

An Interview with

Willis H. Ware

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Conducted by Jeffrey R. Yost

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### Abstract

Distinguished computer scientist, longtime head of the Computer Science Department at the RAND Corporation, and pioneer and leader on issues of computer security and privacy discusses the history of Computer Science at RAND. This includes the transition of RAND to digital computing with the Johnniac project, programming and software work, and a number of other topics. Dr. Ware relates his work with and role and leadership in organizations such as ACM, and AFIPS, as well as on the issues of computer security and privacy with the Ware Report on computer security for the Defense Science Board committee, HEW's Advisory Committee on Automated Personal Data, and the Privacy Protection Study Commission. Finally, Dr. Ware outlines broad changes and developments with in the RAND Corporation, particularly as they relate to research in computing and software at the organization.

### Descriptors:

RAND Corporation  
Institute for Advanced Study  
Privacy Protection Study Commission  
Association for Computing Machinery  
Advisory Committee On Automated Personal Data  
Computer Security  
Computer Privacy  
Johnniac

TAPE 1 (Side A)

Yost: I'm here today with Willis Ware at the RAND Corporation. This interview is part of the NSF sponsored project, "Building a Future for Software History."

Yost: Willis, could you begin by giving some biographical information about where you grew up and your evolving educational interests both before and in college and graduate school?

Ware: I was born in Atlantic City, New Jersey on August the 31, 1920, so you can figure out how old I am. My first few years were in Pleasantville, New Jersey; then in Ambler, PA, which is a small community northeast of Philadelphia. I attended Ambler High School where I was valedictorian. I had a scholarship to University of Pennsylvania and I received my Bachelor's in electrical engineering from there in 1941. I was then fortunate to receive a fellowship from Tau Beta Pi, so I did a Master's degree at MIT in 1942. At that point, World War II was in full swing. I rejoined Hazeltine Electronics Corporation, which is in Little Neck, New York on Long Island. During the War, I was exempt from military service because of the work we were doing on IFF, or Identification Friend or Foe, equipment for the military. At the conclusion of the War, I was fortunate to land a job with John von Neumann's Electronic Computer Project at Princeton's Institute for Advanced Study (IAS). So I went there in the spring of 1946. I worked concurrently as a full-time engineer on the project, and did my Ph.D. at Princeton University.

Yost: What were the circumstances that led to that opportunity, to work with von Neumann at IAS?

Ware: How did it happen? I had a colleague at Hazeltine. I don't know how he found out about the opportunities at IAS, but he mentioned it to me and invited me to come along if I wished, and so I did. We both knew that the military work would not continue at Hazeltine, so in a sense we were just protecting ourselves by looking around. So we took the train down to Princeton, interviewed with Julian Bigelow for most of the day, and then he drove us back in his small, Austin vehicle to New York City.

Yost: And concomitant to this job you were also completing work towards a doctorate at Princeton University?

Ware: Well one of the nice perks that IAS, or perhaps it was John von Neumann personally, offered to us was the opportunity to take graduate work at Princeton and work on a degree if we wished to. I did, and fortunately the expenses for my Ph.D. were just a few hundred dollars. It was a very unusual circumstance. But I finished that degree, and I was one of two initial Ph.D.'s in computer science at Princeton's Electrical Engineering Department. In the spring of 1951, I began to look around for another position, since I did not expect the IAS position to continue. I went to an IRE (Institute of Radio Engineers) show in New York City, interviewed with Hughes, but they managed to lose the paper work, so that never materialized. I did, however, make connections with North American Aviation, which was one of several Los Angeles area aircraft companies getting into the

electronics world. So I made a job arrangement with them; drove West with my family, which at that time was a wife and young daughter, in August of 1951. I went to work with North American in Downey, California. Things did not progress too well there. Among other things, the aircraft industry had not yet figured out how to deal with professional personnel of the electronics variety. They tended to treat their technical staff as more factory workers. This got tedious after a while so I began to look around. By that time I had met Bill Gunning from RAND, who was in charge of building for RAND a descendent of the machine that was built at Princeton.

Yost: That was the Johnniac.

Ware: That was the Johnniac. RAND was considering that it had all its eggs in one basket by essentially putting Bill in charge of the project, and was glad to have an opportunity to get a back up individual. I qualified and I came here in May of 1952. I have been here ever since.

Yost: What was your original position at the RAND Corporation?

Ware: At that time, in the spring of 1952, RAND was still in the now defunct building that used to exist at Fourth and Broadway, and had at one time housed the local newspaper. The machine project, the Johnniac project, was administratively housed in the mathematics division, which had a branch called the Numerical Analysis Division (NAD) that ran the punch card equipment, but also had this computer project attached to it. So

my initial position at RAND was as a member of an engineering group that had been assembled to build the machine.

Yost: Prior to the Johnniac was RAND using much IBM punch card equipment?

Ware: Yes. For the size of the organization at that time, RAND had a remarkably large installation of IBM punch card equipment. So that gets me started at RAND.

Yost: Who was the director of mathematics and who headed NAD at that time?

Ware: At that time, the mathematics division was run by John D. Williams. He was an astronomer by training, but a very broad gauged mathematically based individual. The branch of the mathematics division that actually did computing, mathematics for computing, was run by George W. Brown. Brown had come by a circuitous route from Princeton to RAND. At Princeton, George had worked on the memory tube called the Selectron, but he left there, made one or two stops, and wound up at RAND in 1950 or 1951. He ran the group that did the computing, ran the punch cards, but he had a punch card supervisor. The individual who ran the punch card group was Paul Armer, who stayed at RAND for probably thirty years or so.

Yost: And he, once the mathematics division was broken off and there was a computer science department, he was the first Head of that Department?

Ware: Computer science hadn't been invented in those days.

Yost: Right. Was it the late 50's when RAND changed the name ... when it was no longer the Math Division of Numerical Analysis, it became the Computer Sciences Department?

Ware: The group that did the punch card work was called the Numerical Analysis Department. And that name survived when the group split from the Math Division, and became an independent department of RAND, and I don't know the date of that switch, but it would have probably been the mid-50's or so.

Yost: What were some of the early applications of the Johnniac?

Ware: The machine went operational...I started to say 1953, but I'm not sure of that date. The software for linear programming and calculations, in large measure, was developed first on the Johnniac, then later moved over on to the IBM equipment. The Johnniac was used for a certain amount of experimental research. There was a lot of specialty software developed for the machine, of course, because there was no commercial supplier. It ran the payroll, it did nuclear effects calculations, and it did work on other nuclear matters for the RAND Physics Department. For a while it was the only electronic device that we had. It was something more powerful and effective than the punch card shop.

Yost: Roughly how many people were working in this area of Numerical Analysis at RAND, and how did it break down between engineers and programmers?

Ware: I'm not sure I can answer that, but I can give you an order of magnitude. The engineering group, that was run initially by Bill Gunning and was building the Johnniac and also had installed and modified an analog machine called the REAC, together with the mechanical shop and the electronics shop was probably fifteen, maybe twenty people. The folks that were doing programming, at first with the punch card, and later for the Johnniac, and then later for the IBM equipment, gradually grew and I think it may have gotten as big as fifty within a couple of years.

Yost: Were they broken down into particular research areas of applications for RAND such as physics or economics?

Ware: There was a certain amount of specialization, in the sense that teams of people in NAD would establish a relationship with one of the departments at RAND, and they got to be a companion pair, so to speak. So there was a physics team, there was a logistics team, and so on. I don't think I can tell you the numbers of the various team's sizes; typically there were just a few, half a dozen at the most.

Yost: Did you continue in essentially the same work throughout the 50's? Or how did your position evolve into different responsibilities?



Ware: Let me introduce another theme for you. In those days, the attitude of RAND's management was, "If you think it's good for our clients or if you think it's good for the country, go do it, and don't bother to ask." So several of us, many of us, got involved in helping to develop the professional society structures that supported the computer field. So there were many of us that served as officers in the Association for Computing Machinery (ACM); at that time it was the IRE, and they were called PGEC, Professional Group on Electronic Computing. We held Chairs, and we would help to run conferences. That developed from the middle 1950's onward, and was going full blown throughout the 1960's, as I recall.

Yost: Can you describe what roles you had in the various professional organizations?

Ware: In those days I was paying attention to the IRE. The programming group tended to pay attention to the ACM. I had various assignments helping to construct the Johnniac, and that lasted through the middle or latter part of the 50's. I also was fortunate in getting connected with the Air Force Scientific Advisory Board, and I spent a lot of time with the Air Force working on various committee and other assignments. So I established a rather close personal relationship with the Air Force structure as it was trying to determine how it was going to absorb computer technology. But there was an independent connection to the Air Force through RAND's logistics work, because the logistics part of the Air Force was the first part to do much in the way of utilizing digital computers.

Yost: So this was insuring the supply parts, delivery, and areas of operations management?

Ware: In here somewhere there was some shifting of administrator responsibility, and at one point I was given the responsibility that Bill Gunning had, then later, as the department grew I became its Associate Department Head, and eventually I became Department Head of Computer Sciences Department. I can't give you the exact dates when all those things happened, nor can I give you the exact dates when the names and the re-organization happened. It probably can be found, but I can't give it to you from memory.

Yost: I came across documentation of the date that you became Department Head, and it was 1964.

Ware: I felt that my obligation as a Department Head was to spend a third of my time running the department, a third of my time being a computer professional, and about a third of my time with the Air Force. And that's pretty much how it worked out over the years.

Yost: Was that fairly typical of researchers and administrators at RAND, that breakdown of time and responsibilities?

Ware: No, it was not very typical. It was fairly typical of several people in the Computer Sciences Department, but remember that there was no technology going gun-ho like the computer technology. The aerodynamics, and radar, and materials fields, were all progressing along a few percent per year, in terms of capability. And here was the computing business galloping along at 50 percent, or more, enormous growth rates. So from the Air Force's point of view, they were faced with how to figure out how to exploit and deal with this computer technology; how to get organized to deal with it; how to build the training courses for their people, and all that. Several of us from RAND were involved in that relationship. We did things like teach courses for the Air Force and work on their committees, or do informal consulting with the Air Force people by phone.

Yost: Was ALS a primary concern for the Air Force?

Ware: The Advanced Logistics System?

Yost: Yes.

Ware; The Air Force did have a big program to retrofit the logistics institution with an advanced computer system. Unfortunately the primary message that we delivered to the Air Force at that time was, "Whatever you think you're doing, you're doing it poorly and you're not organized to do it well." Which was not a pleasant message to deliver, but the fact of the matter is that the Air Force at that juncture, which was probably late 60's, had never faced or managed the conversion of a huge computer system. And this system was

a huge operation. Then when advanced avionics came along, a few of us got involved in advising the Air Force in those issues. Some of us, for example, advised the Air Force on the software aspects of a fighter called the F-16, which is still around. And once again, it was the same story; the Air Force is an organization that had never dealt with this technology in this context before, namely computers and aircraft, and so they were ill trained to do it well. Generally they lacked the experience to understand where the problems would be and how they would get into trouble. A few of us tried to help them along by “holding hands”, so to speak.

Yost: Around the time you took over as Department Head of Computer Sciences, you and several other researchers at RAND became interested in computer security and privacy? I know that you and Paul Baran published in this area in the middle to late 1960s.

Ware: Well let me first mention one other thing that we did for the Air Force. Three of us, Pat Haverty, Bob Patrick, and myself, drafted the curriculum, wrote a lot of papers to go with it, and were the instructors for the first several rounds for what has come to be called the DoD Computer Institute. So we would periodically journey to Washington and hold forth as three academics for a few days with a military DOD audience, trying to educate them in computer matters. That kind of thing could be done under the flexible arrangement that RAND had with the Air Force at that time. As a few of the RAND people say—in fact, I think it is Paul Armer’s phrase—“the Air Force gave us a pocket full of money and said spend it in our interests.” And that’s a good way to characterize the interface at that time—it is quite different today, of course.

Now, let me move onto computer security. Remember that I mentioned that several of us were very active with the [computer] organizations, in putting on conferences which at that time were called, the Eastern Joint Computer Conference and the Western Joint Computer Conference; one East, one West, two a year. I don't know exactly when it got started, but it probably would have been in the early 60's, some of us began to realize how heavily the military, the Air Force, and the DOD, were beginning to depend on computers, and correspondingly, to realize how heavily the country was beginning to depend on computers. We would talk amongst ourselves in the hallways at conferences and gradually there emerged a concern that we really ought to do something about finding out how to protect computer systems and all that information in them, because the country has become too dependent on them. That was the thread that began what has now become called computer or information security. We: myself, Paul Armer, probably Bob Patrick, maybe Pat Haverty, decided that we ought to put on a session at one of the Joint Computer Conferences addressing the matter of computer security. So we organized such a session—four papers as I remember—offered it to this Spring Joint Computer Conference meeting in Atlantic City, and I think the year was 1967. So that was the first public discussion that I believe ever took place on what we now call computer security. And we essentially laid it out, put it on the table before the IRE, AIEE, and ACM audience.

Yost: What was the reaction of the audience? Was this an issue that many had given thought to previously?

Ware: I doubt if there was much of a reaction. To the audience, here was another technical session that was being presented.

Yost: Given the RAND Corporation's dual focus that is developing around that time, with the military Air Force research on one side, and the broadening social and economic agenda on the other, I am wondering if that played into an interest in social issues, automation, as well as security and privacy?

Ware: There was another part of our concerns; our initial concerns were not the safety and protection of the systems, but the impact of heavy computerization on the labor market. Some of our first discussions were on: what is automation going to do to the labor market in this country. And then having said that, our concern rose for protecting systems. You may have heard this story, if not, it's part of the overall thread. A defense contractor in St. Louis, McDonnell Aircraft asked permission of the Air Force to run classified and un-classified work on the same computer. The genesis of that request was the fact that machines were horribly expensive in those days so anybody who had one would always hunt around trying to find ways to make extra money. So what McDonnell wanted to do was to offer remote job entry capability to local St. Louis industry as a way of generating revenue to pay for computer expenses. The DoD suddenly realized that it had no policy on this issue; it hadn't even thought about this issue as one that would need attention. ARPA existed at that time, and ARPA decided to put an appropriate committee

together and address the question of computer security and hopefully come out with some guidance and recommendations for the DoD.

Yost: Was this in the early 60's or later in the decade?

Ware: It would have been in the second half of the 1960's. I was asked to chair this committee, and we met several times a year, probably in 1968 or 1969. The thrust of the committee's concern at that time, of course, was the DoD. It was not interested, at that time, in civilian applications. So the committee met and delivered its report in 1970. That's the report, which got nicknamed the Ware Report and under the RAND system is called RR609, is titled, "Security Controls for Computer Systems." But that was the first time that any group had ever looked at the issue in a cohesive way, and had tried to address it not only as a technological issue, but also as a policy issue. And that's how computer security got launched in this country.

Yost: Initially, that was a classified document?

Ware: Initially that document was classified confidential. We worked hard not to have that happen, but our member from the CIA was recalcitrant and insisted on classification. It was roughly ten years later that we got it re-classified and republished. So there is an unclassified version; in fact, it's on-line on the RAND website, and it's still a good read.

Yost: Can you discuss the impact of this report on defense agencies and defense contractors when it came out?

Ware: First of all, that report turned down McDonnell Douglas's request, and also we had done a limited amount of penetration studies on the McDonnell Douglas system. So the combination of those events quieted that request. But that report did persuade the Air Force to put together other committees to continue addressing the issue, and the next committee along the line, which would have been 1972 or 1973, was run by James H. Anderson. He and his committee put together for the Air Force essentially a road map of the research it needed to do, and offered and some estimated budget levels. I remember quite distinctly telling Jim, "You're crazy, there's no way you're going to spend several million dollars a year on this problem." That, of course, has proven to be a foolish remark. So there was an Anderson Report, and I think a second Anderson Report, then NSA got involved, and out of the NSA deliberations came the "Orange Book" and that whole chain of literature. That brings the story up to about the early 1980's. I think the publication date of the Orange Book was 1983. Out of the Orange Book and related work NSA tried to get commercial interests involved and tried to get some action going out there in the non-defense field. Unfortunately, that had limited success because security just has been very, very slow to catch on.

Yost: Taking things back a little bit, in dealing with the civilian field in the early 70's, I believe it was 1972, you were appointed to be on the Health, Education, and Welfare (HEW) committee and soon became Chair of that committee.



Ware: What happened there, Jeffrey, was the following: I was just finishing up the computer security study for the DOD when I got a phone call from Secretary Elliot Richardson, Executive Officer, asking if I would join the committee to look at privacy matters. Richardson had become concerned because HEW, which owned Social Security, held enormous amounts of personal information on people. He was concerned because Congress was talking about universal identifiers for everybody, and he felt it was time to air the issue and see what needed to be done. Somebody, and I'm not sure who, understood that security would be an unavoidable part of examining privacy. They looked around and somehow found me and decided they would like to have me join the committee. At first I demurred, because I had just finished leading a rather intense committee, and I didn't know if I had time to continue. Now, remember, I'm concurrently a Chairman of the Department here [at the RAND Corporation]. So you now know what the one-third of my time on the outside was. I demurred at first, then I wasn't sure if I could manage the meeting schedule of the committee. I received a return call saying, "The Secretary [Richardson] wants you so much that he is willing to take you for whatever time you can afford." Well, that is an offer you do not say no to. So I signed on and not initially as Chairman. HEW was having problems with the Chairperson of the committee, and eventually it became clear that she would not be able to perform, and by that time I had made enough inroads around the committee table that the executive director took me aside and said, "We'd like you to be Chairman." So I didn't start out as Chairman, but I wound up as Chairman. So, having done computer security, I was now doing computer privacy, to which of course security is closely related. We delivered that

HEW report in spring or summer of 1973. Congress was excited about privacy at that time, and so I think it is fair to say that the intellectual content of that report funneled directly into, and quite strongly influenced the details that are in the Privacy Act of 1974. That 1974 Act provided for the formation of a full-on commission to examine the commercial aspects of privacy, as opposed to the government aspects that the HEW Committee had examined. So that was the Privacy Protection Study Commission, to which I was fortunate to be appointed by President Ford. And we worked for two years or so—once again I'm guessing at dates, but I think our report was probably presented in 1976 or 1977, we can verify these dates. By the time the HEW Committee had finished its work, Elliot Richardson had moved on to a different job and Caspar Weinberger had taken over as Secretary of HEW. In a formal presentation, the report went to Weinberger, although Richardson had really been the mover and shaker to make it all happen.

Yost: Can you briefly give some idea of the make up of the Committee; what backgrounds did individuals have?

Ware: Being a person with technological training, I was used to dealing with facts and straightforward people. I had never really been embedded in the political scene, but that committee was my first experience with a politically important event. Membership was carefully balanced along every axis you can think of. We had a young person, we had diverse ethnicity, we had lawyers, a sociologist; we had everything that was politically important for the job that the committee was doing, working in the environment that it was working in. I've often wondered what happened to some of our committee members

who at that time were young people. The committee worked well together, and it did converge on the Code of Fair Information Practices, as a reasonable way to go. It produced, I think, an excellent report on the subject, addressing such things even as the social security number and its use in society.

Yost: One of the Fair Information Practices was the right to examine records?

Ware: One of the ways the Committee was balanced was of course computer technology. We had, besides myself as Chairman, two members who were out of the computer world. One was Joe Weizenbaum of MIT, and the other was Guy Dobbs. Between the two of them, they could invent all manner of ways to try to deal with the error problem. And there was a suggestion at one time that every time an error was corrected, the holder of the database in which the error had been found ought to send a correction notice to all parties with which it had passed information, and to the individual as well. We quickly figured out that that would be a full employment job for the post office, mailing all that stuff around. So part of the interesting activity, from my point of view with that committee, was to steer it toward a sense of reality, toward a set of solutions that made sense, could be accepted by the real world, could be effective in the real world. You find, therefore, in the report and also in the Privacy Act, simply a requirement that there should be a way to correct errors. There is no requirement for promulgation of corrections, and that was done by intent.

Yost: There was one piece of specialized federal legislation before that, in 1970, the Fair Credit Reporting Act. Were you or others at RAND consulted on that?

Ware: That was strictly an Alan Westin...

Yost: The Columbia University legal scholar.

Ware: Yes, but that was done under National Bureau of Standards (NBS) sponsorship, as I remember. The HEW committee certainly listened to Alan and shared his views and heard his views, but he had no formal relationship with it. I don't know whether that was his choice, or a political choice, or what.

Yost: So a number of people were brought in to testify before the Committee, legal scholars among them?

TAPE 1 (Side B)

Ware: The way these committees work is that they discuss among themselves or the executive director, or a combination thereof. The committee lays out an agenda of issues that it wants to explore. It then gets people to make presentations by issue as essentially one way to collect research data. Typically, a committee meeting lasting three days would have two days of presentations and a third day of private discussion.

Yost: How many times a year would meetings be held?

Ware: It will vary from committee to committee, but typically four. But there is a great deal of interaction between meetings, commonly between the executive director and the chair. A lot of the fine-tuning of the committee's work is done that way. So when it came time for the next meeting, the ducks are more or less lined up.

Yost: Switching to the Privacy Protection Study Commission, some of the areas addressed were the insurance field, and the medical field. Did you find these to be very unique situations that would require specialized legislation, or did you think that it was possible to come up with broad legislation that could work in different areas?

Ware: It's been a long time, Jeffrey, since I read that report. But as I recall, what we did on each of these issues, medical, insurance, and so forth, was have a set of hearings and move them around the country, for political awareness. We had a set of hearings collecting the views and thoughts of relevant people and organizations. Then the staff of the commission would put together an issue paper and pose a lot of questions that needed to be answered to fine tune the issue discussion. And then the committee would act on suggestions, commonly from the staff, of recommendations of positions that ought to be taken. The Privacy Protection Study Commission (PPSC) was a big operation, in terms of my experience. On the HEW committee, the support staff was an executive director and he had an assistant, with an occasional part-time person. The Privacy Commission rented space in Washington, had an executive director and a full-time staff of a dozen or more.

So it was a big operation compared to any committee work that I had been involved with prior to this. Commonly, one or more members of the staff would be assigned to an issue, and that member then would be responsible for helping to formulate the content of the PPSC meetings, would be responsible for drafting commission papers, and so on. Once again, there was a lot of interaction between meetings among members of the PPSC, and members of the staff. I spent a lot of time on the phone in those days, since email wasn't up and going.

Yost: Did you then, or do you now, find it ironic or paradoxical that in the country that led in digital computing and in the computer industry that it has been so difficult to get legislation accomplished with regard to privacy, while in many European countries, as well as Asian countries, have set up permanent commissions.

Ware: Yes and no. For a long time that did puzzle me, but then I had an opportunity to visit—remember Sweden was the first country to go with a law—and talk with their first data commissioner, who we would call an administrative law judge. And he made an important point. He said, “Sweden is a small country. What you can do in and with a small country may not work for a big one.” I thought about that over the years, and I suspect that that is part of the matter. This country is too big, too diverse, in almost any dimension you can think of, and it has an unmanageable legislative process, so you are not going to get consensus on any one way to solve the privacy problem, even if you could think of it. My view is that privacy in this country is probably going to be relegated

to piece-meal solutions. Although, I do find it a little disturbing that most of the time congressional action is retroactive and not proactive.

Yost: Did the states that instituted particular privacy laws provide a test bed, in any sense, for potential federal legislation?

Ware: The HEW Committee did include a state Senator from Minnesota, but I don't think he carried forward to the privacy commission, and if he didn't, we certainly heard from him. So we did hear, in a limited fashion, what the states were up to. But the states were not all that active either. One of the things that makes the whole business awkward, from the national point of view, is the Interstate Commerce Act; you can't do anything to intrude on state commerce, that's what the law says. Well, privacy, depending on how it's done, can intrude on interstate commerce. You are never going to get fifty states lined up on things, it is just impossible.

Yost: Do you see privacy protection also as fundamentally a class issue where some people have greater means or opportunity to protect privacy than others?

Ware: The issue of privacy has changed. I have thought about trying to pull together a paper to discuss the issue, but I have not done it and maybe I will not. When we addressed privacy in the late 1960's, the issue was the United States government and the data that it held on people. The focus of the data that it held on people was to make decisions about those people; all that data in the social security database has to do with

what rights, benefits, entitlements, you as an individual might derive under that law. So the databases that were assembled tended to be focused within one agency. And while there was some amount of sharing across agencies, there was not wholesale co-mingling with databases. Privacy in those days was sort of like a lot of little stand alone enclaves, each one of which had about the same set of concerns in regard to privacy. With the rise to power of the Internet and electronic support in the private sector, there was a second branch of privacy that has arisen which does not have any of the same attributes that I just mentioned. Privacy these days, what tends to bug people, is the collection of information about them, co-mingling it, selling it, re-selling it, using it for all manner of purposes. So there's a very different aspect to privacy when you talk about the Internet, for example, and when you talked about the Social Security Administration in 1968.

Yost: It has become an industry.

Ware: It has become an industry. Even as late as the Privacy Commission, most people were willing to say, "Yes, the nub of the privacy issue is the U.S. government." Well this is no longer true. There's an equally strong nub called the private information industry.

Yost: Were insurance companies at the time of the Privacy Commission very active in broadly seeking or purchasing information?

Ware: The MIB, the Medical Information Bureau, certainly existed at that time; we knew about it, we heard from it. The MIB is a little bit different than anything you found within



government; different in the sense that it was an industry oriented data source, instead of an individual, corporate, or federal agency. That was primarily what the insurance industry was up to in those days, running the MIB.

Yost: You said early on that your work was essentially divided into thirds, and one third became privacy and security issues, and another third administration in the Computer Sciences Department. What other research were you doing at RAND during the late 60's through the 70's.

Ware: Remember what happened to the Spring Joint Computer Conference and the Fall Joint Computer Conference, it eventually became AFIPS. And what drove that transition was the interest of other professional societies in joining the action. So when the ACM, for example, was pressured to get in the action, the outcome was the formation of AFIPS. And I was elected as the first president of AFIPS, so that took a fair amount of time presiding over that. That was around the 1980's. Privacy and security were hot enough topics in those days that there were a lot of requests for articles or talks and presentations, and that consumed a lot of time too. Because I had to get explicit corporate approval to participate in the privacy commission, I know that that took 20 percent of my time, because that's what the front office was willing to fund for that purpose.

Yost: In general, perhaps not just yourself, but also with other researchers, what was the process with regard to the oversight or top administration on what research was done

within the RAND corporation? Did departments have a lot of leeway to decide research agendas? How did this change over time?

Ware: The first president of RAND gave department heads a lot of freedom. First of all, the department heads had their budgets, and every year a department would put together a budget request and the corporation would negotiate a bottom line. So the department head not only had budget responsibilities, the department had hiring and termination authority. The department head had a great deal of leeway over the content of the research program in the department. The department head's job was a good job in those days; you were essentially running a small company because most of the RAND departments were fairly sizeable. We were always responsible to the front office for quality, but the department heads were the ones that were on the hook for quality. Most of the departments did it the same way, they would have dry-run briefings and document reviews, the usual processes that an organization uses. There was no formal process in place, it was just, here's how we do it. In those days there were no written policies for a lot of things. A corporate secretary Steve Jeffries used to tell me, "Yes, we have these policies if we need to trod them out, but generally we're not interested in making them visible." Well, things are quite different today, of course, for good reason. RAND is a grown up big place, much more diverse, so these days it has to act like a big commercial corporation. So there are written policies for about anything you can think of; there are written procedures for doing this that and the other thing, all of which is a culmination of a shift in the world outside, a shift in the make-up of the RAND clients, and a shift in the size of the place. In those days, RAND's maximum size [annual budget] was probably \$25 million dollars.

And for a long time we had one main client, the Air Force. I do not know how many clients RAND has these days, but its annual revenue is something over \$100 million, I think it's \$125 million even. Well that's a big difference. So the procedures that are in place today are here of necessity.

Yost: In the earlier days, when most of the money was coming from the Air Force, was it easy to do basic research or was that hard to justify?

Ware: Our mechanism in those days was to stay close enough to the client that you knew what the client was interested in. And we would formulate our research accordingly. On the other hand, a lot of the basic research which tended to be concentrated in the Math Department and in the Computer Sciences Department, a lot of that research was driven by what's going on in the world, what's important for us was to be able to provide proper computer support, and with some mix, the client's concerns. Today the mechanism is more likely to be, "What did the client's proposal ask for, what did he want done?" That's part of the formalism of today's world.

Yost: That transition was fairly gradual?

Ware: Yes, Frank Colbohm (RAND's first president) retired in 1967, Harry Rowan came here, and we had the Daniel Ellsberg flap. The result of the Ellsberg flap and other things of the time was that congress directed RAND to diversify, and so Harry Rowan was told

to create a non-defense domestic program. That was really the start of change. So yes, it's been gradual, 1970 to 2000, twenty-five to thirty years for change; I guess that's gradual.

Yost: How long did you remain head of Computer Sciences Department?

Ware: I think thirteen or fourteen years. But what happened was that there was always somebody in charge of the Air Force contract. At one point, that individual was at RAND's Washington office, he wanted somebody out here that would be his deputy and he asked me if I would do it. I said yes, and that's when I stepped down as head of the Computer Science Department. I don't think we changed the name of the department at that time, but not long thereafter it became the Information Sciences Department, and it had three other department heads before RAND decided to get rid of departments. There are no other departments here now. There's one big department that has all the people in it and there are programs and centers. These act as mini departments really, because they are focused on one or a set of clients, they have a group of people that work with them, and they are relatively stable. So they have all the earmarks of small departments.

Yost: Was this official change in structure in response to wanting to be more interdisciplinary, and bring the right people from different departments together?

Ware: That's never been a driver in any real sense. It's always talked about, it's always expected to happen, and it's always anticipated that it has happened, but it has never been

a driver in terms of a proclamation that this is going to make it happen. In fact, I don't know how interdisciplinary the RAND Corporation really is.

Yost: Can you talk a little bit about what you worked on in the past couple decades? Do you remain active in research?

Ware: Not in any real sense. I formally retired from RAND in 1992. And I've been here ten or eleven years now as a resident consultant or adjunct staff member, or some such label. I do things as they come along, and I occupy my time by tracking the world, interacting with the world. And trying to get a history of RAND's computing activities compiled and written, which goes slowly, but it's going at least. If I don't get it done it won't get done.

Yost: How long have you been working on that project?

Ware: I probably wrote the first part of it at least two, maybe three years ago. On the other hand, I don't spend 100 percent of my time on it. There is a great deal that takes place in the world that I like to follow, and I do. I'm sure there's a great deal that I could chose to ignore and the world would not care.

Yost: Moving back a bit can you talk a bit on RAND's early work in programming and software?

Ware: From the punch card days, the evolution of software or punch card procedures, which was the software that went with that, the evolution of the software has been client driven. There's a second level behind that that you have to do or if you don't you won't be able to accommodate the client. So the kinds of calculations that were important to be done in the punch card days were captured in big plug boards that were wired out, checked out, and you put a cover over them so that not everybody could play with them. The plug board was really the PROM of the day. We had plug boards that would do point calculations, that would execute certain simple models, statistical routines, and so forth. There was a lot of sharing in the Southern California basin between RAND and the aircraft industry, from which RAND came. They all had punch card installations. Two years before RAND moved into this building, RAND was looking around in the world for what could be used other than punch cards. They had found there was an analog [computer] industry and, in fact, RAND did buy and made major improvements to an electronic analog computer from Reeves Corporation in New York City. But then we needed to do better, to go digital. They conducted the search and decided there was no industry out there that would build a digital computer, so they decided to build their own; that launched the Johnniac Project. As soon as you launch a project like that you need a whole raft of utility and system level software if you're going to make any valuable use of the machine. So we had to do that. Another thread here: there comes to RAND a man named George Danzig, who had invented linear programming when he was in the Air Force. It became clear that linear programming was such a powerful tool that we needed good software for it. So we evolved Linear Programming Simplex Method, we evolved linear programming software for the Johnniac and we also did it for the IBM 701, and

I'm sure we did it for the IBM 704. RAND has always been very willing to share, and so that software went into the world and it's been shared around, and I imagine most of the world doesn't know where it came from. Occasionally, some of the RAND software would lead to a company, and the most prominent one is the Simscript language, which was developed here, and led to the formation of CACI with Harry Markowitz.

Yost: Right, I interviewed Harry Markowitz last year.

Ware: Sometimes our software was driven by a client's need. The Air Force wanted to improve its mission planning capability so they asked us and we cranked up software to do that. When we got it done we transferred it to SAC, and we sent people there to help them with the installation. We'd be essentially an online help facility; when they ran into trouble they'd call up and solicit help. So RAND has pushed a lot of mathematics and a lot of software out into the world, driven sometimes by our own needs, Johnniac utility stuff, driven sometimes by the client, driven sometimes by a researcher perceiving something a client needs which the client did not think about. That's pretty much gone away though. Computing being what it is today, the RAND folks around here use commercial packages, whatever you can get, and there's enough of it around. We do still have a professional programming staff. I don't know the size of it but it isn't very big. At one time, our professional programming staff might have been as large as fifty or sixty people, all high-grade people.

Yost: Now do they primarily work in very specialized areas where you simply can't find applications on the market?

Ware: Well, these day's people roll around a lot. Everybody's sitting at a terminal with all kinds of commercial software. The researchers do their own stuff.

Yost: Artificial intelligence was another fundamental area in programming at RAND. How did RAND get into that field?

Ware: Like a lot of things that RAND got into, by accident. We had a programmer here named John Clifford Shaw who was an insurance actuarial student by training. He had been a bombardier or navigator during World War II. Cliff came to RAND as a punch card person then converted to the digital world. He got involved with the Johnniac, and I think that was a directed action by the management: "Cliff go do this." He did a lot of the basic utility level software to make the Johnniac a usable machine. Cliff, like the rest of us, circulated in a professional world, and somewhere along the line he met John McCarthy and the other folks at MIT who were talking AI. So Cliff became interested in it here and he also got to know Allen Newell, who was also here at the time. I don't know why Herb Simon came to RAND in the summers, but he did. For several summers Herb Simon would come out here and spend his time. Somehow Shaw, Newell, and Simon got organized as a team. And as a vehicle to explore artificial intelligence technology, they chose game playing. Because they thought that that was one thing that was systemized enough, yet it didn't have a closed set of rules, and was complex enough that it would be



an appropriate foundation to examine that kind of software. So NSS, as that team was called, did five information processing languages, IPL 1-5, each one of which was more and more complex, could handle more complicated situations. The John Williams philosophy was that if you put a bunch of smart people together and make sure that they talk to one another, you'll get good work. In a sense, that's the Newell, Shaw, Simon activity.

Yost: It seems as though it did work.

Ware: Unfortunately, all three of those people are dead, so you can only get the story second-hand from people like me.

Yost: I know Edward Feigenbaum has been a consultant at RAND, did RAND also get heavily into expert systems work?

Ware: Yes. Have you interviewed him?

Yost: I have, and he is one of the Trustees of the Charles Babbage Foundation.

Ware: I'm sure Ed knows part of the Newell, Shaw, Simon work and how the three of them got together; he may be able to tell you that. The other person that might have been able to tell you that is Keith Uncapher, who just died last November, unfortunately.

Yost: Yes he was a CBF Trustee also. We were very sorry to hear the news. He ran the Computer Systems Department?

Ware: When the department really got to be a department, in the sense that it was big enough to be called an entity, it had two sides. One side was a research program, and the other side was computing services program. The computing services program was essentially the descendent of the original punch card operation; they cranked out numbers for research. Keith ran the research side. Keith established a very close relationship with ARPA, and much of what his group did was ARPA-inspired and ARPA-funded. Now there is no computer research program here anymore. In today's world I don't know whether that is all that bad.

Yost: That, of course, includes that networking work that Paul Baran and others did.

Ware: I assume you know the story of what motivated Paul Baran, I don't need to tell you that?

Yost: Yes, his contributions with packet switching.

Ware: That was probably a unique event in RAND. When something that was motivated by a client need, namely a survival communication system, something motivated by the client generated ideas at RAND, that subsequently had so much impact on the real world. That's probably a unique event around here, if not unique certainly unusual. We did other

things that we would claim credit for, like computer security, or privacy, or linear programming software, but they are not influencing the real world in the way that packet-switching has.

Yost: What about other graphics work?

Ware: Once again, that was an effort that was inspired by ARPA's interest. Keith got funding from ARPA and did that work. Including that special machine that IBM built for us. Do you know about that?

Yost: No, I don't.

Ware: I think it was called Video Graphics. I believe it had an IBM 360-50 machine in it, but it had a huge magnetic disc. And the magnetic disc was synced to the events of the machine. So you could store analog images on this magnetic disc, display them, by overlaying those images with stuff that the machine had calculated. That was the Devil's own time, keeping that big disc operational. It was really big. But that was the genesis of the work that later became a wholly digital approach to the same end, namely analog images in which you overlay digitally computed images. One of the things that that the Air Force does a lot of is to make map overlays; they'll have a map and they'll want to put annotations all over it. That's an ideal application of an analog map image and a digital overlay. But if you have a digital map image then the problem suddenly gets easy, if you have enough computer memory, which we do today.

Ware: Since we're talking about video graphics, there's the tablet work, which was a mechanism to insert into a computer free-hand actions. We not only evolved the concept, and developed the detailed design of a tablet, but we also built about a dozen of them and provided them to the ARPA research community, at ARPA's request. That was a way that you could lay hand-written, hand-created stuff on top of a computer generated image. The tablet technology never took off. The world never seemed to like it. There's a little bit of it around today in some of these small tablet machines that you hold in your hand, but it never took off in the way that we tried to exploit around here. The goal of all that work was to provide a terminal at which the user had a keyboard, a tablet, and a microphone, to be able to communicate to a machine. We never got to the microphone phase. But we did have the keyboard and we did have the tablet. There were a few, three possibly four, applications worked up in a fair amount of detail; the map overlay was one, the Chinese dictionary look-up was done. The reason that was picked was that it turns out to look up a word in a Chinese dictionary, you have to know the sequence in which the strokes were drawn. Drawing it on the tablet then, you know that.

Yost: Well that covers the general line of questioning that I planned, are there any other topics or comments that you'd like to add?

Ware: Probably, but I'm not thinking of them. I want to make sure that you get what you came to get.

Yost: It's been very useful, along with archival research I'm doing here. It's very helpful to get a sense of computer and software work that went on at RAND, and the contextual environment of this work, it was quite influential to development the field.

Ware: RAND hasn't, in the past, paid much attention to its history. Only recently has it decided, "We better collect this archival stuff, because it's getting lost."

Yost: I was looking at the recent dissertations of several scholars that were using collections here. While it looks like very interesting work, there's very little on computing within that.

Ware: Yes, very little. Back there, you raised a question about sociology. I thought you were going to ask whether there were any players or roles around here for the soft sciences: sociologist psychologist, etc.

Yost: I know that the organization did bring in a large number of social scientists.

TAPE 2 (Side A)

Ware: RAND the project started in 1946, RAND the corporation started in 1948; soon after that happened, I'm not sure in who's instigation, they convened a whole group of people, I believe they met in New York City, and it was sociologists economists, etc. The group was supposed to advise RAND on what it should be doing in those academic areas.

This is all documented in one of our annual reports. The outcome of that group led RAND to expand into economics sociology, etc. The soft side of the business.

Yost: I guess what I was really interested in was how the combination of researchers might have influenced the broader interest in social issues among the technical staff. It seems that you and others became interested in very important social issues, such as automation and its impact on labor, and privacy.

Ware: Yes we did. Remember it was in a context outside of RAND. It was in the context of the professional conferences that we were running.

Yost: Yes, but it seems that it tended to come from leadership from individuals here more than disproportionately compared to university departments or people from industry who also attended ACM or other conferences. So I was wondering if you felt there was something that you felt was unique here that influenced that.

Ware: I like to say, Jeffrey—and I think I could defend this—I like to say that the computer science community has been very conscientious in terms of judging the impact of their work on society. Unlike the automotive engineering community, for example. I think the computer specialists have been very responsible in their social obligations.

Yost: I would agree, but early on it seems that a disproportionate amount came out of this organization.

Ware: I really don't know why. Because the folks that become computer specialists are not necessarily more socially oriented than anybody else, yet somehow they had that conviction that we're making big impacts on the world, and the world doesn't really appreciate what's going on.

Yost: Thank you very much for taking the time to talk with me today, it has been a great pleasure, and very useful.

Ware: My pleasure. It is nice to meet you. And consider the door open if you have questions that you need resolved. You know where I am, my email, you know my telephone, and you know where I am too.

Yost: Thank you.

Ware: You're welcome.