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The UNIX *System:*

Foreword

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This is the second issue of the *Technical Journal* devoted exclusively to papers on the family of computer operating systems bearing the *UNIX* trademark of AT&T Bell Laboratories. The *UNIX* operating system was created in 1969 by K. Thompson and D. M. Ritchie. Its growth since then, in both the commercial world and the research community, has been truly remarkable.

In the commercial world there are 100,000 *UNIX* systems in operation, and many hundreds of thousands of programmers who have studied the system's commands and its implementation language C. In the research community, dozens of books and thousands of papers have been written about it, and in 1983 Thompson and Ritchie earned the Turing Award for its invention. Virtually every major university throughout the world now uses the *UNIX* system.

UNIX is an evolving system. In the Computing Science Research Center at AT&T Bell Laboratories, where it was invented, the system has developed in a series of releases called "editions" or "versions". The paper by Ritchie in this issue describes the birth of the system in this research environment. *UNIX* System V is available to the commercial world from AT&T in a fully supported form.

Not only has the system provided the computing community a

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programming environment of unusual simplicity, power, and elegance, it also has fostered a distinctive approach to software design: a problem is attacked by interconnecting a few simple parts, often created by software tools taken off the shelf. This approach to solving software problems is eloquently described in this issue in the paper by Pike and Kernighan.

The remaining papers in this issue of the *Technical Journal* represent a small sampling of ongoing system-related research and development work at AT&T Bell Laboratories. The papers cover many topics of current concern to the software community.

I. AN INTELLIGENT TERMINAL

In the first of these remaining papers, Pike describes the software architecture of a programmable bitmap graphics terminal called the Blit, which has evolved into the *Teletype*® Model 5620 terminal. The terminal and its software were designed specifically to interface with the *UNIX* system. The terminal allows programmers to interact with a machine in a natural, visual way. As an important case in point, Cargill describes an innovative, mouse-oriented facility for debugging C programs using the terminal.

II. COMPUTER SECURITY

The next two papers address computer security, a subject of considerable importance. The first paper, by Grampp and Morris, discusses administrative steps to improve system security. In the second paper Reeds and Weinberger present some of the analytic measures and countermeasures that have gone into the development of the encryption command on the *UNIX* system.

III. THE C PROGRAMMING LANGUAGE

In the early 1970's Dennis Ritchie devised the programming language C to implement the system in a higher-level language. Since that time, C has become a major programming language in its own right. Rosler discusses the evolution of C and current efforts to standardize the language. Stroustrup has added SIMULA67-style classes to C to create a modern language, now known as C++, that supports abstract data types in a particularly efficient manner.

IV. PORTABILITY

Because the system was written in the machine-independent language C, it was possible to port the operating system from one machine

to another. Before 1977, the system ran only on the PDP-11* computers. In 1977 experiments demonstrated that the system was indeed portable. Since that time, it has been ported to dozens of different machines ranging from microprocessors to supercomputers. The papers by Bach and Buroff, by Felton, Miller, and Milner, and by Bodenstab et al. describe experiences in porting the *UNIX* system to several different machines including the Intel 8086, the IBM 370, and multiprocessor architectures.

V. PERFORMANCE

The performance of the system and the software that runs on it is of great importance to both users and developers at AT&T Bell Laboratories. Feder talks about the continuing measures that have been taken to improve the performance of the system as a whole. Weinberger presents an effective tool that enables a user to monitor the performance of programs easily. Linderman talks about steps taken to improve the performance of an important utility program—the sort routine. Linderman's paper illustrates the interaction of theory and practice that has gone into the design and implementation of many *UNIX* system programs. Henry discusses improving performance by changing the scheduler to allocate time more fairly to different classes of users.

VI. NETWORKING

The last three papers in this issue describe communications between devices and networks of machines running the *UNIX* system. The paper by Fitton et al. discusses the design of a set of software tools to create portable data communications protocol programs. The paper by Fritz, Hefner, and Raleigh discusses a software environment that was implemented on a network of different machines all running the *UNIX* system. The final paper by Ritchie describes an elegant new stream input-output system that facilitates communication between the *UNIX* system and terminals and networks.

The papers in this issue are only a sampling of the broad range of continuing *UNIX* system work being done at AT&T Bell Laboratories. The system, C language, and the tools have been greeted with considerable enthusiasm and are used increasingly to solve complex software problems. The system is stimulating new computer science research and in turn is benefiting from new advances in computer research. The *UNIX* system approach to software design is influencing a new

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generation of programmers and system designers. The people at AT&T Bell Laboratories are proud to be at the forefront of this advance in computing.

AUTHOR

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