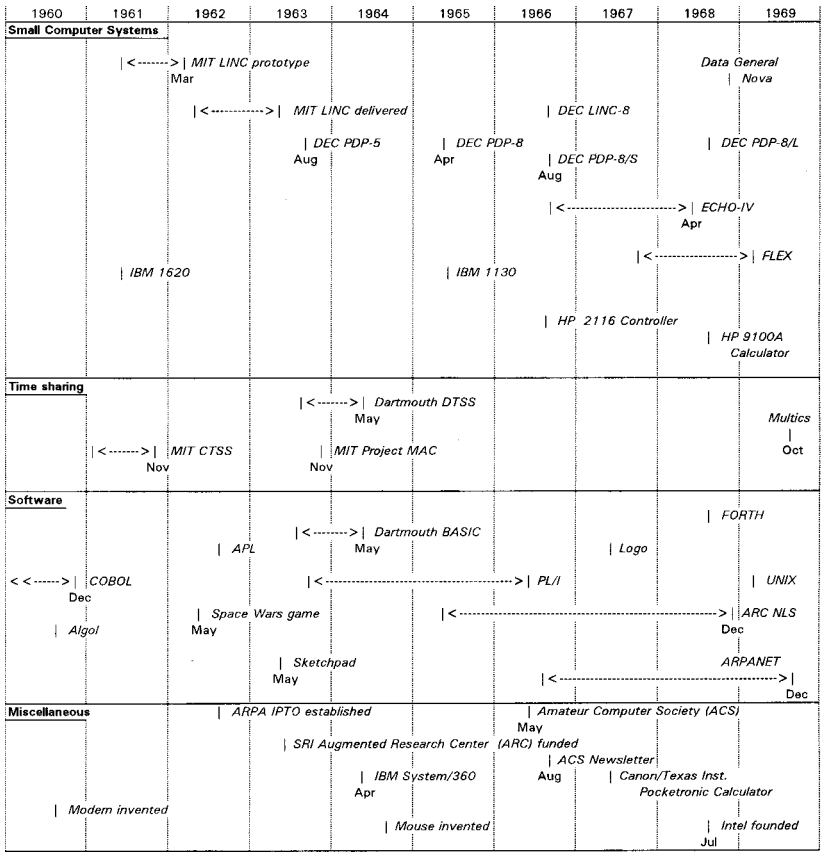

FIGURE 2.1:
A graphical history of personal computing in the 1960's.

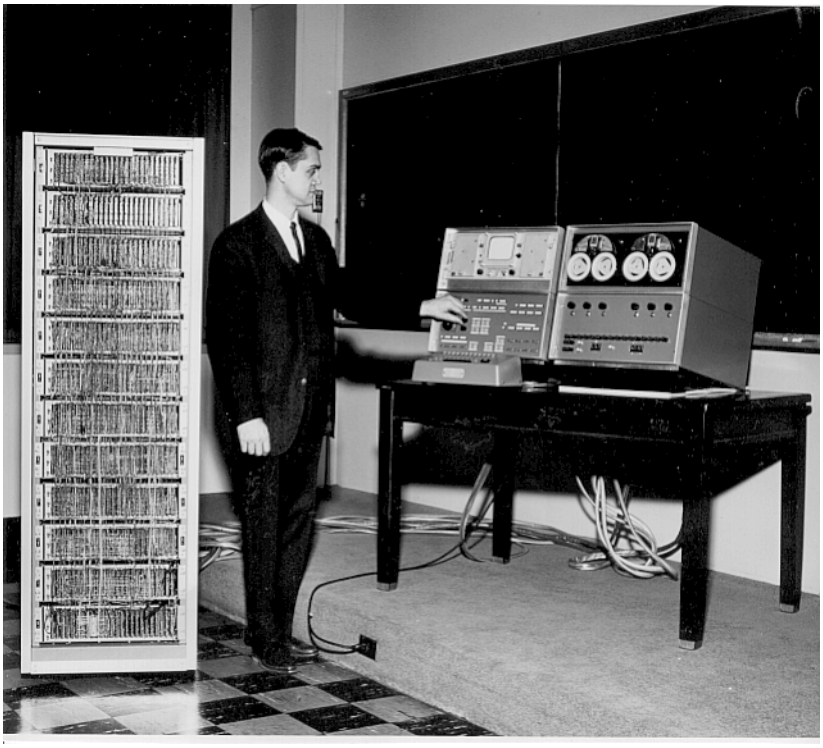

Figure 2.2: Wesley A. Clark and the MIT LINC computer. A number of people consider LINC as being the first personal computer.

Photograph is reprinted with permission of MIT Lincoln Laboratory, Lexington, Massachusetts.

Chapter 2 Personal Computing in the 1960's

Most mainframe computers used a sequential batch process type of operation for computing tasks at the end of the 1950's. This mode of operation resulted in a slow and cumbersome interaction with the user.

The 1960's was a decade that saw many improvements to personalize the computer user interface. The government funded research in organizations such as the Massachusetts Institute of Technology (MIT) and the Information Processing Techniques Office (IPTO) by the Advanced Research Projects Agency (ARPA) of the Department of Defense. This resulted in innovations of significant importance for personal computing. Educational institutions such as MIT, Dartmouth College and Stanford Research Institute (SRI) created items such as the first personal computer, the "mouse," computer networks, BASIC programming language and time sharing.

2.1 ... Time sharing

A time sharing computer system is one that interacts with many simultaneous users through a number of remote consoles. An interleaving in time of two or more jobs on one processor gives what appears to each user, as the dedicated use of the computer. The first paper published describing time sharing was by Christopher Strachey at the Paris International Conference on Information Processing in June 1959.

MIT developed and tested the concepts of time sharing between December 1958 and early 1959 on an IBM 704 computer. Principals in this early development were John S. McCarthy, an early advocate of time sharing and Herbert M. Teager.

A Study Group investigated MIT's computational requirements for research and teaching in 1960 and made recommendations in early 1961. This resulted in the

development of a time sharing system for an IBM 709 computer by Fernando J. Corbató and his staff that was first demonstrated in November 1961. This group developed the system further on an IBM 7090 computer and it became known as the Compatible Time Sharing System (CTSS). MIT presented a paper describing CTSS at the San Francisco Spring Joint Computer Conference in May 1962.

Jack B. Dennis wrote a proposal for a time sharing system on the MIT TX-0 computer in 1959. Then in 1961, MIT received a Digital Equipment Corporation (DEC) PDP-1 minicomputer. Under the direction of Dennis, a graduate student John E. Yates developed a time sharing system for the DEC PDP-1 that became operational in the spring of 1963.

Bolt Beranek and Newman Inc., (BB&N) in Cambridge, developed another time sharing system for the DEC PDP-1 in 1962. Two of the principals in the development were J.C.R. Licklider and John McCarthy. BB&N presented a paper entitled "A Time-Sharing Debugging System for a Small Computer" describing these developments at the Spring Joint Computer Conference of 1963.

The Advanced Research Products Agency (ARPA) appointed J.C.R. Licklider in 1962 to be in charge of the new Information Processing Techniques Office (IPTO). Convinced that time sharing would be an important computer technology, Licklider selected Robert M. Fano at MIT to head the development of a major new system. This new time sharing system became known as Project MAC (Multiple-Access Computer or Machine-Aided Cognition) and an early version was operational by November 1963. Initially it could serve 24 users simultaneously. In less than a year it was serving 200 users with 100 teletypewriter terminals. Improvements made to the system throughout the 1960's resulted in it becoming an important node in the ARPANET.

In late 1963 the Project MAC Group began a search for a more suitable time sharing computer. This resulted in the selection of the General Electric GE-645 computer in 1964. Shortly after, General Electric and Bell Telephone Laboratories joined MIT in the development of a new comprehensive time sharing system. This new system became known as Multics (Multiplexed Information and

Computing Service). It became operational at MIT in October 1969, and within two years was serving 500 users.

These early developments of time sharing technology were important in providing personal computing capabilities in a more friendly interactive mode at lower cost to an increasing number of users. Other institutions such as Dartmouth College started to evaluate these new concepts.

2.2 ... Dartmouth DTSS and BASIC

Between 1956 and 1962, a small university called Dartmouth College in Hanover, New Hampshire, started developing simple high-level programming languages on a small LGP-30 computer. Principals in these developments were John G. Kemeny and Thomas E. Kurtz. Kemeny and Kurtz had a conviction that, "...knowledge about computers and computing must become an essential part of a liberal education." To implement this objective and achieve acceptance by the students they had to simplify both the computer interface and the programming language used by the students.

Existing languages such as FORTRAN and ALGOL were too complex for the majority of students. The early languages developed at Dartmouth were: DARSIMCO (**DAR**tmouth **SIM**lified **CO**de), DART, ALGOL 30, SCALP (**S**elf **C**ontained **AL**gol **P**rocessor) and DOPE (**D**artmouth **O**versimplified **P**rogramming **E**xperiment). During this period Kurtz became aware of time sharing technology at MIT and BB&N. To meet their computer educational objectives they decided to develop and implement a new time sharing system and a new simple programming language for interactive computing.

In 1963, Dartmouth College selected a new hardware system consisting of a General Electric (GE) GE-225 computer for user programs, a GE Datanet-30 computer for communications and scheduling, a disk drive and other peripherals. Kurtz supervised undergraduate students in the development of the time sharing software,

emphasizing simplicity of use for the novice. This software became known as the Dartmouth Time Sharing System (DTSS). At the same time Kemeny developed a compiler for the simple high-level programming language they had designed, named Beginner's All-purpose Symbolic Instruction Code (BASIC). Features incorporated in the BASIC programming language were influenced by the knowledge and experience of using ALGOL, FORTRAN and the early languages developed at Dartmouth. The College received the new computer system equipment in February 1964 (the GE-225 computer was changed to a GE-235 in the summer). The new time sharing system, BASIC compiler and the first test programs operated successfully on May 1, 1964. Subsequently, the College put the programming language in the public domain in order to improve its widespread acceptance.

Between 1964 and 1965, Dartmouth College began an association with GE that resulted in a joint effort to develop a time sharing system and a BASIC compiler for a new GE-635 computer. The College developed the BASIC compiler that became known as GE-BASIC. GE became a significant contributor in the dissemination of the BASIC programming language on larger computers. Other companies such as Digital Equipment Corporation (DEC) and Hewlett-Packard (HP) developed interpreter implementations of BASIC for smaller computers in the late 1960's.

The Dartmouth College development of a simple time sharing system and the BASIC programming language made a significant contribution to personal computing in the mid 1960's and following years. Continued improvements to the language were made with the release of versions two to five between 1965 and 1968. All implementations of BASIC at Dartmouth College have been compilers, whereas most of the later implementations on small personal computers were interpreters. Time sharing became widespread and BASIC became a popular programming language for personal computing.

However for intensive computational applications, time sharing could not provide the processor resources required. Also the convenience and flexibility of having

one's own dedicated processor led to the development of the personal computer.

2.3 ... The First Personal Computer

To avoid confusion, one has to define the term "personal computer" as being a computer designed for use by one person. In the 1960's most computers were large mainframes, shared by many users.

A number of people consider the MIT LINC to be the first personal computer. The Massachusetts Institute of Technology (MIT) developed LINC to facilitate the use of computer technology in biomedical research laboratories. LINC is an acronym for **L**aboratory **IN**strument **C**omputer. Principal designers were Wesley A. Clark and Charles E. Molnar. MIT demonstrated a prototype in March 1962 at the Lincoln Laboratory and completed sixteen units in mid 1963. The scientific users assembled the units to improve their understanding of the system that cost about $32,000. Initial software was a text editor, an assembler and some utilities.

The LINC system had four console modules, an electronics cabinet and a keyboard. The electronics cabinet was about the size of a refrigerator. The processor logic circuits used transistorized system modules from Digital Equipment Corporation (DEC). Memory was a magnetic core type with a basic capacity of 1,024 twelve-bit words, expandable to 2,048 words.

The four console modules consisted of a control console, an oscilloscope module, a tape module with two magnetic-tape drives and a terminal module. The oscilloscope module could display a 512 by 512 point image.

A small number of scientific laboratories used the LINC computer in dedicated applications. In 1966, DEC released a refined version of the LINC computer that they named LINC-8 and sold for $43,000. During this period of time other companies were extending the low end of the market by developing small computer systems.

2.4 ... Small Computer Systems

Other organizations developed small computer systems or minicomputers during the 1960's for scientific and commercial users (See Chapter 1.6 for earlier small computer systems). This continued to lower the cost of computers and extend the concept of personal computing.

DEC delivered the first production version of the 18-bit PDP-1 minicomputer in early 1961. A minimum system cost $85,0000. This was followed by the PDP-4, then the 12-bit PDP-5 that cost $27,000 in August 1963. The 12-bit PDP-8, which became very successful, was announced in late 1964 and the first units delivered in April 1965. DEC marketed the PDP-8 as "the world's lowest-priced, fully programmable computer system." The computer used new technology such as small scale hybrid integrated circuits to reduce the price of the unit to $18,000. The PDP-8 had 4K words of core memory, expandable to 32K words. Then in August 1966, DEC introduced the low cost PDP-8/S system with a console teletype for $10,000. In 1967, DEC developed the PDP-8/I computer that incorporated TTL technology in place of the hybrid integrated circuits. This was followed in the summer of 1968 by a similar machine with fewer options called the PDP-8/L. The PDP-8/L with 4K of memory and a teletype sold for $8,500.

IBM introduced small systems for technical and professional users starting with the Model 1620 in 1961. This was a batch-oriented system for FORTRAN users. Then IBM released the Model 1130 computing system in 1965. The 1130 was a single-user system with an integrated disk-based operating system.

William Hewlett and David Packard founded Hewlett-Packard (HP) as a partnership in January 1939 and incorporated it as a company in 1947. It was initially a manufacturer of electronic test equipment. HP began evaluating computers to automate their instrument measurement systems in September 1964. This resulted in the development of the Model 2116 instrument controller in 1966. This was the company's first computer and HP

sold many units as stand-alone minicomputers. The HP 2114A minicomputer was released shortly after at a price of $9,950. HP also started development of the 9100 series of electronic desktop calculators in 1966. The company released the HP 9100A in 1968, that has been described as a "computing calculator." It was a predecessor to the programmable calculators released in the early 1970's.

Other companies competed with DEC, HP and IBM for a share of the small system market. Some of these companies were: Computer Control Corporation (3C), Control Data Corporation (CDC), Data Machines, Honeywell, Scientific Control Systems (SCS), Scientific Data Systems (SDS) and Systems Engineering Laboratories. A group of people from DEC established Data General in April 1968 and announced their first 16-bit minicomputer called the Nova later that year.

Time sharing, simple high-level programming languages and small low cost computer systems were significantly increasing the number of users. However the interaction between the user and the computer was in most cases an awkward process through a teleprinter type of console. The 1960's was a decade of significant early improvements to the user interface

2.5 ... Graphics and the User Interface

Douglas C. Engelbart developed concepts for augmenting the human intellect at the Stanford Research Institute (SRI) in Menlo Park, California between 1957 and 1960. In March 1960, J.C.R. Licklider wrote an important paper entitled "Man-Computer Symbiosis" [12, pp. 306-318]. The paper contained ideas similar to Vannevar Bush's Memex concept, but extended them through the use of interactive computer technology. In late 1962, Engelbart presented his SRI report entitled "Augmenting Human Intellect: A Conceptual Framework" and a proposal to the newly formed Information Processing Techniques Office (IPTO). Licklider, who was the first IPTO director, approved the proposal that provided early

government funding for an Augmented Research Center (ARC) at SRI in 1963.

Various graduate students at MIT and staff at General Motors Corporation did research on computer assisted drafting in the early 1960's. However a turning point occurred when Ivan E. Sutherland conducted significant research on computer graphics for a doctoral thesis in 1962 at MIT. Sutherland created an interactive graphics system, that enabled a user to create graphical figures on a video display using a light pen. The geometrical shapes could be copied, expanded, moved, rotated and shrunk. This also resulted in the development of the first user interface that incorporated a split screen (two-tiled windows), menus and the use of icons for such things as constraints to limit line lengths. Sutherland published the results of this research in an article entitled "Sketchpad: A Man-Machine Graphical Communications System" in May 1963. This became the basis for computer assisted drafting (CAD) and computer assisted engineering (CAE) software systems. In the late 1960's various companies such as Applicon, Calma and Computervision offered turnkey CAD systems.

The ARC research on facilitating the use of computers to extend human knowledge and intellect, resulted in the development of significant improvements to the user interface. Engelbart concentrated his research on an interactive graphics environment as compared to the then prevalent teletype communication interface. Engelbart evaluated various methods of interacting with the screen display. During this research he developed the "mouse" in 1964, for which he holds the patent. The interactive graphics system also used a small five-key keyset that supplemented the selection capabilities of the mouse. Another principal in the research was William K. English.

Engelbart's group also developed an on-line system with new capabilities called NLS. NLS was an acronym for "on-line system." He demonstrated the new system at the ACM/IEEE-CS Fall Joint Computer Conference in San Francisco, California in December 1968. The NLS system incorporated the capabilities for mixing text and

graphics on the screen display. It also used a split screen (two-tiled windows) that led to the development of multiple tiled windows in 1969. The group also developed an electronic-mail (e-mail) system and incorporated it into NLS.

Between 1967 and 1969, Alan C. Kay and Edward Cheadle built a computer called FLEX at the University of Utah. Kay and Cheadle also developed a user interface that included multiple tiled windows and square icons representing data and programs.

The graphics and user interface research at ARC, MIT and the University of Utah led to significant developments later at Xerox PARC, Apple Computer and Microsoft. SRI transferred activities of the ARC research group to Tymshare, Inc., of Cupertino, California in 1977. Tymshare renamed the NLS system AUGMENT and provided marketing for the product. McDonnell Douglas Corporation acquired Tymshare in 1984.

2.6 ... Software

COBOL

The CODASYL group had started development of COBOL in 1959. In 1960 the United States government advised that they would not accept computer equipment without a COBOL compiler. The development groups defined the language and compilers were operating by December of 1960.

PL/I

IBM decided to create an advance common programming language that would meet the requirements of both the scientific, commercial and system users in 1963. The SHARE user's group assisted in the language development. IBM initially intended to release the language with IBM's new line of System/360 computers. The first description of the language was in March 1964.

The initial name assigned to the new language was NPL - New Programming Language. However in 1965 the name became PL/I - Programming Language /I. Some ambiguity exists in the suffix (I). The pronunciation is

"Programming Language One," however the suffix is the Roman character I and not the Arabic numeral 1. IBM released the PL/I compiler in 1966.

The American National Standards Institute (ANSI) subsequently defined a version of the language with a reduction in the number of features. ANSI named this version, the "G" Subset of PL/I.

Logo

Bolt Beranek and Newman Inc., (BB&N) in Cambridge, Massachusetts started developing Logo in 1966. They then pilot-tested the language in the summer of 1967. Principals in the development were Seymour Papert, Daniel Bobrow, Richard Grant and Wallace Feurzeig who gave Logo its name. Charles R. Morgan and Michael Levin developed an extended version of Logo during 1967-68. The language is designed for use in education by children.

FORTH

Charles H. Moore developed the FORTH programming language around 1968. The language was designed by Moore to improve programming productivity. Additional features were that it was easy to move to a different machine and it required a small amount of memory.

UNIX

UNIX is an operating system developed by Kenneth L. Thompson and Dennis M. Ritchie at AT&T's Bell Laboratories. The main feature of the operating system was its portability that enabled it to run on almost any computer. Bell Laboratories released UNIX in 1969 and provided a free license to educational users. This resulted in its widespread use at academic institutions.

ARPANET

In the 1960’s most computers were large mainframes with restricted user access. Some had time sharing and remote terminals. However remote communication by a phone line and data transfer between different computers was difficult.

Paul Baran conducted distributed communications research at the RAND Corporation as early as 1962, and published details in 1964. Then between 1965 and 1966, Donald Davies from the National Physical Laboratory (NPL) in the United Kingdom wrote papers describing concepts of digital communications using short messages or "packets." J.C.R. Licklider, who was the first director of the Information Processing Techniques Office (IPTO) of the Advanced Research Projects Agency (ARPA), had also been promoting the concept of an "Intergalactic Computer Network." A concept that tried to define the benefits and problems of computer networking.

Around this time period the IPTO was funding computer research projects and wanted to improve data communications for time sharing and networking. Bob Taylor who was the current director of the IPTO and a proponent of computer communications, recruited Lawrence G. Roberts to lead this networking project.

Roberts began the experimental computer network research in 1966. He then received an appointment to manage the IPTO programs for the ARPA in 1967. This led to an initial plan for an ARPANET being published in October of that year. This network plan would enable load sharing, message service, data sharing to link university computers and researchers. It would also use the "packet" concept, interface message processors (IMP's) and leased telecommunication lines. ARPA awarded a contract to develop the network to Bolt Beranek and Newman (BB&N) in January 1969. Robert Kahn was a principal in the overall system design. By December of that year they had four nodes of the network installed and operating. This packet switching data communication system became highly successful in connecting many major universities, government organizations and research institutions. The ARPANET formed the basis for what subsequently became known as the Internet.

Games

Student hackers and academic staff developed some of the earliest games at the Massachusetts Institute of Technology (MIT) on the TX-0 and PDP-1 computers. One of the games was for a mouse, that would poke its way

through a maze constructed by a light pen to find a blip in the shape of cheese.

Then in 1961 Stephen Russell who was a science fiction enthusiast and a student hacker created an interactive game called "Space Wars" on the PDP-1 computer. The game displayed rocket ships that could fire missiles in a celestial battlefield. MIT displayed the game at the annual Science Open House in May 1962. The software was free and received wide distribution. J. M. Graetz, Peter Samson and others contributed various enhancements to Space Wars that provided additional challenges to participants.

Ralph Baer of Sanders Associates in Nashua, New Hampshire received a patent for a ball-and-paddle video game using a TV set. Development started in September 1966. Baer had basic ball-and-paddle games working in early 1967 and a hockey game by September. Magnavox marketed the game system as Odyssey 100, the world's first home video game.

2.7 ... Hobby & Amateur Computing

This aspect of personal computing started from an interest by many enthusiasts in the building of their own computer. These people were both amateurs and professionals with a strong technical interest in hardware and software. Prior to the development of large scale integrated (LSI) memory chips and the microprocessor, it was not easy to build a computer. It required a knowledge of vacuum tube or transistor circuitry, digital logic, core memory, peripherals and other areas. It could also be a costly investment to create a complete system.

In May 1966 Stephen B. Gray founded the Amateur Computer Society (ACS). In August of that year he published the first *ACS Newsletter* devoted to hobby computing. The society and newsletter were a significant source of information for building a computer in the late 1960's and early 1970's.

The November 1967 issue of the *ACS Newsletter* included a survey requesting details of each member's

computer. The January 1968 issue reported the following results. Clock speeds ranged from 500 kHz to 1 MHz, with the average 500 kHz. Instruction sets were small ranging from 11 to 34 instructions. The number of registers ranged from 2 to 11, with three being the most common. Word sizes were from 4 to 32 bits, with 12-bits being the average. Memory size ranged from 4 to 8K, all magnetic core. Most computers used discrete transistors and a few reported the use of integrated circuits. A Teletype terminal was the most common input/output device. Cost ranged from zero to $1,500, with an average of $650.

The April 1968 issue of *Popular Mechanics* included an article entitled "A Computer in the *Basement*?" The article described the ECHO IV, one of the few home-built computers actually completed. ECHO was an acronym for **E**lectronic **C**omputing **H**ome **O**perator. It had a designation of IV because it used surplus boards from a Westinghouse PRODAC IV computer. James F. Sutherland designed and built the computer between 1966 and 1968. ECHO IV was seven feet long, six feet high and 18 inches deep. A console desk included an electric typewriter keyboard, surplus teletype printer, 8-channel paper tape punch and an 8-channel paper tape reader. The unit had 120 circuit boards using 2N404 transistors and NOR logic elements. It had four registers, used 18 instructions with a clock speed of 160 kHz. Memory was an 8K surplus core unit. The computer is now located at The Computer Museum in Boston.

Many amateurs copied existing designs of small computer systems. Some based their designs on instruction sets from IBM 1620 or DEC PDP-8 computers. Enthusiasts started many computers. However only the most determined completed them.

Time sharing, small computer systems and to some extent, amateur computing started personal computing in the 1960's. Research had also improved the human interface to the computer. However the personal computer was still complex and expensive to construct. New integrated circuit developments that led to the creation of the microprocessor significantly reduced this complexity.