Chapter 6
Cybernetics, Time-sharing, Human-computer Symbiosis And On-line Communities
Creating a Super-community of On-line Communities

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Part I - Foundations of the Cybernetic Revolution

In 1961, MIT was to celebrate its centennial anniversary. Martin Greenberger, who had joined the MIT faculty in 1958, describes how a call went out for interesting ways to celebrate. "I proposed a series of lectures," he recalled, "on the computer and the future. We threw open the hatches and got together the best people we could assemble – whatever their fields. We asked these thinkers to project ahead and help us understand what was in store."[1]

Charles Percy Snow, a British writer was invited to be the keynote speaker. His talk "Scientists and Decision Making," discussed the need for democratic and broad based participation in the decisions of society. "We happen to be living at a time of a major scientific revolution," he observed, "probably more important in its consequences, than the first Industrial Revolution, a revolution which we shall see in full force in the very near future."[2]

He and the other speakers expressed their concern that the challenges represented by the computer be understood and treated seriously. They felt that there would need to be government decisions regarding the development and application of the computer. They cautioned that these decisions be entrusted to people who understood the problems they were dealing with. Also, they were concerned that the smaller the number of people involved in important social decisions, the more likely it would be that serious errors of judgment would be made. They urged that it was necessary to open up the decision making process to as broad a set of people as possible.

Present at this gathering were several of the pioneers who had helped to set the foundation for the developing cybernetic revolution. What was the revolution they were describing?

John Pierce, a pioneer in electronics research at Bell Labs, was one of the speakers at the MIT Centennial Conference. In an article published several years earlier in *Scientific American*, Pierce described the foundation of the cybernetic revolution that was then unfolding.[3] Pierce noted the intellectual ferment that accompanied two publications in 1948. One was "The Mathematical Theory of Communication" by Claude Shannon, published in July and October 1948 in the Bell Labs Journal. The other was the publication of Norbert Wiener's book *Cybernetics: Control and Communication in the Animal and the Machine*.

Summing up Shannon's contribution, Pierce noted that Shannon had changed communication theory from guess work to science. Shannon, Pierce wrote, "has made it possible for communication engineers to distinguish between what is possible and what is not possible. Communication theory has disposed of unworkable inventions that are akin to perpetual motion machines. It has directed the attention of engineers to real and soluble problems. It has given them a quantative measure of the effectiveness of their system."[4]

In the 1930's, the mathematician and computer pioneer, Alan Turing had determined that it was possible to design a universal or general purpose computer. Such a computer would be able to solve any calculation that could be solved by a machine, provided the computer had a program describing the calculation. Building on Turing's contribution, Shannon had demonstrated how Boolean algebra and logic could be used in the analysis and synthesis of switching and computer circuits.

Another founder of the Cybernetics Revolution was Norbert Wiener. Pierce recalled the important intellectual catalyst that Wiener's book provided when it appeared in 1948. Wiener was interested in the means by which feedback could be communicated to help correct the problems that develop in an organism. Describing the contribution Wiener's work made in defining the need for feedback, Pierce gives the example of a community "where the Lords of Things as They Are protect themselves from hunger by wealth, from public opinion by privacy and anonymity, from private criticism by the laws of libel and the possession of the means of communication." It is in such a society, he explains, that "ruthlessness can reach its most sublime levels." And he points out that the creation of such a society requires "the control of the means of communication" as "the most effective and important element."[5] Such a community, he observed, is very unstable.

Wiener, in an interview in 1959, explained why such a community is unstable. Describing the importance of accurate information and feedback, Wiener referred to someone driving a car, but "instead of seeing where you are going, somebody puts a picture in front of you. Clearly, it won't be very long before you hit the curb. This is true in other spheres. Facing the contingencies of life depends on adequate and true information. The more that information is conditioned by the people who are doing the controlling, the less they will be able to meet emergencies. In the long run, such a system of misinformation can only lead to catastrophe," warned Wiener.[6]

In Cybernetics, Wiener defined three central concepts which he maintains were crucial in any organism or system. They are communication, control and feedback. Wiener coined the term "cybernetics" to designate the important role that feedback plays in a communication system. He took the word from the Greek term "kybernetes" meaning "governor" or "steersman."[7] Wiener believed that the digital computer had raised the question of the relationship between the human and the machine, and that it was necessary to explore that relationship in a scientific manner. He wrote that what "functions should properly be assigned to these two agencies" is the crucial question for our times.[8]

Important to Wiener's vision was the understanding that the more complex the machine, like the developing digital computer, the more, not less, direction and intelligence were required on the part of its human partner. Wiener often pointed to the literal way in which the computer interpreted the data provided to it. He explained the necessity for increased human guidance and forethought when directing computers: “Here I must enter a protest against the popular understanding of computing machines and similar quasimechanical aids. Many people suppose that they are replacements for intelligence and have cut down the need for original thought…. This is not the case. If simple devices need simple thought to get the most out of them, complicated devices need a vastly reinforced level of thought…. Moreover this work cannot be put off until the machines have already processed their data. It is very rare, and to say the least, by no means normal, that data that has been thoughtlessly selected can be organized by an after thought so as to produce significant results.”[9]

In the introduction to Cybernetics, Wiener described some of the important influences on his development as a scientist and on his thinking in the field of cybernetics. He told of how in the 1930's, he was invited to attend a series of private seminars on the scientific method held by Dr. Arturo Rosenblueth of the Harvard Medical School in Cambridge, Massachusetts. He and Dr. Rosenbleuth had a common interest in understanding the scientific method and both believed that science had to be a collaborative endeavor.[10] Scientists involved in a variety of fields of study were invited to the seminars to encourage an interdisciplinary approach to the problems of communication in machine and animals that those in the seminars explored. Describing the methodology of the seminars, Wiener writes: “In those days, Dr. Rosenblueth…conducted a monthly series of discussion meetings on scientific method. The participants were mostly young scientists at the Harvard Medical School, and we would gather for dinner about a round table in Vanderbilt Hall…. After the meal, somebody – either one of our group or an invited guest – would read a paper on some scientific topic, generally one in which questions of methodology were the first consideration, or at least a leading consideration. The speaker had to run the gauntlet of an acute criticism, good-natured but unsparing…. Among the former habitues of these meetings there is more than one of us who feels that they were an important and permanent contribution to our scientific unfolding.”[11]

Wiener was a member of this group until the onset of WWII ended the seminars. After the War was over, Wiener began a set of seminars near MIT modeled on his earlier experience in the seminars with Dr. Rosenblueth. The post war seminars that Wiener convened were to have an important influence on the work of several of the pioneers of the upcoming computer networking revolution.

Jerome Wiesner, another MIT computing pioneer, who later became a Science Advisor to President Kennedy, described the role Wiener’s seminars played in helping to develop the interdisciplinary tradition of research at MIT’s Research Laboratory for Electronics (known as the RLE). Wiener’s ideas about communication and feedback in man and machine, along with Shannon’s work in information theory “spawned a new vision of research for everyone interested in communications, including neurophysiology, speech, and linguistics investigation,” wrote Wiesner, “The work was both theoretical and experimental as well as basic and applied. It led to exciting new ideas and to their implementation in practice which “remains a hallmark of the present-day RLE.”[12]

Wiesner provides the following account of the seminars that Wiener set up after WWII: “In the winter of 1947, Wiener began to speak about holding a seminar that would bring together the scientists and engineers who were doing work on what he called communications. He was launching his vision of cybernetics in which he regarded signals in any medium, living or artificial, as the same; dependent on their structure and obeying a set of universal laws set out by Shannon. In the spring of 1948, Wiener convened the first of the weekly meetings that was to continue for several years…. The first meeting reminded me of the tower of Babel, as engineers, psychologists, philosophers, acousticians, doctors, mathematicians, neurophysiologists, philosophers, and other interested people tried to have their say. After the first meeting, one of us would take the lead each time, giving a brief summary of his research, usually accompanied by a running discussion. As time went on, we came to understand each other's lingo and to understand, and even believe, in Wiener's view of the universal role of communications in the universe. For most of us, these dinners were a seminal experience which introduced us to both a world of new ideas and new friends, many of whom became collaborators in later years."[13]

Part II - Interactive Computing, Time-sharing and Human-Computer Symbiosis

Wiener's stress on interdisciplinary and practical work in the field of communications helped to set the foundation for the upcoming developments in digital computers. By the mid 1950's, several members of the MIT community had been introduced to a new form of computing – interactive computing – in their work on the Whirlwind Computer. Whirlwind research began at MIT in 1947, providing those involved with important practical experience in digital computing. Whirlwind came on line around 1950 and was used until 1957 when the MIT Computation Center began using another vacuum tube computer, the IBM 704.[14] Only when the Computation Center computer was upgraded to the first transistorized computer in the IBM family, the IBM 7090, from vacuum tube computers, did time-sharing become possible.[15]

IBM, which was a main provider of computers during this period, promoted batch processing and saw it as the form of computing for the future. Researchers at MIT, however, had a different vision. Some had worked on the Whirlwind Computer and had experienced a form of interactive computing that made it possible to use the computer directly, rather than having to submit punch cards to a central computer center and await the results.[16] The experience of real time activity at the computer had been a significant advance over the frustration of awaiting the results of one's program under the batch processing system.

Computer resources during this period were very expensive. In general, the cost prohibited a single person from using a computer in real time. A few farsighted researchers, however, had the idea of a time-sharing system which would take advantage of the speed of the computer to allow several users to work with the computer at the same time. The computer scheduled their different work in a way that gave the illusion that the computer was being used by each independently. In June, 1959, Christopher Strachey, a British researcher, presented a talk at the International Conference on Info Processing, UNESCO, proposing time-sharing.[17] Also, in 1959, John McCarthy, an MIT faculty member, wrote a memo describing a new form of computing that time-sharing would make possible and proposing that MIT begin to plan to implement this form of computing once the

IBM 7090, the new transistorized computer that they were expecting from IBM to replace the IBM 704, arrived. McCarthy advocated developing a "general-purpose system where you could program in any language you wanted."[18] In his memorandum to MIT Professor P.M. Morse in January 1959, McCarthy writes: "This memorandum is based on the assumption that MIT will be given a transistorized IBM 709 about July 1960. I want to propose an operating system for it that will substantially reduce the time required to get a problem solved on the machine…. The proposal requires a complete revision in the way the machine is used…. I think the proposal points to the way all computers will be operated in the future, and we have a chance to pioneer a big step forward in the way computers are used."[19]

At the same time as McCarthy was proposing a new form of computing, – i.e. time-sharing and interactive computing – another computer pioneer, J. C. R. Licklider, who would play an important role in the developing computer revolution, was working on a paper exploring the concept of human-computer interaction that Norbert Wiener had stressed was so crucial.

Licklider had done his graduate degree in psychology and after WWII, did research at Harvard and worked as a lecturer. He attended the postwar Wiener circles. "At that time," he explained in an interview, "Norbert Wiener ran a circle that was very attractive to people all over Cambridge, and Tuesday nights I went to that. I got acquainted with a lot of people at MIT."[20] He describes how another importance influence on his work was the Summer Projects at MIT that he attended, starting in 1951. Beginning in the summer of 1952, an interdisciplinary series of summer projects were carried on at MIT for several years which Licklider found "exhilarating." He remembered how "they brought together all these people – physicians, mathematicians. You would go one day and there would be John von Neumann, and the next day there would be Jay Forrester having the diagram of a core memory in his pocket and stuff – it was fantastically exciting."21

Licklider became involved with MIT and Lincoln Laboratory and "computers and radar sets and communications." As their token psychologist, he was the only psychologist in this interdisciplinary group of physicists, mathematicians and engineers. "So it was a fantastic opportunity," he noted. The lab he worked at was run by the RLE and he described how it "gave me a kind of access to the most marvelous electronics there was."[22]

By 1958-9, Licklider was working with the engineering company, Bolt, Beranek and Newman doing acoustical research. There he had access to digital computers, first a Royal McBee LGP-30, and then one of the earliest DEC PDP-1 computers. Licklider learned how to program on the LGP-30 and when the PDP-1 arrived, one of the earliest time-sharing systems was created for it. Licklider notes the grand time he had exploring what it made possible: "Well, it turned out that these guys at MIT and BBN. We'd all gotten really excited about interactive computing and we had a kind of little religion growing here about how an was going to be totally different from batch processing."[23]

It was during this period that Licklider carried out an experiment to try to determine how the computer could aid him in his intellectual work. "More significantly," he explained, "from my point of view, a lot hinged on a little study I had made on how I would spend my time. It showed that almost all my time was spent on algorithmic things that were no fun, but they were all necessary for the few heuristic things that seemed to be important. I had this little picture in my mind of how we were going to get people and computers to really think together."[24]

Inspired by the Wiener seminars, Licklider tried to set up an interdisciplinary study circle to conduct a study for the Air Force. He explains: "Oh, yes. We had a project with the Air Force Office of Scientific Research to develop the systems concept. Now it's corny, but then it was an interesting concept. We were trying to figure out what systems meant to the engineer and the scientific world. That involved some meetings in which we brought [together] good thinkers in several fields. We wanted a kind of Wiener circle…we put a lot of hours into trying to do that."[25]

This study is described in the article "Man-Computer Symbiosis". Norbert Wiener had proposed that man-computer symbiosis was a subset of the man-computer relationship. Licklider took that observation seriously and wrote an article which was published in March 1960 exploring the meaning and import of man-computer interaction and interdependence.

"Man-computer symbiosis," he wrote, "is an expected development in cooperative interaction between man and electronic computers. It will involve very close coupling between the human and electronic members of the partnership. The main aims," he outlined, "are 1) to let computers facilitate formulative thinking as they now facilitate the solution of formulated problems, and 2) to enable man and computers to cooperate in making decisions and controlling complex situations without inflexible dependence on predetermined programs."[26]

The article became an important formulation of a vision of computing for the developing computer revolution in time-sharing and networking. Licklider did not promote the computer as a replacement for humans nor see humans as servants to computers. Instead he proposed research exploring the role of humans and machines. His goal was to enhance the symbiotic relationship between the human and computer partners needed to aid intellectual activity.

Part III - CTSS and Project MAC

One of those who was to play an important role in implementing the vision of human-computer symbiosis was Robert Fano. Fano worked at RLE after doing his Ph.D. at MIT in June 1947. In his introduction to his book "Transmission of Information", he described his early contact with Norbert Wiener and Claude Shannon.27 He explained how he studied the theoretical questions raised by Wiener and Shannon and did research to explore the theories they had pioneered.

In 1960, Fano was a senior faculty member at MIT. Gordon Brown, then Dean of the Engineering School of MIT, arranged for several faculty members to take a course in computing taught by Fernando Corbato and John McCarthy. Fano, remembering his excitement in learning how to program during this course, recalled, "I wrote a program that worked."[28]

Gordon Brown, according to Fano, understood that the computer was going to be very important and encouraged his senior faculty to become familiar with it. In 1960, the MIT administration appointed a committee to make recommendations about the future needs of MIT regarding computers. Fano was one of the faculty members appointed to the committee. This committee created a technical committee made up of Fernando Corbato, John McCarthy, Marvin Minsky, Doug Ross, and Jack Dennis, with Herb Teager acting as Chair. This committee became known as The Long Term Computation Study Group.

It was during this period that the celebration of the MIT centennial was being planned. Eight talks were scheduled. After one of the speakers cancelled at the last minute, John McCarthy, who had been working on the long range computer study, was invited to speak. In his talk, McCarthy described the rationale behind time-sharing and the important vision for the future of computing that it represented. Other participants at the conference included Norbert Wiener, Claude Shannon, John Kemeny, Robert Fano, Alan Perlis, and J. C. R. Licklider.[29] In the course of the conference, Wiener explained that "a computing machine is a general-purpose device that can be programmed to do very specific jobs." But, Wiener warned, if you fail to give a necessary instruction to a computer, "you cannot expect the machine itself to think of this restriction."[30] Wiener explained that humans had to oversee the computer. "An unsafe act thus," Wiener cautioned, "may not show its danger until it is too late to do anything about it."[31]

In his comments, Licklider described how a human being "must not so clutter his mind with codes and formats that he cannot think about his substantiative problem."[32] Licklider described his vision of the future of the computer: "In due course it will be part of the formulation of problems; part of real-time thinking, problem solving, doing of research, conducting of experiments, getting into the literature and finding references.... And it will mediate and facilitate communication among human beings."[33]

He expressed his hope that the computer "through its contribution to formulative thinking...will help us understand the structure of ideas, the nature of intellectual processes."[34] And he proposed that the "most important present function of the digital computer in the university should be to catalyze the development of computer science."[35]

Another participant at the conference, the linquist Y. Bar-Hillel, pointed out no one at the conference knew what was going to happen in the long term future, or even in the short term. Because of this uncertainty, it was important to decide what type of future it would be worthwhile to encourage. There were two paths to choose from, and he posed the question as to which path should be taken. "Do we want computers that will compete with human beings and achieve intelligent behavior autonomously, or do we want what has been called man-machine symbiosis?"[36]

"I think computer people have the obligation to decide which of the two aims they are going to adopt," he proposed. Arguing that the human brain was more developed than it would be possible to make a machine brain at the current stage of technological development, he recommended that the best path was that of man-machine symbiosis. "I admit that these two aims do not definitely exclude each other," he acknowledged, "but there has been an enormous waste during the last few years in trying to achieve what I regard as the wrong aim at this stage, namely, computers that will autonomously work as well as the human brain with its billion years of evolution."

Fano, taking a sabbatical in the Summer of 1961, had gone to work at Lincoln Labs because he hoped to learn more about digital computers there. "You know," he explained, "we used to talk about components such as modulators and detectors and all the gadgets that went into communication systems. That's the past. We have to talk about functions now, because with a computer you can implement any function you want."[37] He proposed one had to begin to think about communication in the general purpose way that the digital computer was making possible.

In the meantime, the Long Term Computation Study Group published its reports. There were two proposals for how to proceed. One, from Herbert Teager, who had been Chairman of the Committee, and a second Report from the rest of the committee. Fernando Corbato, a member of the committee and then Associate Director of the MIT Computing Center set out to implement an "interim" solution to the kind of computing the majority report proposed. Corbato describes the subsequent events, "I started up with just a couple of my staff people Marjorie Daggett…and Bob Daley. We hammered out a very primitive prototype. We started thinking about it in Spring of 1961. I remember that by the summer of 1961 we were in the heat of trying to work out the intricacies of the interrupts."[38]

He explains how he and the other programmers were acting on the vision that had been developed by the majority of the Long Term Study Group Committee. "I sketched out what we would try to do," he explains, "and Marjorie, Daley and I worked out the hairy details of trying to cope with this kind of poor hardware. By November, 1961," he notes, "we were able to demonstrate a really crude prototype of the system."[39]

They gave a seminar and demonstration with their prototype time-sharing system in November 1961. "That's the date that's branded in my mind," Corbato notes. "It was only a four-Flexowriter system. People were pleased that there were finally examples surfacing from [the work]. They did not view [it] as an answer to anybody's problem. We made the [first] demo in November 1961 on an [IBM] 709," he recalls. "The switch to the [IBM] 7090 occurred in the spring of 1962 at the Computation Center."[40]

Corbato describes how CTSS (Compatible Time-Sharing System), as the time-sharing system he was working on was called, couldn't go into operation until the transistorized IBM 7090 hardware had arrived and could be used in early spring of 1962.[41] Only then could they begin to deal with the real problems to make a working system.

Corbato gave a talk at a Conference about CTSS in May, 1962, but they still didn't have a working system running. By October, 1962, however, J. C. R. Licklider had accepted a position with ARPA under the U.S. Department of Defense on his condition that he would be allowed to implement the vision of interactive computing and time-sharing.

In November, 1962, Licklider and Fano both attended an unclassified meeting held for the Air Force in Hot Springs, Virginia. Fano had been invited to chair a session on Communications, and he and Licklider both attended some of the sessions on command and control. On the way back from the conference, on the train returning to Washington D.C., several people from the meeting were in the same car. They all chatted about what had happened and moved from seat to seat to talk to different people. "And I did spend quite a bit of time with Lick," Fano recalled, "and I understood better what he had in mind."[42]

Fano spent Thanksgiving Day 1962 thinking over the discussion he had had with Licklider. The day after Thanksgiving he had a meeting set up with the Provost at MIT, Charlie Townes. When he told the Provost what he had been thinking, the Provost told Fano, "Go ahead." Fano wrote out his thoughts in a 2 page memorandum that he distributed broadly around MIT. In the proposal, he put forward three goals: 1) time-sharing 2) a community using it and 3) education, which meant supporting research projects.

The following Tuesday, Fano met with Jay [Julius A] Stratton, then President of MIT. Fano was surprised that Stratton asked him which building he would use for the project, encouraging him to begin to implement his proposal.

In reviewing the period, Corbato described how Licklider went to ARPA "as a 'Johnny Appleseed' with a mission" and that was more than his superiors had expected. They tolerated it, Corbato observed, but Licklider was "the one who was driving it rather than them."[43] Lick added that while his superiors called for Command and Control, he made clear he was going to be involved with "interactive computing."[44] "I just wanted to make it clear," Lick noted, "that I wasn't going to be running battle planning missions or something. I was going to be dealing with the engineering substratum that [would] make it possible to do that stuff [command and control]."

Fano developed a funding proposal for Project MAC. It was submitted to ARPA. The contract was signed on July 1, 1963, the day the 1963 summer study began at MIT to demonstrate and create enthusiasm for time-sharing and interactive computing. "Time-sharing," Martin Greenberger recalled, "on the Computation Center machine was available on the opening day of the summer study project."[45]

When asked how he felt when he learned that there would be funding to develop CTSS as part of Project MAC, Corbato recalled, "Well, it was a cooperative thing. Nobody had license to run wild – but you had license to try to make something happen."[46] Corbato clarified, "I wasn't trying to start a company or anything like that; my goal was to exhibit it."

By mid October a second time-sharing computer was available for Project MAC. And it was operating within a week.

Reviewing the reasons for the success of Project MAC, Greenberger explained, "CTSS was an open system. It challenged the user to design his own subsystem, no matter what discipline he came from, no matter what his research interests."[47]

Fano significantly pointed out that one of the goals of Project MAC had not been achieved. This goal identified an important technical and social need that would inspire future networking developments. The ever developing and changing computer hardware and software posed the challenge of providing a support network for users, both locally and remotely. "One of our goals," Fano explained, "was to make the computer truly accessible to people wherever they were. We did not succeed. For people who lived in the community that used the system, it was fine. In any system like that, you keep learning things, you keep using new things, and so you keep having troubles. If you can go next door and say, 'Hey, I was doing this and something strange happened, do you know what I did wrong?' usually somebody in your neighborhood will be able to help you. If instead you are far away, you are stuck…. We tried to develop some way of helping remote users…. Well, we never did. So in fact, we failed to make the computer truly accessible regardless of the location of the user."[48]

Despite the problems, Greenberger observed, "I think one of the greatest successes was that CTSS gave so many people, with such widely different backgrounds, a system and experience that they would not have gotten any other way at that point." Fano explained the importance of developing time-sharing was not just in developing something technical. Rather, he noted, "I am really talking about the interaction of users in the sharing. That's important," he emphasized, "I feel that systems that do this as easily as time-sharing systems do not exist."[49] Remembering how Project MAC created an on-line community, Fano recalled, "friendships being born out of using somebody else's program, people communicating through the system and then meeting by accident and say 'Oh, that's you.' All sorts of things. It was a non-reproducible community phenomenon," he concluded.[50]

Offering his summary of the achievements, Corbato explained: "Two aspects strike me as being important. One is the kind of open system quality, which allowed everyone to make the system kind of their thing rather than what somebody else imposed on them…. So people were tailoring it to mesh with their interests. And the other thing is, I think, we deliberately kept the system model relatively unsophisticated (maybe that's the wrong word – uncomplicated), so we could explain it easily."[51]

The achievements of Project MAC and the other time-sharing systems built as a result of Licklider's tenure at ARPA provided the basis for the vision that would guide the development of the ARPANET.[52] In the paper, "The Computer as a Communication Device," Licklider and Robert Taylor predicted, "In a few years, men will be able to communicate more effectively through a machine than face to face…. We believe that we are entering into a technological age, in which we will be able to interact with the richness of living information – not merely in the passive way that we have become accustomed to using books and libraries, but as active participants in an ongoing process, bringing something to it through our interaction with it, and not simply receiving something from it by our connection to it."[53]

While they acknowledged that technical uses like the switching function were important in the transfer of information, such uses were not the aspect they were interested in. Instead they proposed that there was a power and responsiveness that online interaction with a computer made possible that would significantly affect the communication possible between humans using the computer.

Though they were familiar with commercial time-sharing facilities that called themselves "multiaccess," they explained that these had not succeeded in creating the kind of multiaccess computer communities that the academic and research time-sharing systems spawned.

They described these time-sharing communities, of which Project MAC was one of the early examples, as "socio-technical pioneers…out ahead of the rest of the computer world." They attributed this to the fact that some of the members of these online communities were computer scientists and engineers who understood both the concept of human computer interaction and the technology of interactive, multiaccess systems. Among the members of these online communities were creative people in different fields and disciplines who recognized the potential value of these multiaccess communities to their work. Thirdly, the online communities had access to large multiaccess computers and knew how to use them. Fourthly, they maintained that the efforts of those online had a regenerative effect.[54]

Elaborating on what they meant by regenerative, they wrote, that in the half dozen time-sharing on-line communities in existence during the 1960s, those doing research and development of computer systems and applications provided mutual support for each other. The product was a growing quantity of resources including programs, data, and technical know how. "But we have seen only the beginning," they predicted, "There is much more programming and data collection – and much more learning how to cooperate – to be done before the full potential of the concept can be realized." They go on to caution that these systems could only be developed interactively. And they explain that, "The systems being built must remain flexible and open-ended throughout the process of development, which is evolutionary."[55]

They also describe how there were systems that were advertising themselves via the same labels as "interactive," "time-sharing" and "multiaccess." But these were commercial systems and they found that there were distinct differences between the commercial systems and the academic and research time-sharing ones. The commercial systems did not offer the same "power", "flexibility" of software resources and the general purposeness that the research and academic time-sharing system at MIT, UCB, Stanford and SDC had made available to over 1000 people for a number of years.[56]

They discussed their vision of the future, predicting that linking up the existing online communities would create a still more powerful and important development – online super-communities made up of the existing communities created by the time-sharing systems. "The hope," they explained, "is that interconnection will make available to all the communities the programs and data resources of the entire super-community." They predicted that the future would bring "a mobile network of networks – ever changing in both content and configuration." And just as Licklider and Taylor realized that a time-sharing system was more than a collection of computers and software, Fano recognized that a time-sharing system was more than just a set of people using common resources; it was also a means of communicating and sharing ideas.[57]

Another time-sharing pioneer, Doug Ross, observed that Project MAC made CTSS available rather than waiting for the ideal technical system to be developed, as others had favored. By producing a prototype and encouraging others to contribute to it, CTSS had a significant impact on others who, therefore, had the ability to build into the system what they needed and to contribute so it would serve their needs. "I always say," Ross concluded, "you can't design an interface from just one side."[58] This quality of putting an open system out and encouraging people to contribute to it to make it what they needed, was building a human centered rather than technology centered system.[59]

Summing up the achievement of the Project MAC pioneers, John A. N. Lee, editor of two special issues of The IEEE Annals of the History of Computing which document the development of time-sharing and Project MAC at MIT, writes: "With the development of computer networking, which almost naturally followed on the development of time-sharing and interactive computing, it is as if the whole world now time shares myriad computers, providing facilities which were beyond the dreams of even the MIT researchers of 1960…. But this is where it started – with the ideas of John McCarthy, the implementation skills of Fernando Corbato, the vision of J. C. R. Licklider, and the organizational skills of Robert Fano."[60]

Part IV - The Implications

The pioneers of cybernetics and multiaccess computing who gathered at the MIT centennial in the Spring of 1961 to discuss the future of computing proposed that the crucial issue one must determine in trying to solve a problem is how to formulate the question. They expressed concern that the computer would bring great changes into our world and that people who understood the issues involved be part of setting government policy regarding these developments.

The pioneers also observed that there were opposing visions of what the future should be. One road was that of human-computer symbiosis, of a close interaction between the human and the computer so each could function more effectively. "The hope is that, in not too many years," J. C. R. Licklider wrote, "human brains and computing machines will be coupled together very tightly, and that the resulting partnership will think as no human brain has ever thought and process data in a way not approached by the information-handling machines we know today."[61] The other road was that of creating computers that would be able to do the thinking or problem solving without human assistance. Pioneers like Licklider explained that "man-computer symbiosis is probably not the ultimate paradigm for complex technological systems" and that in the future at some point "electronic or chemical 'machines' will outdo the human brain in most of the functions we now consider exclusively within its province." He maintained, however, that, "there will nevertheless be a fairly long interim during which the main intellectual advances will be made by men and computers working together in intimate association."[62] Though Licklider was willing to concede, "dominance in the distant future of celebration to machines alone," he recognized the creative and important developments that the partnership between the human and computer would make possible. He predicted that the years of human-computer symbiosis, "should be intellectually the most creative and exciting in the history of mankind."[63]

In the years following the development of CTSS and Project MAC and the linking of different time-sharing systems to create a super-community of on-line communities which became known as the ARPANET, the firm foundation set by CTSS and Project MAC and the helpful vision and direction set by Licklider and Fano and other pioneers of the period, gave birth to the sprawling and impressive networking communities that today we call the Internet and Usenet.

The pioneers of time-sharing and interactive computing provided a vision of human-computer symbiosis as an intellectual advance for humans. Online human-computer, and computer facilitated human to human communication was seen as the embodiment of this symbiosis. The vision of the computer pioneers of the 1960's, of human-computer symbiosis, and of creating a multiaccess, interactive, network of networks, or a super community network as they termed it, is the vision that can still fruitfully guide the work to build and extend the global computer network in the U.S. and around the world today.

Notes for Chapter 6

1. "The Project MAC Interviews," IEEE Annals of the History of Computing, Vol. 14 no. 2, 1992, p. 15. The interviews were conducted on October 18, 1988. They were in two group interviews/recollection exchanges. The interviewers were John A. N. Lee and Robert Rosin. The participants were Fernando J. Corbato, Robert M. Fano, Martin Greenberger, Joseph C. R. Licklider, Douglas T. Ross and Allan L. Scherr.

2. Martin Greenberger, ed, Management and Computers of Future, The MIT Press, Cambridge, Massachusetts, 1962, p. 8.

3. John R. Pierce, "Communication," *Scientific American*, Vol. 227 no. 3, September, 1972.

4. Ibid., p. 33.

5. Ibid., p. 41.

6. "Challenge Interview: Norbert Wiener: Man and the Machine", June 1959, in Collected Works of Norbert Wiener with Commentaries, Vol. 4, The MIT Press, Cambridge, Massachusetts, 1985, p. 717.

7. Norbert Wiener, Cybernetics: or Control and Communication in the Animal and the Machine, The MIT Press, Cambridge, Massachusetts, 1948, pp. 11-12. Wiener wrote, "In choosing this term, we wish to recognize that the first significant paper on feedback mechanisms is an article on governors, which was published by Clerk Maxwell in 1868…. We also wish to refer to the fact that the steering engines of a ship are indeed one of the earliest and best-developed forms of feedback mechanisms."

8. God and Golem, The MIT Press, Cambridge, Massachusetts, p. 71.

9. "A Scientist's Dilemma in a Materialist World," by Norbert Wiener, in Collected Works, Vol 4, p. 709.

10. Norbert Wiener, I Am A Mathematician, The MIT Press, Cambridge, Massachusetts, 1956, p. 171.

11. Norbert Wiener, Cybernetics, p. 1.

12. From "The Legacy of Norbert Wiener: A Centennial Symposium," Cambridge, Massachusetts, 1994, p. 19. Licklider, Fano, Minsky and other MIT pioneers refer to the important influence that being part of the RLE had on their subsequent work.

13. Ibid.

14. One of the reasons that a computer using vacuum tubes was not appropriate for a time-sharing system, according to Robert Fano, was that the "mean time between failures was seven or nine [hours]." See IEEE Annals of the History of Computing, Vol. 14 no. 2, 1992, p. 25.

15. Chronology from IEEE Annals of the History of Computing, Vol. 14 no. 1, 1994, p. 18. (Here after, Annals)

16. See Annals, Vol. 14 no. 1, 1992, p. 38 for a description of the frustrations of batch processing.

17. See Strachey, C. "Time sharing in large fast computers," Proc Int. Conf. on Info Processing, UNESCO, June, 1959, pp. 336-341. See also Frederick P. Brooks Jr., The Mythical Man-Month, Essays on Software Engineering, Reading, Massachusetts, 1972, p. 146.

18. See Annals, Vol. 14, no. 1, 1992, "John McCarthy's 1959 Memorandum," pp. 20-21. See also J. A. N. Lee "Claims to the Term Time-Sharing", ibid, p. 16-17.

19. "John McCarthy's 1959 Memorandum", p. 20.

20. Annals, vol. 14, no. 2, 1992, p. 16.

21. Ibid.

22. Ibid.

23. Interview by William Aspray and Arthur L. Norberg, Tape recording, Cambridge, Massachusetts, 28 October 1988, OH 150, Charles Babbage Institute, University of Minnesota, Minneapolis, Minnesota.

24. J. C. R. Licklider, "Man-Computer Symbiosis", IRE Transactions on Human Factors in Electronics, Vol HFE-1, pp. 4-11, March, 1960. Reprinted in In Memoriam: J. C. R. Licklider 1915-1990, Digital Systems Research Center, Palo Alto, California, August 7, 1990, pp. 1-19.

25. Ibid.

26. Ibid., p. 1.

27. Robert Fano, Transmission of Information, MIT Press, Cambridge, Massachusetts, p. .

28. "An Interview with ROBERT M. FANO," Conducted by Arthur L. Norberg on 20-21 April 1989, Cambridge, MA, Charles Babbage Institute, Center for the History of Information Processing, University of Minnesota, Minneapolis

29. The book was first published under the title Management and the Future of the Computer by The MIT Press, Cambridge, Massachusetts, in 1962 and later in hardback and paperback under the title Computers and the World of the Future. It was edited by Martin Greenberger.

30. Ibid., p. 24.

31. Ibid., p. 32.

32. Ibid., pp. 204-5.

33. Ibid., p. 205.

34. Ibid., p. 206.

35. Ibid., p. 207.

36. Ibid., p. 324.

37. Annals, Vol. 14 no. 2, 1992, p. 20.

38. Annals, Vol. 14 no. 1, 1992, p. 44. Teager's recommendations are described on pages 24-27. Excerpts from the Long Range Computation Study Group's recommendation for a time-sharing systems which resulted in Corbato's work on CTSS are in the same issue on pages 28-30.

39. "What we had done was [that] we had wedged out 5K words of the user address space and inserted a little operating system that was going to manage the four typewriters. We did not have any disk storage, so we took advantage of the fact that it was a large machine and we had a lot of tape drives. We assigned one tape drive per typewriter." Ibid., p. 45.

40. Ibid., pp.45-46. Corbato describes how he thought CTSS would be running on the IBM 7090 by the time he was to give a talk on it at the AFIPS Spring Joint Computer Conference in May, 1962. But that they were not able to get it running by the time the paper was presented. Despite his disappointment, the paper is an important historical document. See "An Experimental Time-Sharing System," by Fernando J. Corbato, Marjorie Merwin-Daggett, Robert C. Daley, Proceedings of the American Federation of Information Processing Societies, Spring Joint Computer Conference, May 1-3, 1962, Vol. 21, pp. 335-344.

41. It was called the Compatible Time-Sharing System as it was developed in the Computation Center and so had to be compatible with the batch system running there.

42. Annals, Vol. 14 no. 2, pp. 21-22.

43. Ibid., p. 24

44. Ibid.

45. Ibid., p. 26. Fano explained that Licklider wanted interactive computing with time-sharing. He notes that "one was the 'tool' the other the 'goal'. This is where the name MAC came from. There was a goal and there was a tool – the tool that was most appropriate at that time." He goes on to explain that there had been the vision on the part of people like John McCarthy and later Licklider "of what could come out of it when you started building a computer utility. It didn't exist then. It didn't exist until the time of Project MAC because it was just that year that Corby finished the model that really could serve a community. It didn't exist before." Ibid., p. 23.

46. Ibid. p. 26.

47. Ibid. Greenberger describes how he designed a subsystem for CTSS where students created a set of commands to simulate stock market, accounting, production scheduling, online modeling, etc. They put these commands together into a system under CTSS that they called OPS, (On-line Programming and Simulation). Ibid., p. 27.

48. Ibid., p. 31.

49. Ibid., p. 35.

50. Ibid.

51. Ibid., p. 33.

52. By Fall, 1967, there were 35 time-sharing systems operational or planned, at research and academic sites, mainly in the U.S., according to the "Time-Sharing System Scorecard." ("Prolog to the Future", Annals, Vol. 14, no. 2, p. 42-47.) The scorecard also lists 15 commercial time-sharing installations being planned or in existence.

53. "The Computer as a Communication Device," IRE Transactions on Human Factors in Electronics, volume HFE-1, pages 4-11, March 1960, as reprinted in "In Memoriam: J. C. R. Licklider: 1915-1990", Palo Alto, August 7, 1990, p. 21.

54. Ibid., pp. 30-31.

55. Ibid., p. 31.

56. The time-sharing systems they are describing are listed in the "Time-Sharing System Scorecard" as having been begun in the following years:
MIT [Project MAC at MIT begun in May, 1963],
UCB [Project GENIE at the University of California at Berkeley begun in April, 1965],
Stanford University [Stanford, California begun in August, 1964],
and SDC [Systems Development Corporation in Santa Monica, California, begun in August, 1964].

57. Corbato explains that Robert Fano "correctly saw that a time-sharing system was more than just a set of people using common resources; it was also a means of communicating and sharing ideas." Annals, Vol. 14 no. 1, p. 48.

58. Ibid., p. 51.

59. Annals, Vol. 14, no. 2, one of the interviewers, Robert Rosin noted, "You see, if what you're trying to do is optimize technical resources (physical resources), Herb's point of view was exactly right. If you try to optimize the use of human resources, then the point of view you were taking was a lot closer to reality."

60. Annals, Vol. 14, no. 1, p. 3-4.

61. "Man Computer Symbiosis," p. 3. Licklider proposes the role that each partner will play in the symbiotic relationship. The human partner will "set the goals, formulate the hypotheses, determine the criteria, and perform the evaluations." The computers "will do the routinizable work that must be done to prepare the way for insights and decisions in technical and scientific thinking." p. 1.

62. Ibid., pp. 2-3.

63. Ibid.

MAC is an acronym that has had several explanations, including Machine Aided Cognition, MAN and Computer and Minsky against Corbato, according to Peter Elias, in the 25th Anniversary Project MAC Time Line.

Thanks to Tom Van Vleck, Alex McKenzie and to Fernando Corbato for pointing out sources that were helpful in doing the research for this paper. Also, thanks to Scott Dorsey who suggested I try to find out about Project MAC. Another source which covers this material in a way that is helpful is “The Evolution of Interactive Computing Through Time-Sharing and Networking” by Judy Elizabeth O'Neill, June 1992. The interviews in the IEEE Annals of the History of Computing Special Issues (Vol. 14 no. 1 and no. 2) are an important source of information about the period. They are supplemented by interviews that are available from the Charles Babbage Institute.
