The ALOHA System

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THE ALOHA SYSTEM is composed of a related series of contracts and grants from a variety of funding agencies with principal support from ARPA, which deal with two main themes: computer communications (TASK 1), and computer structures (TASK 2).

Under computer-communications there is work in (a) Studies on computer communications using radio and satellites, (b) The development of a prototype radio-linked time-sharing network, (c) System studies and planning for a Pacific area computer communications network linking major universities in the U.S., Japan, Australia and other Pacific countries.

Under computer structures, we are engaged in research/development in multiprocessor computing structures, computer networks, and geographically distributed computing systems. This work is being undertaken in two phases: 1) the establishment of a research facility and 2) the research work itself. The research facility is centered around the BCC 500 computing system.

TASK 1: RADIO COMMUNICATIONS

Developments in remote access computing during the latter part of the 1960's have resulted in increasing importance of remote time-sharing, remote job entry and networking for large information processing systems. The present generation of computer-communication systems is based on the use of leased or dial-up common carrier facilities, primarily wire connections. Under many conditions such communication facilities offer the best possible communications option to the overall system designer of a large computer-communication facility. In other circumstances, however, the organization of common carrier data communication systems seriously limits the possibilities of a large information processing system.

Since September 1968, THE ALOHA SYSTEM Project at the University of Hawaii has investigated alternatives to the use of conventional wire communications in a geographically diffuse computer system. When the constraint of data communications by wire is eliminated a number of options for different methods of organizing data communications within a computer-communications net are made available to the system designer. THE ALOHA SYSTEM Project has investigated the use of a new and simple form of random access communications for a statewide university computing system; the first links in this UHF radio-linked computer system, were set up in mid-1971.

Since that time the ALOHA SYSTEM has been in continuous operation. The ALOHA network uses two 24,000 baud channels at 407.350 MHz and at 413.475 MHz in the upper UHF band. ALOHA uses packet switching techniques similar to that employed by the ARPANET, in conjunction with a novel form of random-access radio-channel multiplexing.

We are now developing a Phase II ALOHA network with mini- and micro-computers as programmable terminals and repeaters. This effort is part of the work undertaken by the Packet Radio Group under the direction of Robert E. Kahn of ARPA. In conjunction with the hardware development we are also conducting system studies on the effects of different channel protocols upon system performance and also on the properties of the random-access channel (known now as the ALOHA Channel) used in different modes.

TASK 1: SATELLITE COMMUNICATIONS

We are now conducting experiments on the effective uses of high capacity satellite channels for packet switched communications. The experiments are centered around the geosynchronous satellites ATS-1 of NASA and INTELSAT IV of COMSAT.

With the development of new digital communications systems by COMSAT in which data at the rate of 50K baud can be transmitted through a single voice channel, data transmission by satellite has become both technologically and economically realizable. During the past year we have initiated two specific research projects for satellite extension of THE ALOHA SYSTEM and several theoretical studies involving the unique properties of satellite channels. The first of the projects involves the use of large commercial ground stations and the establishment of an ARPANET SATELLITE SYSTEM; the second involves the use of small inexpensive ground stations in a joint research effort with NASA Ames Research Center. In regard to the ARPANET SATELLITE SYSTEM we have been involved in a joint study with ARPA, BBN, UCLA, and Xerox PARC to design a suitable protocol for packet communications via satellite.

In December 1972, a 50 kilobaud data channel using a single PCM voice channel was installed between the COMSAT ground stations at Paumalu, Hawaii and Jamesburg, California. The first subscriber of this service was ARPA for inclusion of THE ALOHA SYSTEM into the ARPANET. The BCC 500 computer is planned to be the main HOST of the Hawaii TIP. We are also planning to connect the MENEHUNE (the communications computer for the ALOHA net) as the second HOST.

The second satellite project involves the use of the NASA satellite ATS-1 using small inexpensive ground stations which cost less than $5,000 each. Thus far we have progressed to the point where an ALOHA random access burst mode channel is in operation between the University of Hawaii, NASA/AMES Research Center and the University of Alaska. During the following year we plan to interface this channel into a computer near each of these ground stations, extend the number of ground stations to other sites, including possibly universities in Japan (Tohoku), Australia (Sydney), and other Pacific countries and establish a small ground station satellite network on an experimental basis.

We are also studying the possibility of using a complete transponder on a U.S. domestic satellite for ARPA Network operation. Such a transponder might provide megabit or higher data rates using a transponder dedicated to packet switched operation and terminating in a large number of moderately priced ground stations at a cost of only a fraction of the expected land line costs by the end of 1974. In addition to lower costs and higher speeds, a packet switched transponder on a domestic satellite would provide for higher network connectivity and enhanced possibilities for new forms of resource sharing.

TASK 2: BACKGROUND

Task 2 of THE ALOHA SYSTEM is concerned with multiprocessor computing structures and systems. Its primary research facility is the large BCC 500 system which was brought from Berkeley, California when Berkeley Computer Corporation ceased activities.

The main ideas involved in the 500's design were formulated by project GENIE at UC, Berkeley during 1967 and 1968. At that time it was planned that a private company would participate with UC in a joint design effort for a multi-user computing system designed expressly for on-line activities. This arrangement did not work well, however, and in early 1969 a number of persons from the project left UC and formed BCC with the specific goal of building a working prototype of a similar system.

This effort came to an end two years later when, with the nation's economy in a severe recession and the entire computing industry in an accompanying 'adjustment', the company ran out of available development capital a few months short of its goal of producing income on its prototype. The system itself, however, was almost complete and had been running an operating system for six months.

The equipment was acquired by the University of Hawaii upon the formation of Task 2 and was brought to Honolulu in early 1972. Since that time much of the Task's efforts have been directed to setting up the system once again and reconstructing some of the hardware after careful analysis of its state. Software development has also been done since the system has been locally usable beginning in March, 1973. By December, 1973 the system will achieve full host status on the ARPANET and will be operated regularly. By virtue of the time difference between Hawaii and the mainland — especially the East Coast — the system might be especially attractive for browsers.

TASK 2: BCC 500 SYSTEM

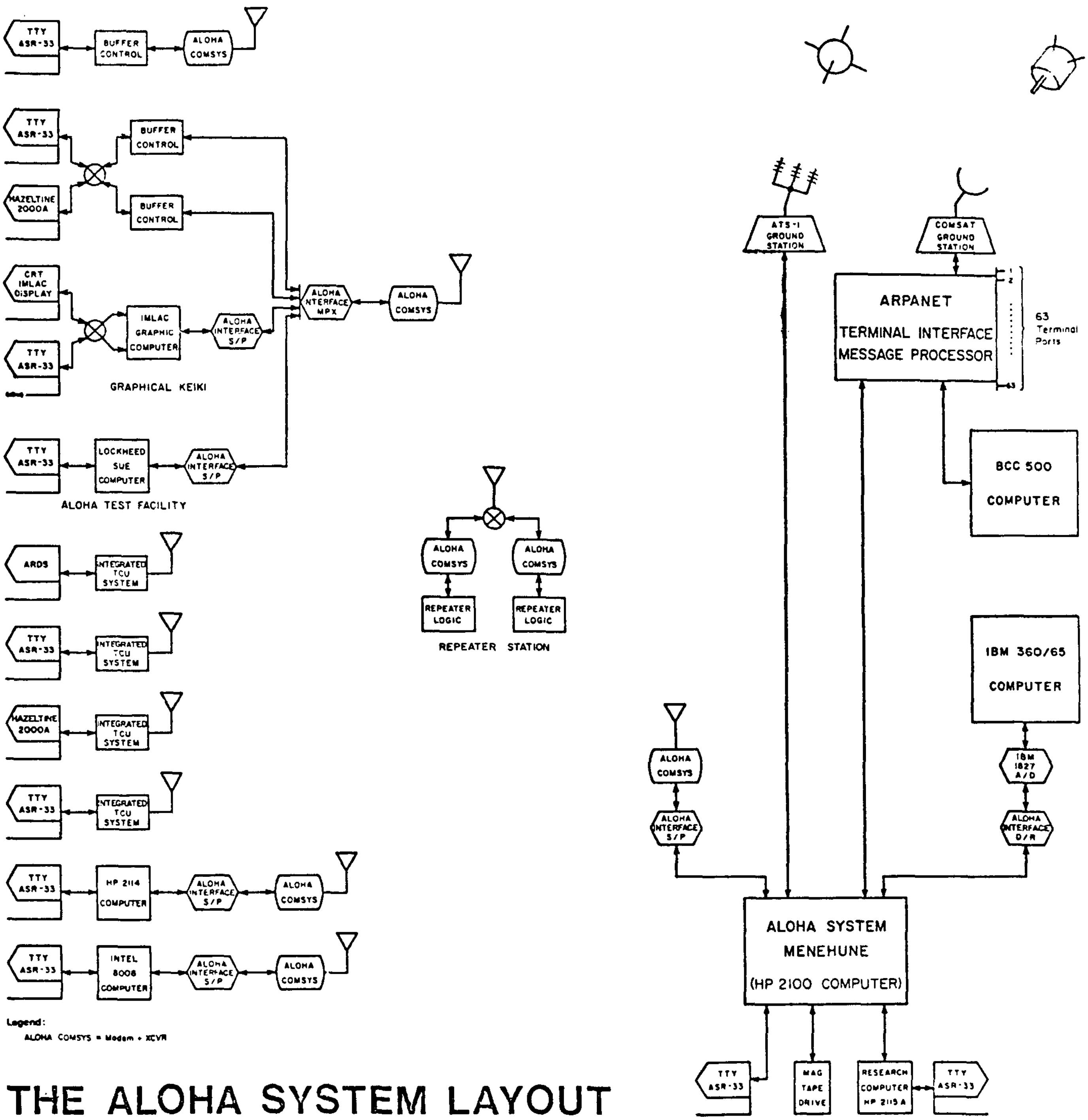
The system hardware includes two central processors and five special-purpose processors, 128K 24-bit words of central memory (i.e. visible to all processors), 32K words of additional memory connected to some of the special purpose processors, 4 million words of drum storage (transferring at 2 megawords/sec, or 6 megabytes/ sec) and 380 megabytes of disk storage. The central processors are provided each with memory maps giving them the ability to address 256K words of paged, virtual memory of which half is available for user programs.

The special-purpose processors implement those portions of the operating system which are concerned with global system tasks. These include memory management--central memory allocation, dynamic drum allocation, disk allocation and all page traffic between these devices; character input/output--to and from terminals including the handling of break and/or wakeup characters and remote echo strategies; central processor scheduling; and the NCP process for network protocol handling. Those operating system functions which are oriented toward the individual user process, i.e., which can be done by calls from the user process not requiring its blocking, are performed on the CPU's in a conventional manner. The systems code for these functions resides in one of two hardwareimplemented system rings (a third ring permits the user process to run while permitting the system full protection from it).

All system software is written in SPL, a systems-programming language developed by BCC for operating systems and utility subsystems 'like compilers) There is no assembly language. All compiled code is reentrant and sharable between tasks.

The CPU's have a special mode selectable in their state word which permits them to execute XDS 940 machine language directly. A utility program, called the 940 Emulator, is available to all users and operates in conjunction with 940 programs, serving to translate 940 system calls which are otherwise trapped into equivalent sequences of 500 system calls. In this fashion all available 940 software will run on the 500 system.

We will welcome your on-line exploration of our system as it assumes host status and direct your attention particularly to the SPL language. Please address your questions and comments to: Wayne Lichtenberger, 486 Holmes Hall, University of Hawaii, 2540 Dole Street, Honolulu, Hawaii 96822.



THE ALOHA SYSTEM LAYOUT