1.5 million years of Information Systems:

From Hunters-Gatherers to the Domestication of the Networked Computer

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"The comparative evolutionary success of humans by developing their specific individual, social and ecological regimes, their cultures, is ultimately grounded in the increasing capacity to communicate with one another. This has allowed us to coordinate our ideas and behaviour on a greater scale and in more effective ways than any other species known to have lived on this planet" (Spier 1996, p.35)

Abstract This paper develops the argument that information systems have not only existed for the last 50 years (as most accounts of ICT argue) or since the 1700 century (as some more accurate readings would propose), but they are indeed as old as mankind. It provides a historical account of how information and communication systems have greatly interacted with some major transformations in human society, in addition to demonstrating the implications of the most recent changes in the last 10 years with the Internet. It builds on literature which distinguishes 3 major phases in the history of mankind and provides accounts of the role of information and communication systems in each of these phases. The main argument is that the "*domestication of information systems"* is better understood when previous regime transformations and their dynamics are taken into account and investigated. Implications of these developments in relation to innovation and learning are provided.

1. Introduction

Information and Communication systems, their design and use and the role of information have been studied by biologists, economists, ecologists, linguistics and

historians to explain human and animal behaviour. Nothing would work in the absence of information [1]. Hauser argues that basically 3 reasons underlie all communication among animals: 1) mating, 2) socialization and 3) survival. Whereas we humans have developed more or less sophisticated and increasingly electronic means for these 3 basic reasons, animals have not been as creative. The last decade it was claimed that we humans are going through a communication revolution or that we are entering an Information age [2,3]. However, we argue that our information age is not the first information age in history. Humans have always needed and communicated information and the field of information systems did not start in 1976 as the IFIP call for papers might suggest. For all organisms, including humans, communication and information systems provide a vehicle for conveying information and for expressing to others what has been perceived [4]. We argue with Headrick [4] that the information age has no beginning, for it is as old as mankind. We live in such an age but it is certainly not the first information age nor is the PC the first information system we have built.

This paper intends to deliberately take a broad perspective and investigate the role of information and communication systems and their impact on humans and the societies they live in. It is our objective in this paper to give a historical account of how information and communication systems have greatly interacted with some major transformations in human society. A second objective is to show the implications of the most recent changes in the last 10 years with the Internet.

This paper is organized as follows: the next sections will first discuss the role of information systems in regime transformations. To introduce the concept of regimes and their role in human history we need to introduce the construct by which Spier [5] has conceptualized the structure of human ecology. In a subsequent section we argue that a fourth regime transformation can be distinguished, related to the "*domestication of information systems"* which is better understood when previous regime transformations and their dynamics are considered and investigated. We argue that each of the previous regime transformations have had information and communication systems implications. We will discuss each of these periods from a multi-disciplinary perspective. Although not discussed explicitly by many world historians, they each implicitly refer to the communication and information systems´ implications of their findings. The objective of this section is to make these arguments more explicit and analyze them profoundly. The final section of this paper discusses the implications of the patterns associated with communication and information systems and will shed new light on understanding of the role of communication and information systems in the past and future.

2. Information and Communication Systems In History

We believe no profound understanding of the impact of information and communication systems can be obtained when limiting our study to the last 20-30 years, the years of the "invention" and proliferation of the computer and the Internet. It is our firm belief that the rise of the network society [3], the information society [2,6], the information age [7] has firm roots in previous ages. Sociologists and

historians as well as information systems researchers have traced the roots of our present information age. However most of these accounts go back to, at most the industrial revolution [2,8].

A notable exception is a book by the historian Headrick who claims that in the age of reason (1700-1850) information systems of all kinds were flourishing. He makes the important distinction between the use of the specific technology and the information systems applying that technology. The purpose of his book is to argue that the current information revolution is a result of a cultural change that began roughly three centuries ago, a change as important as the political and industrial revolutions for which the 18th and 19th centuries are so well known. Increasing interest in information of all sorts, led to information systems, which are the basis for today's information age. Systems of nomenclature, classification (plants and chemicals) measurement and the visual display of information (graphs, maps) are examples of information systems provided by Headrick. He argues that "Most historians attributed great significance to certain machines: the printing press, telegraph, the computer, but between the printing revolution and the 19th century lies a period that was less significant for its information handling machines but just as fertile in new information systems" [1]. To my knowledge he is one of the few writers that go back to the seventeen hundreds for the origins of our information age. Most authors stop at the industrial revolution when looking at factors to explain or predict the changes that are occurring in our present day societies and organization of economic activities.

We argue that the way societies and groups of people have organized themselves has always been closely related to the way they communicated and transmitted and gathered information. This argument however has been made before and is not new. The fundamental questions of why people have organized themselves in specific network configurations and how communication infrastructures and information ecologies have evolved and adapted or driven certain configurations, remain underdeveloped. Access to resources such as food and shelter were often the driving force behind settlements and the development of groups and nations [9] but the access and specific role of information and communication systems has not received sufficient multi-disciplinary attention.

3. Structuration using the Notion of Regimes

To provide an historical account of how information and communication systems have greatly interacted with some major transformations in human society we base our arguments on the concept of "regime transformations" developed by Spier [5]. When introducing the term regime, an important issue to address first is that Spier's timescale is slightly larger than we as information system scientists are used to, in

1 We follow Headrick´s views of information systems as being much broader than communication systems. Communication systems in his view are systems like telegraphic and postal systems while information systems are systems that organize, transform, display, store or communicate information. In his view communication systems are a subset of information systems ([4]p. 181)

our very young field of barely 30 years or 2-3 generations of researchers[2]. As is common among world historians [5,9-12] phenomena are viewed from the origins of mankind or often even on cosmic scales. As a result, even the inhabitants of (post)modern societies by and large have the physiological make-up of gatherers and hunters."

The word "regime" comes from the Latin "regimen", which means both "guidance" and "rule". Spier [5] prefers the word `regime' to terms such as system, order, pattern, constellation, configuration, field, etc. since in his eyes `regime' is the only term that can be utilized without hindrance, as he sees regimes as structuring elements for all cosmic, planetary and human history. I will use the term regime in line with Spier's definition and "a more or less regular but ultimately unstable pattern that has a certain temporal permanence" p.14. Spier's main argument is that the history of humanity can be structured referring to the three great ecological regime transformations which have taken place so far:

1) the domestication of fire (1.5 million years ago),
2) the domestication of plants and animals (8000-10000 years ago) and
3) the industrialization on the basis of engines driven by inanimate energy (late 1700 s).

While information systems researchers hardly ever go back more than 40 years, sociologists investigating the information society usually go back to the origins of the transformation of the agrarian into the industrial age. Only very few historians go back more than 200-300 years in their analysis to understand information and communication systems. As a result communication science as a field often starts with the invention of technologies like the telegraph, radio and TV . Not much truly multidisciplinary research has been done on the topic. An exception being a recent integrative work by Hauser discussing the evolution of communication from a multi-disciplinary perspective (biology, linguistics, cognitive psychology) which does go back to the origins of communication among living species but as a biologist, he spends more time in his book on communication among other animals than primates.

The domestication of fire, animals and plants has interacted with and affected the way the human web has organized itself but has never influenced mankind as profoundly as the impact that new forms of ubiquitous computing and the domestication of information and communication systems have had. We argue that the roots of the domestication of information and communication systems are in the previous regime transformations and that a profound understanding of their impact can only be achieved by analyzing what these changes were and why some of these changes took place in certain societies but not in others. Each of these regime transformations had a significant impact on the way humans interacted and lived together. We will briefly discuss Spier's regimes in turn. We argue that there has been an information and communication regime playing a role in mankind in each of these periods. In the discussion below of the regime transformations and their drivers and interaction, we will complement Spier's arguments where possible with those of other authors with information and communication systems implications.

2 On February 13th 2005 the question : How old is the field of Information Systems? was put on ISWorld asking whether the field started with the first course in IS, its first PhD student graduated or its first significant journal publication.

3.1 The First Great Ecological Regime Transformation: The Domestication of Fire

Spier bases his description of his first regime transformation on the argument that the possession of fire control may have been of decisive importance in an elimination contest that would have taken place both within and among the various hominid subgroups, as a result of which only the fire-possessing victors survived [5, p. 46]. Control of fire indeed became so valuable that only those groups that learned the full spectrum of fire's uses survived [11]. The human fire regime had further consequences on an ecological, social and communicative level. Spier argues that while people tended to flee rather that fight, [5, p. 51] people steered away from social conflicts as long as there was enough free land available.

Information and Communication Systems during the first regime transformation

During the gatherer –hunter social regime, technical skills appear to have developed slowly. The same seems to apply to social organization. For a long time, humanity formed one single, very loosely connected network which shared many characteristics and exhibited only limited local variations [11]. In comparison with later periods, communication in the form of messages and material exchanges progressed slowly, while local cultural developments followed suit. Consequently, inventions could easily spread everywhere before any group developed a decisive cultural advantage [5, p.50]. Symbolic meanings, capable both of exceedingly rapid evolution and also of coordinating the behaviour of infinite numbers of individuals [11], have coordinated actions of humans over the last thousands of years. Language and dance and ritual were important breakthroughs that allowed humans with these new kinds of communication, to form larger and larger yet still cohesive and coordinated groups. Not much is known about how a " perpetual web of social interactions within small bands of humans permitted and rewarded incremental improvements in the speed, scope and accuracy of communication [11].

3.2 The Second Great Ecological Regime Transformation: The Transformation to an Agrarian Regime.

The domestication[3] of plants and animals around 8000-10000 years ago had significant implications on the ways in which humans organized themselves. Why did the same crop have to be domesticated in several different parts of the world and why are there such huge differences in the spread of crops between continents? Diamond's "tilted axis theory" [9] links the spread of food production techniques to the diffusion of other technologies and inventions. He argues that through indirect links of food production systems and their consequences with other innovations like wheels and writing which were used to facilitate the transportation of food and its administration (goods inventories, record keeping) [9] certain innovations were

3 Spier defines domestication as " human efforts to actively influence the reproductive chances of other species" In English it refers to both home and country.

communicated and spread around the world in distinct patterns related to the efficiency of the communication systems used.

The evolving agrarian social regime was very different from the hunters and gatherers [11]: "Since the early plant cultivators became tied to the land they had come to depend on, they also became more tightly bound to one another, processes of social differentiation accelerated. This had consequences for the social structures of these people. In addition the way they gathered information and communicated changed significantly. The first human webs of our distant ancestors were formed through the rise of speech, migration, and primitive agricultural groupings. The development of settled farming injected new kinds of information into the human web. Apprentice farmers exchanged and communicated skills, knowledge and breeding stock with their neighbouring communities".

Information and Communication Systems during the second regime transformation

Spier argues that "the effort to reign over the forces of fire may have stimulated the need for more intense social interaction, and thus contributed to a growing ability to communicate and think in abstract terms" [5, p. 49]. Sedentary agriculture lead to complex societies and more advanced communication and information systems. People designed more complex information systems and communicated more intensively through ever expanding human webs [11], resulting in a need for more advanced communication and information systems. He concludes that: "much later, the agrarian regime would prove to be a major precondition for the industrialization of society, likewise the fire regime was a necessary precondition for the agrarian regime. It was hard to imagine that any sedentary agrarian life would have been possible for long without control over fire of various kinds". Information and communication systems are interactive and need to be supported by the societies and the environment in which they have been adopted by or invented.

The effect of information and communication networks is defined by the volume and variety of the information being pooled and the efficiency and speed at which information is shared [10]. The size of the information network or the number of communities and individuals that can share information has changed significantly since humans were gatherers and hunters. In any given network the number of links between nodes (n) is $n \times (n-1)/2$. "The number of possible connections (and thereby the potential information synergy of the entire network) increases faster than the number of nodes and the difference between the two rates, increases as the number of nodes increases [10,11]. Increased population density tends to stimulate innovation and as networks expand in size, their potential intellectual synergy increases much faster: larger and denser populations equal faster technological advance [12]. In our view the effects of the internet are interesting in this regard as the internet obviously does not affect population density but it does increase the number of possible connections. An important question is whether this will trigger a period of significant increase of information sharing and innovation and thus change the knowledge ecology of the inhabitants of this globe.

According to [10]: "the variety of the information being pooled may be as important as the sheer volume. Neighbouring communities living similar lifestyles maybe able to help each other to finetune technologies and skills but they are unlikely to introduce radically new ideas. Fundamentally new forms of information are likely to be shared only where two communities living different lifestyles come into significant contact. Indeed when dissimilar groups belong to the same information networks we are most likely to find processes of collective learning leading to significant changes in technologies and lifestyles. It is important to describe the size and variety of information networks – the regions over which information can be exchanged. " p. 183

3.3 The Third Great Ecological Regime Transformation: The Transition Towards An Industrial Regime

The Industrial Revolution may be defined as the application of power-driven machinery to manufacturing. "The third large ecological regime transformation, industrialization on the basis of the large-scale use of engines driven by fossil fuels, lay at the root of this remarkable discontinuity. Because it happened so very recently and left such a great many traces, the emergence of the industrialization process is known with a precision unattainable for the preceding two great ecological regime transformations. On an ever growing scale and at an ever increasing rate the world was turned into a provider of natural resources for industry and into a market for its products" Spier [5]. In other words, social regime development stimulated improvements of the human ecological regime [5, p.37-38].

Information and Communication Systems during the third regime transformation

Improvements in infrastructure (transportation, communication technologies) in the late 1800s led to massive vertical integration because allocation of resources within the firm became cheaper than the cost of using the market. The way the telegraph and telephone contributed as communication systems to support the industrialization of societies has been very significant[4] [2]. The rapidly growing and intensifying means of long-distance communication would not have been possible either without an economy increasingly based on inanimate fuels: " The coupling of ever refined techniques of information processing to machines driven by inanimate fuels can be related to the rapidly growing and intensifying communication networks of various kinds. [5, p. 78]

Diamond [9] relates the development of certain technologies to the way societies organized themselves and communities communicated: " No hunter-gatherer society ever developed states, writing, metal technology, or standing armies. Those developments depended on food production (agriculture and herding), which arose

4 Interesting in this regard is the argument by [8] that we have faced several control crises in periods were communication systems could not keep up with the speed of for example transportation or complex energy generating systems. He provides examples of train collusions due to the fact that the scheduling and location information was exchanged slower than the speed by which the trains traveled leading to significant numbers of accidents in the late 1800s.

independently in different parts of Eurasia by 8000 BC. The resulting dense populations, food storage, social stratification, and political centralization led in Eurasia to chiefdoms (5500 BC), metal tools (4000 BC), states (3700 BC), and writing (3200 BC). Multiplied over succeeding millennia, that huge head start let Eurasians eventually **to** sail and conquer peoples of other continents."

The development of communication systems and information systems in all periods discussed above is heavily related to the way humans organized themselves. An important tool humans have to alter their environment has always been innovations in technology and **so** to coordinate their actions collectively they have always used communication and information systems. In summary, the industrialization of society could not have taken place without a long history of specific political, economic, socio-cultural, technical and scientific developments, most notably the first and second great ecological regime transformations as well as some of the social regime transformations associated with them, such as the formation of a regime of competing states and the associated drive for economic and military inventions. Like the domestication of plants and animals and, undoubtedly, gathering and hunting, too, industrialization is an ongoing process.

3.4 The Fourth Regime Transformation: The Domestication of the Computer

Humans had designed increasingly complex production, transportation and other systems in the industrial revolution that required increasingly more computation and calculation. As a result various attempts to build calculating machines had been done mechanically (Babbage's Engines) and later electrically (punch card machines and the Mark 1). However, we start our 4th regime transformation from the moment that these calculating machines became available to individuals with microprocessors that contained memory, logic, and control circuits , an entire CPU on a single chip and allowed for home-use personal computers or PCs, like the Apple (II in 1977 and Mac in 1984) and IBM PC in 1981. Fourth generation language software products like Lotus 1-2-3, dBase, Microsoft Word, and many others and Graphical User Interfaces (GUI) for PCs arrived in the early 1980s with the clunky MS Windows debuting in 1983. Windows would not take off until version 3 was released in 1990. We refer to this period in the 1980s as the domestication of the computer, when PC´s started to enter the home and workplaces of ordinary citizens. Once these PC´s were networked a real communication transformation began. Kelly writing about 10 years of the Internet marvels: " In the years roughly coincidental with the Netscape IPO, humans began animating inert objects with tiny slivers of intelligence, connecting them into a global field, and linking their own minds into a single thing. This will be recognized as the largest, most complex, and most surprising event on the planet. Weaving nerves out of glass and radio waves, our species began wiring up all regions, all processes, all facts and notions into a grand network. From this embryonic neural net was born a collaborative interface for our civilization, a sensing, cognitive device with power that exceeded any previous invention. The Machine provided a new way of thinking (perfect search, total recall) and a new mind for an old species. It was the Beginning."

As we have seen above in all periods, the transmission and exchange of information about technological innovations and thus for the survival of groups was crucial. Innovations like fire control, hunting techniques, food production systems but also of guns, germs and steel spread around the world in distinctive patterns interacting with the social structures of their societies. Some innovations were slow (the wheel), some fast (the steam engine) depending on the communication systems in place at the time and in the society of the invention. The spread of innovations was always tightly linked to the communication and information systems available to distribute and share the new knowledge obtained [9,10]. The new wired information and communication we humans have had access to over the last 10 years obviously surpasses any communication system we have had before: "With a significant number of people connected, the scope of the Web today is hard to fathom. The total number of Web pages, including those that are dynamically created upon request and document files available through links, exceeds 600 billion. That's 100 pages per person alive. How could we create so much, so fast, so well? In fewer than 4,000 days, we have encoded half a trillion versions of our collective story and put them in front of 1 billion people, or one-sixth of the world's population. That remarkable achievement was not in anyone's 10-year plan."

This information and communication system brought great changes in the organization, transmission, display, storage and communication of information. Making instant sharing with unlimited numbers of people possible, this technology provides us with the opportunity to have access to anything that has ever been written, designed, sung, drawn or painted and instantly share it and build upon it. The world wide web has only been around for ten years but has allowed the human web to expand, interact and communicate more intensively and with more impact on societies then any period before. The domestication of the networked pc is our latest transformation which only really started 10 years ago (on the cosmic scales of world historians an invisible dot).

4. Conclusions and Suggestions for Further Research

Up to 500 years ago three different world zones were moving through similar trajectories at different speeds governed by different synergies of informational exchange [10]. I argue that only during the last 500 years have we slowly moved to a single global system of information exchange with collective learning at the human species level. The exact implications of collective learning through the ever more dense global communication since the internet, will remain unknown for a while, but other periods of intense communication (e.g. 18th century) led to quick transmission of innovations across cultures. With significantly increased volume and variety of the information being pooled and increased efficiency and speed at which information is shared, in the last 10 years since the world started to communicate through hypertext, I expect to see major implications for collective learning and collective knowledge exchange. While one of the central problems of all individuals of any species is finding food whilst avoiding becoming food [11], ecology is concerned with the relations between organisms and their environment and the

survival mechanisms that species adopted. Information and communication systems have been key to the survival of the human species and to the supremacy of one group over another in our history. As discussed earlier, Christian [10] is very explicit about the role of information and communication for innovation. He argues for the general principle that the size, diversity, and efficiency of information networks should be an important large-scale determinant of rates of ecological innovation (p. 184). Examining the size and variety of information networks in different parts in the world, together with the varying efficiency with which information is pooled within those networks, he considers this of key importance to the understanding of communication systems for the spread of innovation. I argue that innovations for mankind have been closely linked to the communication systems that transmitted and facilitated adoption by other groups or nations. Humans made use of information systems and these played a role in gaining control and influence over other groups across the world and societies. In earlier days obviously to define the size of a region within which information was exchanged to a large extent defined the spread of certain innovations. To define the size of a region within which information is exchanged is one thing but within that region the speed and regularity of exchanges may vary greatly. The ecological and natural environment in combination with food production techniques to a large extent defined which direction innovations were spreading [9].

Based on Christian [10] who states that the efficiency of information exchanges reflect above all, the nature and regularity of contacts and exchanges between different communities which may be shaped by social conventions, geographical factors and technologies of communication and transportation (p. 184) I argue that the size, diversity and efficiency of information networks should be an important large scale determinant of rates of ecological innovation. Tracking the changing synergy of processes of collective learning, by examining the size and variety of information networks in different parts of the world, as well as the varying efficiency with which information was pooled within those networks, might be an important indicator for innovation. (p.184). In the Paleolithic era, the existence of small groups that had limited contact with each other meant that exchanges of ecological information worked sluggishly. In a single lifetime, each individual was unlikely to encounter more than a few hundred individuals and most of that lifetime would have been spent in the company of no more then ten to thirty individuals who belonged to the same family. The amount of information that could have been exchanged in these networks was clearly limited."

I argue that because these information and communication systems increase the efficiency and speed at which information is shared will stimulate ecologically significant learning and innovation at the human species level. Information systems facilitated processes of collective learning and associated changes accelerated by the accumulation of ecologically significant knowledge. As McNeill and McNeill note, agriculture and the wheel were invented in a number of places, but the steam engine only had to be invented once. While hunter-gatherers used information systems to gain control over fire, we use information systems to gain control over each other.

For a long time, humanity formed one single, very loosely connected web-like network that shared many characteristics and exhibited only limited local variations. In comparison with later periods, communication in the form of messages and

material exchanges progressed very slowly, while local cultural developments followed suit. Consequently, inventions could easily spread everywhere before any group developed a decisive cultural advantage. The development of our current information and communication infrastructure will significantly change this. Collective learning at the human species level will significantly increase and the spread of innovations in the years to come will be much faster and more efficient than in previous times. Only by understanding these changes in a larger historic perspective and understanding how humans have communicated in the past and how this affected their social structures and lives, can we begin to understand the changes that information and communication technologies will bring. The domestication of the personal, networked and increasingly mobile computer will have a greater impact than any other type of domestication has ever had before. Capturing and sharing content is what humans have done since the dawn of mankind but doing this through networked computers is significantly different. The domestication of the networked computer should be seen as another major regime transformation.

Further research should investigate the interplay between information and communication systems and the effects on innovation of capturing and disseminating content instantly in a global context. The fact that we are no longer living in isolated communities without information exchange but are functioning in "an online global human web" where discoveries, innovations, patents, scientific publications and paradigms shifts can be shared instantly with all online, humans on our planet will reduce the "re-inventing of the wheel phenomenon" and provide us with the ability to build upon each others innovations. An important aspect of this development is obviously the potentially increased effects of the "digital divide". Research questions to be addressed by future research could involve: Does learning at the human species level increase as a result of the fact that the number of possible connections (and thereby the potential information synergy of the entire network) increases faster than the number of nodes, and that the difference between the two rates will increase as the number of nodes increases as McNeill and McNeill 2003 predict? How will certain groups in our global society be able to retain control over crucial information systems and therefore survive while others will not?

History though seems to have come full circle: many of us roam around cyberspace as gatherers and hunters, picking up whatever information item we encounter on our way. Even though we know what we came for and started off purposeful searches, the web in its present shape, keeps distracting us and providing us with information items that we are not really looking for. We end up back again as nomads and gatherers, surfing endlessly to where we think we might find the information of our interest and of our survival.

References

1. M.D. Hauser. The Evolution of Communication. Cambridge MA, MIT Press. (1996).
2. F. Webster. Theories of the Information Society. London, Routledge. (2002).
3. M. Castells. The Rise of the Network Society. Malden, Blackwell Publishing. (2000).
4. D.R. Headrick. When information Came of Age: Technologies of Knowledge in the Age of Reason and Revolution, 1700-1850. New York, Oxford University Press. (2000).

5. F. Spier. The Structure of Big History. Amsterdam, Amsterdam University Press. (1996).
6. R. Mansell and W. E. Steinmueller Mobilizing the Information Society: Strategies for Growth and Opportunity. Oxford, Oxford University Press. (2000).
7. A.D. Chandler and J. W. Cortada, Eds. A Nation Transformed by Information: How Information Has Shaped the United States from Colonial Times to the Present. Oxford, Oxford University Press. (2000).
8. J.R. Beniger. The Control Revolution: Technological and Economic Origins of the Information Society. Cambridge MA, Harvard University Press. (1986).
9. J. Diamond. Guns, Germs and Steel: The Fates of Human Societies. New York, Norton & Company. (1997).
10. D. Christian. Maps of Time. Berkeley, University of California Press. (2004).
11. J.R. McNeill and W. McNeill The Human Web: A Bird's Eye View of World History. New York, Norton & Company. (2003).
12. R. Wright. Nonzero: The logic of Human Destiny. New York, Random House. (2000).