TO: MSPM Distribution
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This BC.1.01 contains several minor typographical corrections,
and the addition of a comment about bulk input/output
devices.

Identification

Minimum Configurations and Configuration Restrictions
for Multics Operation on the GE-645
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Purpose

This section lists all known restrictions on possible
GE-645 hardware configurations which must be observed
in order for Multics to 1) operate at all, 2) operate
well, and 3) operate continuously. All the restrictions
indicated here are reflected in assumptions made by Multics
software. Some restrictions may be doubly enforced by
hardware limitations also--no distinction is made.

Minimum Configuration (suitable for testing only)

The following items represent the minimum GE-645 hardware
configuration on which a Multics supervisor can sustain
operation:

1.   1 645 Processor

2.   1 GIOC containing

            a.   1 bootload adapter

            b.   1 communication line adapter

            c.   1 common peripheral (tape) adapter

3.   1 System Controller

4.   1 System Clock

5.   192K words of addressable memory

6.   2 Magnetic Tape Drives (7 or 9 channel)

7.   1 Model 37 Teletype or 2741 console

8.   1 DSU-10 Disk Storage unit or 1 EMU-302 Drum system

A reel of magnetic tape containing the Multics system
is also needed, as well as a supply of blank magnetic
tape reels for file system backup.

Note: It is not suggested that a completely minimum system
             is either balanced or useful; this list merely serves
             as a guide to minimum equipment which allows a Multics
             supervisor to operate at all.

Performance Considerations

As indicated in the note at the end of the above list,
the minimum configuration listed above will technically
support the Multics supervisor. However, such a minimum
system may only be useful for brief tests or experiments
because of performance considerations. Although it is
recognized that performance aspects of the system vary
both with progressive tuning of the supervisor design,
and with specific applications or specialized requirements,
the following considerations are suggested in configuring
a minimum practical system.

1.   Currently, 256K words of addressable memory are required to
     avoid excessive paging activity.

2.   1 EMU-302 drum system is required to keep secondary
     storage access from being a limiting bottleneck.

3.   The number of system controllers must be no fewer than
     the number of Processors plus the number of MDU-200 drum
     systems, to avoid excessive interference in access to
     core memory. If one or more GIOC's are to be driven near
     their capacity, one additional system controller is
     needed.

4.   Some consideration should be given to attachment of
     additional input/output devices to provide I/O capacity
     beyond that of the operator's teletype. Interactive users
     will require additional teletypes. For bulk input and
     output and batch type usage, one might include line printers,
     card readers and punches, and magnetic tape capacity beyond
     the 2 drives required by the system.

Continuous Operation

The configurations listed above do not take into account
any attempt to obtain continuous operation. Although
Multics is not yet capable of dynamic reconfiguration,
which is a prerequisite for true continuous operation,
one can describe a somewhat larger minimum hardware complement
necessary to allow operation with only brief stops for
reconfiguration in case of trouble and preventive maintenance.

If the hardware complement is reduced below this larger complement, preventive maintenance or a single hardware failure can force operation to be discontinued until maintenance is completed or the failure is repaired.

Minimum Configuration for Continuous operation:

1.   2 645 processors

2.   2 GIOC's, each outfitted as above

3.   2 system controllers

4.   2 system clocks

5.   Sufficient core memory that failure of 1 controller will leave at least 192K words of core memory in working controllers. (e.g., 4 - 64K controllers, 3 - 128K controllers, or 2 - 192K controllers)

6.   4 Magnetic Tape Drives (7 or 9 channel)

7.   2 Model 37 Teletype or 2741 typewriter consoles.

8.   2 DSU-10 Disk storage units, or 2 EMU-302 Drum systems, or 1 of each.

     (As before, this minimum is technically capable of operating continuously, but may be neither balanced nor useful in a practical sense. As an example, for a 2-processor system to operate near capacity a larger quantity of core memory might be indicated. Also, the above minimum continuous configuration does not consider the question of performance when operating with a partial configuration during preventive maintenance or repair).

Restrictions

The term "all" and "every" used below (e.g. all processors) generally refer to all subject items being used in a logical system with a Multics supervisor in control. It is possible to operate two (or more) Multics supervisors independently on logically independent but electrically connected equipment, provided only that sufficient equipment is available to meet minimum hardware requirements of all of the logical systems. In such cases, the restrictions listed here apply to "all" the equipment within each logical system.

1.   Every processor must be a control processor for some system
      controller. It follows that there must be at least as many
      system controllers as processors. This implication is in-
      consequential: if there were more processors than system
      controllers, memory access interference would wash out all
      of the excess processor capacity.

2.   Every active device (processor, GIOC, drum) must be able to
      access every memory location in every system controller. In
      addition, every active device must use the same address for
      any given memory location. It follows that cable
      connections, port selection logic panels and interlace
      settings on all active devices must be identical.

2a.   Every processor must be able to address all system clocks,
      using the same address. (Applicable only to Prototype
      Clock; this requirement is taken care of by 2, above, when
      a Production Clock is used.)

3.   At least one GIOC must contain a bootload channel preset with
      the program described in section BC.4.01.

4.   All processors must have the same value in their "processor
      base address" switches.

5.   All GIOC's must have "GIOC base address" settings which
      are different. Similarly for Drums.

6.   All System Controllers which are interlaced into a group
      must contain identical amounts of memory.

7.   If Prototype System Clocks are used, all clock controllers
      must be given higher priority than all other system con-
      trollers.

One performance consideration turns up as a restriction
on allowable configurations: to avoid excessive
interference in access to core memory, at least
2 - way interlace must be used at all times.