Abstract: Knowledge-based development produces wealth and opens the frontiers of competitiveness, technological innovation and wealth distribution. In developed countries the process is intrinsically bound to the ability in producing innovation and the dynamics of network knowledge construction. Within this process the academic and research communities participate effectively in the dynamics of knowledge and innovation, an environment strongly based on Information and Communication Technology (ICTs). However, when compared to the developed countries’ dynamics, the formation of such communities in Latin America is rare. In this context CLARA (Latin American Cooperation in Advanced Networks) and ScienTI (Information and Knowledge Network in Science, Technology and Innovation) networks are strategies for the establishment, dissemination and foment of scientific knowledge in Latin America. CLARA network integrates national academy networks in Latin America linking some 700 universities and research centers in the area. ScienTI network establishes and links scientific information sources in eleven countries within the area. The formation of a gigantic Latin American research community linking researchers, projects, studies and researches has an important role in the building of the world of science and education of the future. The formation and the functioning of the networks will be discussed from the point of view of community’s knowledge building in Latin America.

1. INTRODUCTION

Information and Communication Technologies (ICTs) have become intrinsic to the construction of the Society of Knowledge. Since Science, Economics and Society as a whole are being revolutionized by technology, its understanding constitutes a study object in important research centers and several international organizations.

Analysts of current world situation hold that society transformed itself into a network society. According to Castells (1999) networks are the new social morphology of our societies and the expansion of network logic changes in a very deep way the workings and the results of experience, power, culture and productive processes. The same author insists that the new paradigm of information technology provide the material basis for the increasing insertion of network in all social structure.

The representation of the scientist as a solitary being absorbed in his research is a thing of the past. The process of scientific knowledge currently requires competence, partnership, cooperation, negotiation, guidelines and strategies that will interlink the greatest number of people to promote knowledge building (Silva, 2005). In this context, a dependence
on infrastructure resources exists. Research and development system is sought after which, concomitantly, makes possible the advance of scientific and technological knowledge, favors a large scale formation of highly qualified human resources which are important for the research system and the firm’s personnel (Tidia, 2005).

According to Melo & Machado (2004), the warrant of an effective participation of national research communities is of paramount importance within the dynamics of knowledge producing and innovation processes. According to these authors, Latin American countries show a highly embryonic heterogeneous position with regard to ICTs infrastructure in research, especially in advanced digital networks. ICTs shall make one follow the trends and identify opportunities of use and development of special applications in several areas of knowledge.

Within this context there are two new highly promising scenes for Latin America: the consolidation of the Latin American Cooperation in Advanced Networks (CLARA network) and the Information and Knowledge Network in Science, Technology and Innovation (ScienTI network). The former establishes the infrastructure in the linking of the region’s academic networks; the latter establishes homogeneous and inter-operational national information resources in Science, Technology and Information (ST&I) throughout the region.

Current research discusses the importance of scientific cooperation and academic networks within the Society of Knowledge, extant networks in Latin America and the new situation CLARA and ScienTI networks introduce in the region as promoters and developers of knowledge in the scientific community.

2. THE SOCIETY OF KNOWLEDGE

Changes in social, economic, political, cultural and institutional changes have characterized the early 21st century. A consensus has been reached that knowledge is not a mere additional means for wealth but its predominant factor. The formation of great economic blocks and the integration of different financial markets, a result of globalization, are only the economic surface of this new society whose background consists of speedy growth of the more intensive sectors of information, based on linking, and especially on technological interoperationality. Wealth is thus concentrated on the capacity and on the speed with which information is transformed into actions or into knowledge.

Transformation of information into actions has been foreseen by Drucker (1992) who stated that technologies, as technologies, would not produce a higher productivity in labor. The updated rule in the new economy is to prepare oneself to compete proficiently since the past will never repeat itself. Yesterday’s success will not warrant today’s success and consequently will not guarantee tomorrow’s.

In the new society knowledge is wealth which, in turn, has become the source of the highest impact in development. As a corollary, the search for wealth mechanisms projects itself in the control of communication media and the dissemination of information. ICTs are wealth factors only when the communication infrastructure is competent to transform information into knowledge. Education is thus the key element for the construction of the Society of Knowledge in which the most important differentials are innovation and the conversion of knowledge in competition (Freitas Junior, 2003).

The scale factor is another key element in the Society of Knowledge, besides the transformation factor of production means. The ICTs are challenged to link more and more people in cooperation projects that would promote knowledge. Actually this is the context for scientific cooperation networks. When ICTs are joined, the classical form of producing knowledge in a community adopts the scale factor, connects complementary realities and promotes development.
3. COOPERATION NETWORKS AND SOURCES OF SCIENTIFIC INFORMATION

Scientific collaboration is as ancient as science. Cooperation involving researchers of different countries was already known in the 19th century. As a rule, scientific collaboration is a cooperative work which involves common objectives, coordinated efforts and results by which the collaborators share responsibility and merit (Balancieri, 2004). Scientific collaboration of all types may be frequently found within the environment of “invisible colleges”, identified by Price (1963) in the 1960s, which were made up of informal communities of scientists. Meeting periodically to exchange experience and information these scientists had an important role in formal publications and in the dissemination of state-of-the-art scientific knowledge.

According to Velho (2001), these scientists are characterized by their high rate of production, sharing research priorities, student training, producing and monitoring knowledge in their specific area. They meet in congresses, conferences, gatherings on their specialties, inter-institutional exchanges and collaborative researches. This type of organization goes beyond the limits of the department, institution, country, and brings together scientists from all the corners of the world where relevant scientific research is taking place in that specific area of knowledge or specialty.

Informal networks established by scientists are part and parcel to scientific knowledge. Macedo (1999) states that the final output, frequently expressed by publications of results by the researchers involved, is the result of a series of information and knowledge exchanged informally and consolidated throughout a period of time by several scientific communities. The latter, their institutions and their countries are easily identified.

In the last decades Big Science activities have been intensified through their impact on the social organization of certain areas of knowledge and caused the establishment and the functioning of important laboratories and biological projects which have required the participation of research groups in different countries. Due to the scientific complexity needed and chiefly because of the high costs involved, they have caused a significant rise in international cooperation indexes (Velho, 2001).

Recently two events have modified this type of international scientific cooperation: on the one hand, concerns on issues that go beyond geographic frontiers (for example, greenhouse effect and the gradual depletion of the ozone layer), on the other hand, the growth of high technology industrial sectors that enhance scientific sharing between enterprises and between industrialized countries. Through joined investments in scientific research, these issues compel transnational firms to produce, as joint ventures, new technological opportunities and capacitate them to explore them separately. Favored by governments’ special programs, this new form of cooperation is becoming a constant in industrialized nations.

Two factors are especially favorable towards the formation of networks in science. First, the specific way by which scientific knowledge is articulated, or rather, the manner it is intrinsically linked to the cooperation between research groups and researchers; second, the broadening of cooperation opportunities through the rise of new resources in Information and Communication Technology. The outcome has been the research academic network.

3.1. Academic Research and Networks

During the last decades Academic Research and Networks have been profoundly involved in economical, social, political and technological transformations. The computer, the deployment of techniques and tools of modeling and simulation, and chiefly the rise of the Internet represent transformation factors within the process of knowledge production. This includes the organization of research (Melo; Machado, 2004).
Since transformations have shortcut the research-development-product cycle, according to Weisz & Roco (1996), research demands the formation of a wide scientific base, an increasing science globalization and openness of the market to world competition. New scientific ideas, the establishment of new technologies and the training of good professionals supplement the work of isolated institutions. Further, increasing budget restrictions, the existence of particular centers with similar capacities, the internationality of science and technology and the availability of the best communication means have engendered the formation of research activity networks.

Research networks are made up of researchers who exchange information and knowledge and have some type of production as their final output, which may be bibliographical, technological, artistic or cultural. The networks’ chief aims are research, training, cooperative technological development, international cooperation and interdisciplinary activities (Balancieri, 2004).

Telecommunications have made possible research networks when mechanisms furthering the collaboration and the sharing of information and resources between researchers were introduced. According to Stanton (2005a), these mechanisms include high performance communication network with distributed computer resources, normally deploying many individual computers, or a set of mechanisms, called grid computing, that together work up a solution for larger problems.

The networks’ characteristics indicate, according to Melo & Machado (2004), the capacity for transference and sharing of data between countries. On the other hand, since they have high rates of data transmission and interoperability between computers in several geographical sites, they establish the bases for the development of a collaboration environment between research groups that work in different places, even those widely dispersed around the globe.

Research networks have in fact a multifunctional aim: (a) they form a high performance infrastructure in information and communication based on the most advanced technologies to give support to researchers; (b) they facilitate research by providing a platform for new services and the network’s advanced technologies. When state-of-the-art technological developments are present, research networks are in an ideal position to test new services in advance of the telecommunication markets (Clara, 2005).

Melo & Machado (2004) stated that increasing storing capacity, information processing and interactivity are the features of the new digital environment. Revolutionary applications (for instance, access to information in real time and remote instrumentation), access to large infrastructures existing in only a few countries (for instance, astronomy observatories or particle accelerators), and sharing of data and information distributed processing are thus available. Considerable advances in several fields of knowledge and in industry-related research are made possible.

With the arrival of nanotechnologies, new wireless communication technologies, optic transmissions and new technological paradigms will further transform the world research landscape in the years to come. Melo & Machado (2004) point out the huge investments announced by developed countries in the new infrastructure for research, such as the Advanced Cyberinfrastructure Program of the National Science Foundation (NSF) in the United States.

The European Community prides itself of IST Program (Information Society Technologies), its most important development program, that for many years have enhanced a wide range of research and development activities in ICTs (Stanton, 2005a). Actually there is a special concern for electronic infrastructure with a focus on the improvement of the GÉANT network, the high speed pan-European network, and on the building of a grid-distributed
computer capacity which will be at the service for electronic science in the production context.

Since GÉANT is the most advanced network in the world with vast extension and coverage (interlinking more than 3500 teaching and research institutions in 32 countries), it is merely the visible investment section which Europeans have in high performance communication (Stanton, 2005a). Besides investments in its infrastructure, the European Community is investing in further connections with Africa, Middle East, Central Asia, Far East Asia and Latin America. It aims at highlighting Europe in the digital communication world.

3.2. Information Sources in Science, Technology and Innovation

Besides connecting labs and research groups, cooperative network requires access to information sources. The latter should not only pinpoint financing sources but they themselves must be the source of knowing the scientific community. Key questions in research network are: (a) Who – which groups and specialists are working with a specific type of knowledge? (b) Where – in which country or in which institution may these specialists be found? (c) What – what contributions do these groups bring to the area of knowledge in which they are engaged? (d) How – how may these contributions be reached (projects, scientific production)? (e) With whom – what other groups and specialists cooperate in these activities?

In the wake of the above questions several investments have been made by national and international organizations. CORDIS (Community Research and Development Information Service) and CERIF (Common European Research Information Format) are prominent in Europe. The former is an initiative of the European Community which organizes and makes available information on ST&I, which includes looking for partners, projects, financing sources, scientific production (monographs, documents and scientific articles). EuroCris, a profitless European association, is a common ground for individuals and organizations interested in the use of information technology in all research information in business systems. CERIF, the outcome of a group of specialists hailing from the member states of the European Community, establishes standards and common formats for research-related information which is extremely important in the context of interoperability of information sources.

3.3. Research and Academic Networks and Information Sources in Latin America

The time is propitious for the advancement in capacity and in international connections of research and academic network in several regions of the world at the national, regional and local levels. Melo & Machado (2004) believe that these networks should be the focus for strategies in the promotion of economical and social development, as has been the case in East European countries and in Asia.

Latin America, a vast geographic area which comprises more than 700 universities and research institutions, has currently only a starting position characterized by heterogeneity with regard to research and academic networks. High communication service costs and diminishing investments in the ST&I systems of each country, especially in universities and in public research centers, reveal great disadvantages when compared to other regions (Melo & Machado, 2004).

America Latina Interconectada con Europa [Latin American interconnected with Europe], ALICE, the name given to the initiative of linking the national networks of Latin American countries to establish links with GÉANT, constructed the Cooperación Latino Americana de Redes Avanzadas network (CLARA). It integrates the region’s research and academic national networks.
There are two prominent initiatives in Latin America in information sources: (a) Red Iberoamericana de Indicadores de Ciencia y Tecnología (RICYT network); (b) Red de Información C&T para America Latina y el Caribe (INFOCYT). Whereas RICYT establishes standards and produces indicators for the region’s ST&I similar to OCDE (Organization for Economical Cooperation and Development), INFOCYT is an initiative of the Organization of American States that has established a gate for information sources on ST&I in Latin America and in the Caribbean.

The international scene in developed countries and in Latin American points towards a broadening of research networks in two fronts: (a) ICT infrastructure connectivity available in the countries; (b) establishment and interoperability between information sources in ST&I. The chief projects in Latin America within the context of these fronts are the CLARA and ScienTI networks which will be described below.

4. CLARA NETWORK

The CLARA network started at a meeting of the Alliance for the Information Society, financed by the European Community in June 2002. Representatives of the chief Latin American academic networks were faced with the opportunity of establishing a Latin American network which had been postponed several times (RNP, 2005). In 2003 representatives of academic networks from 18 Latin American countries signed the organization’s constitution. The CLARA network started in August 2004 and at present is a facilitating strategy within the region’s advanced academic networks (RNP, 2005).

CLARA network with its headquarters in Uruguay is a profitless civil association with two working fronts: (a) the formation of an infrastructure that unites advanced Latin American networks; (b) the non-governmental organization management that represents the network’s interests. The networks have been planned and implemented from national education and research networks of the member countries, coupled to commercial networks. Efficient access is thus guaranteed for all users according to inter-network agreements. Only one network of a country may be a CLARA member which should be overtly supported by the government of that country. Its strategic aims include the coordination with other blocks, cooperation for the promotion of scientific and technological development, the planning and establishing of network services for regional interconnection and the development of a regional network (CLARA network) to interconnect national research and academic networks which will be deployed by its members (CLARA, 2005).

At present CLARA comprises the following networks: RETINA (Argentina); ADSIB (Bolivia), RNP (Brazil), REUNA (Chili), Universidad de Cauca (Colombia), CR2Net (Costa Rica), RedUniv (Cuba), RAICES (El Salvador), CEDIA (Ecuador), RAGIE (Guatemala), UNITEC (Honduras), CUDI (Mexico), CNU/RENIE (Nicaragua), RedCyT (Panama), ARANDU (Paraguay), RAAP (Peru), RAI (Uruguay) and REACCIUN (Venezuela) (CLARA, 2005). In fact CLARA connects more than 700 universities and research centers in Latin American and in the Caribbean.

Figure 1 shows CLARA’s topology with its chief national networks in the region (Argentina, Brazil, Chile and Mexico) and its access to Central American countries. The network will also be linked to the GÉANT network through connections from Brazil and Mexico for California, accessing Canada, United States and Asia (CLARA, 2005). According to Melo & Machado (2004), such options will make feasible the formation of inter-institutional research groups with universities, research centers and national agencies between network countries and will integrate common research and teaching applications in different fields of knowledge such as Medicine, Physics, Astronomy, Health, Environment, Education, Biodiversity and others.
CLARA’s activities are: (a) support to member networks; (b) network implementation and management; (c) establishment of a data base of researchers and specialists; (d) formation of security groups (CLARA, 2005).

According to Simões (2005), this is the first time that South American countries are connected by an advanced network, while the European connection favors a wide opening for scientific collaboration between these two immense regions. Stanton (2005b) states that short term advantages include new access to international advanced networks with better communication facilities to European and Latin American networks. It is expected that network will develop considerably to attend the international needs for collaboration with researchers, laboratories and observatories in the region’s countries.

Latin American researchers and academics will be able to undertake collaborative projects in research and education that go beyond national borders. CLARA represents not only a step forward within the development of infrastructure in research network passing through Latin American and subsequently to Europe, but also upgrades the region towards the highest level of scientific and technological development (CLARA, 2005).

Although great possibilities are brought by CLARA network for the Latin American academic and research community coupled to its cooperation project with Europe, it surely needs information tools that would implement the expected aims. ACLARA, a Latin American Standard Catalog for Research and Development Projects, is being planned which will be a standard transregional information service that would assist CLARA institutions to establish a repository according to a scheme distributed by each country and standardized with relevant information on Latin American research projects (based on EuroCris and CERIFD metadata). Its aim is to establish a unique and public information structure for member institutions. REUNA (Chili) coordination and its administration and development services of information systems, supported by the CLARA network infrastructure, will establish the information base for research collaboration projects through ICTs (CLARA, 2005).

In the case of direct support for scientific cooperation, Geraque (2005) refers to the CLARA network making feasible the monitoring of a state-of-the-art telescope in the Andes from a room in the São Paulo; the participation in shared computer projects in Rio de Janeiro.
which are being developed in Paris; the giving of a videoconference between Brasilia and Lisbon without any mediation since digital signals will not need be redirected from the United States.

Since these initiatives may be of great benefit for many people in Latin America (Cabral, 2005) and due to the important work being done by several people and institutions in Latin America, it is expected that these networks be known and produce long-term projects for the benefit of Latin American society.

The CLARA network is thus an important landmark since it favors the development and the establishment of networks in places in which they are not extant and produce opportunities for the building of a research schedule in regional and global interests. Since a few years ago high telecommunication costs restricted the possibilities of inter-regional connections in Latin America, it is currently possible for countries to plan connectivity in Latin America at the same rate as between each country and, say, Miami. Besides autonomy and capacity produced and disseminated, the interregional network allows the expansion of sensitive applications or of remote or assisted control, in less time than that taken at present (with current working infrastructure) in the dissemination of huge quantities of data. High quality in collaborative application at remote stations (education, health and others) and support of interregional future projects in great scientific and technological complexities will be guaranteed through the intra-regional network.

The Commission of the European Community is financing up to 80% of costs (some 12.5 million euros) for the network’s implementation, support and maintenance till 2006. Whereas the explicit support of the government in each country is required, negotiating differentiated tariffs with telecommunication incorporations will be necessary due to the network’s non-profit stance. Each national network has to endorse its share of the remaining 20% of costs which are the responsibility of the project’s Latin American beneficiaries (CLARA, 2005). CLARA’s sustainability depends on alternative forms of payments which will take their time to be satisfactorily solved.

5. **ScienTI NETWORK**

The International Information and Knowledge Network in Science, Technology and Innovation (ScienTI) originated from a 2000 agreement between the Brazilian Council for Scientific and Technological Development (CNPq) and the Pan-American Health Organization (OPS). The agreement combined the experiences of the above organizations in two projects involving the establishment and the administration of information sources in ST&I, or rather, the Lattes Platform of the CNPq and the Health Virtual Library (HVL) of OPS/BIREME. Whereas the former systemized a section of data within a national innovation system (curricula, research groups, institutions and projects), the latter became the chief access to data (digital libraries) and cooperation sources in health in Latin America and the Caribbean.

The blending of these experiences occurred through the construction of an architecture based on information standards and systems in the Lattes Platform (Pacheco; Kern, 2003). In 2001 the CNPq, OPS, and the Stela Group of the Federal University of Santa Catarina structured a pilot model called Latin American Curriculum Vitae in Health Sciences (CVLACS) from the Brazilian CV-Lattes. After being applied in Chili, Colombia, Cuba, Mexico and Venezuela under the monitoring of the countries’ National Science and Technology Organizations (ONCYTs), its success gave rise to a new network, with the admittance of Portugal, Peru, Panama, Ecuador and Argentina and the international organizations UNESCO and RICYT. In December 2002 the network was formally inaugurated in Florianopolis SC Brazil. The administration of ScienTI Network is structured on four nuclei: (a) ONCYTs represent the government of each country that use the ScienTI
structure and are responsible for the national sources of information in ST&I; (b) OICYTs include international organizations supporting ST&I (including OPAS, UNESCO, RICYT); (c) GDIs are Research and Development Groups in information systems applied to ST&I (including Stela-Brazil, CT&S-National University of Colombia, Quipu/PUC-Peru and DSI-University of Minho-Portugal; (d) IPs or Promoting Institutions’ Network Nucleus. The Network has an executive secretariat (currently administered by OPAS/BIREME) and an Inter-Institutional Committee made up of representatives of each nucleus and responsible for the Network’s guidelines.

The main aim of ScienTI Network is the establishing of an international ST&I space based on information and knowledge sources for scientific activity and technological innovation. It is an interactive space and open network platform operating in an information system, directories, Web portals and tools for data and information collection. The Network consists of an international cooperative system between ONCYTs, OICYTs and GDIs for the continuous development of methodologies and tools that support the administration of the countries’ scientific and technological activities, especially the developing ones.

The ScienTI Network in each country has produced national information sources in ST&I and its systems are already officially used in Brazil (with more than 580000 curricula and more than 20000 research groups), in Colombia (with more than 40000 curricula and more than 2000 research groups), in Venezuela (approximately 10000 curricula), Ecuador (approximately 4000 curricula), Argentina (approximately 3000 curricula), Chili (approximately 4000 curricula). Procedures are being taken by Peru, Portugal, Panama, Mexico, Paraguay and Uruguay (currently merely Network observers) for its launching in these countries.

Information sources are produced in each country under ONCYT administration through the national GDI support, when extant. Sources come through the insertion of ScienTI systems within the C&T process and based on the sending of curricula and research groups (in certain countries) to ONCYT. Within the latter’s structures, web services and interoperability mechanisms publish information for external consultation (Figure 2). Consultation in the ScienTI Portal is accessed wholly so that the search for a specialist may be disseminated throughout the entire region.

Figure 2: Information flow in ScienTI Network (national panorama)
Source: ScienTI (20005)
Besides making information sources available, ScienTI is inter-operational with digital libraries (BVS, SciELO, LILACS, MedLine) and has made possible scientific studies in health (undertaken by OPAS and RICYT), with high perspectives in the forming of communities dealing with the practical application of specific health themes. There are also high expectations in the application of knowledge systems so that search for specialties in ST&I could be more effective (Gonçalves et al., 2005).

Conversely to the CLARA network, ScienTI Network is maintained by each partner organization. So that sustainability could be maintained, the possibilities of forming thematic sections, of widening the number of partners and the forwarding of specific projects to financing organizations (similarly to what Colombia did at the Organization of American States) are being considered.

ScienTI may be the immediate access in the region on information about the scientific community. The promotion of knowledge and the region’s development are the ScienTI’s contribution about people, places, themes and groups that develop research in Latin America.

6. CONCLUSION

Undoubtedly the role of ICTs is the building and the dissemination of knowledge coupled to international collaboration in knowledge production. Exchange of experience and collaboration in knowledge deepens the search for border-less science and chiefly contributes towards sustainable development within international cooperation.

ICTs-produced exchange may increase research capacity, ability for research and access to knowledge. This fact is increasingly developing in research and academic networks in which institutions and researchers involved in research work cooperate in the production of knowledge and innovation especially in developed countries. The establishment of electronic infrastructure at the national and international levels has straitened remote cooperation among scientists who depend on extensive computerized resources for their researches. It will also be a model for the provision of high performance or large scale computerized resources for the production sector.

Infrastructure and the construction of scientific information sources in Latin America are inscribed by two initiatives: the CLARA and the ScienTI networks respectively.

In the region’s communication infrastructure the CLARA network is an important landmark for a greater integration between national research and academic networks in the region. Latin American and European research communities will benefit from the new infrastructure of data communications with new possibilities in swift information exchange. When network development and establishment are facilitated in places where they are not extant and when they produce opportunities for the construction of a research schedule of regional and global interests, CLARA opens new perspectives and possibilities for its users in a partnership that has an important role in the building of a Latin American future in science and education.

On the other hand, ScienTI network assumes the role of content formation, information sources and, in a special manner, the possibility of knowing researchers, research groups and Latin America’s scientific and technological production. Consequently ScienTI must provide a direct access to the Latin American technical and scientific community. At present its chief result has been the establishment of national sources which have already made feasible unpublished studies with regard to the region’s ST&I indexes.

If CLARA and ScienTI are allied, they may establish connectivity and the necessary contents towards the promotion of technical and scientific knowledge of Latin America. Development pathways based on knowledge, wealth production, blurring of borders in competitiveness, technological innovation and wealth distribution are already delineated. The role of academic networks within this context may already be perceived in developing
countries. Initiatives such as those engaged in by CLARA and ScienTI may bring similar responses to Latin America.

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