REPORT ON THE DIGITAL TECHNOLOGY SUMMIT

A CONFERENCE SPONSORED BY THE

UNIVERSITY OF MINNESOTA

MINNESOTA HIGH TECHNOLOGY COUNCIL

MINNESOTA OFFICE OF TECHNOLOGY

October 22 and 23, 1997
Minneapolis, Minnesota

SUBMITTED TO

Mark Yudof, President of the University of Minnesota

EXECUTIVE SUMMARY

In his inaugural address, President Yudof said, "Perhaps vision lies where values and goals intersect." This is an apt epigraph to a summary of the Digital Technology Summit (DTS).

Background

Governor Arne Carlson and University President Mark Yudof, recognizing the need to provide a focal point for a "new beginning" phase of the digital information revolution in Minnesota, called for the organization of the Digital Technology Summit.

The Digital Technology Summit provided the opportunity for representatives from education, business, and government, as well as general citizens, to explore this intersection. Specifically, these constituencies came together to assess and discuss how the state of Minnesota is meeting the challenges and opportunities presented by digital information technologies now and how these challenges and opportunities could be better met in the future.

Recommendations

These general recommendations were advanced as means to supporting excellence and inclusiveness:

1) Support and facilitate collaboration,
2) Establish a climate of responsiveness, and
3) Allocate support through resources.

Evidence

Digital technology was divided into nine economic sectors for the first day presentations by individuals who had been identified as visionaries. These speakers were charged with presenting their views of the trends and challenges for their respective specialties. The nine economic sectors are:

Spatial Data Technologies
High Performance Computing and Visualization
Education
Telecommunications
Digital Publishing
Advanced Design Manufacturing
Technology Enhanced Health Care
Electronic Commerce
Entertainment.

For planning purposes, the second day of meetings was structured around twelve areas of technology. These included all nine economic sectors, but also broke out Visualization(10) from High Performance Computing and added Storage Technologies and Databases(11) and Hardware(12).

The *Evidence* section of the report reviews the highlights of the track presentations comprising the events of Day One of the Summit and summarizes the discussions and recommendations developed in the small working groups that convened on Day Two of the Summit.

Discussion

Summit participants are convinced that Minnesota has the educational, industrial, and governmental resources to support the state in its effort to regain its once pre-eminent standing in the area of digital technologies. Participants agree that the University of Minnesota can serve to facilitate communication and collaboration between various constituencies in the state, efforts which will allow the state to achieve this goal. By serving the state in this way, the University can support excellence in research, in preparation of citizenry for the job market, in industrial innovations, in governmental initiatives, and in the quality of life for all Minnesota citizens.

TABLE OF CONTENTS

OVERVIEW

In his inaugural address, President Yudof said, "Perhaps vision lies where values and goals intersect." This is an apt epigraph to a summary of the Digital Technology Summit (DTS).

The Digital Technology Summit provided the opportunity for representatives from education, business, and government, as well as general citizens, to explore this intersection. Specifically, these constituencies came together to assess and discuss how the state of Minnesota is meeting the challenges and opportunities presented by digital information technologies now and how these challenges and opportunities could be better met in the future.

This report provides an overview on the context of and recommendations resulting from the DTS. The Background section explains the origins, goals, and intended outcomes of the Summit as well as provides an overview of Summit activities. The Recommendations section summarizes broadly the recommendations advanced by participants regarding the University's role in meeting the opportunities and challenges presented by digital information technologies, while the Evidence section provides summaries of Day One presentations and Day Two discussions. Finally, the Discussion section addresses the implications of the recommendations advanced.

BACKGROUND

Governor Arne Carlson and University President Mark Yudof, recognizing the need to provide a focal point for a "new beginning" phase of the digital information revolution in Minnesota, called for the organization of the Digital Technology Summit.

The purposes of the Digital Technology Summit were

- To accelerate the state's entry into the digital information society.
- To focus the attention of citizens on the impact and potential of technology on their daily lives.
- To provide a context from which citizens can understand the significance technology has had, currently has, and will increasing have on the overall economy and standard of living in Minnesota.
- To attract national attention to Minnesota's contribution and potential for increased contribution for the application and advancement of digital technology.
- To announce and reaffirm that the University of Minnesota is a major stakeholder in Minnesota's high technology industry and to demonstrate to industry that the University is committed to being an aggressive leader in a collaborative effort with government, education and industry to build Minnesota's high technology industry.

- To facilitate communication between and within the university, the state, businesses, and the outside world.

The intended outcomes of the Digital Technology Summit were

- To create a general position statement that will articulate to the public-at-large the need to address preparing Minnesotans for a digital information society and how that relates to the future standard of living for the state's citizens.
- To develop a list of recommendations related to the role of the University in helping Minnesota citizens and companies prepare to thrive in the digital information society.

This conference provided the opportunity to articulate to the public the need to prepare Minnesota citizens for a digital information society and to develop a list of recommendations for the University that would prepare Minnesota citizens and industries to thrive in the digital information society.

The Digital Technology Summit was planned and organized by a team consisting of representatives from the University of Minnesota, the Minnesota High Technology Council, and the Minnesota Office of Technology. It was funded by registration fees and contributions from the University of Minnesota and member companies of the Minnesota High Technology Council.

The Summit was held on 22 and 23 October, 1997 at the Hyatt Regency Conference Center in Minneapolis, Minnesota.

Digital Technology Summit: 22 October 1997
Day One of the Summit was open to all interested parties. Presentations were given by visionaries and industry leaders, who provided a perspective on current and future uses of digital technology in the following areas representing economic sectors:

Spatial Data Technologies
High Performance Computing and Visualization
Education
Telecommunications
Digital Publishing
Advanced Design Manufacturing
Technology Enhanced Health Care
Electronic Commerce
Entertainment

Digital Technology Summit: 23 October 1997
Day Two of the Summit provided invited participants from government, education, and business an opportunity to discuss in small groups the role the University can play in fostering the digital information age in Minnesota. There were twelve groups

representing more technology-based subjects than the previous day's nine economic sectors. The groupings were:

Biomedical/Health Care
Digital Publishing and Libraries
Distance Learning and Education
Electronic Commerce
Entertainment
Hardware
High Performance Computing
Manufacturing
Spatial Data Technology
Storage Technology and Databases
Telecommunications
Visualization and Graphics

Each small group was responsible for reporting to all Day Two participants its response to these three questions:

- What does this topic mean to the University?
- Where is the University in this area and how should it change?
- What is the University going to do differently as a result of the Digital Technology Summit?

Day Two participants responded to this task by defining existing challenges in meeting current and future need determined by digital technology; assessing the gap between the current and ideal situations; and making recommendations for how the University, businesses and government could act to close these gaps.

RECOMMENDATIONS

Day Two working groups consistently recommended the following values and goals in formulating initiatives regarding digital technology: Excellence and inclusiveness through collaborations, responsiveness, and support.

Excellence: Group participants value setting the standard for excellence with respect to digital technology and therefore would like to see the University and the state of Minnesota establish the model for excellence with respect to digital technology.

Inclusiveness: However, coupled with the concern for achieving excellence, the groups expressed concern for all Minnesota citizens. Groups consistently stated that excellence in business, in research, and in education should have a decided positive impact on the quality of life for all citizens in the state.

Collaboration within the University: The University must become interdisciplinary in focus, both within and among technologies. For example, with respect to research and development, the Institute of Technology could partner with the Carlson School and the Humphrey Institute in creating, marketing and distributing new products.

Collaboration outside the University: The University must partner with businesses, both large and small, with primary and secondary schools, with vocational and community colleges, with local and state government, and with the citizens of Minnesota through educational, outreach, and extension efforts.

- These collaborative efforts must be, as much as possible, easily established and not prevented due to inefficient bureaucratic structures.
- Data and resource sharing must be encouraged and facilitated by establishing trust-based relationships between and among constituencies and through the use of digital technology.
- Issues of intellectual property must be discussed and "resolved" so the above-mentioned trust-based relationships can be established.

Almost every small group proposed that a Digital Center be established. The purpose of these centers is to provide an "infrastructure" supporting the aforementioned collaborations. The University must be a catalyst to bring together and support all these collaborative efforts. The centers are to be thematic and, as such, should build across traditional collegiate lines. These centers must be responsive to initiatives at all levels from major research grants to internships for students at small companies, to professional exchange programs between businesses and the University.

Responsiveness: Establishing a climate of responsiveness was deemed essential by most small groups. The University must provide a system that is responsive and flexible - because that is the nature of the technology that it is trying to harness. Traditionally, the University has been slow in responding to needs within and without because of established bureaucratic structures. These structures must be re-examined and retooled to establish a climate in which immediate action is possible.

- Thematic centers should be embedded in a University of Minnesota Digital Technology Center, the mission of which would be to coordinate and integrate activities across different colleges, which at the "micro-scale" appear different, but which at the "macro-scale" share a common basis in digital technology. For example, design and visualization of an automobile part and of an architectural structure look very different at the product level, but share common needs in flexible design software, data storage, and display technology. Thematic centers could establish streamlined methods by which, for example, a faculty-student-business collaboration could be set up within hours.

- The curriculum, too, must be responsive to the needs of students and to the needs when they move into the work force. Employing a professional training model with its emphasis on practical, hands-on experience, used in medical schools and law schools, is worth consideration, as are methods for reducing barriers for students to major and minor in technologically oriented areas or to take only one or two courses in a particular area. Additionally, academic programs need to be revised to reflect inter- or multi-disciplinary perspectives.

Resources: Many of the small group panelists acknowledged that allocation of resources is a concern. The University and government must provide financial support for these initiatives if they are going to be implemented. This economic support includes funds for salaries, including new hires at the University; for equipment; for both large and small scale initiatives focused in both urban and remote or rural areas; and for hardware, software, and communication capabilities, i.e. infrastructure.

The University must also look carefully at reallocation of resources, emphasizing the possibilities of sharing and merging resources between and among departments to facilitate interdisciplinary research and teaching efforts.

EVIDENCE

The information following is organized by the Day One tracks at the Summit. For each track represented, a summary of the Day One presentations is followed by a summary of the related Day Two discussions and recommendations.

Because there were nine sections on Day One and twelve on Day Two, the sections "Storage Technologies and Databases" and "Systems and Hardware" only the discussion and recommendations resulting from the Day Two small group work are presented.

SPATIAL DATA TECHNOLOGIES
DAY 1: "NEW DIRECTIONS FOR SPATIAL DATA TECHNOLOGIES" by Jack Dangermond, ESRI

Potential Strengths of Spatial Data Technologies (SDTs)

- The language of visualization transcends the boundaries of verbal languages; it crosses the cultures of disciplines, professions, organizations.
- SDTs make complex things easier.
- SDTs allow us to see the global picture but focus locally.
- SDTs are a way to dip into big, abstract databases and extract information.
- Establishing effective SDT databases encourages cooperation between people and between organizations.
- Those who create and share SDTs must agree how to define reality and then agree which bits of reality should be committed to databases.
- SDTs allow "simultaneity" by tightening the cycle of collecting data and making decisions.
- Making data public through SDTs can increase the accuracy and reliability of the data as more users demand the best possible product.
- SDTs can be good for the economy, for people, and for the environment.
- SDTs can stimulate education at all levels.

Potential Challenges Facing Spatial Data Technology Developers

- Establishing effective SDT databases demands cooperation between people and between organizations.
- Effective SDTs require interfacial standards and common communication protocols.
- Integrating and managing diverse SDT datasets can be fraught with data compatibility problems.
- The importance of assessing client needs, building new intellectual substance, and measuring SDT product usability is often underestimated.
- Data integrity is a critical issue; errors published via SDTs potentially propagate additional errors.

The Future of Spatial Data Technologies

- We will measure everything that changes through space and time.
- We will create intelligent data structures. We will map objects' characteristics, locations, and behaviors.
- The costs of SDTs will decrease and the availability will increase.
- SDTs will diversify, for example, Geographic Information Systems (GIS) will be embedded in other applications.
- We will continue to make SDTs easier to use, faster, more relevant, more affordable, and more accessible.

Spatial Data Technologies and the University of Minnesota

- U of M should take a leadership role in bringing together various cultures (academia, business, government) to cooperate on SDT efforts. Convincing these organizations of the benefits of sharing data is imperative.
- U of M must continue to develop both SDTs themselves and the people who understand the scientific and technical basis of SDTs.
- U of M should become involved in bringing SDTs to k-12 education.
- U of M must produce foresters, geographers, agricultural specialists, and professionals of every other field who are equipped to take full advantage of SDTs.

SPATIAL DATA TECHNOLOGIES
DAY TWO: ISSUES AND RECOMMENDATIONS

The Spatial Data Technologies work group consisted of about 40 representatives from business, government, and academe. The group convened at 8:30am and, after brief introductions by Tom Burk and Will Craig, broke into disciplinary subgroups guided by University leaders. The subgroups and leaders were:

- Natural resources (Marvin Bauer, College of Natural Resources)
- Agriculture (Jay Bell, College of Agriculture, Food and the Environment)
- Infrastructure (Shashi Shekhar, Institute of Technology)
- Health (Lance Waller, School of Public Health)
- Community Planning (Dave Pitt, College of Architecture and Landscape Architecture)
- Marketing and Business (Bob Hansen, Carlson School of Management)

WORKING GROUP: RECOMMENDATIONS

The process the group engaged proceed as follows: the larger group subdivided into six small groups; each of these groups was asked to consider seven general questions (listed below) and to arrive at general recommendations to present to the entire group; the entire group then engaged in discussion to find common themes across subgroups. This discussion resulted in five points that the SDT workgroup presented to President Yudof:

- Spatial data technologies will provide a common language for the information age. A focus on spatial data technologies will offer a high return on the University's investment in terms of quality of life improvement for the public, increasing the competitiveness of Minnesota businesses, and providing the foundation for international leadership on the important applied research problems of the 21st century.
- For spatial data technologies to realize their full potential, data must be shared between organizations. The University should participate in the quest to break through the technological, ethical, legal, fiscal, and institutional barriers that stand in the way of data sharing. This could be effectively facilitated by support of a multi-disciplinary center with representation from all of the nine colleges participating in this Spatial Data Technologies session, and more.
- The University should integrate spatial data technologies into its educational mission. The University should facilitate the integration of spatial data technologies into the K-12, undergraduate, and graduate curricula. University Extension must expand its role in increasing general awareness of spatial data technologies and offering broad training in this area. Awareness within the University should be expanded by holding a "Spatial Data Technologies Day" on campus, with leadership provided by the multi-disciplinary center mentioned above.

- The University should integrate spatial data technologies into its research mission. The University should take a leadership role in creating new spatial-oriented analysis and modeling paradigms, evaluating new sources of spatial data, discovering ways to deal with error propagation in spatial data, developing new three-dimensional spatial modeling technologies, and investigating the institutional issues related to spatial data technologies.
- The University should integrate spatial data technologies into its outreach and partnership development mission. The University should facilitate internships for students in government and business. The University should facilitate faculty and staff sabbaticals in government and business to ensure discovery and solution of real problems.

BASIS OF WORKING GROUP RECOMMENDATIONS

Each of the six subgroups were asked to consider seven general questions. The questions were intended only to motivate discussion; they were not used to organize the workgroup participants' overall conclusions and recommendations. The discussion questions were:

- Why are SDTs critical to progress in your area?
- What is the University doing well now in SDTs that is assisting science and industry in your area?
- What are the most pressing science needs in SDTs in your area (that the University in cooperation with industry and government should address)?
- What are the most pressing science needs in SDTs in your area (that the University in cooperation with industry and government should address)?
- What education needs in SDTs should the University be addressing and how?
- What organizational structures should the University have in place to ensure progress is made on the above?
- How do we get the University, industry, and government together to move SDTs forward in Minnesota?

The conclusions and recommendations of each subgroup are summarized below.

Natural Resources

- The University should mobilize its extension services to facilitate SDT application to the natural resource field
- The University should focus research efforts on
  - New imaging technology
  - Landscape metrics
  - Error propagation
- The University should increase integration of SDTs into curricula
- The University should promote SDT education
  - in K-12 programs
  - by encouraging SDT internship experiences

through continuing education programs

Agriculture

- Goals
  - The University should facilitate spatial information collection and exchange for basic research
  - The University should facilitate the incorporation of spatial reasoning into research, teaching, extension
- Products
  - Trained SDT users
  - Spatial agronomics
  - Rural development
  - Environmental protection
  - Technology transfer

Infrastructure

- The quality of life for the University, industry, and government improves when spatial data and spatial data analyses are shared amongst all.
- The University, industry, and government should expand interactions by way of internships.
- The University should interact more with other organizations and regions, such as other universities and neighboring states.
- The University should improve its relationships with government and industry by aiding the development of SDT standards, by facilitating the distribution of data, and by stimulating the use of data.

Health

- The University could provide a clearinghouse (e.g., a web site) for both internship opportunities for students and the internship needs of industry and government. Such internships provide a valuable connection between the University, agencies, the private sector.
- The University could take a leading role in developing guidelines and criteria for establishing a common spatial data catalog or clearinghouse. This work would include:
  - developing spatial base maps;
  - developing metadata requirements, that is a common set of terms and definitions used when documenting spatial data; and
  - developing data quality standards and criteria.
- The University could sponsor regular state-wide workshops relating to spatial data technologies. This would foster interaction between analysis and mapping.
- The University could facilitate the development of methods applicable to spatial data that protect individual confidentiality (e.g., for confidential health data) but allows data sharing.

Community Planning

- The University should facilitate the development of ethical, legal, fiscal frameworks to address data sharing issues.
- The University should facilitate the development of data standards and conventions to assure comparability.
- The University should strengthen and broaden its involvement with metro GIS (Geographic Information System or Geographic Information Science).
- The University should develop citizen and policy-maker education programs so these people can ask more intelligent questions in process of policy development.
- The University should educate planners to be spatially literate and intelligent consumers of GIS and be able to integrate GIS in day-to-day functions.

Marketing and Business

- The University should facilitate faculty/business seminars to expose teachers in management to current business practice.
- The steps to accomplish this:
    1. Identify key faculty members to participate.
    2. Identify potential business collaborators.
    3. Decide which key ideas to present during the seminar.
    4. Have the joint seminar.
    5. Follow up with a joint meeting on the implications of the seminar on the implementation of teaching, research, outreach.

HIGH PERFORMANCE COMPUTING AND VISUALIZATION

DAY 1: "TOWARD THE VISUAL SUPERCOMPUTER" by Larry Smarr, National Center for Supercomputer Applications, University of Illinois

Technological Trends

- From the Cray X-MP in 1985 to the Nintendo 64 in 1997
- "Victory" of the personal computer
- Exponential shift from vector processors to microprocessors
- Millions of computers driving hardware and software development

Need for Visualization

- Increased computing power
  - Generating huge amounts of data
  - Visualization provides mechanism for interpreting data
- Provides means of taking abstract data and turning them into a visual image to be analyzed
  - Flow of information across the Internet in a month
  - Financial risk
- Applied to
  - Academia: Astronomy
  - Industry: JP Morgan
  - K-12: NICE Project

Specific Projects

- Alliance/Technology Grid
  - Partnerships with other sites
  - Working toward a "metacomputer"
  - Network-centric rather than (super)computer-centric
  - University of Minnesota is an Alliance power

- University of Minnesota Power Wall
  - 6400 x 4800 pixel display
  - High resolution, interactive visual analysis
  - University of Minnesota is a pioneer in this research

- Caterpillar
  - CAVE: immersive virtual environment
  - Virtual prototype versus physical model
  - Reduces length of development phase
  - Promotes global collaboration

What Works in an Academic-Industry Partnership?

- Academia should help industry become more competitive, not try to get industry money to make up for funding shortfall.
- Can't impose cultures on each other.
- Look for mutually beneficial opportunities.

Looking Towards the Future

- Demands from younger generation will drive the industry.
- Application to a broad range of specialties
  - Health
  - Manufacturing
  - Financial
  - Insurance
  - Education
  - Research

Immersive virtual reality environments

HIGH PERFORMANCE COMPUTING AND VISUALIZATION

Note: This track broke into three subdivisions on Day 2: High Performance Computing, Visualization, and Storage Technologies and Databases.

DAY 2: ISSUES AND RECOMMENDATIONS: HIGH PERFORMANCE COMPUTING

Summary

The University of Minnesota has an excellent tradition within the supercomputing discipline. The presence of a strong computing industry within the state of Minnesota leaves the University in a good position to make supercomputing one of its noted research features. However, the situation is changing rapidly in high-performance computing due to a diversity of computing modes, and the University needs to work on tying together various interdisciplinary elements in supercomputing in order to maintain its traditional position as a leader in advanced scientific computation. The panel developed recommendations to achieve this goal under the areas of education, research, and industry initiative/technology transfer. These recommendations are listed below.

The recommendations reflect a synthesis of many hours of deliberation by the panel. During the deliberation, a number of issues arose which matched many of the issues from the first day of the summit.

- **"Thinking is still more important than writing code."**

  Representatives from industry stressed that industry needs educated workers who can think critically and have skills applicable to a diverse range of projects. Industry wants employees with long-term skills rather than those who only know the mechanics of a specific piece of software.

- **"It's not the computers, it's the science"**

  Supercomputing is a tool which has applications in many different disciplines. A successful supercomputing program must think outside of the academic box. This tool needs to be used across departments and college boundaries.

  Also, supercomputing should focus on solving problems of critical importance to society rather than looking towards obtaining the latest, fastest, and best machines. Supercomputing is a tool that can aid in problem solving across disciplines. The supercomputing field needs to center on practical application of its techniques.

• **"We should not solve yesterday's problems faster; we should solve tomorrow's problems sooner."**

The goals of supercomputing research are always focused on the hardest problems, the ones that are not quite solved yet. In order to solve these problems, the University needs to train students to apply the new, research-level software methods to these problems as well as maintain the latest equipment. The University should also promote interdisciplinary approaches since these are often the best way to attack the emerging problems. Keeping the tools of digital technology accessible to new faculty promotes this type of interdisciplinary approach. The final step in solving many problems is the production of usable, documented, stable software (typically, applications software) that can be transferred to industry and/or other academic or government sites. Thus, the barriers to such software development should be lowered.

• **"The best means to technology transfer is often the well educated student."**

The University is doing a good job of working directly with industrial partners to solve critical problems. However, we should not lose sight of the fact that the best technology transfer often occurs when University of Minnesota researchers take their skills out to industry as employees, group leaders, and startup catalysts. This type of technology transfer occurs through the training of undergraduates and graduate students as well as postdoctoral researchers on problems that employ cutting edge digital technology tools. These tools include not only hardware and software but also the computational science that underlies their application.

Recommendations

Education

• Build supercomputing into existing undergraduate science courses.

Supercomputing is a tool which can be used by a number of scientific fields. By integrating the tool into existing courses for a major, undergraduate students learn how to use supercomputing to solve problems within their discipline.

Such an integration will not happen overnight since it requires changes in the way current courses are taught. However, the University can promote this change through two main steps.

Encourage faculty to include supercomputing in their current courses.

The University must invest in this change by rewarding faculty for the time and effort required to make this change.

- Provide more internship opportunities to give undergraduate students to become involved in supercomputing research.

  The funding level for the current undergraduate internship program should be increased.

  This program should bring in students from various disciplines to promote supercomputing use in a variety of fields.

- Strengthen the scientific computing graduate program

Research

- Invest in recruiting outstanding faculty in high performance computing in various disciplines.

- Protect and provide easy access to the highest-end resources for high performance computing (both hardware and software).

- Encourage and nurture new multidisciplinary programs in scientific computing application areas.

- Promote a centralized location for high performance computing activities.

Industry Initiative/Technology Transfer

- Lower barriers to technology transfer between the University and industry.
  A partnership between academic institutions and industry represent the tenuous melding together of two different cultural environments. Each culture has its own focus and needs which must be recognized to form a productive partnership. For example, intellectual property policies often negatively impact industrial partners; thus industries often shy away from working with academic institutions. Existing University policies need review to determine a mutually acceptable process for partnerships with industry.

- Invest in faculty initiation of collaborations and industrial consortia.

- Focus on software transfer as a key mode of technology transfer. Industrial internships for graduate students could catalyze such transfer.

Participants:

- Phil Bording, IBM
- Graham Candler, Professor, Aerospace Engineering and Mechanics and Scientific Computation, University of Minnesota
- James Chelikowsky, Professor, Chemical Engineering and Materials Science, Physics, and Scientific Computation, University of Minnesota
- Paul Crumley, Senior Programmer, IBM
- Diane Gibson, Silicon Graphics, Inc.
- Mike Heroux, Silicon Graphics, Inc.
- Sally Howe, Acting Director, National Coordination Office for Computing Information and Communication
- Kirk Jordan, Senior Program Manager Scientific & Technical University Relations, IBM
- Earl Joseph, Silicon Graphics, Inc.
- Vipin Kumar, Professor, Computer Science and Engineering and Scientific Computation, University of Minnesota
- Charles Louis, Assistant Vice President for Research, University of Minnesota
- John K. Lytle, Associate Program Manager, NASA Lewis Research Center
- Christine Maziar, Vice Provost and Department of Computer and Electrical Engineering, University of Texas at Austin
- Bill McCurdy, Associate Laboratory Director, Lawrence Berkeley National Laboratory
- John Nieber, Professor, Biosystems and Agricultural Engineering and Scientific Computation, University of Minnesota
- Barry Rackner, Bridge Information Systems
- Yousef Saad, Professor, Computer Science and Engineering and Scientific Computation, University of Minnesota
- Harlan Stech, Professor, Mathematics and Statistics and Scientific Computation, University of Minnesota
- Peter Taylor, Deputy Director, San Diego Supercomputer Center, and Adjunct Professor, Chemistry and Biochemistry, University of California, San Diego
- Don Truhlar, Director, Supercomputing Institute, and Professor, Chemistry, Chemical Physics, and Scientific Computation, University of Minnesota (moderator)
- Mary Wheeler, Professor, Texas Institute for Computational Mechanics and Mathematics, University of Texas at Austin

Representative of the Minnesota State College and University System:

- Kurt Ghylin, St. Cloud State University

Recorder:

- Krista Johansen, Rhetoric, University of Minnesota

HIGH PERFORMANCE COMPUTING AND VISUALIZATION

Note: This track broke into three subdivisions on Day 2: High Performance Computing, Visualization, and Storage Technologies and Databases.

DAY 2: ISSUES AND RECOMMENDATIONS: VISUALIZATION

Goal for the Visualization Breakout Session:

Identify opportunities for the University of Minnesota to strengthen existing activities and/or to establish new initiatives which can result in national leadership for the University and its industry partners in visualization technology.

Participants:

Of the 13 participants present, 7 came from the University of Minnesota and 6 from industry. Many of those invited but unable to attend expressed a desire to participate in any follow up events of the this group. The names and affiliations of these participants are listed at the end of this section.

- From the Cray X-MP in 1985 to the Nintendo 64 in 1997
- "Victory" of the personal computer
- Exponential shift from vector processors to microprocessors
- Millions of computers driving hardware and software development

Barriers to More Effective and Productive Visualization

Participants identified the following barriers to more effective and productive visualization:

- Often must throw away most of the data generated because there is no place to store it.
- Often can only look at a small fraction of the stored data because of inefficiency of the visualization software and/or systems.
- Insufficient bandwidth between the storage and image rendering systems is often a problem.
- Inadequate image rendering speed, especially at the high resolution required for display of complex data, slows critical feedback to research or design team.
- Computer monitors are not well suited to viewing by collaborative teams for discussion purposes. Tyranny of the monitor size tends to force visualization and design to be solitary activities, which does not always produce the best results.
- Resolution of standard displays has not kept pace with the rapid growth in the complexity of the data to be visualized.

- Often it is difficult to obtain funds for generation of necessary visualization software (a problem resulting from the interdisciplinary nature of the work).
- Often it is difficult to obtain funds for storage of the data.
- While funds are available to purchase visualization hardware, they are not often available to maintain this hardware.
- Lack of network bandwidth inhibits analysis and visualization of data sets combined from several complementary and geographically separated sources.
- Lack of network bandwidth inhibits collaborative viewing of the visualization by researchers separated by distance.
- Very small supply of people with necessary skills.

Recommendations

The subcommittee divided into two groups, representing scientific visualization and photorealistic visualization applications. The photorealistic group, led by Lee Anderson, produced the recommendation given below, while the scientific group came up with a less specific set of mechanisms and actions, also listed below. In combined discussion, the groups agreed that a single, shared facility and support infrastructure could meet the goals of both groups. The groups also agreed on the list made by the scientific visualization group regarding recommended mechanisms and actions. The recommendations below reflect this final joint voice of the entire subcommittee.

Recommendations for a Shared Facility and Support Infrastructure:

Purposes for the two subgroups:
- Scientific Data Analysis and Visualization (especially of very large data sets)
- Design and Design Visualization (that is, visualization for conceiving the design, not just for communicating a finished design)

Ingredients:
- High resolution, rear-projection display encompassing 180 degree field of view
- Expertise from the University and Industry

Focus:
- Image animation and collaborative environment

Goal:
- National leadership. This requires a scale larger than a single faculty or company

Scientific Visualization Players Might Include:
- *At the University:* LCSE, Computational Biology Center, MSI, and the following Departments: Geology, Astronomy, Chemical Eng & Mat Sci, Pharmacology, Aeronautical Eng and Mechanics, Mathematics, Physics, Computer Science & Eng, Electrical & Computer Eng.

- *Developing Applications of the Infrastructure:* Medtronic, 3M, Mayo Clinic, Amoco, Boeing, Los Alamos Natl. Lab., Livermore Natl. Lab., Sandia Natl. lab., NCSA, NRL, NASA , Goddard.
- *Developing the Infrastructure:* Silicon Graphics, Cray Research, IBM, Imation, GeneSys, Seagate, Ciprico, MTI, Ancor, McData, Brocade Communications, NetStar, US West, Honeywell.

Photorealistic Visualization Players Might Include:

- *At the University:* Human Factors Lab, Minneapolis College of Art & Design, LCSE, and these Departments: Architecture, Mechanical Eng., Computer Science & Eng, Electrical & Computer Eng., Geology, Art.
- *Developing Applications of the Infrastructure:* Lamb & Co., Caterpillar, Minnesota Dept. of Transportation, Ceridian, JPL.
- *Developing the Infrastructure:* Silicon Graphics, Cray Research, IBM, Imation, Kodak, GeneSys, Seagate, Ciprico, MTI, Ancor, McData, Brocade Communications, NetStar, US West, Honeywell.

Ingredients and Mechanisms for Shared Activities:

- From the University: vBNS network access.
- From industry: "Smarr quality" promotional videos, suitable for broadcast on network TV
- Putting together complementary human resources (dealing with needs of interdisciplinary activity and also with the small number of qualified people).
- Central location, with offices for visitors.
- Workshops
- Demonstrations and proof-of-concept prototypes displayed at central location and at exhibitions.

Need for State Funds: At the University we now have:

- Federal funds.
- Industry in-kind contributions.

What if we were to introduce state funding as well? What are the components of a successful program that are most difficult to obtain from our present two sources?

- Network infrastructure.
- Cross disciplinary support.
- State funds would allow scaling up of individual efforts to broaden their usefulness and enhance their impact.
- Vast shared data storage.
- Powerful shared visualization systems.
- Uniquely capable displays.
- Support staff positions (EXPERTS).

Participants:

From the University:

- Paul Woodward, LCSE & Astronomy (working group chair)
- Lee Anderson, Architecture
- Tony Varghese, Pharmacology
- David Yuen, Geology
- Kristen Hansen, Academic Health Center
- Elisabeth Shoop, Academic Health Center
- David Porter, LCSE
- Linda Bruemmer, I.T. Dean's Office

From Industry & Public Agencies:

- Marc Ondrechen, Silicon Graphics
- Cal Kirchhof, Cray Research
- Shannon Madsen, GeneSys
- Scott Gaff, Lamb & Co.
- Gerry Rohrback, MN Dept. of Transportation
- Gary Hatteberg, Minnesota Satellite

HIGH PERFORMANCE COMPUTING AND VISUALIZATION

Note: This track broke into three subdivisions on Day 2: High Performance Computing, Visualization, and Storage Technologies and Databases.

DAY 2: ISSUES AND RECOMMENDATIONS: STORAGE TECHNOLOGIES AND DATABASES

Goal of the Storage Subcommittee

Identify opportunities for the University of Minnesota to strengthen existing activities and/or to establish new initiatives which can result in national leadership for the University and its industry partners in storage technologies. Emphasis was placed on larger, higher performance storage systems rather than smaller, PC based storage issues since this group was part of the High Performance Computing and Visualization track.

Working Definition of Storage Technologies

Storage was defined to mean the permanent or non-volatile storage of digital information. The technologies involved include but are not limited to:

- Storage media (magnetic, optical, hybrids)
- Read/write components (i.e., heads) and associated electronics
- Data encoding algorithms (RLL, PRML)
- Device interfaces (Parallel SCSI, Fibre Channel, IDE, ST506)
- Interface protocols (SCSI, TCP/IP, IPI)
- Host adapters
- System software (device drivers, file systems)
- Hierarchical Storage Management (HSM) software
- Databases including Online Transaction Processing (OLTP), Decision Support Systems (DSS), Data Mining, Data Warehousing.

General Format of the Session

The session started with introductions and moved into an overview of the agenda of the remainder of the session. The basic strategy was to develop a general list of significant *Storage Related Issues* and a list of *Major Storage Industry Trends.* This was then followed by a more detailed description of each item on the *Storage Related Issues* list. These items are all listed below.

At this point Dave Anderson described an advanced research project between CMU and a consortium of storage companies including Seagate, Hewlett Packard, IBM, STK, and Quantum. Referred to as the *Network Attached Storage Device (NASD)* model, this was presented as a model of a "storage architecture for the future."

The group found it useful to use this model as the basis for advanced storage related research that could be performed at the University of Minnesota. The research areas could be derived by applying specific *Storage Related Issues* of interest to the model. For example, one significant storage related issue is that of Storage Management or how to manage the space on disk and/or tape. The solutions to storage management problems change depending upon the underlying storage system architecture. Therefore, given a model of an advanced architecture, a set of possible solutions to the issues within storage management can be explored by researchers at the Digital Technology Center (DTC).

It is important to note that *scalability* and *extensibility* were major themes in these discussions. *Scalability* refers to the ability to grow a storage system in many dimensions independently (such as capacity, bandwidth, connectivity, etc.). *Extensibility* is the ability to scale a storage system while it is running. This is important because it is not until these storage systems and the associated computer systems get very large that the Storage Related Issues start to become serious problems. This emphasizes the need to build a large-scale test facility for data-intensive computing research from which any of the large-data users will benefit.

The remainder of this document highlights the Storage Related Issues believed to be significant in this industry as well as the Major Challenges in Storage Technologies in dealing with these issues. Finally, a list of overall recommendations is given that this subcommittee believed were important in meeting the goals of the DTC at the University of Minnesota.

Storage Related Issues

Storage systems are built using endless combinations of the hardware and software mentioned above. These are many of the significant Storage Related Issues involved in the design of such systems. These issues include but are not limited to:

- Performance
- Bandwidth (Megabytes per Second)
- IOPs (I/O operations per second)
- Capacity
- Connectivity - how are storage subsystems connected together at all levels
- Security - to prevent unauthorized data access
- Cost effectiveness
- Backup, Archive, and Longevity - how to backup or archive large amounts of data and how long will a given piece of media be accessible?
- Interoperability - How easily can data be moved/shared between dissimilar systems
- Storage Management - how to manage the use of disk space, tape libraries, etc.
- Coherency and Data Sharing - how to maintain a single copy of a particular piece of data and efficiently share it amongst many computers.

Again, it is important to realize that each of these issues becomes significant when the storage system scales up.

Major Challenges in Storage Technologies

Given the set of Storage Related Issues, this list highlights the major challenges or areas that can be targeted for research at the Digital Technology Center.

- Assume basic Network Attached Storage Device model
- Storage Management
- Parallel/Clustered Systems
- Backup and Archive
- Data Warehousing
- Emphasis on Performance

Subcommittee Overall Recommendations

- The University of Minnesota needs to have a good Intellectual Property policy in place before any partnerships are formed.
- The University of Minnesota needs to build bridges to industry by encouraging many small, short-term "seed" projects between companies and professors/students which also better prepares students for industry.
- The DTC needs to have a high degree of student involvement.
- Work with other nationally recognized organizations for maximum leverage and effectiveness.
- Any company can be part of this. The University of Minnesota should not limit itself to local companies but should think more nationally and globally.
- Get the Carlson School of Management involved to do market research on trends in areas related to data storage.
- Need real-world end-users in specific market segments (i.e., large databases, scientific computing, imaging, etc.).
- Research at the DTC should be "seamlessly" interdisciplinary.
- Research staff on a particular project should have a great deal of breadth.
- Research staff needs to be dynamic over time.

Participants

Tom Ruwart, University of Minnesota/LCSE
Jim Richardson, 3M Company
Dave Anderson, Seagate Technology
Carla Kennedy, Ancor Communications
Steve Hansen, Ciprico
Pat Donline, LSC
Durkee Richards, Imation
Dave Miller, Sun Microsystems
Pete Potosky, IBM
Sandy Frey, Tricord
Paul Dickson, Unisys
William Rohde, Unisys
Jay Moon, University of Minnesota/EE

EDUCATION
DAY 1: "MEETING TOMORROW'S LEARNING NEEDS" by Carol Twigg, Educom

The key points presented by Carol Twigg were as follows:

- Change, competition, and partnerships face higher education, and it must take the opportunity presented in order to remain viable.
- Workplace trends have an impact on higher education in terms of its students: their demographics, expectations, when and where they go to school.
- The old industrial model of education won't work with the new demands. Students define quality in consumer terms, and non-school-based institutions of education are competing with traditional institutions.
- A new information-age model must be created. This model will retain what works in traditional institutions of higher education, partnering them with business and industry models that have their own strengths.
- These partnerships could lead to a reduction of the monopoly on education and to more accountability in education.
- They also lead to new types of institutions, such as the Western Governors University.
- The University of Minnesota has strengths to build upon and use as a resource as we move through this liminal technological age.
- One of the basic goals of education - to facilitate transcendence - has not changed; technology has only changed how this happens
- The University can bring a clear vision and focus to the decisions about education in a technological age, including a commitment to community.
- Its great strength is its concentration of resources and intellectual power. Universities must take the advantages that they have accumulated and transfer them into this new world.

Universities are not obsolete; rather, there is a burgeoning of new capabilities for an expansion of educational institutions.

EDUCATION
DAY 2: ISSUES AND RECOMMENDATIONS

The planning committee for the Education Group recognized the potential for a broad, far-ranging discussion around education technology and around what must happen in Minnesota to take advantage of technology (current and future) in education, especially in terms of the University of Minnesota's role. To structure such a discussion, the Education Group attempted to focus its discussion around two issues: 1) global competitiveness and 2) change and human resources. Participants were asked to discuss three questions concerning these two issues, structuring their discussion around the Strengths, Weaknesses, Opportunities, Threats (SWOT) model.

What emerged from the rich discussion was a significant list of the University's strengths, weaknesses, opportunities and threats (summarized below in more detail) and a clear feeling that change must happen if the University is to successfully use digital technology to shape Minnesota's information society.

RECOMMENDATIONS RESULTING FROM SWOT ANALYSIS:

Ultimately, the Education Group made the following recommendations: that the University of Minnesota create a subsidiary within the University to lead the educational technology initiative. This subsidiary would clarify the vision and mission of the University with respect to educational technology, in order to guide the University's decisions about its technological focus. Difficult choices must be made.

The University must decide if it will use educational technology to become a world-class global educational institution or to reinforce its connections to the citizens of Minnesota via other educational institutions (e.g., K-12 schools, MnSCU, public libraries), through partnerships with the state business community, and through its role as the flagship institution within the state. Both of these goals can be pursued simultaneously. However, the Education Group articulated its commitment to identifying what is best at the University and to distributing these unique features around the state and around the world.

Strengths tended to center around Minnesota's people and the state's reputation built on its technological achievements. Minnesota's workforce is a strength. People's attitudes are a strength, including their commitment to education, and their embracing of technology. We're a high-tech state, and the business community has a strong international focus, as well as a commitment to education and to partnering with the University. We have alumni all around the globe and international name recognition for certain programs and industries. The University is a flagship institution.

Weaknesses tended to center around structures (or lack of them) and attitudes: "Silo" thinking; no structures are in place to reward entrepreneurs or interdisciplinary work; no mechanisms are in place for companies to approach the University about partnerships;

insufficient infrastructure for decision-making, for technology transfer, and for faculty training; insufficient differentiation of programs across the University; lack of coordination with and recognition of coordinate campuses; unclear University mission makes it difficult to leverage the University's strengths; the public nature of this land-grant institution ties it to the geography; faculty see themselves as researchers and scholars rather than marketers.

Opportunities tended to center around the current exponential growth of technology: it provides an opportunity for the University to redefine faculty roles, to create a process to amplify its strengths, to take a leadership role in partnering with business and collaborating with other educational institutions, to use undergraduates as a resource, to be proactive in selling the University, to build on the network that is in place because of the Minnesota Extension Service and the branch campuses, to use the new state graduation standards as a way to connect with K-12 institutions.

Threats centered around the tangible and attitudinal: other institutions do not have the weaknesses that Minnesota has and have capitalized on some of the opportunities that the state has not; the magnitude of the University and internal scandals can threaten its ability to move forward; traditional behaviors and structures, as well as a lack of understanding of the value of educational technology, can threaten Minnesota's ability to take these opportunities.

Working Group Participants

University of Minnesota
Charles Hopkins, College of Education & Human Development
Billie J. Wahlstrom, Rhetoric Department
Ann H. Duin, Rhetoric Department
Linda A. Jorn, Digital Media Center
Daniel W. Granger, Distance Education
Donald G. Sargeant, Chancellor, University of Minnesota-Crookston
Dan Detzner, College of Ecology
Linda Deneen, Computer Science Dept., University of Minnesota-Duluth
John Butler, Walter Library
Harvey Keynes, Talented Youth Math Program
Harold Miller, University College
Craig Swan, Vice Provost

External Representatives
Paul Wasko, MN Office of Technology
Clark Kirkpatrick, TIES
Dale LaFrenz, QTech Systems, Inc.
Tom Keiffer, Connect Computer Co.
Joe Graba, Acting Dean, Graduate School, Hamline University
Carol Twigg, Educom
Mike Burke, Technology Director, Edina Public Schools
Steve Robinson, William C. Norris Institute
Dale Jensen, MASA
George Welles, Imaging Futures

TELECOMMUNICATIONS
DAY 1: "TELECOMMUNICATIONS AND ADVANCED NETWORKING" by Stephen Wolff, Cisco Systems

Introduction: William C. Hamer

In the coming years, we will see a fundamental shift and a discontinuity in the way we do business. This shift will be analogous to the shift that occurred as a result of the auto industry about 100 years ago. No one would have imagined 100 years ago that today our whole economy would depend on automobiles; it will be the same with telecommunications.

Some statistics about what we can expect:

- Expect a growth in Internet use and expenditures (both expenditures and equipment) of 50% in next year.
- Expect $250 billion worth of commerce on the Internet by 2001(mostly WWW)--only $1 billion this year.
- Expect 30-40 million homes in US to have Internet access by 2000.

Presentation: Stephen Wolff

Two topics to cover:

- Convergence of voice, data, and video
- Demise of intelligent network

Convergence

Convergence does NOT mean convergence of hardware or unified providers.

Convergence DOES mean

Convergence of technology--breaks vertical integration of stovepipe technologies
Possible convergence of regulatory agencies

Universal Bearer Services (UBS) is the key to technological convergence.

UBS gives us the ability to run an application on any bitpipe.
Current examples of UBS: Internet protocol and 3 kHz phone lines
A UBS would be standard, universal, simple, open, ubiquitous.
It must eventually become part of the woodwork so the user only has to think about the application, not the network.

Right now Internet Protocol is the most likely candidate but it has a few problems:

Flat pricing scheme: users need to be able to choose enhanced services because otherwise there's no incentive to provide higher quality service.
Privacy and security
Protection of intellectual property

Intelligent Vs. "Dumb" Networks

Intelligent networks centralize control away from the user--these are great for central control but bad for innovation because they are non-robust (vulnerable to their own assumptions and design).

In contrast, the Internet is a dumb network where the user and machinery is smart. And the Internet is getting smarter, which is good because it allows for greater innovation.

Improvements needed: differentiated services, providers need to agree on what it means to provide better service.

Private networks in the old sense lead to fragmentation; what we need more of is Virtual Private Networks because these provide better support of communities of interest. We've already seen these communities explode.

What should the University do?

Czar of telecommunications--schools who have centralized control over their telecommunications networks have been most successful.

More research and development, in partnership with industry. Some already exist at the University: US West Compass Testbed, MAGIC Testbed, NSF funded Infrastructure Grant, Internet 2 (University is in partnership with Cisco Systems on this).

TELECOMMUNICATIONS
DAY 2: ISSUES AND RECOMMENDATIONS

PROPOSAL:
Establish Minnesota as a center of excellence for Ultra-High Performance Networking by:

- Establishing a multilevel testbed which includes a supercomputer center that is accessible by academic institutions throughout Minnesota, thereby involving the entire state. An expanded test bed will be established to enable future needs of teaching, research, and industrial development. Minnesota (linking metro and outstate) will be a test bed for advanced internet applications, included those employed in education, health care, and financial and public services.
- Developing curriculum and expert instructors who can support the growing demand for experts and technicians.
- Supporting research efforts in this area.
- Providing a benchmark/certification center.

Rationale:

- Telecommunications and networking technologies form the backbone of the information society.
- Minnesota is the ideal place to establish such a center:
    - critical mass of expertise and infrastructure already exist at the University of Minnesota and in Minnesota industry
    - existing testbed infrastructure leverage from Cooperative Service organization
    - Preeminent Super Computing Infrastructure/LCSE
    - Strong industrial base and need
    - Distributed University campuses
    - Potential bridge to K-12
    - Small enough state to make it doable
    - Large enough state to make a difference
- Existing expertise encompasses these critical enabling technologies:
    - High speed digital signal processing
        - Algorithms and architectures for communications
    - Optical/photonics technologies, microelectronics infrastructure
    - Multimedia
    - Wireless technologies/systems
    - Networking

DETAILED DESCRIPTION OF GROUP PROCESS:

Introduction

The session convened with representatives from the U of M, MnSCU, the NSF, and local and regional industry. Hamer stressed the discontinuity we face (in our economic and cultural orientations) with the rise of advanced telecommunications. He broadly defined telecommunications as both telephony and electronic & digital technologies (combining data, voice, and video).

Hamer defined the objectives in three areas:

- teaching (at the graduate and undergraduate level, of benefit both to the students and to industry)
- research (of value on the regional level)
- interaction (the development of partnerships between business and the U of M, like those which link industry in Silicon Valley with Stanford and Berkeley)

University of Minnesota Programs to Date

- Du emphasized the collaborative degree with Hennepin County Technical College, which has expanded U of M courses in Networking to four. Applications to the program are high -- the program typically accepts 25 of the 100+ applicants. However, 2/3 of the students leave study before completing the degree to accept positions in industry. This incompletion rate has led to the proposed development of a certificate program, as an alternative to the B.A.
- Further limitations on the program are access to the research lab. A "virtual lab" is in the works. Similarly, CompSci courses are stretched to the limit (200+ students).
- Du emphasized U of M success in "breaking down the silos" of academic departments at the U of M, and in securing short-term industry funding.
- Kaveh stressed the changes in the field of telecommunications, and the growing interdisciplinarity between electrical engineering and computer science. There is a renewed interest, in industry, in the hardware -- the "deep technology" of the operation. However, there is a shortage of undergraduates in this area, because the computer age has shifted their interests from the nuts & bolts of electrical engineering. Further, due to the "hot" job market, few undergraduates pursue graduate degrees at this time.
- Kaveh noted that the U of M will be offering courses in analog and digital/analog circuit design.
- Kaveh finds a faculty strength in this area -- noting expertise of seven faculty of 43, with two openings in the area this year.
- Kaveh stressed the positioning of the U of M as a national and international institution.

Comments from the NSF Rep

- Further research should stress interdisciplinarity, and an interest in the deep, physical components of the technology; however, funding is tight (3 of 130 projects were funded last year). He discussed the restructuring of the NSF.

Setting the Agenda

- Hamer again stressed the discontinuity. He questioned whether telecommunications is resting on the laurels of the research-intensive decades prior, and whether the shift from R&D to product design is a failing in the industry.

Hamer outlined key terms for discussion. Each was discussed, until consensus was reached on each, and topics not suggested by Hamer were appended to the list.

Topics for Discussion, Telecommunications

- ATM
- IP Switching and Routing
- Optical Systems (Suggesting a shift from the physics of the devices to the integration of optical components into systems.)
- Wireless/Wideband Wireless
- xDSL
- Internet/ Internet II (Has this been researched fully? Have we addressed this topic, if we've addressed the supporting technologies?)
- Video
- Security and Privacy
- Network Mgmt.
- Traffic Engineering
- Low-Orbit Satellites
- Signal Processing
- Network Architecture
- Financial and Regulatory Models
- Distributed Databases

Discussion of Topics

- Is there some form of research to which the University is better suited than industry, and vice-versa?
- Is the University a neutral ground, where various aspects of the telecommunications industry can meet? This neutral ground may be more integral in the telecommunications age than in the industrial age. Is the University of New Hampshire a possible model?

  Gopinath identified three areas of research at the U of M:

  Switching
  Amplifiers
  Analog Linearity
- As we develop applications (email, gopher, WWW, Mosaic), bandwidth needs increase. Can research increase efficiency in this area?
- The Professional MS in Telecommunications did not fly because the industry could not guarantee adequate demand for students with this expertise.
- The University is a place to ferret out long term issues, and bring these issues to the attention of local industry.
- Where do hierarchies of service fit here?
- Is the purpose to serve industry today, to or anticipate its needs in 7-8 years?

- We cannot claim that Minnesota will be the center of the internet. Nor can we claim expertise in three disparate technologies. It must be justified, economically viable, and competitive. We cannot build from scratch; we must strengthen what we have.
- Can we integrate our proposals with other groups, thereby eliminating potentially competitive projects? Is telecommunications the topographical center, upon which other areas are mapped?

High-Speed Networking

- After declaring High-Speed Networking an area of interest, the committee elaborated on its purposes:
  - high-speed storage access
  - optical networking and Wavelength Division Multiplexing (WDM)
  - interoperability certification
  - integration with software
  - wireless broadband media
  - information management

- The committee asked what would distinguish this center from similar centers. How does it integrate with the Medical School? Can investment in the Center not be funneled into general university overhead (like the funding of teaching)? Can it lure investment capital from the financial districts of Minneapolis?

Compelling Arguments:

The committee generated a list of reasons why their argument for a high-speed networking center is compelling.

I. Existing Assets

- Testbed infrastructures for high-speed networks are already in place. These cross academic and operational segments of the University, and we have a strong industrial base in high-speed networking.
- The University is already strong in distance and asynchronous education (including Unite).
- The supercomputing/LCSE connection is already in place.
- Overseas connectivity is in place.

II. Existing Expertise

Critical enabling technologies:

- High-speed digital signal processing, algorithms/architectures for communications.
- Optical/photonics technologies, microelectronics infrastructure, microwaves
- Multimedia
- Wireless technologies/systems
- Networking

III. Does this serve industry needs?

The committee identified three industry needs:
- Network builders
- Research (esp. WDM)
- Software writers (protocol developers)

The committee summarized for the general meeting and departed.

Group Participants/Outside the University:

Pat Borchaert, Director, Engineering, Ascend Communications
Aubrey Bush, Deputy Director of Communication and Network Division, NSP
Asok Chatterjee, VP of Technology, ADC Wireless Systems Group
Gary Delp, IBM, Rochester
Gadi Eisenstein, Professor, Technion, Israel
William Hamer, VP and Chief Technical Officer, ADC
Fred Hendricks, Director, Architecture and Planning Support, US West Communications
Sonny Rao, Director of Network Management Planning, ADC
Lance Smith, CEO, Switched Network Technology
Stephen Wolff, Executive Director, Advanced Internet Initiative Division, CISCO

Group Participants/University of Minnesota:

David Du, Computer Science and Engineering
Anand Gopinath, Electrical and Computer Engineering
Mos Kaveh, Electrical and Computer Engineering
David Naumann, Information and Decision Sciences
Carolyn Parnell, Director, Networking and Telecommunication Services
Ahmed Tewfik, Electrical and Computer Engineering
Zhi-li Zhang, Computer Science and Engineering

DIGITAL PUBLISHING

Day 1: "The Future of Digital Publishing" by Kevin Kelley, WIRED Magazine

What is the current state of digital publishing?

What is happening now is not a digital revolution but an economy revolution. Our central organizing metaphor is a network economy, not information or knowledge. We are here for the communications revolution; we link computers and make a network of minds. Communication is the foundation of culture, society, and education. Computers can amplify that and make it more powerful, which is more crucial than speeding up tasks at work.

Having said that, here are some points:

1) with chips this big •, everything can connect to everything,
2) which is "dumb power," where many dumb chips link together (i.e., they have one function like neurons, the item is on or off, full or empty, etc.), and
3) this is very powerful as a connected intelligence—it takes something stupid and makes it very powerful.

This brings up many intellectual issues. The net is more than just people typing at each other; it is a membrane of a billion different artifacts communicating. We are seeing only a very small portion of it now. and we have to understand it because it is our culture.

We are in a network economy, under which connecting is a base. We are under the law of increasing returns, where we have the fax effect. The value of things increases with plenitude. Networking increases the value of individual components—a fax cannot work alone; you buy access to a network, not material such as a fax machine. With this logic, when not referring to scarce resources, to make something valuable, you should make it ubiquitous and give it away for free. (Of course, not everything is free, or it starts out free then costs, or it approaches free.) Wealth follows the free(e.g., free software as the seeds of wealth).

Now we see:	In the near future we will see:
Subscriptions	Subscriptions
Advertising	**Advertising**
Transactions	**Transactions**

The biggest impacts are not on-line but what spills off line.

What's next?

Flash crowds.
In flash crowds, there is no mass or fixed audience but ebb and flow. In the flow, our own system or infrastructure may not be sufficient and we may need to an adopt something like: "I'll let you use my servers if you let me use yours."

Convergence and divergence.
Convergence to the home and divergence once it gets there. In this picture there is a need for both choice and direct, pull and push. There has to be a way to reach everyone.

Your next computer will be a phone.
Our hands will be free. Once we can think on our feet, we can have different things to think about.

Wireless internet will dwarf wired internet.

Communities precede commerce.
We need communities before commerce works. Companies cannot control community; they must allow them to develop.

Privacy rights.
There are some possible answers.
Privacy audits. Here there is a symmetry of knowledge. You give information for something in return. A trustee informs you about what you gave and what you received in return. People may then expect this symmetry elsewhere (e.g., medical records).
Digital watermark.

Digital instability.
Don't trash libraries. Unless you saved it yourself from the net, it probably doesn't exist on the net.

The net is an ecology of objects and agents—fluid and biological.
Every success creates opportunity for 2 more successes. Niches are created by successes, upon which other success builds.

Economy of abundance.
Things are getting cheaper.
Distributed marketing. If you sell for them, you get a cut.
Stock transitions. Customer owns the transaction.
Recommendation engine. You train an agent to know your tastes

So, what is valuable if all of this is free?

Human attention.
We have only a fixed amount of attention. The interface is what it is about (the airline as interface to airline seat). We should hand things out for free—then attention and ubiquity. We should think in terms of relationships, not products.

We should think of companies as gaining and sustaining relationships with people. We should think of co-created services.

People are the killer app. We should make technology responsive to us.

The great hope is that we can make technology that enhances the best of humans.

Digital Publishing
Day 2: Issues and Solutions

- **Vision/Mission**

  The members of the digital publishing session agreed that they wanted to create a world class environment in Minnesota for digital publishing excellence through education, research, and collaboration of industry and educators.

- **Problem areas**

  Some reasons for this mission include:

  Industry needs
    - more qualified employees
    - university assistance in training

  Faculty needs
    - training by industry
    - publishing opportunities for content

  Students need
    - to be made aware of digital publishing

  State needs
    - to be made aware of its need to become the "information" state

  They all need
    - solutions to digital publishing issues then research
    - need to redirect resources and add new ones, especially with industry support
    - to solve the problem of how academe connects with industry

- **Establish an advisory board widely representative of the digital publishing industry**

  To address these needs, the participants envisioned an advisory board that widely represents the digital publishing industry.

- **Mechanisms to move the University into the digital publishing arena: "Center" for Interdisciplinary Study of Digital Information and Communication**

  The participants believe that one vehicle for making the University more central to Minnesota's publishing industry, for meeting the research and employment needs of that industry, and to enable Minnesota to become the "information state," would be a center for the Interdisciplinary Study of Digital Information and Communication.

- **Research areas addressed by the Center**

  The Center or other mechanism for addressing the previously-stated needs would be to address research in areas such as:
    - document/content encoding
    - digital document management

- computer-human interaction
- media use—sociological, psychological, trends
- wireless communications
- AI/natural language processing

- **People resource development**
  The Center or other mechanism for addressing the previously-stated needs would be to address people resource development in areas such as:
  - internships/coops
  - greater use of adjunct faculty
  - joint development
  - research grants
  - include K-12 students and teachers
  - scholarships/fellowships
  - faculty internships
  - how to attract new students and faculty and retain them in Minnesota

- **Process for collaboration**
  The Center or other mechanism for addressing the previously-stated needs would establish processes for collaboration, especially regarding areas such as:
  - resolution of legal issues, licensing, formation of companies, intellectual property
  - product development teams, funding

- **Raise the entrepreneurship profile in digital technology and make the University an international center for digital research and applications**
  By meeting the previously-stated goals, the advisory board along with those participating in this effort can raise the entrepreneurship profile in digital technology and make the University an international center for digital research and applications, attracting world-class researchers and students and helping Minnesota businesses remain competitive.

Panel Participants

From business and affiliated organizations:

Eileen McCormack, MN Office of Technology
Elizabeth Doyle, MSP Interactive
Thomas Stanley, SGI Inc.
Robert Schafer, Star Tribune Online
John Feikema, Imation
Ken Overstreet, Northstar Computer Forms
Dan Peipho, Precision Powerhouse
Chris Wolff, West Group
Bob Crabb, Univ. of MN Bookstores
Lynette Olson, MnSCU
John Colby, IBM
Elizabeth Zilen, IVI Publishing
Tom Kringstad, Honeywell

From the University of Minnesota:

Robert Seidel
Bruce Bruemmer
Gary Jahn
Miranda Remneck
Bill Sozansky, Duluth
Rick Peifer
Robert Miner
Kathy Hansen
Dick McGehee
Tom Shaughnessy

ADVANCED DESIGN AND MANUFACTURING
DAY 1: THE INFLUENCE OF DIGITAL TECHNOLOGIES ON PRODUCT DESIGN AND MANUFACTURE
by Eric Donaldson, Imation Corp.

There are three main areas on which digital technology had an impact in Design and Manufacturing:

- CAD Design (digital representation of what you are going to build)
- CAE Engineering (brains behind engineering for testing: "what-if" scenarios
- CAM Manufacturing (automation, rapid prototyping)

TRENDS AND THEMES:

- significant increase in speed, performance and complexity
- internationalization allows for working and testing around the clock
- it is possible now to create more information more rapidly for more people
- increasing importance of human resources over technology
- more cross-teaming
- global development teams
- job growth due to digital technology in manufacturing
- technology as time saver or time demander (long wait times, learning times)

FUTURE DIRECTIONS FOR PRODUCT DEVELOPMENT AND MANUFACTURING:

- continued pressure for cost and time to market reduction
- "Green Revolution" will finally kick in
- ever-increasing value of digital technology
- global product development teams will stretch the concept of concurrent engineering (relate to work rather than workers)
- software will continue to "pace" hardware and systems requirements

RECOMMENDATIONS FOR UNIVERSITY-INDUSTRY COOPERATION:

- education as a two-way street
- importance of co-op experience
- more mentoring
- industry sabbaticals for faculty
- more cross-functional training for engineers; cross-teaming
- include management training in engineering training
- include international exposure for engineering students to learn cultural significance of their work

ADVANCED DESIGN AND MANUFACTURING
DAY 2: ISSUES AND RECOMMENDATIONS

Summary of Group Process:

Professor Cohen began the session by reminding participants of their charge, to discuss ways within the context of advanced design and manufacturing to inform the citizens of Minnesota of the significance of digital technology, to attract national attention to the University of Minnesota, to accelerate Minnesota's entry into the digital age, and to define the future role of the University of Minnesota in these enterprises.

Cohen then reviewed Dale LaFrenz's summary of Day 1 sessions, proceeded to provide an overview of the structure of the small group discussion (presentations followed by a general discussion, out of which concrete challenges and solutions would be cited for the afternoon presentation) and a paradigm or heuristic for proceeding with this work (analysis of three categories: Education, Technology Transfer, and Research using Problem-Solution categories).

The following participants gave 15 minute presentations, which set the stage for the subsequent discussion:

Eric Donaldson: "Future Directions for Product Development and Manufacturing"
Arnie Weinerskirch: "Exploring the Practical Frontiers of Virtuality"
Saif Benjaafar: "Next Generation Manufacturing Systems: A Research Agenda"
Caroline C. Hayes: "Intelligent Decision Support Systems"
L. Alden Kendall: "Outreach Services and Experience-Based Education Using Digital Technology'
John Niethammer: "Digital Technology Transfer"
Kim Stelson: "Integrating Humans Into the Automated Design and Manufacturing Environment: The Need for Explanations"

EDUCATION

Problems:

Students lack knowledge of/sufficient experience with the following:

- applications
- real tools used in workplace
- product development--especially as this drives the marketplace

Lack of this experience/knowledge prevents the students from being as "work-ready" as the industry would like them.

Solutions:

Experience-based learning initiatives need to continue, be expanded (need to better prepare students to do productive work from first day on the job).

Expand the co-op program, especially with small companies in mind.

Provide a year long case study that students can approach from many courses and through an extended period--emulates real work world situation better.

Have students establish a "problem portfolio" to use on job and grad school interviews/applications.

Create "virtual labs," that is, JAVA based software hooked to real machines that allow students to use sophisticated equipment housed in industry labs or academic labs even from great distances.

Establish more collaborations, for example between students in the Carlson School and Dept. of Mechanical Engineering, so that students get experience of working in "multi-disciplinary" teams and are exposed to all areas of product development.

TECHNOLOGY TRANSFER

Problems:
Providing service to small companies, resource-constrained companies, and companies geographically removed from major metro areas. This is a problem not only of providing service but one of infrastructure--to be connected, hardware, software and communications capabilities at both sites need to be in place.

How to disseminate new information about technological "product"?

Solutions:
Collaborations must be established among U of MN, large and small corporations/companies, community colleges (and perhaps even secondary institutions).

These collaborations must be easily established, which would facilitate the following:
- Small companies could form consortiums.
- Partnering of industry, government, and the University through MTI and MN Office of Technology
- Center for Technology--a University based resource center--could be established to gather resources, provide a place to meet, systematize, etc.
- Umbrella agreements established at the U (so that small, short term projects can go ahead without the red tape).
- Deal with concerns over intellectual property.
- "Technology extension agents"--as a way to do outreach
- Use university or center to showcase-test new products developed by industry.

RESEARCH
Problems (these are stated as challenges that need attention):

Collaborative Design/Manufacturing /Distribution
- global manufacturing
- supply chains
- manufacturing logistics

Management of Digital Technology
- tech forecasting
- tech mapping
- investments
- partnerships

Human-Centered Systems
- HCI
- organization of work

Reconfigurable Manufacturing Systems
- open architecture
- distributed control

Data Collection/Dissemination
- data entry
- smart sensors
- broadened networks

Also . . .
- new product development
- machine transfer (plug and play)
- distributed decision making

Solutions:

Partnering--exchange of research between industry and the academy (make sure this exchange goes both ways; the traditional way of thinking of this has been as a one way path, academy to industry, but industry voices that the academy often overlooks its most pressing needs). Joint review panels, comprised of representatives from both industry and the University, must be established.

Develop the following: design/manufacturing process models; real time systems; rapid process prototyping software; knowledge-based software systems

The university has to hire faculty in specific research areas.

Assuming the establishment of something like the center for digital technology, make sure that the decision-making structure is one that facilitates new ideas, quick decision making, change.

TECHNOLOGY ENHANCED HEALTH CARE - FUTURE CAPABILITIES AND NEEDS

by Joy Solomon, IVI Publishing, Inc., Dr. Bijoy Khandheria, Mayo Clinic, and Kamil Ugurbil, Radiology Dept., University of Minnesota

No report was available.

TECHNOLOGY ENHANCED HEALTH CARE

DAY 2: ISSUES AND RECOMMENDATIONS

ABSTRACT (prepared by George Wilcox, working group leader)

The Biomedical and Healthcare group resolved that the most apparent weakness of the university's diverse biomedical enterprise (separation between bioengineering, medical devices, biotechnology, biomaterials, bioartificial tissues, drug delivery, genomics, etc.) also presented the single most evident opportunity for application and exploitation of information technology: Integrate more areas of applied research into an invigorated, enriched bioengineering program. The first step in this process should be to reform the mission/vision statement for bioengineering by extending that already established for the Biomedical Engineering Institute (BMEI) with device and informatic components.

This extended and enhanced multidisciplinary program should be more inclusive than the current BMEI including, for example, medical device development, bioinformatics and genomics, and biomedical imaging. In addition, we should explore the possibility of including disciplines not traditionally associated with engineering, such as needs assessment and outcomes analysis for therapeutic devices, procedures and medicines. In essence, we propose to evolve a new interdiscipline, more reliant on digital technology as well as more useful and appropriate to the strengths of our customer/partner base here in Minnesota. We expect that this extended interdiscipline will enhance feedback among clinicians, health services researchers, managed care companies and medical device bioengineers.

In addition to enhancing research opportunities, this program will enhance the opportunities afforded to biomedical engineering graduate students with interdisciplinary training and internship opportunities in industrial and health care settings. It should, in addition, expose graduate students in other disciplines to these new enhanced learning opportunities. We also expect that the enhanced educational programs derived from this new interdiscipline will emphasize development of information skill curricula and

incorporation of multimedia technology in education delivery to health professional students.

This change cannot be implemented without substantial investments in information technology infrastructure. The university must invest in computer and network infrastructure to facilitate bridging collegiate, departmental and physical gaps between disparate components of this new interdiscipline. This infrastructure investment will simultaneously address the needs of interdisciplinary integration, as well as the research, education and outreach missions of the component parts of the new interdiscipline. In addition, this investment may facilitate integration of diverse information-intense fields, such as health services research, healthcare management and epidemiology, through enhanced access to health care provider organizations and state health databases.

Working Group Participants

- Win Wallin - Retired Chairman of the Board, Medtronic, Inc.
- George Wilcox - Convener, Chair of Information Technology in Education, UM Medical School
- David Pryor - VP, Information Systems, Allina Health Care
- Ted Wise -VP, HealthPartners
- Kirsten Libby - Representative for the Commissioner, MN Department of Health
- Nannette Schroeder - MN Office of Technology
- Jim House, MD - Director, UM Telemedicine Center
- Matt Tirrell - Director, UM Biomedical Engineering Institute
- Paul Citron - VP, Science/Technology, Medtronic
- Leo Furcht - Allen-Parde Professor/ Head of Dept. of Lab Medicine and Pathology
- Duane Bensen - Executive Director, Minnesota Business Partnership
- Ernest Retzel - Director, Academic Computing, Academic Health Center
- Greg Vercellotti, MD - Sr. VP, Academic Health Center
- Dave Carroll - CEO, VIA Inc.
- Dennis Omelia - MnSCU
- Dick Holley - MHTC Board member
- Judy Garrard - UM Health Services Research

Addendum (submitted by Judy Garrard)

AHC Digital Technology Professional Exchange Center (PEC)

One of the specific things the University could do to increase collaboration between the University and the healthcare industry is to provide a Professional Exchange Center (PEC) for digital technology in health related activities.

A *PEC* could have at least four goals:

1. Student Internships. Work with private industry to identify the need for training activities and set up student internships for varying lengths of time, e.g., summer

practicums, quarter- and year long-internships. Work with academic departments at the 'U' to promote the value and need for such internships.

2. Faculty Exchange Opportunities. Develop faculty exchange opportunities with the private sector, analogous to student internships. Promote the idea of faculty-student teams going out into the private sector for a limited time period or for project-specific activities. Think about this a 'business sector sabbatical' or a 'public-private exchange' in which the faculty member might get partial salary support and would maintain some teaching and/or research activities at the 'U,' but would also be out in the placement site two to three days a week, i.e., get the faculty out of their offices or laboratories and into the work sites to experience for themselves what the needs and opportunities are in the private sector.

3. Placement Services. Provide both a PEC office (located on the 'U' campus) and a website in which:
   - Faculty and students could suggest ideas for student internships and faculty consultantships,
   - Industry could do likewise -- suggest areas in which they could use/would welcome a student and/or faculty member on a time- or project- limited basis,
   - Placement services could be coordinated, e.g., arrangements for contacts and interviewing, etc., between both parties -- academic and private sector,
   - A coordinator could manage these activities in both an office and on a website, e.g., promote the placement opportunities, seek new ones on both sides (academic and industry), keep track of placement opportunities, obtain evaluation of participants' experiences (from both sides -- academic and industry), and provide a clear picture to the Academic Health Center (AHC) and the President's office of the kinds of academic-industry relationships that could, in turn, be communicated by them to the Governor and legislature.

4. Employment Brokerage Center. Provide physical and website locations for industry to locate qualified students (if they haven't identified them already through the internships) for full time employment after graduation.

Concept

Think of the PEC as a point of contact for industry that would give the private sector quick and reliable access to students and faculty -- a place where industry could do one-stop shopping for human capital. The PEC could also serve as a 'hot bed' of ideas for what's possible, what's needed, and what's currently happening. A Board of Directors for the PEC could be appointed consisting of people from at least two groups: (1) an energetic group of business executives who need to hire people with such expertise now and in the future and (2) forward thinking academics.

PEC activities could be coordinated by a full time person who reports to the Senior Vice President for Health Sciences at the U. Within the Academic Health Center, the PEC could function like the other service centers, i.e., AHC communications, human resources, facilities, financial activities. The PEC could eventually provide a coordinating or vertical integration function with the placement activities within the seven schools and colleges of the AHC. By working with placement centers within each of the AHC schools or colleges, the PEC could provide a conduit for students to inquire about, interview for, or obtain training opportunities that would 'go beyond' their traditional disciplines, e.g., a nurse who is also a systems analyst, a physician interested in electronic decision analysis, a biochemist who does research in the development of medical devices. The PEC shouldn't serve as a placement center for traditional professional activities such as nursing or medicine, etc., rather it could provide such services for the developing expertise and professions that fall in between the cracks -- for example, for the students and faculty with expertise in biomedical-bioengineering. The PEC could be a dynamic organization that helps industry seek out and find people who are on the cutting edge between the traditional professions and the newly developing ones.

Implementation

Funding. Consider letting the majority of the PEC activities be funded by donations (on a rolling three year basis) from local business groups. That way, if the PEC is not serving the needs of the private sector, then the Center would fold. But also let the 'U' provide some funding, especially in the form of University 'private sector sabbaticals' that would give faculty partial salary support to develop and participate in these exchange activities. Whet the appetite and the competitive nature of forward thinking faculty by offering private-public sabbaticals on a competitive basis – thus restricting the costs to a known amount, e.g., 15 quarter-long exchange opportunities per year. Make it clear to faculty that after such a sabbatical (in which they are only guaranteed partial salary support for one-quarter or one-semester), then on-going consultantships might be arranged by and between interested parties.

(Perhaps make clear that in this day-and-age, faculty no longer have to take a vow of financial chastity, although they do have to maintain ethical boundaries....)

Getting Started. Start setting a PEC up now. Appoint a Board of Directors. Ask President Yudof to set a fairly short time table for implementation and a report to him. Charge them with setting goals, developing a budget, and generating a job description for a coordinator. Since there is an acute need for opportunities in the biomedical/bioengineering area, then let the PEC be located there, in the new building, and serve the needs of that group first.

I've used a number of terms interchangeably, 'business sabbaticals,' public-private exchanges,' etc. The PEC Board would need to think of a catchy name for this activity that will attract the attention of students and faculty, without confusing them. Make it clear, however, that the PEC will expand to include all new, interdisciplinary/ multidisciplinary areas of digital technology expertise in the near future. Go beyond the currently defined boundaries of the biomedical/bioengineering activities. Don't limit PEC opportunities to the creation of formal academic Centers at the 'U' because by the time an Academic Center is established and functioning, the newly developing expertise might have either withered or gone elsewhere. Let individual faculty and business people propose ideas to and seek opportunities from the PEC Coordinator and/or Board members.

Extend the scope of the PEC to the public. Get the Board of Directors, together with a newly hired coordinator, to think about an annual Digital-Tech-in-the-Health-Sciences fair, in which the needs and opportunities in these rapidly emerging areas would be presented and promoted to the public. K-12 students could be invited to such a fair, as well as businesses and academic groups to promote the science and the opportunities. Perhaps such a fair could be modeled along the lines of the Inaugural activities or the Brain Fair -- both of which seemed to be very successful.

Above all, keep the goals of the PEC broad, but its activities focused. One of the admonitions mentioned frequently at the Day 2 meeting was that of not trying to do too much. Keep the focus on excellence for a few, well-defined activities! Some issues the PEC Board would need to consider might be the following:

- How can the U technology, research and education be promoted and integrated across disciplinary boundaries?
- How should the U gain industry and public support/funding for biomedical technology research and education?
- How should the U better incorporate new digital technology in biomedical research and education?
- How can collaboration between the U and the health care industry be increased in the areas related to digital technology?
- What strategy does the U have to rapidly deploy information technology in biomedical engineering, biotechnology, and health care activities?

ELECTRONIC COMMERCE
Day 1: "Electronic Commerce: Playing the Global Game" by Jeffrey Ritter, ECLIPS, Ohio Supercomputer Center

Introduction (by John Gunyou)

Electronic commerce is the enabler of the many issues discussed at the Digital Summit and is critical to Minnesota's social and economic future. As the tools of electronic commerce become ubiquitous worldwide, we need savvy and skill in creating appropriate protocols and policy to accompany technological advancements. The role of the government in this process should be first to collaborate with stakeholders to create a solid regulatory foundation. Second, the government needs to promote electronic commerce as a preferred means of doing business with government. We need to invest in research and development not only in technical areas but also in policy. Ritter described electronic commerce as a game.

Defining the Game

Electronic commerce takes two forms. First, electronic commerce involves executing traditional electronic transactions electronically and without paper. Second, electronic commerce involves executing new kinds of transactions in which data in electronic form is the asset of the deal. We need to play the game of electronic commerce only to win. Winning, however, can take several forms: possession of information and control of space (even in cyberspace). The reality is that the true measure of winning is the creation of wealth.

Rules of the Game

The future is transactional. We need to think about electronic commerce in new terms:

- There is no transaction until acceptable payment is made.
- Money is dead.
  Wealth will be measured in payment by the barter of electronic bytes with value. We will see new kinds of wealth: loyalty points, trading stamps, and extended warranties or services.
- Every transaction is a negotiated contract.
  The Web empowers freedom of choice for every customer.
- The net is the ultimate in market freedom.
  Loyalty will be reduced. Relationships will mean little because consumers will constantly search for the better deal.
- Legal rules become competitive products.
  Warranties, payment terms, and privacy of customer data will become selling points.

Playing to Win

The rules for electronic commerce are global. When compared with the policy innovations in other countries, the US is behind. Ritter is concerned that the US is isolating itself from the global necessity of playing the game by the rules. Electronic commerce requires a consistent, predictable, stable legal framework so that everyone can play the game. In order to play to win, the US needs to:

- speak the global languages of electronic commerce.
- do business with those against whom you compete (or you will die).
- collaborate with government to accommodate constituent concerns (for consumers, small business, education, and others).
- make no deals that do not define how to get paid, resolve disputes, and provide the security desired.

ELECTRONIC COMMERCE
DAY 2: ISSUES AND RECOMMENDATIONS

Don Riley and Les Wanninger served as facilitators to the small group workshop. Don Riley began the small group workday by providing an overview of the University's perspective regarding electronic commerce and an introduction to the day's activities. Riley emphasized that it is imperative that the University begin to understand what the relationship between digital technology and electronic commerce is, that the University assess its strengths in this area and decide how to respond to the current and future trends in this area, particularly by continuing the positive dialogue between the University and business represented by the activities of the Digital Technology Summit.

Riley offered the following perspectives regarding digital technology and electronic commerce:

- Strong electronic commerce consists of four components:
  a desktop machine;
  content "out there somewhere;"
  connections from the desktop to a central "machine;" and
  people who support, train, etc. other people to understand and use these systems effectively.
- Success in this area depends on creating a seamless environment, which can be effected only through collaborative partnerships. For example, the University offers free e-mail to all faculty, staff, and students partnered with Control Data's super system.
- To create effective collaborations, Riley cited these components as important:
  finding a common set of key enablers
  creating secure environments and environments of trust.

Riley then offered perspectives on what the University is already doing that exhibits strengths in this area:

- Establishing partnerships with Cisco, MRNet, and the state to build knowledge about the capabilities offered by the Internet.
- Negotiating with IBM to establish a cooperative agreement.
- Participating as a major player in the development of the Virtual University of Minnesota.
- Establishing front-end web registration (the U of MN is leading the country in this area).
- Developing a secure document routing structure--"forms nirvana"--for the grants management area.
- Participating in shared library resources among the Big 10 institutions and developing better systems to authenticate and authorize transactions between and among institutions.

Finally, Riley offered a model for establishing effective partnerships between the University and businesses. This model should incorporate these components:

- The focus should be on students
- Mechanisms (technology) to allow people "from everywhere" to participate
- Flexibility and a recognition of changeability--what works now, works now and may be obsolete in two months
- Ways to support "independent entrepreneurs," that is, faculty and students innovating creative enterprises
- Opportunity to transfer findings through instruction and teaching

Riley turned the floor to Les Wanninger, who offered the following thought-provoking ideas to inform the breakout sessions to follow:

- Wanninger reiterated that the University must work with businesses to define needs, that this collaboration supports both the University's and businesses' missions and purposes.
- Wanninger, in the context of discussing the challenge of need definition, offered this analogy: To define research agendas and industry needs, both parties must "know the customer," the end-user consumer. The university and industry must know their customers as catalogue companies with individualized mailing lists know their customers; these companies are tremendously more effective marketers and sales generators than are companies who don't know their clients.
- Wanninger reminded the group that advertising is a significant part of electronic commerce.

The larger group then formed into smaller groups to discuss more focused topics around the larger topic of electronic commerce. These breakout sessions took up the following topics: marketing, business applications and tools, infrastructure concerns, technology.

RECOMMENDATIONS

After the breakout sessions, the reconvened group put forth the following four priorities for the University, based on the University's mission and leadership:

1. Research
    - technology and tools for electronic commerce
    - business models for use
    - the Rules
2. Leadership: The University as Catalyst
    - leadership to set new standards for new community
    - collaboration framework

- electronic commerce utility “co-op”

3. Education
   - rapid response to critical needs
   - long-term re-tooling
   - electronic commerce education and training via electronic commerce models

4. Outreach, technology transfer, etc.
   - best practices clearinghouse
   - connecting people to “solution packages”
   - “the State Fair”
   - medium- and small-sized businesses

Working Group Participants

University of Minnesota
Donald Riley, CIO
Les Wanninger, CSOM
Dan Wackman, Journalism & Mass Communication
Gordon Davis, CSOM
Carl Adams, CSOM

External Representatives
John Gunyou, MN Office of Technology
Norm Rickeman, Andersen Consulting
Pete Nelson, Hyperport
Chris Mahai, Cowles Media
Lisa Tanner, Microsoft
Mike Lushine

ENTERTAINMENT

DAY 1: "DIGITAL TECHNOLOGY IN THE ENTERTAINMENT INDUSTRY"

by Pete Docter, Pixar Animation Studios

The entertainment industry uses digital technology in myriad ways, for example:
- special effects
- motion capture
- camera control
- virtual sets
- on-line publicity
- sound and light control
- and more

In Minnesota, a vibrant entertainment industry relies on digital technology for:
- animated series production
- special effects for film and TV
- video game production
- enhanced CD production
- satellite distribution
- TV production
- web-based commerce
- light shows during stage and live productions
- set design (CAD)
- virtual environments
- gambling
- music production
- and more

Toy Story was the first fully animated computer film. Pete Docter (Pixar Animation Studios) described the process of creating and producing this commercially successful film—from hiring the animators through distribution of the finished product. The following points emerged from Docter's presentation:

- **Human Resources**: Technology in a film is essentially a gimmick—after the novelty wears off, the film must have substance; it must meet the expectations of the customer. Audiences want to see stories that validate their own life experiences, that point to truths to which the audience can relate. *Toy Story* deals with fear, jealousy, and love—it takes more than knowing how to run a computer to create such a film.

- **Computers as Tools**: Pixar hired animators based on their abilities and creativity—they needed to be able to entertain and amuse. The computers were tools that the animators could learn to use.

- **Collaboration**: The collaborative team for the project was extensive and diverse, and included writers, designers, directors, animators, lighting specialists, sculptors, actors, voice talent, art director, layout people. The computers were the tools through which these people applied their crafts.

- **Importance of End User**: The "end user" was important throughout the project. Engineers designed and developed software to be suitable for their end users—the animators. The team designed and developed a film to attract and hold the interest of end users—the audiences.

ENTERTAINMENT
DAY 2: ISSUES AND RECOMMENDATIONS

NOTE: Group consensus was that it was misleading and risky to call this track "Entertainment." Especially in anything in writing, refer to it as "Entertainment, Arts, and Culture."

The group agreed that something can and should be done to support technology in entertainment, arts, and culture in Minnesota, and that the University of Minnesota should play a leadership role. Although members agreed, for discussion purposes, to refer to the something as a "center," they did not define the specifications or location of such a center—and sometimes called it an "initiative." Their concern was that it is premature to decide on the form of the solution—it is important first to decide on the function and characteristics of the solution.

The "center," which might be called a Center for New Media Arts & Sciences, would:

- promote excellence and be highly visible (students might complete complex capstone projects; work would be international in scope; students would leave with impressive, real projects in their portfolios that would impress potential employers);
- feature interdisciplinary collaboration within the university, and between the university and public and private institutions (the work between university departments would appear seamless; collaboration between students and businesses would be extensive);
- provide an interdisciplinary "home" for arts, culture, and entertainment and their connection with technology;
- incorporate significant shared resources—for example, laboratories, studios, content, experts;
- encourage extensive industry involvement (business/student cooperative projects, connections leading to placement of students, adjunct professors, continuing education programs);
- focus on student collaboration (students form interdisciplinary teams that need to exist but otherwise wouldn't);
- promote outreach (go to students and teachers in kindergarten through 12th grade, and bring them in for programs);
- work with the Office of Technology multimedia initiative.

The group also agreed that this center, or initiative, must:

- yield talented and experienced learners. Graduates must understand how to learn—have the ability to acquire new skills as they move through their lives. Those who complete the program also must have a solid mastery of such fundamentals as writing, speaking/making presentations, visual literacy, principles of business, working effectively in teams, navigating information spaces (e.g., the Web), solving problems, identifying resources, managing personal time, and understanding the big picture from a philosophical and spiritual perspective.

- deliver more broadly. It must include the opportunity for students to earn minors, for people to enroll in outreach programs and take courses offered via distance learning (the program should be global), for UMN to collaborate with other institutions. The center can serve businesses in education and training, and serve to stimulate local industry. Students and teachers in kindergarten through 12th grade must have access to programs.
- build academic excellence in digital media. Establish a program with a solid theoretical foundation that will attract students; initiate and maintain collaborative relationships that will yield access to up-to-date production technology.

More generally, this initiative should result in creation of a national and international model for how other institutions can look at integrating media into the arts and sciences. It can and must be a center of excellence, a magnet for attracting the best and most talented.

Work Group Participants

<u>University of Minnesota</u>
Joe Konstan, Computer Science and Engineering
Thomas Trow, CLA
Alan Wivell, CLA
Matthew O'Keefe, Electrical and Computer Engineering
Lance Brockman, Theater Arts and Dance

<u>External Participants</u>
Susan O'Neil, MN Office of Technology
Peter Weishar, New York University
Pete Docter, Pixar Animation
Colleen Kulhanek, LCS
Kelly (K2) Heikkila, MN Film Board
John Engel, MN Center for Arts Education
Dan Thomas, KTCA
Steve Dietz, Walker Art Center
Larry Lamb, Lamb & Co.
Daniel Gumnit, IVL
Chuck Kundschiem, MNSAT

SYSTEMS AND HARDWARE
DAY 2: ISSUES AND RECOMMENDATIONS

PARTICIPANTS

University Participants:
Keshab Parhi, Moderator
David Lilja
Pen Yew

Invited Participant:
Rajeev Jain, UCLA

Local Participants:
Glenn Batalden and Bruce Petz, IBM
Tony Vacca, Cray Research
Michael Heideman and Wayne Engstrom, Unisys
Joe Vaughan, CDI
Rick Ramseyer and Walter Heimerdinger, Honeywell
Ullas Kamath, ADC
Gordon Priebe, LSI Logic
Ryan Jorgenson, Theseus Logic
Nigel Macleod, Seagate
David Tetzlaff, Rosemount

DISCUSSION

This track addressed hardware systems and technologies for
- Microprocessors
- Hardware for communications, image processing, biomedical imaging, storage and control systems
- System integration technology
- VLSI systems and low-power

RECOMMENDATIONS

Continued presence and growth of electronics companies in Minnesota requires a strong University. It is easier to keep people in Minnesota than to attract them from elsewhere.

Establish a "Center for Excellence" for Digital Systems and Electronics. This Center would be responsible for the following:
- University-Business cooperation
- Collaboration
- Mentorships

- Internships
- Co-ops
- K-12 program interactions

The participants in the center would come from the Universities in the state, businesses, and K-12 programs. This center would be expected to re-establish Minnesota's pre-eminence in the electronics industry and computer engineering.

DISCUSSION

The conversations that ensued as a result of the presentations given on Day 1 of the Summit and the group work engaged on Day 2 pointed to the following:

Participants recognized that Minnesota has temporarily lost its strong standing as a leader in the area of digital technology. However, participants are convinced that the educational, governmental, and industrial components of the state, along with the citizens of Minnesota, have the resources to re-establish Minnesota as a leader in digital technologies.

The participants themselves represented the great capacity and enthusiasm Minnesotans bring to these concerns. Many creative ideas were presented for advancing research, establishing timely educational initiatives, facilitating communication and collaboration between and among educational institutions and groups within the state, state industries, and state government.

Participants were convinced, however, that these creative ideas cannot be brought to fruition without significant structural and financial support. This conviction accounts for the many suggestions offered to establish a central "place" that would serve to facilitate efforts toward advancing digital technologies. Participants observed that "silo" thinking within the University, resulting from traditional University hierarchical structures and supported by long-standing disciplinary divisiveness, prohibits timely and productive action on innovative initiatives, both within the University and with organizations (academic, industrial, governmental) external to it.

Thus, participants assert that a primary responsibility of the University is to provide the means by which ideas can be implemented quickly, support (in the form of time, people, and money) can be accessed easily, and innovation is encouraged and rewarded.

By taking action to facilitate this kind of creative and active climate, the University can not only support the state of Minnesota in regaining its position as a leader in the area of digital technologies but it can also establish itself as an innovative academic institution that truly advances excellence combined with a concern with the well-being for all citizens of the state.

APPENDIX A: GRADUATE STUDENT RECORDERS

It is appropriate to thank these graduate students from the University of Minnesota Department of Rhetoric and Scientific and Technical Communication who devoted an enormous amount of time and energy to recording the events of the Digital Technology Summit. These students served as recorders in all sessions for two days and compiled the draft report. This report could not have been written without their input.

The recorders included:

Deborah Balzhiser-Morton
David Beard
Steven Claas
Linda Clemens
Julie Daniels
Denise Dilworth
Lise Hansen
Krista Johansen
Amy Koerber
Stephen Mai
Alyson Riley
Victoria Sadler
Chris Scruton
Beth Sokolowski
Doreen Starke-Meyerring
Stan Zobel

APPENDIX B: DIGITAL TECHNOLOGY SUMMIT PLANNING COMMITTEE

Following is a list of individuals who assisted in planning the Digital Technology Summit.

University Representatives:

Gordon Amundson, Asst. Professor., University College
Linda Bruemmer, Associate to the Dean, Institute of Technology
Susan Burke, Program Associate, University College
Robert H. Bruininks, Exec. VP & Provost
Tom Burk, Professor, Department of Forestry
Jim Chelikowsky, Professor, Department of Chemical Engineering & Materials Science
H. Ted Davis, Dean, Institute of Technology
Tom DeRanitz, Program Director, University Relations
Ann Hill Duin, Vice Provost
Mostafa Kaveh, Head, Department of Electrical & Computer Engineering
Don Riley, VP & Chief Information Officer
Steven J. Rosenstone, Dean, College of Liberal Arts
Tom Ruwart, Asst. Director, Laboratory for Computational Science & Engineering
Tom Shaughnessy, University Librarian
Beth Sokolowski, Department of Rhetoric
Ahmed Tewfik, Professor, Department of Electrical & Computer Engineering
Mark Yudof, President

Minnesota High Technology Council Representatives:

Kris Burhardt, Imation
Dick Clarke (Retired), MTS Systems
Diane Gibson, Silicon Graphics/Cray Research
William Hamer, ADC Telecommunications
Rick Krueger, MHTC
Dale LaFrenz, Qtech Systems, Inc.
Vance Opperman, Key Investment, Inc.
Larry Shearon, Medtronic, Inc.
Bobby Wangaard, MHTC

Governor's Office Representative:

John Gunyou, MN Office of Technology

APPENDIX C: OFFICIAL PROGRAM

Following is the official program of the Digital Technology Summit.

Digital Technology Summit:
Trends and Challenges

October 22, 1997
Hyatt Regency Hotel
Minneapolis, Minnesota

Program Schedule

7:30-8:30 am	**Registration**	Nicollet Ballroom Foyer
8:30 am	**Welcome and Program Introduction** *H. Ted Davis*, Dean, Institute of Technology, University of Minnesota *Rick Krueger*, Executive Director, Minnesota High Technology Council **Comments and Perspectives** *Arne Carlson* Governor, State of Minnesota **Summit Objectives/Charge** *Mark G. Yudof* President, University of Minnesota **Summit Organization and Logistics** *Rick Krueger*	Nicollet Ballroom Sections B & C
9:30 am	**"The Digital Future"** Presiding: *Rick Krueger* *Vance Opperman*, President and CEO, Key Investment, Inc.,Minneapolis, Minnesota *William Monahan*, CEO and Chairman of the Board, Imation Corp., Oakdale, Minnesota	Nicollet Balroom Sections B & C
10:30 am	**Demonstrations and Break**	Nicollet Ballroom Section D

11:00 am **Concurrent Sessions**

Session 1: Spatial Data Technologies:
Presiding: *Joe Harroun*, Program Manager, Research, Cargill Inc., Minneapolis, Minnesota

Lake of the Woods
5th Floor

"New Directions for Spatial Technologies"

Presenter: *Jack Dangermond*, President, Environmental Systems Research Institute, Redlands, California

University Representative: *Thomas E. Burk*, Professor, Department of Forest Resources, College of Natural Resources

Session 2: High Performance Computing and Visualization

Lake Superior
5th Floor

Presiding: *Rene Copeland*, Vice President, Technical Computing Division, Silicon Graphics/Cray Research, Inc., Minneapolis, Minnesota

"Toward the Visual Supercomputer"
Presenter: *Larry Smarr*, Director, National Center for Supercomputer Applications, University of Illinois, Urbana-Champaign, Illinois

University Representative: *Paul R. Woodward*, Professor, Department of Astronomy, Institute of Technology

Session 3: Education

Nicollet Ballroom
Sections B & C

Presiding: *Dale LaFrenz*, Chairman Q-Tech Systems, Inc., Minneapolis, Minnesota

"Meeting Tomorrow's Learning Needs"
Presenter: *Carol A. Twigg*, Vice President, Educom, Washington, D.C.

University Representative: *Billie J. Wahlstrom*, Professor, Department of Rhetoric, College of Agricultural, Food, and Environmental Sciences

12:30 pm **Networking Luncheon** — Greenway Ballroom, 2nd floor

Presiding: *H. Ted Davis*

"The Impact of High Technology on the American Economy"
William Archey, President, American Electronics Association, Washington D.C.

2:00 pm **Concurrent Sessions**

Session 4: Telecommunications — Nicollet Ballroom, Sections B & C

Presiding: *William C. Hamer*, Vice President and Chief Technical Officer, ADC Communications, Inc., Minneapolis, Minnesota

"Telecommunications and Advanced Networking"
Presenter: *Stephen Wolff*, Executive Director, Advanced Internet Initiatives Division, Cisco Systems, Washington, D.C.

University Representative: *David H. Du*, Professor, Department of Computer Science and Engineering, Institute of Technology

Session 5: Digital Publishing — Lake Superior, 5th Floor

Presiding: *Michael Wilens*, Chief Technology Officer, West Group, Eagan, Minnesota

"The Future of Digital Publishing"
Presenter: *Kevin Kelly*, Executive Editor, Wired Magazine, San Francisco, California

University Representatives: *Tom Shaughnessy*, University Librarian,
and
Richard P. McGehee, Director, Geometry Center, Institute of Technology

	Session 6: Advanced Design Manufacturing	Lake of the Woods 5^{th} Floor

Presiding: *Clint Larson*, Corporate Vice President - Retired, Honeywell, Minneapolis, Minnesota;
and
Ken Jenson, Chief Operating Officer - Retired, Alliant Techsystems, Hopkins, Minnesota

"The Impact of Digital Technologies on Product Design and Manufacture"
Presenter: *Eric Donaldson*, Imation Corp., Oakdale, Minnesota

University Representative: *Avi Bar-Cohen*, Acting Director, Center for the Development of Technological Leadership, Institute of Technology

3:30 pm	**Demonstrations and Break**	Nicollet Ballroom Section D
4:00 pm	**Concurrent Sessions**	
	Session 7: Technology-Enhanced Health Care—Future Capabilities and Needs	Lake of the Woods 5^{th} Floor

Presiding: *Winston Wallin*, Retired Chairman, Medtronic, Inc., Minneapolis, Minnesota

"Manufacturer's Perspective"
Presenter: *Joy Solomon*, President and CEO, IVI Publishing, Inc., Eden Prairie, Minnesota

"Provider's Perspective"
Presenter: *Dr. Bijoy Khandheria*, Mayo Clinic, Rochester, Minnesota

"Researcher's Perspective"
Presenter: *Kamil Ugurbil*, Professor, Radiology, University of Minnesota, Minneapolis, Minnesota

University Representative: *Frank Cerra*, M.D., Sr. Vice President for Health Sciences

Session 8: Electronic Commerce

Nicollet Ballroom
Sections B & C

Presiding: *John Gunyou*, Executive Director,
Minnesota Office of Technology, St. Paul, Minnesota

"Electronic Commerce: Playing the Global Game"
Presenter: *Jeffrey B. Ritter*, Director, Electronic Commerce,
Law and Information Policy Strategies (ECLIPS),
Ohio Supercomputer Center, Columbus, Ohio

University Representative: *Donald R. Riley*,
Associate Vice President and Chief Information Officer

Session 9: Entertainment

Lake Superior
5th Floor

Presiding: *Daniel Gumnit*, President, IVL, Inc.,
Minneapolis, Minnesota

"Digital Technology in the Entertainment Industry"
Presenter: *Pete Docter*, Pixar Animation Studios,
Richmond, California

University Representative: *Joseph A. Konstan*, Assistant Professor, Department of
Computer Science and Engineering
Institute of Technology

5:30 pm **Reception**

Nicollet Ballroom
Promenade

6:30 pm **Dinner and Wrap-up**

Greenway Ballroom
2nd Floor

"Summary of Day's Highlights"
Dale LaFrenz, Q-Tech Systems, Inc.

"University Direction"
Mark G. Yudof, President, University of Minnesota