High attendance indicates interest in computer communications

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This year COMPCON Fall was devoted for the first time almost wholly to a single theme, computer communications and networks. The attendance of 450 at three pre-conference tutorials and 935 at the three-day conference itself demonstrated the strong interest communications is arousing. The field is growing rapidly—one participant reported that his department had expanded from 20 to 120 in the past year—but the shortage of experienced personnel seems to be inhibiting the growth that some companies would like to see.

The underlying reason for this growth is the declining cost of products based on silicon technology—a familiar reason in other branches of the computer field. In the communications area, however, in addition to staff shortages, growth is being hampered by the paucity of standards, problems in the policy environment (see accompanying story), and technical problems.

Communications links still primitive. Communications planners have not been able to buy data communications services the way they can buy voice telephone services. With the exception of Telenet, there was no service tailored to the problems of computers talking to each other. Users have had to take the facilities of the telephone company, designed for voice, and massage them to transmit data. AT&T's proposed Advanced Communications Service is practically the first service tailored to the needs of the data communications user. Because it is a long way from being approved and working, users are in for several more years of non-standard, specially made communications systems.

Obviously, communications systems have to have standards. Two people can talk to each other only if they speak the same language, or else a translator has to be used. But the translator must know both languages—or, if you will, both standards of communication. Similarly, two computers on either end of a transmission link must work through standards.

Standards efforts active. Generating a standard generally presupposes a body of existing practices to work with. Trying to establish a standard early enough to serve as a guide to initial design is another matter. As Professor Maurice Wilkes of Cambridge University said of the current standards work in the communications field, as quoted by Bachman at the conference: "You are doing an international, industry-wide, design effort under the guise of standardization."

A reference model of communications architecture has been developed by the American National Standards Institute and the International Standards Organization committees on architecture. The model contains four levels of transport service:

Level 1, Physical Control, exemplified by EIA RS232C.

Level 2, Link Control, now represented by ANSI X3.66, the bit-oriented Advanced Data Communications Control Procedures. (The earlier ASCII control characters, such as Start of Heading, Start of Text, and End of Text, lacked full transparency.)

Level 3, Network Control, directing the control of switching points, rather than the transfer of data between switching points. Examples are the International Telegraph and Telephone Consultative Committee X.25 Level 3 Packet Formats and the ANSI X3 Project 281, Code-Independent Message Handling.

Level 4, Transport End-to-End Control, including the functions that provide a network-independent interface to users of the Transport Service. Above these four levels are three levels of non-communications functions for users:

Level 5, Session Control, containing functions to structure data, such as session establishment or termination.

Level 6, Presentation Control, providing transformations of the information being transferred, such as number of print characters per line.

Level 7, Process Control, containing functions associated with transferring data between end users.

IBM has announced Systems Network Architecture, and Burroughs, Digital Equipment Corp., and Honeywell have announced distributed systems products: BSA, DECNET, and DSE. All claim special, but different, virtues. On the other hand, the British Standards Institute, believ-
ing in the value of being able to inter-
connect all makes of computers, peti-
tioned ISO Technical Committee 97 to
standardize "open system inter-
connection." Work has been under
way since 1977 and was subdivided
this year into three working
groups—on architecture, transport
services, and users' levels.

A transport end-to-end control pro-
tocol and interface standard is sched-
uled for completion by August 1979,
and four standards on the user levels
are scheduled for December 1980.
These are remarkably short times in
which to develop complex standards,
but those involved believe that it is
critically important to get standards
into existence before too many ad hoc
or one-company solutions create a
new Babel of confusion.

Network design proceeds. Despite
the lack of standards, many organiza-
tions are proceeding with the design
of networks. This work seems neces-
sary, not only to serve the organiza-
tions' needs, but also to uncover and
solve technical problems. To some ex-
tent these solutions have to guide the
standards efforts.

Bell Laboratories, for example, is
developing a modular message-
switching data communications net-
work called BANCS (Bell Adminis-
trative Network Communications
Systems) for use by AT&T's operat-
ing telephone companies. Thus far, four of the 24 operat-
ing companies have operational net-
works. Upstate New York, for in-
cidence, has 800 terminals on multi-
drop lines, hosted by an IBM 370/168
computer, that are used for customer
inquiry. BANCS is intended for in-
ternal applications, but application-level
protocols are still under development.

The Government Communications
Systems division of RCA has de-
digned a distributed data network ex-
pandable to 254 computers.4 The
center of the network is a multiple-
link, space-division switch with an
adaptive controller, capable of sup-
porting a steady-state load of 74
megabits per second. Computer inter-
connections can be established at a
maximum rate of one every four
microseconds. The system was de-
signed to handle an average of 62,000
connections per second. It operates
without overt switch supervision. In-
stead, message destination data is ex-
tracted from ADCCP standard for-
mats and used to route the message
by circuit switching. The circuit is
dropped when the data stream ends.

Paralleling the development of
large-scale networks is the growth of
local area networks, covering single
laboratories or groups of buildings.
The Institute for Computer Sciences
and Technology of the National
Bureau of Standards is currently
developing a network intended to
serve a thousand users in 20 build-
ings.5 Communication is over coaxial
cable employing the Ethernet princi-
ple.6 With Ethernet, each node
monitors all traffic on the bus but ac-
cepts only messages addressed to
itself. Since two packets may occa-
sionally collide, the network protocol
provides for retransmission after a
random waiting period. The coaxial
cable bit rate is one megabit per sec-
ond, and packets contain up to 128
data bytes.

The NBS terminal interface equip-
ment is based on an MCS6512 micro-
processor, which permits user charac-
teristics to be mapped into standard
network-wide virtual types, thus
relieving hosts of having to deal with
the idiosyncrasies of various actual
terminals. Another benefit is the
ability to add data encryption where
desired.

The IBM Zurich Research
Laboratory is experimenting with a
novel approach to the physical link—
the use of diffusely scattered infrared
radiation as the carrier for the trans-
mitted data.7 Experiments dem-
strated that infrared radiation emit-
ted by light-emitting diodes is re-
flected by ceilings and walls to photo-
diode sensors in adequate amounts
for room sizes up to 10 by 10 meters
at reasonable cost. The wireless,
noise-free infrared transmission,
where the components may be easily
rearranged, offers advantages over
hard wiring for industrial applica-
tions.

Technical problems remain. The
variety of systems reported to this
conference suggest the current state of
the art—namely, eclectic. Looking
forward to the future, a series of key
problems can be distinguished.
Although a few standards, such as
CCITT X.25, are beginning to emerge
as working practices for large net-
works, there is lack of understanding of
the requirements of small or local net-
works. It is likely that a variety of
unstandardized networks will be
built. While this variety may con-
tribute to the acquisition of design
knowledge, it may later make com-
communications between individual net-
works difficult or even impossible.
Moreover, many of the techniques
that have been found to work in large
networks are even now being labori-
ously reinvented on smaller network
design projects.

A whole group of technical prob-
lems are associated with packet rout-
ing, in which circuits are fixed and small packets of data are forwarded from node to node and on to a destination specified by a header at the front of the packet. A given node preparing to output a packet may or may not have information about the state of the network. Of course, more information necessitates more logic and more communications overhead. The transmitting node depends on the return of an acknowledgement to find out how its packet has fared amidst the unknowns. Lacking an acknowledgement, it must repeat the transmission.

Under these conditions of uncertainty, it is apparent that packet routing may be quite inefficient. Sometimes particular links from node to node may be used infrequently. Other times they may be congested and packets may be sent on roundabout routes. Sometimes packets may get caught in a loop and both congest a group of links and fail to reach a destination. With extra hardware, packets do get delivered, but at some cost in equipment utilization.

At least five problems in routing await further study:

1. accurate routing in the presence of limited or uncertain information on network status;
2. loop-free routing;
3. efficient routing, that is, obtaining a higher percentage utilization of network resources;
4. broadcast or multideestination routing, possibly increasing efficiency by 20 to 60 percent;
5. integration of routing with congestion control.

It appears that more effective routing will require more knowledge of network status. That, in turn, would have to be based on more computing power or more time, delaying transmissions. Finding out just what the tradeoffs are involves more study. In addition, as networks become larger, the quantity of computing power needed may expand even more rapidly. Consequently, whether network size can increase indefinitely is not yet known.

This glimpse of the remaining technical problems and the need for standards, together with the difficulties of regulation—domestic and international—gives us some conception of the special problems of computer communications and networks. In addition, the field has its full share of the usual problems of growing computer fields—financing, scheduling, staff. Computer communications clearly needs Renaissance men and women to encompass its manifold problems. ■

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References

At plenary session, President Merlin Smith presents (clockwise from above) Special Award to Richard E. Merwin for continued and outstanding service as editor of the *IEEE Transactions on Computers* and for contributions to COMPCON. Honor Roll awards went to John E. Savage for significant contributions while serving as an associate editor of *Transactions on Computers* and to Sheldon B. Akers for ten years of effective and dedicated service as secretary to the Mathematical Foundations of Computing Technical Committee. President Smith presents Certificates of Appreciation to Lynn Hopewell for dedicated and meritorious service as chairman of the Computer Communications Technical Committee and to William Rosenbluth for leadership in computer elements workshops. Harry M. Taxin, who was not present, received a Certificate of Appreciation for his work in organizing and executing the Workshop on Design Automation as a Dependable Business Operation.