MASSACHUSETTS INSTITUTE OF TECHNOLOGY

Project MAC

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To: Project MAC Faculty

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Subject: Brief notes on a Large-Scale Computation Facility for
           Project MAC

        Recent discussion within Project MAC indicates that future
research directions will require a major computing system with a
sophisticated software base. An obvious way to obtain such a system
without need for a development period is to use Multics in combination
with a very large configuration of the same new-technology hardware
currently planned for the M.I.T. Information Processing Center. The
remainder of this note is an outline of some of the issues raised by
such a proposal.

Alternatives and Premises requiring Discussion

1. A reasonable objective is to use off-the-shelf hardware and
    software with minimum engineering, development, and programming
    requirements.

2. Over a five-year period a budget of \$2M to $2\frac{1}{2}$M per year would
    be involved, for hardware and terminals.

3. It would be possible to coordinate plans with the M.I.T. Infor-
    mation Processing Center, so that a single very-large configura-
    tion would handle both Project MAC and M.I.T. needs.

4. It may be appropriate to purchase, rather than lease equipment,
    so as to insure that the facility can remain in operation,
    beyond the five-year initial plan.

5. An assumption is that modern LSI memory technology can provide,
    within the five year period, primary memory so large and cheap
    that a qualitative change in view of system operation is possible:
    with literally millions of words of addressable memory, all infor-
    mation of concern to a program is in primary memory. Traffic to
    and from secondary storage (paging) is minimized, thereby elimi-
    nating real-time delays for interactive response.

Proposed goals

1. Enough computation capacity that processor queuing is the exception rather than the rule.

2. Enough primary memory capacity that pages, once brought in to it, are not removed until after the console session is over.

3. As a minimum, high speed character display output so that a screen full of text is displayed in under one second.

A Proposed target configuration

(This would be the configuration at the end of 5 years; the starting configuration would be, say, that of the Information Processing Center.)

-   16 Million words of primary memory, arranged in 32 blocks of 500K words each. Access times would be in the range of 400 to 1500 nanoseconds; technology would probably be MOSFET. (Price is discussed later.)

-   Ten Honeywell 645-followon central processing units. These run at about 10^6 instructions per second and have an extended instruction set which is designed to directly support PL/I string manipulation.

-   Two I/O controllers, for reliability, with appropriate switching matrices.

-   Two or three DataNet 355 communication line controllers, to handle
    50 - 50 kilobit terminals from Project MAC
    200 - typewriter class terminals (ordinary M.I.T. users.)

-   Secondary storage. Initially, two Honeywell DS-190 disk storage units (equivalent to IBM 3330) with 300M words. Later, perhaps as a separately budgeted item if need requires, a 10^{12} bit file.

-   A complement of peripheral equipment appropriate to support such a facility. In particular,
    - 10 1600 bpi tape drives, for backup and private use.
    - Printers, punches, card readers, remote stations.

Problems currently foreseen

- A small engineering change is required to the current Honeywell memory controllers to allow them to accept more than 8 processors and I/O controllers.

- The reliability (mean time to failure) of such a large collection of hardware must be paid attention to.

- The prices of LSI memory, in quantities of 10^8 bits, must be pushed down in the region below $.01 per bit if the budget is not to be exceeded.

- The physical location of the configuration must be agreed upon. Since distance between processors and memories degrades performance, it may be necessary to approximate a spherical configuration, using two or three adjacent floors. Connection to the ARPA network IMP must be possible.

- The pattern of attaching high-performance terminals leaves several options: hard-wired or switched, local concentration for a distant computer, using an ARPA terminal IMP, etc.

- The choice of an appropriate high-performance terminal will require some study, probably by a committee of interested MAC members. Currently, a candidate typical of the performance of interest is the IMLAC.

- There are many minor questions, such as addition of full duplex interfaces to Multics, availability of dial-up 4.8 or 9.6 Kilobit ports for home or distant use, the number of and location of high speed printers, etc.

Possible budget for final configuration

Central processors	$ 5 M	
Memory	$ 5 M	(.83¢/bit)
Secondary storage	$ 1 M	
Terminals and support	$ 1 M	
Miscellaneous peripherals	$ 1 M	
	$13 M	