Creating the Vision for the Internet

From the Wiener Circles to Licklider and ARPA's Information Processing Techniques Office (IPTO)

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> "I believe that we are indeed participating in an intellectual revolution, that the approach to the solution of difficult, complex, recalcitrant problems offered by on-line man-computer information processing will during the next decade or so revolutionize an important part of our collective intellectual processes....The effect of bringing geographically distributed users into network-mediated interaction seems likely to be greater than the effect that can be achieved through multi-access interaction in any local community... A promising aspect of the information-network idea is that, through information networks, intellectual community may be achieved despite geographical distribution." J.C.R. Licklider 1967

J.C.R. Licklider's vision is widely recognized as having had an important impact on the development of the Internet.[1] The connection between this vision and the cybernetic movement Licklider had been part of, however, is not generally recognized.[2] My article will explore how Licklider's vision is a logical outcome of the cybernetic movement and its concerns. Furthermore, examining Licklider's connection with the cybernetic circles, as well as with the science of information processing techniques, helps one to understand the source and nature of Licklider's vision.

An important problem was identified by the cybernetic circles of the 1940s and 1950s. The problem concerns the nature of systems with human and computer components. In such systems, it is essential to determine which functions should properly be assigned to the human and which functions should be assigned to the computer. This is a subset of a more general problem, the problem of systems with human and machine components. This problem is identified by Norbert Wiener in his book *God and Golem* [Wiener, 1964: 71]. The solution of this problem is at the heart of the development of cybernetic systems like the Internet. More recently, an Internet pioneer proposed that a goal of computer and networking research is "to enable computers to collaborate intelligently on solutions to human problems."[Kahn, 1987: 128]

Wiener clarifies the difficulty of this goal. He offers the familiar story of the "Sorcerer's Apprentice" or the "Monkey's Paw" as analogies of the problem.[3] In these accounts, a human has a wish, but it is carried out by an agency that lacks the human understanding of the constraints on how the wish is to be granted. Wiener recognizes the need for serious attention to the constraints to be invoked when engineering automated systems to accomplish human goals. Wiener also proposes that it is important to understand the highly evolved capacity of the human brain, especially with regard to its capacity to identify and solve human and social problems.

Wiener notes that the human is highly developed in the "ability of the brain to handle vague ideas as yet imperfectly defined."[Wiener, 1964: 73] Recognizing this capability of the human brain, he proposes the value of studies of what he calls "mixed systems." These will be systems involving both human and mechanical (machine) elements.[Wiener, 1964: 73]

Describing a problem, Wiener writes:

> A goal-seeking mechanism will not necessarily seek 'our' goals, unless we design it for that purpose, and in that design we foresee all steps of the process for which it is designed, instead of exercising a tentative foresight which goes up to a certain point and can be continued from that point as new difficulties arise. [Wiener, 1964: 63]

How to anticipate new difficulties that can arise is another problem recognized by Wiener. He explains, "The penalties for errors of foresight, great as they are now, will be enormously increased as automatization comes into full view."[Wiener, 1964: 63] Discussing the difficulty of human goals being achieved indirectly with the direction to attain them being given to others, Wiener writes:

> While it is always possible to ask for something other than what we really want, this possibility is most serious when the process by which we are to obtain our wish is indirect, and the degree to which we have obtained our wish is not clear until the very end. Usually we realize our wishes, insofar as we do actually realize them by a feedback process, in which we compare the degree of attainment of intermediate goals with our anticipation of them. In this process, the feedback goes through us, and we turn back before it is too late. If the feedback is built into a machine that cannot be inspected until the final goal is attained, the possibilities for catastrophe are greatly increased. [Wiener, 1964: 62]

Here Wiener identifies the crucial role that continuing feedback plays. This is to determine and make needed changes in the course of the development of a system, as the system is evolving. In the introduction to his book *Cybernetics* published in 1948, Wiener reflects on the experience he had in the 1930s which helped him to conceive of the science of cybernetics. He describes the monthly discussion group he was invited to, led by Dr. Arturo Rosenblueth at Harvard University.[4] An important aspect of these discussions for Wiener, was the focus on the nature of communication from different scientific perspectives. Wiener reports that scientists in different fields of study were invited to the group to encourage an interdisciplinary approach to the problems of communication and the scientific method. He 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 around the 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. [Wiener, 1948: 7]

Dr. Rosenblueth was a Professor of Physiology at the Harvard Medical School. Both he and Wiener shared the belief that science had to be a collaborative endeavor.

Contrary to the popular image portrayed in the mass media, the Internet is not just computers, software and other technology. The Internet that Licklider and other early networking pioneers envisioned, and helped to make a reality, is a system that includes the human and the computer. The nature of each and of the relationship between these different components, is the question at the heart of both the science of cybernetics, and of the research for the continuing development of the Internet. In this light, it is helpful to understand how Wiener's work influenced Licklider.

Licklider reports that he was influenced by the intellectual ferment in the 1940s around the development of the new science of cybernetics and of information processing. As a neuroscientist interested in the problems of communication and human-computer systems, Licklider did his PhD thesis study on the localization of the perception of sound in the brain of the cat.[5] Continuing his study after his PhD, he did a post doctorate in Gestalt psychology. Gestalt psychology involves looking at the whole rather than focusing on parts and in this way being able to conceptualize systems. In the early post WWII period, Licklider attended study circles discussing Wiener's cybernetic theories. In an interview, Licklider was asked how he became interested in digital computers. He responds:

> LICKLIDER: Well, there was tremendous intellectual ferment in Cambridge after World War II. Norbert Wiener ran a weekly circle of 40 or 50 people who got together. They would gather together and talk for a couple of hours. I was a faithful adherent to that. When I was at Harvard, I came down here and audited Wiener's...series.... Then there was a faculty group at MIT that got together and talked about cybernetics and stuff like that. I was always hanging onto that. Some of it was hard for psychologists to understand. But Walter Rosenblith was understanding and he did a lot of explaining to me.... Routinely we'd talk about it on the way down in the car, and then listen to this stuff. Then on the way back, Walter would more or less explain it to me. (laugh) Digital stuff was big in all of that.... [Licklider, 1988: 13]

Licklider is describing a set of meetings Wiener set up near MIT after WWII. Robert Fano, also an active contributor to the Wiener circles, describes the impact of the Wiener seminars on Licklider. Fano writes:

> The immediate postwar period was also a time of intense interdisciplinary activity in the Cambridge research community, centered on Norbert Wiener's notion of cybernetics, or control and communication in the animal and the machine. Lick became an active member of that community and an assiduous participant in the weekly gatherings led by Wiener. He learned the models and analytical tools of the new statistical communication theory propounded by Wiener, which soon began to pay dividends in his research on hearing. [Fano, 2000: 2]

Similarly, in the early post WWII period, the Josiah Macy Jr. Foundation agreed to sponsor a set of conferences about the nature of 'communication and control' in animals and machines and about information theory. These conferences played an important role in the development and spread of this new science. At the Macy conferences the atmosphere was to be kept informal. The meetings usually took place over a two day period and only two or three speakers would be planned each day, to keep time available for discussion and communication among the participants. The participants were encouraged to challenge each other.

The Macy foundation specialized in support for interdisciplinary scientific exchanges. Licklider was invited to make a presentation to the 7th Macy Conference on Cybernetics in 1950. Licklider had experience and background in electrical engineering. Also he used electronic equipment to do his scientific research. His research linked the biological sciences and engineering. The paper he presented was titled, "The manner in which and extent to which speech can be distorted and remain intelligible."[6]

A stenotype transcription was kept for the last 5 Macy Foundation conferences, starting in 1949, including the conference Licklider attended. These notes were transcribed and edited by Heinz von Foerster. They were published in 5 volumes by the Josiah Macy Jr. Foundation under the title "Cybernetics – circular, causal and feedback mechanisms and biological and social systems". It wasn't easy to make a publication out of the transcribed notes of the conferences, as the discussion had interruptions and could be difficult to follow. The importance of the publications of the conferences is explained by Frank Freman-Smith, the Medical Director of the Macy Foundation. He writes:

> By preserving the informality of our conferences in the published transactions, we hope to portray more accurately what goes on in the minds of scientists and of the interdisciplinary group explaining this phenomena. [von Foerster, 1953: ix]

The Macy Foundation conferences on Cybernetics appear to have provided a model for Licklider. The 10th and last conference was in 1953. The following year, in 1954, a similar conference was arranged under the sponsorship of the US National Science Foundation (NSF) at MIT. It was organized by Licklider and several other psychologists including F. C. Frick, G. A. Miller, W. R. Garner, and E. B. Neuman. The title of this conference was "Problems in Human Communication and Control". It was held on June 15–17 1954. A tape was made of the conference. Licklider edited the notes from the tape. The manuscript was subsequently published in a bound volume as the paraphrased transcription of the conference, much like the volumes published of the Macy Conferences on Cybernetics.

Among the participants whose contributions to the discussion were included were mathematicians like Norbert Wiener, physiologists like Walter Rosenblith, and computer scientists like G.G. Farley, Robert Fano, and Oliver Selfridge. This NSF conference is a link between the Wiener circles and Licklider and the development of the Internet. The proceedings provide a window from which to look at the process and content that was influential in forming the vision for the birth of the Internet and its development. This process was one of creative discussion and dialogue. The content was the discussion of research in cybernetics and information processing.[7]

Among the many questions explored at this conference was a conversation Licklider had with Wiener about how cybernetics is applicable to the problem of providing leadership for scientific research. Wiener explains that he is working on a new book to examine this problem, the book *Invention*. Wiener proposes that it is necessary to have the leadership of a scientific laboratory in the hands of a researcher who can identify significant research even in its earliest form. In this discussion, Licklider and Wiener explore how to establish a geographically dispersed community of skillful researchers. This discussion provides a model for the Intergalactic Network that Licklider would introduce in 1962 when he was invited to the Advanced Research Project Agency (ARPA) to create a computer science research community.

After the 1954 NSF conference, Licklider got a grant to conduct a study that was to have a significant impact on his future work and on the future of computer technology. The grant was to record the process of the scientific work he was doing and to categorize the nature of his activities. Licklider conducted this research in the Spring and Summer of 1957. The effects of this study surprised him. He found that 85% of his time was spent getting into a position to think, often doing tasks like gathering data, making graphs, and other tedious work. Only 15% of his time was available to think about the data, to make decisions or to gain an insight.

As a result of this research, he wrote a paper titled, "Man Computer Symbiosis". The paper was published in March 1960. It describes a dependency relationship between what Licklider considers as two different species, the human species and the computer species. The paper proposes a new conception of the relationship between the human and the computer. Licklider called this relationship 'symbiosis':

> The fig tree is pollinated only by the insect 'Blastophaga grossorum'. The larva of the insect lives in the ovary of the fig tree, and there it gets its food. The tree and the insect are thus heavily interdependent: the tree cannot reproduce without the insect; the insect cannot

> eat without the tree; together, they constitute not only a viable but a productive and thriving partnership. The cooperative 'living together in intimate association, or even close union, of two dissimilar organisms' is called symbiosis. [Licklider, 1960: 1]

In the paper, Licklider describes the different functions of each species. He writes:

> [M]en will set goals, formulate the hypotheses, determine the criteria, and perform the evaluations. Computing machines will do the routinizable work that must be done to prepare the way for insights and decisions in technical and scientific thinking… [T]he symbiotic partnership, will perform intellectual operations much more effectively than man alone can perform them. [Licklider, 1960: 1]

This relationship was a way to implement the proposal that Wiener made in *God and Golem*, to study the appropriate function of the human and computer components of the mixed system. Licklider's 1960 paper includes a technical research program to create the needed computer development for the computer to be able to fulfill its part of the partnership. More importantly, Licklider proposes a vision for the future development of human and computer systems. He writes:

> The hope is that, in not too many years, 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 of today. [Licklider, 1960: 2]

Licklider envisioned a continuum of the abilities of the human mind and of the computer. The computer could then be involved in carrying out some of the steps in the problem solving process for the human. He presented his research about this continuum at a NATO Symposium on Communication Processes held by the NATO Advisory Group on Human Factors. Licklider wrote:

> Because the field of man-computer communication is burgeoning, it will be necessary to select only a few of many problems. These problems are being studied and, indeed, some of them are being solved in a concerted program...The problems are multidisciplinary. The effort involves mathematicians, logicians, linguists, electrical engineers, and computer scientists as well as psychologists. [Licklider, 1965: 260]

Describing the spectrum of ability of the human, up to where the computer can be helpful, Allen Newell, another computer science pioneer and a close colleague of Licklider's, elaborates:

> A spectrum of increasing specification goes on in the human, which we can roughly picture as follows: → goal → idea of solution → detail of solution → computer. At the far left the human already has some way of recognizing, the adequacy and desirability of results.

> Clearly several stages of prior ill-definition exist even further to the left. But a long way also exists toward the right before the procedures for solving the problem are well enough defined to be communicated to a computer, using current programming languages. [Newel, 1965: 241]

Newell's research explored how a computer could do a form of heuristic thinking once the problem to be solved was understood. He writes:

> This paper is concerned with communication just prior to where the man has full detail. It asks how it is possible to communicate with the computer when the man does have an idea of what he wants done, but before he has fully developed and checked his procedures for doing it. It is not concerned with how the man discovers the basic ideas of his solution or how a computer might help him in this respect. [Newel, 1965: 241]

Licklider took a more difficult problem to solve: the problem of how to identify the question that is at the essence of a difficult problem. This is within the most skillful heuristic capabilities of the human.[8] This is similar to that which Claude Shannon described as the capability for creative thinking. Shannon describes his understanding of intelligence as the process of taking a problem no matter how difficult and finding a way to make progress with it. Shannon writes:

> (...)you have to have some kind of a drive, some kind of a desire to find out the answer, a desire to find out what makes things tick. If you don't have that, you may have all the training and intelligence in the world, you don't have questions and you won't just find answers. This is a hard thing to put your finger on. It is a matter of temperament probably; that is, a matter of probably early training, early childhood experience, whether you will motivate in the direction of scientific research... my feeling is that a good scientist has a great deal of what we can call curiosity. He's just curious how things tick and he wants to know the answers to questions; and if he sees things, he wants to raise questions and he wants to know the answers to those... I mean a constructive dissatisfaction... In other words, there is continually a slight irritation when things don't look quite right; and I think that dissatisfaction in present days is a key driving force in good scientists. [Shannon, 1952]

The power of Licklider's work is that he took up the problem of providing for human computer interaction at the furthest point in the continuum of human capability. Licklider took as his concern the whole domain of intellectual processes. At a conference 2 years earlier at MIT in 1961, Licklider elaborates on his view of the importance of the human role in the human computer symbiosis. He refers to the university as the institutional setting to support this scientific development. He explains:

> Let me report, briefly, that preliminary analysis of technical and scientific creative activity suggests that such activity consists of short intervals of insight, invention, and decision making interspersed among long intervals of 'staff operations.' Most of the researcher's

time, most of the scholar's time, most of the student's time is spent in getting into position to take a step, and only a small part of it is spent in taking the step. No one knows what it would do to a creative brain to think creatively continuously... When we have this computer, after the several necessary years of programming, language developing, computer designing, and so forth, I think it will participate in almost every intellectual transaction that goes on in the university. Right now, of course, the computer solves preformulated problems mainly of a numerical nature. In due course it will be part of the formulation of the problems; part of real-time thinking, problem solving, doing of research, conducting of experiments, getting into the literature and finding references you want. It will be part of this for, I think, all the people... In not so many years... it will be regarded less as a handmaiden than as a partner. [Greenberger, 1962: 206]

Licklider was hopeful that, "Through its contribution to formulative thinking," the computer would make it possible to "understand the structure of ideas, [and] the nature of intellectual processes..." He predicted that, "Although one cannot see clearly and deeply into this region of the future from the present point of view... 'information processing,' ...will one day be the field of a basic and important science... One of the most important present functions of the digital computer in the university should be to catalyze the development of that science." [Greenberger, 1962: 207]

Because of his interest in the human and the augmentation of human intellectual capabilities, Licklider was at the human end of the spectrum of research in self organizing systems.[9] Therefore, it would seem surprising for Licklider to be invited to give the keynote talk at a conference on 'self-organizing learning systems.' Acknowledging the unusual nature of his topic, "Interactive Information Processing" as the keynote for such a conference, Licklider writes:

My first obligation is to explain why I think it appropriate to discuss interactive information processing as a way of leading into, and indeed a keynote of, this conference.To put it in a nutshell: I think that interactive information processing is the key to the understanding and synthesis of systems that adapt, organize themselves, learn, and do the other sophisticated things that are to be discussed regarding self organizing systems. [Licklider, 1967: 1]

Licklider believed that developing human computer interactivity was critical to progress in the development of self organizing or adaptive systems. There is a need for such interactivity and collaboration between researchers to develop the self organizing or adaptive systems that the papers at the conference discussed. He outlines 3 stages in the development of the intellectual revolution he is envisioning [Licklider, 1967: 3–4]:

- The first stage is where 'man' and 'computer' are closely intertwined so that the heuristic capabilities of the human can be intertwined with the algorithmic capabilities of the computer. This is the lowest stage of intellectual advancement he is envisioning. For this stage, it is crucial to establish human-computer interaction. There is a need to have libraries of software that make such interaction possible, displays and other kinds of hardware, and languages (he asks for problem-oriented languages) that will be helpful in carrying out this early stage.

- The second stage he describes is the stage where human-computer interaction has been achieved. For this stage he refers to the communities that developed from the time sharing systems that were developed with ARPA's support. These communities hadn't been anticipated. What was observed was that there was 'community cooperation which could make it possible to develop a large and comprehensive software base to support man-computer interaction in a variety of fields.'

Licklider predicted that there would be important developments when interactive computing was introduced into a creative intellectual community. He proposed, however, that there was still much to do 'to develop the techniques for facilitating cooperation and fostering a coherent community software effort....' This presented a need to experiment and deliberately develop such cooperative techniques if the needed software was to be developed in a short period of time.

- The third stage Licklider describes is the stage of networks of geographically distributed computers where there are people on line and computers connected.

When Licklider gave his keynote talk at this conference in 1966, he was able to give numerous examples of the kind of interactive programs that would make it possible to turn his vision into reality. "I am convinced," he writes, "that so many parts of it already exist and operate, that it is a realizable vision and not merely a dream." [Licklider, 1967:8–9]

Licklider believed that a crucial component for the realization of his vision would be the creation of computer networks. Though, at the time, there were "no general purpose networks of geographically distributed computers to point to as examples...." [Licklider, 1967: 6] There were discussions of such networks. He pointed to the conditions that would make it possible to develop these networks. These included:

> a)"The technologies of computation and communication were ripe for a fusion that would make it possible for geographically distributed computers to be able to 'talk' to one another in such a way that would facilitate geographically distributed users being able to 'communicate and cooperate with one another in joint interaction with stored information.' [and]
> b)"The effect to be achieved by bringing 'geographically distributed users into network-mediated interaction seem(ed) likely to be greater than the effect that can be achieved through multiple-access interaction in any local community.' Under previous conditions it had been too difficult or expensive to gather the critical mass needed to work on a difficult problem. But with the development of interactive networks the needed intellectual community would be able to be achieved despite the geographical separation. " [Licklider, 1967: 4]

Licklider explains that, "for a long time the advances in adaptive, self-organizing and learning systems will have mainly the effect of making computers better partners for men – and, of particular significance to this conference, better partners for men engaged in research in computer and information science." [Licklider, 1967: 4] He also describes the need for public directories of useful programs (he uses the word library here) as practical research to be encouraged and the need for creative users to use the programs and to "augment" them through use.

In order to create the basis for such a system, however, there would need to be the proper framework established. An initial system would need to be designed which would be able to "foster creative use and facilitate self-augmentation." [Licklider, 1967, 7] This was the key to creating a "dynamic, self-augmenting system for creative information processing." The framework for such a system would need to "discourage piecemeal proliferation and yet be flexible and open-ended enough to invite creative" contributions. [Licklider, 1967: 7]

In the 1960s, Licklider propagated this vision by referring to "an intergalactic network". [Licklider, 1963a: 1] This would be the logical extension of building networks to link the open-ended, creative, intellectual communities that had been developed through IPTO's time-sharing research. This was his way of presenting a vision to inspire the technical community. The vision proposed collaborative networks of humans facilitated via computers. Licklider envisioned that these networks would think in a much more effective way than ever possible for the human alone.

Not long after the publication of Licklider's seminal paper "Man Computer Symbiosis", he and Wesley Clark (who had taught Licklider to use the TX-O computer at Lincoln Labs at MIT) presented a joint paper at a conference. The paper is titled "On-line Man-Computer Communication". In this paper, Licklider and Clark describe the importance of communication between the human and the computer, and consider how it can be achieved. They write:

> More and more people are sensing the importance of the kinds thinking and problem solving that a truly symbiotic man-computer partnership might accomplish. [Licklider, 1962: 113]

They outline the capabilities of the human and of the computer. They list 10 functions that they propose are essential for creative intellectual work. These functions include those performed best by a computer, those performed best by a human, and those which either the human or the computer excel in. The functions they list which the human excels in include [Licklider, 1962: 114] :

a) to select goals and criteria – human;
b) To formulate questions and hypotheses – human;
c) To select approaches – human;
d) To detect relevance – human;
e) To recognize patterns and objects – human;
f) To handle unforeseen and low probability exigencies – human;

The functions on their list which both humans and computers excelled in include:

g) To store large quantities of information – human and computer; with high precision – computer;

h) To retrieve information rapidly – human and computer; with high precision – computer;

The functions that computers excelled in at the time include:

i) To calculate rapidly and accurately – computer;

j) To build up progressively a repertoire of procedures without suffering loss due to interference or lack of use – computer

Licklider proposed that there would be a need to improve the capability of the computer, if the computer was expected to help the human to solve human problems. Licklider's paper, "Man Computer Symbiosis", included a technical research program to improve the computer. The technical research program he outines in 1960 is still pioneering in its scope and some of the technical goals he identified have not yet been achieved. The anniversary of both his paper and the research program he proposed, provides an occasion to look back at both the goal and the research objectives he identified to evaluate how far we have come.

In 1962 something else important happened. Licklider was invited to join ARPA. ARPA had been created in 1957 within the U.S. Department of Defense. Its mission was to prevent future technological surprises to the U.S. government, such as occurred when the former Soviet Union launched Sputnik in 1957. Licklider soon created an office for research in computing which he called the Information Processing Techniques Office (IPTO). Also he created an office for research in behavioral science. Licklider was the director of these two offices from 1962–1964. The Behavioral Science Office ended after a short while. The IPTO, however, lasted until 1986. In the brief first term of his leadership of IPTO, Licklider created a model and disseminated a vision that guided the majority of the directors of the IPTO who followed him till the office ended. Commenting on Licklider's role in the development of IPTO, Fano writes:

> Much of the credit should go to Lick for starting the program on the right track with policies from which his successors did not materially depart. It was structured like no other government research program, akin to a single widely dispersed research laboratory, with a clear overall goal, with Lick acting as its director and intellectual leader. He fostered close communication and collaboration among all parts of his far flung laboratory, thereby creating what became known as the ARPA community. [Fano, 2000: 6]

Fano also recalls how Licklider's vision and program had its opponents. Licklider did not have an easy time advocating his vision and the processes needed to implement it. Describing Licklider's critics, Fano recalls:

> They believed that online use of computers was wasteful, and therefore, that the whole program constituted a waste of government funds. But Lick stood his ground, and time proved them wrong. They had missed Lick's main point that computers, although still expensive, could be produced on demand, while creative, competent people could not. [Fano, 2000: 6]

The crux of Licklider's vision is the jointly improving evolution of the human and the computer.[11]

In conclusion, Licklider, with help from others in the Wiener circles, like Walter Rosenblith, translated Wiener's writings into a positive vision, along with a program for its implementation. Licklider initiated the IPTO, an institutional form to make it possible to implement his technical research program and plan for a human-computer online community. Licklider describes the means to achieve his vision in a number of articles and papers. He integrates the constraints that need to be fashioned as the computer evolves, along with the developments that should be supported. Licklider also proposes a socio-technical process where the best of the human invents the best of the computer. Conversely, the best of the computer makes it possible for the human to excel. This is a means to achieve the human computer symbiotic partnership that the interaction between the human and the computer make possible. As Licklider and Clark proposed, "We must amalgamate the predominantly human capabilities and predominantly computer capabilities to create an integrated system for goal-oriented on-line-inventive information processing." [Licklider, 1962: 114]

Licklider's vision has been proven to be a viable vision. This is demonstrated by the computer achievements such as time sharing, interactive graphics, VLSI, the development of the ARPANET, and then of the Internet. It is also demonstrated by the leadership provided by the Information Processing Techniques Office in the birth and development of the Internet. The far reaching scope of Licklider's objectives and his plan for implementation raise the question of whether the goal he identified is still an appropriate goal and if so what the scientific and technical objectives are to further the human computer symbiotic systems that he envisioned.

Key to Licklider's vision for the development of the computer and of the human computer relationship is his view that the most important goal in developing the computer is to be able to augment human intellectual power just as earlier machinery augmented human muscle power. The most desired goal, according to Licklider, is to create, in the words of Walter Rosenblith, a self modifiable quasi symbiotic system that will combine the ever improving human and ever improving computer.[12] This vision has become embodied in the birth and continued development of the Internet.[13]

Fano, assessing Licklider's achievement, observes:

> Lick's legacy is obvious to anyone old enough to be familiar with the state of computers and their usage in 1960, when he published his famous paper on man-computer symbiosis. His vision, which was science fiction at that time, is now a reality and is taken for granted by people around the world. The Internet is the embodiment of the 'inter-galactic network' he was talking about with glee as far back as 1963. [Fano, 2000: 8]

The Internet is still young. A human-computer relationship and interaction is at the core of the birth of the Internet and of its successful development. The recognition of the importance of this partnership for the successful development of computer and communications science grew out of the post WWII cybernetic discussion circles. Licklider was a participant in these circles and a contributor to them. The vision he developed, of the need for human-computer interactive collaborative networking communication, inspired the scientific and technical development of the Internet. An understanding of the roots and nature of this vision continues to be critical for the Internet's continued development.[14]

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Notes

1 See for example, Michael Hauben, “The Vision of Interactive Computing and the Future”, Chapter 5 in M. Hauben and R. Hauben, *Netizens: On the History and Impact of Usenet and the Internet*; K. Hafner and M. Lyon, *Where Wizards Stay Up Late*; Simon & Schuster, New York, 1996 and J. Naughton, *A Brief History of the Future: Origin of the Internet*; Phoenix Paperback, London,1999.

2 See for example, Chapter 6 in M. Hauben and R. Hauben, *Netizens* and Chapter 8 in Jérôme Segal: *Théorie de l’information : sciences, techniques et société de la seconde guerre mondiale à l’aube du XXIe siècle,* Faculté d’Histoire de l’Université Lyon, Lyon, 1998. Some historians claim that Licklider’s vision developed separately from the cybernetic movement.

3 *God & Golem, Inc.*; 57–59.

4 *Cybernetics*: 7.

5 Licklider, 1942

6 Licklider, 1951

7 Licklider, 1954

8 Heuristic activity is that activity which follows upon hunches and is used to formulate the question and to revise it. It is activity which makes possible invention, formulates problems, and is able to solve difficult problems. Algorithmic activity is the activity which follows, rapidly and accurately, instructions or procedures which have been pre-specified in advance. [See Licklider, 1965: 224] An integration of heuristic and algorithmic activity is needed to solve difficult problems, because of the nature of the process of trying to solve a difficult problem. Licklider explains, “One of the things that makes a problem difficult, of course, is to have a large space of possible solutions. Another thing that makes a problem difficult is not to have a structure, known ‘a priori’ that relates partial solutions to complete solutions, that organizes hypotheses, or that suggests or limits or constrains approaches. Some problems that have the two properties just mentioned have also a third property that makes them extremely difficult. They are penetrated only a little way by any hypothesis, and to make matters worse – much detailed and necessary precise information processing is involved in testing any hypothesis.” [Licklider, 1967: 2]

9 Licklider explains why human computer interactivity is so important: “The fundamental hypothesis of those of us who advocate close man-computer interaction is that, in most creative intellectual

activity – most thinking, judgment, evaluation, problem solving, decision making – heuristic and algorithmic processes are intimately interwoven. If that hypothesis is correct, one does not have to look further to see why efforts to allocate tasks either to man or to computers have been unsatisfactory, why the computer programs for a new information processing system cost more and take longer to acquire than the computer itself, why military commanders speak of being hemmed in by computers more often than being aided by computers... Thus at the present time, man (or 'life') is the sole source of heuristic power. And, therefore, man-computer interaction is essential to effective use or exploitation of computers." [Licklider, 1965: 224–225]

10 [Licklider, 1960: 7–15]

11 Ronda Hauben, "The Information Processing Techniques Office and the Birth of the Internet A Study in Governance," http://www.columbia.edu/~rh120/other/misc/lick101.doc

12 Walter Rosenbleuth outlines this goal in a helpful way at the 1960 MIT lectures on *Management and the Computer of the Future.* As a discussant for a talk by Claude Shannon, Rosenbleuth responds, "Our distinguished chairman has reformulated the topic as the challenge of the 'parallel race.' My inclination is to substitute coexistence and cooperation for competition. The real challenge then consists in creating a novel, more powerful, self-modifiable, quasi-symbiotic system that will combine the assets which a long evolution has bestowed upon man with those which man's inventiveness has bestowed and will bestow upon the computers of tomorrow. I am therefore less tempted to stress what computers can do better than men than to envisage the benefits that we might derive from an intelligent division of labor between man and computer. Such arrangements are very likely to enhance human capacities in just those areas that are crucial to the functioning of a world whose technology is rapidly evolving. Both the industrial revolution, which bore the imprint of the steam engine, and the cybernetic revolution of automation, which is symbolized by the computer, have given rise to difficulties. These difficulties affect the coupling of man to his devices as well as relations between men. Both revolutions also drastically altered man's image of himself. The promise of the cybernetic era resides in the fact that the new technology may prove capable of providing more than mere substrata for a rational flow of communication and control messages; it is likely that it will furnish some of the needed tools for the development of the sciences of man. We may thus obtain the instrumentalities for the successful management of human wants and institutions, and perhaps even for the self-management of human behavior." [Greenberger, 1962: 311–312]

13 Ronda Hauben, "The Internet: On its International Origins and collaborative Vision," "EuroNets-EuroChannels-EuroVisions" Workshop, May 15-17, 2003, ETH Zentrum, Zurich, http://www.columbia.edu/~rh120/other/birth_tcp.txt

14 Boldur Barbat, "Book Review: *'Netizens: On the History and Impact of Usenet and the Internet', Studies in Informatics and Control,* December 1998, Vol. 4 No 4. www.ici.ro/ici/revista/sic98_4/art06.html

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