Dedication

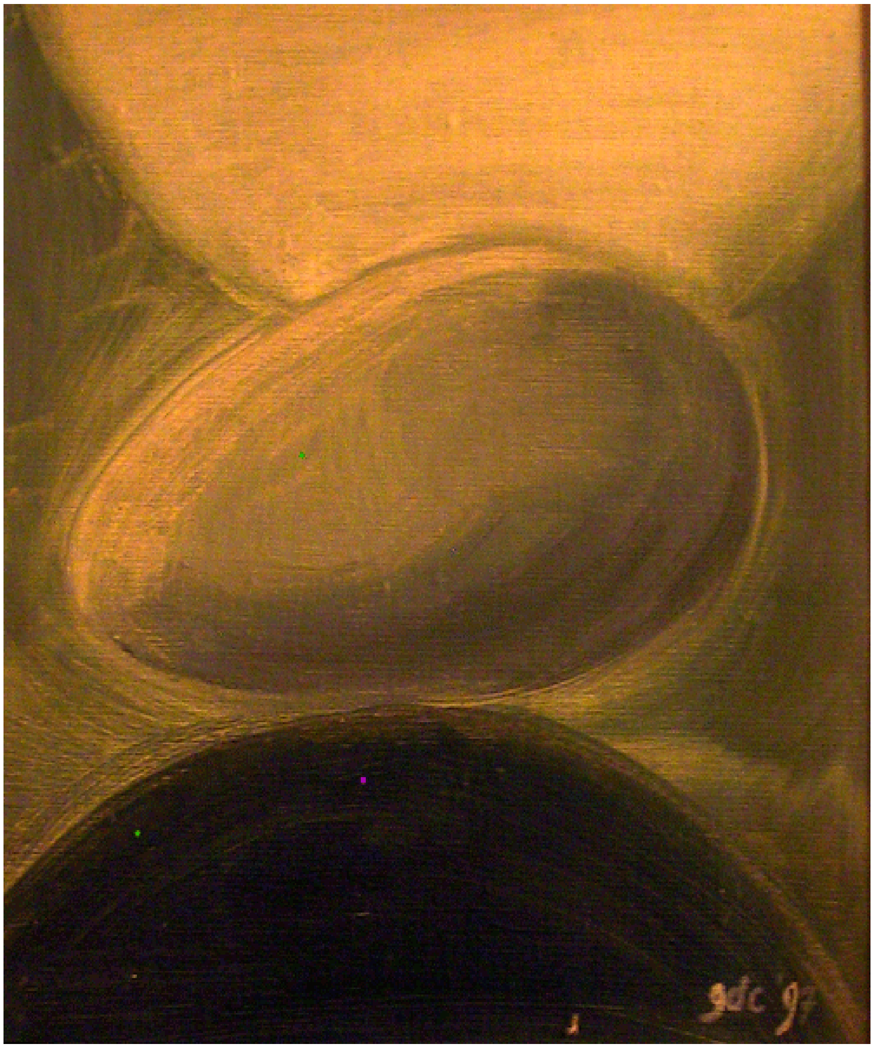
To my teachers, my students and my colleagues
to whom I owe all I know…

and

to my family, my parents, Zdenko and Jelena
and my sister Zdenka,
to Ivica, my husband
and especially to my children Luka and Tea

to whom I owe all I am…

with warmest gratitude!



Dodig-Crnkovic G., *Ab Ovo. Information: Between the Anvil and Hammer – Orphean Theme*, oil on canvas

Abstract

We live in a computing Universe. It is not only that we are vitally dependent on computers in our work, but that we are also surrounded by ubiquitous computing in our daily life, with all kinds of computing devices embedded in various products and in ambient intelligence. Even the Cosmos is envisaged nowadays as a network of computing processes (pancomputationalism). In the complementary view, the Universe, on its most fundamental physical level, is seen as consisting of information (paninformationalism).

In this thesis, a synthetic framework is developed, which is integrating pancomputationalism and paninformationalism. The Universe is perceived as being engaged in the computing of its own future states through physical processes which all may be understood as information processing i.e. computation at different levels of granularity.

Computation is nowadays essential not only for sciences such as physics, chemistry, biology, mathematics, complexity, and cognitive science but also for social sciences and humanities, especially for philosophy and logic. Computation is an integral part of activities in design and engineering, arts and music, and it has become a contemporary conceptual lingua franca.

The recent development of the research field of Computing and Philosophy and especially its Philosophy of Information (PI) branch has triggered investigations into the philosophical, methodological and ethical foundations of computing and information. Philosophy of Computing (PC) is closely related to Philosophy of Information.

This thesis consists of two parts which are the result of studies in two basic areas of PI/PC that concern the production of meaning (semantics) and the underlying value system with its applications (ethics).

The first part, information semantics, develops a unified dual-aspect theory of information and computation, in which information is characterized as structure, and computation is seen as the dynamics of information (process). A generic study of naturalized epistemology is presented, related to

interactive information representation and communication. In the study of systems modeling, questions of meaning, truth and agency are addressed.

Computing is a phenomenon that is not only suitable for the modeling of reality, it has even the capacity to act in the real world in real time – as computing embodied in robots, intelligent agents and other reactive intelligent systems. The ability to interact with the physical world, to adapt, to act autonomously, to learn, to augment our cognitive abilities and intelligence, all these give Computing/Informatics a central role as a field most expressive of our best knowledge and agency capacities. The theoretical approach taken in this work may be described as interactive computational naturalism inspired by process pragmatism, and as a result of a conceptual synthesis based on computational and informational theories.

Pragmatism in the approach, with its strong focus on agency, necessarily entails the analysis of values and ethics. The second part of the thesis addresses one of the central problems within computer ethics/information ethics – information privacy including workplace privacy, including surveillance in the networked society. The value grounds involved are discussed and socio-technological solutions for securing trustworthiness of computing analyzed. Privacy issues clearly illustrate the need for computing professionals to contribute to an understanding of the technological mechanisms of ICT (Information and Communication Technology) as well as their practical consequences in the societal context.

The original contributions of this work include its synthetic approach to the computation/information phenomena, relating this dual-aspect theory to fundamental dichotomies in physical theory such as wave/particle and continuum/discrete. Semantics of information is seen as a part of the data-information-knowledge-wisdom production chain, in which more and more complex relational structures are created in the process of computational processing of information. The results point out the necessity of the advancement of computing methods beyond the Turing-Church limit.The motivation is found in natural computation, or wider in the pancomputationalist/paninformationalist view that the most fruitful model of the Universe we have today is the computing, informational Universe. We have only begun to explore its possibilities and its values.

Acknowledgements

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Prior to publishing this thesis I was given an opportunity to present the theoretical (semantics) and practical (ethics) parts of my thesis at two seminars: at the Seminar in Theoretical Philosophy (Information Semantics, 22 Nov 2002 and 30 Sept 2005) and the Higher Seminar in Practical Philosophy (Privacy, 28 Oct 2005) at Uppsala University. Thanks to Sören Stenlund and Sven Danielsson for inviting me, making it possible for me to expose my ideas to the helpful and constructive criticism of my philosopher colleagues.

During the academic years 2003 and 2004, within a project for organizing a National Course in Philosophy of Computer Science, the PI course, we formed a network of scientists and philosophers from several Swedish universities. I learned much through the work involved and through the PI course. Moreover, I became aware of a number of extremely interesting and relevant open problems that I subsequently addressed in my work. Thanks to the people who made the PI network such a valuable experience: Jan Odelstad, Jan Gustafsson, Björn Lisper, Ulla Ahonen-Jonnarth, Joakim Nivre, Peter Funk, Torbjörn Lager, and our correspondent member from China, Liu Gang.

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Gordana Dodig-Crnkovic, September 2006

Table of Contents

Chapter 1. Motivation

1.1 The Aims, Objectives and Results of the Research

“If one does not know to which port one is sailing, no wind is favorable.”

Lucius Annaeus Seneca, Epistulae Morales ad Lucilium

These investigations are in all essential ways characteristic of our time – they are defined by the fact that we are living in an era of ICT (Information and Communication Technology), the age of the computer as the epoch-making artifact, the epoch that has succeeded the era of mechanical mechanism, the basis of the industrial revolution. The conceptual framework today is still strongly influenced by the industrial, mechanistic way of thinking. Our culture is often called The Information Society, but what we really wish for even more, is to transform it into The Knowledge Society, in which information is not only abundant and available but also meaningful and used for the common good of humanity. One may think of such an envisaged Knowledge Society as a present day Utopia. However, even if the earlier social Utopia of freedom, equality, democracy, and social justice is far from being realized for all people, it is actuality for many, and inspiration for many more. That is generally the role of ideals – they define what will be considered as good, right, preferable, noble, positive, attractive, interesting, relevant and worthy of our effort.

An outstanding characteristic of our time, besides the enormous influence of information/computing phenomena, is specialization. In order to gain recognition by mastering enormous amounts of information, individuals must specialize in very narrow fields – in all kinds of scholarship, arts and crafts and other activities. Specialization has its natural driving force in the need to know the very fine details of a subject and as much as possible about a given problem. Within academia it leads to research communities that resemble isolated islands or villages surrounded by high mountains whose communication with the outside world is infrequent and brief. What is lost in this process of specialization is an awareness of and sensitivity to the context.

In general, there is an urgent need of establishing and thinking through global context in many fields.

The on-going globalization of our planet is a phenomenon which has always depended on the contemporary technology. As a result of ICT, (Information and Communication Technology) and global communications, a global context is emerging spontaneously and without due reflection. Many of the world's diverse societies are connected in complex communication networks. Since the phenomenon of globalization involves the distribution of power and resources having an essential impact on many aspects of our culture, it definitely deserves due scholarly attention. Philosophy as a discipline has much to say about the ways technologies interact with society, change our ways, shape our thinking, modify our value system, increase our repertoire of behaviors and even affect the physical world. Of special interest today in this context are The Philosophy of Information and The Philosophy of Computing. The Philosophy of Information may be defined as: "A new philosophical discipline, concerned with:

a) the critical investigation of the conceptual nature and basic principles of information, including its dynamics (especially computation and flow), utilization and sciences; and

b) the elaboration and application of information-theoretic and computational methodologies to philosophical problems"

(L. Floridi, What is the Philosophy of Information?, Metaphilosophy, 2002)

Philosophy of Computing is a field of research focused on the phenomena that, beside the classical computation represented by the Turing paradigm, encompass even the critical analysis of the emerging field of natural computation.

"Everyone knows that computational and information technology has spread like wildfire throughout academic and intellectual life. But the spread of computational ideas has been just as impressive. Biologists not only model life forms on computers; they treat the gene, and even whole organisms, as information systems. Philosophy, artificial intelligence, and cognitive science don't just construct computational models of mind; they take cognition to be computation, at the deepest levels. Physicists don't just talk about the information carried by a subatomic particle; they propose to unify the foundations of quantum mechanics with notions of information. Similarly for linguists, artists, anthropologists, critics, etc. Throughout the university, people are using computational and information notions -- such as information, digitality, algorithm,

formal, symbol, virtual machine, abstraction, implementation, etc. -- as fundamental concepts in terms of which to formulate their theoretical claims." (Brian Cantwell Smith on "The Wildfire Spread of Computational Ideas", 2003)

Cantwell Smith's writings emphasize the inadequacy of our current understanding of computation, and recommend viewing it instead as an unrestricted site in which to explore fundamental questions about the relation between meaning and mechanism.

It is interesting to observe that the English term "Computing" has an empirical orientation, while the corresponding German, French and Italian term "Informatics" has an abstract orientation. This difference in terminology may be traced back to the tradition of nineteenth-century British empiricism and continental abstraction respectively.

Informatics builds on science (where the term science also encompasses very central disciplines of mathematics and logic) and technology. In some of its parts (e.g. AI), Informatics is closely related to philosophy, psychology, ethics, aesthetics and art. At present there is a vital need to formulate and disseminate critical reflections on the foundations of Informatics, its connections to other fields of human endeavor, its prospects and its limitations within the framework of Philosophy of Information.

In that respect, the following proclamation of the Japanese Philosophy of Computation Project is significant. "The mission of the Philosophy of Computation Project is to reconsider various concepts of computation innocently used in Philosophy, Mathematics, Computer Science, Cognitive Science, Life Science, Social Science, etc., and reveal global problems hidden in each realms. We don't only aim to answer particular questions but also to provide universal viewpoints which are thought of as important for this new subject."

Computing is changing the traditional field of Philosophy of Science in several profound ways: First, as a methodological tool, computing makes possible "experimental philosophy" which is able to provide practical tests for different philosophical ideas. At the same time the ideal subject of investigation of the Philosophy of Science is changing. For a long period of time the ideal of science was Physics (Popper, Carnap, Kuhn, and Chalmers have studied physics). Now the focus is shifting to the field of Computing/Informatics. It will be interesting to follow that development, because Computing/Informatics is "scientific" in a way different from Physics. We may think of a new term "scientificity" instead of the previous "scientism" of "exact sciences" as broadening (generalizing) the definition of science.

There are many good reasons for this paradigm shift, one of these being the long standing need of a new meeting between the sciences and humanities, for which the new discipline of Computing/Informatics offers innumerable possibilities. Moreover, computing is a phenomenon that enables not only the modeling (describing) of reality, *it has the ability to act* in the real world – (computing embodied in robots, intelligent agents and other reactive intelligent systems.) The ability of a computing/informational artifact to *interact with the real world in real time*, even to adapt, act autonomously, learn, .. – all that gives Computing/Informatics a central role of the field most expressive of our best methods, to handle the real world. It implies that not only descriptive and predictive formal methods, but hopefully much more may be incorporated into computing as a meeting place for the best of our knowledge and agency capacities.

Computing in its turn finds inspiration in biology: in the adaptive and autonomous behavior of biological organisms, in the evolutionary process, genetics, self-replicating and self-defining qualities – all of these are a great source of inspiration and productive and novel paradigms for computing.

In a very enlightening way, Philosophy of Computation/Information (PC/PI) brings together phenomena and methods otherwise completely disparate. A future project of synthesis, a new Renaissance with the human at its centre, can be accommodated within the methodological and conceptual space of Philosophy of Informatics. It is necessary to address both questions of semantics (meaning) and of values. Taking a pragmatic stance, focusing on meaning, which is always context-dependent, inseparately interrelates value issues (ethics) with problems of knowledge and reasoning (epistemology).

One of the goals of the PI/PC is to shed more light on the foundations of Informatics and its future possibilities. The research field is based on scientific traditions and relates problems of Informatics to the classical sciences in order to widen the perspective and to explore the sets of values and ethical grounds for the discipline. It does not imply that Informatics itself can be reduced to a science. It is closely related to technology, philosophy, art, music and number of other non-scientific fields The ambition is to explore to what extent and in what ways Informatics builds on scientific (again inclusive mathematics and logic) traditions and what other traditions may be used in order to better understand and further the present and future development of Computing/Informatics, to paraphrase Wolfram – " A New Kind of Science".

1.2 Open Problems Addressed

In his groundbreaking paper Open Problems in the Philosophy of Information Floridi (2004) lists the five most interesting areas of research for the nascent field of Philosophy of Information (and Computation), containing eighteen fundamental questions as follows:

I) **Information definition**

1. *What is Information?*

2. *What is the dynamics of information?*

3. *Is a grand unified theory of information (GUTI) possible?*

II) **Information Semantics**

4. *The data grounding problem: How can data acquire their meaning?*

5. *Truth problem: How can meaningful data acquire their truth value?*

6. *Informational truth theory: Can a theory of information explain truth?*

7. *Informational semantic problem: Can information theory explain meaning?*

III) **Intelligence/Cognition**

8. *Descartes' problem: Can cognition be fully analysed in terms of information processing at some level of abstraction?*

9. *Dennett's reengineering problem: Can natural intelligence be fully analysed in terms of information processing at some level of abstraction?*

10. *Turing's problem: Can natural intelligence be fully and satisfactorily implemented non-biologically?*

11. *The MIB (mind-information-body) problem: Can an informational approach solve the Mind-Body problem?*

12. *The informational circle: If information cannot be transcended but can only be checked against further information - if it is information all the way up and all the way down - what does this tell us about our knowledge of the world?*

13. *The Information Continuum Conjecture: Does knowledge encapsulate truth because it encapsulates semantic information? Should epistemology be based on a theory of information?*

14. *The semantic view of science: Is science reducible to information modelling?*

IV) **Informational Universe/Nature**

15. *Wiener's problem: Is information an independent ontological category, different from the physical/material and the mental?*

16. *The problem of localisation: Could information be neither here (intelligence) nor there (natural world) but on the threshold, as a special relation or interface between the world and its intelligent inhabitants (constructionism)?*

17. *The* "It *from* Bit" *hypothesis: Is the universe essentially made of informational stuff, with natural processes, including causation, as special cases of information dynamics?*

V) **Values/Ethics**

18. *Are computing ethics issues unique or are they simply moral issues that happen to involve ICT? What kind of ethics is CE? What is the contribution of CE to the ethical discourse?*

This thesis will relate to several points of Floridi's program for PI, and suggest a general approach to information/computation logic, that includes the classical approaches as a proper subset. Computation/Information in turn might be seen as the basis of a program of naturalizing epistemology.

If we accept the pancomputational stance as a point of departure, and if all physics may be expressed as computation, meaning the whole universe might be represented as a network of computing processes at different scales or levels of granularity then we may see information in the first place as a result of (natural) computation i.e. ”computation occurring in nature or inspired by that in nature”, MacLennan (2004).

Information and computation are two complementary ideas in a similar way to continuum and a discrete set. In its turn continuum – discrete set dichotomy may be seen in a variety of disguises such as: time – space; wave – particle; geometry – arithmetic; interaction – algorithm; computation – information. Two elements in each pair presuppose each other, and are inseparably related to each other.

The field of Philosophy of Information is so closely interconnected with the Philosophy of Computation that it would be appropriate to call it Philosophy of Information and Computation, having in mind the dual character of information-computation.

Burgin (2005) puts it in the following way:

“It is necessary to remark that there is an ongoing synthesis of computation and communication into a unified process of information processing. Practical and theoretical advances are aimed at this synthesis and also use it as a tool for further development. Thus, we use the word computation in the sense of information processing as a whole. Better theoretical understanding of computers, networks, and other information-processing systems will allow us to develop such systems to a higher level.

As Terry Winograd (1997) writes, The biggest advances will come not from doing more and bigger and faster of what we are already doing, but from finding new metaphors, new starting points.”

Consequently, these investigations are associated with a global discourse, and are aimed at acquiring an understanding of phenomena on general levels of abstraction. The recurrent theme is information/computing as the underlying structure/process. At present, however, there is an obvious difference between the two main streams of Philosophy of Information and Computing - computation-oriented and information-oriented. The computation stream is particularly focused on the nature of the process of computing, its meaning and its mechanisms. It is traditionally much more focused on mathematic and logic than the information-oriented stream which is typically social and human-centered and has many broad interfaces to humanities (such as e.g. library information science). The concept of information itself is so fundamental that it is common to all our knowledge and in a wider sense it embraces every perception and even every physical/material phenomenon. This is the reason for it being impossible to draw a sharp line between the streams.

So the question of nomenclature [Philosophy of Computing or Philosophy of Information?] can be seen in the light of particle/field dichotomy. In one view, particles may be considered as the primary principle, while fields/interactions are defined as particle exchange. On the other hand, beginning with field as the primary principle, particles are the result of field quantization. In any event, two concepts are mutually defining and interdependent.

In much the same way, information (structure) might be considered as the primary interest, while computation (dynamics) is the secondary – or the vice versa. In any case, there is no computation without information to perform computation on, and also: in order to get any information, there must be a computational process.

We will return to Floridi's Open Problems in the Philosophy of Information in Chapter 5.

1.3 Summary of Publications Included in the Thesis

The dissertation is a collection of five articles (papers A-E) described in the next section and reproduced at the end of the thesis. A common context for the research is given in the introductory kappa chapter that constitutes the background of the work.

The outline of the thesis is as follows:

Paper A

Dodig-Crnkovic G., *Shifting the Paradigm of the Philosophy of Science: the Philosophy of Information and a New Renaissance*

In Minds and Machines: Special Issue on the Philosophy of Information, Volume 13 (4), p521-536, Kluwer, November, 2003

> This paper presents the big picture of the field, its historical roots, its state of the art and its future prospects. Computing is characterized as a future ideal of human-centric intentional science, where the concept of science is a collaborative field with contributions from both classical sciences and humanities, where also technology and arts have their roles to play. Philosophy of information/Philosophy of Computing is identified as the philosophy field of highest significance, that will replace Philosophy of Physics as The Philosophy about the world. The

Computer itself is a new research field and its object of investigation is an ever-developing artifact, the materialization of the ideas that try to structure knowledge and the information about the world, including computing itself.

Paper B

Dodig-Crnkovic G. *Semantics of Information and Interactive Computation*

Minds and Machines: Special Issue on the Philosophy of Computer Science, submitted

This article deals with interaction as a new computational paradigm. Computers are information-processing devices that have changed dramatically compared to their original function of sequential processing of data (calculation). Contrary to traditional algorithmic computation, interactive computation implies communication of the computing process with the external world during the computation. In general, computational processes are conceived as distributed, reactive, agent-based and concurrent. Turing computation is a special case in which the number of communicating systems is equal to one. This paper points out the significance of logical pluralism and its consequences for a multi-agent communicating system.

Paper C

Dodig-Crnkovic G., *Model Validity and Semantics of Information*

In Model-Based Reasoning In: Science and Engineering Abduction, Visualization, and Simulation, Pavia, Italy, December 16-18, 2004, King's College Publications, London, Editor(s): L Magnani, June, 2006

The article addresses the fundamental question of the field, that of the relationship between meaning, truth and information. The pragmatic view of information as meaningful data is presented. The meaning is understood in terms of Wittgenstein’s langage game, where language may be any kind of formal system, not only the natural language. Here a researcher is an agent in the active interplay with the world which is generating meaning, using models as exploratory tools.

Paper D

Dodig-Crnkovic G., Horniak V., *Ethics and Privacy of Communications in Global E-Village*

In ENCYCLOPEDIA OF DIGITAL GOVERNMENT, 2006

This paper studies problems of privacy and personal integrity connected with global networked societies. Our personal computers are at present extremely vulnerable to privacy invasion. Being a new type of communication between people, computer-mediated communication must find its way across the "policy vacuums" of James Moore. This means that we must analyze the inherent meanings (disclosive ethics) and assure the trustworthiness even in the domain of privacy, which is a socio-technologic project. The paper was written by me, and discussed on several occasions with a former student of mine, Virginia Horniak, who read the manuscript and contributed with comments and remarks. I profited highly from rewarding discussions with my co-author.

Paper E

Dodig-Crnkovic G., *Privacy and Protection of Personal Integrity in the Working Place*

Presented on the Workshop on Privacy and Surveillance Technology - Intercultural and Interdisciplinary Perspectives, February 11, 2006 at ZiF - Centre for Interdisciplinary Research University of Bielefeld, Germany.

This article considers problems of privacy in a work-related sphere, discussing human rights and the individual's entitlement of personal space. It explores the phenomenon of surveillance, its consequences and different legislative strategies. It also addresses the need for a global dialog between cultures with different ideas of personal integrity.

1.4 Other Related Publications

Journal Papers

1. Dodig-Crnkovic G., *Model Validity and Semantics of Information*, Mind & Society, Springer, forthcoming 2006

2. Dodig-Crnkovic G., Larsson T., *Game Ethics - Homo Ludens as a Computer Game Designer and Consumer*, International Journal of Information Ethics, Special Issue, ICIE, December, 2005

3. Dodig-Crnkovic G., Horniak V., *Togetherness and Respect - Ethical Concerns of Privacy in Global Web Societies*, Special Issue of AI & Society: The Journal of Human-Centred Systems and Machine Intelligence, on

"Collaborative Distance Activities: From Social Cognition to Electronic Togetherness", CT. Schmidt Ed., Vol 20 no 3, 2006

Conference Papers

1. Dodig-Crnkovic G., *What is Philosophy of Computer Science? Experience from the Swedish National Course*, European conference on Computing and Philosophy - ECAP'06, June 2006, NTNU, Trondheim, Norway

2. Dodig-Crnkovic G., *Knowledge as Computation in vivo: Semantics vs. Pragmatics as Truth vs. Meaning*, i-C&P Conference on Computers & Philosophy, Laval, France, May 2006

4. Dodig-Crnkovic G., *Philosophy of Information, a New Renaissance and the Discreet Charm of the Computational Paradigm*, L. Magnani, Computing, Philospphy and Cognition, King's College Publications London, Editor(s): L Magnani, R Dossena, , October 2005

5. Dodig-Crnkovic G., *On the Importance of Teaching Professional Ethics to Computer Science Students*, Computing and Philosophy Conference, E-CAP 2004, Pavia, Italy, Associated International Academic Publishers, Pavia, Editor(s): L Magnani, January, 2006

6. Dodig-Crnkovic G., *Model Validation, and Semantics of Information*, Model-Based Reasoning In Science And Engineering Abduction, Visualization, And Simulation, Pavia, Italy, December 16-18, 2004, King's College Publications, London, Editor(s): L Magnani, June, 2006

7. Dodig-Crnkovic G., Crnkovic I., *Professional Ethics in Software Engineering Curricula*, Cross-disciplinarity in Engineering Education, CeTUSS, Uppsala, December, 2005

8. Dodig-Crnkovic G., Horniak V., *Good to Have Someone Watching Us from a Distance? Privacy vs. Security at the Workplace*, Ethics of New Information Technology, Proceedings of the Sixth International Conference of Computer Ethics: Philosophical Enquiry, CEPE 2005, Brey P, Grodzinsky F and Introna L., University of Twente, Enschede, The Netherlands, July, 2005

9. Dodig-Crnkovic G., *System Modeling and Information Semantics*, Proceedings of the Fifth Conference for the Promotion of Research in IT, Studentlitteratur, Lund, Editor(s): Bubenko jr. J., Eriksson O., Fernlund H. & Lind M., April, 2005

10. Dodig-Crnkovic G., *Om vikten av att undervisa datavetare och datatekniker i professionell etik*, Den femte nationella kvalitetskonferensen - Högskoleverket i samarbete med Malmö högskola, March, 2003

11. Dodig-Crnkovic G., Crnkovic I., *Computing Curricula: Teaching Theory of Science to Computer Science Students*, Hawaii International Conference on Education, Honolulu, Hawaii, USA, January, 2003

12. Dodig-Crnkovic G., Computing Curricula: *Social, Ethical, and Professional Issues*, Proc. Conf. for the Promotion of Research in IT at New Universities and at University Colleges in Sweden, (May 2003), Jan 2003

13. Dodig-Crnkovic G., *Scientific Methods in Computer Science*, Proc. Conf. for the Promotion of Research in IT at New Universities and at University Colleges in Sweden, Skövde, April, 2002

14. Dodig-Crnkovic G., *What Ultimately Matters, Indeed?*, Proc. Conference for the Promotion of Research in IT at New Universities and at University Colleges in Sweden, Part III, p 12, The Knowledge Foundation, Ronneby, Editor(s):Janis Bubenko jr, April, 2001

1.5 Contributions of the Thesis to the Research Field

The following are original contributions of this PhD thesis to the research field:

- The synthesis of knowledge and ideas from different fields, disparate today, to create a coordinated network within the common frame of pancomputationalism/paninformationalism. The introductory part gives an account of the newly emerging research field, its relevance for computing and philosophy, as well as for the related fields. The relation between computation and information is explicated, relating these two phenomena to the fundamental dichotomies in physics such as wave/particle energy/mass and continuum/discrete. A unified picture of dual-aspect information/computation phenomenon is presented, applicable in philosophy, natural sciences, (especially physics and biology), information science, cognitive science and similar.

- The critical investigation which presents semantics of information as a part of data-information-knowledge-wisdom chain, in which more and more complex relational structures are created in the process of computational processing of information. Different thinking traditions are introduced and critically analyzed. A pragmatic evolutionary view of semantics of information and computation is described and argued for. The approach may be characterized as interactive naturalism inspired by process pragmatism. After relating phenomena of information and computation understood in interactive paradigm, investigations in logical pluralism of information as interactive computation are presented.

- The thesis points out the necessity and possibility of advancement of our computing methods beyond Turing-Church limit, computation in the next step becoming able to handle complexity of phenomena such as knowledge, living processes, multifaceted social phenomena, etc. The source of inspiration is found in natural computation, or wider in the pancomputationalist/paninformationalist philosophical view that the most productive model of the Universe we have today is the computing, informational Universe.

- The important coupling between computing and ethics is explicated. Computing, as seen in its embodied and embedded manifestations, have direct practical consequences, and therefore relevant ethical aspects. Epistemology is based not only on rational reasoning but also on an intentional choice, dependent on preferences and value system. The novel research is done within the field of computer ethics: personal integrity, privacy of communications in global networked society and workplace privacy.

1.6 Thesis Conceptual Organization

The thesis is based on five research papers reproduced in the end of the book. The introductory part of the thesis, kappa, aims at integrating and presenting a common context, giving the big picture which makes the individual publications stand out as a part of a wider project.

The thesis begins with motivations (Chapter 1), background and the aims of the research, including the overview of the papers included. In the Introduction, (Chapter 2) technological grounds are presented to explain why this research is a relevant contribution to the subject of computing. Present day technologies are becoming increasingly information-intensive and oriented towards information processing, refinement and management. Products contain embedded computers, that often are connected in networks and communicating, and it is very often desirable that products have a certain degree of intelligence. Comprehension of conceptual relationships between data, information, computation, knowledge and intelligence is essential for our understanding of the field.

Specific chapters are dedicated to computing and information. A pragmatic process view of computing is presented in the chapter on computing (Chapter 3). Information on the other hand is seen as the result of the computing process (Chapter 4). The chapter on information also presents different theories of information and their aims.

Information and computation are taken together to be a basic principle in a dual-aspect ontology. In that framework, the physical world is a network of computational processes on a structure that is informational. So information/computation phenomenon is seen as the most fundamental way of describing the physical world, the approach known as pancomputationalism. In its most general formulation based on natural computation, pancomputationalism needs no explicit assumption about the digital or the analog nature of computation process in the world. Natural computation can be both analog and digital. On this interpretation, epistemology can be naturalized in a sense that knowledge is understood as a result of the process of structuring multi-layered and multi-channel information that a cognitive agent exchanges with the world, increasing chances for survival, and even optimizing some other preferred outcomes for more complex organisms. The cognitive processes being implemented in physical bodies, as well as all the processes of information communication or storage - all those dynamical information transformations are the result of computational processes. From the simplest organisms to the most complex, information is processed on many different levels – from the metabolic processes in the organism, to the reproduction processes in which DNA is involved as an informational mechanism par excellence.

Taking information and computation together, a common framework is explicated in Chapter 5, which concludes the first part of kappa dedicated to information semantics.

The second part of kappa (Chapter 6) is devoted to ethics and it gives first a raison d'étre for ethics in the computing and information field. Ethics is necessary because, within the pragmatic framework, meaning is defined as the result of acting in the world, and the action is always goal-oriented. This means that it has an underlying value system, preferences and therefore also ethical aspects. Computing has changed our ways of communication and resulted in globally-networked societies. Peoples with different ethical traditions come into contact and become aware of each other and of the relativity of their own positions. A new set of rules, laws, codes of ethics and practices needs to be worked out in order to make the technology trustworthy, safe, secure and beneficial for its users. Privacy and personal identity are issues with the highest priority for computer ethicists and professionals to discuss. Special attention is paid to the phenomenon of global e-democracy, surveillance and workplace privacy.

In conclusion, it should be pointed out that the thesis takes a pragmatic approach to questions, of interest to the computing professionals' community, within computing and philosophy. In the first place the focus is on the role of computation in the understanding of information, its meaning and use, and also its relevance for intelligent systems. The related question of value systems and ethics is brought to the fore, as ethics is becoming both an issue frequently debated within the computing community and an integral part of computing curricula.

Chapter 2. Introduction

2.1 Information, Communication and Knowledge Technologies

The Universe is an idea deeply rooted in our human culture, different in different places and during different epochs. At one time, it was a living organism (tree of life, Mother Earth), at yet another time, mechanical machinery - the Cartesian-Newtonian clockwork. Today's metaphor for the Universe is more and more explicitly becoming a computer. In a pancomputational/paninformational view (Zuse, Wiener, Fredkin, Wolfram, Chaitin, Lloyd), the universe is a network of computing processes, essentially defined by information, which is a result of a multitude of computation processes (see Paper B, Information Physics links). Whether the physical universe really is anything like a computer is of no interest in this context. The main question is how fruitful and productive computational models might be.

Technology, science and philosophy have always been closely related and intertwined. It is apparent that during the previous mechanistic epoch, the current technological paradigm of mechanical machinery was also the leading idea of scientific models and even the one dominant of philosophy.

Contemporary ICT (Information and Communication Technology) is centered on information processing, information appearing as a link in the semantic enrichment chain, which consists of the following:

(raw) data – information – knowledge – wisdom

Here each subsequent element of the "semantic food chain" takes the previous, and enriches it semantically. In this way information is an essential input for knowledge. Present day technology operates on data we use to synthesize information, and on information that we take from different contexts to synthesize knowledge. It is envisaged that technology in the future will be able to structure not only data and information but also knowledge, possibly even in its most general form of embodied knowledge. (Abstract knowledge is seen as a special case of embodied knowledge.) What is vital for the future knowledge technology that will be able to manage (structure) knowledge, is intelligence.

The dream of the intelligent machine is at least as old as Greek mythology. It is also related to the ancient dream of the possibility of breathing life into matter (met in variety of creation myths such as Golem, Frankenstein, Robot).

Intelligent artifacts appear in literature as mechanical devices envisioned as showing “intelligence”. Over the past fifty years, with the development of computers, numbers of disciplines related to intelligence have attained results valuable both generally and for specialist applications. The cognitive and information sciences are making groundbreaking advances that will radically improve our understanding of the architecture, design and control of intelligent systems.

2.2 Intelligent Systems, Knowledge, Information

This chapter will discuss the current state of the art of the Intelligent Systems technology and its possible future developments. These will include the better understanding of information and its processing needed in order to set the adequate “real world” frame of reference. It is based on Meystel, Albus, Feldman and. Goertzel’s accounts.

Intelligence may be described as the characteristic of an agent that increases the probability of the success of its actions in its relationship with the “world” (including itself). Consequently, the functioning of intelligent agents must be understood in their interaction with the environment and related to their goals.

The mechanisms of intelligent behavior are data acquisition (perception), information processing, knowledge management capabilities including anticipation and decision making. Intelligent agents often have actuators to execute their decisions, especially in the case of living organisms.

Recent studies in biology, ethology (study of animal behavior) and neuroscience, which have increased our knowledge of biological brain functions has led to the insight that *the most important feature of cognition is its ability to deal efficiently with complexity*, in apparently common ways in living organisms. Such insights into natural intelligence, together with the increase in power of electronic computing bring us closer to the modeling of intelligent behavior and even the designing of better, increasingly intelligent, systems.

Modern computers, (not to mention future ones) will eventually enable us to cope with complex systems in a way completely impossible to earlier science, unaided by such powerful computational tools.

It is worth to mention, that the idea of artificial intelligence is based on the belief that intelligent behavior can be understood in such a detail so that a machine can be constructed able to simulate it.

From the computationalist point of view, intelligence may be seen as based on several levels of data processing:

Information (sensory data processed) can be understood as an interface between the *data* (world) and an agent's *perception* of that world. Patterns of information should thus be attributed both to the world and to the functions and structures of the brain. Models of data processing (including recognition – extracting information from data) are presently developing from earlier template-based correspondence models (the spectator model) toward multi-faceted, multi-resolution interactive (iterative) models.

In an analogous way, *knowledge* can be understood as an interface between *perception* and *cognition*. Structures of knowledge can be attributed both to percepts (information) and to the brain organization. Meaning and interpretation are the results of the processes of temporal development of information, its refinement (relating to already existing memorized information), and thus conversion to knowledge.

Wisdom, the highest stage in the data-information-knowledge-wisdom chain is obtained when knowledge is processed by consciousness. *Wisdom* thus may be seen as an interface between *cognition* and *consciousness*. Of course not all information is based on perception. A good deal is also derived from existing data/information stored in the memory. In this context it can be mentioned that invention and insight are linked to combinatorial cognitive processes s, while reflection is regarded as a component of processes of consciousnes.

Reasoning, decision making and agency have been shown to be closely related to the phenomenon of meaning. Consciousness is nowadays recognized as a legitimate and important factor of intelligent human behavior. Consciousness is understood as self-awareness on a conceptual meta-level that hopefully, at least partly, can be programmed into an intelligent agent to enable it to reflect over its own behavior, in order to be able to better adapt and respond to environmental changes.

Data, information, perceptual images and knowledge are organized in a multiresolutional (multigranular, multiscale) model of the brain and nervous system. Multiresolutional representation has proven to be a way of dealing with complexity in biological systems. Search and sort are basic mechanisms of the architectures of representation and the processing of data/information/knowledge.

From cognitive robotics, it is becoming evident that *intelligence is closely related to agency*. Anticipation, planning and control are essential features of intelligent agency. A similarity has been found between the generation of behavior in living organisms and the formation of control sequences in artificial systems.

Current development is directed towards the creation of intelligent agents with following capabilities:

- information gathering, perception, processing, sensor fusion, and situation representation
- decision making, goal pursuit, and reaction to unanticipated situations
- action planning, resource management, and task scheduling and decomposition
- path planning for automated route selection, navigation, and obstacle avoidance

The following are accepted intrinsic properties of natural intelligent systems:

- **self-organization** (including self-control and self-regulation/self-governance) - can be considered a process of reducing the cost of functioning via the development of a multi resolution architecture of representation and decision making
- **self-reproduction** - can be understood as a tool of reducing the cost of survival as a part of temporal functioning
- **self-description** (or self-representation) - can be recognized as the most efficient tool for supporting the processes of self-organization and self-reproduction by learning from experience.

They are studied within the field of Artificial Life (AL), which is a subfield of the AI/IS field.

Learning is an essential part of each of the above three capabilities and it requires among others the development of a symbolic system which is easy to maintain and use. It is possible to build intelligent control systems that can collect and process information, as well as generate and control behavior in real time, and cope with situations that evolve among the complexities of the real world, inspired by the sophisticated abilities of biological organisms to cope with complexity.

Learning systems are developed in a number of new directions.

- neural networks
- fuzzy systems
- evolutionary programming (including genetic algorithms), etc.

We may conclude that any intelligent system, in analogy with biological systems, should be based upon a multiresolutional hierarchy of the loops of functioning. Each of these loops can be treated as a control system per se. Structures of the sensory processing (data), information, knowledge representation and decision making are built in a multiresolutional way, with many contemporary pattern recognition and control methods hardwired.

Goertzel hypothesizes that (intelligent) mind is basically a superposition of two systems: a structurally associative memory and a multilevel perceptual-motor process hierarchy. By superposing these two systems, the mind emerges combining memory (structure) and process (control).

Research in intelligent system control has by now led to the development of a number of techniques and tools. Neural networks and fuzzy controllers have already become standard. Future developments are to include semiotic control, control structures for open systems, controllers with discovery of meaning, and possibly even value-driven controllers.

2.3 Intelligence Augmenting Technologies

“Amplifying intelligence. ... It is also clear that many of the tests used for measuring "intelligence" are scored essentially according to the candidate's power of appropriate selection. ... Thus it is not impossible that what is commonly referred to as "intellectual power" may be equivalent to "power of appropriate selection". Indeed, if a talking Black Box were to show high power of appropriate selection in such matters — so that, when given difficult problems it persistently gave correct answers — we could hardly deny that it was showing the 'behavioral' equivalent of "high intelligence". If this is so, and as we know that power of selection can be amplified, it seems to follow that intellectual power, like physical power, can be amplified. Let no one say that it cannot be done, for the gene-patterns do it every time they form a brain that grows up to be something better than the gene-pattern could have specified in detail. What is new is that we can now do it synthetically, consciously, deliberately.” (Ashby, 1956, 171-172).

Apart from cognitive robotics and similar tools for generating intelligent behavior, there are other Knowledge-Management (KM) technologies that might augment humanity with intelligent services. The Semantic Web is a project intended to create a universal medium for information exchange by publishing documents with computer-processable meaning (semantics) on the World Wide Web. The Semantic Web extends the existing Web through the use of standards, markup languages and related processing tools that help define semantics.

The Semantic Grid refers to Grid computing in which information, computing resources and services are described in a standardized manner. This makes it easier for resources to be connected automatically, to create virtual organizations. Semantic Grid computing uses the technologies of the Semantic Web. By analogy with the Semantic Web, the Semantic Grid can be defined as "an extension of the current Grid in which information and services are given well-defined meaning, better enabling computers and people to work in cooperation."

As in the case of the Internet, the Semantic Grid was first used for the needs of e-Science, in order to enable flexible collaboration and computation on a global scale. The use of the Semantic Web and other knowledge technologies in Grid applications is sometimes described as the Knowledge Grid. (Source: Wikipedia)

Other interesting related fields of intelligence-enhancing application include

- Service-oriented information- and knowledge-level computation
- Interactive agents, inter-agent dialogues, learning, belief change
- Semantics-assisted problem-solving on the semantic grid
- Ontology-enabled problem-solving environments
- Knowledge discovery
- E-science
- Wisdom Web and Knowledge Grids

What is typical of all of the above mentioned computational fields under development, from the perspective of theoretical computing, is that they do not resemble Turing Machines. If we have an ambition to be able to develop the theory of the Semantic Web, we must also generalize our ideas of what computation is and what it might be. In the words of Ray Kurzweil (2002):

"Wolfram considers the complexity of a human to be equivalent to that a Class 4 automaton because they are, in his terminology, "computationally equivalent." But class 4 automata and humans are only computationally equivalent in the sense that any two computer programs are computationally equivalent, i.e., both can be run on a Universal Turing machine. It is true that computation is a universal concept, and that all software

is equivalent on the hardware level (i.e., with regard to the nature of computation), but it is not the case that all software is of the same order of complexity. The order of complexity of a human is greater than the interesting but ultimately repetitive (albeit random) patterns of a Class 4 automaton.”

We will have reasons to return, later on, to the relationship between data, information and knowledge understood as different levels of organizational complexity. We will also comment on the limitations of the Turing machine as a model of universal computation. It is becoming obvious that generalizing the idea of computation to encompass natural computation in its entirety as in the pancomputational view implies that the Turing Machine is the special case of more general natural computation.

Complexity is a typical phenomenon that is best explored with the use of computers. It is not surprising that the field has experienced an unprecedented growth during the past twenty years. Computer modeling and simulation are becoming invaluable tools in complexity studies. The following is a list of issues of the highest interest:

- Dynamic computer simulations
- Dynamic field approach
- Dynamic systems theory and developmental theory
- Dynamics of control of processing
- Emergence
- Intermodality
- Brain and cognitive function
- Language development
- Neurobiological constraints
- Perceptual learning
- Self-organization of behavior
- Sensory-motor and perception-action loops

One of the promising approaches to complex systems is from the process perspective, taken by Ben Goertzel, in his Chaotic Logic (1994):

“Therefore, I propose, it is necessary to shift up from the level of physical parameters, and take a "process perspective" in which the mind and brain are viewed as networks of interacting, inter-creating processes.

The process perspective on complex systems has considerable conceptual advantages over a strictly physically-oriented viewpoint. It has a long and rich philosophical history, tracing back to Whitehead and Nietszche and, if one interprets it liberally enough, all the way back to the early Buddhist philosophers. But what has driven recent complex-systems researchers to a process view is not this history, but rather the inability of alternative methods to deal with the computational complexity of self-organizing systems.

George Kampis's (1991) Self-Modifying Systems presents a process perspective on complex systems in some detail, relating it with various ideas from chemistry, biology, philosophy and mathematics. Marvin Minsky's (1986) Society of Mind describes a process theory of mind; and although his theory is severely flawed by an over-reliance on ideas drawn from rule-based AI programs, it does represent a significant advance over standard "top-down" AI ideas. And, finally, Gerald Edelman's (1988) Neural Darwinism places the process view of the brain on a sound neurological basis. "

This work advocates the process view of computing in conjunction with the structuralist view of information, and it is instructive to see how many relevant consequences it may have for both our understanding of the physical world, including humans, and also which implications it may have for the future development of computing.

It is difficult not to share Ed Fredkins fascination with the prospects of informationalism/computionalism: (quoted from Ray Kurzwei, 2002):

"Fredkin is quoted by Robert Wright in the 1980s as saying:

"There are three great philosophical questions. What is life? What is consciousness and thinking and memory and all that? And how does the Universe work? The informational viewpoint encompasses all three…"

Indeed. I would just remind that "informational" means informational/ computational within a dual aspect framework.

Chapter 3. Computing

According to ACM/IEEE (2001), the field of computing can be described as encompassing Computer Science, Computer Engineering, Software Engineering and Information Systems.

The German, French and Italian languages use the respective terms "Informatik", "Informatique" and “Informatica” (Informatics in English) to denote Computing.

Computation is the process of performing a task of computing. The definition of computation is currently under debate, and an entire issue of the journal Minds and Machines (1994, 4, 4) was devoted to the question “What is Computation?”

The notion of computation as formal (mechanical) symbol manipulation originates from discussions in mathematics in the early twentieth century. The most influential program for formalization was initiated by Hilbert, who treated formalized reasoning as a symbol game in which the rules of derivation are expressed in terms of the syntactic properties of the symbols employed. As a result of Hilbert’s program large areas of mathematics have been formalized. Formalization means the establishment of the basic language which is used to define the system of axioms and derivation rules defined such that the important semantic relationships must be preserved by inferences defined only by the syntactic form of the expressions. Hilbert’s Grundlagen der Mathematik, and Whitehead and Russell’s Principia Mathematica are examples of such formalization projects. However, there are limits to what can be formalized, as demonstrated by Gödel’s incompleteness theorems.

A second important issue after formalization of mathematics was to determine the class of functions that are computable in the sense of being decidable by the application of a mechanical procedure or an algorithm. Not all mathematical functions are computable in this sense. It was first Alan Turing who devised a general method to define the class of computable functions. He proposed the logical “computing machine", which is a description of a procedure that processes symbols written on a tape/paper in a way analogous to what a human mathematician does when computing a function by application of a mechanical rule. According to Turing, the class of computable functions was equivalent to the class of functions that could be evaluated in a finite number of steps by a logical computing machine (Turing machine).

The basic idea was that any operations that are sensitive only to syntax can be simulated mechanically. What the mathematician following a formal algorithm does by recognition of syntactic patterns, a machine can be made to do by purely mechanical means. Formalization and computation are closely related and together yield the result that reasoning that can be formalized can also be simulated by the Turing machine. Turing assumed that a machine operating in this way would actually be doing the same things as the human performing computations.

Some critics have suggested that what the computer does is merely an imitation or simulation of what the human does, even though it might be at some level isomorphic to the human activity, but not in all relevant respects. I would add an obvious remark. The Turing machine is supposed to be given from the outset – its logic, its physical resources, and the meanings ascribed to its actions. The Turing Machine essentially presupposes a human as a part of a system – the human is the one who poses the questions, provides material resources and interprets the answers. The possibility of genuine autonomy and intentionality of a machine in general is under debate, even in the case of intelligent robots which are embodied physical machines, unlike Turing machines which are idealizations and pure logical constructions.

The Church-Turing thesis states that any kind of computation corresponds to an equivalent computation performed by the Turing machine. In its original formulation (Church 1935, 1936), the thesis says that real-world calculation can be performed using the lambda calculus, which is equivalent to using general recursive functions. The thesis addresses several kinds of computation, such as cellular automata, register machines, and substitution systems. As a matter of fact, the Church-Turing thesis has served as a definition for computation. There has never been a proof, but the evidence for its validity comes from the equivalence of a number of different computational models.

The Church-Turing thesis has been extended to a proposition about the processes in the natural world by Stephen Wolfram in his Principle of computational equivalence (Wolfram 2002), in which he claims that there are only a small number of intermediate levels of computing before a system is universal and that most natural systems can be described as universal.

Nowadays, a number of computing specialists and philosophers of computing (Hava Siegelman, Mark Burgin, Jack Copeland, and representatives of natural computing) question the claim that all computational phenomena in all relevant aspects are equivalent to the Turing Machine.

George Kampis for example, in his book Self-Modifying Systems in Biology and Cognitive Science (1991) claims that the Church-Turing thesis applies only to simple systems. According to Kampis, complex biological systems must be modeled as self-referential, self-organizing systems called "component-systems" (self-generating systems), whose behavior, though computational in a generalized sense, goes far beyond the simple Turing machine model.

“a component system is a computer which, when executing its operations (software) builds a new hardware.... [W]e have a computer that re-wires itself in a hardware-software interplay: the hardware defines the software and the software defines new hardware. Then the circle starts again.” (Kampis, p. 223)

Goertzel (1994) suggests that stochastic and quantum computing models would be more suitable for component systems.

3.1 The Computing Universe - Pancomputationalism

Konrad Zuse was the first to suggest (in 1967) that the physical behavior of the entire universe is being computed on a basic level, possibly on cellular automata, by the universe itself which he referred to as "Rechnender Raum" or Computing Space/Cosmos.

Wolfram in *A New Kind of Science* advocates a new dynamic reductionism, in which complexity of behaviors may be derived from a few basic mechanisms. Natural phenomena are thereby the products of computation. In a computational universe new and unpredictable phenomena emerge as result of simple algorithms operating on simple computing elements - cellular automata. In that view, complexity originates from the bottom-up emergent processes. Cellular automata are equivalent to a universal Turing Machine (Wolframs Rule 110).

Wolfram’s critics remark however that cellular automata do not evolve beyond a certain level of complexity. The mechanisms involved do not necessarily demand evolutionary development. Actual physical mechanisms at work in the physical universe appear to be quite different from simple cellular automata. Critics also claim that it is unclear if the cellular automata are to be thought of as a metaphor or whether real systems are supposed to use same mechanisms on some level of abstraction.

Ed Fredkin, in *Digital Philosophy,* suggests that particle physics can emerge from cellular automata. The universe is digital, time and space are not continuous but discrete. He goes a step beyond the usual “computational universe” picture: even humans are software running on a universal computer.

Wolfram and Fredkin assume that the universe is discrete system, and as such a suitable framework for an all-encompassing digital computer. Actually the hypothesis about the discreteness of the physical world is not the decisive one for pancomputationalism. As is well known, there are digital as well as analogue computers. There are interesting philosophical connections between digital and analog processes. For example, DNA code (digital) is closely related to protein folding (analog) for its functioning in biological systems.

3.2 Dual – Aspect Ontology

3.2.1 Dichotomy – A Simplest Kind of Classification

Empirical method relies on observations and experiments, which lead to a collection of data describing phenomena. In order to establish a pattern or regularity of behavior, we must analyze (compare) the results (data) searching for similarities (repetitions) and differences. All repetitions are approximate: the repetition B of an event A is not identical with A, or indistinguishable from A, but only similar to A.

As repetition is based upon similarity, it must be relative. Two things that are similar are always similar in certain respects. We find that some objects are similar with respect to color, others are similar with respect to shape and some are similar with respect to edge or size. Generally, establishing similarities, and consequently repetition, always presupposes the adoption of a point of view: some similarities or repetitions will appear if we are interested in one problem and others if we are interested in another problem.

Searching for similarity and differences leads to classifications i.e. the division of objects or events in different groups/classes. The simplest tool for classification is the binary opposition or dichotomy (dualism). When we use dichotomy, we only decide if an object is of a kind A or of a kind ~A. Examples of frequent dichotomies are given in the following table:

Table 1: Common dichotomies

yes/no	true/false	positive/nega tive	right/wrong accept/reject	good/evil good/bad
being/ nothingness	presence/ absence	alive/dead	active/passive	on/off open/closed
body/mind physical/ mental	matter/energy	particle/wave	information/comp uting	discrete/ continuous instant/ temporal
form/meaning	static/dynamic	structure/ agency structure/ process	active/passive	message/mediu m
in/out include/ exclude	up/down top/bottom	front/back	left/right	light/dark
before/after	high/low	here/there	figure/ground	text/context
one/many	similar/ different	part/whole	less/more	unity/diversity
simple/ complex	continuous/ discrete	quantity/ quality	differentiate/ integrate	particular/ general
thought/ feeling	reason/emotion	fact/fiction	practice/theory	objective/ subjective
subject/object self/other	order/chaos	local/global	concrete/abstract	token/type
nature/culture natural/ artificial	form/content	semantics/ syntax	means/ends	cause/effect

Dualism is deeply rooted in the development of human cognition. Jakobson and Halle (1956) observe that “the binary opposition is a child's first logical operation. At the most basic levels of individual survival humans share with other animals the need to quickly distinguish between their own species and others, safe and dangerous, edible and inedible, dominance and submission, etc. Neurophysiologic roots of dichotomy might be found in the oldest parts of visual recognition, where the basic distinction is made between light and dark (input signal: yes/no).

The ability to make binary distinctions may be seen as the simplest fundamental mechanism of making sense, providing a fast and efficient basis for agency, which certainly increases the chances of survival of an organism and thus gives an evolutionary advantage.

3.2.2 Leibniz's Binary Notation

An interesting point is made by Debrock (2003) who reports that Leibniz (1697) was the first one to introduce binary notation. In his book On the Method of Distinguishing Real from Imaginary Phenomena, Leibniz points out that the numbers zero (nothing) and one (God), are all that is needed to construct the universe. He demonstrates this with the illustration with title, "In order to make everything from nothing the One suffices". Beginning with the numbers 0 and 1 he shows how to represent other natural numbers in terms of the two basic digits (1=1, 2=10, 3=11 etc).

Debrock comments: *"To his contemporaries, the picture must have seemed like a somewhat outrageous joke. To us it looks both prophetic and frightening, because it appears as a confirmation of the trend to think the word in terms of digital information. But Leibniz´s picture suggests that we must even go beyond thinking world in terms of digital information, for he presents the world as* ***being*** *the set of all digital information."*

3.3 Dualism in Physics: Discrete vs. Continuous

Binary logic that is a result of the systematization of simple common-sense reasoning allows for only two values of the truth variable – one or zero. These two opposite values may be considered as exhausting the whole space of possibilities. This is expressed as Tertium non Datur, ("The third is not given"), also known as the law of the excluded middle. In connection with dual-aspect characterization, the analysis of a number of binary concepts in physics such as wave - particle; potential - actual; real - virtual; electric – magnetic, which may be used within certain domains to describe all possible characteristics of a physical phenomenon, is of interest.

3.3.1 Wave-Particle Dualism

"There are therefore now two theories of light, both indispensable, and - as one must admit today in spite of twenty years of tremendous effort on the part of theoretical physicists - without any logical connections." Albert Einstein (1975 [1924])

Neils Bohr (1928) formulated his Complementarity principle, stating that particle theory and wave theory are equally valid. Scientists should simply choose whichever theory worked better in solving their problem.

The currently accepted solution of wave-particle "problem" is given in quantum electrodynamics (QED), that combines particle and wave properties into a unified whole.

Wave-particle dualism can be seen as a special case of continuum-discrete dichotomy. In terms of computational applications, the question of discrete - continuum dichotomy may be found in the difference between symbol-based approaches and connectionist (neural network, for example) approaches. However, it is sometimes stated that there is no dichotomy because most neural networks are modeled in (discrete) software. Moreover, in a transistor which is a physical device implementing binary 0/1 logic in terms of electric current, the current itself is not discrete, but basically a continuous phenomenon – so it is a matter of convention to assign "zero current" to a sufficiently low current in a transistor. On the same grounds one can argue that there is no difference between discrete (countable) and continuous (measurable) phenomena because digital technology can represent continuous phenomena such as sound and speech, photographs and movements.

Chalmers (1996) claims that continuous systems would need to exploit infinite precision to exceed the powers of discrete systems (p. 330-331). Interestingly, an analog system which computes a superset of the Turing-computable functions in polynomial time and with finite linear precision is given in Siegelman and Sontag (1994).

3.4 The Finite (Discrete) Nature Hypothesis

"A fundamental question about time, space and the inhabitants thereof is "Are things smooth or grainy?" Some things are obviously grainy (matter, charge, angular momentum); for other things (space, time, momentum, energy) the answers are not clear. Finite Nature is the assumption that, at some scale, space and time are discrete and that the number of possible states of every finite volume of space-time is finite. In other words

Finite Nature assumes that there is no thing that is smooth or continuous and that there are no infinitesimals." (Fredkin, Digital Philosophy)

One obvious question one may ask is: Why would we need this hypothesis about the discrete nature of the physical world? Actually, again, pancomputationalism is not critically dependent on computers being discrete (digital). They can equally well be analogue. How did that idea arise in the first place? The reason may be that in analogy with the digital computer; the universe was conceived as digital, in the same way as the Newton-Laplace universe was a mechanical mechanism. Actually we can make the next turn in reasoning and say – what if the universe is a computer, and it is both discrete and continuous? Equally well the universe might be neither discrete nor continuous. In any event we have both discrete and continuous computational processes. So for the most general formulation of pancomputationalism there is no special reason to consider only discrete aspects of the universe – we may learn from nature how to compute in both discrete and continuous regimes.

3.5 The Real Nature of the Universe – Discretely Continuous?

Now having said that, the interesting question remains: is the universe actually discrete or is it continuous?

This brings us back to the questions of epistemology and cognition – questions of our conceptualization of the universe and its (physical) phenomena. There are the following possibilities:

a) The universe is fundamentally discrete

b) The universe is fundamentally continuous

c) The universe is both continuous and discrete

d) The universe is neither continuous nor discrete

Even though as already mentioned the idea of pancomputationalism is not crucially dependent on any of the above, different options might have different interpretations and also different practical consequences.

A very convincing and interesting argument for (c) is given by Luciano Floridi in his E-CAP 2006 talk.

Here I will try to argue for (c) and (d) and I will refer to the previous chapter about the use of dichotomies in the epistemological analysis.

In *The Age of Intelligent Machines*, Ray Kurzweil discusses "the question of whether the ultimate nature of reality is analog or digital," and points out that

"as we delve deeper and deeper into both natural and artificial processes, we find the nature of the process often alternates between analog and digital representations of information. As an illustration, I noted how the phenomenon of sound flips back and forth between digital and analog representations. In our brains, music is represented as the digital firing of neurons in the cochlear representing different frequency bands. In the air and in the wires leading to loudspeakers, it is an analog phenomenon. The representation of sound on a music compact disk is digital, which is interpreted by digital circuits. But the digital circuits consist of thresholded transistors, which are analog amplifiers. As amplifiers, the transistors manipulate individual electrons, which can be counted and are, therefore, digital, but at a deeper level are subject to analog quantum field equations. At a yet deeper level, Fredkin, and now Wolfram, are theorizing a digital (i.e., computational) basis to these continuous equations. It should be further noted that if someone actually does succeed in establishing such a digital theory of physics, we would then be tempted to examine what sorts of deeper mechanisms are actually implementing the computations and links of the cellular automata. Perhaps, underlying the cellular automata that run the Universe are yet more basic analog phenomena, which, like transistors, are subject to thresholds that enable them to perform digital transactions. "

Seth Loyd makes the equivalent claim in case of quantum mechanics:

"In a quantum computer, however, there is no distinction between analog and digital computation. Quanta are by definition discrete, and their states can be mapped directly onto the states of qubits without approximation. But qubits are also continuous, because of their wave nature; their states can be continuous superpositions. Analog quantum computers and digital quantum computers are both made up of qubits, and analog quantum computations and digital quantum computations both proceed by arranging logic operations between those qubits. Our classical intuition tells us that analog computation is intrinsically continuous and digital computation is intrinsically discrete. As with many other classical intuitions, this one is incorrect when applied to quantum computation. Analog quantum computers and digital quantum computers are one and the same device." (Lloyd, 2006)

Thus establishing a digital basis for physics at certain level of granularity, will not resolve the philosophical debate as to whether physical universe is ultimately digital or analog. Nonetheless, establishing a feasible computational model of physics would be a major achievement.

3.5.1 Continuum as a Result of Interaction

Let us start from the fact that dichotomy exists between the discrete and continuous nature of physical reality. From the cognitive point of view it is clear that most of the usual dichotomies are coarse approximations. They are useful, and they speed up our reasoning considerably, but on closer inspection one would find all shades of gray between black and white dichotomies. Following Kant we can safely say that “Ding an Sich” (thing-in-itself) is nothing we have knowledge of. This is also so in the case of the discrete-continuous question.

Our cognitive categories are the result of our natural evolutionary adaptation to the environment. Given the bodily hardware that we have, they are definitely strongly related to the nature of physical world in which we live, but they are by no means general tools for understanding the universe as a whole at all levels and for all types of phenomena that might exist.

Even though the (d) would be the Kant’s ontological choice, one might nevertheless ask: if we adopt the dichotomy as our own epistemological necessity (at least for the time being), how could the continuum/digital universe be understood?

In what follows I will argue that digital and continuous are dependent upon each other – that logically there is no way to define the one without the other. So, let us begin by assuming that the basic physical phenomena are discrete. Let us also assume that they appear in finite discrete quanta, packages, amounts or extents. If the quanta are infinitely small then they already form a continuum. [1]

Figure 1: Constructing continuum from finite discrete signals.

[1] However, the idea of quantities that can be made arbitrary small, such as Newton’s fluxions – is logically problematic, though very useful for practical applications where “arbitrary small” is some finite value. “And what are these fluxions? The velocities of evancescent increments. And what are these same evanescent increments? They are neither finite quantities, nor quantities infinitely small, nor yet nothing. May we not call them the ghosts of departed quantities...? Bishop Berkeley, - The Analyst: A Discourse Addressed To An Infidel Mathematician (1734)

See even Chaitin’s argument against real numbers in Dodig-Crnkovic & Stuart (2006).

Starting with finite quanta one can understand the phenomenon of continuum as a consequence of the processes of communication between different systems (see Figure 1). Even if the time interval between two signals that one system produces has always some definite value different from zero, (discrete signals) two communicating phenomena can in principle appear arbitrarily in time, so that the overlap is achieved, which means that a continuum is realized in a communicative (interactive) process such as computation.

3.5.2 Can Cognition be seen as Computation? Is Computational Cognition Necessarily Digital?

Cognitive theories of intelligent behavior have been the basis for designing and implementing intelligent artificial systems. Although it is commonly agreed that an autonomous intelligent action implies intentionality, meaning, representation, and information processing, diverse theories of information assume different interrelations as well as different functional activations outside and inside the system. The necessity of representation of information is tacitly assumed, either in form of a hard, explicit and static representation or a more implicit and dynamic one.

Different concepts of representation result in different frameworks for analyzing and modeling of cognition, in which meaning and information are given different functional and explanatory roles. The dominant frameworks of cognition are all characterized by inherent limitations such as the inability to account for both low and high-level cognition or to scale between them (the symbol grounding problem - how symbols get their meanings, and of what meanings are). Neither symbolic nor connectionst framework is able to account for the emergence of representation in a purely naturalistic manner, see Taddeo and Floridi (2005).

Argyris et al. (2005), propose a system-theoretic framework which seems to suggest a way out of the above difficulties. The proposed framework uses elements from cybersemiotics and tries to model the basic cognitive concepts (representation, meaning and information) by incorporating them in an anticipative and interactive context of information dynamics. The second order cybernetics and self-organization properties are used to account for a complex and emergent relational structure of representation.

The Argyris et al. approach is not a dynamic/symbolic hybrid, but involves interplay between analog and digital information spaces, in which they model the representational behavior of a system. The focus on the explicitly referential correlation of information between system and environment is shifted towards the interactive modulation of implicit internal content and therefore, the resulting pragmatic adaptation of the system via its interaction with the environment. This approach, not unlike Whitehead's explanation of how 'symbolic reference' may arise as interplay between two modes of perception: 'causal efficacy' and 'presentational immediacy', (Whitehead 1978), shows that computational cognition does not necessarily need to be (only) digital.

3.6 After All: Is Computing a Subject Matter?

Brian Cantwell Smith in his book On the Origin of Objects analyzes computation, and In Search of Philosophy of Computing, comes to the conclusion that computers do not constitute subject matter and that they are interesting mainly as intentional artifacts. So in the first place Smith is interested in intentionality expressed by computers. He says:

"Where does that leave things? Substantively, it leads to the third and final cut on the intellectual project, depicted in the figure I-II (below) that metaphysics, ontology, and intentionality are the only integral intellectual subject matters in the vicinity. This book can be understood as an attempt to undertake the project conceived in this third and final way. Methodologically, it means that our experience with constructing computational (i.e. intentional) systems may open a window onto something to which we would not otherwise have any access: the chance to witness, with our own eyes, how intentional capacities can rise in a "merely" physical mechanism."

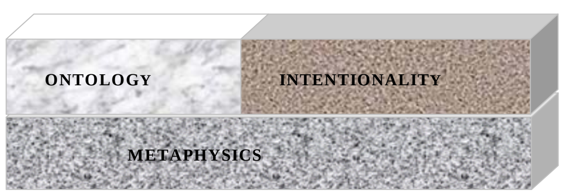

Figure 2: B C Smith's view of what constitutes subject matter.

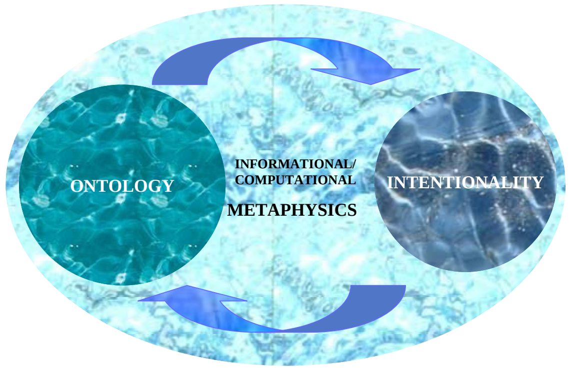

Figure 3: A possible alternative view of what constitutes subject matter, the computational/informational view of the universe.

What is the difference between Smith's proposed model (figure 2) and the alternative suggested in figure 3? The geometry of Smiths model suggests that our intentionality in parallel with ontology is based directly on metaphysics. This makes ontology separate from intentionality, a debatable point of view.

The proposed alternative model is the dynamic interplay between ontology (all that exists and can exist) and intentionality (adaptive evolutionary processes going on in a living organism that optimizes the chances of survival of a cognizing system or favour the achievement of some other goal that an agent may have) all of which by definition is chosen to be computational. This is indicated by the space where this dynamics takes place – the computationalist conceptual space defining metaphysics (general preconditions for the theory, in which the universe of discourse is created).

Chapter 4. Information

Jon Barwise (1986) has noticed an analogy between the Bronze Age and the Information Age. People in the Bronze Age were skillful at working with bronze, their material culture was characterized by Bronze artifacts, but it was many centuries after the end of the Bronze Age that scientists were able to establish the chemical and physical nature of bronze. Similar can easily be the case for us and information.

The word information is derived from the Latin *informare* which means "give form to". It originates in an Aristotelian concept of substance in which form informs matter, while matter materializes form to become a substance.

Nowadays concepts of information present a complex body of knowledge that accommodates different, not seldom contradictory views:

"Inconsistencies and paradoxes in the conceptualization of information can be found through numerous fields of natural, social and computer science." Marijuan (2002)

Or, as Floridi (2005) formulates it, *"Information is such a powerful and elusive concept that it can be associated with several explanations, depending on the requirements and intentions."*

As in the case of computation, the corresponding question "What is Information? is the subject of lively discussion, and a special issue of the Journal of Logic, Language and Information (Volume 12 No 4 2003) is dedicated to the different facets of information. A *Handbook on the Philosophy of Information* (Van Benthem, Adriaans) is to appear in 2006.

In the same vein, Capurro and Hjørland (2003) analyze the term "information" explaining its role as a constructive tool and its theory-dependence as a typical interdisciplinary concept. They review significant contributions to the theory of information from physicists, biologists, systems theorists, philosophers and documentalists (Library and Information Science) over the past quarter of century.

On the other hand Capurro, Fleissner and Hofkirchner (1999) question if a unified theory of information (UTI) is feasible, answering in a cautiously affirmative way. According to the authors, UTI is an expression of the metaphysical quest for a unifying principle of the same type as energy and matter.

In the reductionist unification approach, reality is an information-processing phenomenon. “We would then say: whatever exists can be digitalized. Being is computation.” (ibid) An alternative to a unified theory of information would be the networked structure of different information concepts which retain their specific fields of application (Wittgenstein’s family resemblance).

4.1 The Informational Universe – Paninformationalism[2]

The present-day informatisation of society is the result of the ubiquitous use of computers as an information and communication technology. Information is to replace matter/energy as the primary constitutive principle of the universe, as (von Baeyer, 2003) suggests. It will provide a new basic unifying framework for describing and predicting reality in the twenty-first century.

At a fundamental level, information can be said to characterize the world itself, for it is through information we gain all our knowledge - and yet we are only beginning to understand its meaning. (van Benthem J., 2005) The following is an attempt to define some basic concepts constituting and relating to the idea of information, in the sense it is used in the field of computing. (Dodig-Crnkovic, 2005).

[2] This chapter follows essentially my contribution to the forthcoming article: Knowledge Map of Information Science: Implications for the Future of the Field, Zins C., Debons A., Beghtol C., Buckland M., Davis C. H., Dodig-Crnkovic G., Dragulanescu N., Harmon G., Kraft D. H., Poli R., Smiraglia R. P.

4.2 Information Structures. Data – Information – Knowledge - Wisdom[3]

Raw data (sometimes called source data or atomic data) is data that has not been processed for a given use, in the spirit of Tom Stonier's (1997) definition. Here "unprocessed" means in an operational sense that no specific effort has been made to interpret or understand the data prior to the use. They are recorded as "facts of the world"; either given/chosen at the outset, the result of some observation or measurement process, or the output of some previous data generating process (as often is the case for computer data). The word "data" is the plural of Latin "datum", "something given", which one also could call "atomic facts".

Information is then the end product of data processing. Knowledge is the end product of information processing. In much the same way as raw data are used as input, and processed in order to get information, the information itself is used as input for a process that results in knowledge.

"Data is generally considered to be a series of disconnected facts and observations. These may be converted to information by analyzing, cross-referring, selecting, sorting, summarizing, or in some way organizing the data. Patterns of information, in turn, can be worked up into a coherent body of knowledge. Knowledge consists of an organized body of information, such information patterns forming the basis of the kinds of insights and judgments which we call wisdom.

The above conceptualization may be made concrete by a physical analogy (Stonier, 1983): consider spinning fleece into yarn, and then weaving yarn into cloth. The fleece can be considered analogous to data, the yarn to information and the cloth to knowledge. Cutting and sewing the cloth into a useful garment is analogous to creating insight and judgment (wisdom). This analogy emphasizes two important points: (1) going from fleece to garment involves, at each step, an input of work, and (2) at each step, this input of work leads to an increase in organization, thereby producing a hierarchy of organization."

Stonier (1997)

The work added at each subsequent higher organization level is, at the same time, (is) input of new information to the existing lower level of organization. (Dodig-Crnkovic, 2005)

4.3 Schools of Information

Apart from Stonier's structuralist view, there are many other schools of information theory. So let us have a brief look at the diversity of existing approaches, trying to answer the question "What is the difference between information defined in different terms?" following Holgate (2002).

Communication School (Quotidian School, Documentalism) – Information is communicated knowledge, or any "notifying matter" Machlup (1983) referring to "telling something or to the something that is being told". Documentalists (the theorists of Library and Information Science) have tended to define information as either evidentiary documentation to be managed (Buckland's information-as-thing) or as a type of searching behavior in which the individual navigates a textual universe using the tools of Information Storage and Retrieval.

Batesonian School - Information is in the pattern or 'formation' (formative interaction) which data takes, 'difference that makes a difference' (Bateson). Information is associated with patterned organization and the reduction of uncertainty - an organizing principle in nature (Collier's 'symmetry breaking'). The informatory dialectic is between presence and absence, potentiality and expression. Javorszky (2002): 'what matters, is that <such> comes next to <such>'.

Logic School - Information can be inferred from data, knowledge and other information (Floridi's Information Logic, Popper's Logical Positivism, Leyton's Process Grammar of Inferred Shapes). An underlying model is the data/information/knowledge pyramid. How 'meaningful and contextualised data (information) becomes knowledge or wisdom is an unresolved issue.

Hermeneutic School (Capurro - diachronic form information (moulding) and Descartes' 'forms of thought which inform the spirit')

Quantum School (Weizsacker, Lyre). Information is a 'double image' appearing as both form and relationship (and in that way it has a property of Wittgenstein's duck/rabbit's ambiguity). (Capurro, Hjørland 2003)

"Information as a second order category (not as the quality of things but as a quality ascribed to relationships between things) in the sense of 'selection' that takes place when systems interact and choose from what is being offered" (Capurro 2002).

Heraclitian School – 'continuous present'' (Matsuno), 'information flow' (Dretske) Situational Semantics (Barwise, Perry, Israel), Process Philosophy (Whitehead), information is in the dynamic process of formation' (Hofkirchner/Fleissner). Marijuan sees information as a self-regulating entity which moves 'in formation', adopting Conrad's 'vertical information flow' circulating through molecules-cells-organisms-niches and linking the computational and the biological:

"The living entity is capable of continuously keeping itself in balance, always in formation, by appropriately communicating with its environment and adequately combining the creation of new structures with the trimming down of obsolete, unwanted parts" Marijuan (2002)

Semiotic School - data/sign/structure is situated in an environmental context for an interpreting system - Cybersemiotics (Brier). Physico-chemical Semiosis (Taborsky); Burgin ('proper information related only to biological infological systems.'). Mahler (1996) claims that "Information can only be defined within the scenario; it is not just out there." Frenzl (2002) says "signs are differences of input and they need to be "interpreted" by the receiver to be information FOR the receiving system. If the organization pattern, the logic of its structural organization, enables the open system to react to the incoming signs (to actualize its own inner structural information), we can say that the system processes the signs to information."

Stimulus School - Information' as stimulus/trigger/ignition (Karpatschoff), Neural Net Activation in Cognitive Neurology. Karpatschof (2000) "It is a relational concept that includes the source, the signal, the release mechanism and the reaction as its relatants."

Mechanicists School (Hayles Posthumanism, AI, robotic cognition) - have a belief in the power of computation and artificial intelligence to fill in the void left by the postmodern deconstruction of human reason. *"Located within the dialectic of pattern/randomness and grounded in embodied actuality rather than disembodied information, the posthuman offers resources for re-thinking the articulation of humans with intelligent machines."* (Hayles, 1999)

Sceptic School (Rifkin, Bogdan, Miller, Spang-Hanssen, Maturana):

"These concepts of information are defined in various theories such as physics, thermodynamics, communication theory, cybernetics, statistical information theory, psychology, inductive logic, and so on. There seems to be no unique idea of information upon which these various concepts converge and hence no proprietary theory of information." (Capurro and Hjorkland p.18)

A similar skepticism is implied in the view of Maturana (and the Vienna School) that 'information' lies outside the closed system that is autopoiesis. Cybersemiotics (Brier adopting Pierce's sign theory) attempts to rescue 'information' (as a possibility of 'openness').

Phenomenological School – ‘information’ is in the situated action/interaction/experience (Luhmann (Husserl), Merleau-Ponty’s ‘lived experience’, ‘horizon of numerous perspectival views’) or ‘information’ is in the perspective (Perspectivist School - von Bertalanffy’s Perspectivism, Dervin’s Structural Multiperspectivity).

4.4 Theories of Information

After having said that about the current views of the phenomenon information, it might be interesting to briefly review several characteristic theories of information, (see Paper C).

4.4.1 Syntactic Theories of Information

In the syntactic approaches, information content is determined entirely by the structure of language and has nothing to do with the meaning of messages.

Shannons Statistical Communications Theory

Shannon’s theory gives the probability of transmission of messages with specified accuracy in the presence of noise, including transmission failure, distortion and accidental additions. The statistical interpretation of information assumes an ensemble of possible states each with a definite probability. The information is the sum of the base 2 log of the inverse of the probability of each, weighted by the probability of the state,

$H = \sum prob(s_i)\log(1/prob(s_i))$

which is an expression similar to the expression for entropy in Boltzmann's statistical thermodynamics.

Wiener’s Cybernetics Information

The Cybernetics theory of information, formulated by Norbert Wiener, was based on the view that the amount of information, entropy, feedback and background noise are essential for characterizing of the human brain. Wiener (1948) p. 18 says:

“The notion of the amount of information attaches itself very naturally to a classical notion in statistical mechanics: that of entropy. Just as the amount of information in a system is a measure of its degree of organization, so the entropy of a system is a measure of its degree of disorganization."

Wiener defines information as an integral, i.e. an area of probability measurements (p.76):

"The quantity that we here define as amount of information is the negative of the quantity usually defined as entropy in similar situations."

Wieners view of information is thus that it contains a structure that has a meaning:

"It will be seen that the processes which lose information are, as we should expect, closely analogous to the processes which gain entropy."

Information is for Wiener closely related to communication and control. For system theorists, building on Wieners concept, information is something that is used by a mechanism or organism, for steering the system towards a predefined goal. The goal is compared with the actual performance and signals are sent back to the sender if the performance deviates from the norm (feedback). The concept of feedback has proven to be a very powerful control mechanism.

The Complementarity of the Wiener and Shannon Definitions of Information

There is an important difference between Shannon and Wiener. While Wiener sees information as negative entropy, i.e. a "structured piece of the world", Shannon's information is the opposite, positive entropy.

The difference could be explained by the fact that Shannon's information describes the phenomenon of information transfer, or information communication, whereas Wiener's information is a structure, pattern or order in a medium (biological organism, human brain), literally Marshall McLuhan's "The Medium is the Message". Focusing on a structure, negative entropy measures the degree of order. On the contrary, during the process of communication via message transmission, the background settings represent the originally structured state, whereas a message transmitted through the channel causes "disorder" in the background structure.

Algorithmic Information Theory (Kolmogorov, Chaitin)

Algorithmic information theory was developed by Kolmogorov, Solomonoff and Chaitin. There are several formulations of Kolmogorov complexity or algorithmic information. Algorithmic information theory combines the ideas of program-size complexity with recursive function theory. The complexity of an object is measured by the size in bits of the smallest program with which it can be computed.

It was Kolmogorov who suggested that program-size complexity provides an explication of the concept of information content of a string of symbols. Chaitin later adopted this interpretation.

The intuitive idea behind this theory is that the more difficult an object is to specify or describe, the greater its complexity One defines the complexity of a binary string s as the size of the minimal program that, when given to a Turing machine T, prints s and halts. To formalize Kolmogorov-Chaitin complexity, the types of programs must be specified. Fortunately, it doesn't really matter: one could take a particular notation for Turing machines, or LISP programs, or Pascal programs, etc.

Fisher Information

Fisher information is the amount of information that an observable random variable X carries about an unobservable parameter θ upon which the probability distribution of X depends. Since the expectation of the score is zero, the variance is also the second moment of the score, and the Fisher information can be written

$$\mathcal{I}(\theta) = \mathrm{E}\left[\left[\frac{\partial}{\partial\theta}\ln f(X;\theta)\right]^2\right],$$

where f is the probability density function of random variable X and, consequently, $0 \leq \mathcal{I}(\theta) < \infty$. The Fisher information is thus the expectation of the square of the score. Random variable carrying high Fisher information implies that the absolute value of the score is frequently high.

Frieden (2004) begins with the statement that the amount of Fisher information designated the physical information is always lost while observing a physical effect. Frieden minimizes/maximizes the physical information through variation of the system probability amplitudes, called the principle of extreme physical information EPI. This results in differential equations and probability density functions describing the physics of the source effect.

Frieden uses Fisher information to derive a number of contemporary physical theories, laws of biology, chemistry, and economics

4.4.2 Semantic Theories of Information

Although Shannon (1948) declared that “semantic aspects of communication are irrelevant to the engineering problem", his approach is often termed “The Mathematical Theory of Information”, and it is frequently regarded as the description of the semantic information content of a message. Bar-Hillel (1955) notes, “it is psychologically almost impossible not to make the shift from the one sense of information, i.e. information = signal sequence, to the other sense, information = what is expressed by the signal sequence."

The semantic theory of information explicitly theorizes about what is expressed by messages, i.e. about their information content. As a systematic theory it was initiated by Carnap and Bar-Hillel and has been developed and generalized since then by Hintikka.

Information in the semantic approach is the content of a representation.

Carnap and Bar-Hillel (Bar-Hillel, 1964) used inductive logic to define the information content of a statement in a given language in terms of the possible states it rules out. The basic idea is that the more possibilities (possible states of affairs) a sentence rules out, the more informative it is, i.e. information is the elimination of uncertainty. The information content of a statement is thus relative to a language. Evidence, in the form of observation statements, (Carnap's “state descriptions", or Hintikka's “constituents") contains information through the class of state descriptions which the evidence rules out. (The essential underlying assumption is that observation statements can be related to experience unambiguously.)

Carnap and Bar-Hillel have suggested two different measures of information. The first measure of the information content of statement S is called the content measure, cont(S), defined as the complement of the a priori probability of the state of affairs expressed by S

$$\mathrm{cont}(S) = 1 - \mathrm{prob}(S)$$

Content measure is not additive and it violates some natural intuitions about conditional information. Another measure, called the information measure, inf(S) in bits is given by:

$$\inf(S) = \log_2 (1/(1 - \mathrm{cont}(S))) = -\log_2 \mathrm{prob}(S)$$

prob(S) here again is the probability of the state of affairs expressed by S, not the probability of \`S' in some communication channel. According to Bar-Hillel cont(S) measures the substantive information content of sentence S, whereas inf(S) measures the surprise value, or the unexpectedness, of the sentence H.

Although inf satisfies additivity and conditionalisation, it has the following property: If some evidence E is negatively relevant to a statement S, then the information measure of S conditional on E will be greater than the absolute information measure of S. This violates a common intuition that the information of S given E must be less than or equal to the absolute information of S. This is what Floridi (2004) criticizes as the Bar-Hillel semantic paradox.

A further serious problem with the approach is the linguistic relativity of information, originating in difficulties of the Logical Empiricist program which supports it, such as the theory-ladenness of observation, Collier (1990).

Dretske's Information

In his book Knowledge and the Flow of Information Dretske (1981) develops epistemology and a philosophy of mind using ideas from Shannon's mathematical theory of communication. Information is defined as an objective commodity through the dependency between distinct events. Knowledge is information-caused belief, and perception is the conveyance of information-caused belief in analog form (experience) for conceptual utilization by cognitive mechanisms. Within Dretske's theory meaning (or belief content) has information-carrying role.

Situated Information, Barwise and Perry

Jon Barwise and John Perry developed the theory of situation semantics, in which they allow the context in which an utterance is used to affect its interpretation. In the formal account, statements are represented by n-tuples, one element of which is the sentence uttered (syntactic view), other elements being a discourse situation and set of speakers connections and resource situations (Israel, 1983). Situated information is thus information specific to a particular situation. A situation is a projection of the environment external to the agent via some sense medium onto the agent's senses. A situation is thus an agent-centered notion.

"Reality consists of situations - individuals having properties and standing in relations at various spatiotemporal locations." (Barwise & Perry, 1983).

Individuals, properties, relations and locations make up uniformities across different situations. Living organisms are adjusted to various uniformities, depending on their biological needs. Meanings are seen as special kinds of uniformities: the meaning of a simple declarative sentence is uniformity in the relations between the utterance situations in which the sentence is produced, and the situations that it describes. Barwise & Perry call this idea "the relation theory of meaning."

Situation semantics relocates meaning in the world (environment) instead of it being in human heads:

"Meanig's natural home is the world, for meaning arises out of the regular relations that hold among situations, among bits of reality. We believe linguistic meaning should be seen within [a] general picture of a world teeming with meaning, a world full of information for organisms appropriately attuned to that meaning" (Barwise & Perry, 1983).

In other words, they try to go beyond the dichotomy between natural and non-natural meaning - to deal with linguistic meaning as just an especially complex set of regularities of information flow. Instead of being in an abstract world of sense (Frege), meaning is located in the flow of information between situations. Linguistic meaning is a special manifestation of the relational nature of meaning.

Leyton's Information

Michael Leyton defines information as identical with shape, which is applied most easily to natural information:

"… we should note that there is a possibility that a third term information is equivalent to those other two. Certainly, in statistical information theory, the term information is defined as variety, and that makes the term similar to the term asymmetry which we are defining as distinguishability.

Algorithmic information theory can also be regarded as a measure of the variety in a set. Thus, the ingredient of the present, from which one is extracting the past, might therefore be considered to be information in the abstract sense of some information theory; e.g., statistical or algorithmic information theory.

Therefore, we might be able to regard the terms shape and information as identical terms. That is, we might be able to regard the mathematical study of shape as a general, and more thorough, information theory than has been attempted in the current approaches to the study of information measurement." (Leyton, Symmetry Causality Mind, 1992)

4.4.3 The Difference that makes a Difference: Syntactic vs. Semantic Information

"If you take care of the syntax, the semantics will take care of itself."

Haugeland, 1985

One of the widely appreciated general definitions of information is "the difference that makes the difference" (Bateson).

When it comes to making a difference, the most fundamental is the decision whether one regards a sensory input as identical with its background or as different, whether it is one object or several objects; whether a set of objects is regarded as a collection of separate individual things (here, one recognizes the differences between objects in the collection) or as a group which share properties (here, one recognizes the similarities between objects in the collection). So the two elementary processes are differentiation and integration.

A system might be described by its "state" - and one might describe that state and call the description "data." In any system of states "information" is then the difference between any two states. A collection of such differences therefore allows us to consider "patterns of information." Neither "state," "information" nor "patterns" in these definitions require any complexity in their interpretation; a mechanical interpretation is sufficient. "Recognition" (as opposed to "comparison") involves complex transformations in organisms.

"Where Shannon defined his information concept as a technical aspect of human communication, Norbert Wiener and Schrödinger brought information out in nature through thermodynamics, and from there into animals and machines, Gregory Bateson developed it to a mind ecology where cybernetic mind is based on this natural idea of information uniting nature and human mind in an evolutionary cybernetic world view; where information is 'a difference that makes a difference'." (e-mail from Søren Brier)

Within the syntactic-semantic distinction, theories of information can be grouped as:

1. *Syntactic* information theories (Chaitin-Kolmogorov, Shannon-Weaver, Wiener, Fisher) which are quantitative, mathematical, "objective". The semantics is tacit, and syntax is explicated.

2. *Semantic* information theories (Bar-Hilel, Barwise and Perry, Dretske, Devlin) are interested in interpreted information, whose syntax is tacit, and semantics is explicated.

The dichotomy between semantic and syntax corresponds basically to form/content dichotomy.

Semantic information on the individual level is subjective. For the semantic information to become "objective" it must be inter-subjectively negotiated through communication. Of course different communities of people exchanging the same information may have a different use for it. The same phenomenon may have different meanings not only for different individuals, but also for different groups. “Information” is a typical example of such a phenomenon.

An interesting feature of the concept of information is precisely that it describes an entity which can be found in many domains of human inquiry, and in a sense bridges the gaps between the fields. It is not surprising, if we adopt a pragmatic view of meaning as use, that different scientific and scholarly fields with their different practices have varying views of information. However, there is a core of common intuitions that relates all of these, as in Wittgenstein’s family resemblance.

4.5 Correspondence Models vs. Interactive Representation

"Information is not a disembodied abstract entity; it is always tied to a physical representation. It is represented by engraving on a stone tablet, a spin, a charge, a hole in a punched card, a mark on paper, or some other equivalent. This ties the handling of information to all the possibilities and restrictions of our real physical world, its laws of physics, and its storehouse of available parts." (Landauer 1996)

In the tradition of Western thought, since the ancient Greeks, information was understood in conjunction with representation. In correspondence theory mind is identical with consciousness that is carrying out passive input processing.

Figure 4: Informational correspondence model.

Figure 4 represents a symbolic process of information transmission via several steps of physical transformations. The step 3 symbolizes information in the brain. It should be noted that this "correspondence scheme" does not need to imply any special kind of transformation, or any type of encoding the information, so the step 3 may stand for an emergent result of a dynamic process in the brain. The transformations are usually supposed to be causally related.

There are several versions of the correspondence (encoding-decoding) models of representation, such as isomorphic correspondence, as in the physical symbol system hypothesis (Newell, Vera & Simon); trained correspondences, as in connectionist models (Rumelhart, McClelland); causal/nomological (general physical/logical) relationships (Fodor) and representation as function (Godfrey-Smith, Millikan).

In the traditional view, the information is caused by some external past event. The problem in this model is to explain what exactly produced the representation in the animal or machine.

"Some state or event in a brain or machine that is in informational correspondence with something in the world must in addition have content about what that correspondence is with in order to function as a representation for that system -- in order to be a representation for that system. Any such correspondence, for example with this desk, will also be in correspondence (informational, and causal) with the activities the retina, with the light processes, with the quantum processes in the surface of the desk, with the desk last week, with the manufacture of the desk, with the pumping of the oil out of which the desk was manufactured, with the growth and decay of the plants that yielded the oil, with the fusion processes in the sun that stimulated that growth, and so on all the way to the beginning of time, not to mention all the unbounded branches of such informational correspondences. Which one of these relationships is supposed to be the representational one? There are attempts to answer this question too (e.g., Smith, 1987), but, again, none that work (Bickhard & Terveen, 1995)." (Bickhard, 2004)

This passage from Bickhard indicates the importance of intentionality in forming representations. Informational content of the world is infinite, and each object is a part of that all-encompassing network of causation and physical interaction. The only way one can explain the fact that the agent extracts (registers) some specific information from the world is the fact that it acts in the world, pursuing different goals, the most basic one being that of survival, and in that way an agent actively chooses particular information of interest.

As the alternative to the correspondence model of representation, pragmatic theory has developed during the last century (Joas, Rosenthal, Bickhard). Pragmatism suggests that interaction is the most appropriate framework for understanding mind, including representation.

There are several important differences between the interactive model of representation and standard correspondence approaches. Interactive explanation is future oriented; based on the fact that the agent is concerned with anticipated future potentialities of interaction. So the actions are oriented internally to the system, which optimizes their internal outcome, while the environment in the interactive case represents primarily resources for the agent.

Correspondence with the environment is basic to interactive systems also. Connectionist models in particular are very attractive, but they are not sufficient for the complete account of representation, see http://www.lehigh.edu/~interact/isi2001/isi2001.html.

In sum, representation emerges in the anticipatory interactive processes in (natural or artificial) agents, pursuing their goals while communicating with the environment.

Goertzel's (1994) hypothesis is that every mind is a superposition of two structures: a structurally associative memory (also called "heterarchical network") and a multilevel control hierarchy ("perceptual-motor hierarchical network") of processes. In our dual-aspect framework, the structure designated memory corresponds to information structure, while control hierarchy corresponds to computational process network. Goertzel's hypothesis supports the interactivist view of representation.

"The "complex function" involved in the definition of intelligence may be anything from finding a mate to getting something to eat to building a transistor or browsing through a library. When executing any of these tasks, a person has a certain goal, and wants to know what set of actions to take in order to achieve it. There are many different possible sets of actions -- each one, call it X, has a certain effectiveness in achieving the goal.

This effectiveness depends on the environment E, thus yielding an "effectiveness function" f(X,E). Given an environment E, the person wants to find X that maximizes f – that is, is maximally effective in achieving the goal. But in reality, one is never given complete information about the environment E, either at present or in the future (or in the past, for that matter). So there are two interrelated problems: one must estimate E, and then find the optimal X based on this estimate." Goertzel's (1994)

In the contemporary fields of artificial intelligence, cognition, cognitive robotics, consciousness, language and interface design, interactive models are becoming more and more prominent. This is in parallel with the new interactive computing paradigm (Wegner, Goldin), and new approaches to logic (dialogic logic, game-theoretic approaches to logic), see Paper B.

Chapter 5. Computation as Information Processing

“Insistence on clarity at all costs is based on sheer superstition as to the mode in which human intelligence functions. Our reasoning grasps at straws for premises and floats on gossamers for deductions."

(Whitehead, 1967)

After having introduced Computation and Information as traditionally separate fields in previous chapters, it is time to apply the dual-aspect unified framework already outlined.

5.1. Open Problems Revisited

Let us try to make a synthesis, beginning by returning to Floridi’s (2004) Open Problems in the Philosophy of Information list. We will recall certain novel concepts and suggested possible answers to some of the questions which have arisen in preceding chapters.

I) **Information definition**

1. *What is Information*?

See Chapter 4. The concept of information is fluid, and changes its nature as it is used for special purposes in various fields. An intricate network of interrelated concepts has developed in accordance with its uses in different contexts. In Wittgenstein’s philosophy of language, this situation is described as family resemblance, applied to the situation in which some concepts within a concept family share some resemblances, while other concepts share other. Wittgenstein compares it to a rope which is not made of continuous strands, but many shorter strands bound together, no one running the entire length of the rope. There is no universal concept of information, but rather conepts held together like families or ropes. “*The view epitomised by Wittgenstein’s Philosophical Investigations is that meaning, grammar and even syntactic rules emerge from the collective practices (the situated, changing,* *meaningful use of language) of communities of users (Gooding, 2004b)."* (Addis, Visschera, Billinge and Gooding, 2005). On a more elementary level, as a part of dual-aspect theory of physical universe, one may see information as structure of the material world, while computation is its time-dependent evolution.

2. *What is the dynamics of information*?

If we adopt informationalism, with the entire existing physical universe having an informational structure, computation (in the sense of a natural computation) can be seen as the process governing the dynamics of information.

3. *Is a grand unified theory of information (GUTI) possible*?

Yes, in a dual - aspect theory in which the universe is considered to possess an informational physical structure; while computation is conceived of as information processing. Of course, this will not help to unify different uses of the term information in different applications, but on the fundamental level it provides an insight which gives a deeper understanding of the nature of physical phenomena.

II) **Information Semantics**

4. *The data grounding problem*: How can data acquire their meaning?

Within pragmatic tradition, meaning is the result of use. Data semantics (especially evident in computer science) is therefore defined by the use of the data.

5. *Truth problem*: How can meaningful data acquire their truth value?

Truth might be ascribed to meaningful data in the sense of "correct data", implying that the data are correctly obtained, transmitted and stored, that they have not been damaged in communication or storage or used inappropriately. Such correct data might be called "true data" but this is not the usual terminology in physical sciences and technology.

6. *Informational truth theory*: Can a theory of information explain truth?

Yes, even though truth is not the central issue in this theory. Within the naturalized epistemology framework, theory of information is more concerned with meaning in the first place. Being internalized by an agent, data becomes information for an agent, classified as interesting or irrelevant in the context of the agent's previous experiences, habits, preferences (all of it materialized in the agent's bodily (including brain) structures. Any sensory input in a living organism might be characterized as information, because it is automatically processed and structured, from data to information. This makes the relationship between information and meaning very natural.

Meaning is what governs an intelligent agent's behavior, within certain (for an agent) meaningful data sets, structured to information and further structured to knowledge. Truth is arrived at first in the interaction between several agents (inter-subjective consensus about knowledge). In the sense of Chaitin's truth islands (Paper A), some well-defined parts of reality can be organized and systematized in such a way that truth may be well-defined within those sets, via inter-agent communication.

7. *Informational semantic problem*: Can information theory explain meaning?

Yes. In Chapters 5.4 and 5.5 we placed information theory in an evolutionary context and claim that information is fundamental for intelligent agents. Its meaning is to optimize their behavior and increase their chances of survival, or otherwise optimize some other behavior that might be a preference of an agent. In this pragmatic framework, meaning in general is use, which is also the case with respect to meaning of information.

III) **Intelligence/Cognition**

8. *Descartes' problem*: Can cognition be fully analysed in terms of information processing at some level of abstraction?

Yes. See Naturalized epistemology, Chapter 5.5.

9. *Dennett's reengineering problem*: Can natural intelligence be fully analysed in terms of information processing at some level of abstraction?

Yes. Intelligence (the capacity to acquire and apply knowledge) is closely related to cognition (high level functions carried out by the human brain, including speech, vision, attention, memory, and executive functions such as problem-solving and self-monitoring). Naturalized epistemology presupposes that all mental activity arises as an emergent phenomenon resulting from brain-body ineraction with the environment.

10. *Turing's problem*: Can natural intelligence be fully and satisfactorily implemented non-biologically?

It really depends of what is meant by "natural intelligence" and "fully and satisfactorily". If we consider a fish as a naturally intelligent organism, which features of its natural intelligence shall we be able to reproduce (fully and satisfactorily)? The development of AI (IS) seems to suggest that we will quite soon be able to reproduce the intelligent behaviour of some simple living organisms.

11. *The MIB (mind-information-body) problem*: Can an informational approach solve the Mind-Body problem?

Yes. From a pancomputational/paninformational viewpoint, the body is a physical structure which corresponds to information, while the mind is a computational process that is dynamically re-configuring (re-structuring) that information, according to physical laws.

12. *The informational circle*: If information cannot be transcended but can only be checked against further information - if it is information all the way up and all the way down - what does this tell us about our knowledge of the world?

If we adopt Stonier's view that information is structured data, and that knowledge is structured information, while wisdom is structured knowledge, we may say that information is a building block in those more organized structures, but the *structure* is what makes the whole difference. The analogy may be found in the atomic or molecular structure of matter. Data would be the analogue of atoms, information of molecules, knowledge the analogue of living organisms and wisdom might be thought of as the eco-system. So if we want to understand the behaviour of a living organism, we must know those structural relationships, both upwards and downwards in the complexity hierarchy.

13. *The Information Continuum Conjecture*: Does knowledge encapsulate truth because it encapsulates semantic information? Should epistemology be based on a theory of information?

If information is meant as strongly semantic information, then the answer is obviously yes: the knowledge which encapsulates strongly semantic information, encapsulates truth.

Even in the case of "information in the wild" (e.g. biological information) it is good to base epistemology on a theory of information, so as to get phenomenologically informed, naturalized epistemology.

14. *The semantic view of science*: Is science reducible to information modelling?

Information modelling is at the very heart of every empirical science. Much, of course, depends on how we understand modelling. Theoretical physics, for example, uses the results of empirical models to build a further layer of theory (additional complexity) upon those already existing. New results and new knowledge might thus be obtained from existing theories, not only from empirical data. But then one may view all theoretical work as a kind of modelling, too. In that case the answer would be yes. At this stage we are however only in the beginning of automated discovery, automated knowledge minig, automated theorem proving, and similar techniques based on the idea that science is reducible to information modeling.

IV) **Informational Universe/Nature**

15. *Wiener's problem*: Is information an independent ontological category, different from the physical/material and the mental?

Information may be conceived of as the most fundamental physical structure. It is in permanent flow, in a process of transformation, as known from physics. In dual-aspect theory of information/computation there is no Cartesian divide between body and mind.

16. *The problem of localisation*: Could information be neither here (intelligence) nor there (natural world) but on the threshold, as a special relation or interface between the world and its intelligent inhabitants (constructionism)?

In the Naturalized epistemology framework, information is both here (intelligence) and there (world) and on the threshold, as information constitutes the basic structure. Its structural changes are the results of computational processes. We have a long way to go in learning how those computational processes are to be understood and simulated, but the first step is to establish the common conceptual framework.

17. *The* "It *from* Bit" *hypothesis*: Is the universe essentially made of informational stuff, with natural processes, including causation, as special cases of information dynamics?

Yes. The fundamental claim of this work is that the universe is essentially made of informational stuff, and computation, which might be seen as encompassing causation, is what governs information dynamics.

V) **Values/Ethics**

18. *Are computing ethics issues unique* or are they simply moral issues that happen to involve ICT? What kind of ethics is CE? What is the contribution of CE to the ethical discourse?

In the pragmatic outlook adopted in this work, agency is the central idea. For an agent to interact with the world requires the making of goal-oriented choices based on a certain value system. Some preferences are rudimentary, such as that the preferred next state is required to sustain the life of the agent. Some preferences might be ethical choices, which might not be simple and straightforward, and which might require deeper examination. This is the main motivation for the study of the ethics of intelligent agents – both humans and robots. Ethics is needed as a support for agents making rational decisions in their interaction with the world.

5.2 Information Processing Beyond the Turing Limit

Computerized information processing affects more and more of our civilization today – we are surrounded by computer systems connected in global networks of multitasking, often mobile, interacting devices.

The classical mathematical theory of computation is based on the theory of algorithms. Ideal, classical theoretical computers are mathematical objects and they are equivalent to algorithms, or abstract automata (Turing machines), or effective procedures, or recursive functions, or formal languages.

Present day's syntactic mechanical symbol manipulation is to be replaced by information processing, with both syntactical and semantical aspects being expressed in the computing. Knowledge management is more effectively implemented based on information management than on data management, which is the current practice. (Paper B)

Compared with new computing paradigms, Turing machines form the proper subset of the set of information processing devices, in much the same way that Newton's theory of gravitation is a special case of Einstein's theory, or Euclidean geometry is a limit case of non-Euclidean geometries.

According to Burgin (2005), information processing is performed on several levels. The following operations are carried out on the basic level:

- Preserving information (protecting information from change – identity operation)

- Changing information or its representation

- Changing the location of information in the physical world (this can actually be categorized as changing the representation, and is therefore a subset of the previous set).

Both computation and communication imply the transformation and preservation of information. Bohan Broderick (2004) compares notions of communication and computation and arrives at the conclusion that computation and communication are often not conceptually distinguishable. He shows how computation and communication may be distinguished if computation is limited to a process within a system and communication is an interaction between a system and its environment.

An interesting problem of distinction arises when the computer is conceived as an open system in communication with the environment, the boundary of which is dynamic, as in biological computing.

Burgin identifies three distinct components of information processing systems: hardware (physical devices), software (programs that regulate its functioning), and infoware which represents information processed by the system. Infoware is a shell built around the software-hardware core which is the traditional domain of automata and algorithm theory. Semantic Web is an example of inforware.

For implementations of computationalism, interactive computing is the most appropriate model, as it naturally suits the purpose of modeling a network of mutually communicating processes. (See Paper B)

5.3 Interactive Naturalism and Process

Interactivism (Birkhard, Stojanov, Kulakov) is a philosophical approach especially suited to the analysis of agency. On the ontological level, it involves naturalism, which means that the physical world (matter) and mind are integrated, with no Cartesian divide. It is closely related to process metaphysics (Whitehead, 1978), in which the fundamental nature of the universe is understood as organization of processes.

The interactivist theory has been applied to a range of mental and social phenomena, including perception, consciousness, learning, language, memory, emotions, development, personality, rationality, biological functionality, and evolution. The approach is inspired, among others, by Piaget's interactionism and constructivism, but it differs from Piaget because it gives a central role to variational construction and selection.

The interactive model is pragmatist in its process and action approach, in its critique of correspondence or “spectator” models of cognition, and in its focus on the consequences of interaction. Peirce’s model of representation, for example, although pragmatist, is not agent-centered; and it more resembles external representation than (agent-centered) cognitive representation. The interactive model of representation is more like Peirce’s model of meaning. The essential difference between the interactivist concept of perception and Peirce’s concept is the emphasis in the former on the process (interactive) nature of perception (data) and information (representation).

5.3.1 Phenomenal Consciousness, Naturalism and Pancomputationalism/Paninformationalism

"Dynamics lead to statics, statics leads to dynamics, and the simultaneous analysis of the two provides the beginning of an understanding of that mysterious process called mind."

Goertzel, Chaotic Logic

Contemporary philosophy of mind is for the most part inspired by the naturalist intuition that the mind is an integral part of the natural universe. The majority of contemporary philosophers presume a physicalist concept of mind, according to which mental phenomena derive from neurophysiologic phenomena. Many cognitive scientists, in attempting to naturalize the concept of mind, rely on computational/informational metaphors and tools.

One of the central debates in cognitive science is about the extent to which our understanding of brain processes can be used for understanding mental processes as well. On one side are the *dualist* views of Chomsky and Fodor, who think that there is no point in using our knowledge about the brain to understand the mind. On the other is the *monist* view of Churchlands, who claim that if we want to understand the mind, all we must have is a deep enough understanding of the brain.

Within the framework of dual-aspect informationalism/computationalism (info-computationalism) theory the matter may be viewed as a structure (information), in a permanent process of flow (computation). Mind is the process, which is computational, both in its discrete and in its analog view.

The consequence for artificial systems is obvious – there is no impossibility, in principle of constructing artificial mind. To do so is a matter of learning how natural computation behaves, and learning to simulate/emulate those processes.

5.4 Naturalizing Epistemology

"For pragmatists, there are no special cognitive or epistemological values. There are just values. Reasoning, inquiry and cognition are viewed as tools that we use in an effort to achieve what we value. And like any other tools, they are to be assessed by

determining how good a job they do at achieving what we value. So on the pragmatist view, the good cognitive strategies for a person to use are those that are likely to lead to the states of affairs that he or she finds intrinsically valuable. This is, of course, a thoroughly relativistic account of good reasoning. For if two people have significantly different intrinsic values, then it may well turn out that a strategy of reasoning that is good for one may be quite poor for the other." Stich S. (1993)

Naturalized epistemology in general is an idea that epistemology may be based on natural (empirical) science. It may take different directions, depending on the problem to be solved, which might be:

- Definition and characterization of knowledge
- Belief formation and revision
- Argument against a skeptic.

We will situate this discussion within the first kind of naturalized epistemology projects, as our specific interest is in how the chain reaction from data to information and knowledge develops on a phenomenological level in a cognitive agent (a biological organism or an artificial agent) in its interaction with the environment.

One can say that living organisms are "about" the environment, they have developed adaptive strategies to survive by internalizing environmental constraints. The interaction between an organism and its environment is realized through the exchange of physical signals that might be seen as data, or when structured, as information.

A very interesting idea presented by Maturana and Varela (1980) is that even the simplest organisms possess cognition and that their meaning-production apparatus is contained in their metabolism. Of course, there are also non-metabolic interactions with the environment, such as locomotion, that also generate meaning.

The question is: how does information acquire meaning naturally in the process of interaction of an organism with its environment? The prerequisite for naturalizing of epistemology is to understand evolution and its impact on the cognitive, linguistic and social structures of living beings (Bates, 2005)

Various animals are equipped with different physical hardware (bodies), different sets of sensory apparatuses (compare an amoeba with a mammal), and very diverse goals and behaviors. For different animals the meaning of the same physical reality is different in terms of causes and effects.

Thus the problematic aspect of any correspondence theory (including spectator models of representation) is the difficulty of deciding whose reality is to be considered "the true one". If the same cat is "a lovely pet" and "a bloodthirsty monster"; what does the information representing a cat actually convey, if it is considered as "objective"?

Artificial agents may be treated in analogy with animals in terms of different degrees of complexity; they may range from software agents with no sensory inputs at all, to cognitive robots with varying degrees of sophistication of sensors and varying bodily architecture.

An agent perceives inputs from the physical environment (data) and interprets these in terms of its own earlier experiences, comparing them with stored data in a feedback loop. Through that interaction between the environmental data and the inner structure of an agent, a dynamical state is obtained in which the agent has established the representation of the state of affairs. The next step in the loop is to compare the present state with one's own goals and preferences (saved in an associative memory). This process is related with the anticipation of what various actions from the given state might have for consequences. Normally this takes time, but there are obvious exceptions. In cases when the agent is in great danger, those situations are usually hard-coded and connected via a short-cut to activate a immediate, automatic, unconscious reaction. For a living organism, the efficiency of the computation process is decisive for the survival.

"Over the billions of years of life on this planet, it has been evolutionarily advantageous for living organisms to be able to discern distinctions and patterns in their environment and then interact knowingly with that environment, based on the patterns perceived and formed. In the process of natural selection, those animals survive that are able to feed and reproduce successfully to the next generation. Being able to sense prey or predators and to develop strategies that protect one and promote the life success of one's offspring, these capabilities rest on a variety of forms of pattern detection, creation and storage. Consequently, organisms, particularly the higher animals, develop large brains and the skills to discern, cognitively process and operationally exploit information in the daily stream of matter and energy in which they find themselves … In the broadest sense then, brains are buffers against environmental variability." (Bates, 2005)

One question which may be asked is: Why does organism not react directly to the data as it is received from the world/environment? Why is information used as building blocks, and why is knowledge constructed? In principle, one could imagine a reactive agent that responds directly to input data without building an elaborate structure out of raw input.

The reason may be found in the computational efficiency of the computation concerned. Storage of data that are constant or are often repeated saves enormous amounts of time. So if instead of dealing with each individual pixel in a picture, we can make use of symbols or patterns that can be identified with similar memorized symbols or patterns, the picture can be handled much faster.

Studies of vision show that cognition focuses on that part of the scene which is variable and dynamic, and uses memorized data for the rest which is static (frame problem of AI). Based on the same mechanism, we use ideas already existing to recognize, classify and characterize phenomena (objects). Our cognition is thus an emergent phenomenon, resulting from both memorized (static) and observed (dynamic) streams. Considering chunks of structured data as building blocks, instead of performing time-consuming computations on those data sets in real time is an enormously powerful speed-up mechanism. With each higher level of organization, the computing capacity of an organism's cognitive apparatus is further increased. The efficiency of meta-levels is becoming explicitly evident in computational implementations.

Cognition as the multilevel control network in Goertzel's model is "pyramidal" in the sense that each process is connected to more processes below it in the hierarchy than above it in the hierarchy. In order to achieve rapid reaction, not every input that comes into the lower levels can be passed along to the higher levels. Only the most important inputs are passed.

Goertzel illustrates this multilevel control structure by means of the three-level "pyramidal" vision processing parallel computer developed by Levitan and his colleagues at the University of Massachusetts. The bottom level deals with sensory data and with low-level processing such as segmentation into components. The intermediate level handles grouping, shape detection, and so forth; and the top level processes this information "symbolically", constructing an overall interpretation of the scene. This three-level perceptual hierarchy appears to be an extremely effective approach to computer vision.

"That orders are passed down the perceptual hierarchy was one of the biggest insights of the Gestalt psychologists. Their experiments (Kohler, 1975) showed that we look for certain configurations in our visual input. We look for those objects that we expect to see and we look for those shapes that we are used to seeing. If a level 5 process corresponds to an expected object, then it will tell its children [processes] to look for the parts corresponding to that object, and its children [processes] will tell their children [processes] to look for the complex geometrical forms making up the parts to which they refer, et cetera." (Goertzel, 1994)

In his book What Computers Can't Do (1978), Hubert Dreyfus points out, that human intelligence is indivisible from the sense of presence in a body (see also Stuart, 2006). When we reason, we relate different ideas in a way that resembles the interrelations of parts of our body and the relation of our body with various external objects.

So, in conclusion, let me sum up the proposed view of naturalized epistemology, based on the following insights:

- All cognizing beings are in constant interaction with their environment. They are open complex systems in a regime on the edge of chaos, which is characterized by maximal informational capacity (Flake, 1998). The central role of interaction is succinctly expressed in this quote by Goerzel:

"Today, more and more biologists are waking up to the sensitive environment-dependence of fitness, to the fact that the properties which make an organism fit may not even be present in the organism, but may be emergent between the organism and its environment."

- The essential feature of cognizing living organisms is their ability to manage complexity, and to handle the environmental convolution with a variety of responses which are results of adaptation, variation, selection, learning, and/or reasoning.

- It is not unexpected that present day interest in living systems places information in focus, as information and its processing are essential structural and dynamic elements which distinguish living organisms alive from the corresponding amount of dead matter.

- As a result of evolution, living organisms arise that are able to survive and adapt to their environment. It means they are able to register inputs (data) from the environment, to structure those into information, and in more developed organisms into knowledge and eventually, possibly into wisdom. The evolutionary advantage of using structured, component-based approaches is improving response-time and efficiency.

- The Dual network model, suggested by Goertzel for modeling cognition in a living organism describes mind in terms of two superposed networks: a self-organizing associative memory network, and a perceptual-motor process hierarchy, with the multi-level logic of a flexible command structure.

- Naturalized epistemology acknowledges the body as our basic cognitive instrument. All cognition is embodied cognition, in both microorganisms and humans. Those important insights were neglected in early AI research, when a belief prevailed that intelligence is unrelated to the physical body.

- Naturalized epistemology, is based not only on rational reasoning but also on an intentional choices, dependent on preferences and value systems.

Chapter 6. Ethics and Values

IV

How much we have to take on trust every minute we live in order not to drop through the earth!

Take on trust the snow masses clinging to rocksides over the town.

Take on trust the unspoken promises, and the smile of agreement, trust that the telegram does not concern us, and that the sudden axe blow from inside is not coming.

Trust the axles we ride on down the thruway among the swarm of steel bees magnified three hundred times.

But none of that stuff is really worth the trust we have.

The five string instruments say that we can take something else on trust, and they walk with us a bit on the road.

As when the light bulb goes out on the stair, and the hand follows-trusting it-the blind banister rail that finds its way in the dark

Tomas Tranströmer, 1997[4]

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[4] I would like to thank Staffan Bergsten for mentioning the poem to me during one of our philosophy club meetings when discussing questions of trust. More about the poem may be found in a chapter of the book: Den trösterika gåtan. Tio essäer om Tomas Tranströmers lyrik, 1989, Staffan Bergsten.

Dodig-Crnkovic G., *Disintegrating Josephine K*, oil on canvas

"Someone must have told on Joseph K., for without having done anything wrong he was arrested one fine morning." (Kafka, The Trial)

6.1 Ethics, Epistemology and Ontology

Strawson (1959) makes a distinction between descriptive metaphysics and revisionary metaphysics, in the following way:

“Descriptive metaphysics is content to describe the actual structure of our thought about the world; revisionary metaphysics is concerned to produce better structure.”

Based on Strawson’s distinction, Debrock (2003) extends the terms “descriptive” and “revisionary“ to philosophy in general, arguing that the distinctions regarding what there is (ontology) are to be extended to the question of how do we know that (epistemology), and also how should we act (ethics).

In the revisionary framework intentionality is the central point of departure, while it is assumed that the descriptive framework is somehow independent on who chooses, when and why, to “describe” the universe “as it is”.

As mentioned in the chapter on computation, Brian Cantwell Smith in his book On the Origin of Objects makes intentionality one of the three fundamental subject matters; the other two being metaphysics and ontology.

Assigning intentionality such a prominent role in characterizing the continuous process of our interaction with the world means implicitly acknowledging the importance of us having freedom of choice – both in our understanding of the world (epistemology) and in our acting in the world. Given the fact that all alternatives are not completely equivalent, questions of values and priorities arise which imply ethical judgment.

Revisionary philosophy having the ambition to produce better structures is intimately related to questions of priorities and decisions that in turn presuppose ethics.

The research has been carried out systematically and rigorously, which makes the observations and analyses presented in the thesis reliable. The main limitations of the general validity of the results are the relatively few number of cases that have been studied and the bias towards Swedish and western organizations and cultures; this bias can be discerned in the selection of cases studied as well as in the (partly unconscious) mindset of the author. It should also be remembered that at the beginning of this research the focus was on process aspects and software architecture; other approaches and viewpoints would likely give different types of answers.

The last research phase – aiming at validating and quantifying the results gathered so far – could easily be continued, as the data collection instrument and analysis guidelines have been designed and tested (in the form of the questionnaire and the analysis already performed and documented). With a larger number of cases, preferably involving more application domains, more national cultures – and more cases from the domains and cultures already represented – the results will be further confirmed. I also welcome studies of this topic from other viewpoints, such as those of organizational and decision-making psychology experts and those of other cultures.

At a more detailed level, there are a number of loose threads I consider would be challenging and interesting to pursue further. First, the observations made so far concerning the elicitation and documentation of the requirements of a future system are in my opinion very interesting, and worth further study as a separate topic. Second, the architectural patterns and styles of systems could be an additional indicator that the systems are sufficiently similar for the *Merge* strategy to be practically possible. Third, the merge method and tool need to be evaluated for usefulness in realistic cases. Also, during their further development viewpoints or languages other than the simple module viewpoint currently implemented should be considered; in particular, by keeping a use-case view synchronized with other, more technical views, the architects could more easily communicate the impact of various alternative designs to the users.

6.2 Technology and Culture: A New Renaissance

"The futures are out there in the setting of a coastline before someone goes out there to discover it. (...) The futures have yet to be built by us. We do have choices." (Cooley 1999 as cited in Gill 2002)

The industrial-technological era was characterized by the ideal of the perfect machine and "objective knowledge" reduced to an algorithm for constructing a "theory of everything" (Hilbert's program), with strict division of labour within different fields of endeavour. Each of the sciences was searching for its own specific and certain truths.

The post-industrial age has, however, abandoned the rigid mechanical model of a monolithic, deterministically controlled system based on "the one right way" and the one absolute truth. On the contrary: it has embraced the fact that social cohesion through pluralism and polycentrism, cultural diversity, self-organisation and contextual truth is more productive and appropriate for the new epoch. Flexibility and fluidity have replaced rigidity and conformance, dynamics have replaced statics. The effort to determine the eternal unchangeables is superseded by the endeavour to capture dynamic balances and emergent phenomena.

In the Information-communication era there is a trend toward a human-centrism with the potential for a new Renaissance, in which science and the humanities, arts and engineering can reach a new synthesis, through modern computing and communication tools used in global virtual societies (Dodig-Crnkovic 2003). This meeting of cultures is largely occurring in cyber space, making issues of cyber ethics increasingly important.

6.3 Ethics of Computing and Information

Information and communication technology, ICT, is value-laden, as is technology in general, and is changing our ways of conceptualizing and handling reality, (Bynum and Rogerson, 2003, Spinello, 2003). It is not always easy to recognize intrinsic values incorporated in an advanced technology. Specialized technical knowledge is often needed for an understanding of the intrinsic functionality of a technology, for example, how information is processed in a computer network.

The need for a specific branch of ethics for computer and information systems, as compared with a straightforward application of a general ethical theory to the field of computing is discussed by (Bynum, 2000, Floridi and Sanders, 2002 and Johnson, 2003). Tavani (2002) gives an overview of this so called uniqueness debate. While the philosophical discussion about its nature continues, computer ethics/cyber ethics is growing in practical importance and is establishing itself as a consequence of the pressing need for the resolution of a number of acute ethical problems connected with ICT.

The changing capabilities and practices appearing with ICT both yield new values and require the reconsideration of those established. New moral dilemmas may also appear because of the clash between conflicting principles when brought together unexpectedly in a new context. Privacy, for example, is now recognized as requiring more attention than it has previously received in ethics, (Moor, 1997). This is due to reconceptualization of the private and public spheres brought about by the use of ICT, which has resulted in the recognition of inadequacies in existing moral theory about privacy. In general, computer ethics can provide guidance in the further development and modification of ethics when the existing is found to be inadequate in the light of new demands generated by new practices, (Brey, 2000).

For Moor (1985), computer ethics is primarily about solving moral problems that arise because there is a lack of policy (policy vacuum) about how computer technology should be used. In such a case, the situation that generates the moral problem must first be identified, conceptually clarified and understood. On the other hand, Brey claims that a large part of work in computer ethics is about revealing the moral significance of existing practices that seem to be morally neutral. ICT has implicit moral properties that remain unnoticed because the technology and its relation to the context of its use are not sufficiently understood. Disclosive computer ethics has been developed in order to demonstrate the values and norms embedded in computer systems and practices. It aims at making computer technology and its uses transparent, revealing its morally relevant features.

6.4 Two Studies in the Ethics of Computing

Privacy and surveillance are topics of growing importance, spurred by today's rapid technical development which has a considerable impact on privacy. The aim of this investigation is to analyse the relation between privacy and surveillance, considering the existing techniques, laws and ethical theories and practices.

A brief analysis of the phenomenon of privacy protection and its importance for democracy is given in (Moor, 2004), beginning with Moor's justification of privacy as the expression of a core value of security. The question arises consequently, especially actualized by the global phenomenon of terrorism: How should situations be addressed in which privacy and security are complementary? There are namely situations in which more privacy for some people means less security for others. Ethical, political and legislative debate has intensified after September 11th, and bomb attacks in Madrid and London.

In Warren and Brandeis' argument, privacy stems from a representation of selfhood which they call "the principle of inviolate personality" and personal self possession. Charles Fried claims that human feelings such as respect, love and trust are unimaginable without privacy, meaning that intimacy and privacy are essential factors in relationships. Privacy is not merely a means to achieve further ends; it is also seen as being of an intrinsic value in human life.

The psychiatrist Thomas Szasz claims that each person has the right to bodily and mental self-ownership and the right to be free from violence from others. Szasz believes that for example, sexual relations and the medicine records, should be private and outside state jurisdiction.

According to Rosen (2000), privacy has political, social and personal values and costs. The political value involves the fact that thanks to privacy, it is possible for citizens, who might disagree on a subject, to communicate with each other without needing to reveal the details of their identity. Privacy reaches beyond individual benefit by being a value which contributes to the broader good, becoming an essential element of democracy (Grodzinsky and Tavani, 2004). In intruding on privacy, which is closely related to freedom, surveillance can be considered to have, ultimately, a negative effect on democracy.

Privacy at the workplace is an interesting issue. The workplace is an official place par excellence. With modern technique it is easy to identify and keep under surveillance individuals at the workplace where using a range of devices from security-cameras to programs for monitoring computer usage may bring about a nearly total control of the employees and their work.

How much privacy can we reasonably expect at our workplaces? Can electronic methods of monitoring and surveillance be ethically justified? A critical analysis of the idea of privacy protection versus surveillance or monitoring of employees is presented in the following.

One central aspect of the problem is the trend toward the disappearance of boundaries between private and professional life. Users can work at their laptop computers anywhere today. People send business e-mails from their homes, even while travelling or on vacations. How can a strict boundary be drawn between private and official information in a future world pervaded with ubiquitous computers?

An important fact is that not everybody is aware of the existence of surveillance, and even fewer people are familiar with privacy-protection methods. Such awareness and familiarity demands knowledge as well as engagement and is also a question of democratic right to information in the society.

6.5 Privacy, Integrity and Surveillance

6.5.1 The Question of Values and Ethics for E-Polis

Viewing the human as not only a component of an automated process but as an end in itself leads unavoidably to the question of choices, values and ethics. We are not only given the world we inhabit as a fact, we are inevitably changing it, for better or worse.

One expression of a nascent human-centrism is the emergence of e-government which changes the citizen-government relation, making the political system transparent and more accessible to the citizen in the participatory democracy. It is therefore argued that a rethinking of the idea of development in the contemporary globally-networked civilization is necessary (Gill, 2002). Networking at the global level must be seen in a symbiosis with local resources. Social cohesion in this context results from the ability to participate in the networked society through mutual interaction, exchange of knowledge and sharing of values. The problem of promoting e-government in developing countries via virtual communities' knowledge-management is addressed by Wagner, Cheung, Lee, and Ip (2003).

The worldwide expansion of digital government services makes questions of digital privacy increasingly important. The historical organization of classical government, with separate departments with their own personal data banks has inherently provided some privacy protection through practical anonymity, data matching being expensive in a distributed environment, (Hansen, Pfitzmann, 2004). The advent of IC technology has made data matching technically extremely easy. Moreover, a huge amount of data is collected by non-governmental organizations in business and the like, making commercial Little Brother, in addition to governmental Big Brother (McCrone, 1995) a potential threat to privacy, further complicating the situation. As Etzioni (1999) points out "Although our civic culture, public policies, and legal doctrines are attentive to privacy when it is violated by state, when privacy is threatened by the private sector, our culture, policies, and doctrines provide a surprisingly weak defence".

As a remedy Hes and Borking (2000) present privacy-enhancing technologies protecting anonymity. Hansen and Pfitzmann (2004) give a terminological analysis of identity management including anonymity, unobservability and pseudonymity.

Data protection law, in spite of its central importance, cannot cover the entire digital privacy field. It focuses mostly on larger databases and their use (Wayner, 2004) and disregards other privacy-related problems, notwithstanding the fact that many privacy-invasive technologies acquire digital records that should be subject to data protection. Examples of such potentially privacy-invasive technologies are different positioning devices, RFID and video surveillance, whose results may not be recorded, although they can still be a threat to privacy.

The ideals of democratic government must be respected and even further developed in the future e-government. Ethical questions and privacy of communications require careful analysis, as they have far-reaching consequences affecting the basic principles of e-democracy.

We are already witnessing the emergence of an e-polis which is finding its specific ways of expression of the concept of the social good. “Policy vacuums” (Moor 1985) of a new kind of socio-technological system are being investigated, and new policies and strategies formulated.

6.5.2 Ethics and Privacy of Communications in the Globally Networked Societies

The electronic networking of physical space promises wide-ranging advances in science, medicine, delivery of services, environmental monitoring and remediation, industrial production, and the monitoring of persons and machines. It can also lead to new forms of social interaction [..]. However, without appropriate architecture and regulatory controls it can also subvert democratic values. Information technology is not in fact neutral in its values; we must be intentional about design for democracy. (Pottie, 2004)

Information and communication technology, ICT, has led to the emergence of global web societies. The subject of this article is privacy and its protection in the process of urbanization and socialization of the global digital web society referred to as the e-polis. Privacy is a fundamental human right recognized in all major international agreements regarding human rights such as Article 12 of the Universal Declaration of Human Rights (United Nations, 1948), and it will be discussed in the chapter under the heading Different Views of Privacy.

Today’s computer network technologies are sociologically founded on hunter-gatherer principles. As a result, common users may be possible subjects of surveillance and sophisticated Internet-based attacks. A user may be completely unaware of such privacy breaches taking place. At the same time, ICT offers the technical possibilities of embedded privacy protection obtained by making technology trustworthy and legitimate by design. This means incorporating options for socially acceptable behavior in technical systems, and making privacy protection rights and responsibilities transparent to the user.

6.6 Grounding Privacy in Human Dignity and Personal Integrity

"… a change in our ontological perspective, brought about by digital ICTs, suggests considering each person as being constituted by his or her information and hence regarding a breach of one's informational privacy as a form of aggression towards one's personal identity." Floridi (2005)

In his article The Ontological Interpretation of Informational Privacy, Floridi makes a strong point about the central role of information for defining our personal identity. Privacy invasion may be seen as a process in which an individual's integrity is threatened. In the context of cultural embeddedness of the idea of privacy, one can add that in Swedish, "privacy" is translated as "personal integrity" that actually much more suggests the core value that is to be protected. When rethinking and globalizing "privacy" greater emphasis should perhaps be put on what it basically is – the integrity of ones person, or ones identity.

There was an interesting discussion about the concept of privacy and its understanding in different cultures at a workshop "Privacy and Surveillance Technology - Intercultural and Interdisciplinary Perspectives", (http://viadrina.euv-frankfurt-o.de/~mibpriv/workshop), at Zentrum für interdisziplinäre Forschung, ZiF, University of Bielfeld, Germany (February 2006). Muslim countries seem to traditionally attach the privacy right to families (hence protect family affairs both physically – by typical walls surrounding private houses and also via habits in social communication). Unlike the West, where the individual is the basis of the entire legislative and social structure, in many cultures of the East the right to integrity is acknowledged in the first place to different groups, from which an individual inherits an identity. All over the world it seems to be self-evident that business groups have the right to integrity and it is usually both accepted and common for businesses to decide freely upon their own identity, image, strategies etc. Other groups, like states, are also given the right to self determination, and guaranteed the right to integrity by international law. Cultural differences appear in the first place when it comes to personal integrity of an individual citizen. The question is essential for Western type of democracy – the whole democratic governance is based on the assumption that the society consists of free individuals with ability to express practically freedom of choice. A dystopic vision of George Orwell's 1984, or Franz Kafka's The Trial, as discussed in Daniel Solove's book The digital person: Technology and privacy in the information age, pictures societies in which individuals have lost their personal integrity either under the pressure of a selfish, exploiting ideologized social system, or even worse, in case of The Trial, of a system that is totally meaningless and non-transparent to an individual in which defendants wait hopelessly for information about their "cases".

"He does not know his judges, scarcely even his lawyers; he does not know what he is charged with, yet he knows that he is considered guilty; judgment is continually put off -- for a week, two weeks -- he takes advantage of these delays to improve his position in a thousand ways, but every precaution taken at random pushes him a little deeper into guilt. His external situation may appear brilliant, but the interminable trial invisibly wastes him away, and it happens sometimes, as in the novel, that men seize him, carry him off on the pretense that he has lost his case, and murder him in some vague area of the suburbs." (Jean-Paul Sartre, An Exploration of the Etiology of Hate)

A following quote from Kafka's Metamorphosis illustrates well the total absurdity and grotesque of a situation where "the identity" is imposed on the individual from the outside, the identity one can not identify himself/herself with:

"As Gregor Samsa awoke one morning from uneasy dreams he found himself transformed in his bed into a gigantic insect..."

In grounding the idea of privacy understood as personal integrity, one can start with the Kantian respect for the dignity of human beings. Central for Kant's ethical theory is the claim that human beings must be respected because they are *ends in themselves*. An end in itself has intrinsic value that is *absolute*. Humans have the unique characteristics which Kant calls "dignity", which is worth respect. In Kant's theory, dignity is the highest value and only persons have dignity. Our most fundamental moral duty is to respect people as ends in themselves. Dillon (2003) gives the following characterization of respect.

"Respect is a responsive relation, and ordinary discourse about respect identifies four key elements of the response: attention, deference, valuing, and appropriate conduct. First, as suggested by its derivation from the Latin respicere, which means "to look back at" or "to look again," respect is a

particular mode of apprehending the object: the person who respects something perceives it differently from one who does not and responds to it in light of that perception. (..) The idea of paying heed or giving proper attention to the object that is central to respect often means trying to see the object clearly, as it really is in its own right, and not simply seeing it through the filter of one's own interpretations, desires, fears, etc. Thus, respecting something contrasts with being unaware or indifferent to it, ignoring or quickly dismissing it, neglecting or disregarding it, or carelessly or intentionally misidentifying it. An object can be perceived by a subject from a variety of perspectives; for example, one might rightly regard another human individual as a rights-bearer, a judge, a superlative singer, a trustworthy person, or a threat to one's security. The respect one gives her/him in each case will be different, yet all will involve careful attention to her/him as she/he really is as a judge, threat, etc. It is in virtue of this aspect of careful attention that respect is sometimes thought of as an epistemic virtue."

6.6.1 Personal Integrity Matters!

Before the advent of ICT, communication between people was predominantly verbal and direct; (Moore, 1994, Agre and Rotenberg, 1997). Today we increasingly use computers to communicate. Mediated by a computer, information travels far and fast to a virtually unlimited number of recipients, and almost effortlessly (Weckert, 2001). This leads to new types of ethical problems including intrusion upon privacy and personal integrity. Privacy can be seen as a protection of two kinds of basic rights:

- *Right to ones own identity*. (This implies the right to control the use of personal information that is disclosed to others, as personal information defines who you are for the others. As a special case the freedom of anonymity can be mentioned. In certain situations we are ready to lend our personal data for statistical investigations, for research purposes and similar, under the condition that anonymity is guaranteed.)
- *The right to ones own space*. (This is generalized to mean not only physical space but also special artifacts that are exclusively associated with a certain individual, such as a private diary or private letters - or disk space.) The privacy of ones' home is a classic example of a private space which moreover is related to ones own identity. It is also an instructive archetype because it shows the nature of a private space as a social construction. You

are in general allowed to choose whom you wish to invite to your home. However, under special circumstances it is possible for police, for example, to enter your home without your consent, this being strictly regulated by law.

Historically, as a result of experiences within different cultures a system of practices and customs has developed that defines what is to be considered personal and what is public, see (Warren and Brandeis, 1890), (Thompson, 2001). A basic distinction in human relations is consequently that between the private (shared with a few others) and the common (shared with wider groups), (DeCew, 2002). Fried (Rosen, 2000) claims that only closely related persons can have true knowledge of an individual.

According to Mason (2000), privacy can be studied through the relationships of four social groups (parties). The first party is the individual himself/herself. The second party consists of those others to whom the first party provides specific personal information for the sake of creating or sustaining a personal relationship or in return for services. The third party consists of all of the other members of society who can get access to an individual's private information, but who have no professional relation to the individual and no authority to use the information. Finally, the fourth party is the general public who are in no direct contact with the individual's private space or information. During the interaction between parties, individuals invoke different levels of privacy. The advantages of close relationships are compared with the risks of the release of information and its inappropriate use which could result in a loss of personal space or harm to ones identity.

Journal Ethics and Information Technology, Volume 7, Number 3, September 2005 (Springer) was dedicated to Ethics of New Information Technology Papers from CEPE 2005 with guest editors P Brey, L Floridi and F Grodzinsky. It includes P Brey's paper on Freedom and Privacy in Ambient Intelligence which discusses the necessity of taking care of privacy issues related to developing ubiquitous computing (ambient intelligence), while Paul B. de Laat in Trusting Virtual Trust argues for the necessity of trust even when it comes to the communication of complete strangers via internet.

The subsequent issue of Ethics and Information Technology, Volume 7, Number 4, December 2005 was dedicated to Surveillance and Privacy with Philip Brey as guest editor. It gives the most recent state of the art cross section through contemporary information privacy and surveillance issues. Papers include Floridi's The Ontological Interpretation of Informational Privacy, in which Floridi sees individuals as essentially constituted by their information, which has for a consequence that breaches of informational privacy damage one's personal identity. Other papers in the same issue address vehicle safety communication technologies and wireless share information, under the rubric "privacy in public" (Zimmer). Data mining in personal and financial databases motivated by terrorism combat with clear privacy problems is analyzed by Birrer. Lockton and Rosenberg focus on RFID (Radio Frequency Identification) tags and their potential threat to privacy. An interesting question of responsibility, and if morality can be delegated to a machine is addressed by Adam. Grodzinsky and Tavani describe the Verizon vs. RIAA case – and discuss the question of balancing privacy rights with property rights. Finally an article by Wiegel, van den Hoven and Lokhorst offer a model of interactions between software agents sharing personal information, where information itself is modeled as an agent with a goal of preserving its own integrity and regulating its own spreading.

6.7 Privacy in a Global Perspective

By its nature, computer ethics is a worldwide phenomenon and cannot be addressed exclusively on an individual and local scale, (Johnson, 2003). For computer ethics with its specific contemporary questions, Floridi and Sanders (2003) advocate the method of ethical constructionism. The constructionist approach concentrates not only on the dilemmas faced by the individual but also addresses global computer ethics problems. Issues involved in e.g. the sharing and revealing of information about oneself introduce even more fundamental questions including the cultural and social context which must be considered when formulating policies.

The acquisition, storage, access to and usage of personal information is regulated and limited in most countries of the world by legislation. However, each part of the world has its own laws. In the US, separate laws apply to different kinds of records. Individual European countries have their own specific policies regarding what information can be collected, and the detailed conditions under which this is permissible. (For an international survey of privacy laws, including country-by-country reports, see Privacy and Human Rights 2004; see also Briefing Materials on the European Union Directive on Data Protection).

The current political situation in the world and the threat of terrorist attacks has led to governmental proposals in the European Union requiring Internet Service Providers to store personal information, for example data relating to Internet traffic, e-mails, the geographical positioning of cellular phones and similar, for a period of time longer than is required of them at present (ARTICLE 29 Data Protection Working Party).

Although relevant legislation is in effect locally, there are difficulties with respect to the global dissemination of information. To avoid conflicting situations, there is a need for international agreements and legislation governing the flow of data across national borders.

A special issue of the journal Ethics and Information Technology (2005, Volume: 7:1, Kluwer) edited by Charles Ess, is dedicated to Privacy and Data Privacy Protection in Asia. Editor Ess sets the stage by posing a question “Lost in Translation"?: Intercultural Dialogues on Privacy and Information Ethics. An interesting fact is that the concept of privacy comes together with Internet and other IC technology devices to Asia, and it takes time for a new concepts to root in the new context of an old Asian culture. Of course, the entirety of cultural context in Asia is different, and hence references must be established and the relationships woven into the fabric of Asian cultures. Such a process takes time, but communication requirements and financial interests drive this integration process energetically forward.

An interesting case of Privacy and Data Privacy Issues in Contemporary China is presented by Yao-Huai, Lü, while the corresponding Thai case is given by Kitiyadisai, Krisana, Privacy Rights and Protection: Foreign Values in Modern Thai Context.

Intercultural perspectives are opened from both the eastern and western sides in articles by Nakada, Makoto; Tamura, Takanori, Japanese Conceptions of Privacy: An Intercultural Perspective and Rafael Capurro, Privacy. An Intercultural Perspective. Summarizing the issue one can say that it also present the current state of affairs in a field which is characterized by vigorous development. Technical developments continue at an unprecedented pace, bringing about all kinds of social changes, including the opening up of networked individuals towards other social groups with different cultural standards.

6.8 Fair Information Practices

One of the fundamental requirements related to the expansion of community networks is the establishment of fair information practices that enable privacy protection. At present it is difficult to maintain privacy when communicating through computer networks, as these are continually divulging information. An example of a common concern is that many companies endeavor to obtain information about the behavior of potential consumers by saving cookies on their hard disks. Other possible threats against citizen's privacy include the unlawful storage of personal data, the storage of inaccurate personal data, the abuse or unauthorized disclosure of such data that are issues surrounding government-run identity databases. Especially interesting problems arise when biometrics is involved (for identity documents such as passports/visas, identity cards, driving licenses). Remote electronic voting is dependent on the existence of a voters' database, and there are strong privacy concerns if the same database is used for other purposes, and especially if it contains biometric identifiers.

Many countries have adopted national privacy or data protection laws. Such laws may apply both to data about individuals collected by the government and to personal data in the hands of private sector businesses. The OECD has defined fair information practices which include the following principles: Collection limitation, Data quality, Purpose specification, Use limitation, Security, Openness, Individual participation and Accountability (see OECD Guidelines on the Protection of Privacy).

Exceptions to these principles are possible in specific situations, such as law enforcement investigations, when it might not be appropriate to give a suspect access to the information gathered by the police. Nonetheless, the principles of fair information practices provide a framework for privacy protection. As in the advice of Bennet and Grant (1999): “apply the fair information principles, build privacy in, factor privacy into business practices, think privacy globally, and protest surveillance out”.

6.9 Protection of Personal Integrity in the Working Place.

The four basic **S**’s of computing technology (**S**earching, **S**orting, **S**torage and **S**imulation) make computers unprecedented tools of control. The ease with which data stored in a computer can be manipulated, “as if it were greased” (Moor, 2004) makes the use of monitoring, surveillance, and spyware methods extremely easy from the technical point of view. The consequences of the use of modern computation and communication tools in this connection are interesting both from the viewpoint of the individual employee (citizen) and from that of society.

Present-day surveillance tools include closed circuit television (CCTV), night vision systems, miniature transmitters, smart cards, electronic beepers and sensors, telephone taps, recorders, pen registers, computer usage monitoring, electronic mail monitoring, cellular radio interception, satellite interception, radio frequency identification (RFID), etc.

There are indications that the use of monitoring at workplaces has increased and is likely to continue to increase rapidly in coming years (Wakefield, 2004). The issues of concern leading to such surveillance are business information protection, the monitoring of productivity, security, legal compliance and liability, inter alia by means of e-mail-, spam-, pornography- and similar filters.

There is in fact, already legislation in effect in various countries permitting the monitoring of employees by their employers and one-third of the work force in the US working on-line is under surveillance [Hinde (2002)]. VIDEO is a report summarizing an investigation of video surveillance practices in a number of countries (certain European countries, USA, Australia and Canada) and their effects on privacy. Here are some of its conclusions.

"The evidence presented to the Inquiry suggests that video surveillance has the potential to have a far greater impact on the privacy of employees than is evident presently.

Covert surveillance involves an extremely serious breach of employee privacy. Evidence presented to the Inquiry indicates that there is an urgent need for measures to address the use of covert video surveillance in workplaces. Without any legislative protection, employees have no protection against secret and ongoing surveillance in the workplace. These measures are needed to address the inconsistency in current legislation, which prohibits the covert use of listening devices (refer Paragraph 5.1.2.2), but gives no protection from covert video surveillance. This inconsistency is best explained as the result of regulation being outpaced by technology."

Advocates of workplace monitoring claim that it nevertheless might be an acceptable method when justified by business interests (Wakefield, 2004). However, recent studies show that employees under surveillance feel depressed, tense and anxious when knowing that they are monitored (Uyen Vu, 2004), in comparison with those who are not under (or who are unaware of) surveillance (Rosen, 2000). Psychologists consider that it is obvious that an individual (who knows/suspects that he/she is) under surveillance behaves differently from another not monitored, the monitored person restricting his/her actions, aware that they are being observed by a suspicious third party. The climate of distrust is detrimental to the motivation, creativity and productivity of employees.

The report for the European Parliament, carried out by the parliament's technology assessment office, says the use of CCTV should be addressed by the MEP's Committee on Civil Liberties and Internal Affairs, because the technology facilitates mass and routine surveillance of large segments of the population. Automated face or vehicle recognition software allows CCTV images to be digitally matched to pictures in other databases, such as the photographic driver licenses now planned in Britain. The unregulated use of such a system would amount to an invasion of privacy, says the report, (MacKenzie, 1997)

6.10 Legislation

"Technology can go a long way toward protecting the privacy of individuals, but we also need a legal framework to ensure that technology isn't outlawed (Bernstein: http://www.eff.org/bernstein/.) We can't protect privacy through case law, and self-regulation hasn't worked." (Deborah Pierce)

Privacy is a fundamental human right recognized in all major international treaties and agreements on human rights, as stated in Article 12 of the Universal Declaration of Human Rights (United Nations, 1948), Article 12.

"No one shall be subjected to arbitrary interference with his privacy, family, home or correspondence, nor to attacks upon his honour and reputation. Everyone has the right to the protection of the law against such interference or attacks."

Article 17 of the UN's International Covenant on Civil and Political Rights (see ICCPR), uses essentially the same formulation as Article 12.

Nearly every country in the world recognizes privacy as a basic human right in their constitution, either explicitly or implicitly. Most recently drafted constitutions include specific rights to access and control one's personal information (Council of Europe Convention and Legislation Links). According to PRIVACY AND HUMAN RIGHTS report:

Interest in the right of privacy increased in the 1960s and 1970s with the advent of information technology (IT). The surveillance potential of powerful computer systems prompted demands for specific rules governing the collection and handling of personal information. In many countries, new constitutions reflect this right. The genesis of modern legislation in this area can be traced to the first data protection law in the world enacted in the Land of Hesse in Germany in 1970 This was followed by national laws in Sweden (1973), the United States (1974), Germany (1977) and France (1978). [fn 34]

Two crucial international instruments evolved from these laws. The Council of Europe's 1981 Convention for the Protection of Individuals with regard to the Automatic Processing of Personal Data [fn 35] and the Organization for Economic Cooperation and Development's Guidelines Governing the Protection of Privacy and

Transborder Data Flows of Personal Data [fn 36] articulate specific rules covering the handling of electronic data. The rules within these two documents form the core of the Data Protection laws of dozens of countries. These rules describe personal information as data which are afforded protection at every step from collection through to storage and dissemination. The right of people to access and amend their data is a primary component of these rules.

The expression of data protection in various declarations and laws varies only by degrees. All require that personal information must be:

- obtained fairly and lawfully;
- used only for the original specified purpose;
- adequate, relevant and not excessive to purpose;
- accurate and up to date; and
- destroyed after its purpose is completed."

There is a growing trend towards the wide-ranging privacy and data protection acts around the world. Currently over 40 countries have already adopted or are in the process of adopting such laws, among others to promote electronic commerce and to ensure compatibility with international standards developed by the European Union, the Council of Europe, and the Organization for Economic Cooperation and Development.

6.11 Ethics of Trust

Trust is one of the building blocks of a civilized society. We trust train and airline time-tables and plan our journeys accordingly, we trust the pharmaceutical industry in taking their pills, believing that they will cure us and not kill us, we trust our employers and colleagues, assuming that what they promise or claim is what they, at least, believe to be true. As any other factor in human relations, trust has many different aspects in the different contexts. Wittgenstein's dictum "meaning is use" applies here as well. One can consider trust as a cognitive process or state, within the psychology of personality as a behavioral/developmental process, as a social psychology/sociology related phenomenon. In connection with cultural history and privacy, it is influenced by and influences social politics and society at large, for example, defining our responsibilities (Kainulainen, 2001).

Hinman (2002) puts it in the following way:

"Trust is like the glue that holds society together -- without it, we crumble into tiny isolated pieces that collide randomly with one another. In a world without trust, individuals cannot depend on one another; as a result, individuals can only be out for themselves. Economists have shown that societies where trust is low have stunted economic growth because a robust economy demands that individuals be able to enter into cooperative economic relationships of trust with people who are strangers."

Hinman claims that trust is one of the three universal core values found across cultures:

- caring for children
- trust
- prohibition against murder.

This even holds in the most primitive artificial (computer-simulated) populations, in that case having the following effects:

- assuring the continuity of population in terms of number of individuals and ways of behavior
- respecting the commonly accepted set of rules, which provides predictability and stable relationships
- preventing the extinction of the population.

Trust thus has deep roots in both the needs of individual humans for security, safety, confidence and predictability and in the basic principles of social dynamics.

One field that has traditionally focused on the problem of trust is medical ethics. In Francis (1993) the section 'Ethics of Trust vs. Ethics of Rights' discusses autonomy, informed consent and the rights of patients. The relationship of dependence and usually significant difference in knowledge, which characterises doctor-patient communication and the position of the patient within the health-care system, have its counterpart in the relation between a common computer user and a computer professional knowing how to configure the machine or the network and communication in ways that have significant consequences for the user. Basically, the relation between a specialist and a lay-person is that of power and subjection and must be grounded on mutual trust.

Historically, however, such unconditional trust on the part of the general public in the inherent goodness of technology has been shown to be unwarranted.

Technology is far too important to everybody to be left to the specialist alone. Agre (1994) says:

"The design of computer systems has not historically been organized in a democratic way. Designers and users have had little interaction, and users have had little control over the resulting systems, except perhaps through the indirect routes available to them through resistance in the workplace and the refusal to purchase relatively unusable systems for their own use. Yet over the last ten or twenty years, a growing movement, originating in Scandinavia but now increasingly influential in other industrialized countries, is attempting to reform the design of computer systems in a more democratic direction (Bjerknes, Ehn, and Kyng 1987, Schuler and Namioka 1993). This movement, sometimes known as participatory design, invites the participation of, and in many cases gives formal control over the design process to, the people whose work-lives the system affects."

6.12 Legitimacy by Design and Trustworthy Computing

Quis custodiet ipsos custodes? (Who watches the watchers?)

Decimus Iunivs Ivvenalis (Juvenal), Roman poet, 2nd century AD, Satires, VI

Legitimacy is a social concept developed during human history, meaning "socially beneficial fairness". It concerns classical social problems such as the prisoner's dilemma and the "tragedy of the commons" in which the only concern of each individual is trying to maximize their own advantage, without any concern for the well-being of the others. Social interactions without legitimacy lead society into an unsustainable state. Whitworth and de Moor (2003) claim that legitimate interaction increases social well-being, and they analyze the ways in which societies traditionally establish legitimacy, and how the development of socio-technical systems changes previously established patterns of behaviour.

However, traditional mechanisms that support legitimacy, such as laws and customs are particularly ineffective in the cyberspace of today with its flexible, dynamic character, (Whitworth and de

Moor, 2003). The remedy is the incorporation of legitimacy by design into a technological system. That process begins with a legitimacy analysis which can translate legitimacy concepts, such as freedom, privacy and ownership into specific system design demands. On the other hand it can interpret program logic into statements that can be understood and discussed by a social community. Legitimate interaction, with its cornerstone of accountability, seems a key to the future of the global information society we are creating, (Dodig-Crnkovic, Horniak, 2005).

This means that democratic principles must be built into the design of socio-technical systems such as e-mail, CVE's (Collaborative Virtual Environments), chats and bulletin boards. As the first step towards that goal, the legitimacy analysis of a technological artefact (software/hardware) is necessary. Legitimacy analysis can be seen as a specific branch of disclosive ethics, specialized for privacy issues. Fischer-Hübner (2001) adress the problem of IT-security and privacy, discussing the design and use of privacy enhancing security mechanisms.

In any computer-mediated communication, trust ultimately depends not on personal identification code numbers or IP addresses but on relationships between people with their different roles within social groups. The trust necessary for effective democracy depends on communication and much of the communication is based on interaction over computer networks. Trust and privacy trade-offs are normal constituents of human social, political, and economic interactions, and they consequently must be incorporated in the practices of the e-polis. The bottom line is of course the transparency of the system and the informed consent of all the parties involved.

"Trust is a broad concept, and making something trustworthy requires a social infrastructure as well as solid engineering. All systems fail from time to time; the legal and commercial practices within which they're embedded can compensate for the fact that no technology will ever be perfect. Hence this is not only a struggle to make software trustworthy; because computers have to some extent already lost people's trust, we will have to overcome a legacy of machines that fail, software that fails, and systems that fail. We will have to persuade people that the systems, the software, the services, the people, and the companies have all, collectively, achieved a new level of availability, dependability, and confidentiality. We will have to overcome the distrust that people now feel for computers.

The Trustworthy Computing Initiative is a label for a whole range of advances that have to be made for people to be as comfortable using devices powered by computers and software as they are today using a device that is powered by electricity. It may take us ten to fifteen years to get there, both as an industry and as a society. This is a "sea change" not only in the way we write and deliver software, but also in the way our society views computing generally. There are immediate problems to be solved, and fundamental open research questions. There are actions that individuals and companies can and should take, but there are also problems that can only be solved collectively by consortia, research communities, nations, and the world as a whole." Mundie, at al. (2003)

It is apparent that the problem of trust involves more than the establishment of privacy standards; it concerns even security, reliability and business integrity. The Trustworthy Computing Initiative is an indication of how serious the problem is and how urgent is its solution for the development of a society supported by computer technology. It is good news that business shows awareness of the social impact of the technology they produce and understanding of how basic public acceptance, confidence and trust is for the general direction of the future development of society. It gives hope that at least some important aspects of privacy problems of today will be solved within the decades to come.

The first phase of the intentional design for democracy is the explication of the embedded moral significance of ICT while the next is the development of the corresponding technology (Yu and Cysneiros, 2002). The existing analyses of the state of the art of privacy issues worldwide (fifty countries in http://www.gilc.org/privacy/survey) bear witness to how much work remains to be done.

"The electronic networking of physical space promises wide-ranging advances in science, medicine, delivery of services, environmental monitoring and remediation, industrial production, and monitoring of people and machines. It can also lead to new forms of social interaction, as suggested by the popularity of instant messaging (...). However, without appropriate architecture and regulatory controls it can also subvert democratic values. Information technology is not in fact neutral in its values; we must be intentional about design for democracy." (Pottie 2004).

What we as users have a right to expect in the near future is that the ICT follows Privacy/Fair Information Principles:

"Users are given appropriate notice of how their personal information may be collected and used; they are given access to view such information and the opportunity to correct it; data is never collected or shared without the individual's consent; appropriate means are taken to ensure the security of personal information; external and internal auditing procedures ensure compliance with stated intentions." (Mundie, at al., 2003)

6.13 Possible Solutions

"Yes, safeguards can be built into any system, such as the checks and balances in a good accounting system. But what keeps them in place is not the technology, but people's commitment to keeping them.

We cannot expect technology alone to solve ethical dilemmas. Technology is a tool made by people to meet people's needs. Like all tools, it can be used in ways undreamed of by the inventor. Like all tools, it will change the user in unexpected and profound ways." Weiser (1995)

ICT supports and promotes the formation of new global virtual communities that are socio-technological phenomena typical of our time. In an e-democracy government, elected officials, the media, political organizations and citizens use ICT within the political and governance processes of local communities, nations and on the international stage. The ideal of e-democracy is greater and more direct citizen involvement. For the modern civilization of a global e-polis, the optimal functioning of virtual communities is vital. What are the basic principles behind successful virtual community environments? According to Whitworth there are two such principles:

- Virtual community systems must match the processes of human-human interaction.
- Rights and ownership must be clearly defined.

It is technically possible for ICT to incorporate these principles which include privacy protection via standards, open source code, government regulation etc. (Pottie, 2004, Tavani & Moor, 2000), including also trustworthy computing, (Mundie, at al., 2003). Here an improved legislation is an important cornerstone.

A process of continuous interaction and dialogue is necessary to achieve a socio-technological system which will guarantee the highest standards of privacy protection. Our conclusion is that trust must be established in ICT, both in the technology itself and in the way it is employed in a society.

After analyzing several kinds of ethic approaches (an ethic of care, an ethic of broad empathy, an ethic of trust and a dialogical ethic) Kohen (1998) finds a dialogical ethic to be the most suitable modern ethics approach. Its main feature is interactivity and dynamic, and it is based on the culture of trust. That is how the problem of privacy can be seen. It is a part of a more general problem of the digital era, life in a global, networked e-village implies that the problem must be solved on a global level. Not only through legislation (even though it is a very important building block), not only through technology (even thought it is essential), but through an informed ethical dialogue.

The conclusion is that mutual trust which is one of the basic ethical principles on which human societies rely must be established in the use of ICT. This in the first place presupposes the informed consent of all the parties involved as a conditio sine qua non. Moreover, trust must also be established globally because the data contained in networked computers virtually knows no boundaries.

Chapter 7. Conclusions and Future Work

7.1 Conclusions

"Out of clutter, find simplicity. From discord, find harmony. In the middle of difficulty, lies opportunity." Albert Einstein

This work presents a synthesis of two paradigms within contemporary philosophy – computationalism and informationalism into a new dual-aspect info-computationalist framework. The meaning of this dualism might be seen in the light of the analogy with wave-particle or matter-energy dualisms in physics. The dualism itself does not mean that the phenomena are separated, and exclude each other; on the contrary, they are mutually determining, constraining and completely indissoluble. In that sense, one may speak of dual-aspect monism.

Computation is seen as a process, dynamic, time-dependent, information as an instantaneous structure. These are both aspects of the same phenomenon in the physical world – there is no computation without a structure to compute on, and there is no completely static physical (informational) structure. The physical world as we know it is in continual transformation. Even the vacuum as described by today's physics has zero-point oscillations that never cease, not even at the absolute zero temperature. The process, the change, seems to be a very basic feature of the physical world. In sum: both structure and process are essential, both information and computation are necessary for a holistic picture.

This fact has several profound consequences. If we want to understand the dynamic of the physical world, we must take both informational and computational aspects into account.

Two current paradigms of information studies and computation theory have developed two separate traditions, with separate goals and different conceptual apparatuses. Theory of information, in particular, has a number of schools, each focusing on the different roles that information plays.

Computation has its roots in mathematics (Hilbert's program) – has been therefore traditionally limited to the natural sciences and technologies. However, the recent development of ubiquitous computing, with computational processes embedded in ambient intelligence, has resulted in a shifting of focus and a change in the use of computation, which today, is at least as much interaction and communication as it is calculation. It is not only so that ICT (information and communication technology) has changed our way of communicating with other people, globally but what is happening now is that even ambient intelligence is being added to the network of communicating processes. No wonder that the interactionalist paradigm is winning an increasingly prominent place. From the computationalist perspective, there is good reason to see information as the central concept for computation in the globally-networked communicating society currently developing.

To sum up, the thesis begins as a search for possible answers to Floridi's Open Problems, recognizing that informationalism is inseparably intertwined with computationalism, and that those two together suffice to account for every physical phenomenon, its structure and dynamics. Considering the universe as a network of computers calculating their next state by implementing physical laws, one can say that it must be possible to derive all phenomenology via computations, not only via mathematical functions as we are accustomed, but also by simulation. The significant difference between a function and a simulation is that each step of simulation must be executed in order to reach a certain state – which means running a program - it is not possible just to read it off at once, as the value of a function is obtained.

The following are the results of the unified info-computational theory:

- Dual-aspect unification of information and computation as physical phenomena, and as research topics

- Natural computing as a new paradigm of computing that goes beyond the Turing-Church conjecture- - Call for novel logical approaches – dialogic logic, game logic, chaotic logic, quantum logic, etc. in the pluralistic logical framework

- Continuum - discrete controversy bridged by the same dual-aspect approach. This counters the argument against computational mind which claims that computational mind must be discrete. It is also an answer to the critique that the universe might not be computational as it might not be entirely digital.

- Computationalist and informationalist frameworks meet in the common domain of complex systems. The Turing-Church conjecture is about mechanical, syntactic symbol manipulation as implemented on the hardware level. All complexity is to be found on the software level. Different levels of complexity have different meanings for different living organisms.

All computation is equivalent to TM in the same way as an eco-system consists of atoms. Knowledge of the atomic structure of a complex system is, of course, fundamental and central, but if we want to learn about the behavior and structure of a complex eco-system, its atomic structure is several levels below the informational level of interest. Structure (complexity, information) is what makes the difference for living organisms, and even more so for the intelligent beings.

- Semantics is essential; information has both declarative and non-declarative forms (e.g. biology), each of them with their own merits

- This approach is supported in common by biologists, neuroscientists and philosophers of mind

- Ethics and values are an integral part of the entire informationalist - computationalist endeavor

- This approach is agent-centered which allows for pluralism: logical, epistemological and ethical.

7.2 Future Research

One interesting question is what kind of computation can be developed in the future, and what can we learn from Nature that might be useful for forthcoming computing theory and technology.

Intelligent systems, IS, is a vigorously expanding research field. An accurate understanding of the underlying processes that govern intelligence; the structuring of data into information and information into knowledge, including dynamics and goal-oriented behaviors in intelligent agents, is essential.

The info-computationalist framework can be applied in different fields; one of the immediate applications being in bioinformatics, as a tool for conceptualizing processes in living organisms. The idea of natural computation encourages the ambition to advance beyond Turing-Church limit.

Computation in its implementations is interactive today – that is obvious, on the one hand. Its theory, on the other hand, is oriented towards calculating mathematical functions. No doubt, functions are an important part of computing, but nowadays, the semantic web is what dictates the priorities, and among others, dynamic semantics.

Agency and agent-centered thinking makes it necessary to generalize logic – logical pluralism is a real- life fact for communicating, interactive agents. It is not so that it would be impossible to take a standard logic for each and every agent. It is just simply so that the agents´ main characteristic is their agency, as their reasoning is goal-oriented. This means that agents may use different reasoning strategies, and, in general, they might wish to apply different existing logics. Games as logical models are very interesting tools, as are dialogical logics and their possibilities are to be investigated in the future.

Computing, and especially in its informational orientation has the potential to support consilience, (the unity of knowledge which has its roots in the ancient Greek concept of an intrinsic order that governs the cosmos, comprehensible by logic). The rational worldview was recovered during the Renaissance and further developed in the Enlightenment. During the last two centuries, modern sciences have lost their sense of unity in the growing specialization in separate fields. Contemporary computing is contributing to a new meeting of the sciences, humanities, arts and crafts, not unlike a new Renaissance (Paper A). New interdisciplinary research is needed within the computational framework that will develop connections with other fields. A new theory of science with its focus on computing/information is on the advance.

Chapter 8. Bibliography

Abramsky S., Semantics of Interaction: an Introduction to Game Semantics, in Proceedings of the 1996 CLiCS Summer School, Isaac Newton Institute, P. Dybjer and A. Pitts, eds. (Cambridge University Press) 1997, 1--31.

Abramsky S., Sequentiality vs. Concurrency in Games and Logic, Mathematical Structures in Computer Science vol. 13, 2003, 531—565

ACM/IEEE, (2001), Computing Curricula 2001, http://www.computer.org/education/cc2001/index.htm

Addis, T., Visscher, B. Billinge, D., Gooding D. (2005). Socially Sensitive Computing: a Necessary Paradigm Shift for Computer Science. Grand Challenges in Computing, CPHC, Newcastle, http://www.cs.york.ac.uk/nature/workshop/index.htm

Agre, E. P. (1994) Design for Democracy, http://polaris.gseis.ucla.edu/pagre/oksnoen.html

Albus, J.S., 1981, *Brains, Behavior, and Robotics,* Byte/McGraw-Hill

Albus, J.S., 1991, Outline for a Theory of Intelligence, *IEEE Transactions on Systems, Man and Cybernetics,* Vol. 21, No. 3

Albus, J.S., Meystel, A., "A Reference Model Architecture for Design and Implementation of Semiotic Control in Large and Complex Systems", in Proceedings of 1995 ISIC Workshop, Monterey, 1995

Allison A., Currall J., Moss M., Stuart S. (2005) Digital identity matters, Journal of the American Society for Information Science and Technology, Volume 56, Issue 4, Pages 364-372

Allo P., 2006, Formalising Semantic Information. Lessons From Logical Pluralism, in Computing, Philosophy, and Cognitive Science to be published by Cambridge Scholars Press

Amit, Daniel (1989). Modeling Brain Function: The World of Attractor Neural Networks. Cambridge University Press.

Antsaklis, P. J., Passino, K. M., (eds.), *An Introduction to Intelligent and Autonomous Control*, Kluwer Academic Publishers, Boston, 1993

Arnellos A., Spyrou T., Darzentas J., The Emergence of Interactive Meaning Processes in Autonomous Systems

ARTICLE 29 Data Protection Working Party. Retrieved December 11, 2004, from http://europa.eu.int/comm/internal_market/privacy/workingroup_en.htm

Ashby, W.R., An Introduction to Cybernetics, Chapman and Hall, London, UK, 1956. Reprinted, Methuen and Company, London, UK, 1964 http://pespmc1.vub.ac.be/books/IntroCyb.pdf

Baeyer von H.C., 2003, *Information: The New Language of Science*, Weidenfeld and Nicolson

Bandura, A.: *Self-Efficacy: The exercise of control*, New York:Freeman, 1997.

Barwise, Jon and John Perry, 1983 *Situations and Attitudes*. MIT Press, Cambridge, MA

Barwise, Jon, (1986) ”Information and Circumstance”, Notre Dame Journal of Formal Logic 27 No. 3 pp 307-323; reprinted in *The Situation in Logic*, CSLI Lecture Notes No 17

Bates, Marcia J. Information and knowledge: an evolutionary framework for information science. Information Research, 10 (4) paper 239, 2005 [available at http://InformationR.net/ir/10-4/paper239.html]

Bateson, G., 1973, Steps to an Ecology of Mind, Paladin. Frogmore, St. Albans

Beall JC and Restall G, Logical Pluralism, Australasian Journal of Philosophy, 78 (2000) 475–493.

Beall, JC, Restall, Greg, Logical Consequence, The Stanford Encyclopedia of Philosophy (Winter 2005 Edition), Edward N. Zalta (ed.), URL = <http://plato.stanford.edu/archives/win2005/entries/logical-consequence/>.

Benford S, Greenhalgh C, Rodden T, Pycock J (2001) Collaborative Virtual Environments, Commun. ACM, 44(7), 79-85

Bennet C. J. and Grant R. ed. Policy Choices for a Digital Age. (1999) Visions of Privacy, University of Toronto Ppress

Benthem Van J., 2001, Extensive Games as Process Models, in M. Pauly & P. Dekker, eds., special issue of Journal of Logic, Language and Information

Benthem Van J., 2003, Logic and the Dynamics of Information, Minds and Machines 13: 503–519.

Benthem Van, J. and Adriaans P., ed., 2006, Handbook on the Philosophy of Information; Volume 8 in the Handbook of the Philosophy of Science, Elsevier, Amsterdam, forthcoming

Benthem Van, J. and R. van Rooy, 2003, Connecting the Different Faces of Information, Journal of Logic, Language and Information, 12(4): 375—379.

Bickhard, M. H. (2004). The Dynamic Emergence of Representation. In H. Clapin, P. Staines, P. Slezak (Eds.) Representation in Mind: New Approaches to Mental Representation. (71-90). Elsevier.

Bickhard, M. H., Terveen, L. (1995). Foundational Issues in Artificial Intelligence and Cognitive Science -- Impasse and Solution. Amsterdam: Elsevier Scientific.

Block, N. (1978) 'Troubles with Functionalism', in Savage (1978).

Bohan Broderick, P., On Communication and Computation ", Minds and Machines 14 (2004)

Bowyer, K.W. (Ed), (2000), Ethics and Computing, Wiley-IEEE Press

Brey P (1999) The Ethics of Representation and Action in Virtual Reality, Ethics and Information Technology 1/1, 5-14

Brey P (2000) Method in Computer Ethics: Towards a Multi-Level Interdisciplinary Approach, Ethics and Information Technology 2:3, 1-5

Brey, P. The ethics of representation and action in virtual reality Ethics and Information Technology 1(1), 5-14. ISSN 1388-1957. 1999.

Briefing Materials on the European Union Directive on Data Protection. Retrieved December 11, 2004, from http://www.cdt.org/privacy/eudirective/ The Center for Democracy & Technology.

Brier Søren

Buldt B., Löwe B., Müller T., 2006, Towards a New Epistemology of Mathematics http://www.lib.uni-bonn.de/PhiMSAMP/GAP6/

Burgin M., 2003, Information: Problems, Paradoxes, and Solutions, tripleC 1(1) 53-70, http//tripleC.uti.at

Burgin M., Allen Klinger, Three aspects of super-recursive algorithms and hypercomputation or finding black swans, Theoretical Computer Science 317 (2004) 1 – 11

Burgin, M., Super-recursive algorithms as a tool for high performance computing, In: Proceedings of High Performance Computing Symposium (San Diego, 1999) 224-228 http://www.math.ucla.edu/~mburgin/res/compsc/res2/highperfcomp.html

Burgin, M., Super-Recursive Algorithms, Springer Monographs in Computer Science, 2005, ISBN: 0-387-95569-0

Burgin, M., Topological Algorithms, In: Proceedings of 16th International Conference for Computers and Applications ISCA (Seattle, 2001) 61-64

Bynum TW & Rogerson S ed. (2003). Computer Ethics and Professional Responsibility. Blackwell.

Bynum TW (2000) Ethics and the Information Revolution, In: G. Collste. Ethics in the Age of Information Technology. Linkoeping, Sweden: Center for Applied Ethics Linkoeping Universitet, 32-55.

Bynum TW (2000). Ethics and the Information Revolution, In: G. Collste. Ethics in the Age of Information Technology. Linkoeping, Sweden: Center for Applied Ethics Linkoeping Universitet, 32-55.

Bynum, T.W. and Moor, J.H., (1998), The Digital Phoenix, How Computers are Changing Philosophy

Cantwell Smith, B. 1996., On the Origin of Objects, Cambridge, MA: MIT Press

Capurro R., (1985) *Epistemology and Information Science*, REPORT TRITA-LIB-6023, Ed. Stephan Schwarz, ISSN 0346-9042

Capurro R., Fleissner P., Hofkirchner W., 1999, Is a Unified Theory of Information Feasible? A Trialogue In: W. Hofkirchner Ed.: The Quest for a Unified Theory of Information. Proceedings of the Second International Conference on the Foundations of Information Science, Gordon and Breach Publ.

Capurro R., Hjørland B. (2003) *The Concept of Information,* In: Annual Review of Information Science and Technology (ARIST), Ed. Blaise Cronin, Information Today, Inc. Medford, NJ .

Carnap, R. (1994), An Introduction to The Philosophy of Science, Basic Books

Carnap, R., 1950, Logical Foundations of Probability. University of Chicago Press, Chicago

Carnap, R., Bar-Hillel, Y., 1964, An Outline of Semantic Information. In Bar-Hillel, Y. (Ed.) Language and Information: Selected Essays on Their Theory and Application. Addison-Wesley, Reading, Mass.

Chaitin, G.J, (1987), Algorithmic Information Theory, Cambridge University Press

Chaitin, G.J. (1987) *Information Randomness & Incompleteness: Papers on Algorithmic Information Theory*. Singapore: World Scientific.

Chaitin, Lecture, Dijon, 2003, http://www.cs.auckland.ac.nz/CDMTCS/chaitin

Chalmers, A. (1990), What is This Thing Called Science?, Hackett Publishing Co.

Chalmers, D.J. (1995) 'Minds, Machines, and Mathematics', *PSYCHE* 2:1.

Chalmers, D.J. (1996) *The Conscious Mind: In Search of a Fundamental Theory*, Oxford University Press

Cherniak, C. (1984) 'Computational Complexity and the Universal Acceptance of Logic', *Journal of Philosophy* 81: 739-55.

Chisholm, R.M. (1946) 'The Contrary-to-fact Conditional', *Mind* 55: 289-307.

Churchland, P.M. (1981) 'Eliminative Materialism and the Propositional Attitudes', *Journal of Philosophy* 78: 67-90.

Collier, John D., 1990, Intrinsic Information In Philip Hanson (ed) Information, Language and Cognition: Vancouver Studies in Cognitive Science, Vol. 1, University of Oxford Press

Collste G (1999) Ethics in the Age of Information Technology. Linkoeping, Sweden: Center for Applied Ethics Linkoeping Universitet Cooley MJ Invited talk at International Conference: Enterprise Cultures and Innovation in the Information Society, University of Brighton

Cordova, D. I. and Lepper, M. R.: Intrinsic motivation and the process of learning: Beneficial effects of contextualization, personalization, and choice. Journal of Educational Psychology, 88, 715-730,1996.

Crutchfield, Jim. List of publications on computational mechanics: http://www.santafe.edu/projects/CompMech/papers/CompMechCommun.html

Davidson, D. and G. Harman, eds. (1972) *Semantics of Natural Language*. Dordrecht: Reidel.

Davis, P.K., 1992, Generalizing Concepts and Methods of Verification, Validation, and Accreditation (VV&A) for Military Simulations, RAND, R-4249-ACQ

Debrock, G. (Ed.) (2003) *Process Pragmatism*. *Essays on a Quiet Philosophical Revolution.* Rodopi Value Inquiry Book Series 137, Studies in Pragmatism and Values, Amsterdam/New York

DeCew J (2002) Privacy, The Stanford Encyclopedia of Philosophy Edward N. Zalta (ed.), (http://plato.stanford.edu/archives/sum2002/entries/privacy)

DeCew J (2002). Privacy, The Stanford Encyclopedia of Philosophy. Retrieved December 11, 2004, from http://plato.stanford.edu/archives/sum2002/entries/privacy

Dennett, D.C. (1975) 'Why the Law of Effect Will Not Go Away', *Journal of the Theory of Social Behaviour* 5: 179-87.

Dennett, D.C. (1995) 'The Unimagined Preposterousness of Zombies', *Journal of Consciousness Studies* 2(4): 322-26.

Denning, P.J. and Metcalfe, R.M., 1997, eds., Beyond Calculation – The Next Fifty Years of Computation. Copernicus (Springer Verlag). New York

Devlin, K., 1991, Logic and Information, Cambridge University Press, Cambridge

Devlin, K., 1991, Logic and Information, Cambridge University Press, Cambridge.

Dillon, R. S., (2003) *Respect*, The Stanford Encyclopedia of Philosophy, E. N. Zalta (ed.), http://plato.stanford.edu/archives/fall2003/entries/respect/

Dodig-Crnkovic G (2003) Shifting the Paradigm of the Philosophy of Science: the Philosophy of Information and a New Renaissance, Minds and Machines: Special Issue on the Philosophy of Information, Volume 13 (4), p521-536, Kluwer

Dodig-Crnkovic G, Crnkovic I. (2003) Computing Curricula: Teaching Theory of Science to Computer Science Students, Hawaii International Conference on Education, Honolulu, Hawaii, USA

Dodig-Crnkovic G. (2005) Philosophy of Information, a New Renaissance and the Discreet Charm of the Computational Paradigm, L. Magnani, Computing, Philospphy and Cognition, King's College Publications London, Editor(s): L Magnani, R Dossena

Dodig-Crnkovic G. (2006) What is Philosophy of Computer Science? Experience from the Swedish National Course, European conference on Computing And Philosophy—ECAP'06, NTNU, Trondheim, Norway

Dodig-Crnkovic G. (2001) What Ultimately Matters, Indeed?, Proc. Conference for the Promotion of Research in IT at New Universities and at University Colleges in Sweden, Part III, p 12, The Knowledge Foundation, Ronneby, Editor(s):Janis Bubenko jr

Dodig-Crnkovic G. (2002) Scientific Methods in Computer Science, Proc. Conf. for the Promotion of Research in IT at New Universities and at University Colleges in Sweden, Skövde

Dodig-Crnkovic G. (2003) Computing Curricula: Social, Ethical, and Professional Issues, Proc. Conf. for the Promotion of Research in IT at New Universities and at University Colleges in Sweden

Dodig-Crnkovic G. (2005) System Modeling and Information Semantics, Proceedings of the Fifth Conference for the Promotion of Research in IT, Studentlitteratur, Lund, Editor(s): Bubenko jr. J., Eriksson O., Fernlund H. & Lind M.

Dodig-Crnkovic G. (2006) Knowledge as Computation in vivo: Semantics vs. Pragmatics as Truth vs. Meaning, i-C&P Conference on Computers & Philosophy, Laval, France

Dodig-Crnkovic G. (2006) Model Validity and Semantics of Information, Model-Based Reasoning In Science And Engineering Abduction, Visualization, And

Simulation, Pavia, Italy, December 16-18, 2004, King's College Publications, London, Editor(s):L Magnani

Dodig-Crnkovic G. (2006) Model Validity and Semantics of Information, Mind & Society, Springer, forthcoming

Dodig-Crnkovic G. (2006) On the Importance of Teaching Professional Ethics to Computer Science Students, E-CAP 2004 Conference, Pavia, Italy. To be published in: L. Magnani, Computing and Philosophy, Associated International Academic Publishers, Pavia,

Dodig-Crnkovic G. (2006) On the Importance of Teaching Professional Ethics to Computer Science Students, Computing and Philosophy Conference, E-CAP 2004, Pavia, Italy, Associated International Academic Publishers, Pavia, Editor(s): L Magnani

Dodig-Crnkovic G. (2006) Privacy and Protection of Personal Integrity in the Working Place, ZiF-Workshop Privacy and Surveillance, University of Bielfeld, Germany

Dodig-Crnkovic G. (2006) Semantics of Information as Interactive Computation, submitted Minds and Machines

Dodig-Crnkovic G. and Crnkovic I. (2003b), Computing Curricula: Teaching Theory of Science to Computer Science Students, Proc. Hawaii International Conference on Education

Dodig-Crnkovic G. and Stuart S., eds. (2006), *Computation, Information, Cognition – The Nexus and The Liminal*, Cambridge Scholar Press, Cambridge – forthcoming

Dodig-Crnkovic G. and Stuart S., eds. (2006), tripleC journal issue dedicated to E-CAP 2005@MDH Sweden, http://triplec.uti.at/, forthcoming

Dodig-Crnkovic G., Crnkovic I. (2005) Professional Ethics in Software Engineering Curricula, Cross-disciplinarity in Engineering Education, CeTUSS, Uppsala

Dodig-Crnkovic G., Horniak V. (2005) Good to Have Someone Watching Us from a Distance? Privacy vs. Security at the Workplace, Ethics of New Information Technology, Proceedings of the Sixth International Conference of Computer Ethics: Philosophical Enquiry, CEPE 2005, Brey P, Grodzinsky F and Introna L., University of Twente, Enschede, The Netherlands

Dodig-Crnkovic G., Horniak V. (2006) Ethics and Privacy of Communications in Global E-Village ENCYCLOPEDIA OF DIGITAL GOVERNMENT

Dodig-Crnkovic G., Horniak V. (2006) Togetherness and Respect - Ethical Concerns of Privacy in Global Web Societies, In Special Issue of AI & Society: The Journal of Human-Centred Systems and Machine Intelligence, on "Collaborative

Distance Activities: From Social Cognition to Electronic Togetherness", CT. Schmidt Ed., Vol 20 no 3

Dodig-Crnkovic G., Larsson T. (2005) Game Ethics - Homo Ludens as a Computer Game Designer and Consumer, International Journal of Information Ethics, Special Issue, ICIE, December,

Dodig-Crnkovic, G (2004) Philosophy of Information, a New Renaissance and the Discreet Charm of the Computational Paradigm, Computing and Philosophy Conference, E-CAP Pavia, Italy

Dretske, F.I. (1981) *Knowledge and the Flow of Information*. Cambridge, Massachusetts: MIT Press.

Einstein, A., *The Compton Experiment*, Appendix 3, in R. S. Shankland (Ed.), *Scientific Papers of Arthur Holly Compton, X-Ray and Other Studies*, University of Chicago Press, Chicago (1975).

Etzioni A. (1999) The Limits of Privacy, Basic Books, New York

Feldman, R., "Naturalized Epistemology", The Stanford Encyclopedia of Philosophy (Fall 2001 Edition), Edward N. Zalta (ed.), http://plato.stanford.edu/archives/fall2001/entries/epistemology-naturalized/.

Feyerabend, P. (2000), Against Method, Verso

Fischer-Hübner, S. and G. (2001). IT-Security and Privacy: Design and Use of Privacy Enhancing Security Mechanisms. Lecture Notes in Computer Science, Vol. 1958. Berlin Heidelberg: Springer-Verlag

Flake G. W. (1998) *The The Computational Beauty of Nature: Computer Explorations of Fractals, Chaos, Complex Systems, and Adaptation*, MIT Press

Floridi L & Sanders J (2002). Mapping the Foundationalist Debate in Computer Science, a revised version of Computer Ethics: Mapping the Foundationalist Debate. Ethics and Information Technology, 4.1, 1-9.

Floridi L (1999) Information Ethics: On the Philosophical Foundations of Computer Ethics," Ethics and Information Technology, Vol. 1, No. 1, pp. 37-56.

Floridi L, Sanders J (2002) Mapping the Foundationalist Debate in Computer Science, a revised version of Computer Ethics: Mapping the Foundationalist Debate, Ethics and Information Technology 4.1, 1-9

Floridi L, Sanders J (2003) Internet Ethics: the Constructionist Values of Homo Poieticus. In: The Impact of the Internet on Our Moral Lives, Robert Cavalier ed.

Floridi L. (2004) Open Problems in the Philosophy of Information, Metaphilosophy, Volume 35: Issue 4

Floridi L. (2006) Information Logic, in Dodig-Crnkovic G. and Stuart S., eds. (2006), *Computation, Information, Cognition – The Nexus and The Liminal*, Cambridge Scholar Press, Cambridge – forthcoming

Floridi L., 2005, Semantic Conceptions of Information, The Stanford Encyclopedia of Philosophy (Winter Edition), Edward N. Zalta (ed.), <http://plato.stanford.edu/entries/information-semantic>.

Floridi, L., (1999), Philosophy and computing: An introduction, Routledge.

Floridi, L., (2002), "What is the Philosophy of Information?", Metaphilosophy (33.1/2), 123-145

Floridi, L., (2003), Blackwell Guide to the Philosophy of Computing and Information

Floridi, L., 2002, What is the Philosophy of Information?, Metaphilosophy, 33 (1/2): 123—145.

Floridi, L., 2003, Information, in: The Blackwell Guide to the Philosophy of Computing and Information,

Floridi, L., 2004, Outline of a Theory of Strongly Semantic Information Minds and Machines, 14.2, pp. 197-222.

Floridi, L., 2005a, Is Information Meaningful Data?, Philosophy and Phenomenological Research, 70(2): 351–370.

Floridi. L., 2004, Afterword - LIS as Applied Philosophy of Information: a Reappraisal, Library Trends, 52(3)

Francis, C.M. (1993) Medical Ethics, Jaypee Brothers Medical Publishers (Pvt) Ltd) New Delhi

Fredkin, Digital Philosophy, http://www.digitalphilosophy.org/finite_nature.htm

Frieden B. R (2004) Science from Fisher Information: A Unification, 2nd ed. Cambridge University Press. ISBN 0-52-100911-1.

Gelder T. Van and Port R. E, It's About Time: An overview of the Dynamical Approaches to Cognition, in R. E Port & T. Van Gelder (eds.), Mind as Motion: Explorations in the Dynamics of Cognition, 1-43, M.I.T. Press.

Gill KS (2002) Knowledge Networking in Cross-Cultural Settings, AI & Soc 16: 252-277

Gill KS (2003) Future with AI & Society (http://www.it.bton.ac.uk/research/seake/ai_soc6_3.html)

Gill, KS (1997) Knowledge networking and social cohesion in the Information Society, a study for the European Commission

Goertzel, Ben (1993). The Evolving Mind. Gordon and Breach

Goertzel, Ben (1994). Chaotic Logic. Plenum Press. http://www.goertzel.org/books/logic/contents.html

Goertzel, Ben and Cassio Pennachin (2002). Design for a Digital Mind: The Novamente Artificial General Intelligence System. In preparation.

Goldin D, and Wegner P, 2002, Paraconsistency of Interactive Computation, PCL 2002 (Workshop on Paraconsistent Computational Logic), Denmark

Goldin D, Smolka S and Wegner P Ed., 2006, Interactive Computation: The New Paradigm, To be published by Springer-Verlag

Goldin, D. and Wegner, P., 2000, Persistent Turing Machines, J. Symbolic Logic 65, Assoc. of Symbolic Logic. 567-604

Goldin, D. and Wegner, The Church-Turing Thesis: Breaking the Myth, LNCS 3526, Springer 2005, pp. 152-168

Goodman N (1978) Ways of Worldmaking, Indianapolis: Hackett Publishing

Goranson T., (2005) [Fis] First Things First,

Grodzinsky, F.S., Tavani, H.T. (2004) Verizon vs. The RIAA: Implications for Privacy and Democracy, IEEE, 0-7803-8251-x

Grossman, D. and DeGaetano G.: Stop Teaching Our Kids to Kill. Random House, 1999.

Gupta M. M. , Singha N. K. , (eds.), *Intelligent Control Systems*, IEEE Press, 1996

Gärdenfors, P. 2004 "How to make the Semantic Web more semantic", pp. 19-36 in Formal Ontology in Information Systems, ed. by A.C. Varzi and L. Vieu, IOS Press. http://www.lucs.lu.se/People/Peter.Gardenfors/Articles/Fois2004PG.doc

Gärdenfors, P (2003) How Homo became sapiens: On the evolution of thinking, Oxford University Press

Gärdenfors, P (2000) Conceptual Spaces, Bradford Books, MIT Press

Gärdenfors, P, Zlatev J.and Persson T. (2005) Bodily mimesis as 'the missing link' in human cognitive evolution, Lund University Cognitive Studies 121, Lund. http://www.lucs.lu.se/ftp/pub/LUCS_Studies/LUCS121.pdf

Hansen, M., Pfitzmann, A. (2004). Anonymity, Unobservability, Pseudonymity, and Identity Management – A Proposal for Terminology, v0.21.

Haugeland, J. (1985): Artificial Intelligence: the very idea. The MIT Press, Cambridge, Mass

Hempel, C.G. and P. Oppenheim (1948), *Studies in the Logic of Explanation*, Philosophy of Science 15: 135-75

Hendry R. F. and Psillos S., 2004, How To Do Things With Theories: An Interactive View of Language and Models in Science in K. Paprzycka and P. Przybysz (eds.) Idealization and Concretization, Rodopi

Hes, R. and Borking, J. (Eds.) (2000) Privacy-enhancing technologies: The path to anonymity. Revised edition. Registratiekamer, The Hague, August 2000. http://www.cbpweb.nl/downloads_av/AV11.PDF

Hilpinen, R., 1983, On C. S. Peirce's theory of proposition: Peirce as a precursor of game-theoretical semantics. In E. Freeman (ed.), The Relevance of Charles Peirce, pp. 264-270. The Hegeler Institute, La Salle.

Hinde S (2001) 2001: A Privacy Odyssey. Computers and Security, Vol. 20

Hinde, S. (2002) 2001: A Privacy Odyssey Revisited. Computers and Security, Vol. 21, No. 1

Hinman, L.M. (2002) A Moral Challenge: Business Ethics after Enron, The San Diego Union-Tribune.

Hintikka J. and Sandu G., 1997, Game-theoretical semantics, in Handbook of Logic and Language, ed. Van Benthem and ter Meulen, Elsevier, Amsterdam: 361-410.

Hintikka J., Logic, Language-Games and Information: Kantian Themes in the Philosophy of Logic, Clarendon Press, Oxford 1973.

Hodges W., Logic and Games, The Stanford Encyclopedia of Philosophy (Winter 2004 Edition), Edward N. Zalta (ed.), URL = <http://plato.stanford.edu/archives/win2004/entries/logic-games/>.

Holgate J (2002) The Phantom of Information- Peripatetic thoughts on information language and knowing http://www.mdpi.net/ec/papers/fis2002/183/phantom-holgate.htm

Human Rights Act 1998 http://www.hmso.gov.uk/acts/acts1998/80042--d.htm

Israel, D. J. (1989) Concepts of Information: Comparative Axiomatics. in Philosophical Logic and Artificial Intelligence, Kluwer Academic Publishers.

Israel, D. J. (1983) A Prolegomenon to Situation Semantics, in Proceedings of the Conference of the Association for Computational Linguistics, Cambridge.

Jakobson, R. and Halle M. (1956) Fundamentals of Language. The Hague: Mouton

Jaffe, A. and Quinn, F., 1993, `Theoretical mathematics': Toward a cultural synthesis of mathematics and theoretical physics. Bulletin of the American Mathematical Society, Vol. 29 No. 1: 1-14

Japaridze G., 2006, In the beginning was game semantics. In: Logic and Games: Foundational Perspectives. O. Majer, A.-V. Pietarinen and T. Tulenheimo, eds. Springer Verlag, Berlin (to appear).

Johansson, L-G. , 1999, Introduktion till Vetenskapsteorin (In Swedish), Thales

Johnson DG (1997) Ethics Online. Association for Computing Machinery. Communications of the ACM.

Johnson, D.G. (2003) Computer Ethics. The Blackwell Guide to the Philosophy of Computing and Information. Luciano Floridi Ed. Blackwell Publishing

Johnson, D.G. and Powers, M.T. (2004) Computers as Surrogate Agents, ETHICOMP 2004

Kainulainen, A. (2001) Trust and Ubiquitous Computing, http://www.cs.uta.fi/~anssi/work/cogscisempres_7.4.2001.ppt#258,1,Trust%20and %20Ubiquitous%20Computing

Kelly K. T., 2004, Uncomputability: the problem of induction internalized, Theoretical Computer Science 317, 227 – 249

Kim, J. (1989), *Mechanism, Purpose, and Explanatory Exclusion*, *Philosophical Perspectives* 3: 77-108.

Koehn, D. (1998) Rethinking Feminist Ethics: Care, Trust and Empathy, Routledge

Kripke, S. (1972), *Naming and Necessity*, in Davidson and Harman (1972).

Kuhn, T. (1962), The Structure of Scientific Revolutions, Chicago: Univ. Chicago Press

Kuipers T.A.F., 2006 Theories looking for domains. Fact or fiction? Structuralist Truth Approximation by Revision of the Domain of Intended Applications, to appear in: L. Magnani (ed.), Model-Based Reasoning in Science and Engineering.

Kuipers, T. A. F., (to appear), Empirical and conceptual idealization and concretization. The case of truth approximation, in (English and Polish editions of) Liber Amicorum for Leszek Nowak

Kuipers, T. A. F., 1987, ed., What is closer-to-the-truth? A parade of approaches to truthlikeness, Poznan Studies in the Philosophy of the Sciences and the Humanities, Volume 10, Amsterdam: Rodopi

Kuipers, T. A. F., 2002, Inductive Aspects of Confirmation, Information, and Content, To appear in the Schilpp-volume The Philosophy of Jaakko Hintikka

Kuipers, T.A.F., 2000, From instrumentalism to constructive realism: on some relations between confirmation, empirical progress, and truth approximation - Dordrecht Kluwer Academic

Kurzweil R (1999) The Age of Spiritual Machines, When Computers Exceed Human Intelligence Viking, http://www.kurzweilai.net/meme/frame.html?m=15

Kurzweil, Ray (2002). *Reflections on Stephen Wolfram's "A New Kind of Science*, http://www.kurzweilai.net/meme/frame.html?main=/articles/art0464.html

Landauer R., *The physical nature of information*, Phys. Lett. A 217, 1996, p. 188.

Laudan L., 1996, Beyond Positivism and Relativism: Theory, Method and Evidence, Westview Press

Leibniz, GW (1697) *On the Method of Distinguishing Real from Imaginary Phenomena*, in Gottfried Wilhelm Leibniz: Phylosophical Papers and Letters, ed. Leroy E. Loemaker (Dodrecht, Reidel, 1969)

Lelas, S., (2000), Science and Modernity, Kluwer Academic Publishers

Leyton, M. Process Grammar. http://www.rci.rutgers.edu/~mleyton/freeform1.htm

Lloyd S (2006) *Programming the Universe: A Quantum Computer Scientist Takes on the Cosmos,* Alfred A. Knopf

Lycan, W.G. (1987) *Consciousness*. Cambridge, Massachusetts: MIT Press.

MacKay, D. M., 1969, Information, Mechanism and Meaning. Cambridge, MA: MIT Press

MacKenzie, D. (1997) Privacy police caution Big Brother. New Scientist vol 154 - 12, p4

MacLennan B., Natural computation and non-Turing models of computation, Theoretical Computer Science 317 (2004) 115 – 145

Magnani L. (ed.) (2006), Computing and Philosophy, Associated International Academic Publishers, Pavia (Proceedings of the International Conference E-CAP2004).

Magnani L. (ed.), Model-Based Reasoning in Science and Engineering, College Publications, London (Proceedings of the International Conference MBR04).

Magnani L. (forthcoming), Knowledge as a Duty. Distributed Morality in a Technological World, Cambridge University Press, Cambridge.

Magnani L. and Dossena R. (eds.) (2005), Computing, Philosophy and Cognition, College Publications, London (Proceedings of the conference E-CAP2004).Marijuán P. C. 2004, Information and Life: Towards a Biological Understanding of Informational Phenomena, TripleC 2(1): 6-19, ISSN 1726-670X, http://tripleC.uti.at

Magnani L., Nersessian N. J. and Thagard P. ed. (1999) Model-based Reasoning In Scientific Discovery, Kluwer, NY

Marijuan, P. C., 2003, Foundations of Information Science: Selected papers from FIS 2002. Entropy 5, 214-219

Martin, M., Schinzinger, R., (1989), Ethics In Engineering, McGraw-Hill

Mason RO (2000). A tapestry of Privacy, A Meta-Discussion. Retrieved December 11, 2004, from http://cyberethics.cbi.msstate.edu/mason2/

Mason RO, A tapestry of Privacy, A Meta-Discussion. http://cyberethics.cbi.msstate.edu/mason2/

Matsuno, K. (1993) Semantic Openness: A Major Evolutionary Force" Talk at a WESS meeting http://bio.nagaokaut.ac.jp/~matsuno/OPENNESS.htm

Maturana H. and Varela F., (1992) The Tree of Knowledge, Shambala

Maturana H. and Varela F., (1980) Autopoiesis and Cognition: The realization of the living. D. Reidel

McCrone, J (1995) Watching you, watching me. New Scientist, 36-9

Meystel, A., "Nested Hierarchical Control", In *An Introduction to Intelligent and Autonomous Control*, (Antsaklis, P.J., and Passino, K.M. eds.), Kluwer, 1993

Meystel, A., *Autonomous Mobile Robots: Vehicles with Cognitive Control*, World Scientific, 1991

Meystel, A., *Semiotic Modeling and Situation Analysis: An Introduction*, AdRem, Inc., 1995

Millikan, R.G. (1984), *Language, Thought and Other Biological Categories*. Cambridge, Massachusetts: MIT Press.

Milner R., Communication and Concurrency, Prentice-Hall, 1989.

Mitcham, C., (1994), Thinking Through Technology: The Path Between Engineering and Philosophy, Univ. of Chicago Press

Mizutani M, Dorsey J, Moor JH (2004) The internet and Japanese conception of privacy. Ethics and Information Technology

Moor JH (1985) What is computer ethics? Metaphilosophy 16/4. http://www.ccsr.cse.dmu.ac.uk/staff/Srog/teaching/moor.htm

Moor JH (1985). What is computer ethics? Metaphilosophy, 16/4. http://www.ccsr.cse.dmu.ac.uk/staff/Srog/teaching/moor.htm

Moor JH (1997). Towards a Theory of Privacy for the Information Age. Computers and Society, Vol. 27, No. 3.

Moor, J.H. (2004) Towards a Theory of Privacy in the Information Age. Computer Ethics and Professional Responsibility, Bynum, T.W. and Rogerson, S. Edts., Blackwell Publishing

Moore C., Recursion theory on real- and continuous-time computation. Theoretical Computer Science 162 (1996), 23-44

Moore, B, Jr. (1994). Privacy: Studies in Social and Cultural History. Armonk, NY: M. E. Sharpe, Inc.

Morowitz, H. J. (2004), *The Emergence of Everything. How the World Became Complex,* Oxford University Press

Mulhauser, G.R. (1997) *Mind Out of Matter: Topics in the Physical Foundations of Consciousness and Cognition*. Dordrecht: Kluwer Academic Publishers.

Mundie, C, de Vries, P, Haynes, P and Corwine M, (2003) Trustworthy Computing White Paper http://www.microsoft.com/mscorp/twc/twc_whitepaper.mspx

Mundie, C., de Vries, P., Haynes, P. and Corwine M, (2003) Trustworthy Computing White Paper http://www.microsoft.com/mscorp/twc/twc_whitepaper.mspx

Nadel, L., Stein, D. L., (eds.), *1993 Lectures in Complex Systems*, Addison-Wesley, Reading, MA 1995

Newell, A., "Reflections on the knowledge level", *Artificial Intelligence*, v. 59, 1993, pp. 31-38

Newell, A., Simon, H. A., *Human Problem Solving*, Prentice Hall, Englewood Cliffs, NJ, 1972

Oddie, G., 2001, Truthlikeness, The Stanford Encyclopedia of Philosophy, E.N. Zalta (ed.),

OECD Guidelines on the Protection of Privacy - Recommendation of the Council Concerning Guidelines Governing the Protection of Privacy and Transborder Flows of Personal Data (23rd September, 1980)

Omnes, R. (1994) *The Interpretation of Quantum Mechanics*. Princeton: Princeton University Press.

Ören, T.I., 2001, Impact of Data on Simulation: From Early Practices to Federated and Agent-Directed Simulations. In: A. Heemink et al. (eds.) Proc. of EUROSIM 2001, June 26-29, Delft, the NetherlandsAbramsky S., Concurrent Interaction Games, in Millennial Perspectives in Computer Science, J. Davies, A. W. Roscoe and J. Woodcock, eds. (Palgrave) 2000, 1--12.

Papineau, D. (1987) *Reality and Representation*. Oxford: Blackwell.

Perlovsky, L.I. *Computational concepts in classification: neural networks, statistical pattern recognition, and model based vision, Journal of Mathematical Imaging and Vision*, 4 (1), 1994.

Pierce D., Challenges/Threats to Privacy http://www.inetdevgrp.org/20001017/index.html

Pietarinen, A. and. Sandu G., 1999, Games in philosophical logic, Nordic Journal of Philosophical Logic, vol. 4, pp. 143--73.

Poincaré, H., 1982, Science and Method, New York: Dover

Popper, K.R. (1999), The Logic of Scientific Discovery, Routledge

Pottie GJ (2004) Privacy in the Global Village, Communications of the ACM, 47(2): 2-23

Pottie GJ (2004). Privacy in the Global Village. Communications of the ACM, 47(2): 2-23.

Pottie, G.J. (2004) Privacy in the Global Village, Communications of the ACM, 47(2): 2-23

Powers TM (2004) Real wrongs in virtual communities, Ethics and Information Technology, Volume 5, Issue 4, 191-198

Priest, G., Tanaka, K., Paraconsistent Logic, The Stanford Encyclopedia of Philosophy (Winter 2004 Edition), Edward N. Zalta (ed.), URL = <http://plato.stanford.edu/archives/win2004/entries/logic-paraconsistent/>.

Privacy and Human Rights 2004, An International Survey of Privacy Laws and Developments. Retrieved December 11, 2004, http://www.privacyinternational.org/survey/phr2004

Psillos S., 1997, Naturalism Without Truth? Stud. Hist. Phil. Sci., Vol. 28, No.4, pp. 699-713

Putnam, H. (1988) *Representation and Reality*. Cambridge, Massachusetts: MIT Press.

Raatikainen P., Complexity and Information -A Critical Evaluation of Algorithmic Information Theory

Research Projects at Carnegie Mellon CyLab http://www.cylab.cmu.edu/default.aspx?id=10)

Rheingold, H., (1985), Tools For Thought: The History and Future of Mind-Expanding Technology, Simon & Schuster

Rosen J (2000) Why Privacy Matters, Wilson Quarterly. Vol 24, Issue 4

Rosenbloom, P. S., Laird, J. E., A. Newell, (eds.), *The Soar Papers: Research on Integrated Intelligence*, vv I and II, MIT, Cambridge, MA 1993

Russell, S., Norvig, P., *Artificial Intelligence: A Modern Approach*, Prentice Hall, Upper Saddle River, 1995

Savage, C.W., ed. (1978) *Perception and Cognition: Issues in the Foundations of Psychology*. Minnesota Studies in the Philosophy of Science, vol. 9. Minneapolis: University of Minnesota Press.

Schachter, How Does Concurrency Extend the Paradigm of Computation?, Monist; 1999, Vol. 82 Issue 1, p37, 21p

Sebeok, T. A., Signs: *An Introduction to Semiotics*, University of Toronto Press, Toronto, 1994

Seife C (2006) *Decoding the Universe: How the New Science of Information is Explaining Everything in the Cosmos, From Our Brains to Black Holes,* Viking, London

Sells, P., Shieber, S. M., Wasow, T., *Foundational Issues in Natural Language Processing*, MIT Press, Cambridge, MA 1991

Shannon, C. E., 1948, A mathematical theory of communication. Bell Sys. Tech. J., 27, 323-332; 379-423.

Shannon, C.E. and W. Weaver. (1949) *The Mathematical Theory of Communication*. Urbana, Illinois: University of Illinois Press.

Siegelman, H.T. and E.D. Sontag. (1994) 'Analog computation via neural networks', *Theoretical Computer Science* 131: 331-60.

Siegelman, H.T. Neural Networks and Analog Computation, Birkhauser, Berlin, 1999

Sipper M., Machine Nature: The Coming Age of Bio-Inspired Computing, McGraw-Hill, New York, 2002.

Sixth Programme (FP6) of the European Union, Citizens and governance in a knowledge-based society theme. (http://www.cordis.lu/fp6/citizens.htm)

Smith, B.C, (1995), On the Origin of Objects, MIT

Sokal A. D., (1996), “Transgressing the Boundaries: Towards a Transformative Hermeneutics of Quantum Gravity” in Social Text 46/47, pp. 217-252

Solove, D. (2004) The digital person: Technology and privacy in the information age, New York University Press, New York

Spinello RA (2003). Cyberethics Morality and Law in Cyberspace. Jones and Bartlett Publishers.

Squire K. D.: Replaying History: Learning World History through playing Civilization III, Phd thesis, School of Education, Indiana University, Bloomington, IN, May 2004.

Sterelny, K., 1990, *The Representational Theory of Mind*. Oxford: Basil Blackwell.

Stich S. (1993) Naturalizing Epistemology: Quine, Simon and the Prospects for Pragmatism in C. Hookway & D. Peterson, eds., Philosophy and Cognitive Science, Royal Institute of Philosophy, Supplement no. 34 (Cambridge: Cambridge University Press) Pp. 1-17.

Stojanov G, Kulakov A

Stonier, T., 1993, The Wealth of Information, Thames/Methuen, London

Stonier, T., 1997, Information and Meaning. An Evolutionary Perspective, Springer, Berlin, New York

Strawson, P. F. (1959). Individuals. An essay in descriptive metaphysics. Methuen.

Taddeo, M. and Floridi, L. (2005) Solving the Symbol Grounding Problem: a Critical Review of Fifteen Years of Research, Journal of Experimental and Theoretical Artificial Intelligence, Volume 17, Number 4, pp. 419-445(27)

Tavani H. (2002) The uniqueness debate in computer ethics: What exactly is at issue, and why does it matter?, Ethics and Information Technology 4: 37–54, and references therein

Tavani HT & Moor JH (2000). Privacy Protection, Control of Information, and Privacy-Enhancing Technologies. Proceedings of the Conference on Computer Ethics-Philosophical Enquiry.

Tavani HT (2002). The uniqueness debate in computer ethics: What exactly is at issue, and why does it matter? Ethics and Information Technology, 4: 37–54, and references therein.

Tavani HT, Moor JH (2000) Privacy Protection, Control of Information, and Privacy-Enhancing Technologies. Proceedings of the Conference on Computer Ethics-Philosophical Enquiry

Thagard, P.R.,(1993), Computational Philosophy of Science, MIT Press

Thill, G (1994), The relevance of associative networks for a sustainable information and communication society, AI and Society, 6.1: 70-77

Thompson PB (2001). Privacy, secrecy and security. Ethics and Information Technology, 3.

Tranströmer, T., New Collected Poems, Translated by Robin Fulton, Bloodaxe books, 1997, p.122

Turkle, S. (1996). Who am we? Wired, 4(1), 148-152, 194-199

United Nations (1948). Universal Declaration of Human Rights, General Assembly resolution 217 A (III). http://www.un.org/Overview/rights.html

van Benthem J., Adriaans P., eds., 2005, Handbook on the Philosophy of Information, (In Gabbay D., Thagard P., and Woods J., Handbook of the philosophy of science, to be published by Elsevier

Vance, D. The Place of Cyberethics, Information Systems Ethics, http://cyberethics.cbi.msstate.edu/

Vu Uyen (2004) Employees resistant to any form of computer video monitoring, study says. Canadian HR Report, March 8

Wagner C & Cheung K & Lee F & Ip R (2003). Enhancing e-government in developing countries: managing knowledge through virtual communities. The Electronic Journal on Information Systems in Developing Countries, 14, 4, 1-20.

Wagner, C, Cheung K, Lee F, Ip R (2003) Enhancing e-government in developing countries: managing knowledge through virtual communities. The Electronic Journal on Information Systems in Developing Countries, 14, 4, 1-20

Wakefield, R.L. (2004) Computer Monitoring and Surveillance – Balancing Privacy with Security. The CPA Journal

Warren S & Brandeis LD (1890). The Right to Privacy. Harvard Law Review, Vol. 4, No. 5 .

Warren, S.D. and Brandeis, L.D. (1890) The Right to Privacy, Harvard Law Review, 1890-91, No.5, 193-220. http://www.lawrence.edu/fast/boardmaw/Privacy_brand_warr2.html

Wayner, P. (2004) The Power of Candy-Coated Bits. IEEE Security & Privacy, Vol. 2, No. 2, March-April 2004, 69-72.

Weckert J. (2001). Computer Ethics: Future directions. Ethics and Information Technology, 3.

Wegner P., 1998, Interactive Foundations of Computing, Theoretical Computer Science 192 315-51.

Weinberg, S. (1996), Sokal's Hoax, The New York Review of Books, Volume XLIII, No. 13, pp 11-15

Weinberg, S. (2001), Can Science Explain Everything? Anything?, The New York Review of Books, May 31, 2001

Weiser, M. (1995) The Technologist's Responsibilities and Social Change, Computer-Mediated Communication Magazine, Vol. 2, No. 4, p. 17

White, D. A., Sofge, D. A., 1992, *Handbook of Intelligent Control*, VNR, New York

Whitehead, A. N (1978) Process and Reality: An Essay in Cosmology. New York: The Free Press

Whitehead, A. N., (1997), *Science and the Modern World*, New York: Free PressAnderson, C. A. and

Whitehead, A. N., (1967) *Adventures of Ideas*, Free Press

Whitworth B & de Moor, A (2003) Legitimate by design: Towards trusted virtual community environments. Behaviour and Information Technology, 22:1, p31-51.

Whitworth B, de Moor, A (2003) Legitimate by design: Towards trusted virtual community environments. Behaviour and Information Technology 22:1, p31-51.

Whitworth, B. and de Moor, A. (2003) Legitimate by design: Towards trusted virtual community environments. Behaviour and Information Technology 22:1, p31-51.

Wiener, N. (1968) The Human Use of Human Beings. London, Sphere Books

Wildberger, A.M., 2000, AI & Simulation, Simulation, 74

Winograd, T., 1997, The design of interaction. Beyond Calculation: The next 50 years of computing. Copernicus, 149-161

Wolfram, A New Kind of Science

Wolfram, S (2002). A New Kind of Science. Wolfram Science

Yu, E. and Cysneiros, L. (2002) Designing for Privacy and Other Competing Requirements. 2nd Symposium on Requirements Engineering for Information Security (SREIS'02), Raleigh, North Carolina, October 16, 2002. http://www.cs.toronto.edu/pub/eric/SREIS02-Priv.pdf

Zyda M., et al., Entertainment R&D for Defense, IEEE Computer Graphics and Applications, pp. 28-36, 2003.Agre PE & Rotenberg M ed. (1997). Technology and Privacy: The New Landscape. MIT Press

Paper A

Paper A

SHIFTING THE PARADIGM OF THE PHILOSOPHY OF SCIENCE: THE PHILOSOPHY OF INFORMATION AND A NEW RENAISSANCE

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Abstract

Abstract. *Computing is changing the traditional field of Philosophy of Science in a very profound way. First as a methodological tool, computing makes possible "experimental Philosophy" which is able to provide practical tests for different philosophical ideas. At the same time the ideal object of investigation of the Philosophy of Science is changing. For a long period of time the ideal science was Physics (e.g. Popper, Carnap, Kuhn, and Chalmers). Now the focus is shifting to the field of Computing/Informatics. There are many good reasons for this paradigm shift, one of those being a long standing need of a new meeting between the sciences and humanities, for which the new discipline of Computing/Informatics gives innumerable possibilities. Contrary to Physics, Computing/Informatics is very much human-centered. It brings a potential for a new Renaissance, where Science and Humanities, Arts and Engineering can reach a new synthesis, so very much needed in our intellectually split culture. This paper investigates contemporary trends and the relation between the Philosophy of Science and the Philosophy of Computing and Information, which is equivalent to the present relation between Philosophy of Science and Philosophy of Physics.*

Key words:

Computation, Digital Philosophy, Information, Information Society, Information Technology, Information-theoretic Methodology, Philosophy of AI, Philosophy of Computer Science, Philosophy of Computing, Philosophy of Information, Philosophy of Science.

1 What Ultimately Matters, Indeed?

The ideal of Science of the 20th century was Physics (Popper, 1999; Carnap, 1994; Kuhn, 1962; Chalmers, 1990): *relativity*, *quantum mechanics* and finally, *chaos*. Physics was the model of scientific understanding of reality. Questions in focus were:

What is the (physical) Universe (microcosm, macrocosm)?

How is the Universe built up? How does it work (interactions, symmetries)?

What is matter/energy, time, space?

On the threshold of the new millennium we have answers to those questions that seem to fulfill our present needs. At the same time the efforts necessary to further improve knowledge within Physics exceed by orders of magnitude corresponding efforts needed to improve other basic scientific disciplines of interest. Therefore the paradigm of Science changes rapidly.

Historically, parallel with the growth of the body of physical theory, there was the emergence of the "intentional sciences": disciplines that deal with symbols, references and interpretations, such as Logic, Cognitive Science, Psychology, and Neuroscience, parts of Biology and Computing. These new sciences are changing our concept of reality, and that of the relation between Science and reality. Truth and meaning have been brought within the scope of Science pertaining to the completely new context. The views of realism and metaphysics are being modified. Scientists are starting to scrutinize fields of norms and values. Traditionally, it is in Philosophy or in the religious domain that questions of most general significance have been asked, as e.g.: What ultimately matters? (See Dodig-Crnkovic 2001).

In the last century expectations on Science have grown enormously. Whether it knows it or not, Science seems to be entering into the classically philosophical and theological territory taking the place of highest authority. New questions in focus are:

- What is life (its laws, mechanisms, limitations)?
- What is mind?
- What is meaning?

Computing has many interesting methods and techniques making possible new insights that can contribute towards clarifying the above ideas, as for example the issues related to meaning such as truth, proof, and symbol manipulation (how symbols acquire meaning), “location” of meaning, form.

2 What is Computing?

According to ACM/IEEE (2001), Computing can be described as encompassing Computer Science, Computer Engineering, Software Engineering and Information Systems:

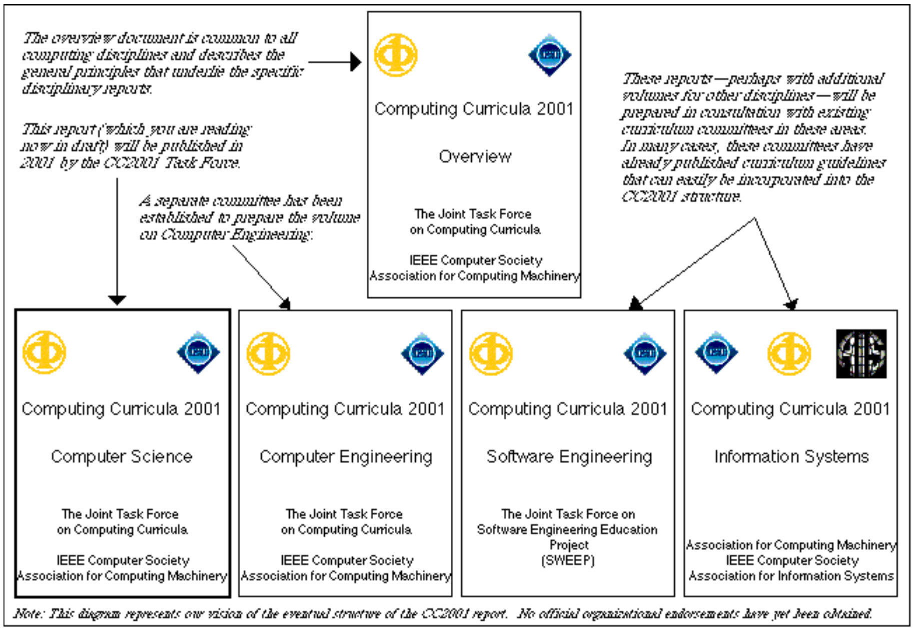

Figure 1: Field of Computing.

The German, French and Italian languages use the respective terms "Informatik", "Informatique" and “Informatica” (Informatics in English) to denote Computing. It is interesting to observe that the English term "Computing" has an empirical orientation, while the corresponding German, French and Italian term “Informatics” has an abstract orientation. This difference in terminology may be traced back to the tradition of nineteenth-century British empiricism and continental abstraction respectively.

The view that information is the central idea of Computing/Informatics is both scientifically and sociologically indicative. Scientifically, it suggests a view of Informatics as a generalization of information theory that is concerned not only with the transmission/communication of information but also with its transformation and interpretation. Sociologically, it suggests a parallel between the industrial revolution, which is concerned with the utilizing of energy, and the information revolution, which is concerned with the utilizing of information.

3 Glimpses of the Philosophy of Artificial Intelligence

Questions of relevance for the Philosophy of Science (as e.g. concepts of mind and meaning) have many practical consequences in the field of the Philosophy of Artificial Intelligence, AI. Among others there is an interesting current controversy about Machines and Minds. The questions simplified are as follows:

- Can machines be intelligent (think)?
- Can machines have self-consciousness?
- Can machines have a soul?

As usual in the history of important controversies there are two confronting groups claiming opposite answers to these questions. That debate is in many ways instructive. First of all it is because it reveals our basic attitude to the question of what ultimately matters? Secondly, and at least equally interesting and illustrative, is the argument itself.

There are a number of results of mathematical logic used to show that there are limitations to the powers of (discrete-state) machines. The best known of these results is Gödel's theorem (1931) which shows that in any sufficiently powerful logical system statements can be formulated which can neither be proved nor disproved within the system, unless the system itself is inconsistent. It is established that there are limitations to the powers of any particular (discrete state) machine due to Gödel's theorem. Yet it has only been stated without any sort of proof that no such limitations apply to the human intellect (which is actually as a rule both incomplete and inconsistent…).

One can as well ask more pragmatic questions, as e.g.: Can a machine be made which can:

- Pass the Turing test
- Create an artefact that can be acknowledged as genuine by experts (compose music, write a sonnet…)
- Prove theorems/check theorem proofs through the "mechanization" of reasoning

- Posses the best knowledge within a certain field and can act like an expert system (medical expertise helping to set an accurate diagnosis), etc.

The question is: does it necessarily need to be one single machine? Do we need humanoid machines? There is namely a difference between the ambition of *representing the common behavior (including knowledge) of the average person and the attempt to construct the machine able to compete with the best of scientists, artists, philosophers etc. within their special fields*.

Part of AI research's objectives is to understand the *computational* principles underlying intelligence in man and machines and to develop methods for building computer-based systems to solve problems, to communicate with people, and to perceive and interact with the physical world. Floridi, 2002, in "What is the Philosophy of Information?", calls the Philosophy of Artificial Intelligence a premature paradigm of the Philosophy of Information, PI.

The researchers in Artificial Intelligence have discovered a wide variety of ways to make machines do pattern recognition, learning, problem-solving, theorem-proving, game-playing, induction and generalization, and language manipulation, to mention only a few. AI is a steadily growing field within computing. To be sure, none of the different AI programs seemed much like a mind, because each one was so specialized. But now we are beginning to understand that there may be no need to seek either any single magical "unified theory" or any single and hitherto unknown "fundamental principle". Thinking may instead be the product of many different mechanisms, competing as much as cooperating, and generally unperceived and unsuspected in the ordinary course of our everyday thought.

What has all this to do with consciousness? Well, consider what happened in biology. Before the 19th century there seemed to be no other explanation of the phenomenon of life but the concept of "vitality" i.e. some sort of life-force. There simply seemed no other way to explain all the things that animals do. But then, scientists gradually came to see no need for a "unified theory" of life. Each living thing performed many functions, but it slowly became clear that each of them had a reasonably separate explanation. The same may apply to the mind.

The next fundamental question is if we can claim to understand the phenomena only on account of their experimental predictability and reproducibility? Does the answer to the question "how?" automatically mean the answer to the question "why?". If we construct the machine that can distinguish sweet from bitter, can we say that *we* understand what "sweet" and “bitter” means? Can we say that *the machine* understands what “sweet” and “bitter” means?

4 What Is That Thing Called Science?

“The whole is more than the sum of its parts.”

(Aristotle, Metaphysica)

In order to be able to talk about Computing, let us take a closer look at the very definition of Science. Saying “Science” we actually mean a plurality of different Sciences. Different Sciences differ very much from one another. The definition of Science is therefore neither simple nor unambiguous. For example, History and Linguistics are often but not always catalogued as Sciences. (See Dodig-Crnkovic 2002).

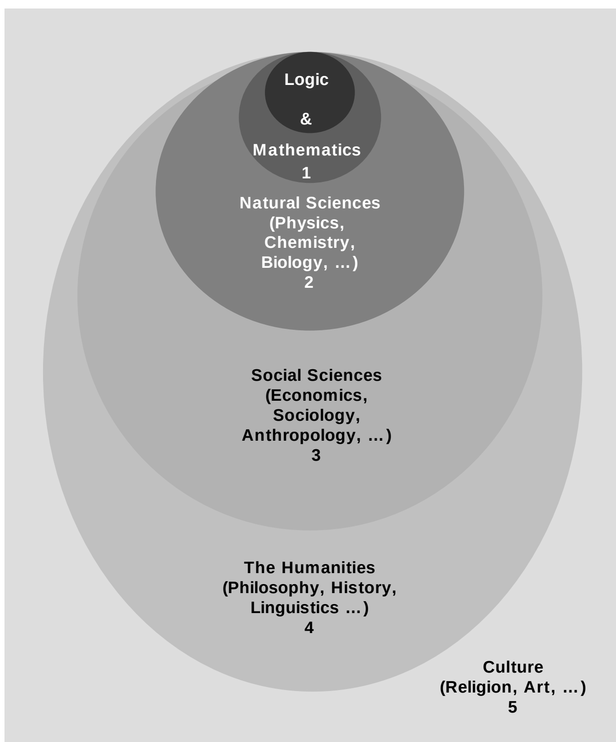

Figure 2. What is Science? - Classical scheme.

The traditional Sciences have *specific areas of validity*. Logic and Mathematics (the most abstract and at the same time the most exact Sciences) are a more or less important part of every other Science. They are very essential for Physics, less important for Chemistry and Biology and their significance continues to decrease towards the outer regions of our scheme. Logical reasoning as a basis of all human knowledge is of course present in every kind of Science as well as in the Humanities.

Figure 2 may be seen in analogy with a microscope view. With the highest resolution we can reach the innermost region. Inside the central region Logic is not only the tool used to form conclusions; it is at the same time the object of investigation. Even though large parts of Mathematics can be reduced to Logic (Frege, Russell and Whitehead), complete reduction is impossible. On every step of zooming out, the inner regions are given as prerequisites for the outer ones. Physics uses Mathematics and Logic as tools, without questioning their internal structure. In that way information about the deeper structure of Mathematics and Logic is hidden looking from the outside. In much the same way, Physics is a prerequisite for Chemistry that is a hidden level inside Biology etc. The basic idea of Figure 2 is to show in a schematic way the relation between the three main groups of Sciences (Logic & Mathematics, Natural Sciences and Social Sciences) as well as their relation to the Humanities, and finally to the cultural environment which the whole body of human knowledge, scientific and artistic, is immersed in and impregnated by.

However, such distinctions of sciences are quite recent, having their origins in the 16^{th} and 17^{th} centuries. In the Middle Ages "Science" was a very different type of academic discipline. Natural Philosophy was the term applied to what would now be known as Physics, but in the medieval era it was a very profound and philosophical subject.

Universities in the Middle Ages were of two main types: "Master Universities" such as Paris or "Student Universities" such as Bologna. The curriculum followed the division of the seven liberal arts into the lower level *Trivium*: Grammar, Rhetoric and Logic and the more advanced *Quadrivium*: Music, Arithmetic, Geometry and Astronomy. These subjects were studied in order to give the student an academic and intellectual foundation before studying the most important part of their course of studies, the three Philosophies - Natural, Metaphysical and Moral. The advanced student was expected to study the Ethics, Physics and Metaphysics of Aristotle and be able to demonstrate significant ability to dispute these topics in learned debate.

It is interesting to notice that during the Middle Ages no sharp distinction was made between Natural Science and religion, magic and the occult, because physical and magical causes were accepted as being equally likely to be responsible for physical phenomena. For example, medieval Astronomy encompassed the disciplines of Astrology and Cosmology.

Early Science (Alchemy, Astronomy, Botany, Cartography, Horology [Time, Calendars], Instruments [Weights, Measures], Mathematics, Medicine, Physics, Technology, Astrology …) was not a neat orderly system. It was a deeply interconnected blend of philosophy, magic, analysis, observation, experimentation and religion. But from these confusing origins scholars slowly began to develop the fields of science with which we are today familiar.

5 The Scientific Method

Having in mind its historical development, we may ask the question: what characterises Science? And a most common answer is: the method. Since the scientific revolution of the sixteenth and seventeenth centuries, many have also argued that Science strives to produce explanations in terms of matter, energy, symmetry, and number, the framework of ideas associated with Descartes, Copernicus, Galileo, Hobbes, Newton, Locke, etc.

This is the reductionist programme of modern Science. Its ideal is a minimum number of the most general laws, expressed by mathematical formulas, that assure description of phenomena, their behavior and precise quantitative prediction.

Traditionally, the reductionist ideal is also implicit in the ranking of disciplines which places Mathematics and most reductionist Natural Sciences, e.g., Physics and Chemistry, above Biology. Within the field of Biology, Bioinformatics, Molecular Biology and Biochemistry rank above Physiology, Morphology, Taxonomy, Ethology and Evolutionary Psychology. Biologists, in turn, are considered more scientific than behavioral and social scientists. The Medical Sciences are all over this map, since some are exquisitely experimental and quantitative, e.g., Neurochemistry and Endocrinology, while others are far from being so, e.g., Psychiatry and Psychotherapy. Outside all this are the Humanities. Nevertheless there are attempts to conform with the reductionist scientific ideal even within the Humanities, and attempts are made to found Linguistics, History and even parts of Philosophy (such as Epistemology) as exact sciences. The question is, however, what sort of method could be common for all those different sciences, that are "scientific" in their specific and varying ways?

The scientific method may be described as the logical scheme used by scientists searching for answers to the questions posed within Science. Scientific method is used to produce scientific theories, including both scientific meta-theories (theories about theories) as well as the theories used to design the tools for producing theories (instruments, algorithms, etc). The simple version looks something like this:

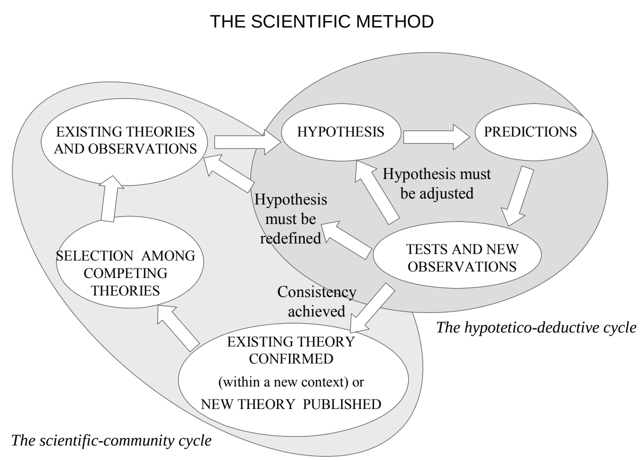

Figure 3. Diagram describing iterative nature of the scientific method.

It is crucial to understand that the method of Science is *recursive*. Prior to every observation or experiment or theoretical test there is a hypothesis that has its origins in the pre-existing body of knowledge. Every experimental/observational result has a certain world view built in. Or, in the words of Feyerabend, 2000, every experimental data is "theory-contaminated".

The scheme of the scientific method in Figure 3 is without doubt an abstraction and simplification. Critics would argue that there is in fact no such thing as "the scientific method". By the term "the scientific method" they actually mean the concrete set of rules defining how to proceed in posing new relevant questions and formulating successful hypotheses. Of course, no such magic recipe exists!

The important feature of the scientific method is that it is impartial ("objective"): one does not have to believe a given researcher; one can (in principle) repeat the experiment/theoretical derivation and determine whether certain results are valid or not. The question of impartiality is closely related to the openness and universality of Science, which are its fundamental qualities. A theory is accepted based in the first place on the results obtained through logical reasoning, observations and/or experiments. The results obtained using the scientific methods have to be reproducible. All scientific truths are provisional. But for a hypothesis to acquire the status of a theory it is necessary to win the confidence of the scientific community (the scientific community cycle of Figure 3).

6 Interdisciplinary Sciences

The development of human thought parallel to the development of human society has led to an emergence of sciences that do not belong to any of the classic types we have described earlier, but rather share common parts with several of these. Many of the modern sciences are of the interdisciplinary, eclectic type. It is a trend for new sciences to search their methods and even questions in very broad areas. It can be seen as a result of the fact that the communications across the borders of different scientific fields are nowadays much easier and more intense than before.

There are also new methodological trends that emerge as a consequence of the development of AI: more and more “manual work” of the scientist is now done by computers. The exciting new field of Automated Discovery is already showing results within Bioinformatics, Vision, Chemistry, Genetics, etc. We seem to be witnessing an exciting paradigm shift:

“We should, by the way, be prepared for some radical, and perhaps surprising, transformations of the disciplinary structure of Science (Technology included) as information processing pervades it. In particular, as we become more aware of the detailed information processes that go on in doing Science, the Sciences will find themselves increasingly taking a meta-position, in which doing Science (observing, experimenting, theorizing, testing, archiving) will involve understanding these information processes, and building systems that do the object-level Science. Then the boundaries between the enterprise of Science as a whole (the acquisition and organization of knowledge of the world) and AI (the understanding of how knowledge is acquired and organized) will become increasingly fuzzy.”

Allen Newell, in: D.G. Bobrow and P.J. Hayes, "Artificial Intelligence - Where Are We?" Artif. Intell. 25 (1985) 3.

Here we can find a potential of the new synthetic (holistic) world view that is about to emerge in the future.

Problem with the Traditional View: In What Way is Computing a Science? AI Example Again

Let us take as an example Artificial Intelligence (AI) that is a branch of Computing according to Computing Curricula. AI is a discipline with two distinct facets: Science and Engineering which is the case for Computer Science in general. The scientific part of AI attempts to understand intelligence in humans, other animals, information processing machines and robots. The engineering part attempts to apply such knowledge in designing new kinds of machines. AI is generally associated with Computing, but it has many important links with other fields such as Mathematics, Psychology, Cognition, Biology, Linguistics and Philosophy, Behavioral and Brain Sciences among many others. Our ability to combine knowledge from all these fields will ultimately benefit our progress in the quest of creating an intelligent artificial being.

The scientific branch, which has motivated most of the pioneers and leaders in the field, is concerned with two main goals attempting to:

- understand and model the information processing capabilities of typical human minds,
- understand the general principles for explaining and modeling intelligent systems, whether human, animal or artificial.

This work is often inspired by research in Philosophy, Linguistics, Psychology, Neuroscience or Social Science. It can also lead to new theories and predictions in those fields.

The engineering facet of AI is concerned with attempting to design new kinds of machines able to do things previously done only by humans and other animals and also new tasks that lie beyond human intelligence. There is another engineering application of AI: using the results of the scientific facet to help design machines and environments that can help human beings. This may include the production of intelligent machines.

The Complexity of AI and its numerous connections to other scientific and further cultural phenomena is suggested by the following table:

Table 1

Sub-fields of AI	Related Fields
Perception, especially vision but also auditory and tactile perception, and more recently taste and smell.	Philosophy, Cognition, Psychology, Mathematics, Biology, Medicine, Behavioral Sciences, Brain Sciences
Natural language processing, including production and interpretation of spoken and written language, whether hand-written, printed, or electronic throughout (e.g. email).	Linguistics, Psychology, Philosophy, Logic, Mathematics, Behavioral Sciences, Brain Sciences
Learning and development, including symbolic learning processes (e.g. rule induction), the use of neural nets (sometimes described as sub-symbolic), the use of evolutionary algorithms, self-debugging systems, and various kinds of self-organization.	Logic, Philosophy, Mathematics, Biology, Medicine, Behavioral Sciences, Brain Sciences
Planning, problem solving, automatic design: given a complex problem and a collection of resources, constraints and evaluation criteria create a solution which meets the constraints and does well or is optimal according to the criteria.	Logic, Mathematics, Philosophy
Robotics: provides a test bed for integrating theories and techniques from various sub-areas of AI, e.g. perception, learning, memory, motor control, planning, etc. exploring ideas about complete systems.	Philosophy, Cognition, Psychology, Mathematics, Biology, Medicine, Behavioral Sciences, Brain Sciences, Mechatronics

7 Scientific vs. Humanistic View

It is a notorious fact that contemporary scientists do not learn enough in their education and training about the Humanities. In particular, scientists are not expected to reflect over the moral, political and ideological forces and issues from which their work emerges and which it influences. At the same time, as C. P. Snow observed in his lecture on “The Two Cultures and the Scientific Revolution”, modern arts people know even less about Science and Technology. In this context also Alan D. Sokal’s famous hoax article**,** see Sokal A. D., (1996) is very instructive.

“The targets of Sokal's satire occupy a broad intellectual range. There are those "postmoderns" in the humanities who like to surf through avant garde fields like quantum mechanics or chaos theory to dress up their own arguments about the fragmentary and random nature of experience. There are those sociologists, historians, and philosophers who see the laws of nature as social constructions. There are cultural critics who find the taint of sexism, racism, colonialism, militarism, or capitalism not only in the practice of scientific research but even in its conclusions. Sokal did not satirize creationists or other religious enthusiasts who in many parts of the world are the most dangerous adversaries of science, but his targets were spread widely enough, and he was attacked or praised from all sides.“ (Weinberg, 1996)

This shows the width and depth of the existing gap between two cultures. For very interesting attempts to build across the gap, see Lelas, 2000, Mitcham, 1994 and Rheingold, 1985.

The separation of the consideration of technological development from moral, aesthetic, political and ideological determinations has become increasingly problematic. This separation impoverishes people trained in Science, Technology and Medicine, and ignorance of the scientific and technical side impoverishes those who study the Humanities.

Actually, Science, Technology and Medicine - far from being value-neutral - are the embodiment of values in theories, in facts and artefacts, in procedures and programs. All facts are theory-laden and all theories are value-laden, even if the value system is not explicitly given.

The essence of the Humanities is the exploration, maintaining and conducting debates about values. That is central to Literature, the Theatre, Fine Art, much of Philosophy, Cultural Studies, History, Classical Studies and much else.

The separation of fact and value which we associate with modern Science was an innovation of the seventeenth century. The framework of explanation which prevailed in ancient, medieval and Renaissance times was the Aristotelian one in which causes always occurred in fours:

- the material
- the efficient
- the formal and
- the final cause.

All four causes were required for a complete explanation.

Three of the four Aristotelian causes are still a part of the explanatory paradigm of modern Science. The material cause explains out of what kind of matter the effect comes (matter, including the atoms and fundamental particles). The efficient cause is that which imparts energy to the material object and would include intrinsic ideas of energy. The formal cause gives patterns, structures, symmetries. But the final cause or purpose was considered not objective and was abandoned. It is not a part of modern scientific explanation.

That is the idealised story, however, and there are exceptions, e.g. in functional explanations of Anatomy, Physiology and Medicine, in Evolutionary theory, in the functionalist tradition and in the Human Sciences based on biological analogies.

Here it is interesting to mention Steven Weinberg's reflection in Weinberg, 2000:

"It might be supposed that something is explained when we find its cause, but an influential 1913 paper by Bertrand Russell had argued that "the word 'cause' is so inextricably bound up with misleading associations as to make its complete extrusion from the philosophical vocabulary desirable." This left philosophers like Wittgenstein with only one candidate for a distinction between explanation and description, one that is teleological, defining an explanation as a statement of the purpose of the thing explained."

Weinberg, like modern physicists in general, is opposed to the idea of teleological explanation. He presents his arguments that help us understand why scientists rejected teleology historically, which is good to remember.

Alfred North Whitehead, on the other hand, wrote about the modern world of separated facts and values:

"The seventeenth century had finally produced a scheme of scientific thought framed by mathematicians, for the use of mathematicians… The enormous success of the scientific abstractions, yielding on the one hand matter… on the other hand mind, perceiving, suffering, reasoning, but not interfering, has foisted onto philosophy the task of accepting them as the most concrete rendering of fact.

Thereby, modern philosophy has been ruined. It has oscillated in a complex manner between three extremes. There are the dualists, who accept matter and mind as on equal basis, and the two varieties of monists, those who put mind inside matter, and those who put matter inside mind. But this juggling with abstractions can never overcome the inherent confusion introduced by the… scientific scheme of the seventeenth century." (Whitehead, 1997)

Science is a part of culture, and research traditions cannot be reasonably separated from the prevailing world view of the epoch. The social forces affect the origination, funding and deployment of scientific research, the foundations of scientific disciplines and even the scientific world view. Science is *not* value neutral. (See Dodig-Crnkovic 2003a and 2003b).

Natural Sciences are interested in classes of phenomena and sets of undistinguishable individuals. Their basic requirements are reproducibility and predictability. They rest upon idealization/approximation and generalization. On the other hand arts, history and literature are exquisitely particular and allow all sorts of interpretations in their depicting the lives of humans. Their stories are unique and individual.

8 Philosophy of Information and Philosophy of Science

Let us start with a definition.

*“**The Philosophy of Information** is a new philosophical discipline, concerned with*

a) the critical investigation of the conceptual nature and basic principles of information, including its dynamics (especially computation and flow), utilisation and Sciences; and
b) the elaboration and application of information-theoretic and computational methodologies to philosophical problems.”

According to: *What is the Philosophy of Information?* L. Floridi, 2002.

It is obviously much more than the Philosophy of Information Theory (for a very interesting text on Information Theory, including even some philosophical consequences, see Chaitin, 1987.)

The field of Philosophy of Information (PI) is so new that no consensus is yet found about the nomenclature. So there are different names for essentially the same discipline: Philosophy of Information, (see Floridi, 2003), Philosophy of Computing, (see Floridi 1999, Smith, 1995), Cyber philosophy, Digital Philosophy (see Bynum & Moor, 1998) and with related fields such as Philosophy of AI, Computer Ethics, (see Bowyer 2000, Martin & Schinzinger, 1989), Artificial Morality and Computational Philosophy of Science (see Thagard, 1993).

The same is true when it comes to the use of the terms “Computing” and “Informatics”. To make things even more complicated, Informatics is sometimes used in the meaning of Information Systems of ACM/IEEE, 2001. Even Computing is sometimes used as synonymous of Computation, which most commonly is a term for the special discipline which emerged at the intersection of Computer Science, Applied Mathematics and various science disciplines (including modeling with 3D visualization and Computer Simulation, efficient handling of large data sets, and alike), see Dodig-Crnkovic, 2002.

What is the relation between the Philosophy of Information/Informatics/Computation and the Philosophy of Science? The Philosophy of Information is a broader field, encompassing more than different scientific facets of Computing. It includes an important ethical component as well as ontological and even epistemological elements that are different in character from those studied within the Philosophy of Science. However, there are many common interfaces where synergetic effects can be expected in the course of research, such as the Philosophy of Science discovering the new discipline of Computing as a new paradigm of future Science.

9 A 21st Century Renaissance - Cultivating New Ways of Thinking

From the early 14th to the late 16th century, a revival of interest in the values of Greece and Rome led to the cultural age of the Renaissance. The European world image shifted from a religious to a worldly outlook. Renaissance intellectuals had a growing confidence in individual human abilities. This new humanism focused on the personal worth of the individual.

The fundamental idea of the Italian Renaissance was that a man should perfect himself by developing all his faculties. The ideal man should be a scholar and connoisseur of art; he should develop graceful speech and cherish a sense of honor. This Renaissance ideal of the free development of individual faculties and its rules of civilized behavior formed a new conception of humanist personal rights and obligations in Europe.

Nowadays, the outburst of computers and information technologies has created a new environment for the revival of the Renaissance ideal. Computers have enabled the storage, organization, and manipulation of information that was never possible before. The Internet brings about practically instantaneous transmission of information around the world. It is the tool that makes it possible to navigate and surf the oceans of information. Computers have given artists and engineers, scientists and scholars new tools and opportunities of work and communication. Information technology permits faster development of fundamental breakthroughs in virtually every field, including materials, energy, and biotechnology.

As a result we should expect advancements with the character of those of the Italian Renaissance. The technology engine that drove the first Renaissance was the printing press. Today, it is computing and communication that allow faster, wider access to the best information, tools, and practices. What makes it appealing is *humanism*, the force at the heart of the first Renaissance. It placed human needs and aspirations at the center of every endeavor. Assessing Technology and even Science from a humanist perspective will be the greatest challenge to come.

10 Conclusions

"How shall we live?" is, for Socrates, the fundamental question of human existence - and the attempt to answer that question is, for him, what makes human life worthwhile.

Computing is changing our culture rapidly and it affects our lives in a number of most profound ways. The Computer itself is a new research field and its object of investigation is an ever-developing artefact, the materialization of the ideas that try to structure knowledge and the information about the world, including computers themselves. Already the subject of investigation of computing suggests that the traditional science paradigm may not apply for Computing. For classical Sciences the object of investigation is Nature, while scientific parts of Computing to a very high degree have an artefact as an object. Here we can find the first reason of the return to human-centered philosophy: this new field that is partly scientific is about a human project.

However, in spite of all the characteristics that distinguish the young field of Computing from several thousand year old sciences such as Mathematics, Logic, and Natural Sciences we can draw a conclusion that Computing contains a critical mass of scientific features to qualify as a Science. Computing has a traditional core of "hard" (exact) Sciences.

All modern Sciences are very strongly connected to Technology. This is very much the case for Biology, Chemistry and Physics, and even more the case for Computing. The engineering parts in Computing have connections both with the hardware (physical) aspects of the computer and software. The important difference is that the *computer* (the physical object that is directly related to the theory) is not a focus of investigation (not even in the sense of being the cause of a certain algorithm proceeding in a certain way) but it is rather *theory materialized, a tool always capable of changing in order to accommodate even more powerful theoretical concepts*.

Contrary to the present-day scientific ideal of Physics which is defined as the opposite of Metaphysics, Computing/Informatics is vitally connected with Philosophy. It presents an opportunity to rethink from a new fresh perspective our basic concepts from the beginning. Even to reach for a new synthesis of Sciences and Humanities, Arts and Engineering: a fusion of social, cultural, economic, ethical, and ecological values for achieving a rationalization and harmonization of the needs of human society. Technology, humanism, and cross-disciplinary cooperation can combine in the New Renaissance which is the ideal of broad-minded, well-mannered deliberation that cultivates diversity of opinion.

Actually, taking into account the present development within different scientific fields, we must conclude that Science is simply not the same thing it was in the last century. The time is ripe for a paradigm shift in the Philosophy of Science! Computing is winning the ground that was the traditional domain of Physics. The answer to the question what ultimately matters nowadays belongs more to Computing than to Physics. The search for answers to questions about truth, meaning, mind, subjectivity, consciousness etc. lies among others within Computing.

11 References

ACM/IEEE, (2001), *Computing Curricula 2001,* http://www.computer.org/education/cc2001/index.htm

Bowyer, K.W. (Ed), (2000), *Ethics and Computing,* Wiley-IEEE Press

Bynum, T.W. and Moor, J.H., (1998), *The Digital Phoenix, How Computers are Changing Philosophy*

Carnap, R. (1994), *An Introduction to The Philosophy of Science,* Basic Books

Chaitin, G.J, (1987), *Algorithmic Information Theory,* Cambridge University Press

Chalmers, A. (1990), *What is This Thing Called Science?,* Hackett Publishing Co.

Dodig-Crnkovic G., (2003a) Computing Curricula: Social, Ethical, and Professional Issues, *Proc. Conf. for the Promotion of Research in IT at New Universities and at University Colleges in Sweden*

Dodig-Crnkovic G. and Crnkovic I., (2003b), Computing Curricula: Teaching Theory of Science to Computer Science Students, *Proc. Hawaii International Conference on Education*

Dodig-Crnkovic G., (2002), Scientific Methods in Computer Science, *Proc. Conf. for the Promotion of Research in IT at New Universities and at University Colleges in Sweden*

Dodig-Crnkovic G., (2001), What Ultimately Matters, Indeed?, *Proc. Conf. for the Promotion of Research in IT at New Universities and at University Colleges in Sweden*

Feyerabend, P. (2000), *Against Method,* Verso

Floridi, L., (2003), Blackwell Guide to the Philosophy of Computing and Information

Floridi, L., (2002), *"What is the Philosophy of Information?", Metaphilosophy* (33.1/2), 123-145

Floridi, L., (1999), *Philosophy and computing: An introduction*, Routledge.

Kuhn, T. (1962), *The Structure of Scientific Revolutions,* Chicago: Univ. Chicago Press

Lelas, S., (2000), *Science and Modernity*, Kluwer Academic Publishers

Martin, M., Schinzinger, R., (1989), *Ethics In Engineering, McGraw-Hill*

Mitcham, C., (1994), *Thinking Through Technology: The Path Between Engineering and Philosophy,* Univ. of Chicago Press

Popper, K.R. (1999), *The Logic of Scientific Discovery*, Routledge

Rheingold, H., (1985), *Tools For Thought: The History and Future of Mind-Expanding Technology,* Simon & Schuster

Smith, B.C, (1995), *On the Origin of Objects*, MIT

Sokal A. D., (1996), **"**Transgressing the Boundaries: Towards a Transformative Hermeneutics of Quantum Gravity" in *Social Text* 46/47, pp. 217-252

Thagard, P.R.,(1993), *Computational Philosophy of Science,* MIT Press

Weinberg, S. (2001), Can Science Explain Everything? Anything?, *The New York Review of* Books, May 31, 2001

Weinberg, S. (1996), Sokal's Hoax, *The New York Review of Books*, Volume XLIII, No. 13, pp 11-15

Whitehead, A.N., (1997), *Science and the Modern World,* New York: Free Press

Paper B

Paper B

SEMANTICS OF INFORMATION AND INTERACTIVE COMPUTATION

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Abstract

Philosophy of Information, PI, as envisaged by Floridi means a paradigm shift in philosophy, with both ontology and epistemology being based on information, instead of knowledge. That means that the fine structure of both philosophical disciplines becomes explicit, which allows for fundamentally new conceptualizations and interpretations. PI represents thus the ideal domain for the development of new logical approaches, including logical pluralism. One of the claims this paper will make is that logical pluralism comes as a natural consequence of the new multi-agent, concurrent, interactive understanding of computing, which in its turn is understood as information processing.

The argument is based on the unified view of information/computation phenomena. Information is defined as a result of computation. Two concepts, information and computation are considered as dual in a sense that they are two manifestations of the same physical reality of matter-energy. Information is a pattern, instantaneous "still picture" of an ongoing computational process.

It is thus instructive to relate Information Philosophy with the Philosophy of Computing, as developed by Cantwell Smith. The interesting insight he made is that the new development calls for the opening up of computing (as defined by Hilbert's program for mathematics) to the arts, humanities and other non-scientific practices. In my earlier papers I argued that we are at the beginning of a new Renaissance, with computing as a new framework which will enable the meeting and communication between different and today disparate fields. Computing is not merely ordering the world; it is in the world and acting. Computers are not only the devices for mechanizing mathematics of the beginnings of the twentieth century - they have a potential to computationally simulate the world, which itself may be conceived of as a computer (Zuse, Wiener, Fredkin, Wolfram, Chaitin, Lloyd). In expanding its domain, computation goes beyond Church-Turing limits (Burgin, Siegelman, Schachter).

Computational processes are nowadays conceived as distributed, reactive, agent-based and concurrent (Wegner, Goldin). The main criterion of success of the computation is not its termination (after giving the correct answer), but its functioning in the interactive situation: speed of response, generality of response, adaptability, and tolerance to noise, error, faults, or damage (MacLennan). Interaction (i.e. communication of the computing process with the environment during the computation) provides a new conceptualization of computational phenomena. Games with their distributed, reactive, agent-

based concurrency present a very suitable formalism for the modeling of interactive computing, i.e. of information flow and multi-agent interaction (Van Benthem, Japaridze, Wegner).

Key words:

Computation, Semantics, Digital Philosophy, Philosophy of Computer Science, Philosophy of Computing, Philosophy of Information, Interactive Computing, Hypercomputation.

1 Introduction

The Universe is an idea different in different epochs. At some time it was a living organism, at yet another time, mechanical machinery - the Cartesian-Newtonian clockwork. Today's metaphor of the Universe is more and more explicitly becoming a computer. On a pancomputational/paninformational view (Zuse, Wiener, Fredkin, Wolfram, Chaitin, Lloyd), the universe is a network of computing processes, essentially defined by information, (see Information Physics links) which comes as a result of the multitude of processes of computation. (Whether the physical universe *really is* anything like a computer is of no interest in this context. The main point is how fruitful and productive computational models might be.)

Contrary to traditional algorithmic computation, in which the computer was an isolated box provided with a suitable algorithm and an input, left alone to compute until the algorithm terminated, *interactive computation* (Wegner 1988, Goldin et al. 2006) implies interaction i.e. communication of the computing process with the environment *during the computation*. *Interaction* consequently provides a new conceptualization of computational phenomena which involves communication and information processing.

The essential novelty that interactive computing brings about is its articulation of the difference between an *open* and a *closed* system, the distinction being equally relevant for physics, mathematics as for computing itself. The traditional theories are about closed, isolated systems with the environment represented by some average behavior, and treated as a perturbation. An observer is external to the system. In the interactive framework the system is in general communicating with the explicitly expressed environment (which it is not controlling) which also allows for the integration of the observer into the model.

Even though practical implementations of interactive computing are several decades old, a foundational theory, and in the first place semantics and logic of interactive computing is only in its beginning. A theoretical base analogous to what Turing machines are for algorithmic computing, is under development for interactive computing. (Wegner 1998, Abramsky 2003, Japaridze 2006)

Goldin and Wegner (2002) argue e.g. that computational logic must be able to model interactive computation, that classical logic does not suffice and that logic must be *paraconsistent* due to the *incompleteness* of interaction.

"Consider a computer which stores a large amount of information. While the computer stores the information, it is also used to operate on it, and, crucially, to infer from it. Now it is quite common for the computer to contain inconsistent information, because of mistakes by the data entry operators or because of multiple sourcing. This is certainly a problem for database operations with theorem-provers, and so has drawn much attention from computer scientists. Techniques for removing inconsistent information have been investigated. Yet all have limited applicability, and, in any case, are not guaranteed to produce consistency. (There is no algorithm for logical falsehood.) Hence, even if steps are taken to get rid of contradictions when they are found, an underlying paraconsistent logic is desirable if hidden contradictions are not to generate spurious answers to queries." (Priest, Tanaka 2004)

There are several matted strands of new ideas presented here which result in a new view of computing, information, and logic, with even broader consequences for mathematics, physics, and a number of other related fields. What is then the place and role of semantics in this new emerging informational – computational – communicational world? Here is a suggestion for an answer:

"According to computability logic philosophy, syntax - the study of axiomatizations or any other, deductive or nondeductive string-manipulation systems - exclusively owes its right of existence to semantics, and is thus secondary to it. Computability logic believes that logic is meant to be the most basic, general-purpose formal tool potentially usable by intelligent agents in successfully navigating real life. And it is semantics that establishes that ultimate real-life meaning of logic." (Japaridze, 2006)

2 Information Semantics - Open Problem in the Philosophy of Information

In his programmatic paper *Open Problems in the Philosophy of Information* Floridi (2004) lists the five most interesting areas of research for the nascent field of Philosophy of Information (and Computation), containing eighteen fundamental questions as follows:

I) Information definition

1. *What is Information*?
2. *What is the dynamics of information*?
3. *Is a grand unified theory of information (GUTI) possible*?

II) Information Semantics

4. *The data grounding problem*: How can data acquire their meaning?
5. *Truth problem*: How can meaningful data acquire their truth value?
6. *Informational truth theory*: Can a theory of information explain truth?
7. *Informational semantic problem*: Can information theory explain meaning?

III) Intelligence/Cognition

8. *Descartes' problem*: Can cognition be fully analysed in terms of information processing at some level of abstraction?
9. *Dennett's reengineering problem*: Can natural intelligence be fully analysed in terms of information processing at some level of abstraction?
10. *Turing's problem*: Can natural intelligence be fully and satisfactorily be implemented non-biologically?
11. *The MIB (mind-information-body) problem*: Can an informational approach solve the Mind-Body problem?
12. *The informational circle*: If information cannot be transcended but can only be checked against further information - if it is information all the way up and all the way down - what does this tell us about our knowledge of the world?

13. *The Information Continuum Conjecture*: Does knowledge encapsulate truth because it encapsulates semantic information? Should epistemology be based on a theory of information?

14. *The semantic view of science*: Is science reducible to information modelling?

IV) Informational Universe/Nature

15. *Wiener's problem*: Is information an independent ontological category, different from the physical/material and the mental?

16. *The problem of localisation*: Could information be neither here (intelligence) nor there (natural world) but on the threshold, as a special relation or interface between the world and its intelligent inhabitants (constructionism)?

17. *The* "It *from* Bit" *hypothesis*: Is the universe essentially made of informational stuff, with natural processes, including causation, as special cases of information dynamics?

V) Values/Ethics

18. *Are computing ethics issues unique* or are they simply moral issues that happen to involve ICT? What kind of ethics is CE? What is the contribution of CE to the ethical discourse?

Information semantics (II) is of special interest here, but we will come back to a number of closely related questions from the Floridi's program that this paper will connect to.

According to Floridi (2006, 2005) *declarative, objective and semantic information* must be *true* (strongly semantic information). Consequently, for this kind of information (13) "*The Information Continuum Conjecture*: Does knowledge encapsulate truth because it encapsulates semantic information?" has an affirmative answer.

Let us try to go further, following Floridi's program. What about non-declarative objective semantic information? As meaning is not solely a linguistic matter. And regularities in the world lead to a natural (or causal) sort of meaning, allowing us to make inferences such as "Cloud means rain," or "Smoke means fire." Non-declarative information is of great relevance for epistemology. There are many related questions that might be answered in interesting ways if we define the concept of *information* as the *result of computing*, the definition mirroring the complementary description of computing as information processing.

This paper will relate to several points of Floridi's program for PI, and suggest a general approach to information/computation logic, that includes the classical approaches as a proper subset. Computation/Information turn might be seen as a basis of a program of *naturalizing epistemology*.

If we accept the pancomputational stance as a point of departure, and if all physics may be expressed as computation, meaning the whole universe might be represented as a network of computing processes at different scales or levels of granularity then we may see information in the first place as a result of (natural) computation.

Information and computation are two complementary ideas in a similar way to continuum and a discrete set. In its turn *continuum – discrete set* dichotomy may be seen in a variety of disguises such as: *time – space; wave – particle; geometry – arithmetic; interaction – algorithm; computation – information.* Two elements in each pair presuppose each other, and are inseparably related to each other.

The field of Philosophy of Information is so closely interconnected with the Philosophy of Computation that it would be appropriate to call it Philosophy of Information and Computation, having in mind the dual character of information-computation.

Burgin (2005) puts it in the following way:

"It is necessary to remark that there is an ongoing synthesis of computation and communication into a unified process of information processing. Practical and theoretical advances are aimed at this synthesis and also use it as a tool for further development. Thus, we use the word computation in the sense of information processing as a whole. Better theoretical understanding of computers, networks, and other information processing systems will allow us to develop such systems to a higher level.

As Terry Winograd (1997) writes, "The biggest advances will come not from doing more and bigger and faster of what we are already doing, but from finding new metaphors, new starting points."

3 Computation as Information Processing

The world of information processing includes more and more of our civilization – we are surrounded by computer systems connected in global networks of multitasking, often mobile, interacting devices.

The traditional mathematical theory of computation is the theory of algorithms. Ideal, theoretical computers are mathematical objects and they are equivalent to algorithms, or abstract automata, (Turing machines), or effective procedures, or recursive functions, or formal languages.

New envisaged future computers are *information processing devices*. That is what makes the difference. Syntactic mechanical symbol manipulation is replaced by information, with both syntactical and semantical aspects being expressed.

Compared to new computing paradigms, Turing machines form the proper subset of the set of information processing devices, in much the same way as Newton's theory of gravitation is a special case of Einstein's theory, or the Euclidean geometry is a limit case of non-Euclidean geometries.

According to Burgin (2005), information processing is performed on several levels. The basic level consists of following operations:

- Preserving information (protecting information from change – identity operation)
- Changing information itself or its representation
- Changing the location of information in the physical world

Both computation and communication imply the transition, transformation and preservation of information. Bohan Broderick (2004) compares notions of communication and computation which leads him to the conclusion that the two are often not conceptually distinguishable. He shows how computation and communication may be distinguished if computation is limited to actions within a system and communications is an interaction between a system and its environment. The interesting problem of distinction arises when the computer is conceived as an open system in communication with the environment, where the boundary is dynamic, as in biological computing.

Burgin identifies three distinct components of information processing systems: hardware (physical devices), software (programs that regulate its functioning) and infoware which represents information processed by the system. Infoware is a shell built around the software-hardware core which was the traditional domain of automata and algorithm theory.

4 Complexity, Computing, Algorithms and Hypercomputation

Having the ambition of not only describing, but also taking part in the (real-time) universe, computation must be able to match and directly connect to its environments. According to Ashby (1964) it is therefore necessary to match the complexity of the environment. Ashby's "Law of Requisite Variety" states namely, that to control a situation and to perform up to requirements, the variety of system responses must at least match the variety of disturbances. This amounts to the claim that in order *for a computer to achieve adequate control of a complex system, the complexity of the repertoire of its responses must match the complexity of the environment.*

The information and communication technology of today is based on algorithms. The Church-Turing thesis is the basic dogma of the algorithmic model that claims that all of computation can be expressed by recursive algorithms (Turing machines).

Generally speaking, the semantics of mathematical models are relative to a domain of application and they are usually not well-defined outside that domain (Kuipers, 2006 gives some interesting examples of the domain dependence of theory). Even traditional computing has its domain, and the discussion of the presuppositions and context of the Turing machine model is therefore in order. In spite of its validity within a given domain, the Turing machine model is not appropriate for certain important applications.

As is well known, the Turing machine model was developed in a reply to Hilbert's program in mathematics, which attempted to reduce mathematics to a finitary formal system. LCMs (Logical Computing Machines, Turing's expression for Turing machines) were an attempt to give a mathematically precise definition of "algorithm" or "mechanical procedure". In Turing's words: "A man provided with paper, pencil, and rubber, and subject to strict discipline, is in effect a universal machine."

A thesis concerning the extent of effective procedures that a *human being unaided by machinery* is capable of carrying out has no implication concerning the extent of the procedures that other computing systems are capable of carrying out. Among a "machine's" (computing physical system's) repertoire of atomic operations there may be those that no human being unaided by "computing machinery" can perform.

The definition of computation is currently under debate, and an entire issue of the journal Minds and Machines (1994, 4, 4) was devoted to the question "What is Computation?"[5]

It has been argued that Turing computation is what we mean by computation, but MacLennan proposes a broader definition of computation that includes both Turing computation and alternative (in Burgin's terminology super-recursive) hypercomputing models.

If we compare Turing machines with the physical universe, including quantum physics, the latter exhibits a much higher order of complexity. That would imply that we need more powerful computers, than what is represented by Turing machines in order to be able to represent, simulate and even control the real world phenomena.

In exceeding Turing limit, the new area of computer science called the theory of super-recursive algorithms or hypercomputation addresses two distinct problems (Burgin 2005):

- the nature of the computing mechanism and

[5] Corresponding question "What is Information? is also vividly discussed, and a special issue of the Journal of Logic, Language and Information (Volume 12 No 4 2003) is dedicated to the different faces of information. A Handbook on the Philosophy of Information (Van Benthem, Adriaans) is to appear in 2006.

- the nature of the halting problem

The first problem could be answered by natural computation, see next chapter. Computing has an ambition to not only *calculate* but also *simulate* phenomena, which is best done by natural computation in the case of natural phenomena.

The second question is answered by the insight that computing in general has no special need of halting. The Internet neither computes any function nor is it expected to halt. Another way to see the stop problem is conceiving the original question of uncomputability as the internalized problem of induction, (Kelly 2004). Induction, now in a sense of the learning process is stopped at certain point, decided on semantic (pragmatic) grounds.

Hypercomputation consists of several directions. The most important ones are listed here in chronological order (Burgin 2005):

- inductive computations and inference,
- computations and recursive functions with real numbers,
- interactive and concurrent computations,
- topological computations,
- infinite time computations, and
- neural networks with real number parameters.

Each of these computational models presents a new logic of computation.

5 Natural Computation

MacLennan, (2004) defines natural computation as *”computation occurring in nature or inspired by that in nature”,* which includes quantum computing and molecular computation, and might be represented by either discrete or continuous models. Examples of *computation occurring in nature* comprise information processing in evolution by natural selection, in the brain, in the immune system, in the self-organized collective behavior of groups of animals such as ant colonies, and particle swarms. *Computation inspired by nature* include genetic algorithms, artificial neural nets, simulated immune systems, ant colony optimization, particle swarm optimization, and similar.

Natural computational models are most relevant in applications that resemble natural systems, as for example real-time control systems, autonomous robots, and distributed intelligent systems in general. There is an interesting synergy gain in the relating of human designed computing with the computing going on in nature.

If computation is to be able to recreate the observable natural phenomena, relevant characteristics in natural computation should be incorporated in new models of computation. Natural computational systems have the following important features (MacLennan, 2004):

- *Adequacy of real-time response* - deliver usable results in prescribed real-time bounds. The speed of the basic operations is critical, as well as the absolute number of steps from input to output.

- *Generality of response* - with real-time response fixed, a natural computation may be improved by increasing the range of inputs to which it responds adequately.

- *Flexibility in response to novelty* - respond appropriately to novel inputs (which the system was not designed to handle).

- *Adaptability* - adapt to a changing environment, as quickly as possible, while retaining existing competence and stability. Natural computation systems can be compared with respect to the quality and speed of their adaptation and the stability of their learning.

- *Robustness* in the presence of perturbations, noise, faults, errors and damage, or even the ability to exploit perturbations and similar to the advantage of the system in developing new features.

That is why in natural computation, the same features are becoming important characteristics of computation.

6 Computation as Interaction

Interactive computation (Wegner 1998) involves interaction, or communication, with the environment during computation, contrary to traditional algorithmic computation which goes on in an isolated system. The interactive paradigm includes concurrent and reactive computations, agent-oriented, distributed and component-based computations, (Goldin and Wegner 2002).

The paradigm shift from algorithms to interactive computation follows the technology shift from mainframes to networks, and intelligent systems, from calculating to communicating, distributed and often even mobile devices. A majority of the computers today are embedded in other systems and they are continuously communicating with each other and with the environment. The communicative role has definitely outweighed the original role of a computer as an isolated, fast calculating machine.

The following characteristics distinguish this new, interactive notion of computation (Goldin, Smolka and Wegner eds. 2006):

- *Computational problem*: defined as performing a task, rather than (algorithmically) producing an answer to a question.

- *Dynamic input and output*: modeled by *dynamic streams* which are interleaved; later values of the input stream may depend on earlier values in the output stream and vice versa.

- *Environments*: the environment of the computation is part of the model, playing an active role in the computation by dynamically supplying the computational system with the inputs, and consuming the output values from the system.

- *Concurrency*: the computing system (agent) computes in parallel with its environment, and with other agents that may be in it.

- *Effective non-computability*: the environment cannot be assumed to be static or effectively computable; for example, it may include humans, or other elements of the real world. Hence we cannot always pre-compute input values or predict the effect of the system's output on the environment.

Even though practical implementations of interactive computing are several decades old, a foundational theory, and primarily the semantics and logic of interactive computing is only in its infancy. A theoretical foundations analogous to what Turing machines are for algorithmic computing, is under development (Wegner 1998, Abramsky 2003).

Computational logic is a tool that both supports computation modeling and reasoning about computation. Goldin and Wegner (2002) argue e.g. that computational logic must be able to model interactive computation, that classical logic does not suffice and that logic must be paraconsistent, able to model both a fact and its negation, due to the role of the environment and incompleteness of interaction.

6.1 Concurrent Interactive Computing

If the semantics for the behavior of a concurrent system is defined by the functional relationship between inputs and outputs, as within the Church-Turing framework, then the concurrent system can be simulated by a Turing machine. The Turing machine is a special case of a more general computation concept.

The added expressiveness of a concurrent interactive computing may be seen as a consequence of the introduction of *time* within the perspective. Time seen from a system is defined through the occurrence of external events, i.e. through interaction with the environment. In a similar way, spatial distribution, (between an inside and an outside of the system, also between different systems) gets its full expression through interaction. Different distributed agents, with different behaviors, interact with different parts of the environment. In interactive computing, time distribution and generally also (time-dependent) spatial distribution are modeled in the same formalism (Milner 1989 and Wegner 1998).

The contribution of concurrency theory to the toolbox of formal models that may be used to *recreate observable natural phenomena*, are according to Schachter (1999):

"Furthermore, it is possible to express much richer notions of time and space in the concurrent interactive framework than in a sequential one. In the case of time, for example, instead of a unique total order, we now have interplay between many partial orders of events--the local times of concurrent agents--with potential synchronizations, and the possibility to add global constraints on the set of possible scheduling. This requires a much more complex algebraic structure of

representation if one wants to "situate" a given agent in time, i.e., relatively to the occurrence of events originated by herself or by other agents."

Theories of concurrency are partially integrating the observer into the model by permitting limited shifting of the inside-outside boundary. By this integration, theories of concurrency might bring major enhancements to the computational expressive toolbox, and capture phenomena beyond Church-Turing framework.

7 Philosophy of Computing and Logical Pluralism

One can see the development of computer science in the light of historical experiences. Historically science was forced to leave absolutes, one by one. We were shifted from the absolute center of the Universe with an unique and privileged coordinate system, and placed in the outskirts of our galaxy which in no way is special among galaxies, only to later on be forced to leave the idea of absolute space altogether and what is even worse to give up absolute time. Now it is time to leave the absolute truth, which is connected to leaving the idea of one and only true logic (logical monism).

How does the change in logic relate to computing, computers and information? Those elements influence each other and the development within one field induces the development in the others, which in its turn, influences the original field, and so on.

There are several points of departure one can take in order to explore the alternatives of logical monism in the context of Philosophy of Information and Computation.

Focusing on information instead of knowledge can be the smooth way to go from logical monism. The alternative, logical pluralism (Beall and Restall, 2000, 2005)[6] is motivated by an analysis of disagreement within the classical first-order logic, relevant logic and intuitionistic

[6] For earlier reference to logical pluralism, see W Kneale and M Kneale, The Development of Logic, Clarendon Press, Oxford, 1962. IX.5 "Suggestions for Alternative Logics"

logic in the account of logical consequence (and hence of logical truth). Allo (2006) is arguing that logical pluralism could also entail semantic informational pluralism as informational content depends upon the underlying logic one assumes. Furthermore:

"An elementary consequence of this point of view is that, when a formal account of semantic information is elaborated, the absolute validity of logic cannot be taken for granted. Some further — external — evidence for its applicability is needed."

Allo presents an interesting, and for practical purposes relevant, case of communication between agents adhering to different logics in a multi-agent system. Taking examples from the Philosophy of Computing, I will illustrate why information pluralism (as a consequence of logical pluralism) is not only interesting theoretical problem, but has relevant practical consequences. Understanding of contexts where it appears may help us computationally articulate fields outside the domain of traditional computing.

This is the central point: information is something that is characteristic of a dynamical system; knowledge presupposes static, steady states. Knowledge is not something you receive today and discard tomorrow. Information is.

"I believe it inevitable that we revisit logic. Many have concluded this as well. (I've mentioned Barwise before.) Alternative logics already exist in fields that presently seem remote from science - in fact this is the point, they seem remote from science precisely because their logics are so different. I suggest we consider artistic and humanity-centric "logics" also, as we hunt for tools, and be open to a scope that includes internal conceptual mechanics: desires, intuitions, emotions, creativity."
Goranson (2005)

The new interactive (communicative) role of computing is apparent in the Internet, the phenomenon that allows global communication and data transfer, making information easily available for people in different fields, establishing completely new preconditions for interdisciplinary learning, communication and collaboration. Related to the question of influence from other fields on computing, let us mention the work of Cantwell-Smith (1996).

In his book *On the Origin of Objects,* Cantwell Smith gives an outline of the foundations for Philosophy of Computing, which may be understood as a philosophy of the phenomena that produce, transfer, or preserve information. The book ascertains that the old digital, mechanical computing paradigm is not enough; there is only a vague intuition of something new that will result from the opening up of computing (as defined by Hilbert's mathematical research agenda, i.e. algorithms) to the arts, humanities and other non-scientific practices. Let me illustrate by the following quotes:

"Not only are notions of mathematical proof being revised (...)*. Other distinctions are collapsing, such as those between and among theories, models, simulations, implementations and the like. "* (p. 360)

"Logic, truth, and mathematics will not even be available en route; they are prizes to be won from the contest, not stage props or road equipment brought along for the journey…" (p. 93)

"Furthermore, modern practice is bursting with possibility, as designers, playwrights, artists, journalists, musicians, educators, are drawn into the act along with the original scientists and engineers, and now also anthropologists, linguists and sociologists. In fact few fields, if any, are being left behind. And to repeat something said earlier, it would be a mistake to think that these people are just users of computation. On the contrary, they are participating in its invention – creating user interfaces, proposing architectures, rewriting the rules on what it is to publish, disrupting our understanding of identity. Moreover, the line between specifically computational expertise and general computational literacy is fading ..." (p. 359)

"In the main the answer will emerge slowly, as appropriate vocabularies and intuitions are developed. But one thing can be said here. To the extent that the project is foundationalist or has foundationalist leanings on anyone's conception, it is intended to be a common foundation for everything, not just, more even preferentially, for the technical or scientific or "objective". (…) *Hence the reference to CP Snow in the opening paragraph: the story is intended to be neutral in respect to – and thereby, perhaps, to help heal – the schism between the sciences and humanities."* (p. 94)

Some years later, the positive side of what is going on become salient – computing is bringing together sciences and arts, in a development parallel to that of the Renaissance, (Dodig-Crnkovic, 2003), now with the computer in the place of the printing press:

"All modern Sciences are very strongly connected to Technology. This is very much the case for Biology, Chemistry and Physics, and even more the case for Computing. The engineering parts in Computing have connections both with the hardware (physical) aspects of the computer and software. The important difference is that the computer (the physical object that is directly related to the theory) is not a focus of investigation (not even in the sense of being the cause of a certain

algorithm proceeding in a certain way) but it is rather theory materialized, a tool always capable of changing in order to accommodate even more powerful theoretical concepts.*"*

New technological developments are exposing new sides of our relations with each other, as articulated in the arts and humanities, as well as in our relations with nature, as expressed in sciences. These changes have of course feedback mechanisms. Technology changing culture in its turn changes technology.

What becomes especially visible is the *intentionality*[7] of human actions, even the intentionality implicit in technologies. Computers are as much theoretical devices as the material ones. Our new aim is to make computers capable of accommodating natural computation, as the most expressive way of computation able to simulate natural phenomena.

The possibility of choice and its consequences makes value systems one of central questions (Point (18) of Floridi's program). All this becomes the subject of the investigation of Philosophy of Information and Computing. Traditional computing is not enough; computing is expanding its domains.

I definitely agree with the need for new logic, including logical pluralism. Actually pluralist logics are developing within the theory of computing (Allo, 2006) and they will soon show as tools we need to re-conceptualize the world (or at least the computational theory of it). In terms of the new interaction paradigm computational processes are conceived as distributed, reactive, agent-based and concurrent. Agents, in general, may use different logics. Interaction provides a new conceptualization of computational phenomena which involves communication and information exchange, and makes way for logical pluralism.

7.1 Logical Games

"One difficulty in extending logic from the sentence level to a discourse level has been the scarcity of mathematical paradigms satisfying the standards that one has become used to at the sentence level. In recent years, a congenial mid-size level has been found in game theory. Games are typically a model for a group of agents

[7] The state of having or being formed by an intention.

trying to achieve certain goals through interaction. They involve two new notions compared with what we had before: agents' preferences among possible outcome states, and their longer-term strategies providing successive responses to the others' actions over time. In particular, strategies take us from the micro-level to a description of longer-term behaviour." (Van Benthem, 2003)

The recently initiated *computability logic* views games as foundational entities in their own right. Hitherto games in logic have been used to find models and semantic justifications for syntactically introduced intuitionist logic or linear logic.

The *computability logic* is motivated by the belief that syntax (axiomatization or other deductive constructions) should serve a meaningful and motivated semantics rather than vice versa. (Japaridze, 2006)

"The concept of games that computability logic is based on appears to be an adequate formal counterpart of our broadest intuition of interactive computational tasks, --- tasks performed by a machine for a user/environment. What is a task for a machine is a resource for the environment and vice versa, so computability-logic games, at the same time, formalize our intuition of computational resources. Logical operators are understood as operations on such tasks/resources/games, atoms as variables ranging over tasks/resources/games, and validity of a logical formula as existence of a machine that always (under every particular interpretation of atoms and against any possible behavior by the environment) successfully accomplishes/provides/wins the task/resource/game represented by the formula. With this semantics, computability logic is a formal theory of computability in the same sense as classical logic is a formal theory of truth. Furthermore, the classical concept of truth turns out to be nothing but computability restricted to a special, so called elementary sort of games, which translates into classical logic's being nothing but a special elementary fragment of computability logic." (Japaridze, 2006)

The basics of a logical game are as follows: it normally involves just two players, often has infinite length, the only possible outcomes are winning and losing, and no probabilities are attached to actions or outcomes (Hodges 2004), (Pietarinen and Sandu 1999), (Hintikka and Sandu 1997).

There are two players: $\forall$ 'Abelard' and $\exists$'Eloise'. The players play by choosing elements of a set, called the *domain* of the game. Their choices build a sequence of elements:

$a_0, a_1, a_2, ...$

Infinite sequences of elements are called *plays*. The central idea is that of a winning strategy for the player ∃. Often these strategies turn out to be equivalent to something of logical importance, such as for example a proof. But games give a better definition because they provide a motivation: ∃ is trying to win. This raises a question important for semantics of logical games, (Hodges 2004):

"If we want ∃'s motivation in a game G to have any explanatory value, then we need to understand what is achieved if ∃ does win. In particular we should be able to tell a realistic story of a situation in which some agent called ∃ is trying to do something intelligible, and doing it is the same thing as winning in the game. As Richard Dawkins said, raising the corresponding question for the evolutionary games of Maynard Smith,

The whole purpose of our search ... is to discover a suitable actor to play the leading role in our metaphors of purpose. We ... want to say, 'It is for the good of ... '. Our quest in this chapter is for the right way to complete that sentence. (The Extended Phenotype, Oxford University Press, Oxford 1982, page 91.)"

The above is what Hodges refers to as *Dawkins question* (essentially the question of intentionality).

Hintikka has in his Game-Theoretic Semantics extended the above variant of the games to natural language semantics and to games of imperfect information.

7.2 Game Semantics

According to Abramsky (1997) the key feature of games, compared to other models of computation, is that they make possible an *explicit representation of the environment*, and thus model interaction in an intrinsic way.

Multi-agent interactions may be expressed in terms of two-person games. A one-person game is simply a transition system.

Here is Wegner's (1998) account of the interaction as a two-player game:

"Interactive expressiveness can be modeled by a two-person game in which player 1 controls machine Ml, player 2 controls machine M2, and player 2 wins if she can find a sequence of moves on M2 that cannot be replicated by player 1 on Ml. Player 2 may be viewed as an omniscient adversary who looks for a move that cannot be matched by player 1 at each step. If player 2 cannot find a sequence of moves to

defeat player 1, then player 1 wins and Ml is as expressive as M2. This game expresses dynamic (lazy) commitment because player 2 defeats player 1 if she has greater freedom of choice at any move. If player 1 can replicate any sequence of moves of player 2, then the machine Ml is said to simulate M2."

In the Dialogue Game, one of the players (Proponent), represents the System, and the other (Opponent) represents the Environment. Conventionally, it is the Opponent who always makes the first move in the game. As usual, who is the Proponent and who is the Opponent depends on the point of view.

It is interesting to note that even then Aristotle regarded logic as being closely related with the rules of debating. The common medieval name for logic was *dialectics*. Charles Hamblin retrieved the link between dialogue and the sound reasoning, while Paul Lorenzen had connected dialogue to constructive foundations of logic in the mid twentieth century, (Hodges, 2004).

Hintikka (in 1973) raised the Dawkins question (of purpose, intention) for semantic games. His answer was that one should look to Wittgenstein's language games, and the language games for understanding quantifiers are those about seeking and finding. In the corresponding logical games one should think of ∃ as Myself and ∀ as a Nature (which can never be relied on); so to be sure of finding the object I want, I need a winning strategy. Hodges (2004) criticizes this interpretation as not being very convincing with the claim that the motivation of Nature is irrelevant, but in the light of biological computing, Hintikka's suggestion seems to be an ingenious and fruitful metaphor.

8 Conclusions

Philosophy of Information, PI is a paradigm shift in philosophy, with ontology and epistemology being based on information, instead of following the tradition of foundation on the idea of knowledge, Floridi (2002-2006). That means that the fine structure of both philosophical disciplines becomes explicit, which opens up for fundamentally new conceptualizations and interpretations. PI represents the ideal domain of logical pluralism.

Arguments for pluralism that Allo (2005) is asking for are given based on methodological considerations emerging from PI.

One of the claims this paper makes is that logical pluralism comes as a consequence of the new interactive understanding of computing, conceived as information processing. On a pancomputational/paninformational view (Zuse, Wiener, Fredkin, Wolfram, Chaitin, Lloyd), the universe is a computer, or rather a network of distributed communicating computing processes, essentially described by information, which comes as a result of the multitude of processes of computation.

In the domain of objective non-declarative information, and under the assumptions of pancomputationalism, Floridi's open problem (17) has the positive answer: the universe is made of information that is in a constant flow, transformed and communicated through processes of computation/communication under the assumption of paninformationalism, i.e. if even computational mechanism (matter/energy plus physical laws) is informational. Pancomputationalism settles problems (1) and (2) about the character of information and its dynamics. The research area (II), Information semantics in the present unified information/computation framework, on the level of basic informational processes, has its semantics foundation in interactive computation, computability logic and game semantics.

What becomes especially visible in this interactive framework is the *intentionality* of the agent's actions, even the intentionality implicit in technologies. The possibility of choice and its consequences makes value systems one of the central questions (problem 18).

The only research area that we have not touched upon yet is III (Intelligence/cognition) which also may be seen as a part of the same program: Computation/Information turn in *naturalizing epistemology*. A special chapter in (Dodig-Crnkovic 2006) will be devoted to that problem.

This essay addresses several matted strands of new ideas intertwined to result in a fundamentally new view of computing, information, and logic, with broad consequences that affect physics, mathematics, and a number of other related fields. Following ideas and their consequences for the Philosophy of Information are discussed: the duality of information and computation; pancomputationalism and paninformationalism; natural computation and hypercomputation; interactive computing; games and logical pluralism.

The arguments are presented for the need of a new approach to the semantics of information, where information is defined as a result of a computing process.

Games with their distributed, reactive, agent-based concurrency present a very suitable formalism for the modeling of interactive computing, i.e. of information flow and multi-agent interaction (Van Benthem, Japaridze, Wegner).

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10 References

Abramsky S., *Concurrent Interaction Games*, in Millennial Perspectives in Computer Science, J. Davies, A. W. Roscoe and J. Woodcock, eds. (Palgrave) 2000, 1--12.

Abramsky S., *Semantics of Interaction: an Introduction to Game Semantics*, in Proceedings of the 1996 CLiCS Summer School, Isaac Newton Institute, P. Dybjer and A. Pitts, eds. (Cambridge University Press) 1997, 1--31.

Abramsky S., *Sequentiality vs. Concurrency in Games and Logic*, Mathematical Structures in Computer Science vol. 13, 2003, 531—565

Allo P., 2006, *Formalising Semantic Information. Lessons From Logical Pluralism,* in Computing, Philosophy, and Cognitive Science to be published by Cambridge Scholars Press

Ashby W Ross, *An introduction to Cybernetics*, London: Methuen, 1964.

Beall JC and Restall G, *Logical Pluralism*, Australasian Journal of Philosophy, 78 (2000) 475–493.

Beall, JC, Restall, Greg, *Logical Consequence*, The Stanford Encyclopedia of Philosophy (Winter 2005 Edition), Edward N. Zalta (ed.), URL = <http://plato.stanford.edu/archives/win2005/entries/logical-consequence/>.

Benthem Van J., 2001, *Extensive Games as Process Models*, in M. Pauly & P. Dekker, eds., special issue of Journal of Logic, Language and Information

Benthem Van J., 2003, *Logic and the Dynamics of Information*, Minds and Machines 13: 503–519.

Benthem Van, J. and Adriaans P., ed., 2006, *Handbook on the Philosophy of Information*; Volume 8 in the Handbook of the Philosophy of Science, Elsevier, Amsterdam, forthcoming

Benthem Van, J. and R. van Rooy, 2003, *Connecting the Different Faces of Information*, Journal of Logic, Language and Information, 12(4): 375—379.

Bohan Broderick, P., *On Communication and Computation* ", Minds and Machines 14 (2004)

Buldt B., Löwe B., Müller T., 2006, *Towards a New Epistemology of Mathematics,*
http://www.phimsamp.uni-bonn.de/GAP6/moreinfo.html

Burgin M., 2003, *Information: Problems, Paradoxes, and Solutions,* tripleC 1(1) 53-70, http//tripleC.uti.at

Burgin M., Allen Klinger, *Three aspects of super-recursive algorithms and hypercomputation or finding black swans,* Theoretical Computer Science 317 (2004) 1 – 11

Burgin, M., *Super-recursive algorithms as a tool for high performance computing*, In: Proceedings of High Performance Computing Symposium (San Diego, 1999) 224-228 http://www.math.ucla.edu/~mburgin/res/compsc/res2/highperfcomp.html

Burgin, M., *Super-Recursive Algorithms*, Springer Monographs in Computer Science, 2005, ISBN: 0-387-95569-0

Burgin, M., *Topological Algorithms*, In: Proceedings of 16th International Conference for Computers and Applications ISCA (Seattle, 2001) 61-64

Cantwell Smith, B. 1996., *On the Origin of Objects*, Cambridge, MA: MIT Press

Devlin, K., 1991, *Logic and Information*, Cambridge University Press, Cambridge.

Dodig-Crnkovic G., 2003, *Shifting the Paradigm of the Philosophy of Science: the Philosophy of Information and a New Renaissance*, Minds and Machines: Special Issue on the Philosophy of InformationVolume 13, Issue 4

Dodig-Crnkovic G., 2006, *Investigations into Information Semantics and Ethics of Computing*, PhD Thesis, http://www.idt.mdh.se/personal/gdc/work/publications.html, forthcoming

Floridi L., 2004, *Open Problems in the Philosophy of Information*, Metaphilosophy, 2004, 35.4

Floridi L., 2005, *Semantic Conceptions of Information*, The Stanford Encyclopedia of Philosophy (Winter Edition), Edward N. Zalta (ed.), <http://plato.stanford.edu/entries/information-semantic>.

Floridi L., 2006, *Information Logic,* in Computing, Philosophy, and Cognitive Science to be published by Cambridge Scholars Press

Floridi, L., 2002, *What is the Philosophy of Information?*, Metaphilosophy, 33 (1/2): 123—145.

Floridi, L., 2003, *Information*, in: The Blackwell Guide to the Philosophy of Computing and Information, Floridi, ed., Blackwell Publishing, Oxford: 40–61.

Floridi, L., 2005a, *Is Information Meaningful Data?*, Philosophy and Phenomenological Research, 70(2): 351–370.

Gelder T. Van and Port R. E, *It's About Time: An overview of the Dynamical Approaches to Cognition*, in R. E Port & T. Van Gelder (eds.), Mind as Motion: Explorations in the Dynamics of Cognition, 1-43, M.I.T. Press.

Goldin D, and Wegner P, 2002, *Paraconsistency of Interactive Computation*, PCL 2002 (Workshop on Paraconsistent Computational Logic), Denmark

Goldin D, Smolka S and Wegner P Ed., 2006, *Interactive Computation: The New Paradigm*, To be published by Springer-Verlag

Goldin, D. and Wegner, P., 2000, *Persistent Turing Machines*, J. Symbolic Logic 65, Assoc. of Symbolic Logic. 567-604

Goldin, D. and Wegner, *The Church-Turing Thesis: Breaking the Myth*, LNCS 3526, Springer 2005, pp. 152-168

Goranson T., (2005) [Fis] *First Things First*, http://webmail.unizar.es/pipermail/fis/2005-November/001169.html

Hilpinen, R., 1983, *On C. S. Peirce's theory of proposition: Peirce as a precursor of game-theoretical semantics.* In E. Freeman (ed.), The Relevance of Charles Peirce, pp. 264-270. The Hegeler Institute, La Salle.

Hintikka J. and Sandu G., 1997, *Game-theoretical semantics*, in Handbook of Logic and Language, ed. Van Benthem and ter Meulen, Elsevier, Amsterdam: 361-410.

Hintikka J., Logic, *Language-Games and Information: Kantian Themes in the Philosophy of Logic*, Clarendon Press, Oxford 1973.

Hodges W., *Logic and Games*, The Stanford Encyclopedia of Philosophy (Winter 2004 Edition), Edward N. Zalta (ed.), URL = <http://plato.stanford.edu/archives/win2004/entries/logic-games/>.

Jaffe, A. and Quinn, F., 1993, *`Theoretical mathematics': Toward a cultural synthesis of mathematics and theoretical physics*. Bulletin of the American Mathematical Society, Vol. 29 No. 1: 1-14

Japaridze G., 2006, *In the beginning was game semantics*. In: Logic and Games: Foundational Perspectives. O. Majer, A.-V. Pietarinen and T. Tulenheimo, eds. Springer Verlag, Berlin (to appear).

Kelly K. T., 2004, *Uncomputability: the problem of induction internalized*, Theoretical Computer Science 317 227 – 249

Kuipers T.A.F., 2006 *Theories looking for domains. Fact or fiction? Structuralist Truth Approximation by Revision of the Domain of Intended Applications*, to appear in: L. Magnani (ed.), Model-Based Reasoning in Science and Engineering.

MacLennan B., *Natural computation and non-Turing models of computation,* Theoretical Computer Science 317 (2004) 115 – 145

Milner R., *Communication and Concurrency*, Prentice-Hall, 1989.

Moore C., *Recursion theory on real- and continuous-time computation*. Theoretical Computer Science 162 (1996), 23-44

Pietarinen, A. and. Sandu G., 1999, *Games in philosophical logic,* Nordic Journal of Philosophical Logic, vol. 4, pp. 143--73.

Priest, G., Tanaka, K., *Paraconsistent Logic*, The Stanford Encyclopedia of Philosophy (Winter 2004 Edition), Edward N. Zalta (ed.), URL = <http://plato.stanford.edu/archives/win2004/entries/logic-paraconsistent/>.

Tranströmer, T., *New Collected Poems*, Translated by Robin Fulton, Bloodaxe books, 1997, p.122

Schachter, *How Does Concurrency Extend the Paradigm of Computation?,* Monist; 1999, Vol. 82 Issue 1, p37, 21p

Siegelman, *H.T. Neural Networks and Analog Computation*, Birkhauser, Berlin, 1999

Sipper M., *Machine Nature: The Coming Age of Bio-Inspired Computing*, McGraw-Hill, New York, 2002.

Wegner P., 1998, *Interactive Foundations of Computing*, Theoretical Computer Science 192 315-51.

Winograd, T., 1997, *The design of interaction. Beyond Calculation*: The next 50 years of computing. Copernicus, 149-161

Information Physics Links

http://www.research.ibm.com/quantuminfo/

http://info.phys.unm.edu/

http://www.physics.uiuc.edu/Research/QI/

http://www.santafe.edu/research/computation.php

http://ic.arc.nasa.gov/projects/ne/ip.html

http://www.qubit.org/

Paper C

Paper C

MODEL VALIDITY AND SEMANTICS OF INFORMATION

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Abstract

Do predictions obtained from models constitute information on which reliable decisions can be made? Is it necessary, that to be of interest, predictions and other information generated by models must be true? This paper investigates the relation between the model and reality, information and truth. It will argue that meaningful data need not necessarily be true in order to constitute information. Partially true information or even completely false information can lead to a desirable outcome such as a technological innovation or a scientific breakthrough. Sometimes sheer serendipity gives rise to an invention. A combination of true and false information may result in an epoch-making event such as Columbus' discovery of America, on his intended voyage to India. An even more basic problem prevents scientists from thinking exclusively in terms of "true" information in the research process. In beginning from an existing theory (say Aristotelian physics), and developing a new theory (say Galilean physics) one can talk about the truth within each model, but during the transition between the two, there is a mixture of old and new concepts in which truth is not well defined. Instead of the veridicity of a model, the two basic concepts that are commonly used in empirical sciences are models correctness (validity) and its appropriateness within a context.

The conclusion is that despite the empirical models being in general not true but only truthlike, they may nevertheless produce results from which adequate conclusions can be drawn, and therefore can serve as the grounds for decision-making. In that sense they can yield information vital for improving our knowledge about the actual empirical world that is the precondition for technological innovation and scientific discovery.

Key words:

Modeling, Computation, Semantics, Digital Philosophy, Philosophy of Computing, Philosophy of Information, Verisimilitude, Simulation.

1. Introduction

The ubiquity of computers and the constantly increasing availability of computer power accelerate the use of computer-based representations, simulations and emulations, modeling and model-based reasoning and contribute to their dynamic development, see Denning and Metcalfe (1997). Administration, sciences, technology and businesses all rely on models of systems which they use to describe, understand, predict and control. This paper focuses on the relation between models, information, truth and reality.

2. System Modeling and Simulation: Validation and Verification

A model is a simplified representation of a complex system or process developed for its understanding, control and prediction. A model resembles the target system in some aspects while at the same time it differs in other aspects that are not considered essential, Johansson (1999). It follows that a model, which is valid for one objective, may not be valid for another. Models are abstracted or constructed on the grounds that they potentially satisfy important constraints of the target domain.

Model-based reasoning supports conceptual change and facilitates novel insights as clearly demonstrated in Magnani, Nersessian and Thagard (1999).

When discussing models, two concepts are central: verification and validation, see for details Irobi, Andersson, and Wall (2004), and Davis (1992).

Model verification is the substantiation that the model is transformed from a problem formulation into a model specification as intended, with sufficient accuracy. Model verification deals with building the model right.

Model validation is the substantiation that the model, within its domain of applicability, behaves with satisfactory accuracy consistent with the objectives. Model validation deals with building the right model.

Consequently, in using the term ‘valid’, we refer to models that adequately represent their target systems in their domains of applicability. The issue central for an appropriate assessment of model validity is that of the correctness, and not necessarily of the truth. Determining whether or not a model is an appropriate representation of the reality, for a well specified goal, is the essence of model validation, but there are other significant factors to be considered such as the relevance of the goal itself, Dodig-Crnkovic (2003).

Experimentation is the backbone of scientific thinking and the sine qua non technique of Francis Bacon’s scientific method, as presented in his Novum Organum. Conducting empirical tests allows us to go beyond the limits of Aristotelian logic in our investigation of the physical reality.

A special case of the use of the model is a simulation which is time-dependent goal-directed experimentation with a dynamic model. When actual experimentation cannot be performed on the real system, it can be replaced by simulation. Simulation can be used in addressing analysis, control, and design problems, Wildberger (2000). Simulation is a tool which facilitates the gaining of insight, the testing of theories, experimentation with control strategies, and prediction of performance. In the concept of simulation as a model-based computational activity, the emphasis is on the generation of model behaviour. Simulation can be interpreted as model-based experimental knowledge generation, Ören (2001), and can be combined with different types of knowledge generation techniques such as optimization, statistical inferencing, reasoning and hypothesis processing.

A simulation depends essentially on the quality of the input data with respect to correctness, reliability, sufficiency, relevance etc. It is the actual data representation of the information at hand which makes possible an analysis of the effects of changes in the underlying process based on changes in the model.

Questions of interest are to what degree can the results of simulation results be trusted and can simulation be said to generate information at all? The former can be answered in a pragmatic way, by asking what would be the alternative. In the case of weather forecasting, for example, we know that the reliability of the prediction is not extremely high, but it is improving, and it should be compared to a pure guess which is obviously a less successful prediction method. The output of a model for producing weather forecasts may be seen as information that is probable but not certain (true), yet necessary and useful.

3. Information Theories

Data is generally considered to be a series of disconnected facts and observations. These may be converted to information by analyzing, cross-referring, selecting, sorting, summarizing, or in some way organizing the data. Patterns of information, in turn, can be worked up into a coherent body of knowledge. Knowledge consists of an organized body of information, such information patterns forming the basis of the kinds of insights and judgments which we call wisdom.

The above conceptualization may be made concrete by a physical analogy (Stonier, 1983): consider spinning fleece into yarn, and then weaving yarn into cloth. The fleece can be considered analogous to data, the yarn to information and the cloth to knowledge. Cutting and sewing the cloth into a useful garment is analogous to creating insight and judgment (wisdom). This analogy emphasizes two important points: (1) going from fleece to garment involves, at each step, an input of work, and (2) at each step, this input of work leads to an increase in organization, thereby producing a hierarchy of organization.

Stonier (1997)

In his Open Problems in the Philosophy of Information Floridi (2004) suggests a list of the eighteen most important problems of PI (Philosophy of Information). Among those, the most fundamental is the question: “What is information?”.

“Inconsistencies and paradoxes in the conceptualization of information can be found through numerous fields of natural, social and computer science.” Marijuan (2002)

Or, as Floridi (2005) formulates it, “Information is such a powerful and elusive concept that it can be associated with several explanations, depending on the requirements and intentions.”; see even van Benthem, Adriaans (2005). In the same spirit, Capurro and Hjørland (2003) analyze the term information explaining its role as a constructive tool and its theory-dependence as a typical interdisciplinary concept.

On the other hand Capurro, Fleissner and Hofkirchner (1999) discuss the question if a unified theory of information (UTI) is feasible, answering in a cautiously affirmative way. According to the authors, UTI is an expression of the metaphysical quest for a unifying principle of the same type as energy and matter.

In the reductionist unification approach, reality is an information-processing phenomenon. “We would then say: whatever exists can be digitalized. Being is computation.” (ibid) In other words, at a fundamental level information characterizes the world itself, for it is through information we gain all our knowledge, and yet we are only beginning to understand its real meaning. If information is to replace matter as the primary stuff of the universe, as von Baeyer (2003) suggests; it will provide a new basic unifying framework for describing and predicting reality in the twenty-first century.

An alternative to a unified theory of information would be the networked structure of different information concepts, which retain their specific fields of application.

It is interesting to observe that information can be understood in conjunction with its complementary concept of computation. Cantwell Smith finds the relation between meaning and mechanism the most fundamental question, Dodig-Crnkovic (2004).

Having said that about the current views of the phenomenon information, it might be interesting to briefly review the existing theories of information following Collier's account of the subject.

3.1 Syntactic Theories of Information

In the syntactic approaches, information content is determined *entirely by the structure of language* and has nothing to do with the meaning of messages.

Statistical (Shannon's communications theory)
Shannon's theory gives the probability of transmission of messages with specified accuracy in the presence of noise, including transmission failure, distortion and accidental additions. The statistical interpretation of information assumes an ensemble of possible states each with a definite probability. The information is the sum of the base 2 log of the inverse of the probability of each weighted by the probability of the state,

$$H = \sum \mathrm{prob}(s_i)\log(1/\mathrm{prob}(s_i))$$

which is an expression similar to the expression for entropy in Boltzmann's statistical thermodynamics.

Combinatorial information theory is general, and has the same form as statistical formulation. The difference is that probability is replaced by frequency,

$$H = \sum \mathrm{freq}(s_i)\log(1/\mathrm{freq}(s_i))$$

Algorithmic information theory (Kolmogorov, Chaitin) combines the ideas of program-size complexity with recursive function theory. The complexity of an object is measured by the size in bits of the smallest program for computing it.

It was Kolmogorov who first suggested that program-size complexity provides an explication of the concept of information content of a string of symbols. Later Chaitin adopted this interpretation.

The intuitive idea behind this theory is that the more difficult an object is to specify or describe, the more complex it is. One defines the complexity of a binary string s as the size of the minimal program that, when given to a Turing machine T, prints s and halts. To formalize Kolmogorov-Chaitin complexity, one has to specify exactly the types of programs. Fortunately, it doesn't really matter: one could take a particular notation for Turing machines, or LISP programs, or Pascal programs, etc.

If we agree to measure the lengths of all objects consistently in bits, then the resulting notions of complexity will differ only by a constant term: if $K_1(s)$ and $K_2(s)$ are the complexities of the string s according to two different programming languages L_1 and L_2, then there is a constant c (which only depend on the languages chosen, but not on s) such that

$$K_1(s) \leq K_2(s) + c$$

Here, c is the length in bits of an interpreter for L_2 written in L_1. For more details see http://en.wikipedia.org/wiki/Information_theory An interesting critical analysis of this approach may be found in Raatikainen's Complexity and Information; the main argument being that it is one thing to specify (by an algorithm) an object, and another thing to give instructions sufficient for finding the object. This points back to the fact that the information concept itself is under intense debate.

3.2 Semantic Theories of Information

Although Shannon declared that "semantic aspects of communication are irrelevant to the engineering problem", Shannon (1948), his approach is often termed a Mathematical Theory of Information and treated as describing the semantic information content of a message. Bar-Hillel (1955) notes, "it is psychologically almost impossible not to make the shift from the one sense of information, i.e. information = signal sequence, to the other sense, information = what is expressed by the signal sequence."

The semantic theory of information explicitly theorizes about what is expressed by messages, i.e. about their information content. As a systematic theory it was initiated by Carnap and Bar-Hillel and has been developed and generalized since then by Hintikka.

Information in the semantic approach is the *content* of a representation.

Carnap and Bar-Hillel (Bar-Hillel, 1964) used inductive logic to define the information content of a statement in a given language in terms of the possible states it rules out. The basic idea is that the more possibilities (possible states of affairs) a sentence rules out, the more informative it is, i.e. *information is the elimination of uncertainty*. The information content of a statement is thus relative to a language. Evidence, in the form of observation statements, (Carnap's "state descriptions", or Hintikka's "constituents") contains information through the class of state descriptions the evidence rules out. (*The essential underlying assumption is that observation statements can be related to experience unambiguously.*)

Carnap and Bar-Hillel have suggested two different measures of information. The first measure of the information content of statement S is called the content measure, cont(S), defined as the complement of the a priori probability of the state of affairs expressed by S

$$\mathrm{cont}(S) = 1 - \mathrm{prob}(S)$$

Content measure is not additive and it violates some natural intuitions about conditional information. Another measure, called the information measure, inf(S) in bits is given by:

$$\mathrm{inf}(S) = \log_2 (1/(1 - \mathrm{cont}(S))) = -\log_2 \mathrm{prob}(S)$$

prob(S) here again is the probability of the state of affairs expressed by S, not the probability of `S' in some communication channel. According to Bar-Hillel cont(S) measures the substantive information content of sentence S, whereas inf(S) measures the surprise value, or the unexpectedness, of the sentence H.

Although inf satisfies additivity and conditionalisation, it has a following property: *If some evidence E is negatively relevant to a statement S, then the information measure of S conditional on E will be greater than the absolute information measure of S*. This violates a common intuition that the information of S given E must be less than or equal to the absolute information of S. This is what Floridi (2004) calls the Bar-Hillel semantic paradox.

A more serious problem however with the approach is the *linguistic relativity* of information, and problems with the Logical Empiricist program that supports it, such as the theory-ladenness of observation, Collier (1990).

For recent semantic theories such as Dretske (1981), Barwise and Perry (1983), Devlin (1991), see Collier, http://www.nu.ac.za/undphil/collier/information/information.html.

4. The Standard Definition of Information

In his Outline of a Theory of Strongly Semantic Information as well as in Information (The Blackwell guide to the philosophy of computing and information) Floridi (2004) discusses the question of the fundamental nature of information. A standard definition of information which is assumed to be declarative objective and semantic (DOS) is given in terms of data + meaning. In this context Floridi refers to The Cambridge Dictionary of Philosophy definition of information:

an objective (mind independent) entity. It can be generated or carried by messages (words, sentences) or by other products of cognizers (interpreters). Information can be encoded and transmitted, but the information would exist independently of its encoding or transmission.

It is instructive to compare the above formulation with the Web Dictionary of Cybernetics and Systems,
http://pespmc1.vub.ac.be/ASC/INFORMATION.html that offers the following definition of information:

that which reduces uncertainty. (Claude Shannon); that which changes us. (Gregory Bateson)

Literally that which forms within, but more adequately: the equivalent of or the capacity of something to perform organizational work, the difference between two forms of organization or between two states of uncertainty before and after a message has been received, but also the degree to which one variable of a system depends on or is constrained by (see constraint) another. E.g., the DNA carries genetic information inasmuch as it organizes or controls the orderly growth of a living organism. A message carries information inasmuch as it conveys something not already known. The answer to a question carries information to the extent it reduces the questioner's uncertainty. A telephone line carries information only when the signals sent correlate with those received. Since information is linked to certain changes, differences or dependencies, it is desirable to refer to theme and distinguish between information stored, information carried, information transmitted, information required, etc. Pure and unqualified information is an unwarranted abstraction.

In the background there is the most fundamental notion of information, ascribed to a number of authors; “a distinction that makes a difference", MacKay (1969), or "a difference that makes a difference", Bateson (1973).

Floridi’s Outline of a Theory of Strongly Semantic Information (2004) contributes to the current debate by criticizing and revising the Standard Definition of declarative, objective and semantic Information (SDI). The main thesis defended is that meaningful and well-formed data constitute information only if they also qualify as contingently truthful. SDI is criticized for providing insufficient conditions for the definition of information, because truth-values do not supervene on information. Floridi argues strongly against misinformation as possible source of information or knowledge. As a remedy, SDI is revised to include a truth-condition.

Accordingly, SDI is modified to include a condition about the truth of the data; so that

“σ is an instance of DOS information if and only if:

1. σ consists of n data (d), for $n \geq 1$;

2. the data are well-formed (wfd);

3. the wfd are meaningful (mwfd = δ);

4. the δ are truthful.”

Floridi’s concept of strongly semantic information from the outset encapsulates truth and thus can avoid the Bar-Hillel paradox that we mentioned in the previous chapter.

It is important to remember that Floridi analyses only one specific type of information, namely the alethic (pertaining to truth and falsehood) declarative objective and semantic information which is supposed to have definite truth value. Non-declarative meanings of “information”, e.g. referring to graphics, music or information processing taking place in a biological cell or a DNA molecule, such as defined in Marijuán (2004) are not considered.

Apparently there is a dilemma here and we are supposed to choose between the two definitions of information; the weaker one that accepts meaningful data as information, and the stronger one that claims that information must be true in order to qualify as information. Yet, both approaches will prove to have legitimacy under specific circumstances, and I will try to illuminate why the general definition of information does not explicitly require truth from the data.

5. Information, Truth and Truthlikeness

...by natural selection our mind has adapted itself to the conditions of the external world. It has adopted the geometry most advantageous to the species or, in other words, the most convenient. Geometry is not true, it is advantageous.

Henri Poincaré, Science and Method

Science is accepted as one of the principal sources of "truth" about the world we inhabit. It might be instructive to see the view of truth from the scientific perspective, Dodig-Crnkovic (2005). When do we expect to be able to label some information as "true"? Is it possible for a theory, a model or a simulation to be "true"? When do we use the concept of truth and why is it important?

Popper was the first prominent realist philosopher and scientist to proclaim a radical fallibilism about science (fallibilism claims that some parts of accepted knowledge could be wrong or flawed), while at the same time insisting on the epistemic superiority of the scientific method. Not surprisingly, Popper was the first philosopher to abandon the idea that science is about truth and take the problem of truthlikeness seriously. In his Logik der Forschung Popper argues that *the only kind of progress an inquiry can make consists in falsification of theories.*

Now how can a succession of falsehoods constitute epistemic progress? Epistemic optimism would mean that if some false hypotheses are closer to the truth than others, if truthlikeness (verisimilitude) admits of degrees, then the history of inquiry may turn out to be one of steady progress towards the goal of truth. Oddie (2001)

> While truth is the aim of inquiry, some falsehoods seem to realize this aim better than others. Some truths better realize the aim than other truths. And perhaps even some falsehoods realize the aim better than some truths do. The dichotomy of the class of propositions into truths and falsehoods should thus be supplemented with a more fine-grained ordering -- one which classifies propositions according to their closeness to the truth, their degree of truthlikeness or verisimilitude. The problem of truthlikeness is to

> give an adequate account of the concept and to explore its logical properties and its applications to epistemology and methodology.

On those lines, Kuipers (2000) developed a synthesis of a qualitative, structuralist theory of truth approximation:

> In this theory, three concepts and two intuitions play a crucial role. The concepts are confirmation, empirical progress, and (more) truthlikeness. The first intuition, the success intuition, amounts to the claim that empirical progress is, as a rule, functional for truth approximation, that is, an empirically more successful theory is, as a rule, more truthlike or closer to the truth, and vice versa. The second intuition, the I&C (idealization and concretization) intuition, is a kind of specification of the first.

According to Kuipers the truth approximation is a two-sided affair amounting to achieving 'more true consequences and more correct models', which obviously belongs to scientific common sense.

The conclusion from the scientific methodology point of view is that, at best, we can discuss truthlikeness, but not the truth of a theory. Like Poincaré's geometry, other models or theories are more or less correct and advantageous.

6. Conclusion

There are two major approaches to the individuation of scientific theories, that have been called syntactic and semantic. We prefer to call them the linguistic and non-linguistic conceptions. On the linguistic view, also known as the received view, theories are identified with (pieces of) languages. On the non-linguistic view, theories are identified with extralinguistic structures, known as models. We would like to distinguish between strong and weak formulations of each approach. On the strong version of the linguistic approach, theories are identified with certain formal-syntactic calculi, whereas on a weaker reading, theories are merely analysed as collections of claims or propositions. Correspondingly, the strong semantic approach identifies theories with families of models, whereas on a weaker reading the semantic conception merely shifts analytical focus, and the burden of representation, from language to models.

Hendry and Psillos [2004]

Here we can refer to Laudan's Methodological Naturalism, (Laudan, p.110) in Psillos (1997) formulation:

- All normative claims are instrumental: Methodological rules link up aims with methods which will bring them about, and recommend what action is more likely to achieve one's favoured aim.

- The soundness of methodological rules depends on whether they lead to successful action, and their justification is a function of their effectiveness in bringing about their aims. A sound methodological rule represents our ´best strategy´ for reaching a certain aim (cf. pp 103 and 128 ff)

In the actual process of discovery and in model building information is the fundamental entity. Very often information is transformed and it changes its place and physical form. Depending on context, it also changes its meaning. When dealing with empirical information we always meet the fact that the real world never perfectly conforms to the ideal abstract structure (Plato's stance). Ideal atoms might be represented by ideal spheres. Real atoms have no sharp boundaries. In the physical world of technological artefacts and empirical scientific research situations in which the result of a model can be sharply divided into two categories (true-false) are rare. However, it is often possible to conventionally set the limits for different outcomes that we can label as "acceptable"/"non-acceptable" which can be translated in terms of "true"/"false" if we agree to use the term truth in a very specific sense.

There are cases in the history of science in which false information/knowledge (false for us here and now) has lead to the production of true information/knowledge (true for us here and now). A classical example is serendipity, making unexpected discoveries by accident. The pre-condition for the discovery of new scientific 'truths' (where the term 'true' is used in its limited sense to mean 'true to our best knowledge') is not that we start with a critical mass of absolutely true information, but that in continuous interaction (feedback coupling) with the empirical world we refine our set of (partial) truths. With good reason, truth is not an operative term for scientists.

Christopher Columbus had, for the most part, incorrect information about his proposed journey to India. He never saw India, but he made a great discovery. The "discovery" of America *was not* incidental; it was a result of a combination of many favourable historical preconditions combined with both true and false information about the state of affars. Similar discoveries are constant occurrences in science.

"Yet libraries are full of 'false knowledge' ", as Floridi rightly points out in his Afterword - LIS as Applied Philosophy of Information: a Reappraisal (2004). Nevertheless we need all that "false knowledge". Should we throw away all books containing false information, and all newspapers containing misinformation, what would be left? And what would our information and knowledge about the real world look like?

In the standard (general) definition of semantic information commonly used in empirical sciences information is defined as meaningful data. Floridi in his new Theory of Strongly Semantic Information adds the requirement that standard semantic information should also contain truth in order to avoid the logical paradox of Bar-Hillel's semantic theory. This paper argues that meaningful data need not necessarily be true to constitute information. Partially true information or even completely false information can lead to an outcome adequate and relevant for inquiry. Instead of insisting on the veridicity of an empirical model, we should focus on such basic criteria as the validity of the model and its appropriateness within a given context.

7. References

von Baeyer H.C., 2003, Information: The New Language of Science, Weidenfeld and Nicolson

Barwise, Jon and John Perry, 1983 Situations and Attitudes. MIT Press, Cambridge, MA

Bateson, G., 1973, Steps to an Ecology of Mind, Paladin. Frogmore, St. Albans

van Benthem J., Adriaans P., eds., 2005, Handbook on the Philosophy of Information, (In Gabbay D., Thagard P., and Woods J., Handbook of the philosophy of science, to be published by Elsevier

Carnap, R., 1950, Logical Foundations of Probability. University of Chicago Press, Chicago

Carnap, R., Bar-Hillel, Y., 1964, An Outline of Semantic Information. In Bar-Hillel, Y. (Ed.) Language and Information: Selected Essays on Their Theory and Application. Addison-Wesley, Reading, Mass.

Capurro R., Hjørland B., 2003, The Concept of Information In: Annual Review of Information Science and Technology (ARIST), Ed. Blaise Cronin, Information Today, Inc. Medford, NJ

Capurro R., Fleissner P., Hofkirchner W., 1999, Is a Unified Theory of Information Feasible? A Trialogue In: W. Hofkirchner Ed.: The Quest for a Unified Theory of Information. Proceedings of the Second International Conference on the Foundations of Information Science, Gordon and Breach Publ.

Chaitin, Lecture, Dijon, 2003, http://www.cs.auckland.ac.nz/CDMTCS/chaitin

Collier, John D., 1990, Intrinsic Information In Philip Hanson (ed) Information, Language and Cognition: Vancouver Studies in Cognitive Science, Vol. 1, University of Oxford Press

Devlin, K., 1991, Logic and Information, Cambridge University Press, Cambridge

Dodig-Crnkovic, G., 2005, System Modeling and Information Semantics, Proc. Conf. for the Promotion of Research in IT at New Universities and at University Colleges in Sweden, Studentlitteratur, Lund (forthcoming)

Dodig-Crnkovic, G., 2004, Philosophy of Information, a New Renaissance and the Discreet Charm of the Computational Paradigm, Computing and Philosophy Conference, E-CAP Pavia, Italy

Dodig-Crnkovic, G., 2003, Shifting the Paradigm of the Philosophy of Science: the Philosophy of Information and a New Renaissance, Minds and Machines: Special Issue on the Philosophy of Information, Volume 13, Issue 4

Davis, P.K., 1992, Generalizing Concepts and Methods of Verification, Validation, and Accreditation (VV&A) for Military Simulations, RAND, R-4249-ACQ

Denning, P.J. and Metcalfe, R.M., 1997, eds., Beyond Calculation – The Next Fifty Years of Computation. Copernicus (Springer Verlag). New York

Dretske, F., 1981, Knowledge and the Flow of Information, MIT Press Cambridge, MA

Floridi, L., 2004, Information. In Floridi L., ed., The Blackwell guide to the philosophy of computing and information Blackwell, Oxford UK

Floridi. L., 2004, Afterword - LIS as Applied Philosophy of Information: a Reappraisal, Library Trends, 52(3)

Floridi, L. (forthcoming), Is Information Meaningful Data?, Philosophy and Phenomenological Research, http://www.wolfson.ox.ac.uk/floridi/papers.htm.

Floridi, L., 2004, Outline of a Theory of Strongly Semantic Information Minds and Machines, 14.2, pp. 197-222.

Floridi L., 2004, Open Problems in the Philosophy of Information, Metaphilosophy, Volume 35: Issue 4

Hendry R. F. and Psillos S., 2004, How To Do Things With Theories: An Interactive View of Language and Models in Science in K. Paprzycka and P. Przybysz (eds.) Idealization and Concretization, Rodopi

Irobi I. S., Andersson, J. and Wall A., 2004, Correctness criteria for models' validation – A philosophical perspective; in Models, Simulations and Visualization conference (MSV'04), International Multiconferences in Computer science and Computer Engineering, Las Vegas

Johansson, L-G. , 1999, *Introduktion till Vetenskapsteorin* (In Swedish), Thales

Kuipers, T.A.F., 2000, From instrumentalism to constructive realism: on some relations between confirmation, empirical progress, and truth approximation - Dordrecht Kluwer Academic

Kuipers, T. A. F., 1987, ed., What is closer-to-the-truth? A parade of approaches to truthlikeness, Poznan Studies in the Philosophy of the Sciences and the Humanities, Volume 10, Amsterdam: Rodopi

Kuipers, T. A. F., 2002, Inductive Aspects of Confirmation, Information, and Content, To appear in the Schilpp-volume The Philosophy of Jaakko Hintikka

Kuipers, T. A. F., (to appear), Empirical and conceptual idealization and concretization. The case of truth approximation, in (English and Polish editions of) Liber Amicorum for Leszek Nowak

Laudan L., 1996, Beyond Positivism and Relativism: Theory, Method and Evidence, Westview Press

Leyton, M. Process Grammar. http://www.rci.rutgers.edu/~mleyton/freeform1.htm

MacKay, D. M., 1969, Information, Mechanism and Meaning. Cambridge, MA: MIT Press

Magnani L., Nersessian N. J. and Thagard P., 1999, ed., Model-based Reasoning In Scientific Discovery, Kluwer, NY

Marijuan, P. C., 2003, Foundations of Information Science: Selected papers from FIS 2002. Entropy 5, 214-219

Marijuán P. C. 2004, Information and Life: Towards a Biological Understanding of Informational Phenomena, TripleC 2(1): 6-19, ISSN 1726-670X, http://tripleC.uti.at

Oddie, G., 2001, Truthlikeness, The Stanford Encyclopedia of Philosophy, E.N. Zalta (ed.), http://plato.stanford.edu/archives/fall2001/entries/truthlikeness/

Poincaré, H., 1982, Science and Method, New York: Dover

Psillos S., 1997, Naturalism Without Truth? Stud. Hist. Phil. Sci., Vol. 28, No.4, pp. 699-713

Raatikainen P., Complexity and Information -A Critical Evaluation of Algorithmic Information Theory http://www.helsinki.fi/collegium/eng/Raatikainen/information.pdf

Shannon, C. E., 1948, A mathematical theory of communication. Bell Sys. Tech. J., 27, 323-332; 379-423. http://cm.bell-labs.com/cm/ms/what/shannonday/paper.html

Stonier, T., 1993, The Wealth of Information, Thames/Methuen, London

Stonier, T., 1997, Information and Meaning. An Evolutionary Perspective, Springer, Berlin, New York

Wildberger, A.M., 2000, AI & Simulation, Simulation, 74

Ören, T.I., 2001, Impact of Data on Simulation: From Early Practices to Federated and Agent-Directed Simulations. In: A. Heemink et al. (eds.) Proc. of EUROSIM 2001, June 26-29, Delft, the Netherlands

Paper D

Paper D

TOGETHERNESS AND RESPECT - ETHICAL CONCERNS OF PRIVACY IN GLOBAL WEB SOCIETIES

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Ethics and Privacy of Communications in Global E-Village

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Abstract
Today's computer network technologies are sociologically founded on hunter-gatherer principles; common users may be possible subjects of surveillance and sophisticated Internet-based attacks are almost impossible to prevent. At the same time, information and communication technology, ICT offers the technical possibility of embedded privacy protection. Making technology legitimate by design is a part of the intentional design for democracy. This means incorporating options for socially acceptable behaviour in technical systems, and making the basic principles of privacy protection, rights and responsibilities, transparent to the user. The current global e-polis already has, by means of different technologies, de facto built-in policies that define the level of user-privacy protection. That which remains is to make their ethical implications explicit and understandable to citizens of the global village through interdisciplinary disclosive ethical methods, and to make them correspond to the high ethical norms that support trust, the essential precondition of any socialization. The good news is that research along these lines is already in progress. Hopefully, this will result in a future standard approach to the privacy of network communications.

Keywords Privacy, Cyberethics, *E-polis* ethics, Legitimate by design, Disclosive ethics, Intentional design for democracy.

1. Technology and Culture - ICT and a New Renaissance

"The futures are out there in the setting of a coastline before someone goes out there to discover it. (...) The futures have yet to be built by us. We do have choices." (Cooley 1999 as cited in Gill 2002).

The industrial-technological era was characterized by the ideal of the perfect machine and "objective knowledge" reduced to an algorithm for constructing a "theory of everything" (Hilbert's program), with strict division of labour within different fields of endeavour. Each of the sciences was searching for its own specific and certain truths.

The post-industrial age has, however, abandoned the rigid mechanical model of a monolithic, deterministically controlled system with "the one right way" and one absolute truth. On the contrary: it has embraced the fact that social cohesion through pluralism and polycentrism, cultural diversity, self-organisation and contextual truth is more productive and appropriate for the new epoch. Flexibility and fluidity have replaced rigidity and conformance, dynamics have replaced statics. The effort to determine the eternal unchangeables is superseded by the endeavour to capture dynamic balances and emergent phenomena.

In the Information-communication era there is a development toward a human-centrism with a potential for a new Renaissance, in which science and the humanities, arts and engineering can reach a new synthesis, through modern computing and communication tools used in global virtual societies (Dodig-Crnkovic 2003). This meeting of cultures is largely occurring in cyber space, making issues of cyber ethics increasingly important.

2. The Question of Values and Ethics for E-Polis

A view of the human, not only as a component of an automated process but as an end in itself, leads inevitably to the question of choices, values and ethics. We are not only given the world we inhabit as a fact, we are inexorably changing it.

Typical of the information-communication era is the formation of global web societies - planetary e-villages. Networking (Gill 1997, 2002) at the global level exists in the symbiotic relationship with local resources. Gill argues that a rethinking of the development idea in the contemporary globally-networked civilization is necessary. In the information society, a shift from the techno-centric to a human-centred framework is necessary in consideration of the diversity and the complexity of cross-cultural collaboration. Social cohesion in this context results from the ability to participate in the networked society through mutual interaction, exchange of knowledge and sharing of values. The relevance of associative networks for a sustainable information and communication society is discussed by Thill (1994), while Wagner, Cheung, Lee, and Ip (2003) address the related problem of enhancing e-government in developing countries via virtual communities' knowledge-management.

We are witnessing the emergence of an e-polis which is finding its specific ways of expression of the concept of the social good. "Policy vacuums" (Moor 1985) of a new kind of socio-technological system are being investigated, and new policies and strategies formed.

3. Why Privacy Matters

Before the advent of ICT, information was often spread by direct verbal communication. Today we frequently use computers to communicate and information travels far and fast, to an unlimited number of recipients, virtually effortlessly. This leads to new types of ethical problems including intrusion upon privacy. Privacy protects two kinds of basic rights:

- priority in defining ones own *identity*
  As a special case *the freedom of anonymity* can be mentioned. (In certain situations we are ready to lend our personal data for statistical investigations, for research purposes and similar, under the condition that anonymity is guaranteed.)
- the right to private *space* (generalized to mean not only physical space but also disk space or special artefacts that are exclusively connected to a certain individual, such as a private diary or private letters)

Privacy of ones' home is a classic example of a private space. It is also instructive because it shows the nature of a private space as a social construction. You are normally allowed to choose whom you wish to invite to your home. Under certain special circumstances it is however possible for police, for example, to enter your home without your consent, this being strictly regulated by law.

The following is from Article 8; Right to respect for private and family life of the British Human Rights Act (1998)

1. Everyone has the right to respect for his private and family life, his home and his correspondence.

2. There shall be no interference by a public authority with the exercise of this right except such as is in accordance with the law and is necessary in a democratic society in the interests of national security, public safety or the economic well-being of the country, for the prevention of disorder or crime, for the protection of health or morals, or for the protection of the rights and freedoms of others.

Historically, as a result of experiences within different cultures a system of practices and customs has developed that define what is to be considered private and what is public.

According to Charles Fried (Rosen 2000), true knowledge of individuals is only achievable by persons closely related to them. Individuals have the right to choose the degree of intimacy in their relationships with other people. For a close relationship to develop there is a need of privacy and this privacy excludes the surroundings which have the role of "the others". The characteristics by which the individual is to be defined must however be decided by him/her. This is enabled through his/her rights to privacy in the sense of the control of ones' own personal information. Often when personal information is taken out of its context, there can be a risk of misinterpretation and misjudgement of a person.

An issue which might arise in policy-making is that privacy is seen differently in different parts of the world (Mizutani, Dorsey, Moor 2004). For example, there is a different attitude to privacy in Japan because of its specific cultural, linguistic and historical development. The view of privacy of a Japanese individual differs from that of an individual in the US. There is nevertheless a basic and a common understanding of privacy in any developed culture, which is called *the minimal conception of privacy*. But the culturally developed privacy in individual countries, which is called the rich conception of privacy, is what mainly differentiates the Western world and Japan in this respect. Remembering this, it is obviously difficult to establish global policies, because of the need to decide which view of privacy should be adopted. The Internet is a global technology and each part of the world has its own laws and rights to privacy.

4. Phenomenology of Cyber Privacy: Many (Inter)Faces of Self

"Virtual communities are a flourishing result of the free exercise of the constructionist drive. In them, users reveal personal facts, "flame", and switch personae by endlessly constructing, deconstructing and reconstructing alternative selves. They collaborate with and participate in a common social project. In general, they behave quite differently from the way they would behave in person. (..) The web empowers new categories of users with the possibility of constructing a new self and an *e-polis*." (Floridi and Sanders 2003).

4.1 Social Fraud?

Let us not forget that the social value of privacy can be questioned (Rosen, 2000). It is sometimes argued that there is a risk that the abuse of privacy rights can encourage people to conceal true information about themselves in order to gain social or economic advantages. Another opinion is that having a private life, in addition to a public life, is a social fraud which can lead to deception and hypocrisy. The counter-argument is that every society relies on *trust*. If anybody is entitled to define the characteristics of an individual, it must primarily be the individual himself/herself. By default we normally *trust* a person before we have a strong reason not to do so.

With respect to the difference between the public and the private life of a person leading to a social fraud, some see it as the wearing of different "masks" depending on the current situation in which the person is (Rosen, 2000). People wear different types of "masks" in public and in private. An influential executive who plays two different roles, depending on whether he/she is at the office with his/her colleagues or at home playing with his/her children is but one example. In general, people play different roles on different occasions and the "masks" they wear are only an expression of the different sorts of relations they have with different people.

Just How Many of You is There??

"There are many Sherry Turkles. There is the "French Sherry," who studied poststructuralism in Paris in the 1960s. There is Turkle the social scientist, trained in anthropology, personality psychology, and sociology. There is Dr. Turkle, the clinical psychologist. There is Sherry Turkle the writer of books - Psychoanalytic Politics (Basic Books, 1978) and The Second Self: Computers and the Human Spirit (Simon & Schuster, 1984). There is Sherry the professor, who has mentored MIT students for nearly 20 years. And there is the cyberspace explorer, the woman who might log on as a man, or as another woman, or as, simply, ST." (Turkle 1996).

Today's ICT-mediated experiences make the picture increasingly complex. Windows allow us to be in several contexts at the same time - in a spread sheet, in a word-processing program, in a chat room, in e-mail (ibid). Virtual spaces that many computer users could share and collaborate within, called MUDs (Multi-User Dungeons) are a new kind of social virtual reality. Obviously each user is represented by a virtual persona created/invented for the purposes of the game. Chat personae are less obviously fictive, but they are not at all expected to correspond to real life persons. This is commonly experienced in chat rooms, and the identity problem and correspondence with the real world is settled differently from case to case according to a mutual agreement. Problems arise in situations in which reality and fiction are mixed and it becomes difficult to distinguish between the two.

Noli turbare circulos meos![8]

“Studies of cooperative work in real-world environments have highlighted the important role of physical space as a resource for negotiating social interaction, promoting peripheral awareness, and sharing artifacts [2]. The shared virtual spaces provided by CVEs (Collaborative Virtual Environments) may establish an equivalent resource for telecommunication.” (Benford, Greenhalgh, Rodden, Pycock 2001).

Early studies of social interaction in CVEs stressed the interdependence between virtual and physical space. (ibid) We see the parallels between the symbolic space handling in VR and the privacy expressed as ones right to private space.

On a symbolic level, this problem can be studied in the CVEs which are virtual worlds shared by users across a computer network. Participants are represented by graphical objects called avatars that express their identity, presence, location, and activities. Avatars interact with the world and communicate via different media (audio, video, graphical gestures, and text).

Even if all the participants in CVEs are well aware of the fact that they are involved in a virtual social interplay, the CVE nevertheless presents definite reflections of their real selves. The question might be asked: Where does semblance of life stop and reality start?

”What distinguishes genuine from spurious worlds? What are worlds made of? How are they made? What role do symbols play in the making? (…) If I ask about the world, you can offer to tell me how it is under one or more frames of reference; but if I insist that you tell me how it is apart from all frames, what can you say? We are confined to ways of describing whatever is described. Our universe, so to speak, consists of these ways rather than of a world or of worlds.“ (Goodman 1978).

These questions, central to philosophy, are also keys to the moral understanding of the online world. Powers (2004) discusses some ethically relevant aspects of virtual, online communities by reference to more basic philosophical concepts in theories of moral realism, speech acts, and social practices. His conclusion is that in spite of the fact that “sticks and stones can break your bones, but the snerts of virtual reality can rarely hurt you…

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[8] Don't upset my calculations! - Archimedes (Supposedly said in deep thoughts over geometrical shapes drawn in the sand at the moment a Roman legionary broke into his house and slew him, during the fall of Syracuse.)

unless you let them." – virtual communities are able to *engage in real wrongs*. As any other human communities they have a capability of expressing both positive and negative intentions and feelings. With the development of ever more sophisticated techniques the expressive power of virtual reality (VR) is constantly increasing which also leads to its more effective representation of whatever sort of relations the participants might be involved in.

Now if we agree that the real wrongs of virtual worlds can really hurt us, the question is what to do about it. What sorts of wrongs can they be? How can they be prevented?

Brey (1999) addresses ethical aspects of the design and use of VR systems, focusing on the behavioral options made available in such systems and the manner in which reality is represented or simulated in them. The representational aspects of VR applications are defined as features that articulate the way in which objects are depicted or simulated, while behavioral aspects refer to the actions or behaviors implemented in VR environments. Misrepresentation and biased representation in VR systems is one of the ethical concerns of VR especially where the virtual world and the everyday physical world are closely intertwined in a relationship.

Privacy as Architecture of Relationships

Human associations are characterized by their layered architecture which can be viewed through the degrees of privacy. The basic distinction is the one between the private (shared with a few others) and the common (shared with wider groups), (DeCew 2002). According to Mason, privacy can be studied through the relationships of four social groups:

- The first group consists of an individual, I, who has the right to privacy, both to physical privacy and to the protection of personal information.
- The second group consists of all people with whom individual I shares his/her information or private space in return for relationships or services. Individuals should acquire information about the second group before beginning a relationship with it. They must be aware of what sort of information they must provide, and how this information will be used subsequently. This type of relationship is called a negotiated relationship.

- The third group does not directly receive the information shared between I and the second group. This group has access to the information about I as a result of their professional role. The information however should not be used, since the third group is involved in activities which are irrelevant to I, who is not even aware of the fact that they might have access to such information.
- The fourth group consists of the rest of society, the public, who are not in any direct contact with I's private space or information. Tabloid newspapers profit greatly by selling private pictures of and gossip about celebrities to the public.

Each of these four social groups has its own rights and duties towards the other groups (Mason). During the interaction between groups, individuals invoke different levels of privacy. The advantages of close relationships are compared with the risks of the release of information and its inappropriate use, resulting in loss of personal space or harm to ones identity.

As mentioned before, there are differences between cultures with respect to attitudes towards privacy. That which constitutes the right to privacy is a social construction. The convention in Japan, for example, says that even if a third group were to gain information about the first group, in a certain situation where the information was not supposed to be available, the third group should act as if the information was unknown to them (Mizutani, Dorsey, Moor 2004). An example is the network administrator who has access to private information about the students, but (s)he is supposed to act as if (s)he did not have such access.

When the rights and duties of these four groups have been settled, a technical problem raises - how to design and implement a system, which makes the information available to the groups who are entitled to the specific information at a specific time.

State of the Art: Disclosive Ethics

"While the scholarly debate continues as we define the field, it seems not unreasonable to suggest that such a task is best handled by those equipped to understand both the capabilities and limitations of the technology, on one hand, and to wield the tools of philosophical and ethical reasoning as developed over the millennia, on the other." (Vance, Information Systems Ethics page)

The classic foundational problems of computer ethics are discussed by Bynum (2000); Floridi and Sanders (2002); Floridi (1999) and Johnson (2003, 1997). Tavani (2002) gives an overview of the uniqueness debate.

For computer ethics with its specific contemporary ethical questions, Floridi and Sanders (2003) advocate the method of *ethical constructionism*. They see a parallel in the fact that there is a need for ethical policies which define the consumer's right to privacy when products and services are developed. It cannot be up to each individual to set up ethical rules for a globalized world of computer ethics. Therefore Floridi and Sanders mean that virtue ethics is not an appropriate base for computer ethics. Computer ethics is a global problem and should not be solved in a case-by-case fashion. The constructionist approach to computer ethics is, according to Floridi and Sanders better, because it does not concentrate only on the dilemmas within computer ethics faced by an individual but addresses instead, global computer ethical problems. Problems involved in, for example, the sharing and revealing of information about oneself do not only imply denial of access to the individual's information; they include more fundamental questions including the cultural and social context which must be considered when formulating policies.

Moor (1985) proposed that the central aim of computer ethics is to formulate policies to guide individual and collective action in the use of computer technology. Brey (2000) claims that not just the uses of computer technology, but also other practices that involve computing technology, such as its development and management, require the formulation of policy guidelines:

The changing resources and practices that emerge with new computer technologies yield new values, as well as requiring the reconsideration of old. There may also be new moral dilemmas because of conflicting principles that unexpectedly clash when brought together in a new context. However, according to Brey applying moral theory is only part of the computer ethicist's agenda. Privacy, for example, is now recognized as requiring more attention than it has previously received in ethics. This is due to reconceptualizations of the private and public spheres brought about by the use of computer technology, which has resulted in inadequacies in existing moral theory about privacy. It is therefore pertinent for contemporary computer ethicists to contribute to the development of moral theory about privacy. In general, it is part of the task of computer ethics to further develop and modify existing moral theory when existing theory is insufficient or inadequate in the light of new demands generated by new practices involving ICT (Brey 2000).

For Moor, computer ethics is primarily about solving moral problems that arise because there is a policy vacuum about how computer technology should be used. In such a case, the work that is to be done is the conceptual clarification and description of the practice that generates the moral problem. Brey claims that a large part of work in computer ethics is about revealing the moral significance of practices that seem to be morally neutral. ICT has implicit moral properties that remain unnoticed because the technology and its relation to the context of its use are too complex or are not well known.

Disclosive computer ethics (Brey 2000) is a multi-level interdisciplinary approach concerned with the moral deciphering of embedded values and norms in computer systems, applications and practices. It aims to make computer technology and its uses transparent, revealing its morally relevant features. Research is performed on three levels:

- the disclosure level, at which, ideally, philosophers, computer scientists and social scientists collaborate to disclose embedded normativity in computer systems and practices,
- the theoretical level, at which philosophers develop and modify moral theory, and
- the application level, at which conclusions are drawn from research performed at the previous two levels, and at which normative evaluations of computer systems and practices takes place (Brey 2000).

The first step of the *intentional design for democracy* is the explication of the embedded moral significance of ITC where the disclosive method can be applied. The next step is to develop a technology according to human-centric principles.

Togetherness and Respect – Legitimacy by Design

"The electronic networking of physical space promises wide-ranging advances in science, medicine, delivery of services, environmental monitoring and remediation, industrial production, and monitoring of people and machines. It can also lead to new forms of social interaction, as suggested by the popularity of instant messaging (...). However, without appropriate architecture and regulatory controls it can also subvert democratic values. Information technology is not in fact neutral in its values; we must be intentional about design for democracy." (Pottie 2004).

Legitimacy is a social concept, of “socially beneficial fairness”, developed during human history. It concerns social problems such as the prisoner’s dilemma and the tragedy of the commons, where individuals profit but society doesn’t. Social interactions without legitimacy lead society into an unstable state because of the lack of synergistic gains. Traditional mechanisms that support legitimacy, such as the law and customs are struggling in cyberspace with its flexible, dynamic character (Whitworth and de Moor 2003).

Legitimacy analysis can translate legitimacy concepts, such as freedom, privacy and ownership of intellectual property into specific system design demands. On the other hand it can interpret program logic into statements of ownership that can be understood and discussed by a social community. Legitimate interaction, with its cornerstone of accountability, seems a key to the future of the global information society we are creating.

Whitworth and de Moor (2003) claim that legitimate interaction increases social well-being, and they analyze the ways in which societies traditionally establish legitimacy, and how the development of socio-technical systems changes previously established patterns of behaviour.

This means that democratic principles must be built into the design of socio-technical systems such as e-mail, CVE’s, chats and bulletin boards. As the first step towards that goal, the legitimacy analysis of a technological artefact (software/hardware) is suggested. Legitimacy analysis can be seen as a specific branch of disclosive ethics, specialized for privacy issues.

One of the fundamental questions related to the expansion of community networks is the definition of private space vs. communal space. Spam and similar unwanted communication indicates the failure of the techno-social system which until now has not developed adequate mechanisms to prevent such privacy invasion.

As a remedy, the following three social communication “rights” are proposed:

- the right to block personal data access,
- the right to not interact, and
- the right to return e-mail to its sender.

How these requirements could be implemented is discussed by Whitworth and de Moor (2003).

Intentional Design for Democracy - Implementing Ethical Aspects in ICT

It is difficult to maintain privacy when communicating through present-day computer networks, continually divulging information about oneself. Many companies endeavour to obtain information about the potential consumer's behaviour by, for example, using cookies. [A cookie is information about a user that is stored by the server on the user's hard disk. Typically, a cookie records user's preferences when using a particular site. Web users must nominally agree to cookies being saved for them, but it commonly happens without their knowledge.]

Another method of tracing users is radio-frequency identification (RFID) of products (Pottie 2004). Identifier tags are incorporated in products and return information about the purchaser to the manufacturer. This can be an intrusion upon the consumer's right to privacy because, as a rule, the purchaser is not informed of the presence of the tag (ibid). When developing products and services today there is a need to simultaneously define the rights of the consumer. Each company should take responsibility for setting up policies concerning the ethics of their relations with consumers.

An example of the realization of *intentional design for democracy* is in the work in progress within the CyLab group at Carnegie Mellon. This includes both technical and ethics research into the development of protocols and policies that effectively balance privacy rights with Internet security. Interesting projects presented at CyLabs's web site include the following:

- *Provably Secure Steganography***.** Steganography is the process of sending a secret message in such a way that an eavesdropper is unaware that a message is being sent. In order to achieve this, messages are embedded in apparently innocent communications such as emails or photographs.
- *Secure People Location Service.* A system based on digital certificates and a public key infrastructure, which provides persons and services with information about the location of the user but gives the user fine-grain access-control over who is to be informed of his/her location. It uses a variety of mechanisms to locate people (such as calendar information, badges, wireless location, etc.), and gives users control over when information can be released and the granularity of the information. Users can also delegate access control decisions.
- *Levels of Anonymity and Traceability.* The current technical ability to track and trace Internet-based attacks is primitive. Sophisticated attacks can be almost impossible to trace to their true source using present practices. The anonymity enjoyed by today's cyber-attackers

is a threat to the global information society. The aim of the ICT design must be to balance privacy and security.

Conclusion

“Growing research interest in societal issues such as work and organisational cultures, creativity and innovation, cooperation and participation, and culture and communication among AI and information technology communities shows a sign of hope for future human centred perspectives of IT research and applications. However, we must always be vigilant about the seductive nature of technical solutions of human problems and the narrowness of culture of 'short termism'.” (Gill 2003).

Post-industrial society with a dominating IC technology is becoming less concerned with calculation (the primary application field of computer), and increasingly engaged in communication, less involved with machinery and more with humans. The orientation toward human-centred computing will certainly become even more apparent in the future. ICT supports and promotes the formation of new global virtual communities that are new socio-technological phenomena typical of our time. For a modern civilization of global *e-polis* the optimal functioning of virtual communities is vital.

What are the basic principles behind successful virtual community environments? According to Whitworth there are two such principles:

- Virtual community systems must match the processes of human-human interaction.
- The rights and the ownership must be clearly defined (This can actually be included under the first principle for well defined human interactions within social organizations).

ICT has the technical possibility of embedding those principles that also include privacy protection via standards, open source code, government regulation etc. (Pottie, 2004), (Tavani, Moor 2000).

Communication in contemporary cyberspace is much more then the “real-world” communication based on the identity constructed by a person involved (Floridi, Sanders 2003). This extensive freedom of identity choice has its historical reasons but it may be changed in the future (Hinde 2001, 2002). ICT design must give a balance between privacy and security in order to match the ways of traditional human-human interactions. In any computer-mediated communication, trust ultimately depends not on personal identification code number/ social security number or IP addresses but *on relationships between people* with their different roles within social groups. Trust and privacy trade-offs are normal constituents of human social, political, and economic interactions, and they consequently must be incorporated in the ICT sphere developed on the principles of human-centrism.

5. References

Benford S, Greenhalgh C, Rodden T, Pycock J (2001) Collaborative Virtual Environments, Commun. ACM, 44(7), 79-85

Brey P (1999) The Ethics of Representation and Action in Virtual Reality, Ethics and Information Technology 1/1, 5-14

Brey P (2000) Method in Computer Ethics: Towards a Multi-Level Interdisciplinary Approach, Ethics and Information Technology 2:3, 1-5

Bynum TW (2000) Ethics and the Information Revolution, In: G. Collste. Ethics in the Age of Information Technology. Linkoeping, Sweden: Center for Applied Ethics Linkoeping Universitet, 32-55.

Cooley MJ (1999) Invited talk at International Conference: Enterprise Cultures and Innovation in the Information Society, University of Brighton

Dodig-Crnkovic G (2003) Shifting the Paradigm of the Philosophy of Science: the Philosophy of Information and a New Renaissance, Minds and Machines: Special Issue on the Philosophy of Information, Volume 13, Issue 4

DeCew J (2002) Privacy, The Stanford Encyclopedia of Philosophy Edward N. Zalta (ed.), (http://plato.stanford.edu/archives/sum2002/entries/privacy)

Floridi L (1999) Information Ethics: On the Philosophical Foundations of Computer Ethics," Ethics and Information Technology, Vol. 1, No. 1, pp. 37-56.

Floridi L, Sanders J (2002) Mapping the Foundationalist Debate in Computer Science, a revised version of Computer Ethics: Mapping the Foundationalist Debate, Ethics and Information Technology 4.1, 1-9

Floridi L, Sanders J (2003) Internet Ethics: the Constructionist Values of Homo Poieticus. In: The Impact of the Internet on Our Moral Lives, Robert Cavalier ed.

Gill, KS (1997) Knowledge networking and social cohesion in the Information Society, a study for the European Commission

Gill KS (2002) Knowledge Networking in Cross-Cultural Settings, AI & Soc 16: 252-277

Gill KS (2003) Future with AI & Society (http://www.it.bton.ac.uk/research/seake/ai_soc6_3.html)

Goodman N (1978) Ways of Worldmaking, Indianapolis: Hackett Publishing

Human Rights Act 1998 http://www.hmso.gov.uk/acts/acts1998/80042--d.htm

Hinde S (2001) 2001: A Privacy Odyssey. Computers and Security, Vol. 20

Hinde S (2002) 2001: A Privacy Odyssey Revisited. Computers and Security, Vol. 21

Johnson DG (1997) Ethics Online. Association for Computing Machinery. Communications of the ACM.

Johnson DG (2003) Computer Ethics. The Blackwell Guide to the Philosophy of Computing and Information. Edited by Luciano Floridi. Blackwell Publishing

Research Projects at Carnegie Mellon CyLab (http://www.cylab.cmu.edu/default.aspx?id=10)

Mason RO, A tapestry of Privacy, A Meta-Discussion. (http://cyberethics.cbi.msstate.edu/mason2/)

Mizutani M, Dorsey J, Moor JH (2004) The internet and Japanese conception of privacy. Ethics and Information Technology

Moor JH (1985) What is computer ethics? Metaphilosophy 16/4. (http://www.ccsr.cse.dmu.ac.uk/staff/Srog/teaching/moor.htm)

Pottie GJ (2004) Privacy in the Global Village, Communications of the ACM, 47(2): 2-23

Rosen J (2000) Why Privacy Matters, Wilson Quarterly. Vol 24, Issue 4

Powers TM (2004) Real wrongs in virtual communities, Ethics and Information Technology, Volume 5, Issue 4, 191-198

Sixth Programme (FP6) of the European Union, Citizens and governance in a knowledge-based society theme. (http://www.cordis.lu/fp6/citizens.htm)

Tavani H. (2002) The uniqueness debate in computer ethics: What exactly is at issue, and why does it matter?, Ethics and Information Technology 4: 37–54, and references therein

Tavani HT, Moor JH (2000) Privacy Protection, Control of Information, and Privacy-Enhancing Technologies. Proceedings of the Conference on Computer Ethics-Philosophical Enquiry

Thill, G (1994), The relevance of associative networks for a sustainable information and communication society, AI and Society, 6.1: 70-77

Turkle, S. (1996). Who am we? Wired, 4(1), 148-152, 194-199

Vance, D. The Place of Cyberethics, Information Systems Ethics, (http://cyberethics.cbi.msstate.edu/)

Wagner, C, Cheung K, Lee F, Ip R (2003) Enhancing e-government in developing countries: managing knowledge through virtual communities. The Electronic Journal on Information Systems in Developing Countries, 14, 4, 1-20

Whitworth B, de Moor, A (2003) Legitimate by design: Towards trusted virtual community environments. Behaviour and Information Technology 22:1, p31-51.

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Paper E

Paper E

PRIVACY AND PROTECTION OF PERSONAL INTEGRITY
IN THE WORKING PLACE

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Abstract

Privacy and surveillance is a topic with growing importance for working places. Today's rapid technical development has a considerable impact on privacy. The aim of this paper is an analysis of the relation between privacy and workplace surveillance. The existing techniques, laws and ethical theories and practices are considered.

The workplace is an official place par excellence. With modern technique it is easy to identify and keep under surveillance individuals at the workplace where everything from security-cameras to programs for monitoring of computer usage may bring about nearly a total control of the employees and their work effort.

How much privacy can we expect at our workplaces? Can electronic methods of monitoring and surveillance be ethically justified? A critical analysis of the idea of privacy protection versus surveillance or monitoring of employees is presented.

One central aspect of the problem is the trend toward the disappearance of boundaries between private and professional life. Users today may work at their laptop computers at any place. People send their business e-mails from their homes, even while travelling or on vacations. How can a strict division be made between private and official information in a future world pervaded with ubiquitous computers?

The important fact is that not everybody is aware of the existence of surveillance, and even fewer people are familiar with privacy-protection methods. That is something which demands knowledge as well as engagement. The privacy right of the working force is grounded in the fundamental human right of privacy recognized in all major international agreements regarding human rights such as Article 12 of the Universal Declaration of Human Rights (United Nations, 1948).

The conclusion is that trust must be established globally in the use of ICT (information and communication technology), so that both users (cultural aspect) and the technology will be trustworthy. That is a long-term project which already has started.

Keywords: Privacy, Cyberethics, Ethics of Trust, Legitimate by design, Disclosive ethics, Intentional design for democracy.

1. Introduction

A characteristic of private is that it is not official. Nevertheless, we expect a certain degree of privacy even in the most official situations. Privacy is a fundamental human right recognized in all major international agreements regarding human rights such as Article 12 of the Universal Declaration of Human Rights (United Nations, 1948). But just how much privacy can we expect at the workplace, where in some cases we may be subject to surveillance? Can electronic methods of monitoring and surveillance be ethically justified? We present a critical analysis of the idea of privacy protection versus surveillance or monitoring of employees, based on the data from different cultures with a wide range of practices.

One important aspect of the problem of privacy at the workplace is the trend toward the disappearance of boundaries between private and professional life, when working hours are no longer fixed, when people work at their laptop computers at all places imaginable, following the trend toward the ubiquitous use of the computer. Ubiquitous computing is the third wave, now beginning, in the use of the computer. The first computers were mainframes, the second era, in which we are now, is the personal computing era. Next comes ubiquitous computing, with the computing merged into the background of our lives.

Already, many people send their business-related e-mails from their homes, from airports, while traveling or even on vacations. How can a strict division be created between private and official information in a future world pervaded with the use of computers for both official and private purposes?

2. Modern Electronic Monitoring and Surveillance

The four basic S's of computing technology (Searching, Sorting, Storage and Simulation) make computers unprecedented tools of control. The ease with which data stored in a computer can be manipulated, as if it were greased (Moor, 2004) makes the use of monitoring, surveillance, and spyware methods extremely easy from the technical point of view. The consequences of the use of modern computation and communication tools in this connection are interesting both from the viewpoint of the individual employee (citizen) and from that of society.

Present-day surveillance tools include closed circuit television (CCTV), night vision systems, miniature transmitters, smart cards, electronic beepers and sensors, telephone taps, recorders, pen registers, computer usage monitoring, electronic mail monitoring, cellular radio interception, satellite interception, radio frequency identification (RFID), etc.

There are indications that the use of monitoring at workplaces has increased and is likely to continue to increase rapidly in coming years (Wakefield, 2004). The issues of concern leading to such surveillance are business information protection, the monitoring of productivity, security, legal compliance and liability, inter alia by means of e-mail-, spam-, pornography- and similar filters.

There is in fact, already legislation in various countries permitting the monitoring of employees by their employers and one-third of the work force in the US working on-line is under surveillance [Hinde (2002)]. VIDEO is a report summarizing an investigation of video surveillance practices in a number of countries (certain European countries, USA, Australia and Canada) and their effects on privacy. Here are some of its conclusions.

"The evidence presented to the Inquiry suggests that video surveillance has the potential to have a far greater impact on the privacy of employees than is evident presently."

"Covert surveillance involves an extremely serious breach of employee privacy. Evidence presented to the Inquiry indicates that there is an urgent need for measures to address the use of covert video surveillance in workplaces. Without any legislative protection, employees have no protection against secret and ongoing surveillance in the workplace. These measures are needed to address the inconsistency in current legislation, which prohibits the covert use of listening devices (refer Paragraph 5.1.2.2), but gives no protection from covert video surveillance. This inconsistency is best explained as the result of regulation being outpaced by technology."

Further, the VIDEO report states that:

"Although regulation on video surveillance in workplaces in industrialized nations is still taking shape, many countries have already imposed limitations on its use. It reflects a belief that video surveillance in the workplace is a threat to employees' rights to privacy, dignity and personal autonomy. The two main targets for regulation are covert surveillance and the use of surveillance for monitoring individual employee work practices. The sources of these protections have been the application of constitutional, common law or application of fundamental human rights; privacy and data protection legislation; industrial relations legislation."

Advocates of workplace monitoring claim that it nevertheless might be an acceptable method when justified by business interests (Wakefield, 2004). However, recent studies show that employees under surveillance feel depressed, tense and anxious when knowing that they are monitored (Uyen Vu, 2004), in comparison with those who are not under (or who are unaware of) surveillance (Rosen, 2000). Psychologists consider that it is obvious that an individual (who knows/suspects that he/she is) under surveillance behaves differently from another not monitored, the monitored person restricting his/her actions, aware that they are being observed by a suspicious third party. The climate of distrust is detrimental to the motivation, creativity and productivity of employees.

The report for the European Parliament, carried out by the parliament's technology assessment office, says the use of CCTV should be addressed by the MEP's Committee on Civil Liberties and Internal Affairs, because the technology facilitates mass and routine surveillance of large segments of the population. Automated face or vehicle recognition software allows CCTV images to be digitally matched to pictures in other databases, such as the photographic driver licenses now planned in Britain. The unregulated use of such a system would amount to an invasion of privacy, says the report, (MacKenzie, 1997)

3. Why Value Privacy? Privacy and Democracy

A brief analysis of the phenomenon of privacy protection and its importance for democracy is given in (Moor, 2004), beginning with Moor's justification of privacy as the expression of a core value of security. The question arises consequently: How should situations be addressed in which privacy and security are complementary? There are namely situations in which more privacy for some people means less security for others.

In Warren and Brandeis' argument, privacy stems from a representation of selfhood which they call "the principle of inviolate personality" and personal self possession. Charles Fried claims that human feelings such as respect, love and trust are unimaginable without privacy, meaning that intimacy and privacy are essential parts in relationships. Privacy is not merely an instrumental value to achieve further ends such as respect and trust; it is also seen as having an intrinsic value in human life.

According to Rosen (2000), privacy has political, social and personal values and costs. The political value involves the fact that there is no need to reveal one's rank or family background, to be able to interact with others in a democracy. Thanks to privacy, it is possible for citizens, who might disagree on a topic, to communicate with each other without needing to reveal the details of their identity. Privacy reaches beyond individual benefit by being a value which contributes to the broader good, becoming an essential element of democracy (Grodzinsky and Tavani, 2004). In intruding on privacy, which is closely related to freedom, surveillance can be considered to have, ultimately, a negative effect on democracy.

By its nature, computer ethics is a worldwide phenomenon and cannot be tackled exclusively on an individual and local scale, (Johnson, 2003). For computer ethics with its specific contemporary questions, Floridi and Sanders (2003) advocate the method of ethical constructionism. The constructionist approach concentrates not only on the dilemmas faced by the individual but also addresses global computer ethics problems. Issues involved in e.g. the sharing and revealing of information about oneself introduce even more fundamental questions including the cultural and social context which must be considered when formulating policies.

4. Ethics of Trust

Trust is one of the building blocks of a civilized society. We trust train and airline time-tables and plan our journeys accordingly, we trust the pharmaceutical industry in taking their pills, believing that they will cure us and not kill us, we trust our employers and colleagues, assuming that what they promise or claim is what they, at least, believe to be true. As any other factor in human relations, trust has many different aspects in the different contexts. Wittgenstein's dictum `meaning is use' applies here as well. One can consider trust as a cognitive process or state, within the psychology of personality as a behavioral/developmental process, as a social psychology/sociology related phenomenon. In connection with cultural history and privacy, it is influenced by and influences social politics and society at large, for example, defining our responsibilities (Kainulainen, 2001).

Hinman (2002) puts it in the following way: “Trust is like the glue that holds society together -- without it, we crumble into tiny isolated pieces that collide randomly with one another. In a world without trust, individuals cannot depend on one another; as a result, individuals can only be out for themselves. Economists have shown that societies where trust is low have stunted economic growth because a robust economy demands that individuals be able to enter into cooperative economic relationships of trust with people who are strangers.”

Hinman claims that trust is one of the three universal core values found across cultures:

- caring for children
- trust
- prohibitions against murder.

This even holds in the most primitive artificial (computer-simulated) populations, in that case having the following effects:

- assuring the continuity of population in terms of number of individuals and ways of behavior
- respecting the commonly accepted set of rules, which provides predictability and stable relationships
- preventing the extinction of the population.

Trust thus has deep roots in both the needs of individual humans for security, safety, confidence and predictability and in the basic principles of social dynamics.

One field that has traditionally focused on the problem of trust is medical ethics. In Francis (1993) the section 'Ethics of Trust vs. Ethics of Rights' discusses autonomy, informed consent and the rights of patients. The relationship of dependence and usually significant difference in knowledge, which characterises doctor-patient communication and the position of the patient within the health-care system, have its counterpart in the relation between a common computer user and a computer professional knowing how to configure the machine or the network and communication in ways that have significant consequences for the user. Basically, the relation between a specialist and a lay-person is that of power and subjection and must be grounded on mutual trust.

Historically, however, such unconditional trust on the part of the general public in the inherent goodness of technology has been shown to be unwarranted.

Technology is far too important to everybody to be left to the specialist alone. Agre (1994) says "The design of computer systems has not historically been organized in a democratic way. Designers and users have had little interaction, and users have had little control over the resulting systems, except perhaps through the indirect routes available to them through resistance in the workplace and the refusal to purchase relatively unusable systems for their own use. Yet over the last ten or twenty years, a growing movement, originating in Scandinavia but now increasingly influential in other industrialized countries, is attempting to reform the design of computer systems in a more democratic direction (Bjerknes, Ehn, and Kyng 1987, Schuler and Namioka 1993). This movement, sometimes known as participatory design, invites the participation of, and in many cases gives formal control over the design process to, the people whose work-lives the system affects."

Here one can add "Weiser's principle of Inventing Socially Dangerous Technology:

1. Build it as safe as you can, and build into it all the safeguards to personal values that you can imagine.

2. Tell the world at large that you are doing something dangerous."

Weiser, 1995

This principle aims at the establishment of a trust relationship between the specialists (inventors of dangerous technologies) and common users (people who are affected by the potentially dangerous consequences of technology).

5. Legitimacy by Design and Trustworthy Computing

"Trust is a broad concept, and making something trustworthy requires a social infrastructure as well as solid engineering. All systems fail from time to time; the legal and commercial practices within which they're embedded can compensate for the fact that no technology will ever be perfect. Hence this is not only a struggle to make software trustworthy; because computers have to some extent already lost people's trust, we will have to overcome a legacy of machines that fail, software that fails, and systems that fail. We will have to persuade people that the systems, the software, the services, the people, and the companies have all, collectively, achieved a new level of availability, dependability, and confidentiality. We will have to overcome the distrust that people now feel for computers.

The Trustworthy Computing Initiative is a label for a whole range of advances that have to be made for people to be as comfortable using devices powered by computers and software as they are today using a device that is powered by electricity. It may take us ten to fifteen years to get there, both as an industry and as a society.

This is a "sea change" not only in the way we write and deliver software, but also in the way our society views computing generally. There are immediate problems to be solved, and fundamental open research questions. There are actions that individuals and *companies can and should take, but there are also problems that can only be solved collectively by consortia, research communities, nations, and the world as a whole."*

Mundie, at al. (2003)

It is apparent that the problem of trust involves more than the establishment of decent privacy standards; it concerns even security, reliability and business integrity. The Trustworthy Computing Initiative is an indication of how serious the problem is and how urgent is its solution for the development of a society supported by computer technology. It is good news that business shows awareness of the social impact of the technology they produce and understanding of how basic public acceptance, confidence and trust is for the general direction of the future development of society. It gives hope that at least some important aspects of privacy problems of today will be solved within the decades to come.

The first phase of the intentional design for democracy is the explication of the embedded moral significance of ICT while the next is the development of the corresponding technology (Yu and Cysneiros, 2002). The existing analyses of the state of the art of privacy issues worldwide (fifty countries in http://www.gilc.org/privacy/survey) bear witness to how much work remains to be done.

"The electronic networking of physical space promises wide-ranging advances in science, medicine, delivery of services, environmental monitoring and remediation, industrial production, and monitoring of people and machines. It can also lead to new forms of social interaction, as suggested by the popularity of instant messaging (...). However, without appropriate architecture and regulatory controls it can also subvert democratic values. Information technology is not in fact neutral in its values; we must be intentional about design for democracy." (Pottie 2004).

Legitimacy is a social concept of socially beneficial fairness. Traditional mechanisms that support legitimacy such as the law and customs are not yet well defined in cyberspace with its flexible, dynamic character. Legitimacy analysis can translate legitimacy concepts, such as freedom, privacy and ownership of intellectual property into specific system design demands. On the other hand it can interpret program logic into statements of ownership that can be understood and discussed by a social community. Legitimate interaction, with its cornerstone of accountability, seems a key to the future of the global information society we are creating, (Dodig-Crnkovic, Horniak, 2005).

Whitworth and de Moor (2003) claim that legitimate interaction increases social well-being, and they analyze the ways in which societies traditionally establish legitimacy, and how the development of socio-technical systems changes previously established patterns of behaviour.

This means that democratic principles must be built into the design of socio-technical systems such as e-mail, CVE's, chats and bulletin boards. As the first step towards that goal, the legitimacy analysis of a technological artefact (software/hardware) is necessary. Legitimacy analysis can be seen as a specific branch of disclosive ethics, specialized for privacy issues. Fischer-Hübner (2001) adress the problem of IT-security and privacy, discussing the design and use of privacy enhancing security mechanisms.

What we as users have a right to expect in the near future is that the ICT follows Privacy/Fair Information Principles: *"Users are given appropriate notice of how their personal information may be collected and used; they are given access to view such information and the opportunity to correct it; data is never collected or shared without the individual's consent; appropriate means are taken to ensure the security of personal information; external and internal auditing procedures ensure compliance with stated intentions."* (Mundie, at al., 2003)

6. Whose Responsibility? Agency and Surrogate Agency

According to Kainulainen (2001), A Trust and Ubiquitous Computing, the layers of trust are as follows:

- Individual - machine
- Individual - individual
- Individual - (machine) - individual
- Individual - identifiable small groups (social aspect)
- Individual - groups/organizations (authority, higher levels of hierarchy and abstraction)
- Group - group

As a consequence, a question arises: how, in all these types of interactions, to establish the responsibility, especially when machines and software agents (e.g. intelligent software agents such as web bots - 'software robots') are involved. Johnson and Powers (2004) study the problem of the responsibility of (autonomous) agents which are used as role or "surrogate" mediators to pursue the interests of their clients. We are familiar with surrogate agents who usually act as stockbrokers, lawyers, and managers, performers and entertainers. It is an established praxis that when the behavior of a surrogate agent falls below a certain standard of diligence or authority, the client can sue the agent and the agent can be found liable for his or her behavior. This suggests that similar criteria should be developed with respect to computer agents. Questions arise about the rights and responsibilities of computer agents, their owners and designers. These are matters that should be highlighted and regulated in the immediate future. The surrogate agents already in operation are obvious candidates for a thorough ethical analysis.

7. Conclusion

"Yes, safeguards can be built into any system, such as the checks and balances in a good accounting system. But what keeps them in place is not the technology, but people's commitment to keeping them.

We cannot expect technology alone to solve ethical dilemmas. Technology is a tool made by people to meet people's needs. Like all tools, it can be used in ways undreamed of by the inventor. Like all tools, it will change the user in unexpected and profound ways."

Weiser (1995)

Koehn (1998) makes the following list of characteristics that an ethic should possess. It:

- requires each of us to properly appreciate other human beings' distinctive particularity;
- acknowledges the extent to which we are thoroughly interdependent beings;
- imposes limits on the extent to which we are obligated to be open to others;
- engenders the self-suspicion necessary if our relations are to be free of manipulation, narcissism, self-righteousness and unjust resentment and
- provides for a rule of law and for political accountability.

After analyzing several kinds of ethic (an ethic of care, an ethic of broad empathy, an ethic of trust and a dialogical ethic) Kohen finds all of the above elements in a dialogical ethic. Its main feature is interactivity and dynamic, and it is based on the culture of trust. That is how the problem of workplace privacy can be seen. It is a part of a more general problem of privacy, and in the digital era, life in a global, networked E-village implies that the problem must be solved on a global level. Not only through legislation (even though it is very important building block), not only through technology (even thought it is essential), but through an informed ethical dialogue.

Our conclusion is that mutual trust which is one of the basic ethical principles on which human societies rely must be established in the use of ICT. This in the first place presupposes the informed consent of all the parties involved as a conditio sine qua non. Moreover, trust must also be established globally because the data contained in networked computers virtually knows no boundaries, and is easy to manipulate.

8. References

Agre, E. P. (1994) Design for Democracy, http://polaris.gseis.ucla.edu/pagre/oksnoen.html

Dodig-Crnkovic, G. and Horniak, V. (2005), Good to Have Someone Watching Us from a Distance? Privacy vs. Security at the Workplace, Ethics of New Information Technology, Proceedings of the Sixth International Conference of Computer Ethics: Philosophical Enquiry, CEPE 200, July 17-19, 2005, University of Twente, Enschede, The Netherlands ; Brey P,Grodzinsky F and Introna L. Eds. http://cepe2005.utwente.nl/

Grodzinsky, F.S., Tavani, H.T. (2004) Verizon vs. The RIAA: Implications for Privacy and Democracy, IEEE, 0-7803-8251-x

Fischer-Hübner, S. and G. (2001). IT-Security and Privacy: Design and Use of Privacy Enhancing Security Mechanisms. Lecture Notes in Computer Science, Vol. 1958. Berlin Heidelberg: Springer-Verlag

Floridi, L. and Sanders, J. (2003) Internet Ethics: the Constructionist Values of Homo Poieticus. In: The Impact of the Internet on Our Moral Lives, Robert Cavalier ed. Francis, C.M. (1993) Medical Ethics, Jaypee Brothers Medical Publishers (Pvt) Ltd) New Delhi

Hansen, M., Pfitzmann, A. (2004). Anonymity, Unobservability, Pseudonymity, and Identity Management – A Proposal for Terminology, v0.21. http://dud.inf.tu-dresden.de/Literatur_V1.shtml

Hes, R. and Borking, J. (Eds.) (2000) Privacy-enhancing technologies: The path to anonymity. Revised edition. Registratiekamer, The Hague, August 2000.

http://www.cbpweb.nl/downloads_av/AV11.PDF

Hinde, S. (2002) 2001: A Privacy Odyssey Revisited. Computers and Security, Vol. 21, No. 1

Hinman, L.M. (2002) A Moral Challenge: Business Ethics after Enron, The San Diego Union-Tribune.

http://ethics.acusd.edu/LMH/op-ed/Enron/

Johnson, D.G. (2003) Computer Ethics. The Blackwell Guide to the Philosophy of Computing and Information. Luciano Floridi Ed. Blackwell Publishing

Johnson, D.G. and Powers, M.T. (2004) Computers as Surrogate Agents, ETHICOMP 2004
http://www.ccsr.cse.dmu.ac.uk/conferences/ethicomp/ethicomp2004/abstracts/96.html

Kainulainen, A. (2001) Trust and Ubiquitous Computing,
http://www.cs.uta.fi/~anssi/work/cogscisempres_7.4.2001.ppt#258,1,Trust%20and%20Ubiquitous%20 Computing

Koehn, D. (1998) Rethinking Feminist Ethics: Care, Trust and Empathy, Routledge

MacKenzie, D. (1997) Privacy police caution Big Brother. New Scientist vol 154 - 12, p4

McCrone, J (1995) Watching you, watching me. New Scientist, 36-9

Moor, J.H. (2004) Towards a Theory of Privacy in the Information Age. Computer Ethics and Professional Responsibility, Bynum, T.W. and Rogerson, S. Edts., Blackwell Publishing

Mundie, C., de Vries, P., Haynes, P. and Corwine M, (2003) Trustworthy Computing White Paper

http://www.microsoft.com/mscorp/twc/twc_whitepaper.mspx Pierce D., Challenges/Threats to Privacy http://www.inetdevgrp.org/20001017/index.html

Pottie, G.J. (2004) Privacy in the Global Village, Communications of the ACM, 47(2): 2-23

Rosen, J. (2000) Why Privacy Matters, Wilson Quarterly, Vol 24, Issue 4 Vu Uyen (2004) Employees resistant to any form of computer video monitoring, study says. Canadian

HR Report, March 8 Wakefield, R.L. (2004) Computer Monitoring and Surveillance – Balancing Privacy with Security. The CPA Journal Warren, S.D. and Brandeis, L.D. (1890) The Right to Privacy, Harvard Law Review, 1890-91, No.5,

193-220. http://www.lawrence.edu/fast/boardmaw/Privacy_brand_warr2.html Weiser, M. (1995) The Technologist's Responsibilities and Social Change, Computer-Mediated Communication Magazine, Vol. 2, No. 4, p. 17 Wayner, P. (2004) The Power of Candy-Coated Bits. IEEE Security & Privacy, Vol. 2, No. 2, March- April 2004, 69-72.

Whitworth, B. and de Moor, A. (2003) Legitimate by design: Towards trusted virtual community environments. Behaviour and Information Technology 22:1, p31-51.

Yu, E. and Cysneiros, L. (2002) Designing for Privacy and Other Competing Requirements. 2nd Symposium on Requirements Engineering for Information Security (SREIS'02), Raleigh, North Carolina, October 16, 2002.
http://www.cs.toronto.edu/pub/eric/SREIS02-Priv.pdf

Books

Bennett, Colin J. and Charles J. Raab, The Governance of Privacy:Policy Instruments in Global Perspective, Aldershot: Ashgate, 2002

Flaherty, David H., Protecting Privacy in Surveillance Societies: the Federal Republic of Germany, Sweden, France, Canada, & the United States, University of North Carolina Press, Chapel Hill, 1989

Hansson, S O and Palm E., The Ethics of Workplace Privacy, Peter Lang Bruxelles 2005

Dalenius T. and Klevmarken A., Proceedings of a Symposium on Personal Integrity and the Need for Data in the Social Sciences, Held at Hasselby Slott, Stockholm March 15-17, 1976 and Sponsored by the Swedish Council for Social Science Research, Swedish council for social science research

Legislation links

Council of Europe Convention for the Protection of Individuals with regard to Automatic Processing of Personal Data, CETS No.: 108

http://conventions.coe.int/treaty/Commun/QueVoulezVous.asp?NT=108&CM=8&CL=ENG

EU Directive 95/46/EC (1995). Directive 95/46/EC of the European Parliament and of the Council of 24 October 1995 on the protection of individuals with regard to the processing of personal data and on the free movement of such data. Official Journal L 281, 23/11/1995, pp. 31-50.

http://europa.eu.int/eur-lex/en/index.html

European Council Convention for the Protection of Individuals with Regard to Automatic Processing of Personal Data CETS No.: 108

http://conventions.coe.int/treaty/EN/WhatYouWant.asp?NT=108&CM=8&DF= Data Protection Guide http://www.europa.eu.int/comm/internal_market/privacy/index_en.htm GUIDES (2002). E-Business Guidelines on DPD 95/46/EC.

http://eprivacyforum.jrc.it/default/page.gx?_app.page=entity.html&_app.action=entity&_entity.objec

t=KM------00000000000002C8&_entity.name=guidelines.pdf von Lohmann F, Meditations on Trusted Computing http://www.nr.no/~abie/TrustPolicy.htm ICCPR http://www.unhchr.ch/html/menu3/b/a_ccpr.htm OECD (1980). Guidelines on the Protection of Privacy and Transborder Flows of Personal Data.

http://www1.oecd.org/publications/e-book/9302011E.PDF

OECD (2005) European Data Protection Supervisor

http://www.europa.eu.int/comm/internal_market/en/dataprot/inter/priv.htm

The Dutch Data Protection Authority (2001). Privacy Audit Framework under the new Dutch Data Protection Act (WBP), April 2001.

http://www.cbpweb.nl/en/download_audit/PrivacyAuditFramework.pdf

Treasury Board of Canada Secretariat (2002). Privacy Impact Assessment Guidelines: A Framework to Manage Privacy Risks

http://www.tbs-sct.gc.ca/pubs_pol/ciopubs/pia-pefr/paipg-pefrld-PR_e.asp?printable=True

United Nations (1948). Universal Declaration of Human Rights, General Assembly resolution 217 A (III). http://www.un.org/Overview/rights.html UN guidelines http://www.europa.eu.int/comm/internal_market/en/dataprot/inter/un.htm

Other resources

http://www2.austlii.edu.au/itlaw/articles/efficiency.html#Heading2 Graham Greenleaf: Stopping surveillance: Beyond 'efficiency' and the OECD
http://www.worldlii.org/int/special/privacy/ Australian Privacy Law Project
http://www.worldlii.org/catalog/273.html WorldLII Catalog >>Privacy
http://www.anu.edu.au/people/Roger.Clarke/DV/Intro.html Introduction to Dataveillance and Information Privacy, and Definitions of Terms Roger Clarke
http://www.arts.ed.ac.uk/asianstudies/privacyproject/bibliographyNK.htm Materials in Western languages on privacy issues

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