Global Trends in High Performance Research and Education Networking (REN)

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“In the long course of history, having people who understand your thought is much greater security than another submarine.”

-J William Fulbright
Universities in Transition

• Mission- "facilitation of learning".

• Learning Tools: Make available all the tools necessary for learning to the learner and the teacher (books, journals, laboratories)

• Meeting Place of Ideas: Provide a stimulating and safe environment for the quest for new ideas. It fosters dialogue based on intellectual merit and free from all other prejudice and fear (academic freedom).

• The above is the only known formal institutional means to harvest human knowledge
ICT and Universities

- ICT used to be an auxiliary service for universities in the 1990’s.
- In 2000’s it became an essential limb.
- In 2005 it is becoming the central artery in the running of modern universities.
- Almost all the countries in the world have adopted REN as the centerpiece of their information and communication technology (ICT) plan for higher education.
- Now about 92 countries around the world have REN-- 25+ more are building.
- The concept is marching further forward. Countries worldwide are now forming mega REN alliances of continental proportion with a vision of creating a world community of universities- a grand kiosk of higher education and scholarship.
“if you think education is expensive
try ignorance”

-Derek Bok,
-President Emeritus, Harvard
US universities always needed a network one step ahead..
Internet, Internet2 and REN

- Internet emerged as ARPANET - a network for higher education and research.
- It gradually evolved as NSFNET, HPCC, VBNS, VBNS+
  - The higher education and research networking needs are substantially different.
  - Commodity Internet is often not able to meet their advanced networking need.
  - Nor it is possible to conduct advanced networking experiments.
- Currently there is a worldwide trend for universities to build their own high performance network called Research and Education Network (REN) such as Internet2.
- Goals:
  - Provide best ICT services to the higher education and research community
  - Enable new generation of applications
  - Re-create leading edge R&E network capability
  - Transfer technology and experience to the global production Internet
Green states have Educational Group Participants
Internet2: Organization

• Internet2
  • The “brain” providing intellectual and technical leadership. A non-profit corporation of 207 member universities.

• Abilene
  • Internet2’s current high performance backbone network with 10 Gbps (OC-192) capacity.

• A Set of Taskforces
  • Leading the creation of new applications and services and directions for Internet2.
    • Network and Middleware
    • Applications
ISP or REN?

• ISP’s business model is to satisfy vast pool of general customers, while university is a very special type of customer.

• Security, performance, and applications considerations are very different for Universities.

  • Universities **needs to experiment** with new protocols.
  • Most ports are blocked. Security is old styled, and now blocking services.
  • Experimental protocols are seldom realized/deployed.
  • Many newer services and applications contradict conventional pricing model and thus acts as a disincentive.

• REN is a worldwide phenomena now (service at cost).
• More recently RENs a moving towards dark fiber to further obtain unrestricted capacity links to run much more capable protocols.
Global Trend

Not Just in USA now the idea of REN is spreading all over the world.
### REN A World Phenomenon

<table>
<thead>
<tr>
<th>Region</th>
<th>Installed</th>
<th>In Progress</th>
</tr>
</thead>
<tbody>
<tr>
<td>AFRICA</td>
<td>5</td>
<td>17</td>
</tr>
<tr>
<td>ASIA</td>
<td>35</td>
<td>3</td>
</tr>
<tr>
<td>AUSTRALIA</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>EUROPE</td>
<td>34</td>
<td></td>
</tr>
<tr>
<td>NORTH AMERICA</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>SOUTH &amp; CENTRAL AMERICA</td>
<td>11</td>
<td>7</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>92</strong></td>
<td><strong>24</strong></td>
</tr>
</tbody>
</table>

- **Current MoU Partners**
- **Developing Partnerships**
- **Related Efforts in Formation**
Internet2 International Partners

**Europe-Middle East**
- ARNES (Slovenia)
- BELNET (Belgium)
- CARNET (Croatia)
- CESnet (Czech Republic)
- DANTE (Europe)
- DFN-Verein (Germany)
- FCCN (Portugal)
- GARR (Italy)
- GIP-RENATER (France)
- GRNET (Greece)
- HEAnet (Ireland)
- HUNGRARNET (Hungary)
- Israel-IUCC (Israel)
- NORDUnet (Nordic Countries)
- POL-34 (Poland)
- Qatar Foundation (Qatar)
- RedIRIS (Spain)
- RESTENA (Luxemburg)
- RIP (Russia)
- SANET (Slovakia)
- Stichting SURF (Netherlands)
- SWITCH (Switzerland)
- JISC, UKERNA (United Kingdom)

**Asia-Pacific**
- AAIREP (Australia)
- APAN (Asia-Pacific)
- ANF (Korea)
- CERNET, CSTNET, NSFCNET (China)
- JAIRC (Japan)
- JUCC (Hong Kong)
- SingAREN (Singapore)
- NECTEC / UNINET (Thailand)
- TANet2 (Taiwan)
- NGI-NZ (New Zealand)
- TERENA (Europe)
- MyREN (Malaysia)

**Asia-Pacific**
- MCIT [EUN/ENSTINET] (Egypt)
- TENET (South Africa)

**Americas**
- CANARIE (Canada)
- CLARA (Latin America & Caribbean)
- CEDIA (Ecuador)
- CNTI (Venezuela)
- CR2Net (Costa Rica)
- CUDI (Mexico)
- REUNA (Chile)
- RETINA (Argentina)
- RNP [FAPESP] (Brazil)
- SENACYT (Panama)

*Last updated: 1 October 2005*
• 10Mbps to Japan (APAN)
• Within China:
  • 16x2.5G DWDM system (two lambda’s are currently running)
  • OC48 POS links to 8 cities
  • OC3 POS SDH links to all provincial capitals (except Lhasa)
• unicast and multicast
Korea- KOREN/KREONET2

- Sharing 45mbps link across Pacific to STAR TAP
  - KREONET2 is led by KISTI and funded by Ministry of Sci & Tech
  - KOREN is funded by Ministry of Info and Comm and operated by Korea Telecom
• SINET national backbone network for higher education
• SuperSINET for research projects (~14 versus 300 SINET universities)
  - 10gbps backbone in Japan
  - 155mbps Abilene in Sunnyvale

SuperSINET Sites

- Jan. 2002
- Oct. 2002
- Oct. 2003
• Currently 27mbps across Pacific
  • Peers with Abilene in Sunnyvale
  • 45mbps PVC to STAR TAP/AADS switch
Thailand- UNINNET

- Funded by Ministry of University Affairs in Thailand
- Connects most universities in Thailand
- Via 155mbps links
- Currently has 10mbps PVC to Los Angeles
- Peers with Abilene in L.A.
- Other major net in Thailand is run by NECTEC (Ministry of Science & Tech funding)
Canada- CA*net/CA*net 4

- Wavelength-based
- regional networks
• +71 universities

• International connections:
  • EUA: via Tijuana – San Diego (transit via CALREN2 to Abilene) at 155Mbps
  • 100Mbps between Ciudad Juarez and El Paso (to Abilene)
  • vBNS via Houston
• CEDIA: Consorcio Ecuatoriano para el Desarrollo de Internet Avanzado.
• September 2002: launch ceremony
• October 2003, National Backbone CEDIA operational
• 15 Universities, 2 research centers and 2 government agencies.
• First quarter 2004, International connectivity operational.
• Red Universitaria Nacional – REUNA
• 10 POP’s from Arica to Valdivia
• 155 Mbps ATM/SDH Network
• over 30 universities
• Internet - Internet2 services
• 45 Mpbs to AMPATH
• G-REUNA:
  • backbone proyect
  • Gigabit and application test-bed
  • 140 km dark fiber, Santiago to Valaparaiso
• Red Teleinformática Académica
• Red RETINA:
  • ~25 institutions
  • International connection: 45 Mbps to AMPATH
• Abundance of fiber in main cities but challenge is expanding reachability into rest of country, plus other issues
Brazil – Sao Paulo

- Funded by FAPESP
- Sao Paulo's university networks and research centers
- Connect at 45 Mbps to AMPATH
- RNP PoP in Sao Paulo peers with ANSP

Source: http://www.ansp.br
Ireland - HEANET www.heanet.ie

- Serves the Irish universities
- Using 2 of several OC3 (155mbps) links to peer in NYC
- Upgrading backbone to 155mbps
The NORDUnet Network

- Connects together networks of Denmark, Iceland, Finland, Norway and Sweden
- Reworking 622mbps to New York (plus 155 to StarLight)

Providing transit to RUNNET (Russia), EENET (Estonia), UARNET (Ukraine) and NASK (Warsaw, Poland)
TERENA Snapshot of RENs

2006 Compendium
“Knowledge will forever govern ignorance, and a people who mean to be their own governors must arm themselves with the power which knowledge gives.”

— James Madison
TERENA: Core network capacity

Graph 3.2.1 Core Capacity on the Networks, 2003 - 2006, EU and EFTA Countries

Graph 3.2.2 Core Capacity on the Networks, 2003 - 2006, Other Countries
Connection Policy

- All NRENs connect universities, research institutes and, with few exceptions, institutes of higher education.

- Many NRENs also connect secondary and primary institutions, though there are great differences in policy.

- Some NRENs connect government departments that have a relation to research and education, etc.
Global Trend

Global REN: And now national RENs are connecting to each other creating advanced research and higher education network of continental proportion…
## Federation of RENs

<table>
<thead>
<tr>
<th>Network</th>
<th>Name</th>
<th>Region</th>
<th>Members</th>
</tr>
</thead>
<tbody>
<tr>
<td>APAN</td>
<td>Asia-Pacific Advanced Network</td>
<td>All Asia</td>
<td>All Asia</td>
</tr>
<tr>
<td>TEIN2</td>
<td>Trans-Eurasia Information Network</td>
<td>Asia Pacific</td>
<td>Australia, China, Indonesia, Korea, Malaysia, The Philippines, Thailand and Vietnam with Europe</td>
</tr>
<tr>
<td>EUMEDCONNECT</td>
<td>Europe and Mediterranean Education Network Connect</td>
<td>Mediterranean</td>
<td>Algeria, Cyprus, Egypt, Israel, Jordan, Lebanon, Malta, Morocco, The Palestinain Authority, Syria, Tunisia and Turkey</td>
</tr>
<tr>
<td>Nordunet</td>
<td>The Nordic Internet Highway to Research and Education Networks</td>
<td>Nordic Europe</td>
<td>Denmark, Finland, Iceland, Norway and Sweden</td>
</tr>
<tr>
<td>GEANT2</td>
<td>Network for Southeast Europe</td>
<td>All Europe</td>
<td>30 RENS from all Europe</td>
</tr>
<tr>
<td>ALICE</td>
<td>America Latina Interconectada Con Europa</td>
<td>Latin America</td>
<td>Argentina, Brasil, Chile, Costa Rica, Guetemala, Mexico, Panama, Paraguay, Peru, Uruguay, Venezuela, Bolivia, Columbia, Honduras, Nicaragua, Cuba, El Salvador, and Ecuador</td>
</tr>
<tr>
<td>ERNESIA</td>
<td>The Educational Research Network in East and Southern Africa</td>
<td>East and Southern Africa</td>
<td>Botswana, Ethiopia, Kenya, Lesotho, Malawi, Mozambique, Namibia, Swaziland, Tanzania, Uganda, Zambia and Zimbabwe</td>
</tr>
<tr>
<td>ERNWACA</td>
<td>The Education Research Network for West and Central Africa</td>
<td>West and Central Africa</td>
<td>Benin, Burkina Faso, Côte d'Ivoire, Ghana, Guinea, Mali, Nigeria, Senegal, Sierra Leone and Togo</td>
</tr>
</tbody>
</table>
• 31 countries connecting
• Operated by DANTE
• 10 Gbps core backbone
  • Connectors at 10Gbps(2) and below
• Total of 4x2.5Gbps + 2x1Gbps across Atlantic (DANTE & EuroLink provided)
Europe – International connectivity

REF: Report on present status of international connectivity in Europe and to other continents, From SERENATE – Study into European Research and Education Networking As Targeted by eEurope, http://www.serenate.org/publications/d6-serenate.pdf
• APAN: Asia-Pacific Advanced Network
• Partner in TransPAC link
• Several national networks moving to 10Gbps
• APAN network made up of country-owned point-to-point links contributed to APAN
• Trans Eurasia and Trans Pacific connectivity increasing
• The latest fiber now will connect South Asia with South East Asia RENs.
• Connections APAN to US
  • Currently 2xOC12 Tokyo – Seattle, Tokyo - Chicago
  • Upgrading to 2.5Gbps Tokyo – Los Angeles and 2x1GbE Tokyo - Chicago
  • Funded by NSF and Japanese government

SRC: http://www.transpac.org
During last 3 years, several firms have been building optical fiber rings in LA&C.

- Significant projects underway
- Opening exciting and new possibilities for cooperation in advanced technological and scientific applications

Panamerican
Global Crossing & Emergia
ImpSat
Transandino
UniSur
Global Crossing
Africa

- No dedicated R&E network connectivity from African continent
- Some national inter-university connections:
  - South Africa: Tertiary Education Network (TENET)  
    [http://www.tenet.ac.za/](http://www.tenet.ac.za/)
  - Egypt: Egyptian Universities Network (EUN)  
    [http://www.frcu.eun.eg/](http://www.frcu.eun.eg/)
  - Morocco: Maroc Wide Area Network (MARWAN)  
    [http://www.marwan.ac.ma/](http://www.marwan.ac.ma/)

National Institutes of Health MIMcom project

- Satellite connectivity to malaria research sites in Ghana, Kenya, Tanzania  
REN Services & Applications

RENs are spearheading a new generation of advanced applications and services.
Network Services

- Network Operating Centers
- Network Monitoring and Measurement
- Certificate Server
- Federated Authorization & Authentication Infrastructure (AAI)
- Bandwidth on Demand
- Eduroam a facility that provides roaming access for university users to wireless networks.
Digital Divide & Basic Edge Services

• Many developing world institutions do not have even basic internet services (email for UG, user web-pages).

• A REN can provide cost-effective ways to rapidly bridge the digital divide:
  • Federated perpetual email.
  • Course ware management
  • Web hosting
  • Digital library access.
  • Publishing services/Journal centers

• Paperless University

“But...there is a growing digital divide between those who have access to the digital economy and the Internet and those who don’t, and that divide exists along the lines of education, income, region and race.... The very information technology driving this new economy gives us the tools to ensure that no one gets left behind....”

-Bill Clinton, 1999
Services Applications

- Digital Library
- E-Learning/ Distance Education
- GRID Computing
- IP Telephony (inter REN gateway forwarding)
- Video Conferencing
- Virtual Conference
- Advanced Laboratory Sharing
A look at REN Services:

Federated Digital Library
Grand projects are now underway to digitize all available books that mankind possess. Some estimate as much as 10 million books will be soon freely available on our desktops in few years.

Some of the most valuable resources used to be available only to the limited scholars in the developed world. But now one can ‘scroll’ the intricate details of original Diamond Sutra— which its original printer Wang Jie “reverently made for universal free distribution on behalf of his two parents” in 868 AD, or literally ‘turn’ the pages of Sultan Bayber’s magnificent Quran (digital library of British Library, 2005). Materials now can be made universally available irrespective of constraints of time and distance.

The library connects us with the insight and knowledge, painfully extracted from Nature, of the greatest minds that ever were, with the best teachers, drawn from the entire planet and from all our history, to instruct us without tiring, and to inspire us to make our own contribution to the collective knowledge of the human species. I think the health of our civilization, the depth of our awareness about the underpinnings of our culture and our concern for the future can all be tested by how well we support our libraries.

— Cosmos
Carl SAGAN
• Some of the publishers are very large organization. A federated approach provides higher education community leverage to negotiate better rates for contents.

• Avoid paying duplicate subscription for the same journals by multiple institutions.

• The REN provides fast access to the vast amount of digital education resources which are available worldwide- but can not be accessed otherwise.

• Information property is fast becoming a major commodity in 21st century. communities needs to maintain indigenous expertise to safe guard its financial and strategic rights and interests in this new world. National digital library will help in nurturing this safeguard.
Digital Library Consortium Models

- Developed World/ USA & Europe
  - Initiated by States. (OhioLINK USA)
  - Major libraries are building electronic confederations from state sponsorship, to save and expand into new service.

- Developing World/ INDIA, Pakistan
  - Initiated by UGC/HEC
  - Only opportunity to reduce digital divide.
  - Huge capital saving initiative when most countries are facing rapid expansion of costly higher education need.
OhioLINK: Digital Library Alliance

• The Ohio Library and Information Network (OhioLINK) is a consortium of Ohio’s college and university libraries and the State Library of Ohio. Serving more than 600,000 students, faculty, and staff and researchers at 85 institutions. OhioLINK serves faculty,

• Membership:
  • 17 public universities
  • 23 community/technical colleges
  • 44 private colleges
  • State Library System of Ohio.

• Assets:
  • Campus-based electronic library systems,
  • The OhioLINK Central Site and
  • Internet resources
OhioLINK Electronic Services

• Six main electronic services:
  • A library catalog
  • Research databases
  • A multi-publisher electronic journal center
  • A digital media center
  • A growing collection of e-books, and
  • An electronic theses and dissertations center.
OhioLINK Library Catalog

- More than 44.8 million library items.
- More than 9.67 million unique master records from its 85 institutions.
- Supports more than 4,500 simultaneous users.
- Also available to outside users via the Internet.
- Offers user-initiated, non-mediated online borrowing through its statewide library catalog.
- Students and faculty have the ability to request items electronically while searching the catalog.
- Provides a delivery service among member institutions to speed the exchange of library items.
- Users can create portal to receive alert etc.
OhioLINK Research Databases

- OhioLINK offers more than 100 electronic research databases, including full-text resources covering many academic areas at varying levels of detail.
- Generally, the user can find out which OhioLINK members possess copies of the cited journal or link to the relevant full-text article.
- OhioLINK’s electronic full-text resources include online dictionaries, literature, and journal articles.
- Access to the research databases is restricted to valid patrons at OhioLINK member institutions.
• OhioLINK Electronic Journal Center, a massive collection of full-text research journals.
• The EJC contains more than 6,400 scholarly journal titles from 80+ publishers across a wide range of disciplines.
• More than 4.68 million articles are downloaded each year from the EJC, with a total of more than 19.2 million articles downloaded since its inception.
### Table-1 Some National University Libraries Around South Asia

<table>
<thead>
<tr>
<th>Institution</th>
<th>Books</th>
<th>Serials</th>
<th>DL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jauharlal Nehru University, India</td>
<td>500,000</td>
<td>800</td>
<td>Yes</td>
</tr>
<tr>
<td>Bombay University, India</td>
<td>700,000</td>
<td>n/a</td>
<td>Yes</td>
</tr>
<tr>
<td>Chepauk Library, Madras University, India</td>
<td>509,263</td>
<td>642</td>
<td>Yes</td>
</tr>
<tr>
<td>Calcutta University, India</td>
<td>800,000</td>
<td>795</td>
<td>Yes</td>
</tr>
<tr>
<td>Punjab University, Pakistan</td>
<td>442,300</td>
<td>N/A</td>
<td>Yes</td>
</tr>
<tr>
<td>LUMS, Pakistan</td>
<td>52,000</td>
<td>325</td>
<td>Yes</td>
</tr>
<tr>
<td>Quaid-i-Azam University, Pakistan</td>
<td>195,000</td>
<td>276</td>
<td>Yes</td>
</tr>
<tr>
<td>University of Colombo, Sri Lanka</td>
<td>400,000</td>
<td>970</td>
<td>Yes</td>
</tr>
<tr>
<td>Tribhuvan University, Nepal</td>
<td>n/a</td>
<td>n/a</td>
<td>No</td>
</tr>
<tr>
<td>Royal University of Bhutan</td>
<td>n/a</td>
<td>n/a</td>
<td>No</td>
</tr>
<tr>
<td>University of Malaya Library, Malaysia</td>
<td>1,239,749</td>
<td>3631</td>
<td>Yes</td>
</tr>
<tr>
<td>Maldives has no University</td>
<td>X</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Dhaka University, Bangladesh</td>
<td>550,000</td>
<td>250</td>
<td>No</td>
</tr>
</tbody>
</table>
Potential benefits of digital libraries are more pronounced for the libraries of the developing countries.

An average US university spends about US$ 5 million in journals and periodicals, about US$ 2 million in monographs. It has about 3-8 million books and subscribes about 22,500 serials, and it adds about 30,000 books per year [2]. These are astronomical figures (20-150 times more) compared to the ability of most university in the developing world. For developing world the cost of collection and archiving of traditional print media is becoming prohibitively expensive. Particularly, hard hit areas are cost of periodicals and technological journals. Many libraries are rapidly shrinking.

Digital content reduces the cost to a library by a factor of ten [3]. A Federated model further shrinks the cost per institution. It seems developing countries can benefit more from the digital library technology. Digital technology might be the only way to narrow this access gap.
• Connect the Supercomputers (and all other computing resources) on RENs!
Expected Evolution of Grid

Cluster “Grids:
• Job scheduling and queueing on top of cluster servers

Enterprise and Interdepartmental Grids
• Interdepartmental authentication policy, security, accounting.
• Additional features like load balancing.
• Distributed CPU coordination.

Distributed/Partner Grid
• Distributed enterprise, campus, metro environment
• Introduces inclusion of partner companies.
• Policy management, security, multi-site load balancing
• Increased CPU sensitivity to network latency.

Country/Wide Area Service Grids
• Grid service infrastructure
• Issues below on a regional, national and global scale.
Grid Application in RENs

Currently 71 of EU RENS are running Grid and it will be 100% by next 2 years.
Not only High Energy Physics, the use is expanding in other areas as well.
Applications

Digital Audio & Video
Now that IP telephony and its protocols are becoming more mature and products more manageable, NRENs are starting to deploy it.

50% of the NRENs in the EU/EFTA countries are running an IP telephony deployment, while about 30% of the NRENs in other countries are running one.

NEXT: NRENs will begin exchanging IP telephony traffic- extending global direct dial and virtual phones; currently IP telephony peering architectures are being defined and operators are not yet ready to support it.
Internet2 Digital Videoconferencing Group

- World’s largest videoconference
- Uses H.323 videoconferencing and a system of distributed MCU’s located around the world
- Used in every fall Internet2 meeting

http://www.mega-net.net/megaconference/
Tele-Operation of Remote Equipment

- Computerized excavation backhoe
- Remotely operated, used in hazardous situations.
- Quality of Service is Guaranteed

North Carolina State University
Realistic, Life-Sized, 3D Tele-Immersion

- Brings together geographically distant participants and shared virtual objects
- Tele-immersive recreation of office environment

Advanced Network & Services, Brown University, University of North Carolina, University of Pennsylvania

http://www.cs.unc.edu/Research/stc/office/
Remote Rehearsal for Fine Arts
Unique Performance Events
Applications

Health & Medical
Improved Medical Training

- High bandwidth human interaction
- Low latency virtual reality
- Reliable access to computational resources
- Secure retrieval of medical images and data

Source: Parvati Dev
Stanford
Virtual Pelvic Floor

- Provides 3-D visualization of complex anatomical structures
- Participants use ImmersaDesk™ systems to interact with 3-D anatomical model

http://www.sbhis.uic.edu/vrml/Research/PelvicFloor/PelvicFloor.htm

University of Illinois at Chicago
Applications

Remote Instrumentation & Virtual Laboratories

July 2005
New Instruments for Astronomy
Undersea Oceanography

Images National Geographic
Future of Research & Higher Education

- No university, organization, national or regional body can succeed in isolation.

- Advanced Internet will be the key infrastructure component of an University.

- REN is needed to cope up with the advanced applications and systems being deployed/ envisioned by the current world university community. Universities without REN with be increasingly out of touch.

- RENs will enable advanced collaboration between researchers, scholars, research groups in a much more meaningful way across nations breeding new ideas.
Malaysian universities must place strategic high priority on ICT & networking infrastructure to connect scholars, scientists, and researchers both internally and internationally to keep its higher education system at-par with the world.

However, ICT itself is not the goal it’s a means to build a world-class technologically capable country.
Malaysian universities can be world leader in building digital heritage collections in several areas such as:

- Digital archives for Islamic treasures. [IIUM??]
- Ancient-cultural knowledge archive. [UPM?]
- Asia-Pacific bio-diversity archive. [??]
RENs and Inter-university collaboration can act as a harbinger for a new wave of vibrant intellectual and cultural collaboration in Malaysia.

- Technology is now dictating the collaboration.
- RENs can also revive ancient cultural and intellectual ties via technology (with countries like Singapore, China, Thailand, Indonesia, Pakistan, Bangladesh, Egypt, India, Yemen).
Acknowledgements

- Network MAPS provided by the NRENs.
- TERENA, Trans European Research and Education Networking Association, Compendium of NRENs, 2006.
Thank you!

“In the long course of history, having people who understand your thought is much greater security than another submarine.”

-J William Fulbright