THE COMPUTER MUSEUM MEMBER'S FIRST FIELD TRIP
TO NORTHBAY AN/FSQ7 SAGE SITE AND TO THE
CANADIAN NATIONAL MUSEUM OF SCIENCE AND TECHNOLGY

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The first Computer Museum members' Field Trip just returned from a spectacular trip to Northbay Canada visiting the SAGE AN/FSQ7 computer prior to its decommissioning this winter, having been operational since 1962. The "Q7", once known as Whirlwind II, grew out of the Whirlwind project, initially started as an aircraft simulator. Becoming a prototype for air defense, this technology in turn formed the basis of modern air traffic control! (Lesson: what you get may not be what you start for when project aims are high.)

Seventeen museum members made the trip via chartered DECair, including Bob Crago from IBM, one of the key designers; Kent Redmond and Tom Smith, historians stet. writing the SAGE story; Henry Tropp, who is writing an article for the Annals of the History of Computing; and Richard Soloman who photographed and videotaped as part of an MIT Project on the History of Computing. The flying and trip arrangements were flawless. We left Friday noon, 8 October, from Bedford, Mass. for Northbay, arrived and visited the "hole" where we were completely briefed by members of the staff and original installation team, had dinner with the Canadian Air Force leaders, including the Commanding NORAD General (U.S.), flew on to Ottawa where we spent the night prior to visiting the National Museum of Science and Technology and returned Saturday afternoon.

THE Q7

Bob Everett's paper on the Sage computer was published in '57, and the machine was operational in Canada in '62. The machine created many patents as by-products, including perhaps the first associative store (using a drum). The machine is duplexed with a warm standby (I mean warm since the duplexed machine uses about 1 Megawatt of power to heat 55,000 tubes, 175,000 diodes and 13,000 transistors in 7,000 plugins!). The 6 microsecond, 32-bit word machine has 4 X 64K x 32-bit core memories and about the same memory in 12- 10.7" diameter, 2900 rpm drums, 6 of which are for secondary memory. There is no use of interrupts and i/o is done in an elegant fashion by loading/unloading parallel tracks of the drums with the external world completely in parallel with computing. That is, the i/o state becomes part of the computer's memory state. A single i/o channel is then used to move a drum track to and from the primary core memory.

The main i/o is a scan and height radar that tracks targets and finds their altitude. The operator's radar consoles plot the terrain and targets according to operator switch requests. The computer sends information to be plotted on 20" round Hughes Charactron (vector and alpha gun) tubes or displayed on small alphanumeric storage tubes for supplementary information. Communication lines connect neighboring air defense sectors and the overall command. The operating system of 1 Mword is stored on 728 tape drives and the drums.

The computer logic is stored in many open bays 15' to 30' long, each of which have a bay of voltage marginal check switches on the left side, followed by up to a maximum of 15 panels. The vertical panels are about 7' high by 2' wide and hold about 20 plug-in logic units. The separate right and left half of the arithmetic units are about 30' each or about 2' per bit. Two sets of the AMD 2901 Four-bit Microprocessor Slice would be an overkill for this 32 bit function today. The machine does vector (of length 2) arithmetic to handle the co-ordinate operations. The room with one cpu, drum, memory is about 50' x 150', and the two cpu consoles, tapes, card i/o. printer room is about 25' x 50'. The several dozen radar consoles are in a very large room.

UNDERGROUND SITE

The enormity of the machine was dwarfed by the underground building which encloses it. The building hollowed out of stone by hardrock miners is 600' beneath the surface, and connected by a 6000' tunnel which can be sealed off in seconds if there are very large, atmospheric disturbances. The building is about 150,000 square feet and has 10 standby 100 Kw generators and an air conditioner that can operate closed loop into an underground pond.

COST AND RELIABILITY

The machine and software cost about $25M in 62 and the site about $25M. The facility costs several million to operate per year, including about $1M to IBM including 10 people. Three people are needed to maintain the software. Initially, one hundred people were used to install the machine and set up its maintainence. When you count the radar, planes, etc. and operational costs, the computer cost is almost an incidental.

The reliability is fantastic! With ONE COMPUTER, AVAILABILITY IS 99.83% and with DUPLEX OPERATION, AVAILABILITY IS 99.97%. Having wondered why such an obsolete computer (somewhere between an 11/44 and 11/70) would be still used, it was clear: the reliability and the overwhelming fixed costs for radar, airplanes, etc. There's a parity bit. Marginal checking and incredibly conservative design were the key. Each week they regularly replace 300 tubes and an additional 5 tubes that are showing signs of deterioration.

Even though the program is about 1Mword, written in assembly language and Jovial, the key here is the aging and the fact that the program is NOT interrupt driven. The program simply cycles through the job queue every few seconds in a round robin fashion. This is an excellent example of superb software engineering with an incredibly simple overall structure since it is non-parallel, all the bugs that an interrupt driven system would have had are avoided. Users identify overload by the lengthened cycle time. The high reliability demonstrates learning curves as applied to reliability. This obvious notion just occurred to me: since all the software I see is always changing, it doesn't reach ultra-high reliability.

REPLACEMENT

Hughes has installed a new computer that occupies less space than the computer console.

BOTTOM LINE

I doubt if any of the existing personal computers that operate today will either operate or can be found in 20 years, simply because technology will have changed so much in performance and reliability as to make them uneconomical at the personal level. How many of us still repair and use our 10 year old HP35's? Furthermore, all the floppies will have worn out and we'll be glad to be rid of them.

VISIT TO THE NATIONAL MUSEUM OF SCIENCE AND TECHNOLOGY

Although relatively short on space for computing, the 5,000 square feet is still larger than what the Smithsonian allocates. Ted Paull, the section curator has put together an excellent exhibit on computation. They are archiving relevant Canadian artifacts including the FP6000, a circa '60 machine which could timeshare, and was until recently the basis for the ICL products. In addition videotapes, lots of terminals,and animated displays are used to teach about computing principles and history. A very elaborated, animated soup making machine is used to show analogies to computers (recipe/program, ingredients/data, store/memory, chopping,etc/processing, etc.).

The use of computers within the museum was well ahead of any museum I've seen, probably because the staff is small and willing to take risks. Also, the museum is new and not entrenched with traditional museum personnel who themselves may be museum pieces. The museum is run by a VAX-11/750 which sits in an open computation center within the museum, showing what a computer center is like. About 50 terminals are distributed through the Museum. The user applications include: the usual games, Eliza, questions answering, map generation to find your way through the museum, and descriptions of artifacts and technology A visitor can fill out a form on line to comment on the museum... something all museums should have. The administrative applications run by staff include: word processing, administrative reports, scheduling tours, and a large archive accessed by the Database program, Datatrieve. Their goal was originally to not have papers, typewriters or card files except in the exhibits.

As an extra treat, the original director, Dr. David Baird was there visiting and gave us a talk on how he got it together in a short time. He was a professor before being their first museum director, which explains why the museum is so good. He's now building a new museum of Palentology and says he will aim even higher to automate and self learn via computers.

ARCHIVING THE Q7 AND ITS RELATIONSHIP TO THE MUSEUM

I don't think we can do justice to the SAGE story and am delighted that Bob Everett is doing the videotape with various people including the historians, Redmond and Smith who're writing the history, as a follow-on to the Whirlwind story. I would like to encourage MITRE and IBM to decide who's going to be responsible for archiving the history of the project in toto, including saving many relevant artifacts. I will assume we will not take on this very large burden. However, I'd like to get some kind of commitment from Bob and IBM before we finally decide what to do precisely!

Basically, I think it's a worthwhile machine to go after for the Computer Museum because of its completeness into an integrated application. This is a classic, and it has so many historical firsts vis a vis real time, etc. Also there's the obvious relation to Whirlwind.

Here's what I think The Computer Museum should archive:

1. A set of logic schematics.
2. Theory of Programming (the reference manual which has instruction times, their operation, i/o, etc.)

2a. Any other overview documents that help define the system, especially the consoles and radar programming.

2b. I'd like to look at how big the whole set of Theory of... manuals would be. These would be enormously useful to future scholars in understanding precisely where things fit in such a large scale system. Afterall, this about the largest system ever built by that time.

3. Representative logic bays which have the large array of marginal check switches on the left (facing the bay). Here, I'd like the mag tape control (about 6 + 1 bays) or 12 feet. Alternatively, I'd like two, sawed off sets of bays: switches+logic and 2 logic together... about 4'.
4. 1-713 card reader, 1-723 card punch, 1-718 printer, 1-728 mag tape unit. Here, the idea is that we are moving lots and we might as well take the opportunity to move all this at once rather than later.
5. A 64K core stack in its cabinet (about3 x3 x 8). Not the electronics. This was about the largest stack built and came directly from the large memory work of the tx0 design (used to test it).
6. Spare plugboards (get all they have up to 50 with any wires they have). These are to sell them in the store.
7. 100 Spare plugin units to sell in the store.
8. 2 drums without cabinet. We'll have to sit it somewhere. This is a spare to eventually trade.
9. 2 sets of Sage Radar consoles (I think there are 3 types). One set is for trading.
10. Main CPU console. I talked to Ted Paul about this. This is the left part of the console that has lights and switches to access the registers of the machine. It has a phone in it, and its the half that you stand up to and there's a little lip forming a table.
11. Photographs of the machine as you look down the aisles, in the console room and in the radar console room

(batteries of radar consoles with people at them).

12. Block diagram of the system with the various parameters on it, showing the duplexed machines.

13. A scale model of the machine. I'd give anything for theirs which would come out of the plexi underground model. Let's try to get this now from them or Mitre. Maybe Mitre can do this with IBM.

14. Site diagram showing the tunnels, hole and building. Photographs of the site door, tunnel, above ground.

15. Patents coming out of SAGE. This is something we'll have to ask MITRE for.

16. An overview of the use of the whole system including the operating system. This is an excellent vehicle to understand real time computing of the earliest kind. It also argues for simple program structures.

The museum would display the console for now and probably the core together near the Whirlwind core. The documents and diagrams are essential for understanding and making the display and for eventual understanding in many years.

THE OTTAWA MUSEUM AND US

COMPUTER USE

This was truly impressive. Ted and his staff have done a great job and have shown us that computers can be used to really run a museum. I haven't seen any museum this far along. This is the right way to do the job. I think a museum should have NO typewriters or file cabinets outside unless they're part of the historical displays. Ultimately, videodisks have to be available to illustrate the whole world if one wants to probe deeper into a subject (eg. a computer). I'd like to provide an exchange service for video tapes and disks dealing with computing. Also, I liked many of his photographs and displays. I'd also like to see us think about building these so as to get history without errors and to show the agreed upon significant events. Getting the errors out of exhibits and showing the relevant events is a terribly hard and tedious project... and it's impossible to do it in very many places. History should not be too geographically dependent.

EXHIBITS

In addition, the 5000 feet of the exhibit is really put together well. I liked the long blurbs and photographs that went with the history. There were logic lab booths that demonstrated adders, ands, etc. I didn't care for the videotape or the talking dummies of pythagoras and ?.

LOGIC TRAINERS AND US

I think we ought to get some logic trainers (either the big faced modules that DEC made for the army, or the logic labs, or possibly even the original set of lab modules) to show how the logic functions are performed. I can argue that logic training was important and we would simply show various forms. We would put a trainer on the wall together with some circuits that could be tested there by anyone who wanted to do it. My tendency would be to put the trainer under glass with some wires leading outside to non-destructable switches. Here, show: AND, NAND, NOT, NOR, OR, an ADDER of 1 or 2 stages, a counter of several bits that advances one anytime anyone does an experiment. This could all be wired up in a single logic lab! If we got some trainers by others, including ones that Ed Fredkin's brother's company made, we could show some impressive stuff, with very little work. The Fredkin/Minsky Muse was initially done this way. Of course, we would put them behind glass and simply allow push buttons in the same way that people operate calculators. This is for next summer and for the students, so we ought to start collecting.