Research Networking - Supporting (e)Science with Advanced Networking

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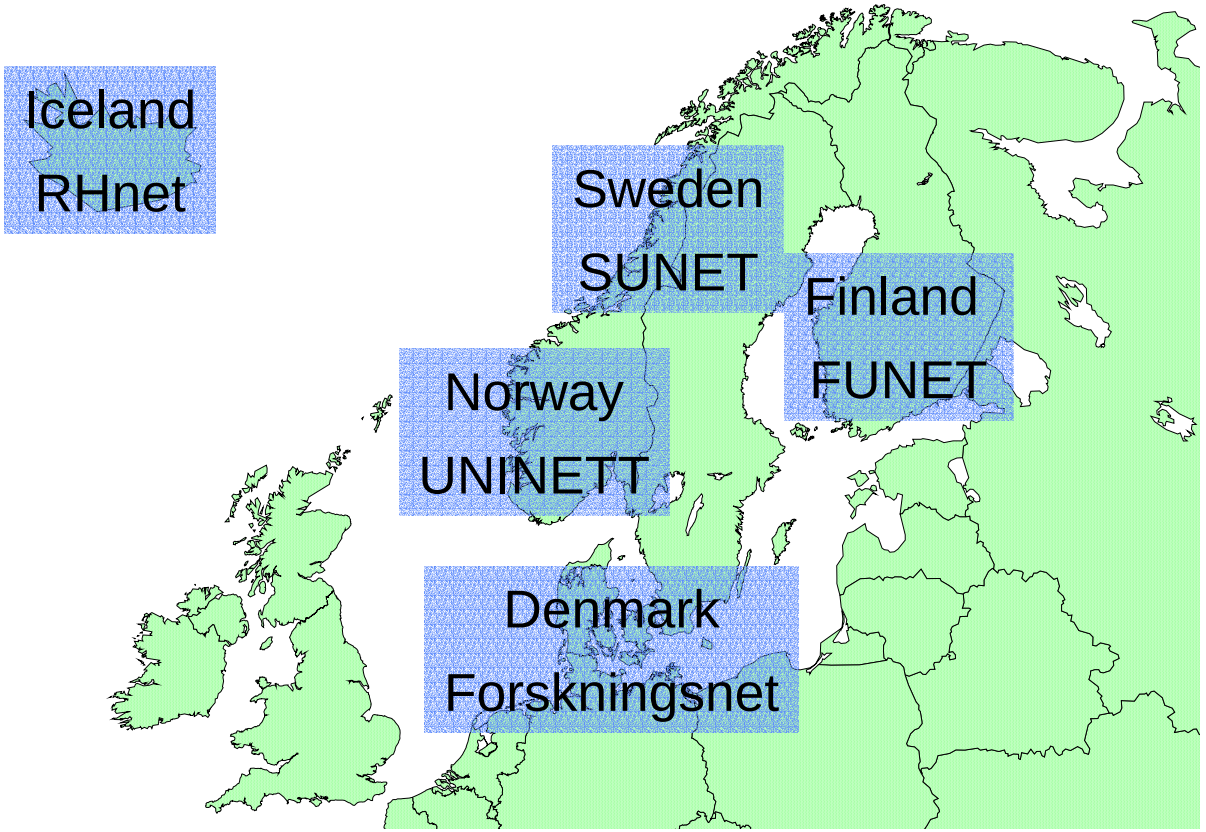
The NORDUnet collaboration



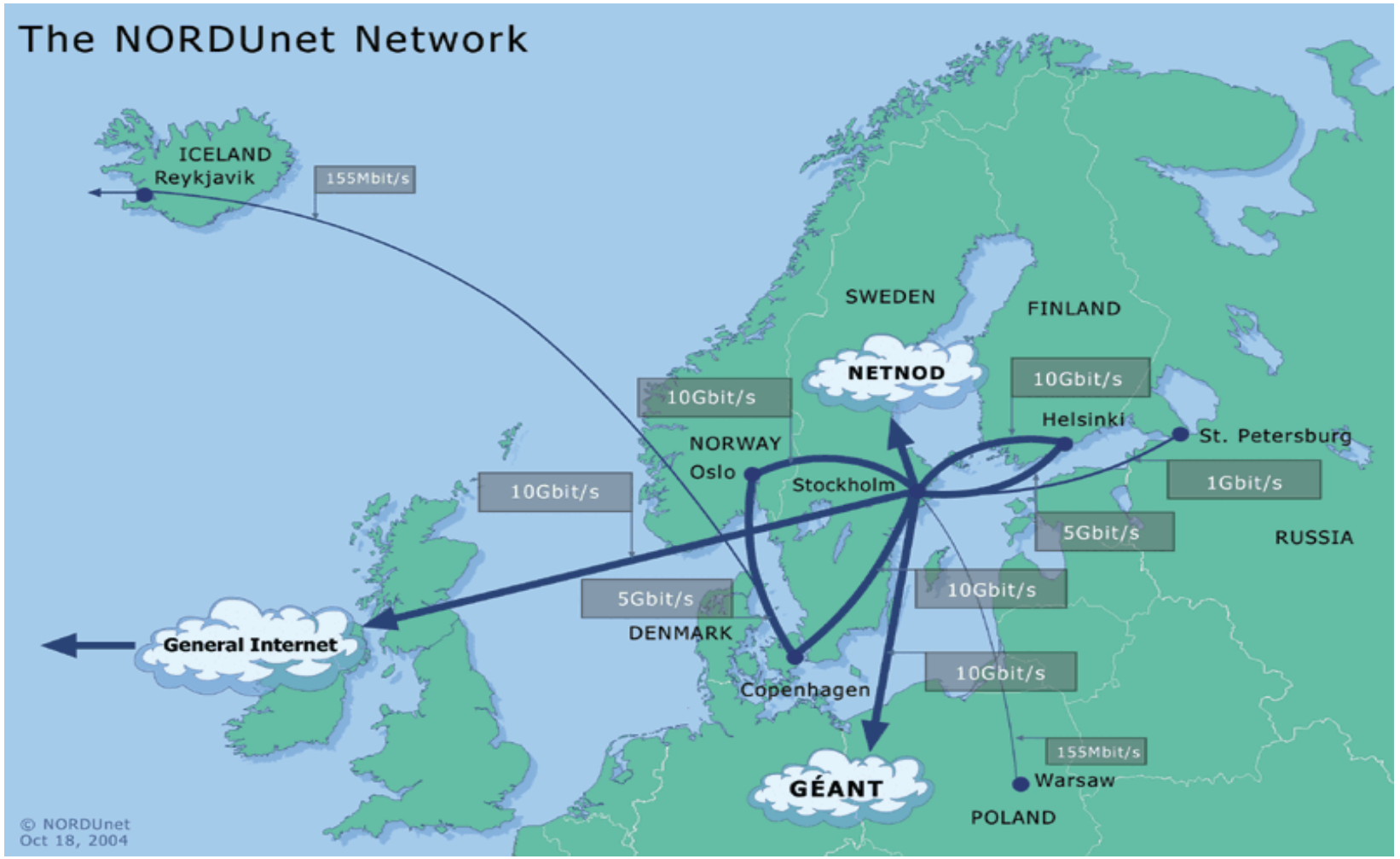
NORDUnet's Mission and Activities

- Mission
  - International service provider for the Nordic national networks for research and education
  - Nordic platform for
    - International research networking
    - Network development
- Activities
  - Research networking
  - Network development
  - Provision of General Internet connectivity

NORDUnet organisation

- Danish limited company
- Shareholders are the Nordic states or state institutions
  - DK - Ministry of Science
  - FI - Ministry of Education
  - IS - University of Iceland
  - NO - UNINETT
  - SE - National Agency for Higher Education
- Board members are managers of the Nordic national networks for research and education
- Financed by the Nordic national networks with GNP based cost sharing

NORDUnet IP network



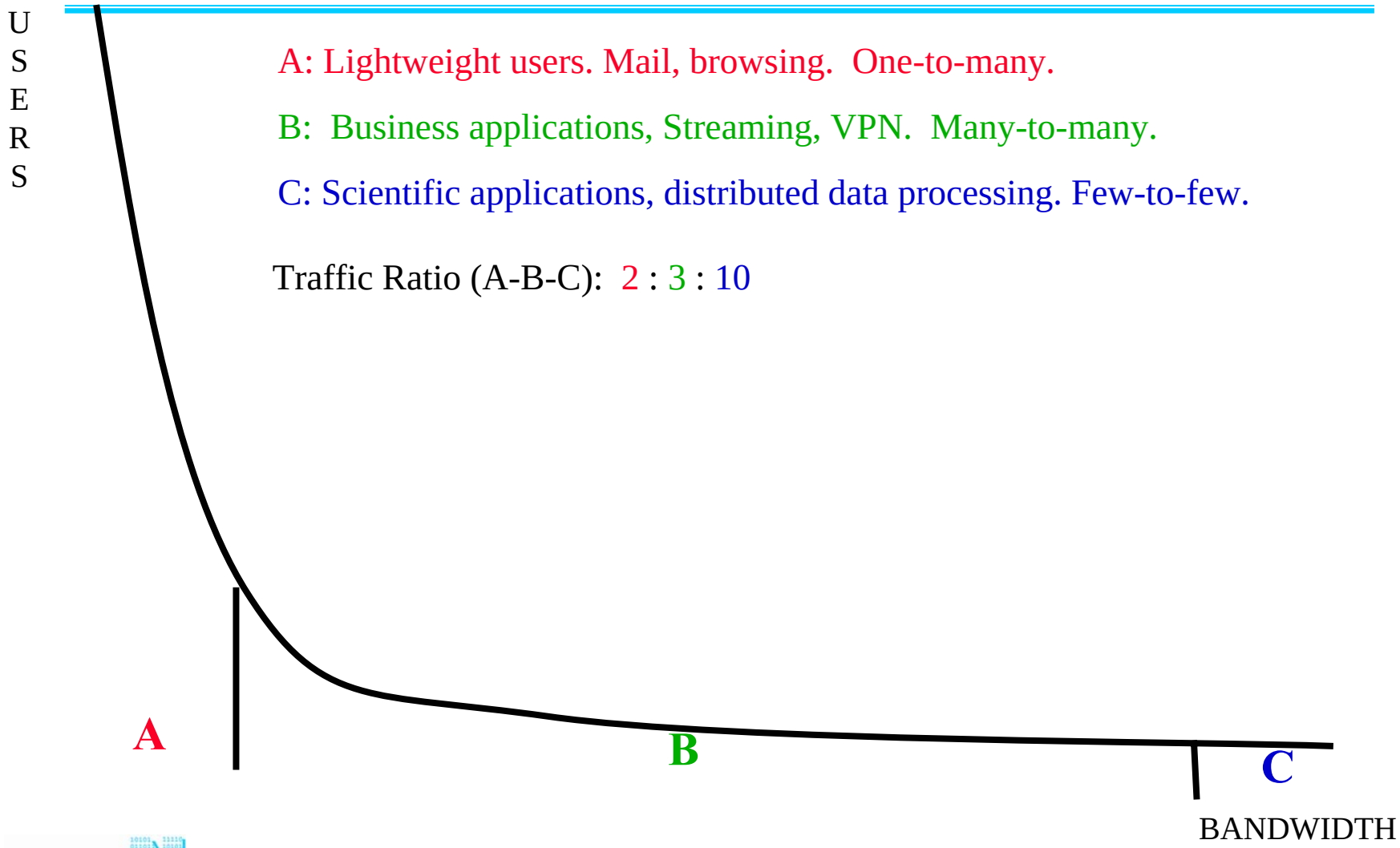
NorthernLight

- Experimental Lambda Network Facility
- Star network with Center i Stockholm, OC48 connectivity to Oslo, Helsinki, Copenhagen, Amsterdam
- Based on Cisco ONS-15445 equipment
- Provides 2 x GbE links between any two cities
- Connects to GLIF community via link to Amsterdam

What is a Research Network

- An ordinary ISP
  - ... and then some
  - Special resources and extra capacity for research
  - Services not yet commercially viable (or available)
- Responsibility for the Future of Networking
  - 25 years ago, NORDUnet was the first non-US network to become part of the Internet
  - NORDUnet brought IP out of the US and into Europe
  - NORDUnet helped Nordic countries secure a leading role
- Future developments
  - The GRID- and e-Science have special needs today. Maybe tomorrow everyone will have these needs
  - Networks for global integration and collaboration are being built today
  - The Baltic Countries, Russia, Asia are joining the club

Users of the Network



Who Are the Heavy Users?

- Small Teams, Groups or Projects
  - Collaboration specific to a discipline or project
  - Shared resources
  - International (global) collaboration
  - Communication mainly internal
- Sharing of Scientific Instruments
  - Radio telescopes
  - Electron microscopes
  - The CERN LHC experiments
- Sharing of Computer Resources or Large Datasets
  - Large, discipline-specific, shared datasets (cancer research, genetics)
  - Global workflow (movie production)
  - Shared computing resources (simulation, environmental modeling)
- Communication
  - Visualization
  - Large-scale video-conferencing

How do we Service the Heavy Users?

- Heavy users cause problems for shared networks
  - Order of magnitude more capacity than ordinary users
  - Heavy Users drive the development & expansion of the network
  - Expensive to support shared-IP functions for big flows:
    - Many-to-many
    - Routing
    - Fault tolerance, resilience
  - Heavy users may not need these functions
- Proposed solution
  - Isolate the Heavy Users in simple, dedicated networks
  - Special-purpose, permanent of time-limited networks for the needs of major applications and projects
  - Use expensive network technology for the many with little traffic, and cheap technology for the few with lots of traffic.

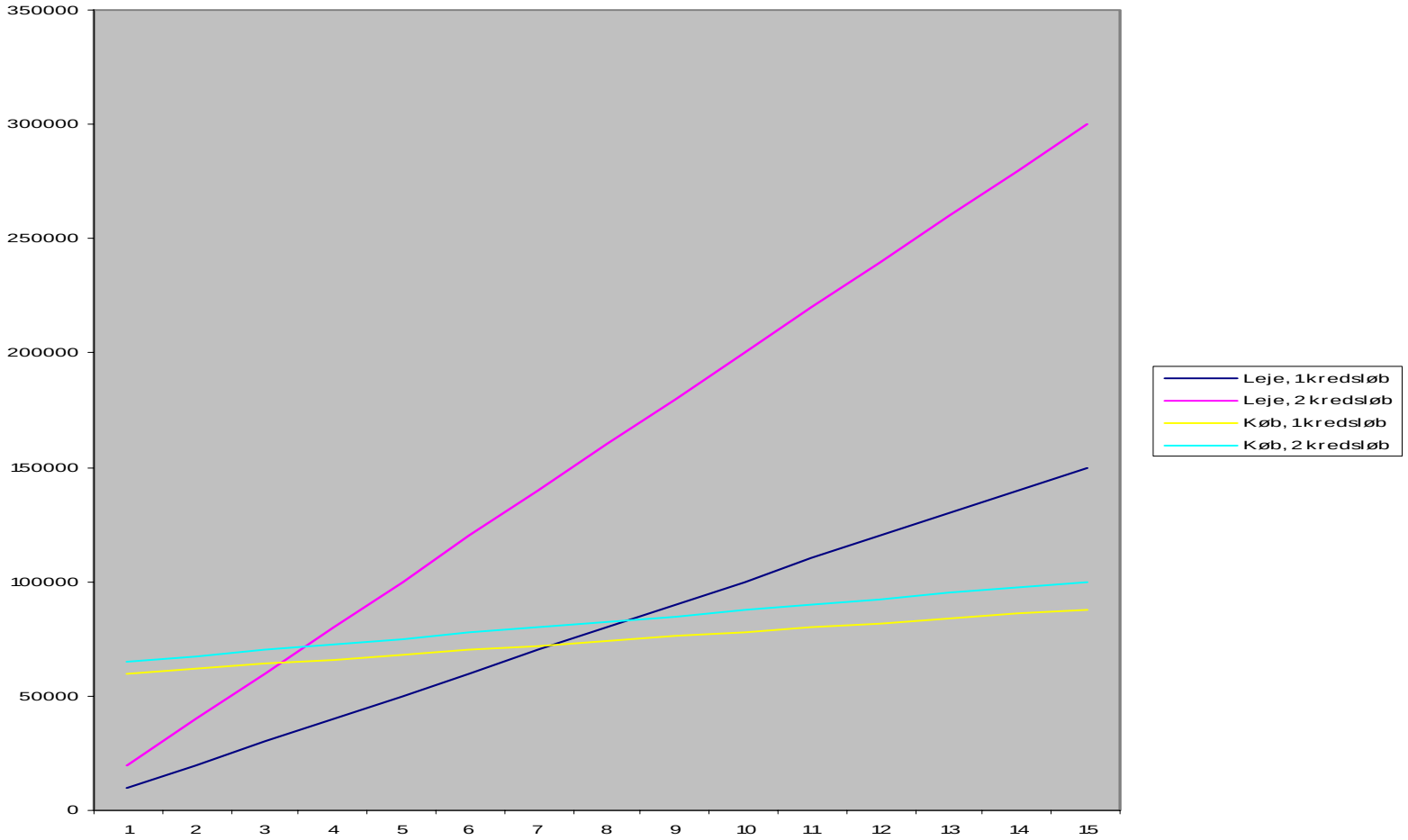
Hybrid Networking

- Design goal:
  - Support all classes of users, with high-quality, high-throughput network, in a cost-effective way
  - Push large flows to the lowest network layer possible
- Rationale: port prices:
  - Layer 1: 0,5 – 1,5 k$/port
  - Layer 2: 5-10 k$/port
  - Layer 3: 75+ k$/port
- Benefits:
  - Layer 3 functionality supported where needed, but not paid for where not needed
  - Enable Optical Private Networks
  - Enable guarantees for performance, capacity
- Not about doing away with shared IP – on the contrary, this increases the value and reliability of shared IP for everybody

Building Hybrid Networks

- Building Hybrid Networks require
  - New technology & skills
  - Control of additional aspects of the network
- Essential Technology: Optical Fiber and DWDM
  - DWDM (Dense Wave Division Multiplexing): using multiple wavelengths (colors) in a single fiber, for up to 72 40 Gbs channels in a single fiber
  - DWDM is independent of higher-level protocols
  - Each wavelength can support a different service and network topology
  - Only one fiber needed for a hybrid network
- Why cotrol Your Own Fiber / DWDM
  - Low incremental cost
  - Ability to use new technologies
  - Well positioned for international collaborations

Network Cost



NORDUnet Hybrid Network

- Hybrid Networking is a Research Networking Trend
  - Many National and International Networks are building
  - SURFnet, CANARIE, GEANT2, NLR, DFN, NORDUnet, SUNET, ...
- Approach
  - Direct access to fiber (multi-year contract)
  - Ownership of DWDM
  - Access to breakout points
- Services:
  - Point-to-point trasport: 1 GigE, 10 GigE, OC48, OC192
  - Hand-over interfaces to member networks and international networks
  - Support higher-level services, i.e., transport for NORDUnet Shared IP service
- Oslo-Stocholm-Copenhagen ring + Stockholm-Helsinki ring
- Operational by June 2006

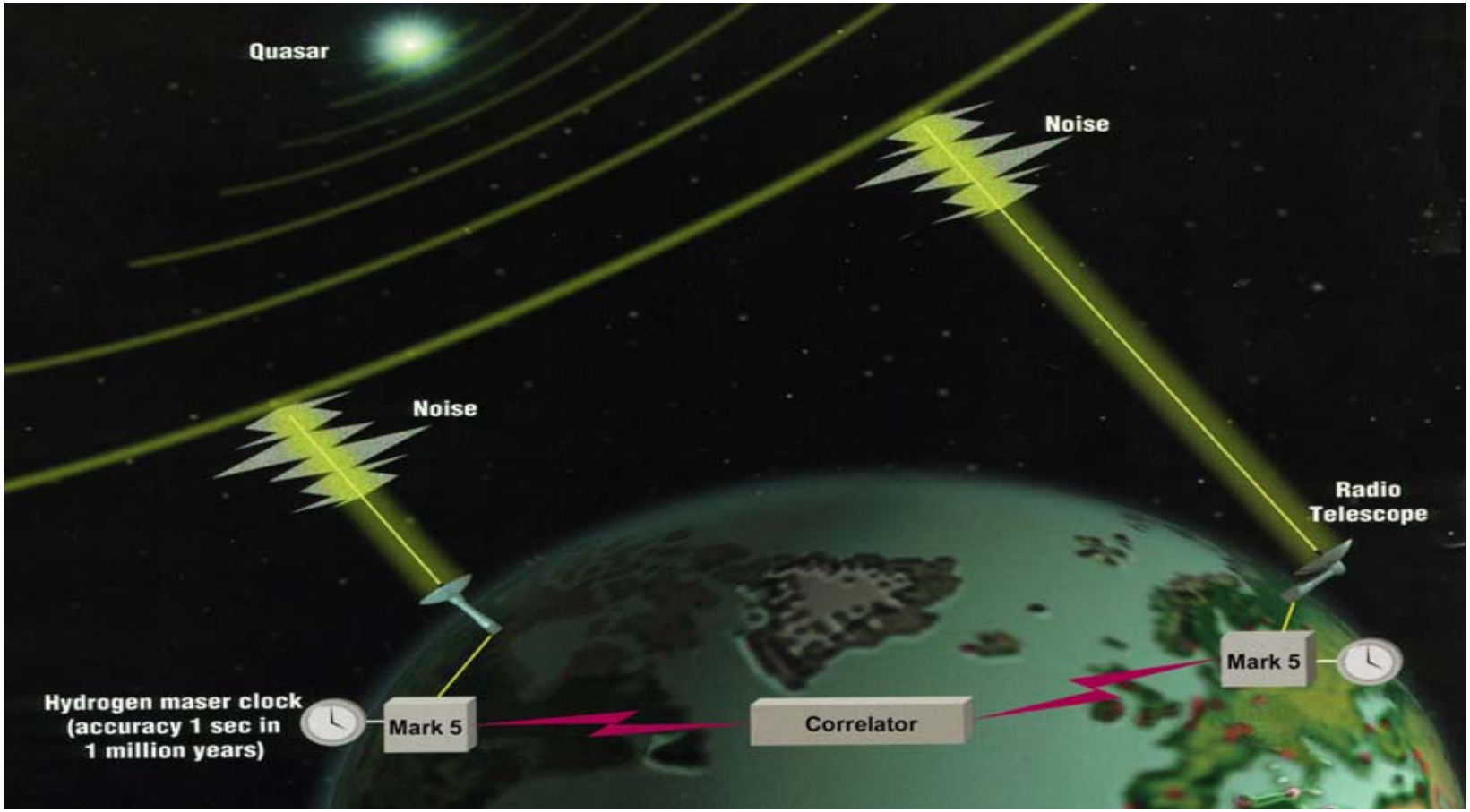
OptoSunet

- New SUNET infrastructure
  - Optical network based on dark fiber
  - To replace existing GigaSunet infrastructure
  - To be fully operational by end of 2006
  - Expects 8-12 year lifetime for fiber infrastructure and 5-8 years lifetime for attached electronics
- A routed IP network
  - 2 x 10GE (redundant) to all universities, upgradeable to 40G
  - Possibly 2 x GE to small, regional universities
- A dedicated point-to-point connection service
  - n x GE
  - (2.5 Gbit/s POS)
  - n x 10 GE
  - 40 Gbit/s

Evolving the Shared IP Network

- More important than ever
  - Increase capacity, quality of service, connectivity
  - More, and more demanding, users
  - Can service the vast majority of users and uses, including at the high end
  - Shared IP is **not** going away anytime soon
- Higher-level services – beyond basic networking
  - Example: Nomadic (mobile) users, i.e., Eduroam
  - Also AAI, storage, resource sharing, grid, etc.
- Instrumentation – supporting high-performance users
  - Enabling path breakdown for bandwidth (BWCTL) and latency (OWAMP) measurements. Semi-public measurement stations a central network locations
  - PerfSONAR: global network measurement infrastructure with public visualization
  - SCAMPI and LOBSTER: 10 gig passive network monitoring

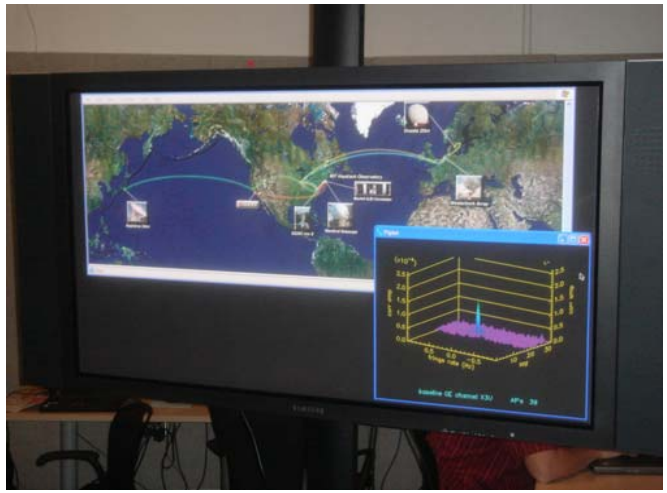
Example: e-VLBI



Very-Long Baseline Interferometry (VLBI)

iGrid2005 e-VLBI demo

- In September 2005, at iGrid2005, at team from USA, Denmark, Sweden, Netherlands, UK, Japan demonstrated for the first time real-time e-VLBI between two continents
- The experiment involved two telescopes in the USA and one at Onsala, Sweden, and a computing centre in USA
- For the experiment, a dedicated network of 512 Mbps for each telescope was used
- The network was completely controlled by the team
- Network supplied by NORDUnet, SUNET, UKLight, HOPI, and others.
- At SuperComputing2005 additional telescopes will be used



NORDUnet

Example: Global Visualization

- **At iGrid2005 (NL) demonstrated visualization streaming. A Simulation was run in Amsterdam and displayed in San Diego.**
- **Total bw: 19 Gbps**

A ”LambdaVision” display, built from 55 LCD screens. Total resultion: 17.600 x 6.000 pixels

Challenges in Hybrid Networking

- Hybrid Network is new and brings new challenges
- New Operations challenges (for research networks)
  - Managing fiber infrastructure – and faults
  - Managing DWDM equipment
  - Provisioning and delivery – across administrative domains
- Cost and Fairness
  - How to calculate and distribute the cost
  - How to ensure that a limited resource (72 channels!) is handed out in a fair manner?
- Supporting Optical Private Network users
  - OPN design?
  - OPN operations?
- Dynamic, User-Controlled Provisioning
  - On-demand provisioning of transport capacity?
  - User control of capacity and topology?

Supernetworking

- 1986- : Supercomputing
  - Supercomputing became the driver for many areas of science
  - Supercomputing made new applications and approaches possible
  - The Internet was built to support and access supercomputing
- 2000- : Supernetworking
  - Supernetworking is a driver for many areas of science
  - Supernetworking makes new applications and approaches possible
  - Accessing computing resources is a service in the network
- At iGrid2005, 200 Gbps from around the globe was supplied to one building in San Diego
- New Infrastructure
  - Supernetworking demands ownership of lower layers of infrastructure
  - Supernetworking requires dynamic networks and user control
  - Will this be the future of networking?

Thank You