of 15 years, there has been a radical change in the role of languages. In 1987, English represented an estimated 98% of the Internet. In May 2003 it represents 35.2%. Chinese is now the second largest language on the Internet (11.8%); Japanese is third (10.3%); Spanish is fourth (8.1%); German is fifth (6.5%), Korean is sixth (4.2%) and French is seventh (3.3%).⁴ There are over 70 major languages online in an Internet⁵ that is said to be growing at a rate of seven million new pages a day with a surface web of 2.1 billion pages⁶ and a deep web (which includes all the databases and sections produced on the fly) of some 550 billion pages.⁷ It is predicted that by 2007 Chinese will be the most used language on the Internet.⁸ These momentous technological developments are only the surface of the ICT revolution which is underway and which this essay seeks to outline. There are equally significant material, organisational, intellectual and philosophical consequences, which characterize the transformations in culture and knowledge in the digital age (figure 2).

2. Invisibility

The shrinking of the world's largest computer from the size of 5 basketball fields to the size of 2 refrigerators is symptomatic of a more fundamental trend towards nano-technology.⁹ Twenty years ago this was largely a topic of science-fiction. Today there are major developments on four fronts: electronic, biochemical or organic, mechanical and quantum. An item on the BBC News (12 January 2000) gave a glimpse where this is leading: "1 gramme of dried DNA can hold as much information as 1 trillion CDs."

Within a generation everyday computers will be invisible. The enormous desktops of the past will disappear into our furniture and our clothing. Wearable computing, a futuristic buzzword only five years ago, will become a reality. Monitors, once enormous boxes, will become one with the windows in our homes. Visionaries at Philips speak of "ambient intelligence,"¹⁰ where everyday pieces of furniture will have their own computer. Indeed ambient intelligence means that every object in our environment, every object of culture, can potentially have their own "computer" that helps to describe its own history. In the past, we often measured progress in terms of large size. The country with the largest machine, the largest airplane was clearly the most advanced. Within a generation this measure could well be reversed: the country with the smallest machine

will be the most advanced.¹¹ The technological consequences of the digital revolution are invisibility.

3. Virtuality

Connected with this technological trend towards invisibility is a material trend towards virtuality. In the past, the real and the virtual were often treated as opposites. In the analog world the real counted and everything else was a poor imitation. In the digital world a high level digital version may in some cases entail something more useful than the original, because the digital or virtual form can readily be “translated” to a series of other media. An analog page of a printed book is no more than a page. A digital page of a printed book can theoretically be output as a handwritten manuscript page, as a spoken page in oral form or even as a cuneiform page in tactile form.

Virtuality affects not only our approach to physical objects but is also transforming our approach to processes. At least from the time of the Romans, there was a clear tradition of making models prior to building “the real thing.” These models have always been seen as useful visualization aids but little else. This is changing. A virtual factory in Manchester (cf. Professor Adrian West) took more than 40 person years to create.¹² It is much more than a simple, small-scale replica of a physical factory. It reconstructs all the major processes that take place within that factory. Similarly, in Virtual Environments for Training (VET), Lockheed Martin and the US Navy are reconstructing in virtual form all the operations of a warship.¹³

This same approach is being applied to historical subjects. At the University of Bologna, scholars are reconstructing silk mills¹⁴ of the seventeenth century virtually in order better to comprehend how they functioned and to use this in studying both the history of technology and economic history. Similarly in Falun, Sweden, at the new Centre for Digital Interpretation, scholars are reconstructing the processes of the mine which once produced 70% of Europe’s copper in order to understand their own past.¹⁵ In Jaen, scholars are using similar techniques to reconstruct the history of olive presses.

Meanwhile models have evolved into virtual reconstructions with simulations of how a physical factory, such as an atomic energy plant, works under ideal conditions. These virtual conditions become a basis for monitoring conditions in the physical world, problems in which are then adjusted on the basis of comparison with the ideal conditions. In this case, the virtual is no longer a poor imitation of the real. Virtuality serves to monitor, adjust and ultimately control the real through what might be called a simulation-reality feedback loop, which has interesting parallels to what Professor Kaynak calls the mechatronics loop.¹⁶

Elsewhere, these new links between the real and virtual are leading to projects which use a Distributed Real and Virtual Environment for Mechatronics and Teleservice (DERIVE, Bremen),¹⁷ wherein combinations of virtual and real environments are starting points in the design of new products. The material consequences of the new media are virtuality.

On other fronts, these new links between the real and the virtual are introducing new ambiguities. There are real cameras in real cities to record traffic and other movements. There are virtual cameras in virtual cities as in the case of the Canal + model of Paris. Increasingly, however, one can move from places in virtual cities to their corresponding locations in virtual cities and conversely. The fictive space of paintings is being reconstructed virtually such that one can walk through it as in the case of Infobyte's reconstruction of Raphael's *Incendio nel Borgo*.¹⁸ This is leading to a new category of interactive paintings as De Pinxi demonstrated in the Mexico Pavilion at Expo 2000.

A recent *Virtual Reality Notre Dame* claims to be the "first gaming based, multi-user, real-time virtual experience"¹⁹ This uses a real cultural monument as the scene of a virtual game. Another recent game, the *Getaway*,²⁰ takes this principle much further. It uses footage of at least 60 miles of real London streets as a starting point for an adventure. Games such as *Its Alive*²¹ and *Terraplay*²² go one step further again. They combine video screens with GPS systems in order to enable children to play virtual spy adventures in the streets of real cities such as Stockholm. The game *Madcatz* goes one stage further still. Instead of just shooting at virtual characters, the game inflicts actual electric shocks on fellow players when they are hit. Granted the shocks are minimal but the conflation of real and virtual is not. It is not surprising then that for some games of *Dungeons and Dragons* become the starting point for adventures in real life. Some cynics would argue that war games are subsidized by the military who see in these "realistic" games virtual training grounds for later battlefields.

Such examples are extreme expressions of more subtle trends. In the past films, video games and physical games were very separate activities. In the seventies there were jokes about having read the book and then seeing the film and conversely. In the last five years, however, there is an increasing tendency for video games to become starting points for films such as the *Matrix*, *Pokemon*, *Crouching Tiger, Hidden Dragon*, *Lara Croft* and *Final Fantasy*.

It is noteworthy that *Final Fantasy*, which was also one of the first films to be completely generated by computer graphics, was arguably the least interesting of these. Blockbuster films such as *Jurassic Park*, *Star Wars* and more recently *Lord of the Rings*, use computer graphics but also continue to use real, physical sets. Hence, the move to virtuality is not a simple rejection of the physical. It entails a new ambiguity between real and phantasy worlds, which challenges the handy subject-object distinctions that, as Cassirer²³ showed so convincingly, were introduced with the rise of early modern science in the Renaissance.

George Lukas, whose monumental *Star Wars* has become the film equivalent of an epic in our times has chosen not to produce ever more sequels in the manner of the James Bond films. At the same time, game versions of the films continue to evolve. The heroic screen versions are becoming the starting points for thousands of variants produced by creative individuals. In the past, this happened with fairy tales and other stories central to our collective memory. A notable difference is that traditionally it was only the official version that was printed and the many variants remained oral and unrecorded. In the *Star*

Wars phenomenon the variants are also recorded. What happens when these become available on-line and become the equivalents of libraries of creative variants to the original story? Foucault, Derrida and other deconstructionists have tried to undermine our notion of a text and even of a source. Is it not possible that these developments in new media challenge us to raise these questions at a new level? Fortunately, as we shall below, the same media also offer new tools for contextuality.

It is tempting to see these new ambiguities between the real and the virtual only in a negative light, as an erosion of a reality, which once seemed so dear. Perhaps it is important to recognize also positive dimensions in these same trends. In a world where the news media claim to bombard us with a reality, which highlights only the disastrous dimensions of the human condition, there is a new need to reactivate the realms of phantasy and the imagination. Films such as *Lord of the Rings* re-enact those dimensions in the great open landscapes of New Zealand and with real sets that include whole villages. They fire our imagination because they are not just virtual sets. We sense that this setting of the imaginary has a compellingly real basis, so much so that we could foresee a new branch of tourism that will one day take us to the places where *Lord of the Rings* was filmed. You've read the book and seen the film, now go to the place where it happened.

In a sense Walt Disney has already succeeded in exploiting this principle within the limited confines of theme parks. But the potentials of *Lord of the Rings* or even films such as *Crouching Tiger, Hidden Dragon* are far greater. They introduce the idea of secular pilgrimages to experience oneself the landscapes of one's imagination, of one's heroes. In this scenario the ambiguity of real and virtual becomes a new stimulus for the creative imagination, a new source of hope whereby the heroic world of dreams is nurtured by pilgrimages through a selectively exciting and inspiring reality.

4. Systemicity

The organizational consequences of digital media entail a new emphasis on systems, which might be called systemicity. Of course, the notion of systems as such is hardly new and goes back at least to the time of the Greeks. In the past, systems focused on the life cycle of a specific medium. For instance, the production life cycle of a manuscript entailed a scriptorium and was very different than the production life cycle of a book, which entailed a printing press. Each medium had its own system. In the digital world, the life cycle of a "manuscript," a book, a video, a film, and a television programme are potentially all connected.

In the past, different aspects of systems were studied. In the manufacturing world, there was Manufacturing Resource Planning (MRP), Supply Chain Management (SCM), and Enterprise Resource Management (ERP) while others dealt with aspects such as Customer Relationship Management (CRM). In the digital world, developments such as the Supply Chain Action Network™ (SCAN)²⁴ attempt to bring all aspects of production within a single systematic treatment. Both physical organization of objects/products and the social organization of personnel now tend to become part of a single vision that

promises to be all inclusive and threatens to reduce individuals to the role of cogs in new conceptual wheels. The organizational consequences of new media are a systemicity which is frequently problematic. To escape the mechanistic determinism of such models some are looking to organic metaphors for new guidance.

5. Contextuality

Pioneers of the Internet such as Vannevar Bush²⁵, Douglas Engelbart²⁶ and Ted Nelson²⁷ were fascinated by the potentials of linking introduced by the new medium. This soon became known as hypertext and hypermedia. Only gradually are we beginning to realise that this entails something much more profound than a neat technological fix.

In the case of a printed book, an author makes claims and then uses footnotes and bibliography to establish the solidity of their claims. In the past, there were jokes that a book which did not have at least half of its page covered with footnotes was not really serious. Interestingly enough both the footnote and the bibliographical reference provide neither proof nor even first hand evidence. Footnotes and bibliographies merely point to sources outside the covers of the citing book, which supposedly have the evidence and proof that is claimed. What makes such printed books serious is that a sceptic can go to the references and check up whether the claims made are justified.

Here electronic books potentially introduce a fundamental advance. Hyperlinks can, of course, perform the same function as footnotes and point to sources elsewhere, but this would simply be to repeat the limitations of an earlier medium in electronic form. The same hyperlinks can be used to link any claim with a digital version of the original source on which the claim is based. Hence, instead of merely referring to a source beyond its covers as in the case of a printed book, the electronic book can connect us directly with the source in question. This greatly facilitates our ability to check on the validity of a claim, so much so that linking to the original source in its place of origin could well become a new criterion for scholarship in future. Hence an electronic work which cites just any copy of the *Mona Lisa* is less serious than one which takes us back to the Louvre's own version(s) of that painting. A reference to *Mona Lisa*, which includes the Louvre's documentation on the same painting is more serious than one that does not. In future every claim can potentially be linked with the objects and concepts about which these claims are made.

Such new bridges between primary and secondary literature provide unexpected tools against the current of constructivism and deconstructionism which claims that nothing is certain, mainly because they are very careful to remove access to the sources whereby their fashionable claims could be checked and challenged. Even so the potentials of digital contextualization go far beyond an ability to link sources with claims about these sources.

Any cultural object exists in a specific place. For instance, the *Mona Lisa* hangs on a wall of the Louvre in Paris, which affects the way it is seen. Earlier it hung in other places. Printed books typically reproduce images of a painting, book or monument but hardly

ever provide us with the context wherein that object or monument exists. With a digital version one could theoretically provide not only an image of the painting but also of the room wherein it hangs as well as reconstructions of where it hung previously. To be sure our ability to do so depends very much on the documentation which is available.

Even so the potentials in a digital world are infinitely richer than those in an analog world. In the case of a church, or monument we can reconstruct not only the building as it looks now but also all its changes: e.g. how what began as a heathen temple devoted to killing bulls in the tradition of Mithra became an early Christian Church, a Romanesque, Gothic and Renaissance church, before becoming San Clemente (Rome) as we know it today. In other cases we can link the evolution of Romanesque and Gothic churches to the rise of pilgrimage routes such as that of Saint James of Compostella. Potentially we can link an object, the room and building where it stands, with its site, town, cultural landscape and cultural route(s).

Given the enormous developments in Universal Mobile Telephony Systems (UMTS) linked with Geographical Positioning Systems (GPS) and Geographical Informational Systems (GIS) it is entirely feasible that spatial contextualization complete with historical and cultural variants could become part of tomorrow's criteria for scholarship. Whereas a traditional analog book cited only a single image of a painting or site, future electronic works could allow us to see any object in their original contexts plus the competing or even conflicting interpretations thereof in the case of archeological and other reconstructions. European projects such as Archeoguide²⁸ allow us to use augmented reality to superimpose on a virtual version of the landscape a Greek reconstruction of the temple of Hera at Olympus. In future, we might use the same techniques to compare differences between British, French, German, and Italian reconstructions of the same building. Rather than merely lamenting that there is interpretation present in all that we undertake, let us make that interpretation visible so that we can compare the differences. If the Germans "see" the world differently let us also see what that looks like.

The University of Bologna's NUovo Museo Elettronico (NUME)²⁹ project, which reconstructs the inner city of Bologna and traces its evolution from the year 1000 to the present is an excellent precursor of this vision. Ironically, this demonstration which is approaching five terabytes in size is not yet available online, except in a summary fashion, because the realities of gigabit connections are not yet part of our everyday infrastructure. A generation ago these limitations were technological. Today, the only real barriers are political will and a certain psychological barriers.

At least since the time of the Sceptics, philosophers have rightly pointed to the problems of certainty in our claims for knowledge. The fathers of exegesis, hermeneutics and modern epistemology have continued this tradition, as do those in cultural studies and Science and Technology Studies (STS) today. Earlier worries about the only constancy is change, have their contemporary equivalents in the claim that the only constancy is constructivism. All these schools have rightly drawn attention to the limits of certainty. Contemporary scholars rightly warn against the dangers of technological determinism and equally rightly insist that technology cannot replace the central importance of human interpretation. Even so, this should not blind us from recognizing the enormous advances

offered by digital technologies that potentially allow us to confront any claim with the sources on which it is based. If the intellectual consequences of the new media are truly contextuality, then they offer us new instruments in our quest for truthfulness and our unending search for truth in all its guises.

6. Spirituality

The US army spends \$50 billion annually on software and along with other branches of the military helps to pay for what was in 2000 the largest computer in the world. By contrast, the Search for Exterrestrial Intelligence (SETI) project has almost no funding. To cope with the enormous computational demands of the information they gather daily from outer space, this project introduced a voluntary scheme whereby individuals could make available their personal computers in idle periods when their screen savers were on. It is impressive that in the year 2000 more than 2000 persons signed up daily such that by July of that year there were over 2 million volunteers who made their screen saver time available. This becomes even more impressive when we realize that the combined computational power of these volunteers' computers was 11.3³⁰ teraflops, i.e. roughly the same as the power of the world's most powerful computer at the time.

The SETI example is emblematic of something very profound. Over the past 50 years hundreds of billions have been invested in software. A few companies and individuals have profited greatly. Yet paradoxically it could be argued that the most effective software is free: UNIX and increasingly Linux and other Open Source software.

There are enormous efforts on the part of a small cartel of companies to own and control content. Billions are being invested in this process. Very little of their efforts have borne serious fruit. Meanwhile, it is striking that small groups of volunteers such as Eulogos³¹ have produced free online access to full text versions of 4124 books in 36 languages.

If one defines the essence of spirituality as sharing without financial or other ulterior motives, art for art's sake (*ars gratia artis* – ironically now the motto of a very financially minded MGM), then the Internet is an unexpected stimulus to spirituality: a return to the old humanist ideals for the sake of helping others, to build on something beyond oneself. American thinkers such as Eric Raymond have tried to persuade us that the Internet is not like the building of a cathedral and more like the banter of a bazaar.³² But this overlooks the motives why volunteers share their personal knowledge for the sake of a greater cause: not to barter for their own gain but to build slowly on something that is far beyond the capacity of a single individual.

In the Middle Ages, the monks who worked selflessly at copying manuscripts in order literally to ensure tradition were conscious of something similar. It was not their single pages that counted, but the cumulative effect of many scriptoria that slowly handed down, then recovered and translated the enormous cumulative heritage of centuries and millennia. Initiatives such as the Gutenberg Project have received much press and these on their own are like the individual pages of the mediaeval scribes. The real power of the Internet lies in the cumulative force of a movement that adds 7 million new pages a day.

The World Wide Web Virtual Library is producing enormous resources on most major topics. Some of these projects are amazing in their detail. There are now four digital versions of the Gutenberg *Bible* (British Library³³, Cambridge.³⁴ Göttingen,³⁵ Keio³⁶ and Austin, Texas³⁷). A fifth is being scanned in by the Library of Congress³⁸ at 767 megabytes per page or nearly half a terabyte for a single tome. We have more access to the *Bible* online today than any individual at any time in the past. And this is true in the case of many other works also.

Other projects are breathtaking in their scope such as the complete digital version of the Buddhist Scriptures, the *Tripattika*, in Korean. In Beijing, the complete *Classics of the Chinese Language* (800 million characters) and the full text digital version of the *Emperor's Library* (over 300 million characters), exist in Unicode today.³⁹

Such enormous accomplishments represent obvious milestones in the digital revolution. There is reason to believe, however, that the deeper dimensions of the revolution have yet to surface. There is much rhetoric that the Internet is creating a digital divide. This overlooks that the advent of the alphabet brought an even more trenchant literacy divide which is still all too visible in countries such as Nepal where up to half the population is illiterate and unable to read.

In the analog world communication is typically limited to a single medium and often to a single sense at a time. A speech needs to be copied to become a manuscript. A manuscript needs to be produced anew in order to reappear as a book. In the digital world this is different. Once an oral speech is recorded digitally, it can be reproduced in cuneiform, in handwriting as a manuscript, or in printed form as a book. Alternatively a digital book can be reproduced as a manuscript or in oral form as a speech or conversation. This means that an illiterate person could speak about their oral knowledge and this could be recorded in book form to become part of our enduring knowledge. At the same time the wisdom of our memory institutions can be made available to this same illiterate person by being conveyed in oral form. Admittedly there are limitations but, for the first time in history, the “computer” offers a bridge for the literacy divide. In India, the developers of the *simputer*⁴⁰ (simple computer) are exploring these potentials in everyday life.

Marshall McLuhan taught us to look at media as a sequence whereby each new medium uses its predecessor for its content. The telegraph used the printed word as its content. Printing used the written word of manuscripts as content. Manuscripts used oral language as content. Language used thought as its content. He also taught us that there each medium brought unexpected side effects, which led him to claim that the medium is the message. In McLuhan's world every medium had its own production life cycle. The production of a manuscript involved a scriptorium, which was very different from the production of a book which required a printing press or a film which required a film studio (and perhaps a post production house).

Following his approach, we would expect that the new media of Information and Communication Technologies (ICT) should use radio and television as their content. In a

certain sense this is becoming true. Computer screens can now carry both radio and television signals. Televisions can increasingly link up with computers. But the story is much more complex. For starters the knowledge production life cycle is no longer limited to a single medium at a time. In a digital world the production of oral radio speeches, manuscripts, books, films, television, and video are potentially all related as part of a single cycle.

Moreover, just as computers allow digital signals to be translated from one medium into another, they also allow conveyance of all five senses: sight, sound, touch, smell and taste and translation from one sense into another. Hence not only can a visible sign be translated into an oral sound. It can also be translated into a physical touch for Braille or even a smell or a taste. This is opening new fields of sensory transduction⁴¹ whereby the sounds of an oscilloscope or of Magnetic Resonance Tomography (MRT) of a pregnant woman's womb can be translated into a visible picture of the unborn child. Potentially these technologies open up many new dimensions of sensory synaesthesia.

Any attempt to explore in detail all these possibilities or even to list them would take us far beyond the confines of an introductory lecture/paper such as this. Our basic point is very simple. The digital revolution is something fundamentally different than the introduction of yet another medium, than yet another variant in McLuhan's list of media. It cannot be defined by catchy terms such as books on steroids or the like. The ICT revolution marks a fundamental change in our relation to all media, to all our senses, to all our expressions. It transcends even the barriers of literacy and introduces a world which will take many generations ere we have fully comprehended its full implications. The new media are transforming our definitions of culture and knowledge itself.

7. Conclusions

Marshall McLuhan taught us to study media not only in terms of their obvious effects, but rather in terms of their unexpected consequences. Ironically, most attention continues to be with respect to the obvious effects of computers, Internet and ICT. Most persons continue to focus mainly on the purely visible technological consequences of ICT. We have shown that, paradoxically these technological consequences lead to invisibility. We have argued that there are also material, organisational, intellectual and philosophical consequences, namely: virtuality, systemicity, contextuality and potentially spirituality. Herein lie the unexpected and truly portentous implications of the ICT revolution.

What makes these implications of the ICT revolution more intriguing is that they change as one shifts one's goals. In the United States, where the goal is an Information Highway, the emphasis is more clearly on the material and organizational consequences. In Europe, where the goal is an Information Society, there is more concern with systemicity and contextuality. In Japan, where the goal is a Knowledge Society, the spiritual consequences are more in the foreground. In this discovery, that we are not determined by the new technologies but rather that the new technologies are determined by our own dreams, lies the stuff of many new horizons beyond the bounds of a simple article.⁴²

Notes

¹ See: <http://www.top500.org/list/2002/11/>

² Jennifer Couzin, "Building a Better Bio-Supercomputer," *The Industry Standard Magazine*, June 18, 2001.

See: <http://www.techinformer.com/go.cgi?id=490875>

³ Cf.: http://www.nua.ie/surveys/how_many_online/world.html. Cf. also Global Internet Statistics: <http://www.greach.com/globstats/index.php3>

⁴ See: <http://www.greach.com/globstats/index.php3>

⁵ See: <http://freespeech.org/terrabay/Internet%20Users.html>.

⁶ Cyveillance report, 10 July 2000.

See: <http://www.cyveillance.com/us/newsroom/pressr/000710.asp>

⁷ "Web Is Bigger Than We Thought, *San Jose Mercury News*, 28 July, 2000,

See: http://www.nua.ie/surveys/?f=VS&art_id=905355941&rel=true

Mark Frauenfelder, "Deep-Net Fishing," *The Industry Standard Magazine*, June 18, 2001.

See: <http://www.techinformer.com/go.cgi?id=490878>.

Mike Nelson (IBM) at the INET 2001 Global Summit claimed that in the next 9 years there will be a 1 million fold increase in information. This amounts to the equivalent of 550,000,000,000,000,000 pages.

⁸ See: http://neasia.nikkeibp.com/nea/200206/srep_188414.html

Cf. http://www.soumu.go.jp/joho_tsusin/eng/Resources/Council/pdf/c_summary_2.pdf

⁹ See: <http://www.foresight.org/NanoRev/index.html#anchor1033984>

¹⁰

See:

<http://www.research.philips.com/InformationCenter/Global/FArticleSummary.asp?INodeId=712>

On ambient intelligence in the workplace see:

<http://www.newscenter.philips.com/InformationCenter/NewsCenter/FArticleDetail.asp?ArticleId=2449&INodeId=610>

¹¹ See: <http://www.gyre.org/news/related/Nanotechnology/U.S.+Military>

¹² See: <http://aig.cs.man.ac.uk/maverik/>

¹³ See: <http://www.isi.edu/isd/VET/vet-body.html>

¹⁴ See: <http://www.cultivate-int.org/issue5/cineca/>

¹⁵ See: <http://www.cdisweden.com/eng/index.html>

¹⁶ Professor Kaynak (UNESCO chair of Mechatronics, Istanbul),

See: <http://mecha.ee.boun.edu.tr/cv/publications/g1.html>.

¹⁷ See: <http://www.brevie.uni-bremen.de/>

¹⁸ See: <http://www.infobyte.it/>

¹⁹ See: <http://www.vrndproject.com/>

²⁰ See: http://simplest-shop.com/The_Getaway--1-468642-B00006Z7I3-0-games-product.html

²¹ <http://www.itsalive.com/>

²² http://www.terraplay.com/the_company.asp

²³ Ernst Cassirer, *Das Individuum und Kosmos in der Philosophie der Renaissance*, Leipzig und Berlin, 1927. Reprint: Darmstadt (Wissenschaftliche Buchgesellschaft) 1994.

²⁴ See: <http://www.supplychainlinks.com>

²⁵ Vannevar Bush, "As we may think," *Atlantic Monthly*, New York, July 1945. See: <http://www.theatlantic.com/unbound/flashbks/computer/bushf.htm>

²⁶ Douglas Carl Engelbart. See: <http://www.bootstrap.org/engelbart/index.jsp>

²⁷ See: <http://ted.hyperland.com/>; <http://www.iath.virginia.edu/elab/hfl0155.html>

²⁸ See: <http://www.archeoguide.it/>

²⁹ See: <http://www.storiaeinformatica.it/nume/italiano/ntitolo.html>

³⁰ See: <http://setiathome.ssl.berkeley.edu/>

³¹ See: www.eulogos.org.

³² Eric S. Raymond, *The Cathedral & the Bazaar. Musings on Linux and Open Source by an Accidental Revolutionary*, Cambridge Mass.: O'Reilly, 1999.

See: <http://www.tuxedo.org/~esr/writings/cathedral-bazaar/>

³³ See: <http://prodigi.bl.uk/gutenbg/background.asp>

³⁴ See: <http://www.humi.keio.ac.jp/treasures/incunabula/B42/>

³⁵ See: <http://www.gutenbergdigital.de/gudi/start.htm>

³⁶ See: <http://www.humi.keio.ac.jp/treasures/incunabula/B42-web/b42/html/index01.html>.

Cf <http://www.gutenberg.de/english/bibel.htm>

³⁷ See: <http://www.hrc.utexas.edu/exhibitions/permanent/gutenberg/scans/scan066.html>

³⁸ See: <http://www.npr.org/programs/atc/features/2002/feb/gutenberg/020219.gutenberg.html>

³⁹ Cynics may note that the same technologies which make possible these miracles of sharing, these harbingers of what could become new streams of spirituality, are also being used to create a Total Information Awareness System (TIA) for the military that aims not only at surveillance but also at prevention almost as a harbinger to the visionary spectres of *Minority Report*. The same tools, which are giving us unprecedented access to our cumulative history, are also threatening cumulatively to destroy our future. This is an age old problem: do we remember Nobel, the inventor of modern dynamite simply as a precursor of terrorist bombs or equally as one whose invention helped to create the tunnels and engineering feats which have made the world an easier place in which to travel?

⁴⁰ See: <http://www.simputer.org/>

⁴¹ Cf. Warren Robinett, "Electronic Expansion of Human Perception", *Whole Earth Review*, 1991; *ibid.*, "Synthetic Experience," *Presence*, MIT Press, Vol. 1, No. 2.

⁴² These topics are studied in more detail in the author's *Understanding New Media: Augmented Knowledge and Culture*. .