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A Quarter Century of UNIX

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debugging, by getting in to the queue for a few seconds, you signed up for an hour. Your program ran in 40 minutes. Or, worse, your program wasn't done at the end of the hour: it was then dropped (and, in most cases, the partially completed work was lost), so you signed up for a future hour-and-a-half (frequently at 1 or 2 or 3 a.m.). The answer to this problem was timesharing.

The Compatible Timesharing System (CTSS) was one of the first timesharing systems. Developed at the MIT Computation Center by a team led by Corbato, CTSS ran on a modified IBM 7094 with a second 32K-word bank of memory, using two IBM 7320As. A second 7094 was connected in early 1965. Remote access was provided to up to 30 users via an IBM 7750 communications controller connected to dial-up modems for access over phone lines. (Actually, no one ever had an hour of CPU time, as that would stretch beyond the maximum time between failures of the system!)

CTSS, as the timesharing portion of Project MAC, was both a service facility and a laboratory for system programmers. It was this second function that led—while the 7094 was still being tuned—to Multics (**Multi**plexed Information and Computing Service).

Multics was a second generation timesharing system, intended to be a prototype of the "computer utility." It was started in 1964 as a joint project of Project MAC, Bell Telephone Laboratories, and General Electric. Corbato was the principal leader of the development effort, which had nine major goals:

- Convenient remote terminal use
- Continuous operation like telephone service
- A wide range of system configurations
- A high reliability internal file system
- Support for selective information sharing
- Hierarchical structures of information
- Support for a wide range of applications
- Support for multiple environments and interfaces
- The ability to evolve the system

Berkley Tague, who had joined BTL in 1962 and the Multics group in 1965 (as a "secretary for the project triumvirate") has said that by 1967 it was clear that the project couldn't succeed because the "three parties had incompatible goals." He went off to AT&T in Whippany, NJ, for three years, where he worked on a project called Safeguard, only to return to Murray Hill in 1970.

Professor Jack Dennis of MIT contributed some influential architectural ideas to the beginning of Multics. When it was time to select a vendor for the computer that would support the new operating system, the folklore says that IBM pitched the machine that would become the 360/65. Doug McIlroy told me:

> This is true. But [Gene] Amdahl wouldn't make VM [virtual machine]. At the last instant IBM let Gerry Blaauw out of the back room to pitch the 360/67, but it was too late.

IBM's staff weren't interested in the MAC team's ideas about paging and Joseph Weizenbaum, who was then a lecturer at MIT, introduced the MAC team to former colleagues of his from GE in Schenectady, colleagues who were receptive and enthusiastic about paging and segmentation, and who proposed what became the GE-645 (the upgrade of the 635). Thus GE became part of the Multics effort.

MIT, BTL, and GE agreed on a structure for cooperation. A trinity made major policy decisions, with one person from each organization: Fano (MIT), E. E. David (BTL), and C. W. Dix (GE). A triumvirate was in charge of actual management of the implementation: Corbato (MIT), A. L. Dean (GE), Peter G. Neumann (BTL). Notable features included segmented memory, virtual memory, high-level language implementation (PL/I), shared memory multiprocessor, multi-language support, and on-line reconfiguration.

PL/I was chosen as the programming language in 1964. Other possibilities were a port of MAD (the Michigan Algorithm Display) or a port of AED-0 (an MIT display). The full PL/I language was harder to implement than expected. A contract was awarded to an outside firm to produce a PL/I compiler, and BTL administered the contract. The contractor assigned two people and had produced no compiler a year later. Bob Morris and Doug McIlroy (at BTL) created a back-up plan for