Allison

DIGITAL COMPUTER MUSEUM CATALOG

INTRODUCTION

The second duchess of Portland, born in 1714, was an insatiable shell collector. She never found a satisfactory artistic arrangement for the specimens until she hired a student of Linnaeus (1707-1778), the father of botanical classification systems. Then the collection was rearranged according to a taxonomy illustrating evolution and relationships between family members.

The collection of the Digital Computer Museum, relating to the whole family tree of computers from their earliest origins, also needs a disciplined classification scheme. Those who have tried to understand computer evolution have intuitively considered a tree structure -- the basis of taxonomies -- but none have been fully developed for the purpose (Bell and Newell, 1971; Bell, McNamara and Mudge, 1978; Rogers, 1980; Science Museum, 1975, Sieworek, Bell and Newell, forthcoming). The National Science Foundation tree of early computers shows roots and connections but does not name branches. A number of partial systems and some generally agreed upon terms exist for defining a classification system. The classification system in Computing Reviews works very well for the extraordinarily broad range of materials including "mathematics, engineering, the natural and social sciences, the humanities, and other fields with critical information about all current publications in any area of the computing sciences" (Sammet, 1980). The work of the AFIPS Taxonomy Committee, Taxonomy of Computer Science and Engineering, provides a convuluted semi-lattice covering all possible issues (AFIPS Taxonomy Committee 1980). Other trees look at only a part of computing (Weizer 1981, Sammet 1969). The evolutionary model has also resulted in the identification of generations (Rosen, 1969).

Generations are the primary organizing element for the collection and the catalog. The first four sections present the pre-computer generations. The fifth section is devoted to the pioneer computers that spanned the revolutionary bridge. The remainder of the catalog and collection is open ended; inclusive of all historic generations, i.e., at least one generation removed from the present technological generation.

THE GENERATIONS

Within the broadly accepted idea of technological generations, clear criteria can be identified to mark each one. These are listed below with examples shown in Table 1.

* A new base technology;
* A new machine structure;
* Satisfaction of a newly perceived need;
* Resulting in significantly different use of computing devices.

TABLE 1. THE GENERATIONS

PRE-COMPUTER GENERATIONS

TECHNOLOGY	MANUAL	CRAFT 1620	MECHANICAL 1810	ELECTRO-MECHANICAL 1900
MACHINE	Abacus	Tables Gunter's Rule	Planimeter Jacquard loom	Hollerith census machine, Friden calculator
NEED	Taxes	Trade Exploration	Industrial Land Division	Census Business
USE	Counting	Arithmetic Navigation	Surveying Weaving	Sorting Accounting

COMPUTER GENERATIONS

TECHNOLOGY	ELECTRONIC 1950	TRANSISTOR 1960
MACHINES	Whirlwind UNIVAC 1 ERA 1101	CDC 160, IBM 7090, IBM 1401 PDP-1
NEED	Defense Weather prediction	Space Science
USE	Firing Tables Weather Forecasting Management	Simulation Training programmers Accounting

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Generational change is modelled by a series of distinct steps with a new base technology at a significantly different level. The technology base never meets the aspirations and dreams of mankind because perceived needs are continually rising. A new base technology only creates a higher takeoff plane. (Maslow, 1943) With each new invention, one or two prominent people often note that it will fulfill all future computational needs; but each time the demand for more computational power only grows.

A number of ideas and machines are designed and even built out-of-phase with a technology. Ideas that occur before their time often lie dormant in an inventor's notebook until the technology evolves to match the idea. Later historians illuminate these early concepts, showing the contemporary entrepreneurs that they are not originators but only implementers of ancient ideas. In the mid-twentieth century, some letters of Wilhelm Schickard dated 1624 were unearthed. These contained the drawings for the first known digital machine to perform calculations. (Cohen 1980) It is doubtful that these ideas transmitted from Schichard to his friend Kepler influenced any of the mechanical calculators that were subsequently developed. Blaise Pascal, whose single-register, mechanical calculator of 1645 was widely known, appears to have invented this machine totally on his own, as a young man intrigued with a mechanical solution to the problems of accounting, with which his father occupied himself. The inventors who actually develop a baseline machine for a technology are often tinkerers, not scholars searching the literature for ideas.

Increasingly, computing devices are not the sole result of one invention but the convergence of many. As a set of benchmark ideas coalesce into a new machine relating to a new technological generation, then additional, incremental inventions result that also become part of the technological base. A new generation is marked after the project has proven itself, shown not to be a fluke, and has added a new layer to the technological base. The Computer Revolution and beginning of the electronic generation saw the use of vacuum tubes in the ENIAC on a scale of magnitude never before experienced and the invention of magnetic core memory on Whirlwind. Since a generation is a convergence of inventions, its emergence cannot be marked by a single event. A clustering of events, including patents, publications, and start-up dates are used to somewhat arbitrarily select a particular year.

Three pre-computer generations and three computer generations are clearly distinguished. Although calculating activities started with early civilization, it was not until the seventeenth century that a variety of calculating devices were invented and used. The collections begin in 1620 with the beginning of the "Craft Generation". Prior to that computation was carried out manually, in much the same manner for all of history. Defining computing power as the product of processing rate and memory size, a 20 order of magnitude increase can be measured from the time when people used stone-based, single register devices to the 1980s. The most significant increase -- a revolutionary change -- occurred with the beginning of the computer era. Before then, memory size was essentially constant at one. Afterwards, computing power began to increase at roughly twice the exponential rate of all past generations.

A generation is named for its predominant technology. The starting date of a generation is set not by the idea leading to a project that triggers the generation, but by the incorporation of a technology into a new product, concurrent with significant use. In most cases devices from a previous generation continue to be designed, manufactured, and used, often supplying a base on which the new generation is built. The electronic computer generation is marked at 1950. By that time the ideas of ENIAC had been replicated and the first commercial machine, the ERA 1101, was announced to the market. In the Computer Age, the naming conventions given by industry have been used, and they seem to accurately fit the model.

Table 1 lists representative needs, uses and inventions for each of the generations. During the pre-computer generations, evolution was exponential -- each period being about half as long as the one preceding it. The rapid change is similar to manufacturing learning curves, whereby a particular unit cost declines by 10-20% each time the cumulative number of units of a given type built doubles.

THE TAXONOMY

A taxonomy has been developed in parallel with the collection and the exhibits at the Digital Computer Museum. The taxonomy's basic framework is the PMS classification that describes the structure of computers (Siewiorek, Bell and Newell forthcoming). PMS allows any computing or software structure to be described hierarchically in terms of eight basic information processing primitives, but it does not deal with functional behavior, such as program interrupts that are not implied by a structure. The PMS system is generally used to provide a structural representation of the components of digital computer systems. In contrast, the Museum taxonomy classifies only whole computing systems and their antecedents. The following compares the two breakdowns:

TABLE 2. COMPARISON OF MUSEUM TAXONOMY AND PMS

MUSEUM TAXONOMY CLASS - CODE	CODE - PMS
Memories - M	M - Memories
Controls - K	K - Controls
Transducers - T	T - Transducers
Links & Switches - S	S - Switches
	L - Links
Calculators - D	D - Data Operation
	P - Processor
Digital Computer - C	C - Computer
Robotics - R	

The criterion defining the tree is the structure of the computing device, not the organization that made it or the purpose that it was meant to fulfill. To make an analogy with the animal kingdom, if the bone structure of a horse is that of a fine race horse then it would be classified as such; it would not matter if it were bred by the government and used to pick up garbage. In computing, the EDSAC, built at Cambridge University, is classified as neither an English nor a university computer, but as an EDVAC-related machine in the same family as the Maniac and ILLIAC. Thus, differentiation by manufacturers, countries, or intended users is not part of the taxonomy.

The classical scientific taxonomy system with its seven levels has been adopted to organize and classify all species of related inventions. The two top levels, kingdom and phylum, are technology and information, respectively. The Museum collection displays seven classes within the phylum of information. Each of these seven classes is broken down into order, family, and genus, and then identified by species. Table 3 lists the criteria used for the breakdown of the classes. Specific descriptions for each of the classes are found throughout the catalog.

Table 3. (in process)

Criteria used in differentiating orders, families, and genus.

CLASS	ORDER (Technology)	FAMILY	GENUS
Memory	Machine interface	Storage material	Structure of access movement
Controls	*	Degree of complexity	*
Transducers	*	Phenomena/material	*
Links & Switches	*	Degree of complexity	*
Calcula	Analog or Digital	Degree of complexity	Structure
Digital Computers	*	*	*
Robotics	*	*	*

* - To be determined.

Memory is probably the oldest class, starting with early markings on caves and continuing as a significant part of both computers and automata, and also as all kinds of human-readable aids to the brain. See Table 4 for more complete explanations.

Controls are rooted in early analog devices, such as the Greek water clocks, and have been significant in the mechanization process. At the beginning of the nineteenth century, card controlled looms introduced sophisticated pattern control to the industrial process through the use of a larger scale memory data-set than hitherto used. Card control ended with a great flourish in the early nineteen sixties with the tabulating machines. Again, with the advent of the computer on a chip, earlier technologies of control devices are rapidly becoming obsolete, being replaced by the "on-board" micro-processor.

Transducers take information in one form and put it into another. They are often associated with memory systems, allowing their replication; for example, printing use type (a transducer) to duplicate the information in books (a memory device). Transducers began with the movable type and include the teleprinter, tape transport, telephone, and television. These machines are becoming more and more sophisticated and less and less distinguishable from computers.

Calculators, other than the manual bead devices, did not develop until the 19th century and have been virtually displaced by computers. In the PMS notation, these are the data operators carrying out arithmetic operations. Either calculators have become embedded in computers or miniaturized computers have been embedded in what have traditionally been considered calculators. The taxonomy of Class Calcula is explained in the text. (See Table 5.

Links and switches evolved out of the needs of a large number of subscribers all desiring the use of a single system. The first telegraph was a simple device transferring information from one place to another. But the growth of telegraphy and telephony systems in the late nineteenth century created a need to establish elaborate networks linked together with a switching system. Computers still depend on linking and switching for cross communication.

Digital computers emerged in the late nineteen forties from a combination of calculator, control, transducer, links and switches, and memory technologies. The section "Pioneer Computers" shows the combination of elements that was adopted by the first 16 machines, many of which were patched together based on different technologies. Class Digital Computer is certainly more than the sum of these parts, as the parts have converged and been modified and molded into a new phenomenon.

Robotics actually started very early with man's desire to replicate life and took the form of doll-like automata. The experimentation in the sixteenth century however only served as entertainment for kings and in travelling sideshows. The ideas for what automata might do ranged far beyond the technology of the time. It was not until the second half of the twentieth century, that robots have become economically utilitarian. With smaller and more powerful computers, on board machines for sensing as well as calculating and thinking, robots will become more widespread in the future. This class is presently not included in the collection; but will be included in the future.

Each class, like a species, starts within a given generation, flowers, and dies or is incorporated within another class. Each started almost as an independent thread but is beginning to merge into one or two dominant classes: computer and automata. Figure 1 illustrates the potential scope of the collections, indicating the period in which each class emerged and for those, becoming extinct, the time of their gradual demise.

THE PIONEER COMPUTERS
1936 THROUGH 195Ø

CATALOG 1 OF THE DIGITAL COMPUTER MUSEUM

NTRODUCTION
- SHORT NARRATIVE
- SCIENCE MUSEUM POSTER PORTION UP THROUGH 195Ø.

'HE MACHINES (AS MUCH AS POSSIBLE OF THE FOLLOWING INFORMATION WILL BE GATHERED FOR EACH OF THE FIRST DOZEN MACHINES: BELL TELEPHONE LABORATORIES CALCULATOR MODELS I, II, III); Z1 AND Z3: HARVARD AUTOMATIC SEQUENCE CONTROLLED CALCULATOR; ATANASOFF-BERRY COMPUTER; THE COLOSSUS; THE ENIAC; THE EDVAC; THE IAS COMPUTER; THE EDSAC, WHIRLWIND; AND THE PILOT ACE.

- Data
  - Word length
  - Memory size
  - Speed
  - Clock rate
  - Instruction format
  - Technology
  - Power consumption
  - Size
  - Component count
  - Cost
  - Maintainability
  - Project leaders
  - Number produced
  - Predessor
  - Successors
- Benchmark dates
- Uses
- Achievements
- Organization chart - showing funders
- List of all personnel through 195Ø with simple bio data
- Floor plan of installation with measurements, including power supply, off-line i/o, submission counters, etc.
- Diagram of machine and key circuits
- Photos
  - Overall
  - I/O units
  - Console
  - Flip-flop, arithmetic registers, logic circuit, control unit, memory
- Contemporary quotes about machine (including press clippings)
- Sources
  - Bibliography
  - Films, slides, and photos
  - Artifacts
  - Acknowledgement to compilers

Program:

Compilation of data

- ENIAC, EDVAC - Beth (John Brainerd)
- EDSAC - Gwen (Wilkes)
- Bell Labs - Beth (Stibitz)
- Atanasoff - Beth (Atanasoff)
- Whirlwind - Beth (MITRE and MIT archives)
- Manchester - Gwen (Edwards)
- Pilot ACE - Gwen (Woodger)
- Zuse - Andy/Beth (Ceruzzi)
- MARK I ~~Harvard~~ - Jamie (Cohen)
- IAS Machine - Jamie (Bigelow)
- Collossus - Beth (Andy) (Flowers)

June 1 - Preliminary checklist - identification of gaps

- Catalog design begins
- Determination of publication schedule

August 15 - Inhouse review of whole work

Sept 1 - Ms sent for outside review - Randall, Cohen

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August 7 1985

memo to: Gwen Bell
from: Michael Templeton
cc: Oliver Strimple
subject: International Collecting.

The Computer Museum's collections are presently primarily from the United States, with limited contributions from the UK, Japan, and other western european countries. There is practically no material from middle european countries allied with the USSR, and none from the third world countries that are beginning to develop their own manufacturing capabilities.

Contacts with these countries are difficult, and little is known about their own understanding of the history of computers and computing. One vehicle for developing contacts and eventually items for the collections is working with science and technology museums in these countries. Most of the European science and technology museums maintain active collection of past and current technologies, and have a strong interest in international communication and exchange. They generally interchange objects for exhibition purposes, and exchange collections items as well.

The primary museum group is CIMUSET, the Committee on Museums of Science and Technology, which is a standing committee of ICOM, the International Council of Museums, a UNESCO agency. CIMUSET meets once a year in host countries in Europe, and is attended by 40-50 museums directors and senior staffs from 10-15 countries. Personal contacts at these meetings can lead to research support, offers of assistance for visits to host countries, and potential exchanges of artifacts.

Most of the museums have limited access to computer technology outside of their own country's trading groups, and systems are maintained in use much longer than in this country. The offer of exchanging surplus or duplicated materials from The Computer Museum's collections for comparable items collected in the host country would likely be warmly responded to. If The Computer Musuem were to sponsor with a manufacturer the donation of early ic computer technology--HP 35's, say--to interested museums, a corresponding relationship could be built for the future.

Cautions to be taken into account would include the question of inadvertent technology transfer, and insuring that the corresponding museums saw The Computer Museum as a partner and equal, rather than as a cultural pirate, seeking artifacts before they had recognized their own national significance.

Another project that might gain the acceptance of CIMUSET would be the documentation of all prototype and manufactured computers in host countries that depended entirely on vacuum tube technology. No issues of secrecy or technology transfer should appear here, and each country's museum would be able to stimulate responses by historians, technologists, or laboratories that would create a CIMUSET publication on early computer development that would complement the museum's present United States vacuum tube computer inventory. The Computer Museum would be responsible for the editorial and publications work of the publication, which would bear a CIMUSET cachet, and which would be distributed to CIMUSET members through ICOM distribution channels.

Contacts for pursuing these initiatives would include the head of the Deutsches Museum, Dr. Otto Mayr, Dr. Victor Danilov, President of the Museum of Science and Industry (Chicago), Dr. Joseph Kuba, head of the National Technical museum (Prague), Dame Margaret Weston, head, the Science Museum (London), and Dieter Schultz, secretary, CIMUSET.