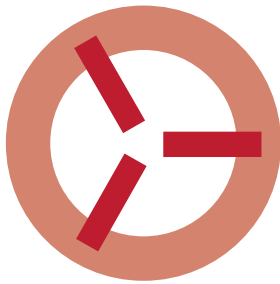# Merit — Who, What, and Why
Part One: The Early Years, 1964-1983

by Eric M. Aupperle, President, Merit Network, Inc.

This four part article looks back at the innovations and ingenuity, trials and tribulations that went into the making of Merit. Reprinted from Library Hi Tech, Vol. 16, No. 1 (1998).

Merit's original logo.

Merit traces its history to the 1960's, less than a score of years after the beginning of the modern electronic computer era. Early, 1940's vintage computers, such as the ENIAC, ran a single user's program at a time, and required skilled, hands-on operators intimately familiar with the machine's technology. Major strides occurred with both computer software and hardware technology over the ensuing years so that by the 1960's it was possible for multiple, application-focused users to run their programs simultaneously on a single mainframe system. Further, by adapting another technology, access to mainframes by users at a distance over the existing telephone system using Teletype equipment and modems evolved. These time-sharing computers began appearing in major university academic computing centers and government laboratories in the late 1960's, and set the stage for interconnecting them via a computer network, as was envisioned by Merit's founders.

A key factor leading to Merit's formation stems from a blue-ribbon commission tasked by former Governor George Romney to review Michigan's higher education role. In response to one of the commission's 1963 recommendations, then University of Michigan Vice President for Academic Affairs, Roger Heyns, had the idea for creating a state-wide learning center. Heyns asked psychology professor Stanford Ericksen, director of the U-M's Center for Research on Learning and Teaching (CRLT), to take the idea and develop a proposal for the 1964 State legislative session. As part of his proposal,

Ericksen asked CRLT staff member, Karl Zinn, for ideas on using computers. Zinn wrote the original networking sub-proposal that subsequently resulted in Merit's creation. The gist of the sub-proposal's vision was that "significant benefits might be gained from sharing computing resources via an electronic linkage between large, timesharing computers."

While Ericksen's proposal primarily focused on education, it was the networking concept that caught the eye of the legislature. In response to a legislative request, Ericksen and Zinn helped form a committee with representatives from all of Michigan's state-supported higher-education schools to study the idea. It took two more years to get a serious effort underway and by that time only the state's three biggest universities were committed to pursing the concept. These universities, Michigan State University, the University of Michigan, and Wayne State University, formed the Michigan Inter-university Committee on Information Systems (MICIS). At MICIS' recommendation, the officers of these three universities with approval from their respective governing boards established the Michigan Educational Research Information Triad, Inc. (MERIT) [1] as a non-profit corporation in October 1966. The members of Merit's initial Board of Directors were: Milton E. Muelder (MSU), Allan F. Smith (U-M), and Robert E. Hubbard (WSU), all senior executives of their respective universities.

Merit's first task was to seek funding to build its network. Michigan's legislature appropriated $200,000 in

1967 and an additional $200,000 in 1968 for the corporation, provided that Merit found at least matching amounts from another source. In 1968 Merit's Board hired Bertram Herzog, a professor in U-M's Industrial Engineering department, on a part-time basis to coordinate proposal efforts for additional funding. Merit applied to the National Science Foundation (NSF) and after two proposal attempts and some lengthy negotiations was awarded a $400,000 matching grant in August of 1969. The NSF grant stipulated that all of its funds were for direct project funding. That resulted in the University of Michigan agreeing to host Merit as a project at its expense and waiving all indirect charges. As a consequence of this initial commitment by the U-M, Merit has always been housed by the University and all Merit staff have been U-M employees.

One sense of what vision was in the minds of Merit's founders comes from the purpose section of the initial Articles of Incorporation:

"To conduct research concerning information processing and exchange through multi-media communication systems for educational and service purposes and develop methods by which independent computer systems can be joined for cooperative utilization and expansion between institutions of higher learning; to foster and engage in research concerning and the development of computer assisted instruction within and between institutions of higher learning; to gather and disseminate by whatever means it may select its findings, information, reports and research to government agencies, educational groups, universities and members of the public; to receive and expend either directly or by contract, for the above purposes, moneys, from government or private sources; and to operate such experimental, research, and service programs as may be developed."

A quote from the NSF proposal sheds additional light on the early Merit vision:

"When the computing facilities of a single university are joined by a common network to the computing facilities of other universities, its computing resources will then be greater than the sum of the resources of all the universities in the network. This seeming paradox occurs because of the cooperative connection of machines with significantly different system characteristics and because of the ability of a network potentially to take advantage of varying total system demand. Thus, to any single user at any point of entry to the network, the whole system appears more powerful and responsive to his needs than the collection of individual systems could be if addressed on an individual basis."

With an $800,000 budget available by the fall of 1969, the Board appointed Herzog as Merit's director. His task was hiring staff to implement a network interconnecting the academic computing center mainframe systems at Merit's three Member universities, as proposed to NSF, and managing the project. Each Member university also appointed an associate director to focus on identifying computer applications that would benefit from the network's presence and educating potential campus users about the new opportunities they would enjoy once the network became operational. The associate directors were Harry Eick (MSU), Karl Zinn (U-M), and Seymore Wolfson (WSU). Herzog recruited Eric Aupperle, a Research Scientist then a member of the U-M's College of Engineering Cooley Electronics Laboratory, as Merit's Project Leader in September 1969 to oversee the technical aspects of the project.

In 1969, computer networking was in its infancy. The only comparable work matching Merit's objectives had recently started at Bolt, Berneck and Newman under a contract from the U.S. Department of Defense's Advanced Research Project Agency (ARPA)--work that soon led to an evolving national network known as the ARPANET.[2] Earlier ARPA also had funded a set of computer-related projects at the University of Michigan under the CONCOMP project rubric, a project focused on the CONversational use of COMPuters. One of these projects led to the development of the Data Concentrator for the U-M academic computing center. The Data Concentrator consisted of a Digital PDP-8 minicomputer augmented with custom interface hardware designed and built by U-M Computing Center staff. Its special operating system software was written by another Computing Center staff member. The Data Concentrator's function was to connect multiple remote users dialing in from their terminals with the Computing Center's IBM 360/67 mainframe computer.

Merit's initial technology strategy melded the best elements from both the pioneering ARPANET and the Data Concentrator implementations. Merit first sought to acquire its desired technology through a request-for-proposal process. While several vendors responded with bids, none adequately matched the specified requirements. Next Merit approached Bolt, Berneck and Newman about adapting their ARPANET technology to meet Merit's specifications, but they declined, wishing to remain focused on the ARPANET. Subsequently Merit elected to hire a systems engineering house to fabricate specific hardware interfaces and integrate them into a packet-switching system with a newly announced minicomputer, the Digital PDP-11, and Merit committed to write its own network operating software for it. The selected systems house was the Saline, Michigan-based Applied Dynamics Division of Reliance Electric. Applied Dynamics manufactured and helped install Merit's first three Communications Computers (CCs) for nearly $300,000.

Working closely together over a two-year period, Applied Dynamics and Merit staff designed and built hardware, developed software, tested the combined system, and installed CCs at each of Merit's three member universities' academic computing centers.[3] On December 14, 1971 at 12:20 a.m., the first experimental connection occurred over Merit's network between the IBM mainframe computers at U-M and WSU. Nearly a year later, the Control Data Corporation mainframe at MSU was added to the network and soon thereafter Merit's network was formally dedicated in a May 1973 ceremony. Merit has provided network services successfully to our Members and later to other organizations ever since. Consequently Merit is among the Internet pioneers and the oldest organization continuously providing data networking services.

Three members of Merit's early software technology team were Al Cocanower, Wayne Fischer, and Brian Reed. They implemented the Communication Computers' network Operation System (CCOS) using a cross assembler developed for the PDP-11, which ran on the U-M's IBM mainframe under the U-M's Computing Center staff-developed Michigan Terminal System (MTS). The binary CCOS code produced on MTS was transferred to the CCs via fan-folded punched paper tapes, a cumbersome, time consuming process.

The first network service this team implemented in cooperation with staff from the three university computing centers was known as a "host-to-host" connection. This service allowed a user to access and control interactively programs or data files on two or more mainframe systems (hosts) from his or her local host over the network's 2,400 bps data circuits. Next file transfer, remote printing, and network batch services between hosts were added. Retrospectively, it's interesting to reflect that Merit's host-to-host connection

ability in the early 1970's allowed a user to do what today would be known as client/server interaction, although in a more cumbersome manner.

The next big technology step happened in the mid 1970's with the development of network dial-in access, a.k.a. direct terminal support. This work was done by Allan Rubens and Robert Husak under Fischer's direction. However, shortly after assigning this project to them, Fischer went on an extended vacation and Rubens and Husak were left doing most this work on their own. Initially, this new capability adapted hardware implemented earlier for the U-M's Data Concentrator. The idea was to allow users to dial into Merit's network directly and access whichever host they selected to use rather than entering the network through their local host. This service, dubbed "Hermes" after the speedy messenger of the Greek gods, made the network easier to use, more reliable, and less expensive for the user. The network's greeting after successfully dialing-in was "Which Host?" and the user would type the name of the desired host. For a few years the greeting would mysteriously change to "Witch Ghost" on Halloween, but this Merit-staff-provided humor stopped after users began complaining about their automated log-on scripts failing to work on their increasingly sophisticated terminals.

Once Merit's network technology was in place and operating, the need for user documentation, training, and help-desk support became a priority. In 1973, Sue Colman joined Merit as the network's first technical support consultant and she was succeeded in 1975 by Christine Wendt. Among Wendt's first tasks was writing a "how-to" manual for the new Hermes service. Later she would lead a growing user support staff as the network's usage grew and became increasingly integrated into the everyday lives of the Member universities' students,

faculty and researchers. As has now been witnessed many times in the Internet's evolution, key applications helped drive this growing interest during this early period. One was the development of an MTS-based computer conferencing system, known as CONFER, created by the U-M's Robert Parnes, and, shortly later, the MTS e-mail system, $MESSAGE, initiated by the U-M Computing Center's Gavin Eadie, which allowed e-mail exchange with remote sites.

In 1974 Herzog elected to step down as Merit's director to return to his love of teaching in the U-M's Industrial Engineering Department. Merit's Board, still the initial three members, appointed Aupperle to succeed him. Soon thereafter Muelder and Smith would be the first members to resign from the Board; they were replaced by Lawrence Von Tersch (MSU) and Charles Overberger (U-M). WSU's Hubbard remained a Board member through mid-1976, when he was succeeded by Stanley K. Stynes.

Several commercial data network companies began offering nationwide services in the mid-1970's. The two most prominent of these were Tymnet and Telenet, an early spin-off of the ARPANET. With dial-in access installed, it was a relatively simple step to interconnect Merit's network to Telenet in the fall of 1976. This allowed Merit's users to access their host computers over dial-up connections from many United States cities. Later Telenet connected with networks in other countries or extended their own infrastructure to provide an expanding international access service. For a period of time, through the latter 1970's to the mid-1980's, this external access, as it was called, was Merit's most rapidly growing service, used both by individuals from our Member universities and their colleagues from around the world. Recall this predates today's Internet by two decades!

Twelve years after Merit was founded, Western Michigan University joined the three charter Members in 1978, an objective long sought by WMU's computing center director, Jack Meager. This presented a new technological challenge, in that Merit only owned the original three Communication Computers built by Applied Dynamics in the early 1970's. With the advances in electronics since then, it did not make sense to replicate the earlier CC implementation. Instead Merit's staff, led by Husak, developed new hardware interfaces for the Digital PDP-11 based on printed circuit technology. The new system became known as a Primary Communications Processor (PCP). Early PCP's were deployed at WMU and the U-M's Electrical Engineering Department.[4] The new hosts at these sites were respectively a Digital PDP-10 and a Digital VAX minicomputer, both adding new and varied resources to the expanding Merit network. Extending Merit connectivity to a U-M department set the stage for deploying UMnet, an extension of Merit's networking technology on the U-M's campus, beginning extensively in 1983.

A myth once believed by some is that after a network is installed and working it requires no further development. I first recall hearing that thought expressed in Merit's earliest days. In reality network technology, like computers, continues to evolve, and Merit has always been committed to pushing the networking state-of-the-art. Networking standards are defined as protocols. After the ARPANET's prototype deployment and its early operation, experience led its architects to define a new protocol identified as the Transmission Control Protocol/Internet Protocol or more commonly as TCP/IP. For reasons described later, TCP/IP is the protocol of today's Internet. Somewhat later another internetworking protocol, known as X.25, was specified by the traditional telecommunications industry standards process. Among the

early adopters of X.25 was Telenet. That, in turn, resulted in Merit's staff implementing X.25 software for its network to replace the dial-in based interconnection between the Merit and Telenet networks, and to allow Merit to connect hosts using X.25 as an alternative to directly attaching a host to a PCP. Merit was among the earliest organizations to have its X.25 implementation certified by Telenet, an effort led by Rubens. Interestingly, Rubens also wound up helping Telenet debug its certification process.

Shortly after the PCP technology was completed a second hardware technology initiative was started to implement smaller Secondary Communication Processors (SCP's). SCP's were based on Digital's newer PDP-11-based LSI micro computers. Much as Merit's initial CC's design stemmed in part from the U-M's Data Concentrator, the SCP's were a networking extension of the U-M Computing Center's development of Remote Data Concentrators. Remote Data Concentrators were designed to support clusters of workstations in campus building sites. They were connected to Computing Center-based Data Concentrators using high speed telephone circuits. SCP's were similarly connected to PCP's; they provided standard terminal support, X.25, and Ethernet LAN connections. The first SCP was installed on February 28, 1983, in the Michigan Union. It marked the beginning of UMnet, a major deployment of Merit technology within the U-M campus. U-M early had recognized the value of an integrated, seamless campus and wide-area network deployment. Later Wayne State University did so too.

Footnotes

[1] Quite early on Merit staff ceased using the formal corporate name or upper case MERIT acronym in favor of names such as Merit Network Project, the Merit Computer Network, or more simply as Merit. The staff wanted to de-emphasize the "triad" limitation of the formal name.

[2] Today the ARPANET is credited as the father of the Internet.

[3] Wayne State University's computing center was a combined academic and administrative center, with its Communications Computer attached to both mainframe systems.

[4] The CC's in the three computing centers were replaced with PCP's too.

See Also

Merit — Who, What, and Why
Part Two: The Middle Years, 1983-1993

by Eric M. Aupperle, President, Merit Network, Inc.

This four part article looks back at the innovations and ingenuity, trials and tribulations that went into the making of Merit. Reprinted from Library Hi Tech, Vol. 16, No. 1 (1998).

By the end of 1983, the combined Merit/UMnet network consisted of eight PCP's and thirty-five SCP's serving eight host computers on Merit's four Member university campuses. The complexity of operating and managing this rapidly expanding network increasingly demanded more attention of the Merit technical staff. This, in turn, detracted from their pursuit of important technology development projects with the necessary vigor. The solution to this dilemma was the establishment of a third staff work group, which became identified as the Network Operations Center (NOC) staff. The NOC's responsibilities included monitoring the network's performance, dealing with outages or other operational problems, loading new PCP and SCP software, and reporting performance statistics. Steve Gold, a member of Wayne State's computing center staff, joined Merit's staff to lead this initiative.

With the NOC staff augmenting our technical and user support teams, Merit was now structured with the three key elements needed by a successful, expanding network organization, and well positioned to serve additional institutions. In short order four more universities joined Merit. First Oakland University in 1985, followed by Central Michigan University, Eastern Michigan University, and Michigan Technology University, all in 1987. Merit's network also began to serve selected non-Member organizations. These included hospitals and automotive companies with research links to Merit's Members. Each non-Member required individual approval of Merit's Board of Directors during this period.

Hans-Werner Braun, a networking specialist from Germany, joined Merit's staff in 1983 and soon led an effort to interconnect Merit's network with ARPANET. To make such an interconnection most effective necessitated implementing the ARPANET TCP/IP protocol suite within the PCP/SCP infrastructure. This software development project, led by Rubens, was supported by an unsolicited grant from the National Science Foundation. This second-time NSF funding aided the evolution of Merit's network. Once this project was completed and the TCP/IP software successfully installed in the PCP/SCP's, Merit's network had the distinction of being the first network to concurrently support both a connection-based protocol suite, e.g., X.25, and the connectionless TCP/IP suite. Meanwhile Braun extended his involvement with the federally funded national networking community, an asset which proved to be quite significant in Merit's future.

In the early 1980's, there was growing agitation for the National Science Foundation to assist the nation's research universities with access to the newest supercomputer technology being developed by Amdahl, Cray, CDC, and IBM. The arguments made were that researchers and graduate students in leading Japanese and European universities had much better access to such computing power that their U.S. counterparts. In response, the NSF issued a solicitation in 1984 to establish several new supercomputer facilities. By 1986, five new centers were in operation across the county with partial support from NSF. They joined an

Since NSF's objective was to make these sites available to ... all research universities, each supercomputer center was required to implement a data network to universities interested in accessing their site.

existing NSF funded supercomputing center operated by the National Center for Atmospheric Research (NCAR) in Boulder, Colorado. Since NSF's objective was to make these sites available to researchers and students in all research universities, each supercomputer center was required to implement a data network to universities interested in accessing their site. The University of Michigan elected to participate with both the newly established San Diego and Pittsburgh-based centers. Merit engineered and operated the satellite link and land line used to access these respective centers for the U-M. A second satellite-based link to NCAR was also managed by Merit. Evidence of this was the presence of two large, readily visible satellite dishes on the roof of the U-M's Computing Center from 1986 to 1989.

While NSF ensured access to the supercomputer sites from the research universities, they had a broader networking vision. They recognized the potential for greater collaboration among scholars at the universities that could be afforded by a national network allowing an easy, fast exchange of data. To this end NSF took several additional networking steps. One was working with DoD's ARPA office to expand the ARPANET to more of the educational community. A second was providing a network to interconnect the six supercomputer sites; this initial NSFNET was implemented with 56 kbps data circuits and Digital LSI-11 computers serving as routers.[5] And the third was NSF's sponsorship of regional networks to interconnect universities within a state or a set of adjacent states.

With the growth of these new NSF networking initiatives, by early 1987 the ARPANET and the NSFNET were so heavily used that their performance suffered badly and their users were frustrated. In response to this crisis, the NSF issued a solicitation entitled Project Solicitation for Management and Operation of the

NSFNET Backbone Network in June 1987. The objectives of this solicitation were to identify an organization which would implement a higher speed backbone network interconnecting the supercomputer centers and the regional networks, operate and manage this network, and provide a set of informational services to the regional networks. This solicitation specified that the NSFNET would exclusively use the TCP/IP protocol, a defining moment in ensuring the use of this protocol as today's Internet standard.

In many respects, Merit was well positioned to respond to NSF's solicitation. We had the three key organizational staff components filled with experienced, respected talent. What Merit lacked was a nationwide support organization and the technology to deploy.[6] In late 1984, Douglas Van Houweling joined the University of Michigan as its Vice Provost for Information Technology, and soon thereafter was appointed as the U-M's representative on Merit's Board of Directors. Van Houweling had earlier cultivated a relationship with IBM and on Merit's behalf promoted and facilitated discussions between IBM and Merit regarding a partnered response to NSF. During preliminary discussions between Merit and IBM about such a response, both organizations quickly realized the value of having a telecommunications provider as a third partner. Through IBM contacts, MCI was invited to join the partnership. During July and early August of 1987, representatives from the three corporations worked out the details of a partnered response and wrote the group's proposal. Merit served as the lead organization and provided the overall project management, engineering, information services, and the 24-hour-by-7-days-a-week Network Operations Center. IBM provided the router and NOC technology along with its deployment and maintenance, and technology support. MCI dealt with the installa-

Almost overnight Merit's role ... was extended to include an extremely significant, highly visible national networking function.

Merit's proposal was one of six submitted to NSF and won the competition.

NSFNET

tion and operation of the data circuits which interconnected the routers. The State of Michigan, through Van Houweling's efforts, also joined the partnership by pledging a million dollars of support for each year of the project's five-year duration.

Merit's proposal was one of six submitted to NSF and won the competition. NSF publicly announced the award in a press conference held at Wayne State University, attended by Michigan's governor and other dignitaries, on 24 November 1987. Even before learning our proposal was successful, teams from all three corporate partners continued to meet during the fall of 1987 to develop further the new NSFNET backbone's design. This proved valuable and helped meet the partnership's commitment to have our backbone service in place by 1 July 1988. The networking community was amazed that this timetable was met, given the then perceived complexities of installing and operating a nationwide T1 (1.5 megabits per second) network. The new NSFNET service was 24 times faster and served more sites than the initial network interconnecting the supercomputer centers.[7] With this significant increase in network bandwidth and coverage, traffic grew in excess of 20% per month, a clear indication of the suppressed demand experienced with the prior congested infrastructure.

The NSFNET project dramatically changed Merit. Our staff nearly tripled. A new Network Operations Center facility was built and staffed daily around the clock in the U-M's Computer Center building. The NOC was managed by Dale Johnson, one of Merit's NSFNET project's new hires. Among his initial challenges was to recruit and train a staff of 16 operators. Braun headed Merit's growing Internet Engineering group and Jim Sweeton assumed responsibilities for the Information Services function of the NSFNET project. Almost overnight Merit's role of providing
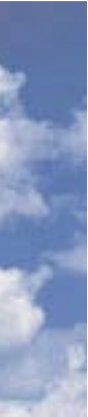
networking services to our Member universities and a handful of other Michigan-based organizations was extended to include an extremely significant, highly visible national networking function. In recognition of this, Merit's Board changed Aupperle's title from director to president of Merit in October 1988.

Merit with exemplary support from our partners succeeded well in this new endeavor. From the start the partnership had a commitment to provide sufficient backbone service capacity to ensure congestion-free performance. Often during the course of the project, IBM and MCI had to and did commit more resources to make this possible. Evidence of the partnership's success is the following quote from the mid-project review conducted by NSF in May 1989.

"One of the most important successes of the NSFNET backbone project has been the demonstration that universities and major high-tech corporations can combine and collaborate in running a large production facility and do it well. It is worth emphasizing this, since the popular wisdom holds that: (a) universities cannot run a production operation, and (b) that university-industry collaborations are only useful for advanced research projects. What the MERIT-IBM-MCI team has demonstrated is that a collaboration between academia and industry is very useful in setting up a production system involving innovative management and new technologies."

During the course of the NSFNET project, NSF committed additional funding to Merit's award to extend the backbone service to additional sites and upgrade the service to T3 (45 megabits per second) speeds, nearly 30 times faster than the T1 network. The T3 upgrade proved to be a major, pioneering, technological challenge for the partnership, one that succeeded although taking longer than expected to implement. In

September of 1990 the Merit, IBM and MCI partners founded Advanced Network & Services, a new non-profit corporation headed by Al Weis. Weis, formerly with IBM, had been involved with the NSFNET project from its inception. ANS assumed the operational responsibilities of the NSFNET backbone service and contributed significantly to the implementation of the new T3 service. Unlike the overnight cutover from the 56 kbps network to the T1 network in July 1988, the T3 network was phased in over several months. It became fully operational over the 1991 Thanksgiving Day weekend.

NSF extended the original five-year NSFNET project through April of 1995 to allow the educational and research communities served by the NSFNET an orderly transition to commercially available backbone services. During the seven-and-one-half-year NSFNET project era, backbone network traffic increased nearly a thousandfold, reaching almost 100 billion packets per month. The number of Internet networks announced on the backbone grew from a handful in 1988 to 50,766 in April 1995, of which 22,296 were non-U.S. networks. The number of countries comprising the Internet grew from 3 to 93. The extraordinary success of the NSFNET project was the dominant factor in converting the ARPANET and early NSFNET research and academically focused Internet into today's worldwide commodity Internet phenomenon. Merit and our partners are proud and pleased to have been a key part of this exciting transition.[8]

Meanwhile Merit's traditional Michigan-based networking role changed too. During a Merit Board of Directors retreat in February of 1990, the Board reaffirmed its desire to maintain Merit's organizational structure as it had been in service to the Member universities. In recognition of the rapidly changing Internet environment and Merit's role in support of it, Merit's mission statement was extended to reflect this. They urged staff to solicit the remaining Michigan public universities to join Merit as new Members. Further and very significantly, they approved a staff proposal to allow organizations other than publicly supported universities to be served by Merit's network without individual Board approval. Such organizations were subsequently referred to as Affiliates to differentiate them from our Members. Aupperle recruited Jeff Ogden, formally an Associate Director of the U-M's academic Computing Center, to lead Merit's Michigan-based networking activities and pursue expanding its services to others in the state. Other changes included formally renaming ourselves to be known as Merit Network, Inc., creating the name MichNet to refer to our statewide network and the part of Merit supporting it, and crafting the new script-style Merit logo we still use today.

Under Ogden's leadership the prior non-Members served by MichNet were soon converted to Affiliate status and new Affiliates added. Three more universities joined as Members, first Saginaw Valley State University in 1991, and then Grand Valley State and Northern Michigan Universities in 1994. To illustrate MichNet's non-Member growth, at the end of 1991 MichNet had 22 Affiliates; by 1993 there were 55, and as the 1995 year ended the number totaled 191. This growth could not be sustained by the then aging PCP/SCP technology. Merit recognized that it no longer made sense to develop a new generation of its own router technology. With the success of the Internet, commercial companies were in the business of selling a variety of suitable network products. Merit chose to use products from Cisco first to augment and ultimately replace its PCP/SCP infrastructure. In mid-1993 Ogden set a goal of having all of the PCP/SCP equipment replaced by October 1995. While that goal was not met, today the only remnants of this early Merit technology serve to interface to Wayne State University's still functioning MTS host system. The PCP/SCP's have had a very successful and remarkably long twenty-year life cycle, with the number of SCP's in service reaching a high of 280 in 1991, supporting a total of about 13,000 asynchronous ports.

Footnotes

[5] The LSI-11 routers, known as Fuzzballs, ran software developed and maintained by David Mills, then at the University of Maryland. While he was at Michigan, Mills had created the earlier networking software used by the U-M's Data Concentrator.

[6] Merit's PCP/SCP technology was considered past its prime and not suitable for national deployment.

[7] NSF's 1987 solicitation specified thirteen sites for service, the six supercomputer centers and their networks, and seven regional networks. Among the latter group was Merit's own network in Michigan.

[8] There is much more to the NSFNET project story than can be included here. For those interested in further reading, Merit has prepared NSFNET: A Partnership for High-Speed Networking, Final Report 1987-1995. Copies of this report are available from Merit's offices, and it is available on Merit's Web site HERE.

Merit — Who, What, and Why
Part Three: Recent Events, 1993-1998

by Eric M. Aupperle, President, Merit Network, Inc.

This four part article looks back at the innovations and ingenuity, trials and tribulations that went into the making of Merit. Reprinted from Library Hi Tech, Vol. 16, No. 1 (1998).

During the latter years of the NSFNET project, NSF was increasingly pressured to transition from funding a federally sponsored network service in support of the education and research communities to an where such service was provided by commercial, commodity backbone services organizations. NSF gathered considerable input from multiple sources before deciding on how best to make this transition. Their solution was defined in a 1993 solicitation entitled Network Access Point Manager, Routing Arbiter, Regional Network Providers, and Very High Speed Backbone Network Services Provider for NSFNET and the NREN Program. This solicitation was structured such that multiple organizations could compete for a suite of services as part of the next generation of the NSFNET architecture. Multiple backbones provisioned by commercial Network Service Providers (NSPs) would replace the NSFNET backbone service. The Network Access Points (NAPs) were envisioned as meet points where the various NSPs could exchange traffic. The Routing Arbiter (RA) was to manage a routing database and provide routing information at the NAPs to ensure an orderly exchange of traffic. The Regional Networks served by the existing NSFNET backbone service were afforded the opportunity to apply for NSF funding to help with their transition to commercial NSPs. The final piece, the very high speed Backbone Network Service (vBNS), was in some sense a step back to a network only serving the supercomputer centers. It was to be an experimental network using the latest and best available high-speed technology.[9]

Merit responded to this opportunity with two proposals. From a MichNet perspective we sought and were awarded partial funding to obtain commodity backbone connectivity from a Network Service Provider to replace our access to the NSFNET. As a follow-on to our NSFNET project we proposed providing the Routing Arbiter function. This time the NSF decided to share the RA's activities between Merit and the University of Southern California's Information Sciences Institute (ISI). From mid-1994 through April 1995, Merit and ISI began ramping up the RA service, while Merit with our NSFNET project partners wound down the backbone service. An extraordinarily smooth, uneventful transition occurred when the NSFNET backbone service finally ended on 30 April 1995.

Merit has also had remarkable success in the area of dial-in internetworking, building on the work first begun in 1975. Our shared dial-in system, one of the nation's most advanced, makes it possible for users to access MichNet with a local telephone number in cities across the state. The system gives participating Members and Affiliates a way to track dial-in usage by their own students, staff, or user community, so they can provide dial-in lines in proportion to the needs of their users. The collection of lines at any dial-in location is then shared in order to reduce overall costs and improve service for all MichNet users. When users dial in to MichNet, they 'authenticate,' or verify that they are eligible to use the network, using a protocol known as RADIUS (Remote Authentication Dial-In User Service). RADIUS was developed by Livingston Enterprises

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Merit has also had remarkable success in the area of dial-in internetworking, building on the work first begun in 1975.

and extended by Merit in the early to mid-1990's. In 1996, Merit began licensing the software worldwide as part of our new AAA (Authentication, Authorization, and Accounting) Consortium.

While users from many organizations can dial in to the MichNet shared dial-in system, there is no single database of IDs and passwords. Instead, the AAA software allows individual organizations--or in some cases, even individual departments within an organization--to maintain their own user accounts, generally using the same IDs and passwords that are used for e-mail and other local computing tasks. This is a great convenience for organizations participating in the dial-in service.

In June 1990 Merit's Board requested staff to accelerate supporting Michigan's K-12 community with network access. This action was an explicit follow-on to the Board Retreat process earlier that year approving Affiliate service. Board members indicated that more interaction with the K-12 community was increasingly becoming an important mission of their universities. Dana Sitzler was given the task of initiating contacts with K-12 schools and districts and encouraging them to consider connecting to MichNet. This turned out to be a slow, time-consuming process requiring considerable education and patience. Typically these schools had little understanding of the Internet or even much experience with classroom computing. The first success of Sitzler's efforts was Project Connect, a cooperative effort among Merit, Novell, and GTE, which resulted in equipping five southeastern Michigan schools with Novell Local Area Networks and connecting them to MichNet in 1992.

Merit's next major K-12 initiative began in early 1994. As a consequence of an earlier Ameritech of Michigan Ratepayer overcharge, Michigan's Public Service Commission approved the use of this money for furthering the K-12 community's network connectivity. The plan called for the governor to appoint an oversight committee to solicit, review and select proposals from regional groups of K-12 schools, and other organizations serving them, to extend their network connectivity. During Merit's January 1994 Board meeting, the Board approved a significant increase in Merit's budget to fund an outreach program to the K-12 community to ensure they understood the opportunities available to them through this one-time source of Ratepayer funding.

Greg Marks, formally with the U-M's Information Technology Division, joined Merit to lead the expanded K-12 effort. The outreach program was successful and helped result in the formation of six regional K-12 groups known as Hubs. The Hubs and Merit applied for and were awarded funding from the Ratepayer fund. Merit's share was used to install and equip MichNet dial-in service for the K-12 community in many new Michigan locations and expand it in others. This program and related dial-in initiatives now led by Scott Gerstenberger have resulted in local MichNet dial-in service in 137 locations collectively equipped with over 5200 modems throughout both Michigan's peninsulas. Over 95% of the State's residents have local-call access to MichNet now. In 1996, some residual Ratepayer funds became available for Merit's use to train K-12 representatives in Internet skills in a program known as SupportNet.

Michigan's libraries and library cooperatives have been another important focus of Merit activities. In the early 90's, Merit was instrumental in the development of the University of Michigan's GoMLink, the first virtual library on the Internet. Merit is a partner, along with the Library of Michigan and the University of Michigan Library, in the Michigan Electronic Library (MEL), a virtual

In June 1990 Merit's Board requested staff to accelerate supporting Michigan's K-12 community with network access.

information system that provides residents of Michigan with no-charge access to a basic set of electronic resources over the Internet. Merit worked closely with the Michigan Library Association to draft its 1994 "Action Plan for Michigan Libraries," which helped position the community for its role in the emerging National Information Infrastructure. Our staff also helped create the Michigan Information Network (MIN) Plan, an effort to create a virtual network connecting all of Michigan's public schools, colleges, universities, and libraries. The Michigan Information Network will be "virtual" in the sense that no single organization is viewed as providing or operating it.

While Merit's user support function dates to the early 1970's, it was not until the mid-1990's that we made a serious commitment to providing services beyond basic network connectivity. The staff now offers training, consulting, and Internet server configuration, as well as a suite of integrated hosting services that includes virtual Web hosting, server colocation, e-mail, and help desk service. Merit offers these services in response to a growing demand by some of the Affiliate organizations we serve.

As an outcome of Merit's successful NSFNET project and expanded MichNet presence, Merit's reputation as an experienced, talented networking organization resulted in many new consortium initiatives, grant awards and consulting opportunities. In 1995 Merit acquired the GateD Consortium from Cornell University, assuming the task of developing the popular "GateDaemon" modular routing software, used to interconnect packet-switched networks worldwide. In 1997 we began the Authentication, Authorization, and Accounting (AAA) Consortium, as noted earlier. Consortia subscription fees provide funding for Merit staff to further develop these software products. For two years Merit participated

with the Society of Manufacturing Engineers as the lead partners of the CoNDUIT project, funded by a technology reinvestment grant from the Department of Defense. The objective of this project was to develop techniques to train staff of small manufacturing businesses in the use of modern technology. Grants from the NSF, the FAA, Mitre and others have funded a variety of projects relating to routing technology, network management tools, and analysis of network statistics. Some of these are completed and others beginning. Consulting work based on our MichNet expertise or our Internet Engineering staff knowledge has been done for a gamut of commercial, governmental, and educational organizations.

Another new activity for Merit is our Route Server next generation (RSng) for-fee service. This service, which began in early 1997, offers Route Server operations and support to NAP service providers. Initially, this same service was included as part of the NSF-funded Routing Arbiter project, but following a 1996 NSF mid-project review of the NAP's and RA's missions and accomplishments, NSF concluded this work need no longer be paid for by them, but had matured to the point that it could be moved to the commercial sector. Similarly Merit's managed Internet outreach activity to the North American Network Operators Group (NANOG) was converted from NSF RA funding to a meeting attendance fee basis. Merit's current Internet Engineering group leader, Bill Norton, successfully led the effort to make these transitions.

Footnote

[9] An external 1996 review of NSF's networking activities recommended that the experimental vBNS program be modified to serve an expanded community of demanding, advanced technology education and research user organizations.

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Merit — Who, What, and Why
Part Four: The Future, 1998 +

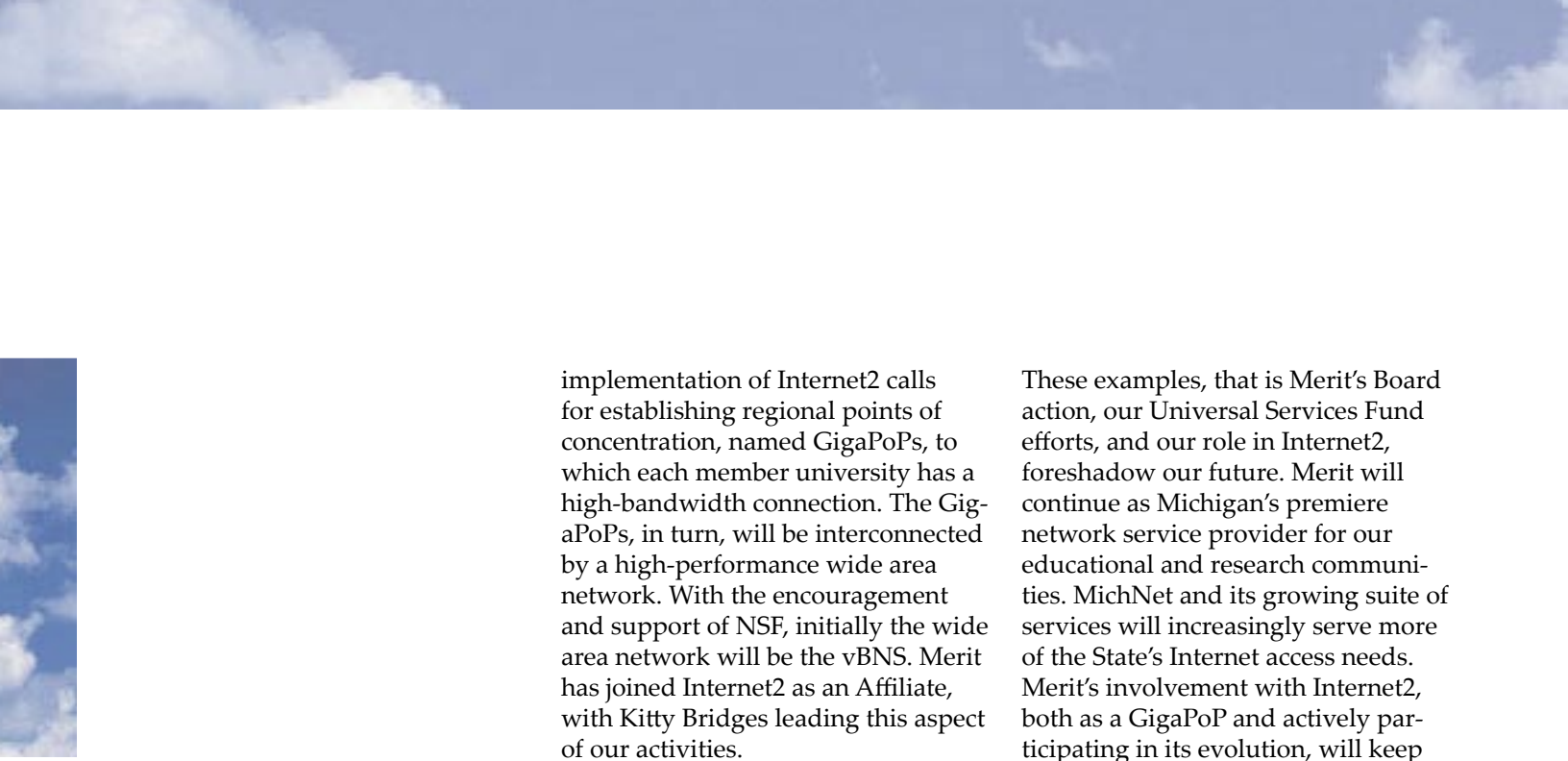by Eric M. Aupperle, President, Merit Network, Inc.

This four part article looks back at the innovations and ingenuity, trials and tribulations that went into the making of Merit. Reprinted from Library Hi Tech, Vol. 16, No. 1 (1998).

Today Merit is a very different organization than it was even as recently as the mid-1990's. We operate a much larger, more complex MichNet, and offer a more diverse, growing set of services and activities. We face increasing competition, yet have many opportunities. Almost all of the NSFNET era's regional networks no longer exist as non-profit organizations. They have either been purchased by commercial network providers or transformed themselves into for-profit companies. There is merger mania among most telecommunication companies, with significant restructuring implications for their Internet service provider sub-units in the near future. So what does all this suggest about Merit's future?

Merit's most recent Board retreat occurred in January 1997. Among the topics addressed in depth by the attendees was whether Merit should convert to a for-profit corporation, create a for-profit subsidiary, or stay its non-profit course. Aupperle invited the executive directors of two NSFNET era regionals who had participated in a for-profit transition of their organizations to share their experiences. In the end the Board, as it had in earlier retreats, reiterated their strong support for Merit as an organization focused on the educational and research communities, and continuing as an independent non-profit corporation.

In 1996, Congress passed a major telecommunications act. Its many provisions included an expanded Universal Services Fund to help K-12 schools, libraries, and rural health care organizations cover the cost of Internet connectivity. This is a major, recurring financial opportunity for the schools and Merit, working with other organizations, is leading an effort to educate Michigan's schools on what this program is and how to apply for funding. This effort illustrates our ongoing commitment in support of Michigan's educational community, one of our primary goals. We anticipate the day when each of the State's schools and libraries is connected to the Internet.

In October of 1996 thirty-four leading universities committed to support an initiative dubbed Internet2. Among the founding Internet2 members were Michigan State University and the University of Michigan. Internet2 is an outgrowth of its founders' concern with the commercial Internet providers' lack of leadership and direction in meeting the Internet2 members' advanced networking requirements, a role the NSF had formerly filled for the higher educational community with its NSFNET program. The Internet2 initiative plans an infrastructure interconnecting its members with a high bandwidth, low latency network ensuring a guaranteed quality-of-service able to support advanced, demanding new applications. The

implementation of Internet2 calls for establishing regional points of concentration, named GigaPoPs, to which each member university has a high-bandwidth connection. The GigaPoPs, in turn, will be interconnected by a high-performance wide area network. With the encouragement and support of NSF, initially the wide area network will be the vBNS. Merit has joined Internet2 as an Affiliate, with Kitty Bridges leading this aspect of our activities.

Also in 1996, NSF announced a new solicitation program to partially fund high performance connections for institutions demonstrating specific research needs for such connections. With Merit taking the lead, Merit, MSU and U-M submitted a joint proposal to implement two OC-3c (155 megabit per second) links to the vBNS, one each from MSU and U-M via MichNet. The proposal was awarded and the first of these links, the one from MSU, became operational in September 1997. With these links Merit is serving as the GigaPoP organization for its two Internet2 Members. More recently WSU also applied for and won a vBNS connection award, and Merit will provision it for them.

These examples, that is Merit's Board action, our Universal Services Fund efforts, and our role in Internet2, foreshadow our future. Merit will continue as Michigan's premiere network service provider for our educational and research communities. MichNet and its growing suite of services will increasingly serve more of the State's Internet access needs. Merit's involvement with Internet2, both as a GigaPoP and actively participating in its evolution, will keep Merit on the forefront of networking research and technology.