Toward a National Higher Education Networking Infrastructure

As many of you know, one of the outcomes of the Monterey Conference this past fall was the creation of an informal group which later called itself the "MFuG" or the Monterey Future's Group. This group has met several times since Monterey and developed a paper which discusses the networking needs and supporting technical requirements of the university community as it is now evolving. Doug Gale and a great many in MFuG contributed to this effort. In addition, there was work by a small group of folks (Stuart Lynn, David Wasley, Russ Hobby, Mike Staman) to write a concept paper describing a National Higher Education Networking Organization. Finally, at the request of the NTTF Steering Committee, Bill Graves wrote a background piece in preparation for the joint NTTF/FARNET meeting on April 15th and 16th.

Three documents are attached below:

1. A background document for the joint NTTF/FARNET meeting
2. White Paper: Telecommunications Requirements for a Virtual University
3. A National Higher Education Networking Organization (NHENO)

Readers will note some overlap at the beginning of the Graves background document and the white paper. At the outset there was a single paper. The discussion in both papers quickly moves to separate and equally important topics, however, and the overlap between the two becomes insignificant after the first paragraph or two.

As part of the process to date there have been a number of NTTF-centric, MFuG, and FARNET conversations of varying intensity. The time has come to place the thinking below into a larger discussion throughout the higher education community.

Finally, kudos to the following individuals, all of whom contributed to this effort:

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Any of the above folks would be very interested in comments from the community on any of the following three documents.

Part I of III:
BACKGROUND FOR THE JOINT MEETING
Author: Bill Graves

EDUCOM Networking and Telecommunications Task Force
Federation of American Research Networks

Washington, DC April 15-16

A recent conference in Monterey (California), "Higher Education and the NII: From Vision to Reality," was sponsored by a wide range of groups representing higher education. The conference focused and articulated higher education's vision for the future of networking, identified barriers to realizing the vision, and recommended an action plan to realize the vision. A particularly noteworthy concern emerged from the conference: today's Internet technologies and services may not evolve to meet higher education's imminent high performance networking capacity and service needs.

Indeed, higher education is experiencing demands for a range of integrated, advanced network services not yet available within the Internet array of services. Because the Internet in its current implementation may not evolve in a timely way to meet these demands, leaders in the higher education networking community are currently refining their understanding of advanced networking requirements and developing an action plan for securing the resulting services. Determined that higher education remain a leadership partner in the global, open, inter-networking community, these leaders hereby invite the collaboration of their interested counterparts from both the profit and non-profit sectors. EDUCOM's Networking and Telecommunications Task Force (NTTF) has agreed to organize and facilitate these activities and, on behalf of higher education, welcomes external expressions of interest.

The recent history of the Internet is a good reference point for considering how the needs of one community can lead to the development of an advanced networking infrastructure which

then catalyzes a much broader market for commercially scaleable network services. Only a few years have passed since modest federal investments (NSFnet) in inter-institutional and inter-agency networking provided leverage for a much larger total investment in campus-based network infrastructure. These investments by higher education and a few key federal and corporate partners were designed to enrich the nation's research infrastructure, but they also quickly resulted in a range of unanticipated, broadly useful applications in the global academic community. The result was the first general purpose (global) Internet. Soon thereafter, the Internet became an integrated set of inter-networking resources and services based on open, de facto standards and offered by an array of competing providers in a commercial environment now exhibiting many of the features of a commodity market. The World Wide Web (Web) and its attendant browsers, with their origins also in the research and academic communities, catapulted the Internet to its current revolutionary status both as a social and an economic phenomenon.

The task at hand is to develop a late 90's strategy to define and secure advanced networking services for the constituencies of higher education and other profit and non-profit communities with similar needs. But this strategy should look with hindsight at the Internet/Web experience to try to precipitate the evolution of today's Internet market to a broad, commercially viable market for advanced network services. Higher education cannot afford to build walls between itself and the larger, open, inter-networking community, and so new advanced networking services should incorporate a continuous migration path from today's Internet services.

To understand higher education's need for network services beyond those available today from Internet providers, we must consider the enriched educational environment envisioned by many academic leaders and frequently captured in the phrase "virtual university." The main features of this environment are the integrated networked delivery of multimedia learning materials and asynchronous and synchronous conversations within learning communities of students and their mentors. The advanced network services that would enable such an environment would also serve advanced learning communities of academic, government, and corporate researchers.

A group of higher education network leaders has reviewed the technical requirements for the virtual university and for today's research community. They determined that by the year 2000, higher education will require an advanced, open, inter-networking fabric with the capacity to:

* support desktop and room-based video teleconferencing,

* support high-volume video streaming from distant video servers,

* incorporate and integrate voice traffic,

* insert large-capacity inter-institutional projects into the fabric at will in response to the needs of research projects and network experiments,

* interconnect enterprise networks that are in various stages of migration from router-based topologies to virtual switched topologies, and

* control costs and pricing/allocation models from within the enterprise.

These requirements are important to higher education because in the traditional configuration of a classroom- and library-centered campus, a college or university is a successful learning community enriched by a comprehensive set of learning resources. The word "Internet" provokes a justifiable resistance to change in some educators, not because they fear the networked delivery of learning and learned materials, but because they have concerns about a "wired" future in which the human connection between student and instructor is diminished to the detriment of higher-order learning and the overall social fabric. They fear the loss of the conversational aspects of learning, often dependent on humanly rich sensory cues and spontaneous give and take. We switch tasks and modes of communication seamlessly in face-to-face learning environments. In contrast, today's computers and network services do not support an integrated, seamlessly rich palette of communication and application. But the requirements listed above can help ensure the quality and seamlessness of technology-mediated human communication and help us retain the nuances and richness of face-to-face communication as time and place become less central to communication and other human activities.

Indeed, time and place have been used forever to organize human activity into face-to-face communities of common purpose. We can all think of examples – the 8-5 office work day, the 10 AM business meeting at O'Hara Airport on March 4, the 8 PM Town Council meeting on Wednesday to discuss proposed changes in zoning laws, the 2 PM seminar on nature-nurture issues in child development, and the meeting of the American Mathematical Society on January 10-13 in San Francisco. But today, communities of discourse are being reorganized around new modes of human communication no longer bounded by time and place. Conference calling and two-way video conferencing have removed some of the constraints of place but have by no means replaced face-to-face group meetings. Instead, the Internet has become today's primary window onto a range of new communications possibilities organized principally by shared interest and only secondarily, if at all, by proximity in time and place.

Nowhere are the constraints of time and place more noticeable, paradoxically, than in today's classrooms on the very campuses which contributed so much to the birth of the anytime-anyplace Internet. Natural inertia and resistance to change contribute to this circumstance, along with the fear of creating a diminished social environment for building and joining communities of discourse. But there is another major barrier to change.

Computers connected to the Internet are not yet pervasive in colleges and universities and the communities they serve. Computers and network infrastructure, like telephones and the telephone network, must be personally accessible to all of higher education's constituents to be useful. In response, institutions of higher education are moving quickly to create campus-based networking infrastructures with the connections and capacity for ubiquity within their bounded physical enterprises of offices, classrooms, libraries, labs, and residence halls – and

with access to the Internet. Connecting their constituencies to their enterprise networks from off campus, however, is a different matter. Remote access to enterprise networks is thus a critical component of any plan to develop advanced networking services for higher education and is especially problematic for institutions with nationally or globally dispersed constituencies or potential constituencies. The technologies and capacities of remote-access services must be consistent with advanced enterprise and inter-enterprise network services. We must simultaneously advance the capacities and the quality of services available through campus networks, inter-campus networks, and networks providing remote access to campus networks from the home and the workplace. Society's expectations of higher education leave us little choice.

Society expects higher education to become more flexible in its course and curriculum offerings in order to meet the new educational needs of a learning society and its learning organizations. Rapid changes in the discipline areas of knowledge are leading to an emphasis on learning to learn. These changes, along with rapid growth in the volume of the overall knowledge base, are driving the need for continuing education throughout a lifetime. Moreover, not all students are interested in a residential experience. Many express tightly focused, self-selected learning objectives as consumers of instruction. This is especially the case with "non-traditional" learners and "life-long" learners who may have legitimate educational needs not easily accommodated by either the time-and-place constraints of traditional campus-based study or the time constraints of multiple-year degree offerings.

Society also expects higher education to link its curriculum offerings, its research agendas, and its public service offerings more closely to social and economic needs. This expectation of relevance raises the issue, for example, of how to balance traditional emphases on general education and free inquiry into the "pure" realms of knowledge with a more pragmatic emphasis on meeting society's current needs.

These increased expectations of flexibility and relevance come at a time when new political and economic forces are making it increasingly difficult to sustain historic financial commitments to higher education. The federal government, for example, is shifting responsibility for many social programs to the states, often without transferring enough resources to cover the full historic costs of such programs. More public resources, moreover, are being directed to programs designed to remedy current social ills, thereby relatively reducing the resources available to programs designed to build the social and economic future. Investments in prisons, for example, are increasing and are fundamentally different in their nature than investments in education. These changed social and economic circumstances have introduced a new dynamic into the relationship between higher education and its constituencies. The times demand that higher education's leaders and supporters rededicate themselves to understanding how best to optimize investments in higher education. Many have already concluded that only by embracing the educational constructs of the virtual university can we both increase access to instruction and maintain the quality of learning while also containing overall instructional costs.

We cannot simply bolt information technology onto existing educational practices if we expect to extend the reach of higher education's services to meet society's need for flexible, relevant educational services. Today s lecture-dominated contact-hour model is a one-size-fits-all model mass produced on an infrastructure of classrooms, chalkboards, and rigid class schedules – an institution-centered teaching infrastructure rather than a student-centered learning infrastructure.

The contact-hour model is labor-intensive, and quality education will be especially costly as long as it is inversely equated with class size, rather than directly equated with learning outcomes. Although face-to-face contact between student and instructor will continue to be important under many circumstances, we must selectively abandon the idea that the primary locus for such contact must be the classroom. The advanced networking services that we envision offer new opportunities to increase the frequency and maintain the quality of communication between student and instructor, wherever they are.

We also must recognize the distinction between instruction aimed, on the one hand, at learning particular skills and bodies of knowledge and, on the other hand, at underpinning the residential undergraduate experience with its goals of socialization and learning to learn. Network applications can be used to mitigate costs in both cases, but the residential undergraduate experience will continue to be expensive because of its residential nature.

We must begin to decouple the residential experience from other parts of the educational experience in order to offer more flexible choices for students. These choices will be limited if we do not also rethink the policies and funding conventions that govern today's enrollment patterns. But this thought takes us beyond the scope of these observations. We therefore conclude by returning to the original theme.

We must act now to migrate higher education's networking fabric to an infrastructure that is advanced in capacity and quality of service. We must work with interested partners in the profit and non-profit sectors to help transform today's commodity Internet into a pervasive, advanced global information infrastructure (GII) capable of further reducing human dependencies on time and place through an array of services which capture and integrate a rich combination of human senses underlying ordinary communication. Without such an infrastructure, higher education will fail in its self imperative to transform its educational modus operandi, to extend its reach with more flexible and socially relevant instructional programs, and, in the process, to change its inwardly focused culture.

To assess the current status of the Internet and to develop a strategy to secure advanced networking services for higher education, EDUCOM's NTTF will facilitate and report working efforts to address several key issues:

Capacity and Pricing: We should try to understand more precisely the nature of the looming problem. Is higher education overreacting? The commercial sector appears not to believe so, as Andrew Seybold, Editor of "Outlook on Communications and Computing," suggested when he wrote: "I believe the Internet network will crash and burn ... I believe the Internet is

very close to where the phone companies are on Mother's Day. They can just barely tolerate the traffic." Has today's Internet reached its capacity? Or, can additional capacity be snapped into the current Internet fabric? Are current pricing schedules for Internet access prohibitive for higher education, especially at speeds of T-3 and higher?

Requirements: The brief list of advanced networking requirements listed herein is but an overview of a more fully developed set of requirements. These requirements were developed in response to an action agenda that emerged from the aforementioned Monterey conference. They are being refined at the moment. They were developed by extrapolating outward from the individual desktop/laptop connection. But we must ask which components of a global network are most likely to evolve affordably through commercial evolution and which require higher education's intervention for reasons of price, capacity, quality of service, or timing: the campus network, the inter-campus network, or remote access to the campus network?

Architectures: What network architecture can best support the delivery of integrated services to meet the identified requirements? "Integrated" is a key word in light of the centrality of seamless communication to building and sustaining learning communities. Today's infrastructure deals separately with voice, data, and video. The separation occurs not only at the level of transport, but also in terms of the charging and billing arrangements supporting each mode. As a result, it is difficult not only to develop applications which support collaboration among human beings in a seamless and natural fashion, but also to merge the revenue streams which support those various modes of communication into a single revenue stream to support integrated communication models cost effectively.

Testbeds: What testbed activities should be developed on what schedule to gain experience with new architectural models?

Partnerships: What partnerships between higher education, government, and industry can be crafted to meet higher education's imminent needs and, in a manner consistent with those needs, to catalyze the migration of Internet services to an integrated set of commercially-viable advanced network services?

Part II of III:
White Paper on Telecommunications Requirements for a Virtual University.
Author: Doug Gale and many in the Monterey Futures Group (MFuG)

Introduction

A recent conference in Monterey, California, The National Information Infrastructure: From Vision to Reality, attended by a wide range of groups representing higher education and government, focused and articulated higher education's vision for the future of networking, identified barriers to realizing the vision, and recommended an action plan to realize the vision. A particularly noteworthy concern emerged from the conference: the commodity

Internet may not evolve rapidly enough to meet higher education's imminent and foreseeable high performance enterprise networking and internetworking capacity and service needs.

A smaller ad-hoc working group was formed to develop a description of network infrastructure requirements for meeting higher education's instructional, research, and public service needs in the year 2000. The group included the track leaders from the Monterey conference as well representatives from CAUSE, the Coalition for Networked Information, the Common Solutions Group, EDUCOM's National Learning Infrastructure Initiative, EDUCOM's Networking and Telecommunications Task Force, and the Federation of American Research Networks.

The group first convened at EDUCOM'95 and then at CAUSE'95. At its third meeting in Chicago in December of 1995, the group expanded its discussion to hear from several technical experts from members' institutions and organizations. The infrastructure requirements outlined later in this document are the result of that meeting. They reflect the group's belief that by the year 2000, higher education will require an advanced internetworking fabric with the capacity to:

- support desktop and room-based video teleconferencing;

- support high-volume video streaming from distant video servers;

- incorporate and integrate voice traffic;

- insert large-capacity inter-institutional projects into the fabric at will in response to the needs of research projects and network experiments;

- interconnect enterprise networks, that are in various stages of migration to higher performance technologies, and;

- control costs and pricing/allocation models from within the enterprise.

The working group believes these infrastructure characteristics will enable higher education's transition toward a collaborative "virtual university" featuring a distributed digital library, a collaboratory environment for conducting research, and new opportunities based on real-time and asynchronous networked multimedia technologies for improving the quality of student learning, increasing access to credit-bearing instruction, and containing instructional costs. Indeed, the group fears that unless such a high-performance infrastructure soon characterizes campus networks, interconnects them, and provides "anywhere, anytime" access to their educational resources, higher education will be unable to respond to the rising social demand for an academic enterprise which, rather than being inwardly focused by the needs of various learned societies, is motivated to collaborate cost-effectively across institutional and disciplinary lines to serve the needs of a democratic learning society.

The virtual university is rapidly becoming a national priority, but many in higher education who were leaders in developing the Internet fear that the performance of today's commodity Internet is declining and may not be raised by the year 2000 to the levels characterized above as necessary to the virtual university. This concern is shared in the commercial sector. Andrew Seybold, editor of Outlook on Communications and Computing, writes: "I believe the Internet network will crash and burn ... I believe the Internet is very close to where the phone companies are on Mother's Day. They can just barely tolerate the traffic." The working group believes that the first step in avoiding a crash-and-burn disruption in higher education's services is to understand the infrastructure requirements undergirding the above list of characteristics and to learn from the history of the Internet.

A few years ago, the National Science Foundation invested in NSFnet to meet a national need in the research community for remote access to supercomputing centers. The NSF investment provided leverage for institutional investments an magnitude of order greater than the NSF's. The result is today's Internet which is serving, not only the academic research community which largely made it possible, but the broader education sector, the commercial sector and the public good. With a sound set of infrastructure requirements in hand, now is the time for the higher education community to explore investment sources and investment vehicles which will provide enough leverage to ensure a much larger collective institutional investment in the future of higher education, just as the NSFnet program did several years ago.

Rationale

The Internet, which was largely developed by higher education, has had a profound effect not only on research and instruction, but also on business and industry. There is a growing consensus among the scientists and engineers that created and now depend upon the network, that the performance of the commodity Internet is declining and may not evolve rapidly enough to meet higher education's future capacity and service needs.

Further, an infrastructure that is able to provide real-time interactive multimedia instruction anywhere at anytime as well as support a collaborative research environment that spans the nation, is required to support what is frequently described as the "virtual university." We have taken those requirements to be our design goals.

Technical Requirements

General Requirements: The following general requirements were identified by the Chicago Workshop attendees to meet higher education needs in the year 2000:

- Improved information security - Authorization, and authentication capabilities - Network management capabilities including performance audit

Quality of Service: The quality of network service is becoming increasingly important as the network is relied upon for day-to-day and mission critical applications. Solutions and standards must be developed that insure adequate levels of:

- Latency and jitter - Bandwidth interrogation capability and bandwidth reservation - Guarantee of delivery

Wide-area Communications: Quantitative predictions of wide-area bandwidth requirements are very difficult to make and must include a remarkably consistent. For example, projections based upon the growth in utilization of the wide-area infrastructure for the past eight years imply a national infrastructure based upon 1.5 gigabit/second (Gb/s) technology by the turn of the century. These projections, however, do not include the growing impact of video and multimedia technologies. Similarly, projections based providing video services to the desktop and twice as many users as present, imply a national infrastructure based upon 1 Gb/s technology. These projections, however, do not include bandwidth intensive research applications or telemedicine.

Rather than further specify the effective bandwidth of a single hypothetical national backbone, the Chicago Workshop attendees developed the following estimates of the wide area connectivity requirements for higher education to meet its needs in the year 2000:

- Scaleable to serve all 3,600 institutions of higher education - Supports integrated, real-time voice, video, and data - OC-12 to OC-48 connections into the national backbone infrastructure for the research universities - Supports individual streams at OC-3 - End-to-end Quality of Service (low latency and jitter) - Supports multicasting - Connections to other networks, both national and international

Campus Communications: The following requirements represent the best estimates of the Chicago Workshop attendees of the campus-wide requirements to meet higher education needs in the year 2000:

- OC-12 (622 Mb/s) or greater bandwidths at the campus core - OC-3 (155 Mb/s) or greater connecting the core to distributed locations (edge boxes) - End-to-end Quality of Service - Support hundreds to thousands of 1.5 Mb/s streams - Multicast capabilities - Symmetric connectivity

Community Infrastructure: The following requirements represent the best estimates of the Chicago Workshop attendees of the community infrastructure requirements to meet higher education needs in the year 2000:

- 1.5 Mb/s to 10 Mb/s into the home - Goal of connectivity in the home being the same as on campus - Support 10BaseT connectivity - Future target of Quality of Service

Workstations: The following requirements represent the best estimates of the Chicago Workshop attendees of the workstation networking requirements to meet higher education needs in the year 2000:

- 10 Mb/s to OC-3 performance to the desktop - Support end-to-end Quality of Service, including coordinated datastreams

Software: The following requirements represent the best estimates of the Chicago Workshop attendees of the software requirements to meet higher education needs in the year 2000:

- Streaming protocol - Point-to-multipoint protocol

PART III OF III:
A National Higher Education Networking Organization (NHENO)
Authors: Stuart Lynn, David Wasley, Russ Hobby, Michael Staman

NATIONWIDE COMMUNICATIONS SERVICES IN SUPPORT OF HIGHER EDUCATION

Since the announcement of the end of the NSFNET, the academic community has anticipated that "privatization" would result in active competition to provide new services at the lowest possible cost. Results to date have shown that we have some time to wait before this expectation might be realized: the overwhelming success of the Internet has resulted in escalating costs and deterioration of basic services. We, as a community dependent upon network communications, must be concerned about (i) maintaining the quality and affordability of connectivity and services in support of our evolving academic programs, and (ii) ensuring future requirements for enhanced network services will be met.

In retrospect the apparent direction of commercialized Internet services should not be surprising. A major market for nationwide network services is in support of commerce: the marketing and selling of commodities to the broadest possible audience. Infrastructure supporting this market may or may not serve the needs of the academic community, not just our production requirements but also the leading edge demands that characterize the constantly changing needs of higher education. We must ensure that our needs, where appropriate, are addressed as a community, not "balkanized" in the tradition of voice communications.

Many in the academic community foresee that we must take the initiative to guarantee our own future in providing the services we need to realize the agenda for higher education in the 21st Century. Greater cooperation and collaboration, sharing of resources, distributed digital libraries, distance education, and telescience are some of the areas in which advanced communications services are essential today. The academic community will continue to stretch the boundaries of communications technologies and services.

How can we come together as a community to ensure that our shared goals will be met? We must have an effective voice in determining the evolution of networking infrastructure and services, regardless of whether meeting our needs entails building our own private virtual network. The window of opportunity is short; the issues are complex; and our expertise and shared vision will dissipate if we fail to act now.

A key first step is to define an organizational model that can form the foundation and speak for our community. The following proposal has evolved based on conversations with many from throughout the higher education community.

A POSSIBLE MODEL FOR THE ORGANIZATION OF NETWORKING FOR HIGHER-EDUCATION

The following outlines a possible set of values, principles, and processes that could form the starting-point for establishing organizational and financially-sustainable models for higher-education inter-institutional networking that are inclusive and scaleable.

1. Higher education should control its own networking destiny as a whole community, and not be "balkanized" into suboptimal solutions. We need an organizational and financial model that enables us to obtain the current and future services we need, at the quality we need, with the lowest possible cost.

2. In general, higher education should fund its own production needs. Nothing else scales into the future. Federal and other funds, however, can be used for planning, prototyping and "moving the envelope forward". Industrial funds and other resources can be used to partner where there are common interests in establishing testbeds and nurturing new directions.

3. We propose a model with three tiers of cooperating organizations consisting of (a) individual institutions, who are members of (b) regional, probably state-based, consortia (SBC's), who in turn are members of (c) a National Higher Education Networking Organization (NHENO). It might be desirable in some cases to form a regional SBC composed of multiple states.

4. The SBC's would consolidate and mediate intra-SBC traffic, leveraging their purchasing power and, where appropriate, state relationships. SBC's would be managed from among their own members. They would take advantage of whatever lower tariffs are available for "regional" traffic. SBC's would decide at what level they buy from the private sector.

5. The NHENO would be a not-for profit organization governed by a Board of Directors partly composed of constituent (SBC) representation and partly composed of distinguished members of our community who can play an important role in the future of higher education networking.

6. The purposes of the NHENO would include: (a) stimulating the formation of SBC's, (b) consolidating purchasing power to provide the most cost effective and favorable solutions for inter-SBC and extra-NHENO traffic, (c) ensuring that services can be rapidly expanded to meet the critical demands of higher education, and (d) providing a focal point for the discussion and prototyping of new communications technologies for broad use by higher education. The SBC's would buy access to the general Internet through the NHENO. One of the main functions of the NHENO, either directly or through subcontracts established by the NHENO, would be to act as broker for a "buying club" for the community.

7. We leave moot at this point at what level NHENO would buy from or contract to the private sector, or whether it would operate its own network as a national bypass. There are strong arguments pro and con. Again, a key function of the NHENO would be to ensure that DS3/OC3 (today) capable network access points (NNAP's) are provided to the SBC's in each state or cluster of states at the lowest possible cost, using the combined purchasing power of our institutions, and with a quality of service appropriate to the needs of higher education. Obviously, the NHENO would not have a long life if it were not to deliver cost effective solutions to the SBC's (i.e., cheaper access than the SBC can obtain on its own) or other compelling value-added services.

8. The notion of SBC's does not rule out individual institutions "buying" directly from the NHENO where there is no SBC operating. Such an institution would normally be expected to form the core of a new SBC. Neither does the notion rule out the possibility of consortia based on other organizing principles where a state-based organization might not be optimal. An early action of the Board would be to establish policy in this area.

9. One potential benefit of SBC's is to leverage state funding sources. Collectively with NHENO and other SBC's they could also leverage industrial sources and partnering opportunities.

10. The NHENO would be largely funded through membership fees (under the assumption that NNAP connections were passed through essentially at cost). All organizations that route traffic across NHENO facilitated NNAP's, whether through direct connections or via "back door" SBC connections, would be members. SBC's would be responsible for NHENO membership fees (in addition to any local membership fees) for all of their members and could pass on those costs to their members under whatever model they chose.

11. Membership fees in part might possibly be used to help mediate regional differences, such as those facing rural as opposed to more highly populated areas. Ascertaining whether and how to achieve this nationally would be a Board responsibility.

12. Cost recovery models for the NHENO may have to be more complex than in the past because the costs of providing infrastructure are more significant now and are increasing. An early task for the Board would be to study various models, their effect on individual members as well as on the membership as a whole, and select a model that will best promote the broadest set of higher education interests.

In fleshing out these principles and ideas further, there is a need to develop detailed technical, financial, organizational, and service/security architectures that expand on the above. This important undertaking must proceed deliberately but as quickly as possible through the phases of planning, prototype service models, and production, with each phase addressing, where appropriate, each architectural component.

We ask for consensus from the higher education community on how best to take the next steps towards achieving out mutual goals.