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The Challenge of the Information Society
by
Marcelo Alonso
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The diversity of cultures in the world makes it interesting but many times it might be a source of conflict, or at least lack of understanding. As long as a community is more or less isolated from the rest, it can preserve its culture and maintain a certain level of harmony among its members. (Perhaps this is one of the reasons why many rulers have tried to keep their people isolated from external influences.) However it is well known that as soon as a community is open to the influence of other cultures, particularly when they have to share the same living space, or when one group tries to impose its culture on another, conflicts potentially may arise, which often are difficult to resolve, as history shows even today. This is due in part to the fact that many aspects of a culture, such as ideology, values and religion, are difficult to modify or adjust in order to coexist with other cultures. When this fact is coupled with intolerance the result is a severe impediment to the harmony among peoples and cultures.

Since the beginning of civilization the interaction among people and communities of the same or different cultures has always been carried out through communication between the people. As long as the means of communication were basically oral and visual, the interaction between cultures was limited, slow, and mostly confined to local levels. However the rapid increase in the means of communication, that has taken place in the last 100 years, has increased considerably cultural interactions throughout the world, becoming a global phenomenon that has received considerable attention. A relevant question is whether in the present world, in which widespread fast communication and travel are common, it is becoming increasingly difficult rather than easier to achieve a harmony of cultures. It is my purpose to examine this question, exploring how the modern means of communication influence cultural relations and the consequent challenges they pose to individuals and to society. Anything that facilitates open and free communication among peoples contributes to the harmony of cultures, or rather to harmony in the world. This is the great potential of the modern information revolution, but there is the possibility that many people may not be able to participate in it or use it improperly, with negative consequences for the world. This is why the information revolution is not just technological, but also social and ethical.

2. KNOWLEDGE, INFORMATION AND COMMUNICATION. Civilizations and their associated cultures arise and evolve as a result of the gradual acquisition of knowledge about their physical environment and about their individuals. Some knowledge is acquired in a natural way, mostly through personal daily experience, and other has to be acquired from external sources, mostly through education, observation and research. As knowledge increases, old civilizations evolve and change and new civilizations emerge, and consequently cultures are profoundly affected., and even replaced. For knowledge to be effective and useful it must be transferred and disseminated and, when appropriate, used or applied to improve the quality of

life, through the process of technological innovation (production of goods, gadgets and services), which in turn affects cultures, posing moral dilemmas, producing economic challenges, and even creating personal and social crisis. In other words, knowledge is a prime factor of cultural and social change.

By communication we understand the process of transfer of knowledge among individuals. The most effective way of communicating knowledge is by expressing it in codified form, for what intelligence is required. By information we understand codified knowledge. (This is why genes contain instructions, but not information.) Only humans seem to be able to codify knowledge and express it in a form adequate for its exchange, storage and retrieval, allowing acquired knowledge to pass to other people and to future generations. Obviously for information to be useful the source and the receiver must share the same encryption methods (coding and decoding). Information differs from just plain knowledge in the sense that it serves to organize knowledge, allowing it to be collected, processed and moved, thus giving knowledge an addtional value. Some even claim that information can be quantified1, but their definition is more restricted than the one I use here.

The simplest form of codifying knowledge is language, which inplies words, arbitrarily chosen units of language, and a syntax to combine them in a meaningful way. The invention of language constituted a first step in information evolution, with far reaching consequences and an important cultural impact. Written language was an information breakthrough by allowing the transfer of codified knowledge without the interlocutors having to be face-to-face, facilitating storing information and passing it to future generations. For that reason there can be no doubt about the profound cultural impact of written language. The written stage in information evolution was consolidated in the 15th. century with the invention, in Europe, of the printing press using movable types. This was the first technological innovation in information or printing stage. The printed press did not change the way knowledge was codified but facilitated the diffusion of written information through distance and time, making reading an important tool of life. Although printed information was a crucial step toward cultural interactions it remained a slow and limited mean of information diffusion and cultural exchanges. Nevertheless printed information contributed to the emergence of modern societies and was an important step towards the harmony of cultures.

The next crucial stage in information evolution, that I call the electromagnetic stage, began in the second half of the 19th century, as we acquired a better understanding of electromagnetic phenomena in general and of the behavior of electrons in metals in particular. The invention of the telegraph, around 1830, was an important technological innovation in information, allowing the transmission of a message at a great speed, using a new code, the Morse alphabet, which in a sense was a precursor of the modern digital system. However the telegraph did not have a relevant cultural impact because the limitation in the kind and amount of information transmitted and the restricted access by the people. A more important step in the electromagnetic evolution of information, with real cultural impact, was the invention about 1905, of the electron tubes or valves (diodes, triodes, etc.), based on the emission of electrons by hot metallic wires discovered in 1885. Electron tubes, combined with special circuits, facilitated the emission and absorption

of electromagnetic waves, also discovered in the second half of the 19th century, opening the door for using electromagnetic signals for transmitting and receiving information almost intantaneously via telephone, radio and eventually television. Electronic technology changed radically the way people communicate, interact and learn about each other, resulting in widespread cultural exchanges. I would say this was the dawn of the global village, term first suggested by M. McLuhan2.

Did the electromagnetic stage in information evolution contribute to the harmony of cultures? Yes and no. On the positive side electromagnetic information has been an important factor for cultural harmony by facilitating with some limitations the access to information by people at all levels and the exchanges of ideas among peoples in different parts of the world, thus contributing to their mutual knowledge. On the other hand there has been the risk that electromagnetic information facilitates special interest groups or dictatorial regimes to manipulate, influence and even control the way people think and behave. The new information technologies also pose a serious challenge to democratic systems, whose governments might be tempted to regulate what information to disseminate and to intervene to make sure that the information provided is truthful, objective and accurate. In a democratic society this responsibility falls in principle on the individuals but there is the danger that not every person interprets that reponsibility in the same way and that might entice governments to get involved. We will return to this point later on.

3. QUANTUM ELECTRONICS AND INFORMATION TECHNOLOGY. For the last two decades a new stage in information technology or infotec has been taking place, that is reaching explosive or revolutionary proportions. I call it the quantum electronics stage, because although modern infotec is an extraordinary combination of old and new technologies, it depends critically on the quantum behavior of electrons and photons in some materials, such as semiconductors, optical fibers and lasers. These new technologies have made possible to amplfy many times the power of the human brain, just as the steam and internal combustion engines multiplied many times the power of human and animal muscles. As this brain amplification has become available to more and more people, it has produced profound social and cultural impacts.

Most of the devices used in the new information stage depend on the electronic properties of silicon (although other chemical elements are also used), which is a rather abundant and inexpensive chemical element (sand is made of silicon oxide or silica). Silicon atoms are very similar to those of carbon but they have many differences (silicon atoms have one more complete shell of eight electrons than carbon atoms) that alter some electric properties. One is that the energy gap at the uppermost electron energy band in solid silicon is relatively small (about 1.14 eV compared with about 5 eV in carbon), which makes silicon a semiconductor. Semiconductors are substances whose electric conductivity increases with the temperature, which is the opposite of what happens to metals. A semiconductor can be doped with impurities whose atoms have more or less electrons than the semiconductor atoms, becoming of two types, n and p, that differ in how electrons move around. Transistors, discovered in 1949 by Bardeen and Brattain, are combinations of n and p semiconductors that perform the same functions of the old vacuum electron tubes but with much reduced energy consumption and size and a much higher reliability. We tend to forget that transistors are all over in modern homes, offices, industries, cars, planes,

etc. Chips are combinations of a large number of transistors, millions some times, arranged in special circuits, that are at the heart of control systems and computers. Electrons behave in transistors in a very special way, quite different from their behavior in a metallic wire or in an electron tube. That behavior is described very accurately by quantum mechanics, a theory developed around 1925 to explain the fundamental properties of matter (atoms, molecules, solids, etc.). For that reason the science dealing with the electronic properties of materials, and in particular of semiconductors and transistors, is called quantum electronics.

Lasers (light amplification by stimulated emission of radiation), that we find in CD's, LD's, CD-rom's, and in many other applications, are a technology related to quantum electronics, that is basic for infotec.. Lasers are devices that depend on the quantum behavior of electrons in certain atoms, molecules and solids when they interact with photons or electromagnetic radiation (microwaves, infrarred, light). Another quantum electronics technology critical for modern information systems is fiber optics, developed in the 1950's. Optical fibers are long and very thin filaments (of the order of micrometers) made of extremely pure silica glass, although other materials are also used, that transmit electromagnetic signals with little attenuation and distortion and large compression and bandwidth. Optical fibers transmit information as a modulated beam of photons, replacing in many instances transmission by electric currents over metallic cables or by electromagnetic waves over free space. The study of the interaction between photons and matter is called photonics.The combination of photonics with quantum electronics is a new branch of physics called optoelectronics. Magnetic storage of information (audio and video tapes, diskettes, etc), based on magnetic properties of subatomic particles (related to their spin), is another critical technology for handling information. There are several other technologies for handling information, such as communication satellites, liquid crystal displays (LCD), the recently discovered phenomenon of giant magnetoresistance, etc, most of which are based also on the electric and magnetic properties of matter3.

Another important innovation in information technology has been digitalization, that is codifying information in digital form using the binary numerical system, that is zeroes and ones (0's & 1's) or bits (binary digits), instead of the analog system. Digitalizing is possible thanks to a property of transistors called electron gates, that allow signal transmission (gate open or 1) or interruption (closed or 0), that is all-or-none. Any numbers, letters or other symbols, can be expressed or codified uniquely in binary form by a string of eight bits, constituting a byte. The advantage of digital vs. analog encoding of information is that every piece of information is expressed uniquely and precisely, reducing noise and errors and improving the manipulation, transmission, storing and retrieval of information4.

This overview of some of the major scientific developments, that have occurred over a short period of time, shows how the current revolution in information technology has been possible, allowing the fast and precise manipulation of vast amounts of information in proportions never imagined before, facilitating the communication among peoples all over the world, and changing the way they live, work, learn, function, even think. As a result, it is having a profound and global social and cultural impact.

4. THE THIRD CULTURE. Parallel to the rapid evolution of information technologies another important sociological phenomenon has taken place. Since the middle of the 19th century, scientific research and technological innovations have been growing in sophistication and complexity at an accelerated pace and with profound social impact, a situation intensified after World War II with the emergence of the post-industrial societies, dedicated to the systematic production of scientific knowledge and its technological applications. As a consequence, the scientific community has become identified as a loose group that is an important, but somewhat apart, component of society, and generally less well recognized than other groups such as artists and writers. One reason might be that scientists have their own way of codifying knowledge, using specialized concepts, terminology, equations, symbols, etc., that often are not easy to grasp by the non specialist and, for sure, are not of public domain. The consequence is that it has become more difficult to communicate scientific and technical information to the non-scientist.

This fact prompted C.P.Snow5 to introduce in 1959 the idea of the existence of two cultures of global dimensions, that are superimposed on the traditional ethnical and local cultures. One is the scientific/technical culture composed of scientists and engineers that, while affecting the whole world with their ideas, research and actions, have very limited direct communication with the public. Its members are concerned with understanding how the physical and biological worlds function (the structure of matter, quantum and relativity theories, genetics and neural networks, etc), with how the human mind works, with how to apply that knowledge for the benefit of humanity. These are problems of universal value and concern, regardless of the ethnical cultures of the scientists, but that are not easily accessible to the people in general. The second is the humanistic/literary culture composed of the much larger group of non-scientific intellectuals (writers, philosophers, religious leaders, lawyers) that have much more direct influence on the public in general and in a sense dominate the scene. Its members appeal to a variety of aspects of human nature such as values and responsibility, social and family issues, beauty and pleasure, art and poetry, justice and order, which are of immediate interest to most people. However these are issues that, although universal, may manifest differently in each traditional ethnical culture, which makes humanistic/literary intellectuals closer to and more dependent on their respective cultures. A serious consequence of the two cultures has been that, because their language and conceptual paradigms are different, the communication among the practitioners of both cultures has been minimal resulting in two parallel global cultures (communication among scientitsts in different fields has not always been good either). I do not think this situation has contributed very much to the harmony of cultures. It should be noted that in the particular case of the scientists they have, in many instances, to harmonize their technical and ethnical cultures, which in general is not the case of the humanistic/literary intellectuals, as noted above.

A new stituation has appeared in recent years with the continuous and rapid growth in diversity and importance of scientific research and technological innovations, affecting most areas of public interest. This situation has forced decision makers in particular and the public in general to understand or at least be aware of, even if to a limited extent, the scientific and technical issues faced by modern societies (genetics, the environment, energy in general and nuclear energy in particular, space exploration, etc.), which in turn require more elaborate and delicate means of communication (not to say of education). The consequence has been the emergence of a third

culture, although not in the sense envisioned by C.P.Snow in 1963, when he forecasted that the gap between the two cultures would eventually be closed, or in the more limited sense suggested by J. Brockman6 of scientists communicating directly with the general public. I rather see the third culture as a new global intellectual environment that encompasses all aspects of relevance to our technological societies and in which all people, regardless of their background, have to participate. In other words, what traditionally was called science has now become, though in a limited way, part of the public culture. It is now a normal practice in all media of communication to deal with scientific problems, within the inherent limitations of professional journalists, and it has also become very popular for scientists to make available their scientific ideas in books, articles, TV programs, etc, within their own limitations for communicating their subject with the public. The success of the third culture depends on those that can bring in a meaningful way the scientific culture to a broad audience, helping other people reach a reasonable understanding of the world we live in and develop a new sort of human relations. Unfortunately this task is far from being accomplished. One way of consolidating the third culture is through education, which after all is an information process. However most educational systems, particularly in the US, are still far from incorporating the third culture. This is an issue that requires, in my opinion, special attention. In any case I am convinced that a sound global third culture is essential for reaching and maintaining harmony in the world. And needless to say, events such as ICUS are a positive contribution to the development of the third culture.

One of the most important factors contributing to the expansion of the third culture is the current infotec revolution. One of the reasons is the simplicity with which information can be exchanged all over the world, facilitating the communication among the most diverse people, regardless of how remote they might be from each other. Another reason is the variety of information, scientific and non-scientific, educational and non educational, relevant and trivial, that can be exchanged with precision and speed. A third reason is that people are induced to use new technological innovations (fax machines, cellular phones, computers) and, willingly or not, are exposed to technical concepts and algorithms never heard of before, although their true meanings are not fully understood by most people. One consequence is the emergence of a new universal vocabulary developed by those involved in the information revolution. Not only people are aware of atoms and electrons, of transistors and lasers, but they have to deal with terabits, gigabytes, ram, dram, rom, megahertz, modem, etc. I suppose this new situation will contribute to the harmony of cultures, although we have to realize that the third culture requires a much higher level of education and responsibility among all peoples of the world, regardless of their traditional backgrounds. We also must be aware of a potentially negative effect: that the people not involved in the third culture and the associated infotec revolution may be left behind, becoming a new kind of illiterates, information illiterates, which might place them in a condition of inferiority relative to the rest. Another question, not yet fully explored by psychologists and sociologists, is whether sharing and using information by a social group, i.e. group information, makes the group more harmonius or more "intelligent". Two relared questions are that of group manipulation of information for the benefit of the group, and of group manipulation by others through information, both of important social implications..

5. THE COMPUTER AND THE INFORMATION REVOLUTION. One of the most important

single components of the information revolution, that has made it possible to reach global proportions, has been the personal computer (PC). The ubiquitous computer, a unique combination of transistors (hardware) and logical instructions (software), has penetrated offices, laboratories, hospitals, businesses, industries, schools and homes, taking advantage of the fact that humans process information visually quite well. Like books before, computers with modems have become a way of life, an extension of human intelligence, a sort of human-computer symbiosis, forcing people to acquire new skills to manage computers in the same way that children have to learn how to write and read. Even for a person like me, that grew in a computerless world, it is hard to imagine a world without computers. Computers can not compete yet with the rational thought of the human brain but are million times more powerful in logical and mathematical operations. In 1947 Norbert Wiener7 initiated a new line of research, that he called cybernetics, to study the entire field of control and communication theory, whether in the machine or in the animal, and its eventual application to electronic systems that mimic the neural networks, an area of importance for the design of feedback mechanisms and robots, which are programmed by computers. However it has proved difficult to this day to fully emulate nervous systems using computers, particularly in respect to rational thought, perception and movement8.

A computer alone, no matter how powerful, is not sufficient to produce an information revolution. What has made it possible has been the two-way linkage of computers, so that they can exchange information. The linkage of several computers constitutes a computers network. There are several ways of communication linkages, of which the most simple and widely used is through telephone lines using what is called a modem (modulator-demodulator). The exchange of information via linked computers is called computer-mediated-communication (CMC). When computer networks are combined with the more traditional technologies of telephone, radio and television, incorporating data, audio and video, the result is what are called multimedia information systems, which have added a new dimension to communication.

For a few years, internal closed computer networks have existed for linking computers for specific purposes as, for example, for communication between separate offices in a business and in airlines and railways reservation systems, but more recently CMC has evolved into a much broader spectrum such as teleconferencing and chatting, electronic mail, bulletin board systems, shopping, etc. over open networks. These considerably expanded CMC applications have been made relatively easy with the internet, or simply the net, which is a network of several thousands networks, consiting of millions of loosely interconnected computers and the switched telecommunication networks. Getting in the internet is simple by using special software such as Mosaic, that provides access to the World Wide Web, a collection of a few thousand independently owned computers scattered all over the world but working together offering a diversity of data, or through some commercial on-line services (Compuserve, Prodigy, America Online, etc.). Although internet began about 20 years ago as a military project, ARPAnet, it became in 1984 a civilian operation with NSFnet as its backbone, and has since grown very rapidly. Today more than 50 million people worldwide have some sort of access to the internet, making it a truly global communication system, although there are still many countries and regions that do not have internet connections or they are not widespread. Ordinary people can turn into publishers, artists, reporters, advocates, organizers, or just communicators, using internet.

More recently other networks have appeared for certain specialized or commercial purposes such as shopping (electronic malls), banking (electronic tellers), advertising, or for scientific research. For example NSFnet linked several computer centers and laboratories in the US, providing a service used by almost every scientist in the US (in April of 1995 NSFnet was privatized and new research links have been established). We do not need to delve here on the many communication avenues within and outside the internet that are available. The important point for our purpose is to recognize that global CMC have become relatively simple and easily accessible to a large number of people worldwide, with considerable cultural implications.

Before the advent of CMC, communication among people was personalized and geographically located (one-to-one) or impersonal and controlled by a few, as that provided by media networks (one-to-many). Internet has changed that situation. In the first place communication has become many-to-many in the sense that anybody having access to the net can use the information available or communicate with any others with access to the net. Also anybody can post any information over the net, without restrictions or limitations, which might be a healthy situation but that also involves some risks by providing a channel for improper information or even disinfomation. In the third place, CMC in the internet has become more cognitive and disembodied. It does not matter with whom we communicate, what kind of person he/she is, or where that person is; what matters is the quality and nature of the information transmitted and the capacity of the interlocutors to maintain a meaningful exchange of information. People can be in communication and enjoy an electronic relationship for a long time without ever meeting face-to-face and without showing their emotions. To ameliorate this situation people involved in CMC have designed graphical renderings, called emoticons, to convey their facial expressions, but that is not enough to reveal true emotions in CMC; that does not mean that CMC are always emontionless and, for example, when somebody posts something improper in the internet it may elicit the most furious comments by others, a reaction called flaming. We may say that CMC has given rise to a transcultural, expressionless and classless electronic democracy or electronic agora, which perhaps goes against human nature or is creating a new one. The need of face-to-face communication is so ingrained in human nature that very often those maintaining a relationship through CMC feel the urge of meeting with each other, and there are many instances in which some couples have fallen in love and even got married after meeting.

At a broader level we have seen the emergence of virtual communities9. A society means in general a group of persons that share the same culture and the same living space, say cities, which in turn are aggregated into larger entities such as nations. The essential places where people in a social group interact is where they live, work and gather for conviviality. CMC has changed that picture with the appearance of virtual communities, that are groups of people, spread geographically but sharing some common interest, that use CMC to interact, communicate and establish relationships. Virtual communities transcend national boundaries and perhaps also cultural barriers, have no common places where to gather, and are held together by common interests and ideas. A valid question is whether virtual communities can help citizens to revitalize democracy and promote genuine transcultural relations, or there is the danger that they will lure people into a substitute for democratic discourse and true human relations. Or in other terms, are virtual communities a positive step toward the harmony of cultures? In principle I would say yes,

but we have to be careful that we do not dehumanize human relations.

The rich and varied information that exists in computer networks, that can be retrieved, transmitted and exchanged, does not reside in any physical place or space, as it happens for example with books in a library, but in what has become called cyberspace, term introduced by W. Gibson10 in his science fiction novel Neuromancer, published in 1984 before the information revolution was in full swing. By cyberspace it is understood a conceptual space in which people interact using CMC to exchange words, data, pictures, ideas, wealth, establish relationships, interact in a variety of ways, even exert power. The term cyberspace has become so popular that it in turn has given rise to new terms related to specific CMC users (cybernauts, cybersnoops, cyberdeviants) as well as to some specific aspects and activities (cybermoney, cybersoftware, cyberoffice, cyberart, cybertravel, cybergames, even cybersex !). In fact the term and its different modifications have become part of our common language, perhaps another contribution to the third culture.

An institution that may be shaken at its roots by the information revolution and emerging virtual communities is the university. Traditionally a university has three functions: scholarly generation of knowledge, its preservation, and its transmission and difussion. How these functions are performed is changing rapidly with the new information technology by taking advantage of computer networks. It is no longer necessary for scholars to have physical proximity to exchange ideas, or to go to a library to obtain a piece of information, or to be in a classroom to transmit knowledge. All these functions can be carried out by electronic means and in cyberspace, at a great savings in time and money. In a sense we are witnessing the emergence of a global university network, a true virtual community of scholars, though not strictly a virtual university or cyberuniversity, because universities as institutions will continue to exist and will need laboratories and other facilities. In a sense it will be the modern realization of the chinese proverb: "A scholar can learn everything without leaving his home". However universities will not have to cover all fields; rather they will become smaller and highly specialized, without that implying a loss of scholarship or a limitation in their functions. This potential departure from traditional universities poses a serious challenge to the academic community and those that support it.

At a higher level of sophistication, well above CMC, we have a new possibility under development called virtual reality11, which makes use of cyberspace in a more elaborate way. Virtual reality systems consist of 3D computer generated representation of a real space with total sensorial immersion of the user through different sensory transducers. The user then perceives what looks like a real space, that does not exist physically, without leaving his place in front of the computer. Virtual reality systems are very complex and for the time being do not have many applications (one is the training of airplane pilots) and I do not foresee them having an immediate cultural input. However a more limited version of virtual reality is already available in softwares that allow the user build virtual objects, manipulate them and navigate through cyberworlds of user's design12. These limited virtual reality programs do not have the sensorial immersion of true virtual reality, rather they are like looking at the ouside world through a window, the monitor screen, instead of being outside, part of the world. However they are sufficiently

"realistic" as to have a multitude of important applications in research, education, architecture, medicine, engineering, industrial design, art, entertainment, etc. In their more elaborate form limited virtual reality systems are a merge of computer technology, animation, simulation, robotics, fiber-optics communications and high tech displays. Perhaps the most dramatic applications of virtual reality are in medical training, diagnostic and therapy13. A recent medical application of virtual reality, called telemedicine, allows a specialist in a big city hospital to examine directly a distant patient, may be in a rural health unit, and look at his medical records transmitted to him, and telesurgery allows a surgeon to operate on a patient that is quite far away, even in another country. In another application of limited virtual reality a person can make a virtual visit to any museum in the world without leaving home, and using internet exchange with other persons his/her experience of the virtual visit, something that certainly has a cultural value. Or those more inclined to relaxation may spend an evening making a virtual visit to several night clubs. It might be interesting to note that an entertainment company13 offers a limited virtual reality system that allows to play interactive multimedia games between groups in different parts of the world, forming a sort of "virtual geographic league". Very soon it will be possible for anybody in the world with access to internet to gamble on-line in a virtual casino or Virtual Vegas, a possibility that although interesting I do not think is very desirable, even if it brings together people with different cultures. Limited virtual reality systems, properly used, may eventually contribute effectively to the harmony of cultures because they make possible that different people share the same dynamic cyberworld experience, but to be truly effective as a cultural tool it must become accessible to a large number of people in many countries.

6. THE IMPACT OF THE INFORMATION REVOLUTION. From the preceding analysis one can see that modern information technologies have produced a genuine information revolution. The impact of this information revolution on the various facets of human interest and endeavor is well known and has been analyzed extensively in books, technical journals and magazines15 and will not be elaborated here. Instead the analysis will be limited to some aspects of the information revolution that have direct social and cultural implications, some of which have already been mentioned.

Perhaps the most serious social challenge is how humans in all parts of the world are going to manage this complex "brave" new world that infotec has contributed to create, and make sure it will help the betterment of all people. This general challenge has many facets that require different treatments, but a common denominator is that information, besides its cultural implications, has now more than ever an economic value, facilitating the acquisition of tangible goods and services. However for information to have value it must be understood and used, which shifts the "value of information" to the "value of understanding". This poses a challenge because there is the possibility that the human capacity for understanding (or the brain capacity to handle information) may not grow as fast as the rate of generation of information thanks to infotec developments, rendering useless or valueless the excess of information. In any case information must be treated as a commodity that has a value and a cost. That means that, regardless their capacity for understanding, not all people can have access to the new information systems because they can not afford them or the necessary infotec facilities are not available where they live. There is also the possibility that modern information systems might not be too

important for people in poor areas in which not many tangible goods and services are available, while boosting the wealth of those already wealthy enough to afford them. Does that mean we are creating two new classes: those who have access to infotec and benefit from it, an infotec upperclass, and those who do not, an infotec underclass? Will that hinder the development of the less developed countries (LDC) while boosting the economies of the post-industrial societies that control infotec? The situation is similar to what existed in the 1960's when it was popular among sociologists and economists to talk about the transfer of technology (basically manufacturing and knowhow) from the more advanced countries to the LDC and the role of the multinational companies. In fact the UN established agencies such as UNDP and UNIDO to deal with that problem. Now we have instead to examine the transfer of infotec and the role of the private and governmental enterprises that are creating the new information technologies and consequently controlling information worldwide.

Of course access to infotec is not a question of preference or interest but of real need because it is crucial for the functioning of a modern society. Is there some sort of moral obligation of those who have, to help those who do not have access to infotec? I do not know how to meet that moral obligation short of giving away computers and miles of optical fibers or providing soft loans to improve communication systems in LDC. Many LDC that have such loans are using technological shortcuts and, for example, have chosen to install microwave and cellular digital communication systems, taking advantage of wireless networks, rather than improving their defficient telephone networks because on the overall it is less expensive, although it might be more expensive for the individual user and will not benefit everybody.

Infotec is also having an impact on the family. Traditionally family relations and cohesion were strengthened by sharing common interests and places: the fireplace, meals, sports, and more recently in the US recreation rooms and TV. Now with the penetration of computers and multimedia systems in homes there is the danger that family cohesion will be softened. Every family member wants to have his/her own computer system and play with it, as it happened before with radios and TVs. The younger ones are becoming computer addicted or computernauts, while the older members are still finding a bit difficult to use computers or enjoy their use. To alleviate this situation in many communities in the US special computer courses for senior citizens are offered with very positive results, specially with those that cannot enjoy outdoors life any more or have some mobility impediments. A specialized service for senior citizens, Senior Net, lets them chat with others and make new acquaintances anywhere in the world, exchange ideas and request advice and services. When seniors join juniors in enjoying using computers a new sort of family cohesion arises, which is a positive impact of infotec. On the other hand there is the possibility of juniors getting acquainted with materials they should not have access to, establish undesirable cyber relations, such as with computer predators and pedophiles, or become addicted to the new counterculture or cyberculture that is emerging in the internet. Its members, called cyberpunks, are mostly young people that cultivate a broad range of rap music, art, psychedelics, smart drugs, and attitudes, similar to the underground pop culture and anarchy of the "antisocial" rebels or hippies of the 1960's. With the support of infotec cyberculture is more dramatic and accessible to young people the world over than the hippy culture, with a more serious potential social impact. Perhaps what is needed for the users of

internet is to provide more relevant entertainment information, or infotainment, that contributes to reinforce human, family and social values16.

An area in which infotec is bound to have a profound impact, if properly used, is education, by changing the learning procedures and the teacher-student relation. Computers can not substitute teachers and books but, when combined with proper softwares such as CD-ROMs, complement them by giving students more flexibility in learning, making it more interesting, explore worlds they can not reach directly, analyze virtual experiments that can not be performed in their laboratories, develop new ideas, acquire new mental skills, and interact with students in other schools or countries. But care must be taken that students exposed to computer assisted education (CAE) do not become computer addicts that push buttons or point and click, navigating in cyberspace without paying attention to content and substance, neglecting putting their hands on the real world and learning by heart some basic skills, such as writing, reading, and arithmetic and algebraic calculations. This requires adequate teachers training and a proper balance between teachers and multimedia programs. Also, since not all schools can be properly equiped with computers, there may be the danger of having two parallel systems of education: those that are equipped to use infotec and those that can not afford to do that. One area that has not been fully exploited is that of edutainment, the combination of education and entertainment, or education-through-games, that might make learning a more pleasant process, but one has to be careful that in this case education does not become too superficial.

The economic and business sectors have also been affected by infotec. Economic growth, though dependent on the production of goods and services, is now driven by computers, softwares and telecommunication systems. Business have become more and more dependent on those systems for improving their productivity and marketing. Manufacturing is increasingly done by automation and robots, which are computer driven, which facilitates customizing almost anything at a minimum cost. Marketing can be done with relative ease through computer networks and the internet. Offices are becoming paperless and people may not have to be physically at a central place to do their job, a situation called teleworking. In most business human relations, lines of command and communication, and decission making channels are changing thanks to infotec. Reengineering corporations and the workplace, making use of infotec and with less people, changing the way they do business, has become the marching order. The consequence is that the job structure is changing very rapidly, with severe dislocations of people. Many jobs, particularly those that do not require skilled workers, are diminishing, while the number of jobs better paid but requiring skilled workers with higher education is growing. Since society does not adjust very fast to new economic and working conditions, many displaced people find it difficult to get new jobs., and this is bound to happen all over the world.

A matter of special concern for the LDC is that labor intensive industries are becoming less relevant for infotec driven economies and therefore LDC must find how to cope with this consequence of infotec.This is particularly important for countries whose populations are growing at a high rate. However that does not mean that LDC should stay away from the information revolution. Rather the question is whether LDC are prepared to make use of infotec, and if not, then how. This challenge has been examined in several forums. For example Syed A.

H. Abidi17 stated at a 1992 PWPA meeting in Kenya that since "communication is the engine of growth and socioeconomic transformation....Africa must adopt information technology to keep up with developments elsewhere in the globe". Similarly at a meeting organized by the United Nations University (UNU) in 1992 in Japan it was recognized that "information technologies may be considered as basic instruments for cooperation", and that there is a need to facilitate the access of LDC to information technologies18. Incidentally UNU established in 1991 in Macau an International Institute for Software Technology (UNU/IIST) concerned fundamentally with the software needs of the developing world.

A new innovation that is emerging, thanks to infotec and that may shake the financial system worldwide, consists in using CMC to make monetary transactions over the internet or other on-line services using what has been called electronic money, E-money or cybermoney, instead of cash, checks or credit cards, to pay for goods, services, or for transfer money between any two places in the world. E-money is equivalent to establish a cashless global electronic commerce and banking system, creating a new type of communication among people all over the world. However E-money has several worldwide implications that must be resolved before the system is fully in place, that we cannot explore here (establish an electronic monetary system, regulate the use of E-money, determine the role of banks, revise tax laws, protect privacy and security and against money launderers, etc.). As is the case with other infotec innovations, there is the risk that E-money will create a financial gap between those that can use it and those that cannot.

One aspect of infotec that may have profound social and political impact is the potential transformation of the democratic process into a continuous instantaneous plebiscitory democracy with free exchange of information but often without substantive debate (what are called electronic town hall meetings). A particular delicate aspect of infotec, that has been mentioned already, is whether to regulate or not the kind and use of information available in the internet and other on-line channels. A related issue is how to protect the intellectual rights of certain information and the confidentiality of records, such as business and bank transactions, another is how to restrict certain types of information, secure data and preserve privacy, avoiding the danger of surveillance and intrusion in our lives, or panopticon, and of disinformation. I shall not elaborate on these important issues for which there is not yet an easy solution, short of violating the freedom of information, essential in a democratic society, and establishing some type of government censorship, unacceptable in a democratic society 19.

A recent phenomenon, that reveals the economic value and importance of infotec, has been the emergence of new types of crimes, computer crimes, that are becoming more daring and imaginative, defying existing laws that do not contemplate such situation. Computer hackers and cybersnoops break codes and obtain restricted information. Computer pranksters post threats, violent emotional fantasies, and anonimous or fake letters in the internet, with potential dire consequences. International gangs run multimillion underground business (the digital underground), comparable to that of drug cartels, duplicating illegally sofware and stealing hardware, such as processors. In fact computer chips are "better than gold" for thieves. Thus a new social challenge, is how to establish a civil order in cyberspace and adopt the appropriate law-enforcement legislation20.

In concluding, the new information revolution is changing society in a very profound way and producing new challenges that are important to understand well in order to make sure that it contributes to the well being of all people, to a better understanding of the world, and to the harmony among people. We cannot expect that in a free democratic environment everything in infotec will be positive and meet high civic and moral standards, thus contributing to that goal, but we have to make sure that the positive aspects, which are many, are strengthened. For that reason I am firmly convinced that for infotec to have a beneficial social influence it is essential that scholars, religious leaders, politicians, educators, business executives, and above all parents, understand the issues and lead the way, and that people recognize the need to strengthen the two basic pillars of democratic societies: individual responsibility and an education that inculcates fundamental values.

From the practical point of view, in order to find how to meet that challenge, it might be desirable to (1) analize the historical record of how the previous stages in information (printing press, telegraph, telephone, radio and TV) have produced cultural and social changes as the speed of information dissemination increased, and the role of the communicators in the process 21, (2) agree on standards to measure the effects on the quality of human life of introducing new faster communication technologies, (3) explore the role of governments and some international instruments in regulating and/or controlling the new information technologies (4) hypothesize on the future effects of the information revolution22.

REFERENCES

1. Several suggestions about how to "measure" information have been made, but they refer more to signal transmission. A message is defined as a discrete or continuous sequence of measurable events distributed in time, and the information content carried by the message must be separated from the noise that accompanies it. This type of information has been related to negative entropy or negentropy, an idea I do not find satisfactory from the thermodynamic point of view. C.E. Shanon, A mathematical Theory of Communication, Bell System Tech. J. 27, p. 379 and 623 (1948); E.J.Jaynes, Information Theory and Statistical Mechanics, Phys. Rev. 106, p. 620, 108, p.171 (1957); L. Brillouin, Science and Information Theory, Academic Press (1962).
2. M. McLuhan, Understanding Media: The Extension of Man, Academic Press (1962)
3. It might be interesting to note that while life has been possible thanks to the properties of carbon atoms (nucleic acids, proteins, etc.), and the industrial revolution was built on carbon (wood and fossil fuels), the information revolution is built on silicon atoms (glass and sand).
4. The revolution in information technology continues unabated. In some instances the new innovations are only incremental, such as incorporating in one disk digital recording of music and video so that it can be played either in a regular CD player for audio or in a computer as a CD-ROM for audio/video, or are radical advances in existing technologies, such aa all photonic networks and intelligent systems. Other innovations might be more profund, such as quantum computers (QC), based on the quantum principle of superposition of states. In this case an atom with two quantum states, say two orientations of electron spin, can be in any of the four

combinations (0,0), (0,1),(1,0),(1,1) called qubits (quadruple bits). Photons can indepedently change either part of the qubits, giving rise to new types of logic gates, the heart of a QC, and to parallel quantum computation. C.H.Bennet, Quantum Information and Computation, Physics Today, 48, p. 24 (1995); D.P.DiVincenzo, Quantum Computation, Science, 270, p. 255 (1995)

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8. H. Moravic, Robotics and Artificial Intelligence, in The World of 2044, C. Sheffield, M.Alonso and M.A.Kaplan, Eds., PWPA/Paragon House, (1994). R.C.Schank and P.Childers, The Cognitive Computer, Addison-Wesley Pub. Co. (1984)

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11. M. Alonso, Introduction, and B. Bova, O Brave New (Virtual) World, in The World of 2044, PWPA/Paragon House, op.cit. (1994); H. Rheingold, Virtual Reality, Summit Books (1991)

12. Joseph Gradecki, The Virtual Reality Construction Kit and Virtual Reality Programmer's Kit, Wiley (1994)

13. See e.g. Ernest G. Cravalho, Medical Technologies, in The World of 2044, op.cit. (1994)

14. Virtual World Entertainment, Los Angeles, California. I have visited one of their facillities and found them very interesting, even if they are still limited in scope.

15. There are three recent publications that I consider useful to those interested in getting a general overview of the infotec possibilities: The Information Revolution, special issue, Business Week (1994), Welcome to Cyberspace, TIME, special issue (1995), The Computer in the 21st Century, Scientific American, special issue (1995).

16. The insertion of objectionable materials in internet has prompted the US Senate to adopt a "Communications Decency Act", that bars obscene materials from internet and threatens violators with fines up to $ 100,000 and jail terms up two years. Though well intentioned, the implementation of this legislation may pose several legal and enforcement problems that are being hotly discussed. However it has already had some positive effect: legal experts, netwwork executives, internet users and many others are actively looking for more palatable alternatives, such as adopting selfrestraint guidelines or using a technology, such as the V-chip, for locking out of internet undesirable information, and an Information Highway Parental Empowerment Group has been formed to look into this problem. The Carnegie Mellon University study Marketing Pornography on the Information Highway, Georgetown Law Journal, Vol. 83, No. 5, June (1995), analyzes the issue in detail. The potential interference of the government on the materials posted in internet is a hotly debated issue in the US, and has aroused a "flaming" outrage among several groups. It should be noted that in the PROC the dilemma is different: how to control access to internet so that people are not exposed to "undesirable" political

information. The social and ethical issues related to the information revolution has prompted many universities to offer infotec and computer ethics courses or establish research groups such as the Research Center on Computing and Society, at the South Connecticut State University, and the Computing Ethics Institute in Washington D.C., in the US, the Centre for Computing and Social Responsibility, at De Monfort University, in Leicester, UK., and more recntly a Computer Ethics Center at Adam Mickiewicks University, in Poznam, Poland.

17. Syed A. H. Abidi, Mass Communication in Africa, in The Second Scramble for Africa, PWPA/Kenya, 1992.

18. Expanding Access to Science and Technology: The Role of Information Technologies, I. Wesley-Tanaskovic et al., eds.., United Nations University Press (1994)

19. In the US the American Civil Liberties Union is carrying out a "Privacy and Technology" project to explore how to protect personal information in the internet, and the US Congress is debating legislation about how to protect the confidentiality of some information, such as medical and financial records. Perhaps the UN should at some point examine this problem and even establish some guidelines in cyberspace. An issue that I hope we will never have to face, is the control by the militarys of all information systems during a conflict, that is an infowar strategy that overrides all confidentiality.

20. In the U.S. fraud and related criminal activity in connection with computers, such as unauthorized access to confidential information (hacking) is dealt with in 18 U.S.Code, β 1030, Crime and Criminal Procedure.

21. The effect of excessive information and the responsibility of the communicators has been discussed by Saul Bellows in his 1990 lecture at Oxford University, "The Distracted Public". For example he said "that on an average week-day the New York Times contains more information than any contemporary of Shakespeare would have acquired in a lifetime, ...although I suspect that an educated Elizabethan was less confused by what he knew. He would certainly have been less agitated than we are. His knowledge cannot lain so close to the threshold of chaos as ours." Regarding the communicators Bellows added that "the ceaseless world crisis, otherwise known as the chaos of the present age, is not the work of the communication industry and its Information Revolution; but for our peculiar pseudoknowledge of what is happening, for the density of our ignorance, and for the inner confusion and centerlessness of our understanding, for our agitation, the communicators are responsible. Intellectuals and universities, from the ideological side, also have much to answer for it." (S. Bellows, "It All Adds Up", Ch. 3, p. 157 and 160, Penguin Books, 1994).

22. It is interesting to note that as early as 1980 Alvin Toffler had the foresight of predicting that quantum electronics and computers would form one of the four clusters of backbone industries of what he calls the Third Wave in the history of human civilization, the stage of synthesis and unification, "bringing with them, once more, major shifts in economic power and in social and political alignments". (A. Toffler, The Third Wave, Ch. 12, W. Morrow & Co,, 1980)

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