

Trilateral Seminar on Science, Society and the Internet

Section IIA: Keynote Presentations

<i>Societal Aspects of Information Technology</i> , Pauline Newman.....	21
<i>Science and Society in the Internet Era</i> , Tsueno Nakahara	29
<i>The Internet: Bridging the Gap between Science and Society</i> , Wang Zhiqiang.....	41

Information Technology and the Law

Pauline Newman

**Judge, United States Court of Appeals for the Federal Circuit
Washington, D.C.**

This coming together of our three nations is quite timely, to discuss our shared interests in the power of this technology and its potential for human betterment.

The Internet rapidly moved out of science and into society, where its full impact is yet to be discovered, as it bridges both territorial and intellectual separations among nations. The way the Internet works is the province of scientists and engineers, but its effects have such broad potential for progress and for change, that many interests and institutions have sought to be heard. That in turn got governmental attention, and soon there were guidelines, and laws, and treaties, and protocols, and lawsuits, and judges. These phases have barely started. The sweet freedom of the early days of the Internet will never return — except perhaps for scientific collaboration, the way the Internet began.

On my court — and courts in general — we see only the dark side, the abuses, the disputes. That is the role of the judges. We see criminal acts and commercial disputes, for e-commerce has become big and profitable. Even for legal issues that we call "constitutional," like invasion of privacy and due process of law, the underlying issue usually has a profit motive. Most legal issues have a monetary component, just as most wrongs have a monetary remedy. Each new technologic capability of the Internet raises new possibilities of fraud, or sharp practice, or exploitation, or conflict. Old laws are being tested, new laws are being enacted.

Law is rarely interested in successes — other than to tax them. So I'm going to talk about the legal problems, and the legislative and judicial approaches to solving them. I share the concern that the power of this technology not be diminished by over-regulation. But the power is so great that controls are inevitable, and are arising in all nations. Many legal and societal issues remain unresolved, and pressures for international control are growing, although consensus is elusive. You who understand this technology, its capabilities and its prospects, can bring special insight to its problems.

I. Law Lags Technologic Change

Law lives in the past. That is its great strength: its stability, its resistance to change. Law tends to preserve the past, to stress the traditional. But the law is challenged by the new situations generated by the Internet. For example, there is no legal precedent that weighs the loss of personal privacy and its effect on human dignity and independence, and balances it against the ease of access to knowledge and the intellectual enhancements that result. Thus our Constitution is frequently invoked on both sides of Internet issues, as the argument for freedom of information is balanced by the rights of privacy and property. Both draw on constitutional rights, the fundamental principles that are common to the laws and culture of all nations.

Rights that Derive from the First Amendment. When considering governmental controls on the Internet, the first issue is freedom of speech, freedom of the media. First Amendment freedom of speech is the defense to attempts to control pornography and hate speech on the Internet—but does it also defend hackers, circumvention, encryption?—does it bar barriers to placing information on the Internet, however vile the information?

Can you place your deepest prejudices on the Internet? Our courts have been very protective of the right to state your hates. Hate speech attacks ethnic and religious groups, women, homosexuals. Our tradition is to permit such speech, at least unless it's "obscene," in the belief that all ideas should be permitted to be aired and discussed, tested for truth in what Justice Oliver Wendell Holmes called the "marketplace of ideas." So hate speech is not barred or subject to censorship, despite the ease of spreading hate on the Internet. Other nations have other views, and prohibit Internet transmission of hate and pornography.

Is pornography protected speech? That's not a new question, but it takes on new force when it so readily enters the home. Our Congress early in Internet life enacted the Communications Decency Act, prohibiting "indecent" or "patently offensive" communications. The Supreme Court struck it down, as too broad and too vague. Now the challenge is to devise technology so that unwanted speech can be excluded from your home computer. I'm told that parents can install various mechanisms for screening incoming information, and that most children can circumvent the screens, in an unending cycle of technologic advance and circumvention.

Everyone deplores the exploitation of children—but many people are equally concerned about the government as censor. Who should decide what's acceptable? The general thrust of our judicial

decisions is that speech should not be subject to stricter or stronger or more punitive controls, simply because it's spread on the Internet. Hate, discrimination, pornography, obscenity, must meet the same standards as before, the weight favoring the free flow of even unpleasant ideas.

Rights that Derive from the Fourth Amendment. What about privacy? The Fourth Amendment to the Constitution concerns the right to be secure in one's person and one's house and one's papers. In the United States we have many safeguards against the power of the police, but electronic surveillance has taken on new authority since the attacks of September 11, raising concerns about increasing the power of investigators to eavesdrop on guilty and innocent alike.

The Patriot Act permits monitoring of Internet mail, chat rooms, web pages. The police still need a search warrant, but it's easier to get and easier to do, and harder to control. The general concern is less for criminal investigation, than for intrusion into personal privacy. The protection of the individual includes allowing us to preserve human distance, to keep our secrets. Perhaps future generations will have a different view of the need for privacy, and will accept its loss as part of electronic life. In Singapore a law was enacted a few weeks ago that allows monitoring of all computers, said to be to prevent hacking, and attempted hacking, and threats to national security. We need to be vigilant to protect our freedoms.

II. Due Process of Law

Another United States constitutional aspect relates to what we call “due process of law.” “Due process” means that the law is administered fairly and openly, that legal procedures are reasonable and the remedies appropriate. It includes such practical considerations as that you can't be sued in a remote or inconvenient area. But Internet violations can originate anywhere in the world, or from unidentifiable space—although I understand that the source is becoming easier to trace—and there may be no physical presence in the nation. Meanwhile, there is growing commerce in cyberspace, some of which is intended to avoid the reach of the law—or the reach of the tax collector.

Here's a recent example in a case of trademark infringement. The rule in the United States is that a person who is being sued has to be served personally with the legal summons, and in a venue convenient to the person being sued. There's a gambling operation that operates from Costa Rica, and does business only on the Internet; the operation used a trademark similar to that of a Las Vegas casino, and the issue was infringement of the United States trademark. The Costa Rican operation had no office in Costa Rica, and couldn't be found to be personally served. The court in

the United States observed that e-mail was the only access to the only known address, and held that due process was not violated. This decision is highly controversial, but it may portend the future.

Electronic Illegalities. There's much interest in developing international rules of jurisdiction of those who enter the territory only electronically, and commit fraud or forgery, or copyright or trademark violations. The Council of Europe has designed a Convention on Cybercrime—the United States and Japan contributed to its development—but very few countries have adopted it, although it's now been sent to our Senate for ratification. Also, there's a proposed international treaty called the Hague Convention on the Enforcement of Foreign Judgments. These treaty provisions are quite controversial; some say they're too strong, some say not strong enough.

There's a lot of resistance to placing legal burdens on Internet activity, national and international. But it's generally agreed that commercial violation must be subject to remedy. There is no significant international law of Internet behavior, no supra-national tribunal with authority to enforce rules and remedy infractions.

An exception relates to disputes over domain names. The ICANN (Internet Corporation for Assigned Names and Numbers) has a dispute resolution process, and has established procedures for international arbitration of rights to domain names. The several designated arbitration bodies include the WIPO (World Intellectual Property Organization). At present the ICANN is under challenge for various reasons, but the consensus seems to be that its system of dispute resolution is effective and efficient. It's been proposed to move the ICANN to the UN, and to change its structure.

There are new criminal laws in the United States and other countries. It's illegal to hack, to inject viruses and worms, to steal information from computers. But in general the law hasn't kept up with the technology. I'm told that each new safeguard against illegality on the Internet has been followed by circumvention. In the area of securities fraud, for example, I'm told that the ingenuity of malefactors is remarkable. The question is, should the public be protected against its own choice to deal on the Internet. I've heard good arguments that no control at all is better than any of the proposals thus far for policing cyberspace. But I think more control is inevitable.

If controls are inevitable, then international collaboration seems to be essential, with a unified body of law, and a unified international capability of enforcement.

III. The Laws of Intellectual Property

Ideas and their embodiments, whether technologic or artistic, are the traditional subject matter of intellectual property law, but new issues have arisen from the virtual realm.

The basic principle of intellectual property rights is that the originator of some new thing is entitled to benefit from what he or she has created. Ideas, once made known, can no longer be controlled by sole possession, but only by operation of law. These laws are intended to provide incentive for artistry, and investment in new technologies and creative products, and the growth of intellectual and industrial capital.

Intellectual property takes the legal form of patents, trademarks, copyrights, trade secrets, proprietary business information, maybe technical data. These laws are being prodded and stretched by the nature and capabilities of cyberspace.

Patents. The concept of commercial incentive through exclusive right was known to the ancient Greeks. Aristotle wrote about the practice at Sybarus, a Greek colony at the tip of Italy, 500 years B.C., where an exclusive right was granted to the inventor of a new “confection,” in exchange for disclosure. And the Venetians in the 12th century instituted a patent system, concentrated on water management systems. Galileo's patents bear a striking resemblance to those of today, in the style of their drawings and their descriptions. The history of the development of mechanics and hydraulics resides in the old English and Venetian patents, an invaluable resource as historians track cultural change and technologic advance.

The new fields of computers and electronic commerce have raised a variety of new questions. For example, twenty years ago chip makers were concerned about the ease of copying of mask works that were not protectable under either patent or copyright law as it then stood. A separate law was enacted protecting mask works, but explicitly authorizing reverse engineering—you could take the chip apart to figure out how it was made, but you couldn't then make it the same way. The reverse engineering aspect of the law resulted from the uncertainty about whether there was a right to use patented subject matter for research purposes. My court has taken a hard line, holding that there is no equivalent of “fair use” under the patent law. Some nations by law expressly authorize research use of protected subject matter. The issues are not simple, particularly when the research use is for commercial purposes.

Copyright. The Venetians also pioneered in the concept of copyright, with the result that in the 16th Century they had the most active publishing industry in Europe.

Questions of copyright in electronic commerce or data compilations have generated a good deal of heat among legal scholars, based partly on misunderstanding. There is the misunderstanding that copyright prevents use of the ideas or information contained in the thing that is copyrighted. That is incorrect. The copyright law doesn't prevent using or building on what is copyrighted, and it doesn't prevent use of the data in a compilation. It does prevent copying of the expression and presentation of the ideas and data.

The ease of electronic copying has led to a lot of litigation, for the commercial consequences can be enormous. For example, the court record in the Napster case said that single records suffered a 40 percent reduction in sales, and it was estimated that three billion songs were being downloaded per month. Napster argued that if the technology for copying was available, First Amendment freedoms protect its use. The courts didn't agree.

I thought that case was easy for judges to decide, as a matter of policy as well as law. Sometimes the cases are hard to decide, particularly on questions of what is "fair use." In a recent case, for example, a member of the Church of Scientology copied church documents to the Internet, for the purpose of discussion and criticism. The church succeeded in stopping him, on the ground of copyright infringement. It has been stated that if he had simply paraphrased or shortened the documents, he would have been protected by "fair use."

Many new issues will surely reach the courts, as the Digital Millennium Copyright Act comes into application. Circumvention is prohibited by that Act, and there are other safeguards. It's a complex law, confronting complex technologies. In the United States the Copyright Office can decide whether to grant exemptions from violation of the anti-circumvention provisions. For example, obsolete computer programs or video games are exempted, and reverse engineering is also exempted. I predict much business for lawyers.

Some critics call this Act an over-response on the part of copyright owners; they say that "piracy" has been defined too broadly and could bar activities that were always permitted, such as recompilations and sharing of copies and routine circumventions. But counterfeiting is widespread, and it is argued that rigor is necessary.

To add to the concerns, the Secretary-General of Interpol (the international police force) told our Congress last summer that terrorist groups are financing themselves with counterfeit DVDs, CDs, and software.

Trademarks, Domain Names, etc. The bad faith registration of the trademarks of others, as domain names, is presumably remediable by the Anticybersquatting Consumer Protection Act. Perhaps more interesting is the good faith use of marks that are territorially valid, but that come into conflict on the Internet, where they're no longer territorially limited.

There is also what's called "cyber piracy," by choosing a similar or misspelled name in order to divert the business. There are many examples: e.g., *WallStreetJournal*, missing an "r." This week a misspelled form of *Airfrance* was held to be a violation of the domain name rules. There is much fraudulent ingenuity. And if fraud isn't controlled, the entire institution will suffer.

IV. Data Bases

Many other property issues reach the courts, or attract the legislators. I'll close with data base compilations, the commercial collection and organization of data, for in the United States for some years we've been trying to design legislation that will meet the commercial needs of compilers and publishers of collections of data.

The latest version, introduced in Congress in October, allows public use of the collected data, but prohibits the commercial sale of a substantial part of a data compilation produced by someone else. This version dropped an earlier provision that gave the owner of the database the right to subpoena Internet service providers to find out who may have violated this law. It also excludes not-for-profit educational institutions, hyperlinking, computer programs, government databases, news reporting, and independent gathering of the same data. [H. R. 3261] There isn't much left, but it would remedy the Supreme Court case that started this concern; that case related to a telephone book, and the right to extract and resell portions of the data in the book.

I don't see this draft legislation as solving all issues, for the exceptions raise new concerns. Meanwhile, the courts are deciding disputes as they arise. A recent case concerned data that a Wisconsin municipality had collected about town property, and copyrighted. The town objected to free use of the data by real estate agents. The court held that the raw data were freely available for use, and that the copyright only protected the compilation. The issue was "fair use," an issue that has been consigned to the courts. That's where the judges come in—to decide what's fair. But

it's also necessary to have clearly stated law, so that only the close cases are in dispute. Litigation—its time and cost—is itself a deterrent to justice.

VI. Law as Social and National Policy

Today, the rapid pace of technology often takes policy issues to the courtroom. There, lawsuits must be decided whether or not the scientific knowledge is complete or conclusive, whether or not the concerned communities have reached policy consensus. When the disputed issue is based on science or technology, our Supreme Court tells the judges to apply the criteria of the scientific community in evaluating the evidence. We're told to think like scientists. Actually, that isn't so hard for judges, for habits of logical reasoning are common to law and science.

But law is not science. Law is social policy. It's also national policy, with similarities and differences among nations. As applied to the Internet, the traditional legal issues of property rights, commerce and trade, national sovereignty, and international remedy, are being examined in this new context. The old rules do not well apply, for this technology has outpaced the law.

As the law catches up, it's essential that there be full participation of you who understand these systems and their capabilities. Adversary litigation of specific disputes does not produce optimum general rules; the future shouldn't be entrusted to the judges or the lawyers. I know that many of you here are involved in these activities, and I look forward to learning from you.

Science and Society in the Internet Era

Tsuneo Nakahara

Sumitomo Electric Industries, Ltd.

I. Introduction

National science policy should be decided based largely on the government policy of each country, as the majority of funds for national research are usually provided by the government to construct the infrastructure of technologies necessary for the security, economy and education of that country.

The progress of the Internet is urging each country to form international global societies in economics and politics. The relationship between science and society is therefore gradually being changed as the Internet spreads and progresses.

A brief review will be made on the intrinsic nature of the Internet as a communication tool compared with the telephone. The future of the Internet will also be discussed from the viewpoint of computer and information technologies. Next, the role of the Internet as a coordinator of science and society will be discussed based on individual and social needs. Finally, the challenges of scientific policy will be considered for future science and global society.

II. The Intrinsic Nature of the Internet as a Communication Tool

First, the intrinsic nature of the Internet as a communication tool will be reviewed. Since the last decade of the 20th century, the majority of communication in terms of quantity has been shifted from the telephone to the Internet.

The intrinsic feature of the telephone is essentially that it is an online real-time communication tool mainly for oral conversation. The telephone has therefore mainly been used for domestic communication by the people who speak the same mother tongue. On the other hand, the intrinsic feature of the Internet is essentially that it is an offline communication tool with the function of record keeping through personal computers. This provides mitigation of time difference problems and the difficulty of communication between people who speak different languages. Demand for international communication using the Internet has rapidly increased as a result of this. Thanks to

the mass construction of long distance optical fiber communication networks, including advanced optical fiber submarine cables, service charges for international communication have been tremendously reduced. This contributes to the rapid spread of the Internet.

The concrete communication tools of the telephone era are fax, teleconferencing and so forth in addition to the telephone itself. In the Internet era there are additional tools such as e-mail, Web, IP telephone and so forth in addition to the Internet.

The discussion so far has been limited just to the range of basic communication between people. When we consider communication between people randomly sampled from around the world, the intrinsic nature of the Internet is further enhanced. It will be able to provide surprisingly innovative applications for a wide range of groups of people. Such groups can be multi-dimensionally structured in principle. For instance, they can be disciplinary societies such as those of science, technology, economics or sociology as well as congenial entities based on geography, ethnic, race, politics, religion, culture, philosophy, and so forth. The possibility for the formation of such a virtual global society may be the most significant intrinsic nature of the Internet.

From the viewpoint of computer application, there are three categories: simulation, communication and real-world system or embodiment.

Simulation started around 1960. This was essentially for stand-alone and offline use in order to allow visualized imagination by the human brain as in virtual reality. So far, the typical example has been Monte Carlo Simulation. However, the progress of computer technology is still ongoing. The recently-developed Earth Simulator in Yokohama also has revolutionary capabilities such as 40T (tera) flops vector calculation. The performance is five times as high as the conventional record holder. On April 24th 2002, the New York Times dubbed this Computenik, reflecting its status as a significant technological breakthrough comparable to Sputnik¹. In the future, we can expect even the concept of an Avogadro Computer that can simulate reaction phenomena among arbitrary atoms and particles. If a super-broadband Internet is deployed in the future, large-scale computer systems such as these may become important online real-time service providers on the network of the Internet.

Communication with the application of computers started in about 1985. This communication is essentially a network-connected, semi-real-time system for the purpose of decentralization.

¹ Sato, T., One Year Old Earth Simulator, *International Supercomputer Conference ISC2003*, Heidelberg, June 25, 2003.

Examples are the Internet including e-mail, World Wide Web, and so forth. E-commerce and E-society are typical applications. These will be presented in detail throughout this paper.

Real-world systems or embodiment will be the next application of computers in the 21st century. Real-world systems here refer to real-world-connected online real-time systems with sophisticated brain interface, advanced sensors and advanced actuators. Embodiment refers to the realization of human will and desire conceived in the human brain, and will start in 2010 according to Dr. B. Lampson². Examples we already see even today are vision, speech, smart dust and so forth. Examples of this image are network robots and cleaning robots. If a very reliable Internet is deployed in the future, this kind of real-time system will provide innovative services using the Internet. Examples of larger systems are network robot and Intelligent Network Manufacturing.

Although the present Internet system has numerous problems and disadvantages such as poor security and incomplete service quality, it is expected that rapid technical innovation will overcome these problems and disadvantages to some extent in the future. However, in order to materialize a sustainable Internet era it is indispensable to continue huge investment in research and development of various technologies not only in information technology (IT), but also in related areas such as cash flow and product flow.

In the Future Internet Era or Ubiquitous Communication Era, people can expect concepts on ubiquitous and everything on IP (Internet Protocol) or IP on everything proposed by Dr. Vint Cerf³, as well as interaction of the Internet with terrestrial digital TV broadcasting. In the future, there will be further advanced additional tools such as super wide-band image, advanced virtual reality, “man to machine”, and “machine to machine” communications associated with unlimited addresses and session initiation protocol.

III. The Role of the Internet as a Coordinator of Science and Society

At this point, a review will be made on the history of the Internet. According to journalist Scott Griffin⁴, the original concept of the Internet is widely recognized as having been given by Dr.

² Lampson, B., Computing Meets the Physical World: Rapid Changes in Computing Will Continue for the Foreseeable Future, *The Bridge*, v. 33, No.1, Spring 2003.

³ Cerf, V. G., The Internet-enabled Future, *Hearing Aid Dealers Presentation* Phoenix, AZ. Feb. 23, 2001, http://global.mci.com/us/enterprise/insight/cerfs_up/presentations/2001/

⁴ Griffin, S., Internet Pioneers, <http://www.ibiblio.org/pioneers/>

Vannevar Bush in 1945⁵. At that time, he facilitated a relationship between the federal government, the American scientific community and industry. He subsequently helped to institutionalize the relationship. As a result, organizations such as the National Science Foundation and the Advanced Research Projects Agency (ARPA) were created. It was at the ARPA that the Internet-like ARPANET first began by the contribution of J.C.R. Licklider and Dr. Larry Roberts in 1969. The ARPANET has become the Internet as worldwide defector standard by accumulating further improvements and numerous inventions: the Ethernet by Bob Metcalfe in 1973, the mouse by Douglas Englebart, TCP (Transmission Control Protocol) by Vint Cerf in 1974, hypertext by Ted Nelson who was directly inspired by the works of Vannevar Bush, interactions with the World Wide Web by Tim Berners-Lee ,and the Mosaic browser by Marc Andreessen.

It should be pointed out that the Internet was invented and developed to fulfill the role of coordinator for science and society. The social function of science is to impose missions on scientists such as serendipity, discovery, the invention and accumulation of scientific knowledge. On the other hand, a society that consists of many and various kinds of people has a duty to show a guideline for humanity and ethics, politics such as law and rules, economy, language and culture. Society must support science to fulfill its own mission. Science must also contribute to society to enable society to perform its. The Internet can help both science and society to carry out their respective missions and duties more effectively and efficiently.

In the case of science, many people all over the world now recognize that the Internet has changed the methods of science. The essential function of the Internet is dissemination and efficiency. Now competition is not possible without the Internet. An example of this is seen in the support of international conferences such as meeting arrangements, online registration, reviewing papers and edition of archives, online patent application, information services through the Web and so forth.

In the case of society, the Internet promotes revolution and reformation such as E-commerce, E-government, and information services such as health, counseling, amusement and so forth.

Since the relationship between science and society is becoming deeper and more directly connected, the role of the Internet will become more important and finally indispensable. Both the Internet system developed for science and that for society will therefore eventually be integrated and fused to each other.

⁵ Bush, V., As We May Think, *The Atlantic Monthly*; v. 176, No. 1; pp. 101-108, July, 1945.

In the 1990's, the IT bubble occurred in the countries around the United States. Many economists and industrialists advocated that the era of a new economy based on knowledge and wisdom had arrived. They insisted business models based on the Internet must have no recession, a phenomenon that never happened in the era of the old economy. However, the reality soon turned out to be entirely different. At the beginning of the 21st century, the bubble collapsed. This is reflected in the dealings and stock price trend of Amazon.com Inc, a typical dotcom company, over the last five years. The stock price has recovered recently because the company changed its business model and its business has improved. The lesson from this phenomenon is that a company such as a book retailer should carefully manage the selection and the mix of alternative channels. This is because society generally has a long time constant to change, especially when traditional customs and laws are involved.

Today, many large mature companies have been affected by worldwide recession because most companies in the borderless economy have met severe competition and have been required to restructure. However, the business structure of large companies is not so simple. It is absolutely necessary to have the Internet to know the status of the company. After understanding the company's situation, managers must plan the necessary restructuring and decide what to do and how to do it. All corporate managers realize that today's business model is not enough. They therefore give targets to each division, for instance output management, strategic alliance and intellectual property strategy to the R & D Division, production technology innovation to the Factory Process Division, M&A and global procurement to the Industrial Ingredients Division, intelligent transportation systems and E-commerce to the Distribution Division, customer satisfaction and new products to the Customer Relations Division and equity finance, global finance and investor relations to the Finance Division. People in each Division have professional know-how as intangible assets. The integration of such know-how is known as intellectual capital. Managers in every division know that the company should create better new business through innovation using intellectual capital. This is an example of interaction between the Internet and the real industrial world.

There will be another alternative to recover from worldwide recession. That is to create a large number of new high technology venture businesses. To start up a new venture business under a free economy, people with the necessary experience convene first. They collect technology, talented people and money, and then legally set up a venture business by appointing an entrepreneur. They also give stock options to investors and the people involved with the business. The target of the venture business is to achieve an IPO (Initial Public Offering) three to seven years

later. If the entrepreneur cannot achieve an IPO, he must retire or start another venture business. If he is fortunate enough to reach the IPO stage, he will receive a reasonable amount of money as capital gain. He can also pay money to the investors and those involved in starting the business.

However, at the IPO stage, the scale of the company will be small. Typically, its sales will be a few million dollars per month. To be called an industry, the sales of the company should be increased by one or two orders of magnitude. One way to become an industry is to use mergers and acquisitions (M&A) to become a big enterprise, and the other way is for the company to grow into big enterprise by itself. It should be noticed that the role of a big enterprise would be extremely important at this stage. For example, venture businesses in the field of biotechnology can make a laboratory-scale company, but usually they need large pharmaceutical companies to sell their research products to end users.

Obviously, there will be a lot of hurdles in the total process starting from invention and reaching to a reasonable scale of new industry. It is essential to use the Internet to remove such obstacles by integrating all possible wisdom.

Recently, many countries have become aware of the importance of creating new high-tech venture businesses and new industries. Governments in almost all countries are also promoting industry-university-government collaboration, networking COE's (Centers of Excellence), and clusters and science parks for regional developments. Here, a combination of socialistic planned economy and free market economy has been tried. Such a complicated relationship can be coordinated only by the use of the Internet. Generally, it is necessary to form a "platform" for the purpose of effective industry-university-government collaboration. First, the missions and goals of each partner in an industry-university-government collaboration should be considered. The mission of industry is to provide a reasonable return to the stakeholder such as stockholders, employees, related society and so forth. The mission of universities is education, fundamental research and contribution to society. The mission of government, either central or local, is to provide comprehensive security to the people and companies located in that territory. Now, the collaboration among industry, university and government with different missions from one another will be considered. The common goal of their collaboration is to proceed from invention to innovation. To pursue this goal, it is first necessary to construct a platform consisting of fused human and information networks among industry, university and government. In order to construct such a platform, industry should invest money and talented people, expecting a return of pointers on how to create new industry. The universities should supply knowledge to the platform, expecting a return of research funds and a

wider field of activity. The government should promote the platform in every possible way, expecting returns of increased employment and improved finances.

Using this platform, each project or high-tech venture business might be formed and supported by investors. Such collaboration must therefore be based mainly on the local culture of each country or region.

IV. Challenges for Future Science and Global Society

Now the relationship between science & technology and societal needs in the 20th and the 21st century will be considered.

There is currently serious discussion around the world on the role of the science. In the 20th century, most scientists thought of discovery and invention. Their top priority was to write academic papers for the creation of knowledge. Peer groups evaluated the achievements of their colleagues from this viewpoint. Their ideal return was a Nobel Prize. Meanwhile, industries confined themselves to pursuing their own businesses to obtain profits for stakeholders with maximum efficiency, independently of academic society. The relationship between industry and universities was not always close in the 20th century.

However, as global competition between industries becomes very severe in a borderless economy, government and industry in many countries strongly wish to strengthen the competitiveness of the industries of their own countries. Recently governments and taxpayers in each country have tended to expect scientists to make more contribution to society or industry. Therefore, the mission of scientists in the 21st century may be modified to include understanding intellectual property rights, to establish business know-how for industry, and even to create start-up venture business as entrepreneurs. In such cases, natural scientists should have a fusion of experience in engineering science and social science. In other words, since science may have a closer relationship with social needs and, conversely, social needs have closer relationship with industries, scientists must in the long run have closer relationship with industry.

Also in the 20th century, individual needs in a society were strong such as *livability*, physical safety and mental health. In the 21st century, societal needs such as social security, democracy, infrastructure and environmental safety will become stronger. In other words, the philosophical values of people will be changed.

Society is essentially an assembly of people looking for three fundamentals: politics, economy and science and technology. Science and technology *per se* is intrinsically universal. Therefore, the globalization of science & technology is making progress most rapidly. The only exception is that there will be some competition for military and industrial applications.

Conversely, politics is essentially nation-based. Every nation has its own constitution, laws and nationalism. However, today there are so many issues that cannot be solved by independent governments, such as anti-terrorism, environmental protection, peacekeeping operations and so forth. Many governments are involved in UN conventions and summit meetings. Even politics is becoming global today.

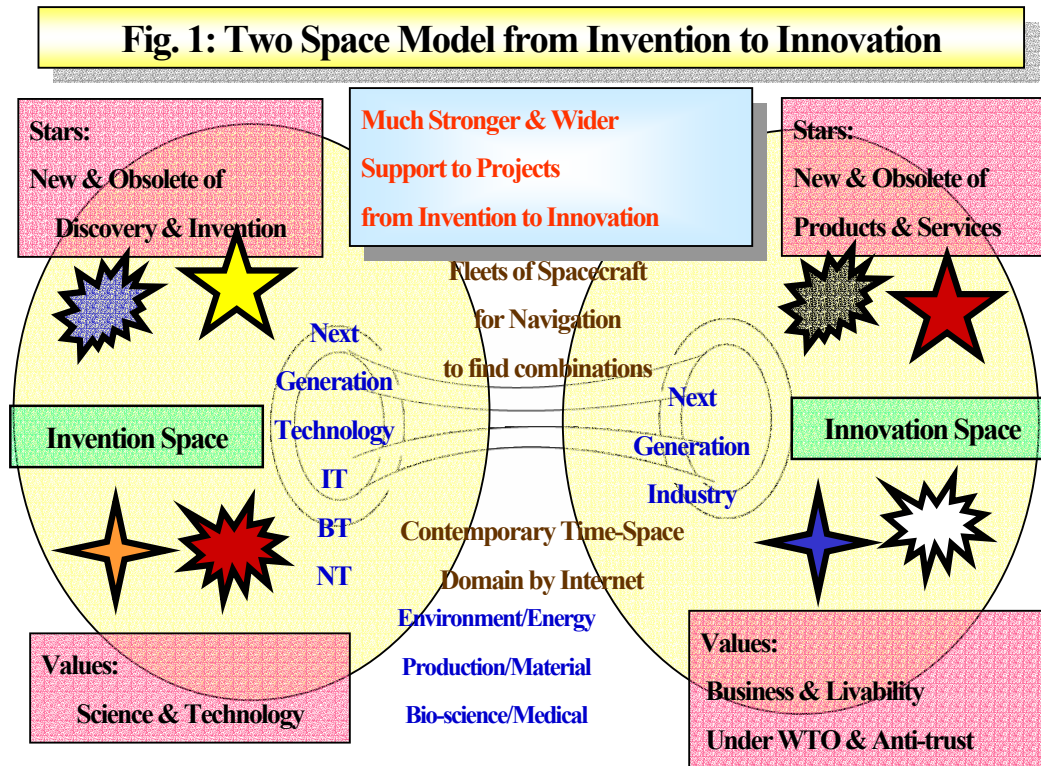
Economics lies between politics and science and technology. At present, countries are moving towards a borderless free economy. Governments are promoting the privatization of manufacturing and services. They are moving toward free competition under anti-trust laws and the rule of the WTO in a borderless market. The WTO has three missions: promotion of trade in goods, promotion of trade in services, and respect of IPR (Intellectual Property Rights). The WTO closely regulates government subsidies of its 150 members. It prohibits or marks as “red” subsidies for export promotion and import restriction. It also marks as “yellow” subsidies for research and pre-competitive development, regional development and environment protection. Yellow means that it is permissible at present and it will be decided case by case in the future. There will also be different regulations for agriculture. In the transition period, regional organizations such as the EU and ASEAN as well as bilateral FTA s (Free Trade Agreements) might appear to complement the WTO.

There are so many issues to be challenged around the world for survival and reasonable livability of human kind. Without doubt, the full use of the Internet is needed.

From a global economic perspective, sustainable growth is indispensable. And it is essential for the sustainable growth to promote invention and innovation and create new industries. It is obviously not enough just to wait for commercial globalization by multinational corporations. Science and technology policy is therefore paramount in managing the process from invention to innovation. US Congressman Dr. Vern Ehlers proposes that there is a Valley of Death between invention and innovation, and that the government should provide a bridge to cross over this valley. Professor Lewis W. Branscomb of Harvard University also proposes that there is a Darwinian Sea between the country of research and invention and the country of innovation and new business. Therefore

society should provide more risk money to high technology venture business by various methods. This might be a more realistic model for invention to innovation.

However, the real world will be much more complicated. The author proposes the two space model shown in Fig.1.



Investment into research and development around the world is increasing, resulting in a rapid increase in discovery and invention. Some old technologies are becoming obsolete. This is akin to an expanding space with a lot of created stars of invention and discovery, and disappearing stars that have lost their technical meaning. The values in this space are science and technology. On the other hand, in the global business world, there is a constant demand for new products, and global wealth is growing in addition to the increase of population. This is akin to another expanding space with a lot of created stars of new products and disappearing stars of obsolete products. The values in this space are business and livability under the rules of anti-trust and the WTO. Therefore, connecting a particular invention to a particular new product is becoming more and more difficult year by year. Fortunately, human and information networks will be available in contemporary time space domains using the Internet. Industry, scientists and governments should prepare fleets of spacecraft to navigate the stars of invention and innovation to find their suitable combinations.

In order to decide the science policy of the governments of various countries and the technological strategies of companies, a compatible philosophy of government and industry management must be established as a consensus.

The philosophy of industrial management is relatively clear. Industry should be strongly competitive in order to survive in a borderless economy. The best way would be to have only one technology in the world, make a business model from it, prepare the necessary core competencies surrounding that technology and protect them by IPR. Industry must also modestly consider strategic alliances such as mutual outsourcing and joint research and development.

To the contrary, the philosophy of government administration will be delicate because national interests usually conflict with global interests. The compromised government mission will be to give comprehensive security to the people and companies within its geographical territory regardless of nationality. To do this domestically, governments should enhance investment in infrastructure, R&D and high technology venture business creation. Internationally, governments should promote cooperation in fundamental research, environmental protection, energy problems and so forth.

In addition, for sustainable growth through the WTO, industry should take responsibility autonomously to create new industry and establish ethics and codes of conduct. Government should also assume responsibility autonomously to take strong action against terrorism and moral hazards, and establish internationally harmonized laws and associated codes of conduct.

The philosophy of the academy or scientists should be that, although the mission of scientists is to pursue fundamental research, discovery, invention, and building knowledge systems, academic society should give technology transfer, consultation, professional education and advice to industry and provide information on emerging knowledge, public education and advice of reasonable policy to government.

In conclusion, for the sustainable growth of global society, science in the 21st century should be moved to a new philosophy emphasizing interaction with human society. Society in the 21st century will be much more globalized and timely global harmonization will become indispensable by fully utilizing the advanced Internet.

Additional References

Nakahara, T., Technology Strategy in a Borderless Economy, *Int. J. Technology Management*, v. 17, No.6, pp.711-724.

Nakahara, T., Innovation Management Using Intellectual Capital, *Int. J. Entrepreneurship and Innovation Management*, v.1, No.1, pp. 96-110.

Nakahara, T., Invention to Innovation in Global Borderless Society, Keynote Speech at *The 8th Asia-Pacific Science and Technology Management Seminar*, Songdo Beach Hotel, Incheon, Republic of Korea, March 10, 2003

Internet: Bridging the Gap between Science and Society

Zhiqiang Wang

Department of Policy and Regulations

China Meteorological Administration

I'm very pleased to have the opportunity to participate in this conference. The biggest reason for being here is that I like the theme in the discussion. It is important and interesting in the sense of the pulsing of whole society, and to a great extent, is challenging human reasoning and thinking.

The second reason for being here is due to Honolulu, an exciting city for this fantastic conference. The beauty of surroundings is even better than what I had expected. And, of course, I appreciate very much this opportunity to be able to communicate and discuss with so many international colleagues.

Therefore, thank to NSF, JSPS, and NSFC for organizing this important conference in right place and for inviting me to give this presentation.

The topic of this conference, "Science, Society and Internet" covers a broad range of issues related to science, technology and ethics as well as inter-relations among them.

Ten years ago, the time when Mosaic was just invented, not many people including most Chinese knew much about the Internet. Nowadays, however, the Internet is deeply penetrating into our daily life. In China, for example, right before I came here, the second International Conference of Internet was held in Beijing, which is regarded as the highest level of Internet conferences that ever held in the country. The title of the conference was "Introspect the Internet, Entering the New Era". One thing I learned is that in China today the total number of online computers has reached approximately 30 million, and there are likely to be approximately 78 million Internet users by the end of the year. It is amazing if you compare the figures from five years ago. The influence of Internet diffusion on society is obviously wide in a number of aspects.

First of all, the communication among ordinary people becomes so much easier and quicker. Even students in middle and high school have now started to use email to keep in touch. Second, the exchange of information, especially scientific reports, becomes much more straightforward.

This has resulted in enormous national and international cooperation which may not be possible ever before.

Third, the Internet provides a novel channel for modern education. Long-distance learning, for example, creates a chance for countryside dwellers to have access to the lessons which are offered far away. Another interesting example is that, earlier this year, when the notorious disease SARS was at large, most of the pupils and students in Beijing obtained regular instruction from their teachers via the Internet.

Nevertheless, the impacts of the Internet can be both positive and negative. On the one hand, it offers society greater efficiency. On the other hand, it has diminished some cultural assets. For example, handwriting has mostly been replaced with typing. In terms of the way of communication, e-mail has become predominate. It is simple and fast but may not be treated as equally important as a conventional letter. And of course cyber crime cannot be ignored. In this aspect, the ethics of scientific research is challenging. The issue I would like to discuss today is in what way of utilization the Internet is affecting the society. In other words, what is the best way to regularize Internet users' behavior through rational legislation or other means in order to facilitate development of the Internet in a positive direction? Being a staff member at the China Meteorological Administration, I would like to share some information relevant to my point.

Conventionally, weather forecasting was released via radio, newspapers, and TV. As the electronic network emerged as an extremely efficient way in transferring data, we have tried to apply it in the weather forecasting system intensively. Today, detailed weather information is reported online on diverse websites. A variety of satellite weather information such as cloud pictures can now be screened and used interactively on these websites, while TV only conveys limited information.

As a crucial source of information, we have set up our net-service tailored to users with different demands. What we have tried is to optimize the websites more specifically for users working in power stations, reservoirs, grain depots, salt industries, airports or forestry centers, for example. Just by logging with their own passwords they can get comprehensive, up-to-minute meteorological information.

We are also active in trying to develop good cooperation between the meteorological sectors and Internet providers. We provide weather information which can be shown on the Internet; of course attracts the public's attention. And because of this information, the web page producers can

benefit by putting up more advertisements. The profit they gain should be reasonably shared with the information producers. And this source of funds can be used for advancing techniques, which, in turn, brings better meteorological service.

As an individual, I have often felt thankful towards Internet. Because of it, I can sit in my office in Beijing, and still have the access to the weather information for other cities in the world. The Internet is having profound effects on all social aspects, e.g. it connects human being with science, science with society, science with technology, and science with ethics. These connections are both concrete and abstract, both emotional and rational.

If there would be a chance to hold a conference in Beijing on topics we are considering here in Honolulu, my suggested title would be: Science, Internet and Society. "SIS" for short. "I" in the middle stands for the sense of bridging. If you do agree to this sense, please be willing to attend it. And hopefully, I will be honored to be the toastmaster for the working dinner like this one today.

Thank you.

Trilateral Seminar on Science, Society and the Internet

Section IIB: Scientific Collaboration via the Internet Plenary Session I

<i>International Scientific Cooperation and the Internet in China,</i> Fan Chunliang.....	47
<i>Activating a Scientific Collaboration Reflecting Cultured and Social Originality,</i> Masao Sakauchi	57
<i>International Collaborative Science on the Net, Gary Olson, et. al.</i>	65
<i>Discussion</i>	79

International Scientific Cooperation and Internet in China

Fan Chunliang
Institute of Policy and Management
Chinese Academy of Sciences

I. The Development of the Internet in China

Digital information technologies in China were first initiated in the 1980s, and developed rapidly in the 1990s.

Since 1994 when China formally connected with the International Internet Network, the development of the Chinese Internet has made considerable progress. According to the survey made by Chinese Interconnection Network Information Center (CINIC), up to June 31, 2003 the number of nationwide Internet users reached 68 million, as compared with the number of the Internet users reaching 620,000 as the results of the first survey in October 1997. That is, the number of the current Internet users is over a hundred times that of the first survey.

The number of computers connected with by June 31, 2003 Internet reached 25.72 million, that is 105 times the 49,000 of the results of the first survey in October 1997. Among users, students account for the largest number, reaching 30.1 percent of the total; specialized technical personnel come next, accounting for 15.9 percent; other significant users are commercial and service personnel (9.1 percent) and office workers and other assistant personnel (9 percent)¹. It is obvious that the increase in the total number of Chinese Internet users is very rapid in the short period of six or seven years. According to another survey, up to June 30, 2001, Chinese websites can be classified into the following categories based on the nature of the principal part of the operation: (1) enterprise websites account for 77.8 percent of the total; (2) government websites account for 8.6 percent; (3) commercial websites account for 5.4 percent; (4) education and scientific research institution websites account for 3.3 percent².

¹ Chinese Interconnection Network Information Center: *Statistical Report on Chinese Internet Development Status 2003 / 7* .

² Chinese Interconnection Network Information Resource Quantity Surveying Group: *Report on Chinese Interconnection Network Information Resource Quantity Surveying* July 2001.

The Internet has brought great changes in the life of the Chinese people in terms of communication, information dissemination, modes of commerce, styles of learning, recreation, and friends-making. From the survey on the individual users, it can be ascertained that the purposes of using the Internet are: obtaining information (46.9 percent), leisure and recreation (28.6 percent), friend-making (7.5 percent), learning (7.2 percent), external communication and liaison (3.2 percent). Additionally, 40.7 percent of the Internet users have had the experience of buying goods or services through the purchase (shopping) network stations (including network markets, network shops) in the last year³.

Since 1999, the construction of websites at various levels of the Chinese government has been developed rapidly. The main services offered by the governmental websites are function/ professional work introduction, government notices/laws and regulations, and guides for handling affairs. Updating news and statistical data on governmental websites is relatively quick. Enterprise websites have developed rapidly with strong support by government, and their number had reached nearly 190,000 by June 31, 2001. The services offered by enterprise website are primarily focused on enterprise introduction and products/service introduction and, additionally, enterprise and news about various trades. The update of news about various trades, recruitment information and enterprise' on-going activities information is relatively rapid.

It is worth noting that remote education based on the Internet is also a significant application. Several universities and colleges in China have set up network (web) courses, even educational qualification education. It is estimated that the number of graduates receiving training by means of network courses in various fields has reached millions. In addition, the applications of network communities, network medical treatments, network survey, network human resource management and so on have been also newly developed.

II. Scientific Development and the Internet

The development of Chinese Internet has provided opportunities and motivation for the country's science and technology development. The earliest Internet connection in China was introduced by the scientific community. In 1988, the Institute of High Energy Physics (IHEP) in the Chinese Academy of Sciences first achieved electronic mail correspondence with Europe and North America by means of dial up connections.

3. Chinese Interconnection Network Information Center: *Statistical Report on Chinese Internet Development Status 2003 / 7*.

In March of 1993, the institute directly connected with the Stanford Linear Accelerator Center at Stanford University (SLAC) in the United States by means of a special data link, and this was the first connection in China with the international Internet network. In the initial stage of opening this special line, there was only a DECNet agreement, and the connection was not yet able to realize the whole function of the Internet. After the opening of the special line, the National Natural Science Foundation of China (NSFC) energetically coordinated this work and made an investment of 300,000 yuan (RMB), thus enabling the leaders of the major projects of various disciplines to dial and connect with this special line of the IHEP. So, several hundred scientists became the first Internet users in China. In May 1994, China achieved the whole function connection with the international Internet.

The successful connection to the international Internet enables the Chinese scientific community to maintain contact with the most recent advance of world science in a more convenient and quicker way. Global scientific knowledge and information available on the Internet, especially various kinds of important databases, promptly aroused the attention of Chinese scientists and offered opportunities for them to keep up with the most recent world scientific development. At the same time, the Internet also creates new opportunities of scientific research and communication for the Chinese scientists.

Access to scientific data. The development of computer and communication technology and the integration of computers with the network enable the dissemination and utilization of information to transcend time and space restrictions, and has made it a very important sharable resource for promoting scientific development.

The rapid development of information and communication technology has increasingly speeded up the processing of a large amount of data and information, whereas the unit costs used for interpreting and retransmitting data storage, filtration, processing, compression and retrieval continue to decline. So the speed of creating and renewing large database increases. At the same time, the development of the Internet has made it possible for scientists from other parts of the world to access these databases more conveniently. This not only promotes the development of a certain number of important scientific fields (such as biology, astronomy and the geosciences), but also offers new collaboration opportunities for scientists of various countries. Important databases such as GenBank have become the main information

resources between biologists, which enable them to conduct research that would have been unimaginable before the appearance of computer.

The rapid development of Bioinformatics in China since the 1990s demonstrates the important influence of the Internet on Chinese science development. One excellent example is the work of Professor Hao Bolin at the Institute of Theoretical Physics in the CAS. Originally, Professor Hao was a theoretical physicist, and an authoritative figure in the field of nonequilibrium statistical physics in China, and now he is a specialist in bioinformatics. Recently he participated in designing a framework for China's Paddy Genomic Project. In his lectures and articles, he mentioned many times that the information resource of Internet had exerted an important role on bioinformatics research in China, and emphasized its significance again and again. According to Prof. Hao's recollections, "as early as 1985, when the research work on non-linear science and complexity was 'hot,' I participated in an enlarged meeting on Chinese Biology Development Strategy which was held by Division of Biology of the CAS. Hereafter, I began to think about this issue and prepared to march strategically towards more non-linear, and more complicated biological system. Since 1991 the research group to which I belong has continuously studied basic knowledge of biology, therefore, I myself purchased a number of books in the original English versions. In 1994, as soon as the local network of the Institute of Theoretical Physics was successfully connected with international Internet, the biological resource on the network caught my eyes and became a object for attention."⁴

Since the 1990s when he entered this field, Professor Hao became one of the advocators of Chinese Bioinformatics to which he has made many contributions. He has also made great contribution in establishing the Chinese Bioinformation Center. Since the 1990s, the development of bioinformatics has attracted many Chinese biologists, computer specialists, even mathematicians and physicists to join, thus greatly promoting the development of this field in China.

Collaborative Networks. The Internet has improved the mode of communication between scientists, which not only has greatly increased the quantity, quality and rate of communication, but also brought profound influence on the organization of scientific research.

4. Hao Bolin: "Short Views Should Be Strictly Avoided towards Basic Research," *Guangming Daily*, May 24, 2002

The first effect of improved communication has been an increase in the size of professional networks. As in many countries, the use of e-mail for exchange new ideas has increased and the “virtual” groups connected by specific e-mail list have evolved since the mid-1990s. The existence of such groups has stimulated the formation of various kinds of research networks on Internet. Some of these collaborative networks came into being around some important areas in universities and research institutes supported formally by funding organizations. Their function is to disseminate and evaluate new ideas.

One of the well known collaborative networks in China is the Virtual Research Center on Science of Complexity at Peking University. There is only one permanent secretary, and two concurrent directors. The Center connects with nearly a hundred specialists in the field of complexity research and related area in China by e-mail to disseminate and communicate new ideas, and the Center’ website has been linked with the related research fields, specialists, foundation organizations and related website all over the world, continuously renewing news about on-going research activities .

Scientific Research Platform and Infrastructure. Since the 1990s, the integration of computer with Internet technology has promoted the construction of scientific research environments (i.e., Scientific research platforms and installations). With the advance of Internet technology, China’s largest scientific database (Scientific Database and Its Information System at CAS initially established in 1982), has rapidly developed since the 1990s. Now the Scientific Database has 21 specialty-established units, and 126 specialty databank, with total data up to 560 billion bytes (560G). The Database through the Chinese Science and Technology Net provides services to both internal and foreign users, There are also 15 concentrated and distributed websites on Chinese Science and Technology Net, 100 specialty databanks logging on the net, with amount of data about 200 billion bytes (200GB). In the Database, the scientific and technical information service system is formed by the central site and several mutually independent local and foreign (nonlocal) specialty, dispersed databank subsites⁵. In company with the formal startup of “the informatization construction of Zhongguancun Science and Technology Park,” the network will be reformed based on the Chinese Science Technology Net as a part of the project, and a high-speed optical fiber network of 100 Mbps will be built up in the Zhongguancun area. No doubt the further construction and development of the Chinese Science and

⁵ Li Wangping, et al.: *General Considerations of the Scientific Research Environment Construction Based on Scientific Database*

Technology Net will create a superior network environment for the Scientific Database as an important scientific and technical information resource.

III. International Scientific Cooperation and Internet

International Scientific Cooperation in China. During the past 10 years, international science cooperation involving China has made a great progress. It has also made a great contribution to basic research in China.

Since the mid-1990s, the Chinese international scientific cooperation has grown rapidly. During the five-year period of 1994-1998, the number of the international cooperative papers produced by Chinese collaboration with 33 countries and areas had increased 20.1 percent every year. The increase of international cooperative papers was the most outstanding in 1998, which was 2.1 times that of 1994.⁶ Among the Chinese scientific papers included in Science Citation Index (SCI) in 2001, there were 8,500 papers produced from international cooperation, accounting for 23.8 percent of the total papers, with an increase of 1462 over the number in 2000, and with an increase of 2163 over the number in 1999. Of the total of the 8500 Chinese papers, there were 3696 international collaborative papers with Chinese authors as the first author, and the copartners involved 55 countries and areas. There were 4804 international collaborative papers with authors from other countries as the first authors and with Chinese authors as the participants, and the copartners involved 81 countries and areas.

The development of international cooperation has made great contribution to the Chinese science undertakings, as shown in the following several aspects:

International Cooperation Has Speeded up a Number of Big Science Projects and Programs, and Raised the Level of Basic Research. China is quit active in international cooperation in big science fields. The construction of experimental facilities such as the Beijing Electron-Positron Collider (BEPC), Lanzhou Heavy Ion Accelerator (LHIA), Hefei Synchrotron Radiation Accelerator, was carried cooperation with the United States, Germany, Japan, France and the United Kingdom and other countries. Additionally, in the operation of these experimental facilities, international communication and cooperation have been very active. The Research

⁶ Liu Yun and Chang Qing: The Scientific Measurement and Determination and Appraisal of International Cooperation on Chinese Basic Research, *Management Science Transaction*, Vol. 4, No.1 (February 2001)

Laboratories at Beijing Electron-Positron Collider have carried out wide cooperation with various developed countries, especially the five leading National Laboratories and some famous universities in the United States. By using these science facilities, Chinese scientists have procured a number of international first-class scientific research achievements such as the precision measurement of the τ lepton mass, and the synthesis of new nuclides (the synthesis of six kinds of neutron-rich new nuclides, such as platinum-202).

A Number of High-quality and Influential Research Achievements Have Been Obtained through International Cooperation. Some important, large-scale cooperative research projects on resources and the environment, such as the Sino-British Qinghai-Tibetan Plateau expedition, the Sino-German glacier expedition, and the Sino-Japanese desertification prevention and control project, have produced substantial achievements. At the same time, many Chinese scientists have obtained a number of high-quality research results through international cooperation.

International Cooperation Has Promoted the Development of New Disciplines and Cross-disciplines. There are many examples indicating that the growth of new disciplines and cross-disciplines was stimulated by understanding related major breakthroughs and progress in time through international communication and cooperation in the research of related new disciplines and across disciplines.

International Cooperation Facilitates the Fostering of Young Talent. International communication and cooperation is very important to development of young scientific and technological talent. It can make young scientists directly involved in the day-to-day progress of world science by taking part in international exchange and cooperation as early as possible, so as to promote their academic level and innovative ability.

While promoting Chinese science development through international communication and cooperation, some research works internally developed in China has also begun to blend into the global scientific network. China's research on global change has been brought into international research program on global change, China's Continental Drilling Program been integrated into the International Continental Drilling Program (ICDP), and China's Ecological Network System has become a constituent part of the global resource and environment monitoring net. In the field of life science, China's research on the Human Genome has broad cooperation with international scientific community. China's research on the Paddy Genome Project has also set up

cooperative relationship with scientists from the United Kingdom, the United States and other countries.

International Scientific Cooperation Based on the Internet. To a great extent, it can be said that the birth and development of the Internet resulted from the internal needs of scientific communication and sharing, and in turn the development of the Internet has greatly promoted scientific communication, sharing and cooperation, which transcends time and space restrictions, thus greatly promoting international scientific communication and cooperation. As mentioned above, the first special line to be connected with the International Internet in China was introduced by the Institute of high energy physics (IHEP) where the Beijing Electron-Positron Collider is located. Similarly, the introduction and development of the Internet in China greatly promoted Chinese international scientific cooperation. In the past few years, international communication and cooperation based on the Internet has made great progress has been highly valued and regarded by scientific community and related organizations.

Construction of Virtual Research Centers. The Internet is an enormous resource pool and a very good tool for communication. If the different elements of scientific research which can be electronized and networked are organically integrated together, a virtual research environment based on the Internet can be established, offering a platform of resource sharing and cooperative research for scientific research personnel, which is the so-called virtual research center.

During recent years, under the support of related Chinese government departments and funding organization, some virtual research centers have been established around some important disciplines and technological fields (for example, machine manufacturing, parallel computation and chemical metallurgy) at some universities and research institutes. One of the functions of these research centers is to supply related research personnel with various levels of information exchange and resource sharing through the integration of the research resources of its own field and construction of a scientific research conference system. Another function is to establish a platform capable of being used for cooperative research on the Internet by setting up virtual research means, virtual cooperation environments and virtual cooperation instruments, according to the characteristics of the relevant disciplines. Generally, the virtual research centers are open to colleagues both in China and

abroad for communication and cooperation. Some of them have carried out successfully international cooperative research.

A good example is the Advanced Manufacture Virtual Research Center at Huazhong Polytechnic University. Its basic members are the related research bases in China and abroad and member units are large, medium and small manufacturing enterprises in China. The virtual centers issue information about research projects, on-going activities, applications for jobs on the website, and the enterprises feedback problems encountered in practical conditions to the virtual center. The center seeks help and cooperation from related research institutions throughout the world scale through the Internet. Since the start, the cooperative platform on the Internet has been preliminarily established, and, such virtual research means as long-distance process, telemonitoring, and coordinated design have been built up, and some cooperation projects on the Internet have been also started up, some of which are international cooperative projects.

International Cooperation with the High-speed Network. The construction of the Chinese high-speed interconnect research and experiment network (NSFCnet), has opened up a wider space for Chinese international science and technology cooperation. The building of the NSFCnet started at the end of 1999 under the support by the National Natural Science Foundation in China (NSFC), and finished in July 2001.⁷ It is the test bed of the next-generation Internet in China. NSFCnet has connected network nodes of units such as Tsinghua University, Peking University, Beijing Post and Telecommunication University, Beijing Aviation and Aerospace University, the Computer Information Network Center at CAS, and NSFC, and has connected the Chinese Education and Scientific Research Computer Network, and Chinese Science and Technology Computer Network. Through the first next-generation Internet switching center independently developed in China by Tsinghua University, NSFCnet has connected with the international next-generation Internet switching center and the Asian-Pacific area high-speed net switching center, and has completed the interconnection of the international next-generation interconnection backbone net, thus establishing basic conditions for China's next-generation Internet research connecting with the world.

⁷NSFC: Proceedings of Development Strategy Discussion and Achievements Exchange in International Cooperation with respect to Science Foundation , 2002

The NSFCnet has established a scientific computation environment integrating high-speed interconnection network, scientific database and high performance computer, which have created the necessary conditions for China to carry out wider international scientific cooperation. In the aspect of real-time video transmission, Tsinghua University and Beijing Aviation and Aerospace University have achieved intercommunication with the access grid system of America's Argonne National Laboratory through Internet-2, thus establishing stable contact with more than 50 universities and research institutions including AG project teams.

By use of the Admire system, Tsinghua University and Beijing Aviation and Aerospace University participated in the International Conference on Global High-Performance Computation and Communication during November 10-16, 2001, which was the first large-scale international conference held on the on the global next-generation Internet. In the aspect of high speed scientific databases, Chinese biology database image point under the high-speed network environment has been established, enabling Chinese scientists engaging in new drug design and algorithm research to obtain up-to-date sequence information from the International Nucleic Acid Sequence Database without paying international network communication charges. Owing to the establishment of a full-text search mechanism aiming at GENBANK database, Chinese scientists can make full-text retrieval of international nucleic acid sequence database through high-speed network. Similarly, the research on solar activity prediction based on astronomy databases has also made great progress. Under the high-speed network environment, the Huairou Solar Observation Station at the Beijing Observatory, the Great Bear Lake Observatory in the United States, the Yunnan Observatory, and the Canlari Island Observatory Observation Station in Spain, have formed a global solar chromosphere observation network, so the data sharing can be realized. Using this favorable condition, Chinese astronomers made nine successful predictions in the 16 predictions of solar proton events, carried out in 2000, so the successful rate nearly doubles that obtained by international colleagues.

Activating Scientific Collaboration Reflecting Cultural and Social Originality

Masao Sakauchi

National Institute of Informatics and University of Tokyo

I. Introduction

The rapid growth of the Internet, especially broadband Internet, gives us a significant chance to activate scientific or academic collaborations via communication-based environments.

At the same time, the necessity of adequate collaboration itself becomes larger and larger under so-called globalization. In this presentation, several important viewpoints are discussed when we try to activate scientific and/or academic collaboration in information technology (IT) fields.

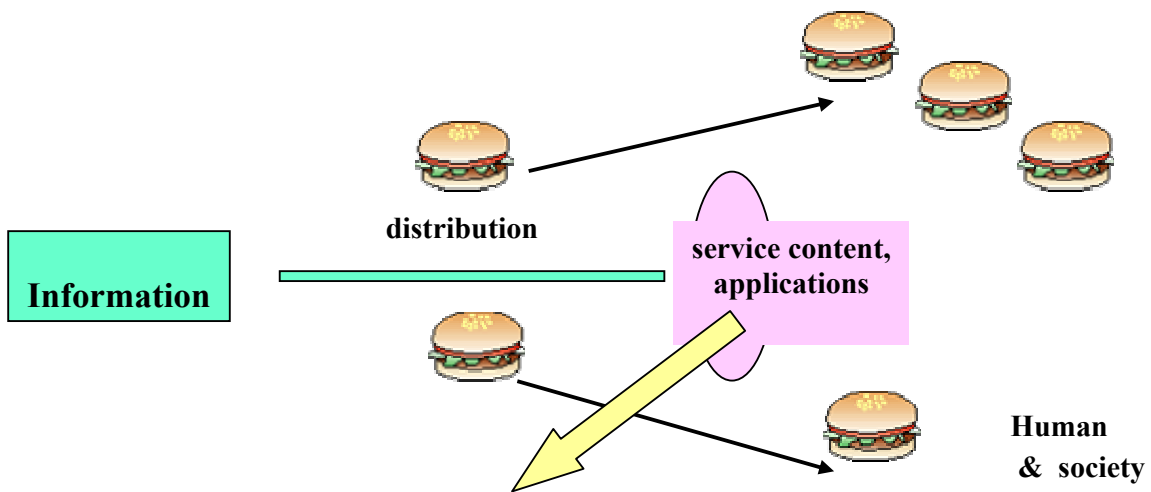
First, the importance of the realization of rich content and adequate setting of targets and missions will be pointed out. Then global collaboration reflecting cultural and social originality is proposed to satisfy these two points. A few concrete examples of the author's research group will also be introduced.

II. Important Directions of IT Research and Targets of Global Collaboration.

Before considering how to activate scientific and/or academic collaboration in the IT field, let's discuss two important background points regarding important directions to activate IT research itself and targets and missions of global collaboration.

Realization of Rich Content and Rich Service on the Internet. During the last decade, we have experienced the so-called IT boom followed by the so-called IT bubble collapse. I believe this history taught us a valuable lesson. The most important lesson learned is whether or not IT enables us to create new real value for humans and society. This can be expressed by analogical keyword "From 'Hamburger World' to 'Roppongi World'". In other words, "From 'poor contents' to 'rich contents' on the Internet".

Fig.1. shows the previous situations of the contents/services on the Internet. Let's call this 'Hamburger World'. Poor content or service (Hamburger content), i.e. mono cultural, fast food type content/service is provided to humans and society through communication tools.



Hamburger contents

mono cultural
 fast food type service
 Encyclopedic information,
 commercials/PR

Fig. 1 . Hamburger (Poor Content) World!

Fig.2. shows the Roppongi World. As you know, Roppongi is the liveliest spots in Tokyo. We can enjoy a variety of specialty restaurants from all over the world. People gather in Roppongi in order to enjoy multicultural, consumer satisfaction based, sophisticated services by these specialty restaurants. Such rich content/services should be realized hereafter on the Internet.

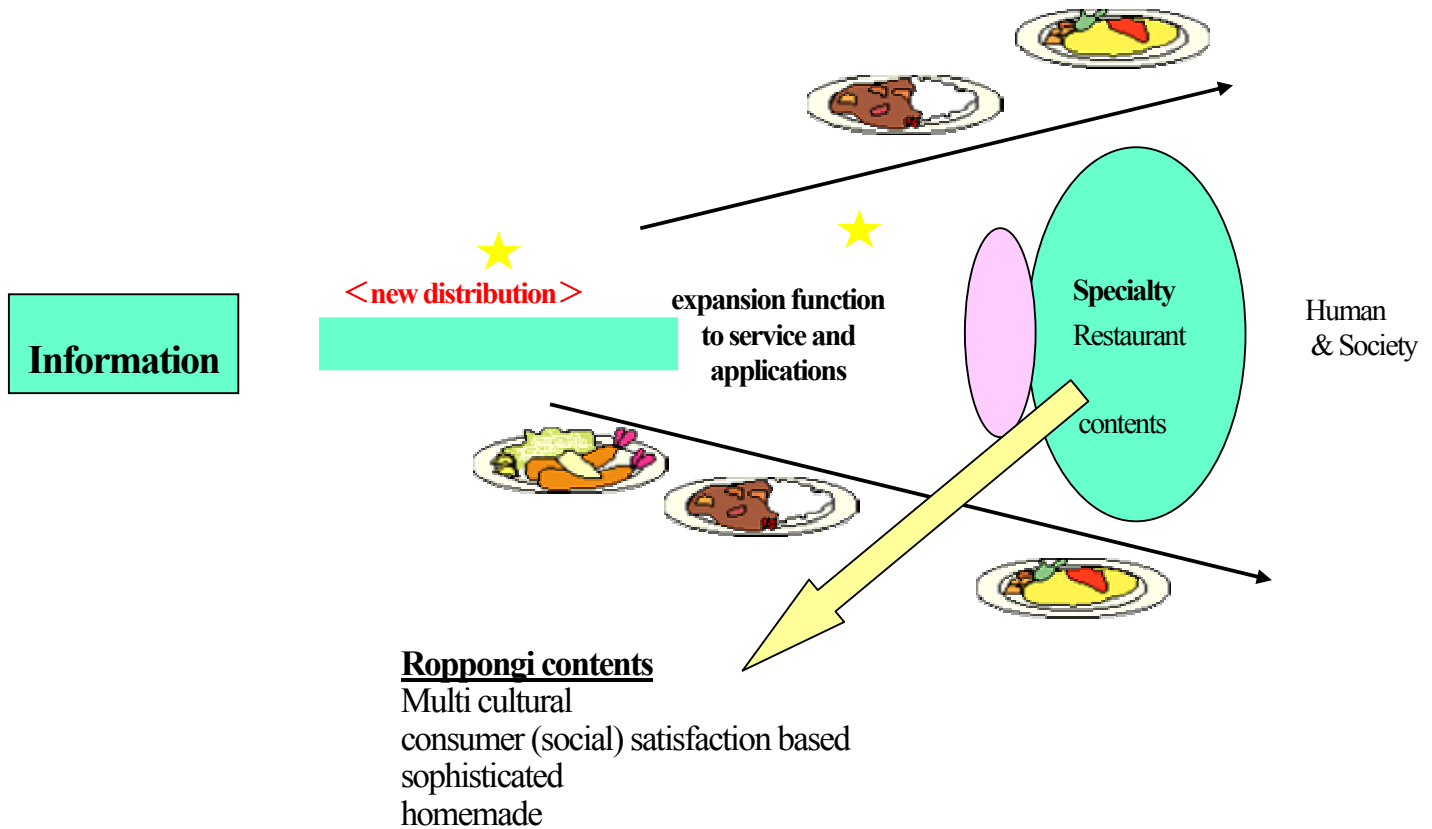


Fig.2. Roppongi (Rich Content) World!

IT Research Trends Required. To realize this Roppongi World on the Internet, new directions or trends for IT research and development (R&D) will be required. Three of the more significant points are emphasized in what follows:

- 1) *Develop IT technologies which provide the functions creating rich content, service and applications.* IT R&D so far have been too much focused on providing infrastructure. Hereafter, however, such mediation systems (corresponding to expansion function's in Fig.2) for customer (or social) satisfaction-based services should be developed.

2) *Tie-up with proposals of 'what to do' (real value creation) for humans and society.* To realize this, IT research hereafter should be fused with the art of individual application fields.

3) *Develop new processing methods for several emerging IT environments.* These includes video or multimedia recognition or understanding techniques, large scale information space on the network, and ubiquitous environments, for example

Adequate Target Setting in IT Research and Global Collaboration. In order to realize real value for humans and society, we have to clarify 21st Century social value targets. Needless to say, these targets, or values, should be determined after many discussions. However, in my opinion one set of candidates is shown in Fig.3: happiness of humans and society from the view points of heart, life and social platform should be targets.

New value creation in the fields of individuality and originality; culture and education; warmth, kindness and connection of people; and comfort and entertainment, could be concrete targets from the heart viewpoint.

New value creation in the field of food; health and life; welfare and employment could be concrete targets from the life viewpoint.

Finally, new value creation in the fields of transportation; social security and safety; disaster mitigation; environment; energy; new economy, new logistics and new community could be concrete targets from the social platform view point.

IT R&D have the potential to realize new real values in every field of these targets. Therefore, new IT technologies to extract value should be research targets.

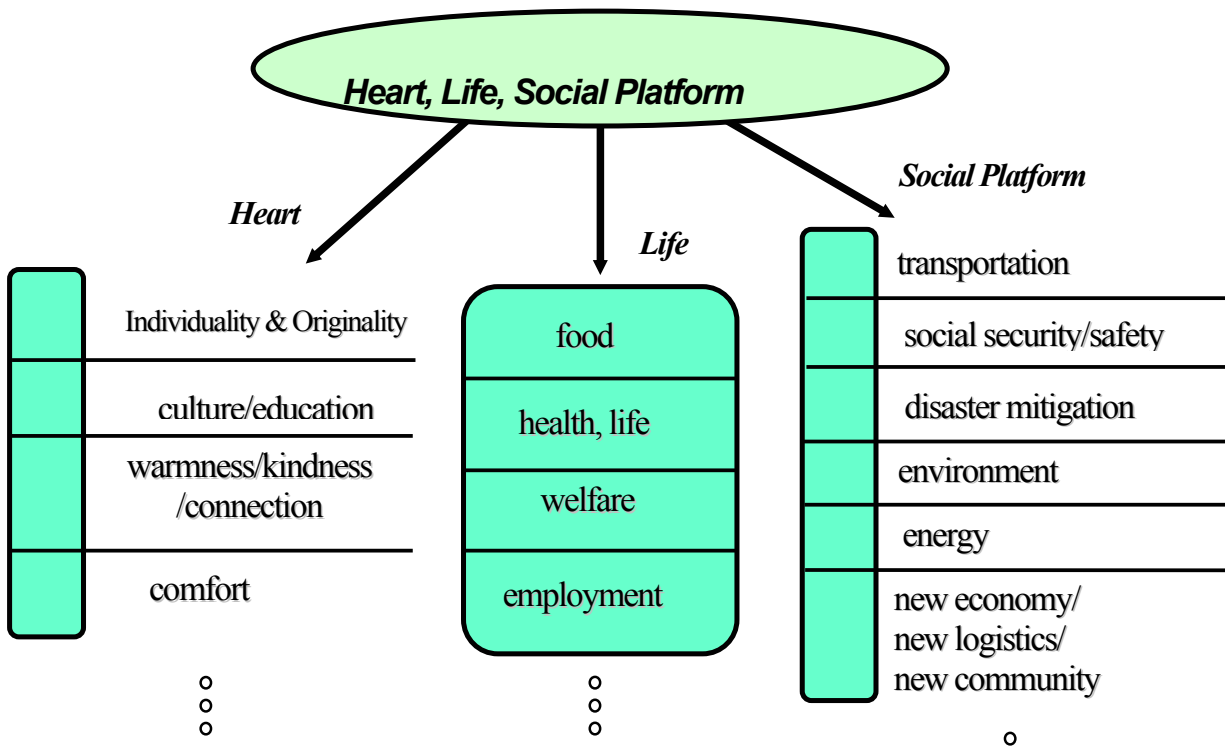


Fig.3 Social Targets in the 21st Century: Happiness of Humans and Society

III. Global Collaboration in IT Fields

Before discussing what the future of global scientific and /or academic collaboration should be, let's remind ourselves about the role or mission of scientific (or academic) research itself.

Although I understand there may be various opinions, I'd like to emphasize the following two basic points:

1) The most important role or mission of scientific and/or academic research is to create intellectual value for the next generation of humans and society.

2) Academic research, especially, should maintain independence from money, political power, and religions power, for example.

These points may be too ideal, but surely we should make our best efforts to realize them.

In view of these considerations, I'd like to emphasize the importance of global collaboration reflecting cultural and social originality.

In order to realize the Roppongi world (rich content and service) on the Internet through global collaboration, the most important point may be to reflect cultural and social diversity. Participant countries or parties should contribute to joint research so as to reflect a good future for society and culture.

To establish such type of scientific research collaboration, ways must be devised for appropriate target setting the selection of IT fields. The following three examples based on current work of my research group provide suggestions for such scientific research collaboration.

ITS, Especially Traffic Accident Casualties Reduction. Approximately 300,000 people are killed and 30,000,000 injured by traffic accidents in the world every year. To realize drastic reductions in these casualties, novel technology should be developed in the field of real time accident detection, prediction, and prevention. Collaboration towards these goals would be an appropriate research theme.

Digital Archives of Cultural Assets. Digital archive can be a powerful tool for every country to prevent the destruction or loss of variable cultural assets in every country. Currently, however, the appropriate technology is insufficiently mature. Let's collaborate to realize common powerful tools for archiving and restoring cultural assets.

Realization of Virtual Scientific Research Environments by Grid Computing. Developing powerful infrastructures for research collaboration itself also would also be an appropriate target for global research collaboration. Grid computing, especially, may be the most easily understood because it aims to give a collaboration tools for computing power, database, or human resources, through broadband networks.

(NB: in my presentation at the Honolulu seminar, my group's approaches to these three targets were introduced with video demonstrations.)

IV. Conclusion

In this presentation, several important viewpoints for global scientific (or academic) research collaboration in IT field were pointed, with examples provided in terms of concrete research problems. I hope this discussion can help stimulate activate global collaboration, especially among the United States, China and Japan.

International Collaborative Science on the Net*

Gary M. Olson, Judith S. Olson, Nathan Bos, and the SOC** Data Team

School of Information

University of Michigan

Science has long been a collaborative enterprise. But as the unsolved problems become more complex, the need for expensive instrumentation increases, and larger data sets are required, the character and complexity of collaborations is increasing. New computational and communication tools today offer more options for collaborators to work together flexibly. The result of this has been the emergence of a new organizational form called a Collaboratory.¹ A collaboratory is:

. . .an organizational entity that spans distance, supports rich and recurring human interaction oriented to a common research area, and provides access to data sources, artifacts and tools required to accomplish research tasks.²

We will later examine this definition in more detail, and describe a taxonomy based on it.

The international dimensions of collaboratories are especially important as they grow in size and number. As Olson and Olson have pointed out, long distance collaborations that span international boundaries present many challenges³. As reported in more detail there, we have seen such problems as cultural misunderstandings, lack of common ground, and large time zone differences all affecting such collaborations. These can all be managed or overcome, but they definitely present special challenges.

* This research was supported by the National Science Foundation grant IIS-0085951.

** The Science of Collaboratories (SOC) is a large project based at the University of Michigan.

¹ Wulf, W.A., The Collaboratory Opportunity, *Science*, **261**, 854-855, 1993; Finholt, T.A., and Olson, G.M., From Laboratories to Collaboratories: a New Organizational Form for Scientific Collaboration. *Psychological Science*, **8**, 28-36, 1997; Teasley, S., and Wolinsky, S., Scientific Collaborations at a Distance. *Science*, **292**, 2254-2255, 2001; Finholt, T.A., Collaboratories, in B. Cronin (Ed.), *Annual Review of Information Science and Technology*. Vol 36. Washington, DC: American Society for Information Science and Technology, 2002 and Olson, G.M. (in press). Collaboratories. In W.S. Bainbridge (Ed.), *Encyclopedia of Human-Computer Interaction*. Great Barrington, MA: Berkshire Publishing.

² This definition was produced by attendees at an invited workshop on *Social Underpinnings of Collaboratories*, held in Ann Arbor, MI June 4-5, 2001.
<http://www.scienceofcollaboratories.org/Workshops/WorkshopJune42001/index.php?FinalSummary>

³ Olson, G.M., and Olson, J.S., Distance Matters, *Human-Computer Interaction*, **15**, 139-179, 2000.

Collaboratories offer up to five kinds of capabilities for their uses:

- **Communication:** tools for people-to-people communication, such as audio or video conferencing, chat, instant messaging, or e-mail.
- **Coordination:** tools for the coordination of management activities, such as schemes for setting access rights, group calendaring, and project management tools.
- **Information access:** tools for accessing on-line information, such as databases, digital libraries, and information repositories.
- **Computational access:** tools for accessing computational resources, such as supercomputers.
- **Facility access:** tools for remotely accessing specialized facilities, such as expensive or remote instruments.

There are many different technical implementations for each of these capabilities.

Success in collaboratories is a complex mix of technical and social factors. The technologies used must match the needs and requirements of the collaborators. Collaboratories that are mainly driven by technologists often fail on this. But even with appropriate technologies there are often complex social and organizational issues to overcome. Later in this paper we will spell out in more detail what some of these are.

Sources of Data

The data for this paper are from a large project called the Science of Collaboratories (SOC - www.scienceofcollaboratories.org). This project is examining a large set of collaboratories that have been built in order to develop generalizations about this new organizational form as well as practical advice both to funders and collaboratory participants. To date we have identified more than 165 collaboratories worldwide, have collected systematic data on about 50 of them, and have gone in-depth on 10.

Types of Collaboratories

We have developed a taxonomy of collaboratory types that has helped us understand some of the variation. A collaboratory that satisfies all elements of the definition we presented earlier is a prototypical collaboratory, or as we describe in our taxonomy, a *Distributed Research Center*. Other kinds of collaboratories have only a subset of the elements of our definition. Those with only some of the elements often evolve over time toward a Distributed Research Center.

Collaboratories with Research Focus

These four collaboratory types support aspects of geographically distributed research.

Distributed Research Center. This type of collaboratory functions like a research center or laboratory, but at a distance. It has a specific area of interest and a general mission, and usually more than one specific project. Person-to-person interaction is a key element of the collaboratory, but there is also support for specialized resources, databases, and a variety of research tools. The Alliance for Cellular Signaling (www.cellularsignaling.org) is a good example of this kind of collaboratory. It is a large distributed organization of universities whose goal is “to understand as completely as possible the relationships between sets of inputs and outputs in signaling cells that vary both temporally and spatially. [from their web site]”

Shared Instrument. The creation and use of specialized instrumentation has always been a key to scientific advancement. Over time the instrumentation required for scientific advances becomes more specialized, complex, and expensive. There are also some kinds of science that need instrumentation in specific, often remote geographic settings. These are the kind of capabilities provided by a Shared Instrument Collaboratory. A good example is the Keck Observatory (www2.keck.hawaii.edu), which provides a consortium of California universities with remote access to an observatory on the summit of Mauna Kea on the “Big Island” of Hawaii.

Community Data System. Data are central to scientific research, and therefore a common collaboratory is one in which a geographically dispersed community agrees to share their data in a central repository. Combining data from multiple sources results in a much more useful set of data, so more powerful analyses can be done. The Zebrafish Information Network (zfin.org) is an on-line aggregation of genetic, anatomical, and methodological information for zebrafish researchers.

Open Community Contribution System. This is a new organizational type that Sproull has described as a “voluntary association.”⁴ In this the members of some community make small contributions (what Sproull calls “microcontributions”) to a larger enterprise. These contributions are vetted by a central organization and placed in a repository. The best known example is open source software, where hundreds or even thousands of contributors assist in the development of a software system.⁵ Several such schemes have appeared in science. The NASA Ames Clickworkers project (clickworkers.arc.nasa.gov) invited members of the public to help identify craters on images from a Viking mission to Mars. Over 85,000 members of the public contributed 1.9 million crater markings. Their contributions were averaged, and this statistical aggregation of their contributions was indistinguishable from the judgments of expert geologists. The Open Mind Common Sense Initiative (commonsense.media.mit.edu) has been collecting instances of common sense knowledge from the public to assist artificial intelligence programs that do reasoning or language understanding.

Practice Focus

These two collaboratory types support the professional practice of a scientific community rather than research projects themselves.

Virtual Community of Practice. This supports individuals who have a research area in common and want to share news, advice, job opportunities, practical tips, and other useful professional information. Ocean US (www.ocean.us) is a representative example. It supports a large community of researchers interested in ocean observations.

Virtual Learning Community. This collaboratory type focuses on learning that supports research, but not research itself. The Ecological Circuitry Collaboratory (www.ecostudies.org/cc/) trains PhD. students in ecology in methods of quantitative modeling.

⁴ Sproull, L., Voluntary Associations on the Net: New Form of Social Organization, presentation given at ICOS, U of Michigan, November 15, 2002.

⁵ Raymond, E.S., *The Cathedral and the Bazaar: Musing on Linux and Open Source by an Accidental Revolutionary*. Sebastopol, CA: O’Reilly, 1999; Torvalds, L., and Diamond, D., *Just for Fun: The Story of an Accidental Revolutionary*, New York: Harper Business, 2001.

Collaboratories Evolve

Collaboratories that last more than a few years tend to evolve. A collaboratory may start as a Shared Instrument Collaboratory, but as those who share the instrument collect data they may decide to add a shared database component. They might then add communication and collaboration tools so they can interact over data collection or analysis. This evolution then results in a Distributed Research Center.

The ten-year history of the UARC/SPARC⁶ collaboratory provides a good example of this⁷. The initial UARC project provided access to remote ground-based instruments in Greenland. A chat facility allowed users to coordinate their data collection efforts. Many additional data sources were added, as well as near real-time supercomputer model predictions. Researchers soon were asking for access to data archives. Finally, the users wanted to conduct electronic workshops, where data sets, models, publications, and future experiments would be discussed outside of real-time data acquisition. So UARC/SPARC evolved from a Shared Instrument Collaboratory to a Distributed Research Center.

This evolutionary path toward a Distributed Research Center is the most common that we have seen. Success in supporting an initial set of functions creates an appetite for additional functions. Indeed, such evolution is itself a kind of success.

Success in Collaboratories

Why do some collaboratories succeed and others fail? Before we can answer this question, we have to examine what is meant by success. This turns out to be a complicated issue, since there are many ways in which a collaboratory might succeed.⁸ We briefly describe the major categories of success here.

Tool development. A number of the earliest collaboratories focused on tool development, as there was not much to draw on more than a decade ago. For such pioneering collaboratories the development of the tools themselves is a kind of success. The tools even being built, or working in an operational environment, or moving into production systems, would all be measures of success.

⁶ UARC = Upper Atmospheric Research Collaboratory; SPARC = Space Physics and Aeronomy Research Collaboratory. The name of the project changed when the source of the funding changed, but the overall project was continuous in its development.

⁷ Olson, G.M., Atkins, D.E., Clauer, R, Finholt, T.A., Jahanian, F., Killeen, T.L., Prakash, A., and Weymouth, T., The Upper Atmospheric Research Collaboratory. *Interactions*, 5(3), 48-55, 1998.

⁸ Again, this was discussed extensively in the *Social Underpinnings of Collaboratories* workshop, *op. cit.*, ref. 2.

Of course, over time, as more tools have appeared, this becomes a less satisfying definition of success, though it is still the case that new tools are emerging.

Use of the collaboratory tools. Ideally, tools built for a collaboratory would be used. There are several kinds of use. The most basic is that of the developers themselves, such as in demonstrations for sponsoring agencies. Next would be use by the domain scientists themselves. And then, we would ask such questions as whether the usage was sustained beyond an initial trial period, did usage increase over time, and were new users recruited to the community. In our analyses only a modest proportion of collaboratories achieved this kind of success.

Generativity of model. Early collaboratories served as inspiration to others to develop new ones. Sometimes the early collaboratories offer proof of concept that must be realized by a successive generation of tools. Remote access tools, developed as prototypes, often become really useful only when replaced by commercially developed imitators. Collaboratory technologies have probably been a driver of advances in networking and middleware⁹. Such widely useful technologies as electronic notebooks¹⁰ have been inspired by scientific collaboratories. The social and organizational structures of collaboratories are also often imitated with great success. Early experiments with shared databases spawned the extremely successful GenBank, Protein Databank, and others. Some early collaboratories like UARC/SPARC inspired other projects. The sharing of lessons learned across collaboratory experiences can be very valuable.

Direct effects on the science. The ultimate measure of collaboratory success would be that new scientific advances were achieved, or were achieved more efficiently or quickly. Related to this, an increase in collaborative publications or grant proposals could be on the road to direct effects on the science. In thinking of such outcomes, it is important to keep some perspective. Few collaborations of any kind, technologically mediated or not, result in scientific breakthroughs¹¹. Collaboration is very difficult, and while it is impossible to put a number on the rate of success in general, it certainly must be a decided minority of collaborations of any kind that result in scientifically important outcomes.

⁹ e.g., Foster, I., and Kesselman, C. (Eds.), *The Grid: Blueprint for a New Computing Infrastructure*. San Francisco: Morgan Kaufmann, 1999.

¹⁰ Extensive information about electronic notebooks is available through The Collaborative Electronic Notebooks Association. See www.censa.org

¹¹ Schumm, C., Crowley, K., and Okada, T., What Makes Collaborations Across Distance Succeed? The Case of the Cognitive Science Community (pp. 407-430), in P.J. Hinds and S. Kiesler (Eds), *Distributed Work*. Cambridge, MA: MIT Press, 2002.

Some collaboratories have resulted in scientific successes. For instance, the Great Lakes Regional Center for AIDS Research (GLR CFAR) led to more collaborative publications and grant proposals¹². Key activities like planning clinical trials took less time as a result of the collaboratory. In the UARC/SPARC project, investigators could respond to unforeseen events because key observational facilities were on line¹³. The Keck Observatory has had more efficient use of its observing time because unexpected open time slots can be easily filled, since investigators do not have to travel.

Science careers. Science depends on attracting young scientists into the field and nurturing their careers. Collaboratories could play a significant role in attracting young talent into scientific fields, aiding in their education, or promoting their career advancement. Geographically distributed mentoring of graduate students took place during the UARC collaboratory¹⁴. These graduate students gained much more experience with data collection at remote sites because they could access them over the network. Students were also sent to remote sites and their adviser supervised their work from home.

The Ecological Circuitry Collaboratory (www.ecostudies.org/cc/) is an explicit attempt to influence science careers. To encourage more students to do complex modeling in ecology, the site provides an opportunity to connect with other students, share their progress and have access to mentoring.

Effects on learning, science education. Many are eager to have the practice of science made more real to students in K-12 or university classrooms. Collaboratories can do this. For instance, the UARC/SPARC collaboratory was featured on an educational web site called Windows to the Universe (www.windows.ucar.edu) that provided access to K-12 classrooms.

Strengthening the social networks of science. Science is a social endeavor, and many breakthroughs have emerged through chance encounters or coincidental relationships between scientists. The Intermed Collaboratory (www.cpmc.columbia.edu/InterMed/) forged professional relationships that spawned multiple follow-up projects, set up longstanding professional collaborations between scientists in different fields (in this case, medical researchers, computer

¹² Teasley, S., and Wolinsky, S., Scientific Collaborations at a Distance. *Science*, 292, 2254-2255, 2001.

¹³ Olson, G.M., Atkins, D., Clauer, R., Weymouth, T., Prakash, A., Finholt, T., Jahanian, F., and Rasmussen, C., Technology to Support Distributed Team Science: the First Phase of the Upper Atmospheric Research Collaboratory (UARC) (pp. 761-783), in G.M. Olson, T. Malone and J. Smith (Eds.), *Coordination Theory and Collaboration Technology*. Hillsdale, NJ: Lawrence Erlbaum Associates, 2001.

¹⁴ *ibid.*

scientists, and cognitive scientists) and resulted in cross hiring of staff and postdocs between institutions¹⁵. Collaboratories may be particularly effective in promoting boundary-crossing collaborations, where boundaries may be ones of institution, discipline, or nationality. One difficulty of assessing this type of impact is that the positive effects often occur years after the funding period of a collaboratory has ended, thus escaping notice of end-of-project summative evaluations.

Factors that Influence the Success of Collaboratories

We now turn to a brief review of factors that we have found to be associated with success in collaboratories. Given the complexity of the definition of success, we have needed to be eclectic in what counts for success. We have focused mainly on usage success, that is, success based on the use of the collaboratory by the scientists themselves.

We have several preliminary reports on success factors in long distance collaboration.¹⁶ As we've studied patterns of success and failure in collaboratories we have been able to confirm some of these as important factors, but have also identified a number of others. Here we review the factors that we think are most critical for collaboratories. See our earlier papers for other factors that are important in distance collaborations.

Collaboration Readiness. Different fields or communities of scientists have quite different traditions of sharing. Upper atmospheric physicists had a long tradition of collaboration before they began using the Internet to support their long-distance interactions. On the other hand, our early efforts to engage several biomedical communities (for instance, HIV/AIDS researchers) were unsuccessful partly because of the competitive nature of these communities. Collaborative technologies will not yield collaboration if the scientists themselves are reluctant to collaborate.

Collaboration readiness is an especially problematic factor when the impetus for a collaboratory comes from an external source, like a funding agency. The recently launched NEESgrid project for earthquake engineers is a good example of this. The collaboratory was mandated by the National Science Foundation (NSF) as an element of a round of major facility upgrades in the field. Only a selected set of sites were to receive facility upgrades, but NSF commissioned an effort to provide remote access to these upgraded facilities so that those sites who did not have state-of-the-

¹⁵ Shortliffè, E. H.; Patel, V. L., Cimino, J., Barnett, O.G., and Greenes, R. A., A Study of Collaboration Among Informatics Research Laboratories, *Artificial Intelligence in Medicine*, **12**, 97-103, 1998.

¹⁶ Olson, G.M., and Olson, J.S., Distance Matters, *Human-Computer Interaction*, **15**, 139-179, 2000; Olson, G.M., Finholt, T.A., and Teasley, S.D., Behavioral Aspects of Collaboratories (pp. 1-14). In S.H. Koslow & M.F. Huerta (Eds.), *Electronic collaboration in science*. Mahwah, NJ: Lawrence Erlbaum Associates, 2000.

art facilities could still benefit from NSF's investment. NSF required them to become Shared Instrument Collaboratories. However, the field had a strong tradition of local ownership of facilities and data. The NSF mandate was at odds with this, and early interviews and analyses surfaced the inevitable problems of collaboration readiness¹⁷. As this project is funded through 2014, it will be interesting to see whether this initial lack of collaboration readiness can be overcome. To its credit, NSF has established a consortium of users to manage the project, and this consortium could be an effective mediator of collaboration readiness.

Technical readiness. Some science communities are sufficiently collaborative to be good candidates for a successful collaboratory. However, their habits and infrastructure may not be ready. Individual scientists may not have much experience with collaborative technologies. The requisite social and technical infrastructure may be missing. We found several emerging collaboratories involving HIV/AIDS researchers in Africa to be extremely high on collaboration readiness but very mixed on technical readiness¹⁸. Or the collaboration tools may be inappropriate designed with respect to the participants' natural social reactions, a concept we call social ergonomics, making their acceptance and fit to work practices problematic.

Individual technical readiness. Individuals in different institutions and in different domains have varied experience with technology. A particular new technology like Centra Symposium may be a leap for some and an easy step for others. We have seen repeatedly that failure often results from attempts to introduce technologies that are too big a leap.

The space physicists we studied are an example of evolving collaboration technology readiness. When we began working with them, some were users of email, telephone and fax. But much of their collaboration was mediated by in-person interactions, such as attending conferences where they would discuss research with colleagues, hallway conversations in their labs, and sitting together in a small building in Greenland during data collection campaigns. The earliest collaboration technology we offered them allowed similar behavior, but at a distance. Data from the upper atmosphere were displayed in the same way as the instruments they had been at the site,

¹⁷ Bimholtz, J., and Bietz, M., Data at Work: Supporting Sharing in Science and Engineering. Draft CREW working paper, 2003.

¹⁸ Olson, G.M., Teasley, S., Bietz, M.J., and Cogburn, D.L., Collaboratories to Support Distributed Science: the Example of International HIV/AIDS Research, in the *Proceedings of South African Institute of Computer Scientists and Information Technologists*. New York: ACM, 2002.

and they chatted about it. Early behavioral data showed that the content and style of the conversations was very similar in face-to-face situations and those now held remotely¹⁹.

The collaboration technology for the space physicists evolved along with their familiarity with these kinds of tools. As the web became more popular, members of the community started putting relevant instruments on line. Those who had used the UARC tools began to demand access to these sites as well, and the entire project became web-based. They shared views in some standard configurations called “rooms.” They developed composite views of the data to match the view of the supercomputer models used for comparisons. The system in the late stages of the project was much more sophisticated than they could have handled at the outset.

Infrastructure readiness. Poor alignment of technology support, existing patterns of everyday usage, and the requirements for a new technology are major inhibitors of successful adoption. The Worm Community System (WCS) was an early collaboratory project²⁰. However, as Star & Ruhleder found, the full-function tools developed by the WCS were on a technical platform (UNIX) that was not commonly used in the laboratories of the scientists, meaning the tools were not well integrated with everyday practice²¹. Furthermore, most labs did not have the necessary technical support for such systems, so problems with the system could not be corrected.

Social ergonomics of tools. Social interactions in work groups are influenced both by characteristics of the group and its participants as well as the communication technologies and other tools that are used. Social ergonomics is the study of the impact of technology characteristics on this group processes. For example, video conferencing systems often ignore such details as screen size, display arrangement in relation to participants, camera angle, and sound volume. These details can have social effects. Huang, et al, found that the apparent height of videoconference participants, as conveyed via camera angle, influenced a negotiation task²². An apparently taller person was more influential in shaping the final outcome than the apparently shorter person.

¹⁹ McDaniel, S.E., Olson, G.M., and McGee, J.C., Identifying and Analyzing Multiple Threads in Computer-Mediated and Face-to-Face Conversations, in *Proceedings of CSCW '96*, 1996.

²⁰ Schatz, B., Building an Electronic Community System, *Journal of Management Information Systems*, **1**, 341-355, 1991.

²¹ Star, S.L., and Ruhleder, K., Steps towards an ecology of infrastructure: Complex problems in design and access for large-scale collaborative systems (pp. 253-264). In *Proceedings of CSCW 94*, New York: ACM Press, 1994.

²² Huang, W., Olson, J.S., and Olson, G.M., Camera Angle Affects Dominance in Video-Mediated Communication. In *Proceedings of CHI 2002, Short papers*. New York: ACM Press, 2002.

Incentives Must Be Aligned

Incentives are an important element of collaboration success. For example, we have looked at the incentives to participate in a Community Data System. We are interested in why a researcher would be willing to contribute data to a shared database, thus giving up exclusive access. We have seen several different kinds of incentive schemes at work.

Goodwill. The Zebrafish Information Network (ZFIN) relies on the goodwill of its members. This collaboratory emerged within a community of researchers who had a personal connection to a senior researcher. He had both pioneered the use of Zebrafish as a model organism, and also set a tone of generosity and collaboration for the community. When Zebrafish was begun, goodwill among this set of researchers was the glue. Now, as the ZFIN expands beyond its founders, it will be interesting to see whether goodwill can continue to motivate participation.

Required contribution for doing other things. A consortium of high prestige journals in biology requires that the authors of a journal submission have a GenBank accession number indicating that they've stored their relevant gene sequences in the shared data base.²³ Thus, participating in this data base was essential for an important professional activity, namely, publishing.

New forms of publication. The Alliance for Cellular Signaling has taken a novel approach to the incentive issue. They are creating a new data base through the gathering together of detailed reports called molecule pages. Because these represent a lot of work, the Alliance worked out an agreement with *Nature* to count a molecule page as a publication in *Nature*. *Nature* coordinates a peer review process, and although molecule pages do not appear in print they are published online under the imprimatur of the Nature Publishing Group. The Alliance's editorial director has already written letters in support of promotion and tenure cases indicating that molecule page contributions are of journal publication quality.

Data Issues

Data are central to all collaboratories. There are numerous issues about how data are represented and managed that can contribute to collaboratory success.²⁴ It is widely recognized, for example, that good metadata is critical as databases increase in size and complexity. Also important is information about the provenance of the data. The data in a database have often been highly

²³ Cinkosky, M.J., Fickett, J.W., Gilna, P., and Burks, C. Electronic Data Publishing and GenBank. *Science*, 252, 1273-1277, 1991; Aldhous, P. Managing the Genome Data Deluge, *Science*, 262, 502-3, 1993.

²⁴ .op. cit., ref. 17.

processed, and researchers will want to know what the path was between the original raw data and the resulting processed data. This aids in understanding the data, and also in correcting any errors later discovered in how a particular transformational step was done.

Moving to Production Versions of Tools

Many collaboratory projects involve collaboration between domain scientists, the users of the collaboratory, and computer scientists, the builders of it²⁵. Most projects experience tensions between users who want hardened tools that do what they need done and computer scientists who are interested in technical innovations and creative software concepts. There is usually little incentive for academic computer scientists to go beyond the initial demonstration versions of tools and to support the long-term operational infrastructure desired by the users. Some fields, such as high energy physics, understand that the costs associated with producing production versions of tools must be included in a project. However, other fields are only discovering this. One organizational innovation is in the NEESgrid project. NSF established two phases to the project, an initial four-year system integration phase in which the tools are developed and tested, followed by a 10-year operational phase overseen by a NEES consortium of user organizations.

Management Issues

Any large organization faces difficult management issues, and practicing scientists may not always have the time or the skills to properly manage a complex enterprise. Geographically dispersed organizations are all the more difficult to manage. A number of the large collaboratories that we have studied have faced key management issues. For instance, two physics collaboratories, GriPhyN and iVDGL, found that it was necessary to hire a full-time project manager for each one in order to help the science project directors manage day-by-day activities. The Alliance for Cellular Signaling has benefited from a charismatic leader who has excellent management skills, and who has set up a rich management structure to oversee the project. The BIRN collaboratory is evolving an explicit governance manual that contains guidance for a host of tricky management issues, and has a steering committee that is responsible for implementing these management guidelines.

Particular Challenges for International Collaboratories

²⁵ In our view the ideal collaboratory project would be a three-way collaboration between users, computer scientists, and behavioral scientists, the latter representing the social elements of what is essentially a socio-technical enterprise. However, very few projects have had this kind of mix, though there are signs that this may be changing.

One of the biggest factors that needs to be addressed as collaboratories become more global is that of cultural differences. As distances are spanned, cultural differences emerge, and such differences can lead to misunderstanding or resentment. American culture is very task oriented and being parts of ad hoc, short-term teams is common. Southern and Eastern Europeans as well as Asians are known to value personal relationships more than the task at hand. They will sacrifice promptness when a previous interaction with a valued colleague is not deemed finished²⁶. Another dimension of difference is a concept called “power distance”²⁷. In Europe and Asia, there is greater respect for authority than in the United States. In the United States, people at different levels of an organization communicate freely. Americans are also notorious for their dominating turn-taking style, making it difficult for the Europeans or Asians to break into a conversation. Specific procedures must be put in place to counteract this. Communication tools like voice over IP or video conferencing add further complications.

Of course, as individuals have more and more experience with global teams, they gain in sophistication about linguistic and cultural differences. Further, individual scientific fields themselves create very strong cultures that span international boundaries. But even for such sophisticates their own cultural habits and viewpoints are the natural and automatic ones. It takes effort to maintain culturally neutral behaviors in the midst of intense interactions. Such sophisticates lose track of their culture-spanning turn taking rules in the heat of discussion. Local conventions about work schedules or the importance of non-work time dominate as deadlines approach. Sensitivity to cultural differences will always take more effort, no matter how good the technology. There is no compelling evidence that cultural differences are receding in our tightly knit global community.

Conclusions

As we indicated at the outset, success in collaboratories is likely to be a complex mix of social and technical factors. We have tried to indicate the character of this mix. Technologies to support collaboration continue to evolve, and the range of options available to potential collaboratory builders is enormous. But failure to consider the joint mix of social and technical factors will put such projects at risk.

²⁶ Hall, E. T., and Hall, M. R., *Understanding Cultural Differences: Germans, French and Americans*. Yarmouth, ME: Intercultural Press, 1990.

²⁷ Hofstede, G., *Culture's Consequences*. Newbury Park, CA: SAGE Publications, Inc., 1980; Hofstede, G., *Cultures and Organizations: Software of the Mind*. London: McGraw-Hill International, 1991.

Discussion: Plenary Session I

Following **Fan Chunliang's** presentation, **Keisuke Taira** intervened with another example of international scientific cooperation via the Internet: another example: the North East Asian Regional -Global Ocean Observing System (NEAR-GOOS) for realtime exchange of oceanographic data among Japan, China, Korea, and Russia. **Paul Uhlir** noted that Fan has said that 3.2 percent of users were external—that is, foreign users. He suggested that it would be interesting to keep monitoring any changes in this percentage over time.

Following the presentation by **Masao Sakauchi**, **Wang Zhiqiang** wondered which was more important, protecting cultural assets or making them available to the public. **Sakauchi** said that both were important.

Yang Deli asked whether antiterrorism and defense security goals should not be included in the list of roles for information technology. **Sakauchi** responded that his list was a reflection of his personal goals, but that certainly such goals as defense and antiterrorism should be discussed¹.

Following **Gary Olson's** presentation, **Barry Bozeman** suggested that it would be valuable to know how collaboratories contribute to the formulation of social capital. Olson replied that this hasn't yet been studied but he went on to suggest that social capital is probably much more difficult to achieve virtually than it is face to face.

Commentary. **Shiniji Shimojo** led off the open discussion following the three presentations by listing a number of points which he considered particularly important:

1. Problems in science are becoming ever more complicated, and therefore collaboration is necessary.
2. There is a need to develop rich, multicultural content on the Internet.
3. The Internet should be used to raise the quality of life.
4. There is an increasing need for the development of tools needed to cooperate on the Internet, including such tools as shared data, computers, and skilled people.

1. See contributed paper by Jody Westby, Section III.

He then listed some of the factors that can contribute to success or failure of collaboration on the Internet:

1. differing incentives;
2. competitiveness vs. collaboration;
3. research vs. infrastructure: i.e., the need for complicated tools and technical staff;
4. need for continuous, stable funding by governments;
5. community outreach; and
6. trust

Open discussion. Gary Olson observed that long-term funding and patience is crucial. He suggested that a decade of stable, patient funding may be necessary for a given collaboratory to prove its value.

Tom Ratchford asked if there have been any examples of acculturation over the Internet. **Olson** replied that the Internet should be used as the social glue for people to interact.

Geoffrey Bowker and **Olson** both pointed out that only a small percentage of “chat” among scientists working in successful projects is on the scientific issues. Most of the chat is personal or off issue and is meant to socialize. The point they were making is that such non-scientific chatter is probably essential to the success of the scientific collaboration.

Somewhat surprisingly, **Wesley Shrum** suggested that trust is not all that important because it doesn't predict success. He added that in the United States, trust is negatively related to conflict. He asked how we could organize international collaboratories where no initial trust has been established.

Bozeman suggested that perhaps the issue is not trust but “humanization,” that is, putting a human face on the collaboration. He ventured that an important factor in a successful interaction over the Internet is to see the counterpart as a human being with a story and a life. He mentioned that on his website he has posted pictures of his pets and family as a way of showing something personal about himself.

Toshihiko Hayashi asked whether collaboratories flourish better under democracy or dictatorship, using these terms metaphorically. In other words, do collaboratories need a strong leader or can

they flourish in a situation where no one leader exists? He also suggested that running collaboratories takes a lot of time and that it may eat away at ones actual research productivity.

Olson responded that sometimes a charismatic, recognized leader in the field is necessary, but that he has also seen some of the marginal participants in the field achieve success by pushing their ideas forward strongly.

Paul Uhler said that new paradigms have emerged in which there is no active leader or manager at all, only passive instructions. The NASA Clickworkers collaboratory is a good example. Another is Project Gutenberg, in which people voluntarily proofread public-domain books placed on line because they are interested in the subject and are self-motivated. He said that you couldn't write a novel this way, but that you can achieve certain collective information products or services if the granularity and type of the information is amenable to such voluntary, distributed activity.

Suguru Yamaguchi observed that distributed collaboration is a beautiful story, but that there is a big overhead to be paid in maintaining the software. He said that sustainability and expandability are important considerations in any collaboratory.

Shimojo mentioned PRAGMA—the Pacific Region Grid Middleware Assembly—as a good example of shared collaboration. However, evaluation is difficult. He suggested that we should adopt the example of movie credits in showing the contributions of all who made the collaboratory possible.

Yamaguchi spoke up to reinforce the point made earlier that stable, patient support by government is essential to the success of collaboratories. He mentioned the particular problem of miscoordinated evaluation systems as especially problematic and implied that the government supporters of international collaboratories must address this issue up front.

Sun Zhaobo mentioned the Nanjing Meteorological Institute's cooperation with the State University of New York at Stonybrook and pointed out that whereas first they cooperated over the Internet, it was an important addition to their success when they met face to face.

Olson mentioned two important factors essential to the success of Internet-based collaboration: 1) determining what you are trying to do in terms of a specific task, and 2) how much common ground exists between and among you.

Yamaguchi agreed with **Olson**: face-to-face meetings accelerate the development of shared notions.

Wang Zhiqiang said that although he had collaborated over the Internet with counterparts, when it came time to writing the paper they found it necessary to meet face to face.

Olson, following up on **Bozeman**'s earlier comments, said that face-to-face and video are necessary but not sufficient. Socializing is all important.

Shrum closed out the discussion by conjuring up a scenario for a subsequent conference in which the assumption was that collaboration is a bad thing. He mentioned also that he is engaged in organizing a science and engineering event at the next World Summit on the Information Society in Tunis in 2005, and suggested that participants in the Honolulu seminar might think about a follow up activity at the Tunis meeting.