

## Challenges of a Knowledge Society

### Thanks

Ah it feels great to be back in West Engineering again...  
...although I never remembered it looking this good!  
Thanks to Mrs. Erlicher.  
Very touched by loyalty and caring of our alumni.  
Virginia Erlicher and her late husband Arthur have  
made a real difference for Michigan.  
Their gift demonstrates the way private giving  
provides the "margin of excellence".  
It will be a focal point for students and faculty of this School  
that is clear a national/international pathfinder,  
leading us forward to a new age.

### Introduction

Lots of talk these days about a new age...  
...the information age  
...the computer age  
...the age of knowledge  
Your profession will play a key role  
...as gatherer  
...as keeper  
...as distributor

### The Age of Knowledge

**Looking back over history, one can identify certain**  
abrupt changes, discontinuities, in the nature,  
the very fabric of our civilization...

**The Renaissance, the Age**  
of Discovery, the Industrial Revolution

**There are many who contend that our society is**  
once again undergoing such a dramatic shift in  
fundamental perspective and structure.

**As Erich Bloch, Director of the National Science Foundation**  
suggests, we are entering a new age, an "Age of  
Knowledge"

**The signs are all about us.**  
**Today we are evolving rapidly to a new post-industrial,**  
knowledge-based society, just as a century ago our  
agrarian society evolved through the Industrial Revolution.

**A transition in which..**  
Intellectual capital--brainpower-- is replacing  
financial and physical capital as key to  
our strength, prosperity, and well-being

**Key element in transformation, is the emergence of knowledge**  
as the new critical commodity, as important as mineral ores,  
timber, and access to low skilled labor were at an earlier time.

**This new critical commodity knows no boundaries.**  
It is generated and shared wherever educated, dedicated,  
and creative people come together...and, as we have learned,  
it spreads very quickly.

**Knowledge and the people who can create and use it are the**  
new strategic resource.

**This is having a profound impact on our social**  
structure, culture, and economy.

### Some examples:

1. Industrial production is steadily switching away from  
material and labor intensive products and processes  
to knowledge intensive processes:  
In a car, 40% materials, 25% labor...  
In a chip, 1% materials, 10% labor, 70% knowledge!!!  
(In fact, the material for computer chips is the  
world's most common substance...sand!!!)

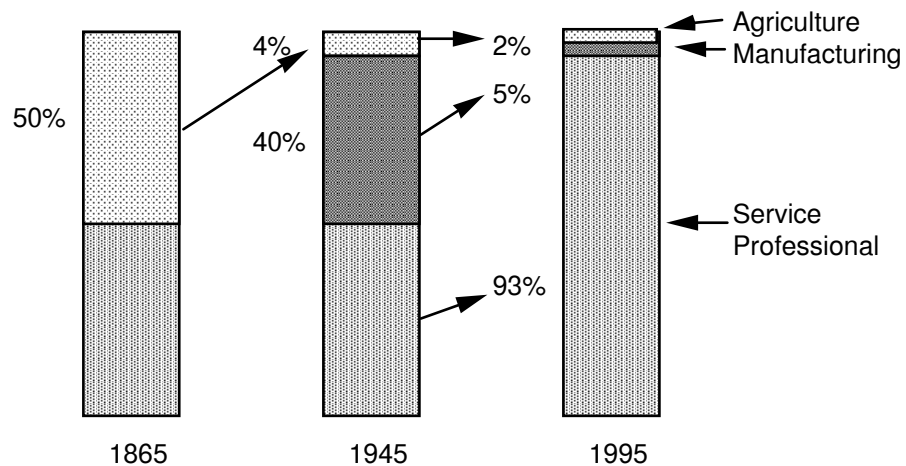
High-tech industries based on knowledge--computers, semiconductors, biotechnology, synthetic materials, are replacing industries based on natural resources as the source of economic growth and strategic strength.

2. Our nation's future has probably never been less constrained by the cost of natural resources. Future areas of growth are likely to come from the application of technologies that require few natural resources.
3. Increasing manufacturing production has come to mean decreasing blue collar employment!

In the 1920s, 1 of 3 was a blue-collar worker  
today 1 in 6 and dropping fast  
probably to about 1 in 20 within a couple of decades...

Indeed, UM economic studies suggest that less than 5% of General Motors' work force will be unskilled labor by the year 2000.

Noland-Norton



4. Recent Office of Technology Assessment report:  
40% of all new investment in plant and equipment goes to purchase information technology
5. What's more, these new technologies magnify the effects of change. "Today the velocity of change is so great... that the tectonic plates of national sovereignty and power have begun to shift" (Walter Wriston)

We are in the midst of an information revolution that is changing the basis of economic competitiveness and world power.

Indeed, if you want to know the real reason why the we are now seeing the extraordinary transformations in the Soviet Union and Eastern Europe, it is not due to diplomacy or economics but rather the silicon chip... that is, to modern communication and information technology which make it impossible for totalitarian governments to isolate their societies from the rest of the world.

Today information and data flow quickly around the world. We learn about events almost as they occur. The world is linked electronically. And, as a result, the relationships between nations and the pace of change are increasing rapidly.

For example, pictures taken by the french commercial satellite and quickly published world-wide forced Soviet officials to disclose the full seriousness of the Chernobyl disaster. A global economy is not only possible; it exists. Markets are

changing and realigning. We have seen it in the far east and now we are seeing it in Europe.

6. Today a microprocess can calculate the orbit of Mars in about 4 seconds, a task that took Johannes Kepler 4 years. A researcher can have on a desktop more computing power than existed in a standard mainframe only 10 years ago. Modern electronic technologies have increased vastly our capacity to know and do things. Moreover, they allow us to transmit information quickly and widely, linking distant places and diverse areas of endeavor in productive new ways. These technologies make many things possible. But they don't make things happen. Only people make things happen. US and Japan already have become postindustrial societies; with predominate sectors in service and high tech. By 1990, 75% of US labor force in services---not burger flipping, but financial services, professional and design services, and human services. Core of postindustrial society is professional and technical services. A fundamental transformation is underway in our economy that is reshaping virtually every product, every service, and every job in the United States. In our country, as in all developed nations, "knowledge workers" have already become the center of gravity of the labor force.

### **The Role of Information Technology**

- Because it is also clear that the knowledge infrastructure of our world provided by information technology will be of increasing importance in the years ahead...
- ...a technology that not only provides a lever for the mind...
    - ...multiplying our talents and extending our intellectual span...
  - ...but provides the tools of interaction that allow us to overcome the barriers of space and time and unite as students, teachers, and scholars...
    - ...indeed, as a people...in ways we never dreamed possible...
- I personally believe that information technology will provide both the infrastructure and the linkages among these themes of change...
- ...our growing pluralism
  - ...our growing interdependence with the global community
  - ...and our growing dependence on knowledge as key to our futures.
- At Michigan we have been convinced for some time that the computer has evolved far beyond simply a tool for scientific computation or information processing.
- It is now a robust technology absolutely essential for the support of all knowledge-based activities...and knowledge-based organizations such as universities, corporations, government.
- Hence it was natural that several years ago, we would accept the challenge of embarking on a great adventure, to turn this University into a gigantic laboratory--an experiment in the development and application of this technology--in our efforts to build a University for the 21st Century.
- Indeed, we sought to make this University a gigantic experiment--a laboratory if you will--for the development of the technology necessary to

support and sustain knowledge-based organizations  
such as universities.

### **Some parameters of the University**

Of many ways, Michigan represented the  
ultimate challenge, since it is long been viewed  
as both the prototype--and indeed the flagship--  
of the comprehensive, public research  
universities which have served America so well  
over the last century.

This is a very large, a very complex,  
and a very decentralized place...

University of Michigan = "multi-versity"

- i) Spans all intellectual disciplines and  
professional areas
- ii) Provides instruction, research, service
- iii) Attempts to conduct programs that rank  
among the nation's best in all areas  
(and succeeds...)

Parameters:

Enrollment: 36,000 (Ann Arbor) (48,000 total)

Faculty: 2,600 (16,000 employees)

Budget: \$1.6 billion

Academic Units

17 Schools and Colleges

Hundreds of research centers, institutes,  
and other types of interdisciplinary  
programs

We also run the largest health care system in  
the Midwest, treating over 750,000 patients each year...

We conduct events in the performing arts which rival

New York and London...

whether it be Leonard Bernstein performing his 70th  
birthday concert with the Vienna Philharmonic  
or, God-forbid, the Grateful Dead....

And, speaking of entertainment, we also have the

Bo and Steve show...the Michigan Wolverines...

playing in the fall to 105,000 every Saturday afternoon

Hence, we viewed the University of Michigan  
as a great challenge for information technology.

If we could undergird this complex, knowledge-intensive  
institution on the infrastructure of information  
technology, then surely we would be well on  
our way toward re-inventing the University for  
the 21st Century.

But of course, we also had one very important  
advantage...the "fault-tolerant" nature  
of the University community...since students,  
faculty, and staff are far more willing to  
put up with occasional glitches and outright bomb-outs  
than most elements of our society.

### **A Case Study: The "Electronic" University**

Personal Background

Always a hacker...

Insatiable appetite for computational cycles...

a "number cruncher"...

Nuclear systems simulation...

Very large systems...

Nuclear reactors...

Nuclear rockets...

Nuclear explosions...

Very complex...

Some of our codes ran 24 hours  
a day on the fastest machines  
available....

Using "supercomputers" even before  
the word was coined...

IBM Stretch  
CDC Star

When Apple-II first appeared in 1979,  
was lured by a colleague, Dick Phillips,  
into developing a introductory course  
on computer for freshmen...

Hence, this perspective had a major impact  
on the strategic directions I have taken  
since...

UM experience...

In 1960s UM was clearly a leader in time-sharing...

MTS was then...and continues today...to be  
one of the most powerful operating systems

UM involvement with IBM, then Amdahl, kept us  
at the lead in the use of large, time-shared  
mainframes...

But...UM fell rapidly behind in the quality of  
computing environment it could provide  
as the new generation of minicomputers  
(VAX, Primes, ...) took root.

Our goal was rather simple:

To build the most sophisticated  
information technology environment of any  
university in the nation...an environment  
that would continually push the limits of what could  
be delivered in terms of power, ease of use, and  
reliability to our students, faculty, and staff.

We sought a distributed intelligence, hierarchical  
computing system linking personal computer workstations,  
superminicomputers (and, more recently, minisupercomputers)  
mainframe computers, function specific machines,  
library access, a host of various servers, and  
gateways to international networks and facilities such  
as the NSF SCC, national data centers, etc.

Managed to recruit people with the vision  
and energy to make this a reality...

Doug Van Houweling  
Lynn Conway  
Carolyn Autry-Hunley  
Doug Hofstadter  
Randy Frank  
Burt Herzog

To create the organizational structures...

ITD

Information Technology Division

CITI

Center for Information Technology Integration

CMI

Center for Machine Intelligence  
Cognitive Science and Machine Intelligence Lab

NSFnet (IBM, MCI)

NSF Supercomputer centers  
NASA, Internet, National Research and Education Network  
ANS

MRLYN

Library system

## MITN

And to build the partnerships with  
the leading information technology companies throughout  
the nation and the world.

### Underlying Philosophy

- i) Determined to stay always at the cutting edge...  
...but with a very strong service focus
- ii) Determined to remove all constraints...  
...no limits whatsoever on student and  
faculty use
- iii) Multivendor environment  
...choosing whatever technology was the most  
powerful
- iv) Relied heavily on "fault-tolerant" nature  
of University community to develop an  
entrepreneurial culture...a "go-for-it"  
philosophy!

### Today...

- i) roughly 3,000 public student workstations  
(funded through \$220-\$400/y fee...  
gives us \$10 M/year of venture capital to  
play with)
- ii) roughly 30,000 workstations
- iii) student purchase plan...  
MacTruck -- truckload sales...
- iv) robust networking...  
digital wire plant...  
LANs...
- iv) one of the largest installations of mainframes in the world...  
all networked together into an institution-wide  
file system
- v) 80,000 users on system
- vi) UM has become the focal point in efforts to build  
the "interstate highway system" of information  
exchange...with EXPRES, NSFnet, internet,  
MITN,...coordinate access to NSF SCCs...  
National Research and Education Network

### Library

UM Library and SILS under Bob Warner have become  
leaders in conceptualizing acquisition, storage,  
retrieval, and sharing of information both on campus  
and throughout networks linking research libraries in  
this country and abroad.

We are on the threshold of an age of knowledge that is  
making the world's accumulated information and  
knowledge accessible to individuals anywhere.

This has breathtaking implications for education,  
research and learning.

It is a profoundly democratic revolution.

### Status

1. Engineering and Bus Admin are clear national  
leaders in this technology
2. UM has not only the most ambitious, but also the  
most effective program of any large university  
in nation
3. UM has become the focal point in efforts to build  
the "interstate highway system" of information  
exchange...with EXPRES, NSFnet, internet,  
MITN,...
4. SILS Leadership  
Our school of Library and Information Science is

in the forefront of this effort.

The new courses headed by Maurita Holland that will prepare undergraduates to function in the information society is one example.

The proposed groundbreaking course for upper level students on social and cultural factors influence access to information is another important new educational contribution.

I am also enthused about the prospect of collaborative research on our evolving information infrastructure.

Tomorrow...

Now riding the "fourth wave" of the use of information technology...where the computer becomes not simply just an information processing tool, but rather a medium of communication, cooperation, and collaboration...an entirely new intellectual endeavor

Personal computing to "interpersonal computing"

As the result of the rapid spread of personal computers and computer networks, and the development of new insights into human cognition and group behavior, we are at the threshold of a major shift in the underlying paradigms and uses of information technology. The shift will be from solo use of personal computers to group use of collaboration technology.

Group process underpin all human activity and work.

Past research in computing technology has focused on the solo user.

But groups activities such as brainstorming, planning, and making decisions in group settings will require new technology.

Center for Collaborative Science and Technology  
UM, MIT, PARC

Organization theory, cognitive psychology, anthropology, human-computer interaction, artificial intelligence, and multi-media information technology

#### + **Specific Comments**

##### + **Technology Advances...**

- i) Every 18 months, the back for the buck doubles...
- + ii) From mainframes to minicomputers to personal computers
  - to workstations to laptops and notebooks to
  - ..."Dynabook"...
- iii) National networks...Gigabit/second transmission rates
- + iv) Unlimited storage...optical disks, cheap memory
  - (16 MB memory chips...)
- + v) Cellular communications technology
  - Motorola's global cellular network...
  - + Startrek type phones...
  - ..."beam me up Scotty"...
- + vi) Two years ago I saw a laptop equipped with a 2400
  - cellular modem...
- + vii) In the 1990s we will probably have laptops with
  - the processing power of 1980s mainframes
  - equipped with sophisticated cellular networking
  - capacity to access robust networks linking together
  - the knowledge of the world...
  - ...the "Dynabook" or "Knowledge Navigator" will be here soon!

##### + **Implications for Learning**

- + For education...
- + In the past we have taught...

- ...facts...
- ...methods of analysis...
- But these are just what computers are good at...
- + Analysis:
  - + Much of the time spent by professionals (engineers, lawyers, doctors,...) used to be spent in laborious diagnosis or analysis.
  - + Today computers can be used to analyze...indeed, to simulate situations
  - + Further, artificial intelligence is rapidly proving far more effective at accurate diagnosis than human intelligence
- + Facts:
  - + No longer any real need to remember more than the most basic information.
  - Can literally pluck information out of the air...
- + Can already see a shift in the activities of professionals...
  - ...from analysis and fact-gathering to creativity...
  - ...from the right to the left-hand side of the brain...
- + (since creativity seems to be one area that computers aren't very effective)
- + Implications for Librarians**
  - + i) Clearly, the function of a library as an archive for physical objects will become less and less important...
    - ...indeed, will probably assume the same role as a museum
  - + ...electronic representations are rapidly replacing physical representations
  - + ii) Clearly, too, libraries as repositories for information will increasingly become just another "database node" on massive, world-wide networks that can rapidly share and deliver information from any of its resources
    - ...The user really could care less where the actual knowledge resides on the network...whether at Michigan...or the Widener Library...or the Library of Congress...or some obscure database in central Transylvania...
  - + ...as long as the network has the capacity to find what he is looking for and download it rapidly into his workstation
  - + iii) So what is the role of the librarian in this rapidly changing technology driven age of knowledge?
    - ...as a "knowledge worker"
  - + iv) Despite the rapidly advancing nature of information technology, we still have far to go in our ability to gather, organize, search, present, and use information.
    - And, here, the experience of library science will continue to prove invaluable since you folks have ways of doing things that go far beyond those of the computer science community.
  - + v) Further, it will be critical for you to help us in managing the "cultural change" necessary to get folks comfortable with these marvelous tools.

**One final comment and observation...**

Many view the computer as a symbol of the de-personalizing nature of modern science and technology. Yet, if ever there was a tool for empowering the individual, it is information technology. This is truly a liberating force in our society, not only freeing us from the mental drudgery of routine tasks but linking us together in ways we never dreamed possible ...overcoming the constraints of space and time.



In part, it is our challenge, collectively, as  
journalists, scientists, educators, leaders of business  
...to build greater public understanding and support  
for this extraordinary tool...  
...so key to our nation and the world as we  
prepare to enter the "Age of Knowledge"  
that is our future.

**T. S. Eliot, the Rock (1934)**

All our knowlege brings us near to our ignorance,  
All our ignorance brings us nearer to death,  
But nearness to death, no nearer to God.  
Where the the Life we have lost in living?  
Where is the wisdom we have lost in knowledge?  
Where is the knowledge we have lost in information?  
The cycles of Heaven in twenty centuries  
Bring us farther from God and nearer to the Dust.