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MICROCOMPUTER STANDARDIZATION PROGRAM AT
LAWRENCE LIVERMORE LABORATORY

A. J. Stripeika

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A. HISTORY:

Standards has been part of the Electronics Engineering Department since the start of the Lawrence Livermore Laboratory in 1952. After only a few years of operations a full time engineer was assigned to coordinate the work. With the requirement for very reliable electronic equipment for weapons testing in adverse climatic conditions, manufacturing of electronic equipment standards were established. Standards were expanded to other areas - relay control systems, nuclear counting, electronic components, power supplies, chassis modules, specification format, etc. From the very beginning of the Laboratory, the Electronics Engineering Department (EE Dept.) recognized the importance of preventing waste wherever possible. It was important to have the engineers work on the difficult problems that had not been solved by others and not waste time reinventing the wheel.

Because of the matrix organization at the Laboratory, electronics engineers are part of the EE Department. This type of organization allows for the potential of standards among all engineers. At Laboratories that have a strong line organization, the electronics engineers are scattered among the project groups. There is usually only a minimum of communication and extensive standards for the whole Laboratory seldom exist. To have standards takes effort no matter what the organization, but it is so much easier in a matrix organization.

B. DIGITAL LOGIC ERA:

The transistor had a major impact on electronics engineering. It especially made possible large digital computers. After the invention of the transistor, the cost of computer systems dropped drastically and made it practical to manufacture minicomputers which could be afforded by many. A major application of minicomputers was the control of experiments and data acquisition. To accomplish this, engineers had to design digital interfaces between the experiment and the minicomputer since they were not available commercially. Interfaces also had to be designed for many peripheral equipment such as magnetic tape drivers, printers, etc. Since the interfaces were complex, engineers kept searching for a less expensive and faster way to accomplish the design.

By 1968, a modular digital system was adopted as a standard at the Laboratory. It was based on a line carried by Control Logic Incorporated. The system is based on a 3" x 4-1/2" printed circuit card with a 44-pin edge connector. The commercial cards available were expanded by Laboratory designers to include circuitry not commercially available. This included the analog circuitry, power drivers, etc. By 1970, the Laboratory carried in their Stores Stock over 40 different logic cards made by Control Logic and 12 different cards designed at the Laboratory and today there are over 70. When there was a need to interface, such as interfacing a minicomputer to a mass spectrometer, an engineer would design an overall system logic diagram, obtain the required logic cards from stock, assemble the cards in a chassis, and connect it into the system. A system could be put together in a matter of weeks instead of months. Some of the components are shown in Fig. 1.

To make the Control Logic Card an effective standard, not only were the cards available in the Stores Stock, but also a large handbook which contained the logic diagrams of available cards was made available to designers. The material is updated through the mail distribution. The logic handbook has become a very popular item and many outside organizations have requested copies. The Lawrence Berkeley Laboratory became interested in the Control Logic cards and has cooperated with us in the design and use of the units.

C. MICROCOMPUTER ERA:

Solid state circuitry made very rapid advances. In only 10 years after Dr. Shockley invented the transistor, techniques were developed to have more than one transistor on a chip, the integrated circuit (IC). By 1970, the technology had advanced further so that instead of a few circuits, it was now possible to have thousands and the era of the large scale integrated circuit (LSI) was born. Using the LSI technology, Hewlett Packard Company developed the Model 35 hand calculators which has revolutionized hand calculators. Soon after, Intel Company developed a 4-bit microprocessor on one chip. This was the start of the microcomputer era. Though there is no definition of a microcomputer, it's generally accepted that it is a "computer on a chip".

A few engineers used the first microcomputer, Model 4004, as early as 1972. However, the large usage at the Laboratory started in 1974 when the 8008, an 8-bit microprocessor, became available and it was added in the Control Logic Standard Card System at the Laboratory. The EE Department sponsored many classes on the fundamentals of microcomputers to bring the engineering staff to at least a familiarity status with microcomputers. By 1976, Intel produced the 8080 microprocessor, which required only 15-30 chips to make a microcomputer system. The usage accelerated even more rapidly so by the end of 1976 over 60, 8000 series microcomputer systems were in use at the Laboratory.

The microcomputers were first used in applications that were formerly done using hand-wired logic. The microcomputer system was usually simpler to implement and allowed changes to be made through software instead of laborious and expensive rewiring of hand-wired logic.

The microcomputer systems became even more popular as higher level languages became available - PLM and BASIC, since the user could quickly make changes.

As memories for the microcomputers became less expensive, larger systems (with more than 8K bytes) became more attractive. The application expanded into data acquisition systems, on-line calculations, and control. Many of these tasks were formerly done by minicomputers. This was further enhanced with the availability of the floppy disc.

In 1975, Digital Equipment Corporation announced the LSI-11 microcomputer which was based on their PDP-11 minicomputer line. The LSI-11 further accelerated the usage of microcomputers at the Laboratory. With the availability of operating systems, powerful BASIC, FORTRAN and the floppy disc, the microcomputer applications expanded rapidly into the digital control of systems. The Laboratory

added the LSI-11 components to the Stores Stock, thus providing the designers a choice of either the 8080 series or the LSI-11. The 8080 series continues to be popular for applications which are relatively simple and can be done with 4 to 8K bytes of memory. The LSI-11 series has taken over the larger applications where memory systems of up to 28K bytes are required and formerly minicomputers were used as well as many small systems.

One reason for the popularity of the LSI-11 is the broad support provided by Digital Equipment Corporation. They provide extensive documentation of their system, both hardware and software. The software, including the operating systems, are very powerful and allow a person with a dual floppy disc to program the system without the need for utility programs residing in the computation worker machines.

The latest applications is the use of LSI-11 microcomputers in distributed systems. The 25-TW SHIVA Laser System will use over 50 LSI-11 microcomputers, many in a distributed system all connected through PDP-11/40s and a PDP-11/70. The National Uranium Resources Evaluation (NURE) Project which requires the neutron activation and analysis of 80,000 soil samples will use eleven LSI-11 microcomputers in the network to automatically control the transport and measurement of the samples.

The microcomputer era is still in its infancy. The number of systems being installed at the Laboratory continues to increase as shown in Fig. 2. This intense activity, along with the continuing advances in technology - more circuits per chip, less expensive memories, etc., will continue to increase the number of possible applications at the Laboratory.

Although the microcomputers are relatively inexpensive, the hardware could cost under \$1,000 for small systems and up to \$15,000 for more complex units. The software can be expensive and so can the mistakes. Thus, the systems are relatively inexpensive. There are, however, many options available, and many subtle considerations have to be made. This is especially important for experimental systems where changes are frequently made. Without careful consideration, the system may not be able to handle the requirement, or it could turn out to not be easily expandable later.

Tragedy frequently happens when an inexperienced person embarks on a system without a great deal of analysis and finds after a lot of effort that the system may not work - data rates are too fast, etc. It may be compared to a person who would start to build a building without a good set of plans - he may get away with it building a small structure but it probably will not come out very well building a skyscraper. Systems Analysis and top down design are being encouraged and in some groups required at the Laboratory.

A great many mistakes and the reinventing of the wheel are hopefully prevented through designers sharing of experiences. This is now being done through publications and informal sharing meetings and project reviews.

We have found through the years that a central staff is required to effectively administer a standards program. The staff makes judgments in consultation with users on what will become a standard, provide the mechanism to have it in the Stores Stock, insure full and complete documentation, communicate the information to users and, most important, to promote the usage of the standards. They also provide training for the designers, the technicians, and the users.

The standardization services provided at LLL will be discussed in the next section.

MICROCOMPUTER STANDARDIZATION SUPPORT

Small Computer Users Library (SCUL)

A library devoted strictly to small computer users (mini and micro) is provided with a full time librarian. The library has the following:

1) Master software tapes;

- Operating systems
- Source tapes
- Application programs

The librarian keeps the master copies up-to-date and provides duplicate copies on paper tape.

2) Documentation;

A large selection of documentation is available:

- a. Software
- b. Specifications
- c. Instruction manuals.

3) Educational Material;

A wide selection of pamphlets, booklets, are available. The library also houses textbooks for classroom instruction.

4) Catalogues;

An extensive library of catalogues are available covering minis, micros, and peripheral equipment.

Software Licensing Agreements

The Laboratory has entered into agreements with vendors to license the use of proprietary software on a wide usage basis. The EE Department provides the liaison, keeps control and records of the distribution, provides updates to the users, and, when possible, provides the funds for the procurement.

LSI-11 Bulletin

A bulletin is published as required (usually about once a month) which is a compilation of notes from users. The subjects cover evaluation of new material, comments on problems encountered, new designs, new applications, etc. Since there are candid remarks made about manufacturer's equipment, it is for internal distribution only.

EE Bulletin

A bulletin is published quarterly which covers new Stores Stock items, reports, publications, etc. This bulletin includes many items related to the mini and microcomputers.

Users Meetings

Informal monthly meetings are held for LSI-11 users. At the meetings first-hand experiences are shared. Problems with hardware and software - new hardware evaluated - new software available - new projects underway. It is planned to have similar meetings for users of the 8080 series.

Stores Stock and Documentation

The 8080 series microcomputer is stocked using Control Logic cards as well as the chips. The LSI-11 series cards and peripheral are also stocked.

Extensive documentation is available on these items.

Publications

The dissemination of work done in the field of microcomputers is encouraged. Appendix A is a partial list of microcomputer publications by designers at LLL.

Educational Facilities

Classes are frequently held for design engineers, scientists and technicians. The classes vary from a few hours to a few weeks. Many of the classes have been pre-recorded on video tape. Some of the classes use a trainer housed in a suitcase on which the student does actual problems and is encouraged to take it home for homework assignments. A typical class is shown in Fig. 3.

Hardware Designs

The policy of the Laboratory is to purchase items whenever possible. When items are needed for the enhancement of a standard and it is not available commercially, a few people are available to design the item and have it made to Laboratory specifications. A special chassis for the LSI-11 was designed at LLL and shown in Fig. 4 and 5.

Memory Programming Center

Facilities are available to program memories for the 8080 series and LSI-11. The 8080 series tapes can be generated on the 7600 computers. The LSI-11 programs can be entered at the center. The 8080 PROM programmer is shown in Fig. 6.

Simulators

Programs are available on the 7600 computers for the simulation of 8080 series microcomputer.

Application Assistance

Experts are available to assist inexperienced designers on special problems.

SUMMARY

The microcomputer is having a major impact on the Laboratory. To date, there are nearly 160 units installed and another 170 will be installed by the end of 1977.

Through a standardization program, only two systems are in use to any extent at the Laboratory - the Intel 8080 series and the LSI-11. The standardization program is based on making it convenient for designers to use these systems. The components for assembling systems are available from Stores Stock. Various aids and a library are available for further assistance. A very helpful program is the LSI-11 Users Meeting where 30 to 50 users meet monthly to exchange first-hand their positive and negative experiences. Also, an LSI-11 bulletin is published which contains experiences, evaluations, new items, etc.

There is always a concern by many that a standardization program will result in the use of old technology and will keep engineering from being able to use the latest and best technology. We have found that if the standardization program is reasonably managed, the engineers will have modern technology available to them. Actually the engineers are able, in most cases, to be more creative by spending their time on solving the problem at hand in the most creative way rather than keep using effort to learn and try out every new product that hits the market.

To be cost effective, the manager of the Standardization Program must be able to make hard decisions; such as dropping old standards when they no longer serve their purpose. If this is not done, soon one will have so many standards that the cost of the standards program will quickly exceed the gains. Standardization programs are expensive and require frequent reviews.

The ever increasing speed with which technology is changing today, especially in the microcomputer field, requires a very dynamic standardization program. A program that offers up-to-date standards meeting the needs of most of the designers and at the same time aware of new technologies becoming available. We have a long ways to go before we have a standardization program that will meet the needs of most microcomputer designers. However, we have made a good start.

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Fig. 1 Some of the Stores Stocked
8080 Microcomputer Components

NO. OF MICROCOMPUTER SYSTEMS
INSTALLED AT LLL

Fig. 2

Fig. 3. Class on Microcomputers at
Lawrence Livermore Laboratory

Fig. 4. Chassis for LSI-11 Designed at
Lawrence Livermore Laboratory

Fig. 5. LSI-11 Chassis Assembly

Fig. 6. 8080 PROM Programming Facility

MICROCOMPUTER PUBLICATIONSAPPLICATION

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