Remarks on the Anniversary of the Merit Computer Network

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Introduction

Happy 40th Anniversary!!!

- It is an honor to be able to participate in this celebration and well-deserved recognition of the extraordinary impact Merit has had on our state, the nation, and, indeed, the world.
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- It is also great to see so many of those responsible for its achievements present…and still ticking!
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- Actually, I arrived at Michigan about the same time that Merit was launched, and my career has been not only heavily influenced by at times interwoven with Merit's.
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- Hence, I thought it might be appropriate to take a quick nostalgia trip through these years, commenting on various aspects of Merit's history from a personal perspective as a user, occasional defender, and strong admirer of the Merit Network.
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- Before dredging up what my failing memory has to offer, let me stay in the present mode for just a moment to mention an experience I had just last week.

Salzburg Seminar

- Just arrived back from Salzburg, where I led a week long session of 45 higher education leaders from 25 nations and all five continents on a discussion of the changing needs and nature of higher education in the face of
    - rapidly changing demographics
    - globalization
    - and the knowledge economy
- Whether in developed nations in Europe, Asia, or North America or in developing nations elsewhere, there is a growing recognition of two imperatives
    - "massification" of teriary education
    - lifelong learning

- And everywhere there is also a recognition that the scaffolding for this effort will be provided by cyberinfrastructure–or as the rest of the world calls it, ICT–information and communications technology.
- It is also clear that the technology and networking paradigms that Merit created during the 1970s and 1980s have not only reshaped the world, in the words of Tom Friedman, "flattening it", but this same technology also holds out the promise of meeting the needs for knowledge and learning of the world's population.

Early History

There are several excellent references on the history of the Merit Network from those directly involved in its achievements

- Eric Aupperle's great series of articles
- John Mulcahy's early history
- The Final Report on NSFNET

In fact, many of the hero's of the Merit saga are in the audience today, so instead I will just add a few perspectives from personal experience.

1960s

1964 Blue Ribbon Commission (Governor Romney)

- Roger Heynes
- Allen Smith
- Stan Erickson
- Karl Zinn
    - "Significant benefits might be gained from sharing computing resources via electronic linkage between large, timesharing computers"
    -

Michigan Inter-University Committee on Information Systems (MICIS)

- Michigan Educational Research Information Triad, Inc (MERIT)

- NSF Support ($400 K)

- Key purpose:
    - To conduct research concerning information processing and exchange through multi-media communication systems for educaito and service purposes and develop methods by which independent computer systems can be joined for cooperative utilization and expansion between institutions of higher learning"
    - 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 grater than the sum of the resoures of all the universities in the network.

Technology (1969)

- Recruited Eric Aupperle (UM Cooley Electronics Laboratory) as MERIT's project leader.

- Bolt, Berneck, and Newman: APRANET

- MERIT used PDP-8 as Data Concentrator along with best elements of APRANET (Transmission Control Protocol/Internet Protocol…TCP/IP)
-
- Hired Applied Dynamics to install first communication computers ($300 K)

On December 14, 1971, the first connection between UM and WSU

JJD: My own research on nuclear systems had rather heavy computation requirements. In fact, at the national labs I was allowed roughly an hour a day on a CDC 7600 and had access to the Octopus file system at Livermore.

While working with a keypunch at Michigan was a pain after using CRTs, the easy of the MTS system and the growing capability of Merit in accessing off-site resources was very helpful.

I usually embraced each new application produced by the Merit team

- "Why Host?"
- CONFER (Robert Parnes)
- $MESSAGE (Gavin Eadie)

Although Dick Phillips and Bill Powers temporarily distracted me with microcomputers, which eventually led Dan Atkins and I to
going them with MTS and Merit to create CAEN, the Computer Aided Engineering Network, during the early 1980s, I continued to be amazed at the growth of the Merit system.

NSF Net

Beyond CAEN, there was another initiative during the 1980s that deserves mention–the effort to compete for one of the new NSF supercomputer centers.

There were a number of faculty with insatiable number-crunching needs at the time.

Because of its strong involvement with Amdahl, the University put together an excellent proposal that received the highest technical ranking.

The only problem was that it was based on the new Amdahl 1200 supercomputer–that was manufactured in Japan by Fujitsu.

With Eric Bloch, an old IBM hand, at the helm of NSF, there was no way that the SCC would invest in Japanese supercomputers!

Hence we lost out…which was probably just as well, for Harold Shapiro recruited Doug Van Houweling as CIO from Carnegie Mellon in 1984, he pointed out–and rightly so–that Michigan's real priority should be "power to the people" rather than "Larry Smarr's personal computer"!

That is, that we should build on our exceptional strength in developing technologies to provide ICT to people

Time-sharing (MTS)

Networking (Merit)

The timing could not have been better, since while NSF had fledging networks to connect users to the new SCCs (NSFNET and CSNET), there was growing agitation for broader access to networks for scientific collaboration.

- Here I should note that in 1984 I was appointed by President Reagan to the National Science Board and strongly supported the effort to extend NSF's role in providing IT support beyond the SCCs to include major networking activities.

The NSFNET backbone

- It was Eric Aupperle, president of Merit, who saw the opportunity to take the fruits of Merit's experience with MichNet beyond Michigan in an effort that would benefit not only the research and education community but the nation as a whole.

- MERIT was well positioned. (DEVH joined in 1984 and had cultivated relationship with IBM, who brought along MCI)

    - IBM would provide the computing systems for the network, including hardware and software.
    - MCI would provide the underlying telecommunications circuits (with over 34,000 global network miles and a coast-to-coast fiber optic network in 1987).
    - This team was able to bring the applied commercial operating procedures to the Internet that were standard in the telephone companies and at IBM.

- As provost, I persuaded Harold Shapiro and the Regents that this was an extremely important effort deserving of full UM support.

- Together MERIT, IBM, and MCI submitted winning proposal. Through a cooperative agreement with NSF, Merit Network, a consortium of Michigan universities, in conjunction with IBM, MCI, and the State of Michigan created the NSF backbone service to serve the research and education community's growing need for network communications.

- State of Michigan pledged $5 million from strategic fund

- NSF Plan
    - The idea was to build a tiered network:
        - the national backbone

        - various regional networks
        - campus networks
    - The overall "internetwork" would link these with TCP/IP.
    - Since NSF has a broad community to serve, it placed fewer restrictions on the use of the NSFNET backbone and used a cooperative agreement as the award vehicle to create a real partnership (Dennis Jennings, Steve Wolff, Jane Caviness, and George Strawn)
    - NOTE: ARPANET was managed by DOD and rapidly fell behind.

- Backbone was in place by July 1988 (T1 – 1.5 MB/s)

- Later upgraded to T3 (45 MB/s)

- In 1990 founded Advanced Network and Services to assume operation responsibilities of NSFNET backbone service.

- NSF extended project to 1995 to allow an orderly transition to commercially available backbone services.

- From 217 networks connected in July, 1988 to more than 50,000 in April, 1995 when NSFNET backbone service was retired, the NSFNET's exponential growth stimulated the expansion of the worldwide Internet.

Observations

- MERIT-IBM-MCI demonstrated that a collaboration between academia and industry is very useful in setting up a production system involving innovative management and new technologies. The partnership of academia, industry, and government that built the NSFNET backbone service also pioneered a model of technology transfer whose rewards are only beginning to be realized.

NSFNET is a critical part of the Internet, since this was the foundation of the Internet and the main catalyst for the explosion in computer networking around the world that followed.

Today

Which brings us to today.

The new buzzword is "cyberinfrastructure", the term used to describe hardware, software, people, organizations, and policies–similar to "e-science" in Europe and ICT elsewhere.

Several years ago my next-door office neighbor, Dan Atkins, chaired a blue ribbon advisory committee for NSF on the growing importance of information and communications technology on research and education.

It is becoming increasingly clear that we are approaching an inflection point in the potential of rapidly evolving information and communications technology to transform how the scientific and engineering enterprise does knowledge work, the nature of the problems it undertakes, and the broadening of those communities able to participate in research activities.

Here the Atkins Committee lumped together all of the components of this rapidly evolving technology–hardware, software, people, organizations, policies–into the all-encompassing term, cyberinfrastructure.

The conclusion of their report is important:

> "A new age has dawned in scientific and engineering research, pushed by continuing progress in computing, information, and communication technology, and pulled by the expanding complexity, scope, and scale of today's challenges.
>
> The capacity of this technology has crossed thresholds that now make possible a comprehensive 'cyberinfrastructure' on which to build new types of scientific and engineering knowledge environments and organizations and to pursue research in new ways and with increased efficacy.
>
> The emerging vision is to use cyberinfrastructure to build more ubiquitous, comprehensive digital environments that become interactive and functionally complete for research communities in terms of people, data, information, tools, and instruments and that operate at unprecedented levels of computational, storage, and data transfer capacity.

Here let me stress the terms:

- comprehensive
- functionally complete
- ubiquitous

Hence the importance of their final observation:

> This digital revolution will pose considerable challenges and drive profound transformations in existing organizations such as universities, national and corporate research laboratories, and funding agencies. Here it is important to recognize that the implementation of such new technologies involve social and organizational issues as much as they do technology itself. Achieving the benefits of IT investments will require the co-evolution of technology, human behavior, and organizations.

Of course, no good deed goes unpunished, and for his efforts, Dan Atkins has been summoned to Washington to head up NSF's new Office of Cyberinfrastructure, launching new efforts such as the petascale initiative.

And, perhaps because the National Academies effort has wound down, I agreed to chair NSF's Advisory Committee on Cyberinstructure, reporting directly to Arden Bement, NSF director, and through him to Jack Marburger and PCAST (since the old PITAC has been set aside for the present).

Although today the budget for these efforts in NSF are only $600 million, it is expected that with the doubling of the NSF budget through the president's American Competitiveness Initiative, it will grow quite rapidly.

The "Meta" University

The Open CourseWare Project

Several years ago the MIT faculty made the bold decision to put the digital assets supporting all 2,000 of their courses into the public domain, enabling their use by students, faculty, and universities throughout the world in a well-organized, searchable manner.

Here it should be stressed that the MIT OCW is not a distance learning effort but rather a web-based publishing venture, offering materials for teachers and learners, not degrees or credits. Metaphorically, it puts the books on the library shelves. To date, the William and Flora Hewlett Foundation, the Andrew W. Mellon Foundation, and MIT itself have provided most of the financial support for OCW, and over 3 million students and faculty around the world currently utilize the system.

It also is important to note that almost 70 percent of MIT's on-campus students make heavy use of OCW. They use it to review subjects they took in the past, to reinforce subjects they are currently learning, and to sample and explore other areas of study.

But above all, MIT OpenCourseWare exists through the generosity of our faculty who chose to share their approach to pedagogy, organization of knowledge, and educational materials in this way. It is a voluntary activity for faculty, and their response has been so positive that we have had no doubt about accomplishing the OCW mission.

As our faculty had hoped, there is an emerging open courseware movement. There are over 70 institutions in the United States exploring the OCW paradigm, with additional initiatives in China, Japan, France, Spain, Portugal, and Brazil. Thirty more initiatives are being planned, in South Africa, the UK, Russia, and elsewhere. With the Sakai development of supporting open source middleware, this number should grow rapidly.

The Sakai Project

In another part of "the library of the future" where I'm housed at Michigan is a major software development effort called the Sakai Project. (Sakai is the name of a Japanese cook in the Iron Chef competition. Don't ask me why they picked that name…)

This is an effort by several universities (Michigan, MIT, Indiana, Stanford, Oxford) and corporations (IBM, Apple, Cisco, and Unisys) to develop open-source middleware to support the instructional and scholarly activities of higher education. Several hundred colleges and universities are now moving to the Sakai platform, including all of our instructional activities at Michigan.

But, interestingly enough, beyond the support of classroom instruction and scholarly activities, the Sakai team and their collaborators are exploring taking elements of their open source middleware up to the enterprise level (for administrative purposes) and down to the desktop level (within the Linux framework). And most recently they are involved in a large development effort to develop technology to support the OpenCourseWare effort pioneered by MIT.

The Google Print Library Project

In December of 2004, five institutions announced an agreement with Google to digitize a substantial part of their book collections (Michigan, Stanford, Harvard, Oxford, and the New York Public Library). Last month the G5 became G6 with the addition of the University of California.

At Michigan we have agreed to digitize our entire collection with Google's assistance (7.8 million volumes).

- Here the fact that Larry Page was an undergraduate engineering major at Michigan, involved in our digital library project, stimulated Google's interest and led to a couple of years of discussion before the announcement.
- Our earlier involvement in JSTOR digitization project, sponsored by the Mellon Foundation, gave us a good head start.
- Note we will receive our own copy of this digitized material for use in our scholarly and educational programs. Google will be able to provide searches through these materials, with we believe appropriate safeguards to protect copyrighted materials.
- This activity is well underway, with digitized materials from Michigan coming on line this past June through Google Book Search and downloads of public domain materials now available both through Google and MBooks.
- We current estimate the completion of this project to take about six years, although Google is moving up the learning curve very rapidly and this timeline could be compressed.

What drove the UM's decision to let Google digitize 7.8 million volumes in its collection. As our provost Paul Courant noted "Our purpose is to extend the realm of ideas in the broad service of society."

Here I should also note that Michigan views this project as dealing head-on with the grand challenge to digital access–namely, copyright–by including a substantial number of works not in the public domain.

- And, of course, most copyrighted and potentially copyrighted material has no street value, while the corpus of it is of great value indeed. Somewhere between 95 and 97 percent of the copyrighted material in the University of Michigan libraries is out of print. The cost of getting permissions and finding rights holders for the vast quantity of material that is neither current nor very old can be prohibitive (Covey, 2005). And there is no gain in this for anyone.
- "The current IP framework is inimical to scholarship. Many people have become more concerned with protecting IP than conveying what they know. Access will drive progress on IP and the orphaned-work problem. We must create general demand to make change."

(I might add here that challenging such norms has become a Michigan tradition, as taking the principle of affirmative action to the Supreme Court in 2003 illustrates. It is also consistent with other efforts such as

- NSFnet (with IBM and MCI) in the 1980s which led to the Internet
- Internet2
- Sakai (which may also end up in court challenging the intellectual property claims of monopolies such as Blackboard)

What would it mean to be able to put online (in one virtual place) a copy of everything, and to put it online in a way that ensured the long-term survivability of the content and, where possible, to provide access to the content digitally?

- The rights that Michigan has secured in the digital images we get back from Google will allow us to pursue that goal.
- That is, Michigan may put its copies of content online in a way that it can be collaboratively curated, collaboratively extended by adding more content, and collaboratively used in the service of ends consistent with our mission as librarians. Michigan is now beginning discussions on how that vision might be made real.

It is estimated that as of January 2005, approximately one month after the Google announcement, WorldCat contained about 32 million records describing print books, or slightly less than 60 percent of the entire database. It is clear that print books account for a significant proportion of library collections, at least to the extent that these collections are reflected in WorldCat.
As of January 2005, the Google 5 have set more than 18 million holdings on WorldCat records describing print books, for an average of about 3.6 million holdings per GPLP participant.
The proportion of the system-wide collection actually covered by GDLP, once duplicate holdings across the five institutions are removed, is about one third (33 percent), or 10.5 million unique books out of the 32 million in the system-wide collection.
The addition of the University of California's collections will expand this even further.

The Meta University

The Google, Sakai, and OpenCourseWare projects are examples of a rapidly growing effort to open up opportunities for learning and scholarship to the world by adopted the spirit of open source software development, putting previously restricted knowledge into the public domain and inviting others to join both in its use and development.

Other examples include the open learning initiative of Carnegie Mellon, the open knowledge initiative, and even the open university philosophy pioneered by the British Open University, removing the traditional constraints on admission and enrollment to broaden participation in higher education on the world level.

Open source, open content, open learning, and other "open" technologies even raise the possibility of developing the scaffolding on which to build truly global universities–what Chuck Vest terms the "meta" university.

It is becoming increasingly clear that the current approaches to higher education are simply inadequate to meet the exploding needs for education and knowledge throughout the world. The incredibly large scale of education world wide; the huge diversity of cultural, political, and economic contexts; and the distribution of public and private financial resources to devote to education are too great.

Instead Vest suggests that through the array of open paradigms, we are seeing the early emergence of a *Meta University* – a transcendent, accessible, empowering, dynamic, communally-constructed framework of open materials and platforms on which much of higher education world wide can be constructed or enhanced. Cyberinfrastructure provides the technology and the open paradigms use it to distribute knowledge and learning opportunities to the world.

So What?

Kevin Kelly began his article by recalling the age old dream of having in one place all knowledge, past and present. All books, all documents, all conceptual works, in all languages.

He noted that the closest we ever came was the great library at Alexandria, constructed around 300 B.C., which once held between 30 and 70 percent of all books in existence then.

Yet this dream was quickly overwhelmed by the explosion of civilization and knowledge throughout the world and became an impossibility.

> "Until now. When Google announced in December 2004 that it would digitally scan the books of five major research libraries to make their contents searchable, the promise of a universal library was resurrected. Indeed, the explosive rise of the Web, going from nothing to everything in one decade, has encouraged us to believe in the impossible again. Might the long-heralded great library of all knowledge really be within our grasp.
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> "We can provide all the works of humankind to all the people of the world. It will be an achievement remembered for all time, like putting a man on the moon." And unlike the libraries of old, which were restricted to the elite, this library would be truly democratic, offering every book to every person.
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> "When millions of books have been scanned and their texts are made available in a single database, search technology will enable us to grab and read any book ever written. Ideally, in such a complete library we should also be able to read any article ever written in any newspaper, magazine or journal. And why stop there? The universal library should include a copy of every painting, photograph, film and piece of music produced by all artists, present and past. Still more, it should include all radio and television broadcasts. Commercials too. And how can we forget the Web? The grand library naturally needs a copy of the billions of dead Web pages no longer online and the tens of millions of blog posts now gone.
>
> "From the days of Sumerian clay tablets till now, humans have "published" at least 32 million books, 750 million articles and essays, 25 million songs, 500 million images, 500,000 movies, 3 million videos, TV shows and short films and 100 billion public Web pages. All this material is currently contained in all the libraries and archives of the

> world. When fully digitized, the whole lot could be compressed (at current technological rates) onto 50 petabyte hard disks. Today you need a building about the size of a small-town library to house 50 petabytes. With tomorrow's technology, it will all fit onto your iPod."

Think a bit what might happen if we can put all of these pieces together

- Internet-based access to all recorded (and then digitized) human knowledge augmented by powerful search engines.
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- A knowledge scaffolding based on open source paradigms
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    - Open source software (SAKAI)
    - OpenCourseWare learning resources (OCW)
    - New, collaboratively developed tools (Wikipedia II)
    - Open learning (Carnegie Mellon, UK Open University)
-
- Ubiquitous cyberinfrastructure
-
    - E.g., Negroponte's $100 laptops (Libya???)

Universal Access to Knowledge and Learning

Imagine a time in the near future where anyone with even a modest Internet connection has access to all of the recorded knowledge of our civilization along with ubiquitous learning opportunities. (Note here that Negroponte's $100 PC could well erase the digitial divide, extending this opportunity to a substantial fraction of the world's population.)

Imagine further the linking together of a substantial part of the world's population with limitless access to knowledge and learning opportunities enabled by rapidly evolving cyberinfrastructure increasing a thousand-fold in power every decade.

While science fiction continues to entertain us with the possible emergence of superhuman artificial intelligence, of far more likelihood and interest in my view is the emergence of a new

form of collective human intelligence, as billions of world citizens interact together, unconstrained by today's monopolies on knowledge or learning opportunities.

Perhaps this, then, is the most exciting vision for the future of the university–no longer constrained by space, time, monopoly, or archaic laws–but rather unleashed by cyberinfrastructure to empower the emergence of a new global civilization of humankind.

Conclusion

Very few of us have the opportunities to participate in activities that truly change our society in the way that Merit did during its 40 years.

Bill Wulf, one of the first directors of NSF's CISE, once told me that looking back over the history of NSF he can find few Foundation efforts that come close to matching the extraordinary impact on research, education,…and society than NSFNET and its successor, the Internet.

The Merit history is really quite an extraordinary story that future historians will rank with Gutenberg, Bell, and Ford as a technological effort that changed the world.

Hence to all of you who contributed so much to this effort, please know that there are a great many of who both understand and appreciate its profound importance.

Congratulations once again, on 40 years of achievement, on changing our world, and on providing the foundation for the global, knowledge-based society that has become our future!