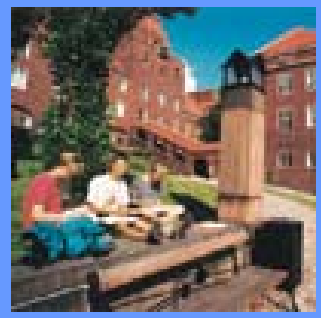
Nordic Grid Consortium

CSC
Helsinki

Parallab
Bergen



PDC
Stockholm

Petter Bjørstad, Parallab

Lennart Johnsson, PDC

Jari Järvinen, CSC

Why Grids

- Science has no bounds
- Science is increasingly based on (international) teams
- Sharing of unique (and scarce) instruments
- Sharing of data
- Sharing of human resources and expertise

Fiberoptic Communication

In 2010

a million books can be sent across the Atlantic for 1$ in 8 seconds

all books in the American Research Libraries can be sent across the Atlantic in about 1 hr for $500

Fiberoptic Communication Milestones

- First Laser 1960
- First room temperature laser, ~1970
- Continuous mode commercial lasers, ~1980
- Tunable lasers, ~1990
- Commercial fiberoptic WANs, 1985
- 10 Tbps/strand demonstrated in 2000 (10% of fiber peak capacity). (10 Tbps is enough bandwidth to transmit a million high-definition resolution movies simultaneously, or over 100 million phone calls).
- WAN fiberoptic cables often have 384 strands of fiber and would have a capacity of 2 Pbps. Several such cables are typically deployed in the same conduit/right-of-way

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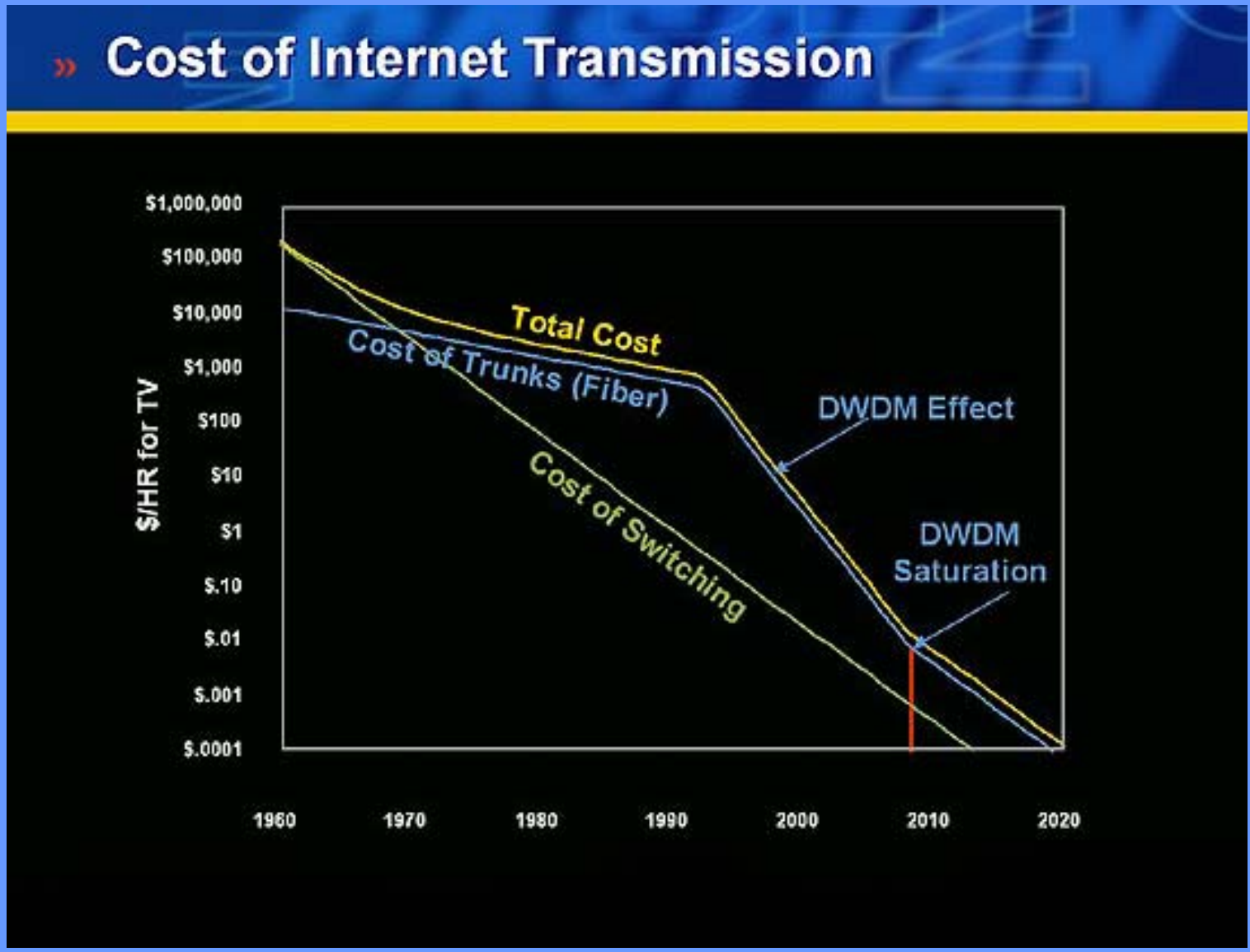

L Roberts
Caspian
Networks

Nordic Grid Consortium

Cost of Fiberoptic Communication (2000)

- Fast Ethernet transceivers, 80 km, $700
- Gigabit Ethernet transceivers, 60 km, $2000
- 10 Gigabit Ethernet transceivers, 40 km, sampled.
- Ethernet typical price curve: factor of two/year
- MAN/WAN fiber cost: $0.5 – 6/strand meter, expected to drop to $0.07 – 0.10.
  - Installation: $3 – 200/m
  - Fiber: $0.05 – 0.15/strand meter
  - Termination: Several hundred dollars plus a few dollars/strand

Fiberoptic Communication Cost

Example: US – Europe

Installation cost: $1billion
Capacity: 384 strands operating at 1 Tbps peak
Utilization: 10 %
Amortization: 10 yr
Cost/sec: 1 billion/(10x8760x3600)= $3/sec
Effective capacity: (384/2)x(1 Tbps)x0.1 = 19 Tbps
Cost/bit: ~$0.15/Tb or about a dollar/Tbyte.
(or ~$100/Tbyte at 10 Gbps/strand)

The Battle of the Atlantic

Capacity coming online	Gbps*	RFS
Level 3/Global Crossing (Project Yellow)	3Q00	1,280
TAT-14 (Club)	640	4Q00
FLAG Atlantic-1 (FLAG/GTS)	2,560**	2Q01
Hibernia (360networks, Inc.)	1,920	2Q01
Atlantic Crossing -2 (Global Crossing)	2,560***	1Q01
TyCom Global Network	2,560	4Q01
Oxygen	No Go!	-------
Total	8,960	

Does not include C&W Apollo cable (RFS 2003)

* = Design capacity
** = Teleglobe buying 2 fibers
*** = Cancelled, AC-2 joining Level 3

The World Wide Computer

- Internet Provides Connectivity
- Web Provides Hyperlinked File System
- Distributed Storage Moving from SAN to NAS
- Peer-to-Peer Computing Provides Vast CPU Power
- Result--The Distributed Global Computer
  - Storage everywhere
  - Scalable computing
  - Wireless Interfaces Greatly Outnumber PC Interfaces

"When the Network is as fast as the computer's internal links, the machine disintegrates across the Net into a set of special purpose appliances"

-Gilder Technology Report June 2000

Courtesy Smarr/Stevens

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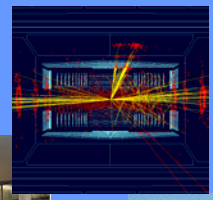
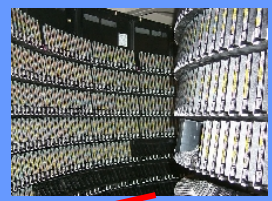
E-Science: Data Gathering, Analysis, Simulation, and Collaboration





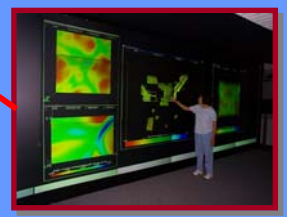












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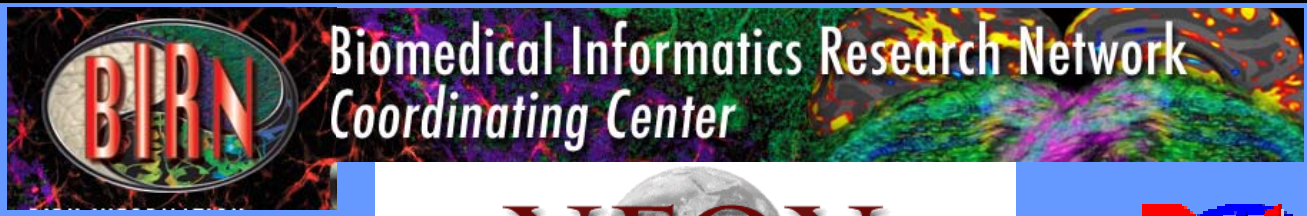
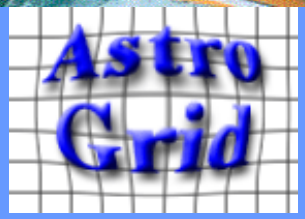
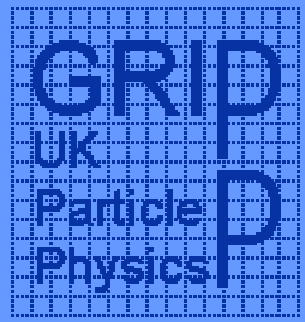
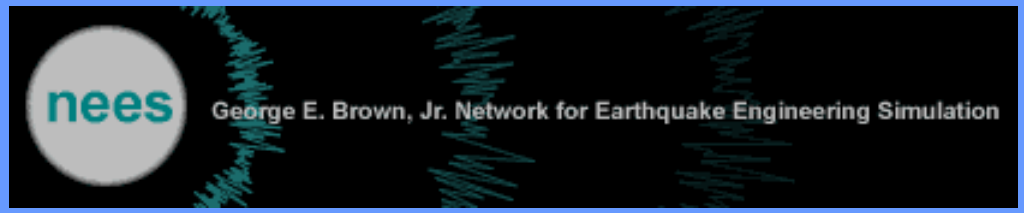


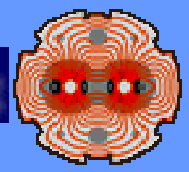
PAMELA





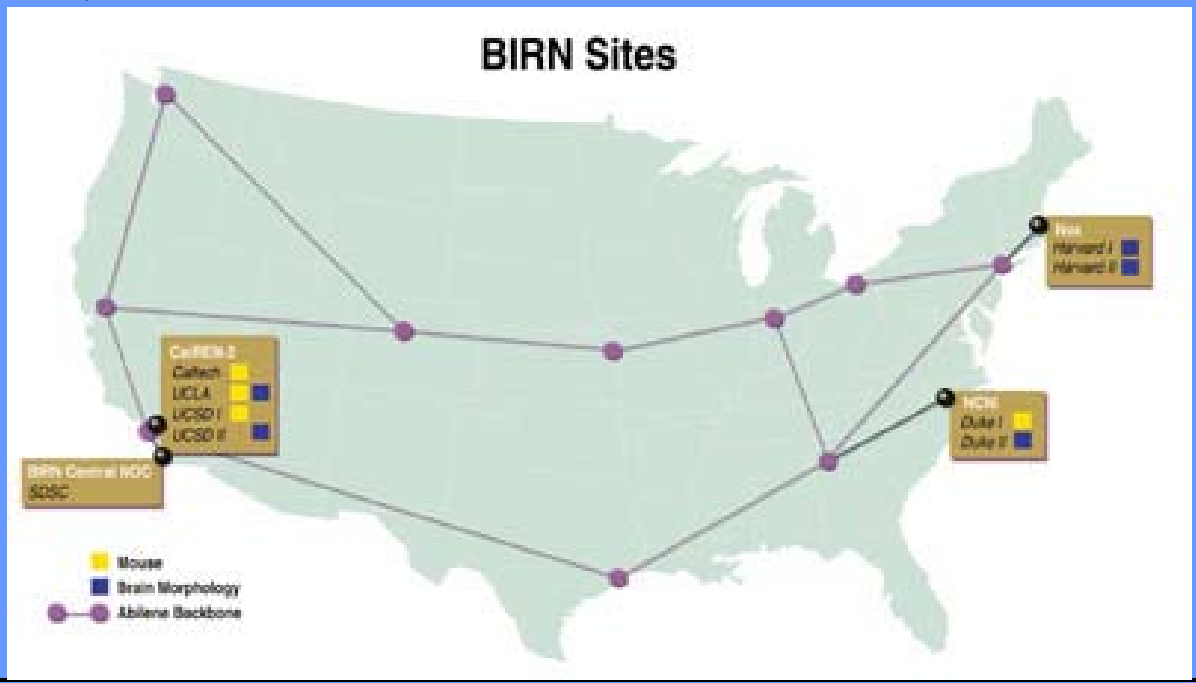


LHC The Large Hadron Collider Project



BIOMEDICAL INFORMATICS RESEARCH NETWORK (BIRN)

The BIRN is an NCRR initiative aimed at creating a testbed to address biomedical researchers' need to access and analyze data at a variety of levels of aggregation located at diverse sites throughout the country. The BIRN testbed will bring together hardware and develop software necessary for a scalable network of databases and computational resources. Issues of user authentication, data integrity, security, and data ownership will also be addressed. $20M.



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A NATIONAL DIGITAL MAMMOGRAPHY ARCHIVE

Digital Mammography

- About 40 million mammograms/yr (USA) (estimates 32 – 48 million)
- About 250,000 new breast cancer cases detected each year
- Over 10,000 units (analogue)
- Resolution: up to about 25 microns/pixel
- Image size: up to about 4k x 6k (example: 4096 x 5624)
- Dynamic range: 12-bits
- Image size: about 48 Mbytes
- Images per patient: 4
- Data set size per patient: about 200 Mbytes
- Data set per year: about 10 Pbytes
- Data set per unit, if digital: 1 Tbytes/yr, on average
- Data rates/unit: 4 Gbytes/operating day, or 0.5 Gbytes/hr, or 1 Mbps
- Computation: 100 ops/pixel = 10 Mflops/unit, 100 Gflops total; 1000 ops/pixel = 1 Tflops total

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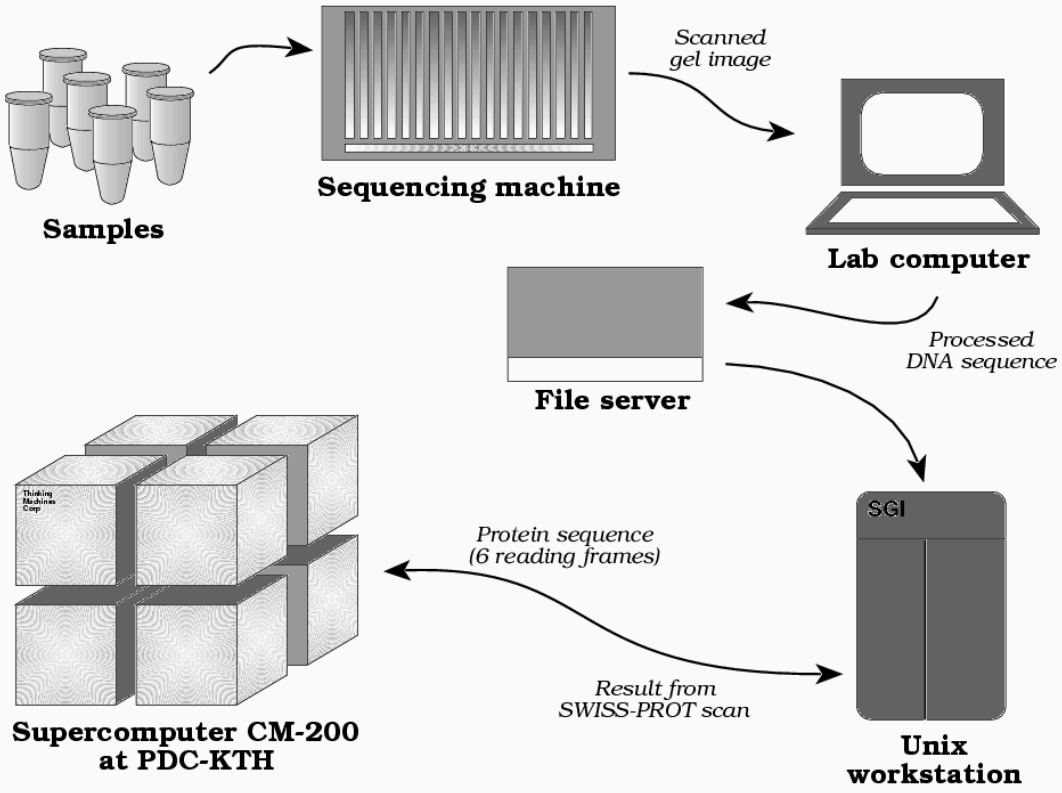
Automated Massive DNA Sequencing

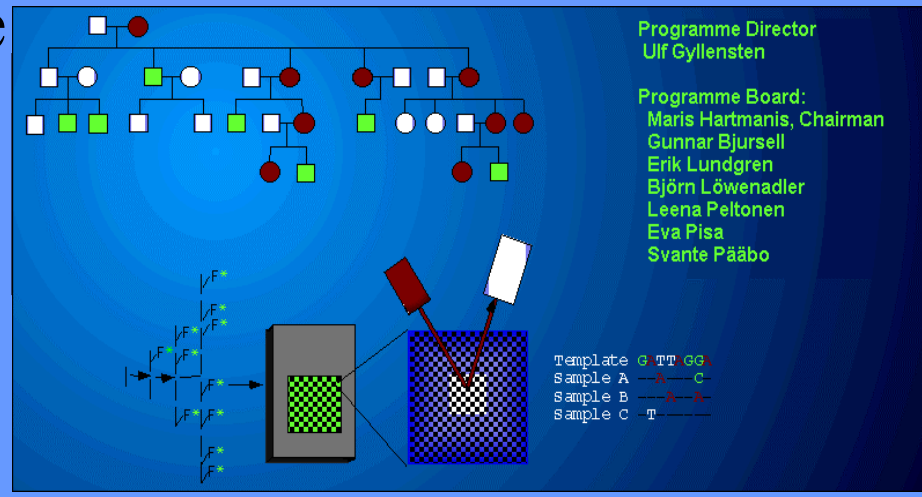


PDC in collaboration with Center for Structural Biochemistry, KI 1992

Nordic Grid Consortium

UU/SSF National Large-Scale Genotyping laboratory, since 1998

- Data repository and long term storage at PDC



Genotyping Machine

HSM

toad.pdc.kth.se

betula.genpat.uu.se

http://genpat.pdc.kth.se:8001/

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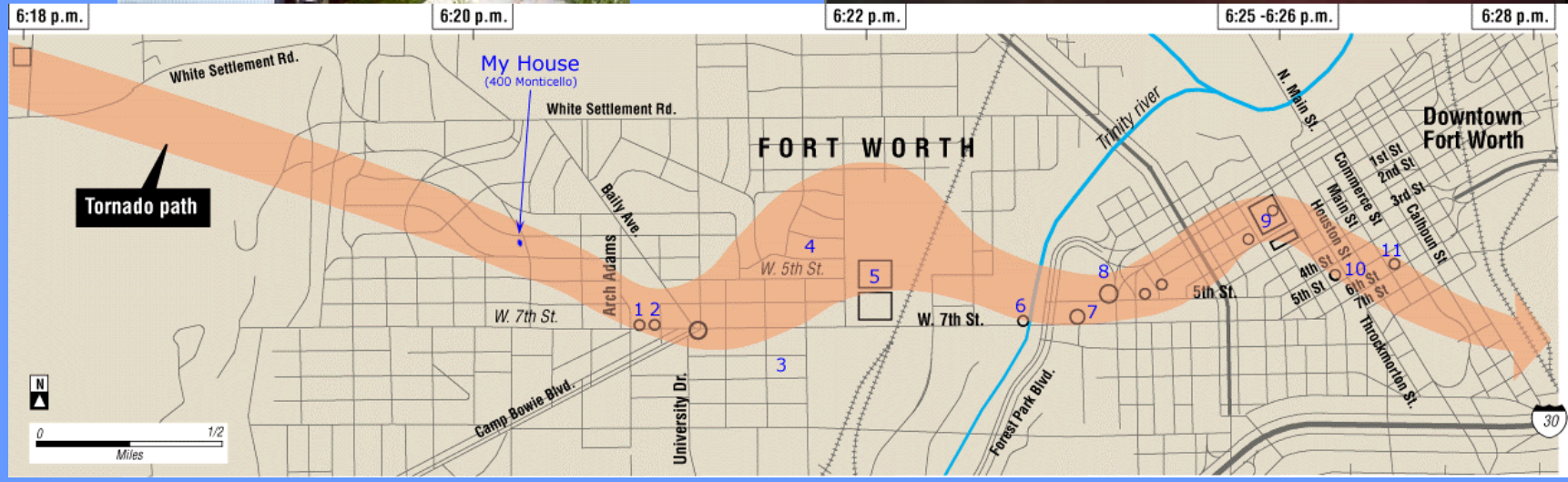
March 28, 2000 Fort Worth Tornado



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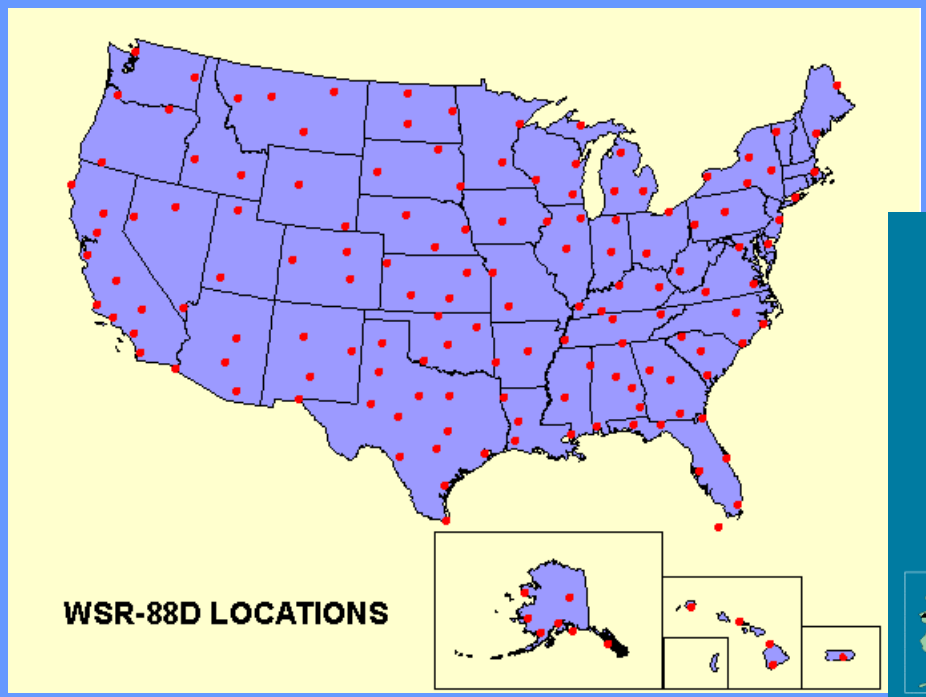
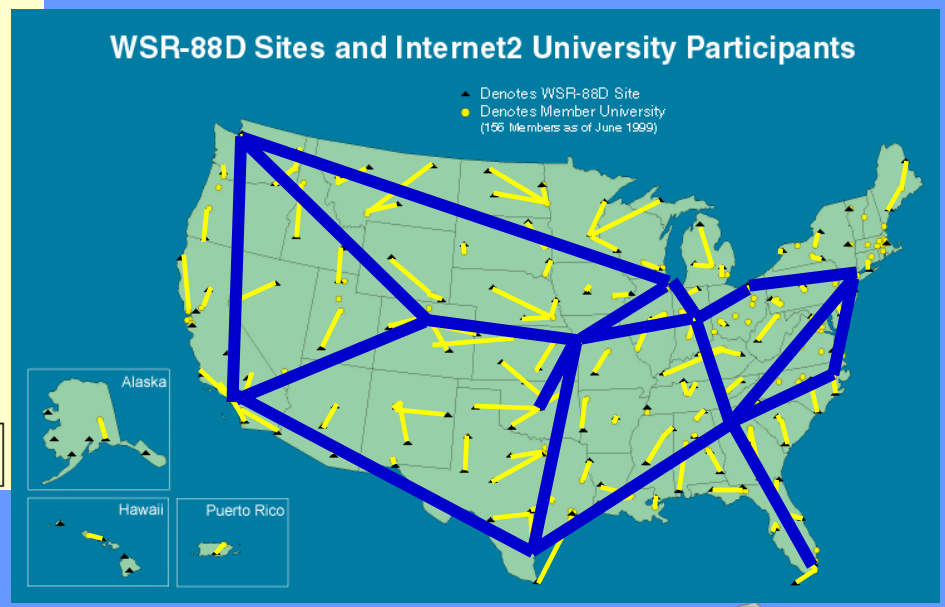
In 1988 … NEXRAD Was Becoming a Reality





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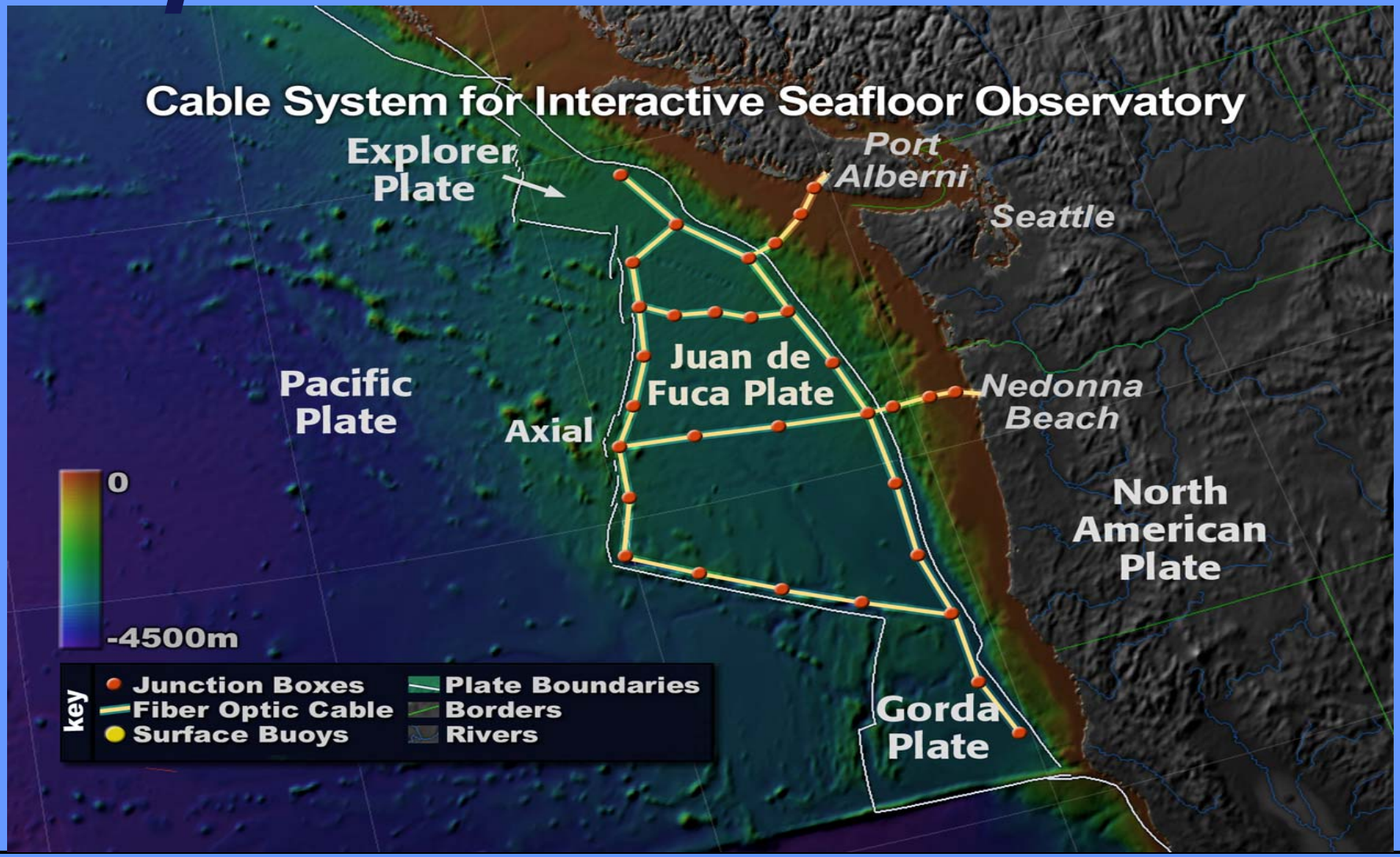
Neptune – Undersea Grid



Neptune
Fiberoptic Telescope to Inner Space

- NEPTUNE's 3000 kilometers of fiber-optic cable will provide power and communications to scientific instruments.
- The system will provide real-time flow of data and imagery to shore-based Internet sites. It will permit interactive control over robotic vehicles on site and will provide power to the instruments and vehicles. NEPTUNE may also serve as a unique testbed for sensor and robotic systems designed to explore other oceans in the solar system.
- The NEPTUNE network is expected to be operational by 2006 and will cost approximately $250 million to develop, install, and operate through the first five years.
- The NEPTUNE system must have the following characteristics to meet the scientific requirements:
  - Plate scale (covering the full Juan de Fuca tectonic plate)
  - Power (order of tens of kW)
  - Bandwidth (order of many Gbits/sec)
  - Real-time data return and robotic control capability
  - Robust design for high reliability
  - Precision timing at all instruments
  - Available for nominal 20-30 years.

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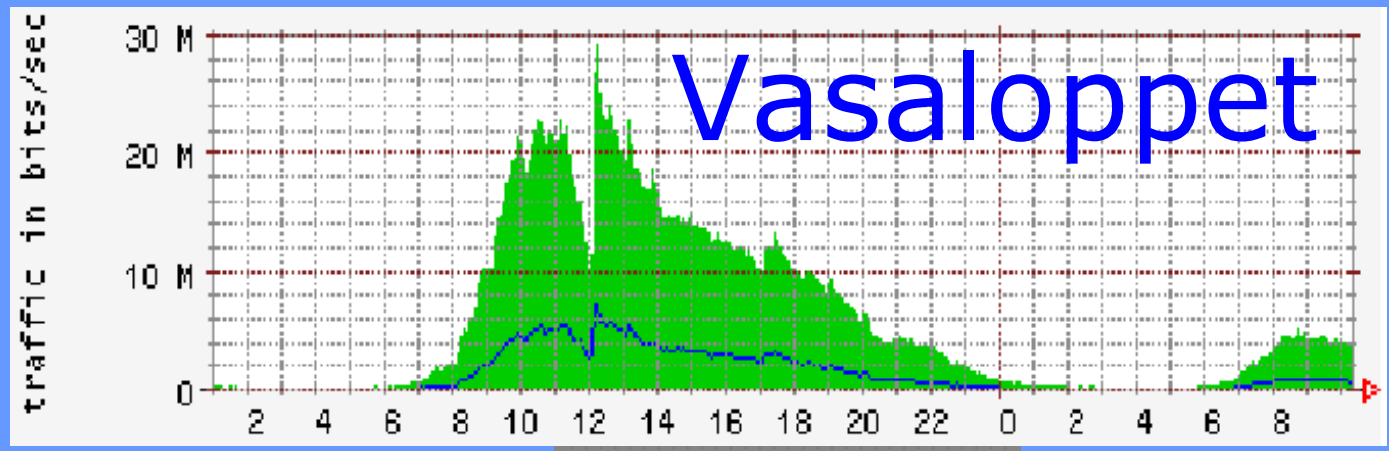

~68.4 milljon hits during the race
~37 thousand simultaneous connections peak
peak rates: 29 Mbps out, 7 Mbps in
peak IP addresses, 165,915
peak one day hits 32,155,188
peak 5 minutes 446,695 hits
160,632 GBytes

http://www.vasaloppet.se

Nordic Grid Consortium

Objectives

- Provide the best possible environment and resources for data and compute intensive research and education
- Provide training and user support across a broad spectrum of applications, computing platforms, data resources, and visualization systems
- Provide convenient, transparent, secure access to eligible users
- Research and development of software systems for enhanced user services and efficient use of Grid resources
- Be a resourceful partner in European and intercontinental endeavors for research, development and deployment of integrated large-scale data, computing and visualization resources and systems serving academia and its partners

Nordic Grid Consortium

Founding Partners

- CSC, the Finnish Ministry of Education's National Center for High-Performance Computing and Networks. http://www.csc.fi

- Parallab, University of Bergen's Computational Science and High-Performance Computing Laboratory. http://www.parallab.uib.no

- PDC (ParallalDatorCentrum), Royal Institute of Technology (KTH), Stockholm, Sweden, the lead national center serving Swedish academic research and higher education funded in part by the Swedish Research Council. http://www.pdc.kth.se

Resources

- Hardware
- Software
- Data
- Staff

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Type of System	GFlop/s / GByte			
	CSC	Parallab	PDC	Total
DM	523 / 90		84 / 36	607 / 127
SMP	2445 / 590	499 / 197	187 / 106	3131 / 892
DSM	79 / 168	25 / 12	4 / 4	108 / 184
V/P			7 / 6	7 / 6
PC-Cluster		81 / 66	273 / 82	354 / 147
Total	3047 / 848	605 / 274	554 / 234	4207 / 1356

Type of System	GByte Disk (global/local)			
	CSC	Parallab	PDC	Total
DM and SMP	2,100	5,800	1 584 / 704	9 484 / 704
DSM	560	35	200 / 594	795 / 594
V/P			128	128
PC Cluster			- / 3 288	- / 3 288
Total	2,660	5,835	1 912 / 4 586	10 407 / 4 586

Type of System	TByte on Tape			
	CSC	Parallab	PDC	Total
Archive	10	32	5	47
Backup	18		20	38
Total	28	32	25	85

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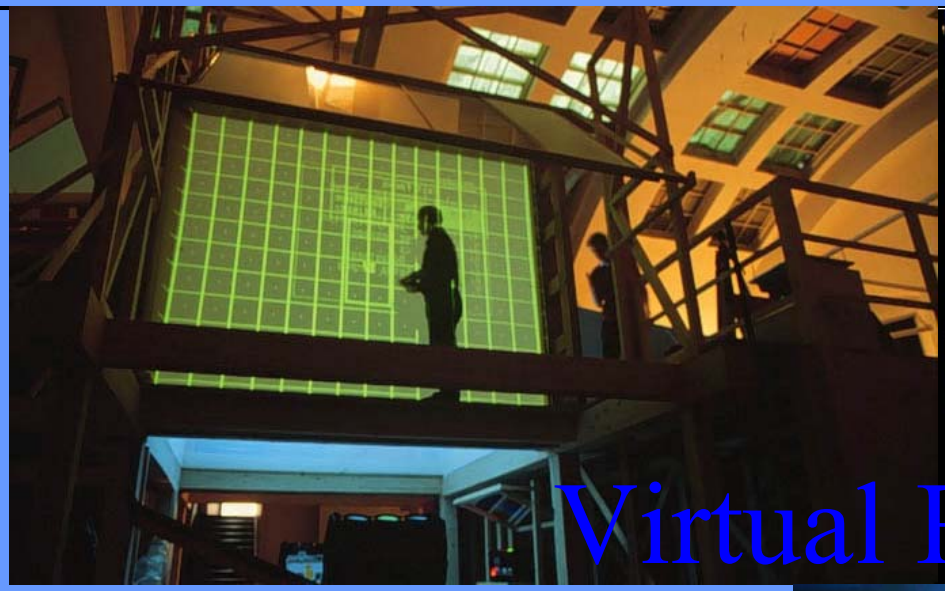

Virtual Reality

Nordic Grid Consortium

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Engineering Software	CSC	Parallab	PDC
ABAQUS/Standard	■		■
ABAQUS/Explicit	■		■
ADAMS	■		
Ansys	■		
CFX	■		
Elmer	■		
FIDAP	■		
Fluent	■		■
Linflow	■		
Opera-3d	■		

Geoscience Software	CSC	Parallab	PDC
Arpege		■	
BOM		■	
GrADS	■		
HYCOM		■	
Melts	■		
MICOM		■	
SU		■	
UNCERT	■		

Numerical Libraries	CSC	Parallab	PDC
ARPACK	■		■
BLACS	■	■	■
BLAS	■	■	■
DXML	■		
ESSL	■	■	■
FFTW			■
IMSL	■		
ITPACKV	■		
LAPACK	■		■
MASS		■	■
METIS			■
NAG	■		■
NAG FL90plus	■		■
netCFD			■
NSPCG	■		
OSL		■	
ParMETIS			■
P_ARPACK	■		■
PBLAS	■	■	■
PDE2D	■		
PESSL	■	■	■
PETSc			■
PSPARSLIB			■
PWSSMP	■	■	■
ScaLAPACK	■		■
SCSL	■		
SPARSKIT			■
SPASPAK	■		
SSL II/VP			■
SSL II/VPP			■
WSSMP	■	■	■

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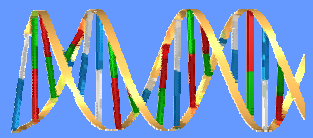
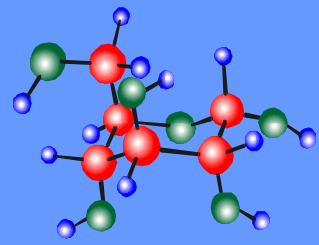
Data Bases



- **Bio/Life-sciences**
  - databases for sequences of DNA and amino acids
  - database of macromolecule construction
  - gene maps
  - Coming up:
    - genomes
    - 3D-databases
    - gene expression databases
    - brain image databases



- **Chemistry**
  - MDL Cross-Fire
    - database of chemistry and material sciences
    - the world's most extensive electronic database of organic chemistry
  - Cambridge Structural Database System
    - databases of compound constructions
  - SpecInfo
    - theworld's largest electronic spectra database
  - MDL Databse
    - for drug development
    - for preparation of chemicals

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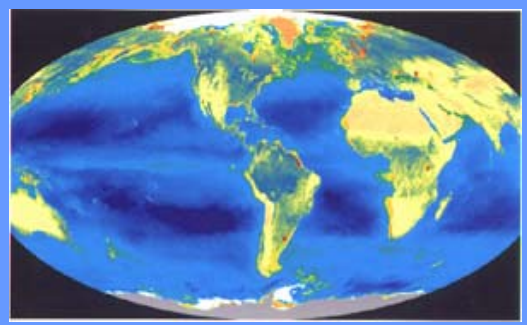
Data Bases

- Geosciences
  - topography models and databases (e.g. GLOBE, Terrainbase
  - characteristics databases (e.g.data on flora, hydrology, glacier, soil, and bedrock)
  - image databases (e.g. satellite images)
  - map databases (basic geographic maps of Finland)



- Language Bank
  - Corpus bank of Finnish texts
    - research material of nearly 180 million words.words of Contemporary Finnish
  - Corpus of Middle French
  - Corpus of contemporary English

Nordic Grid Consortium

Staff

CSC

Systems - 40

Support - 40

Development – 20

Admin/Doc - 20

Total - 120

PDC

Systems - 9

Support - 7

Development - 4

Admin/Doc - 3

Total - 23

Parallab

Systems - 2

Support - 8

Development - 8

Admin/Doc - 2

Total - 20

Network environments

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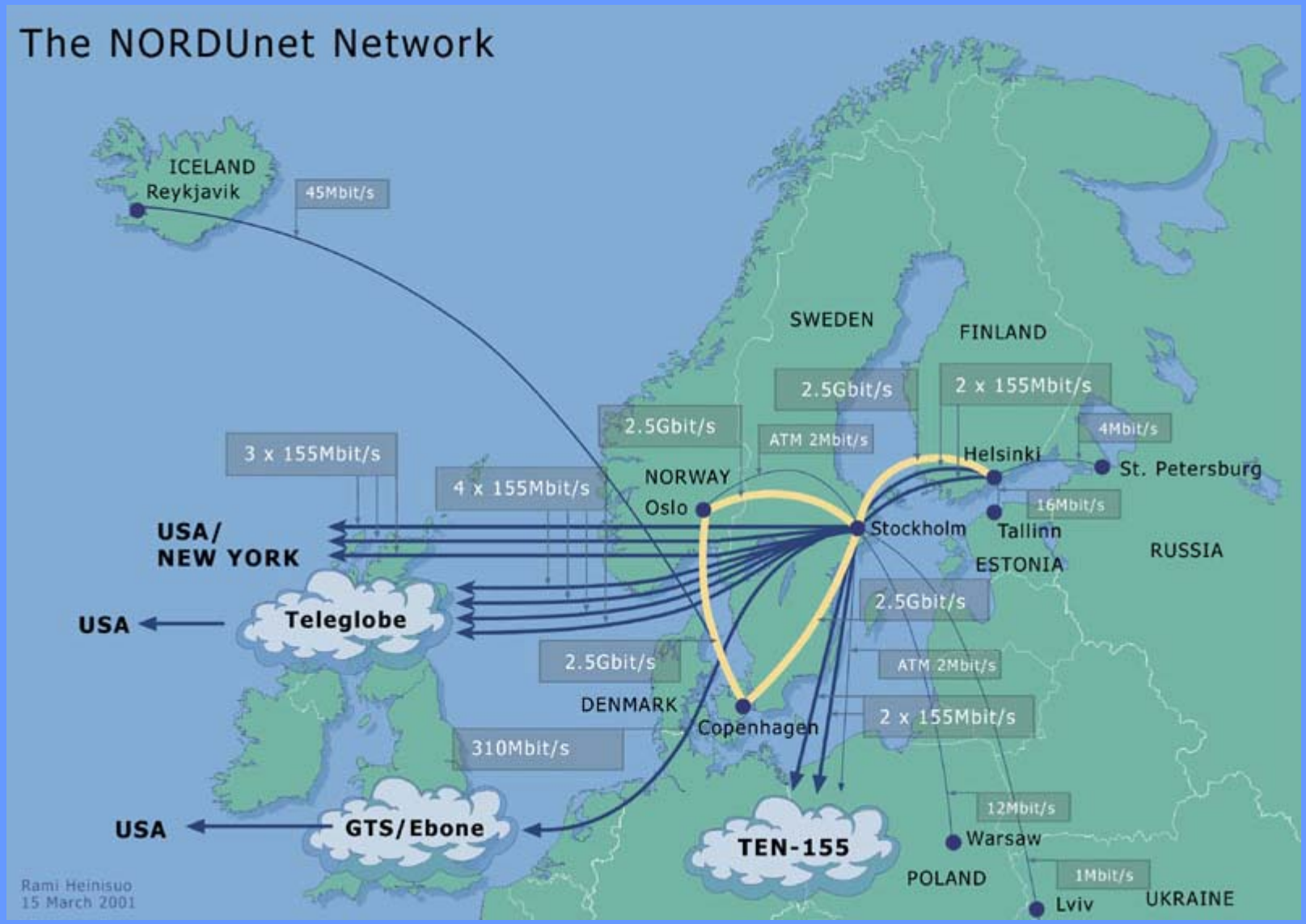

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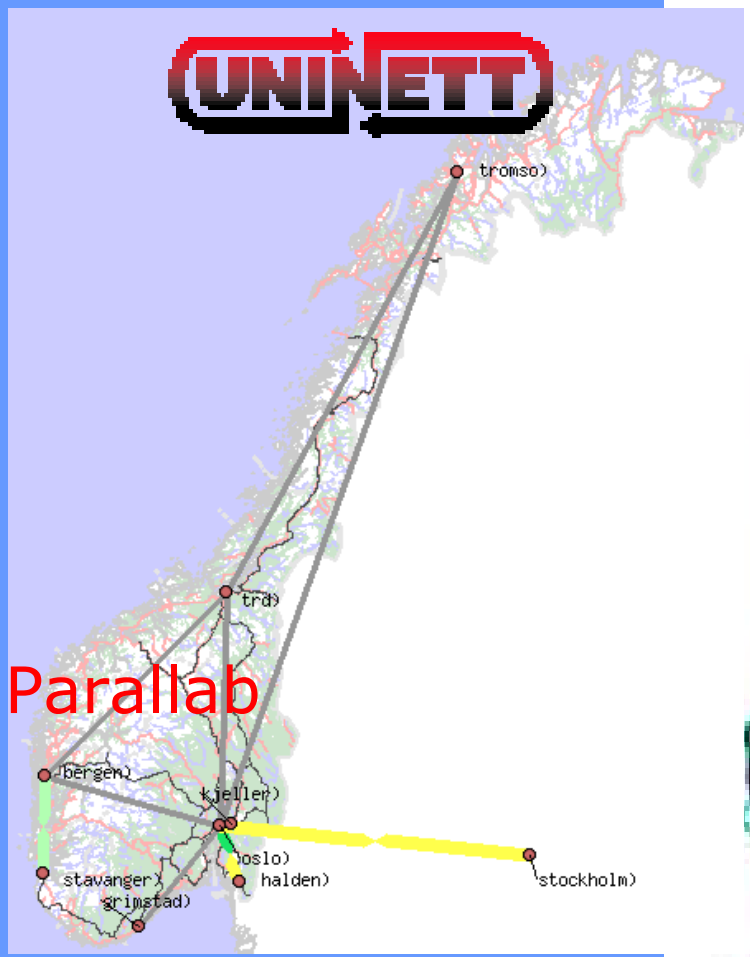

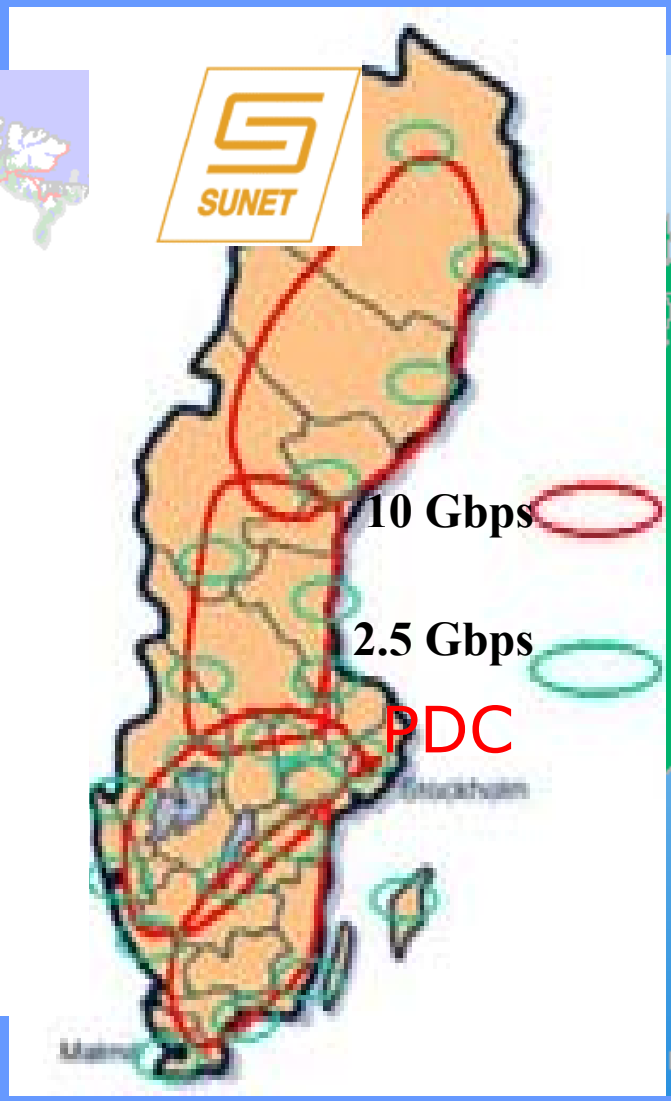

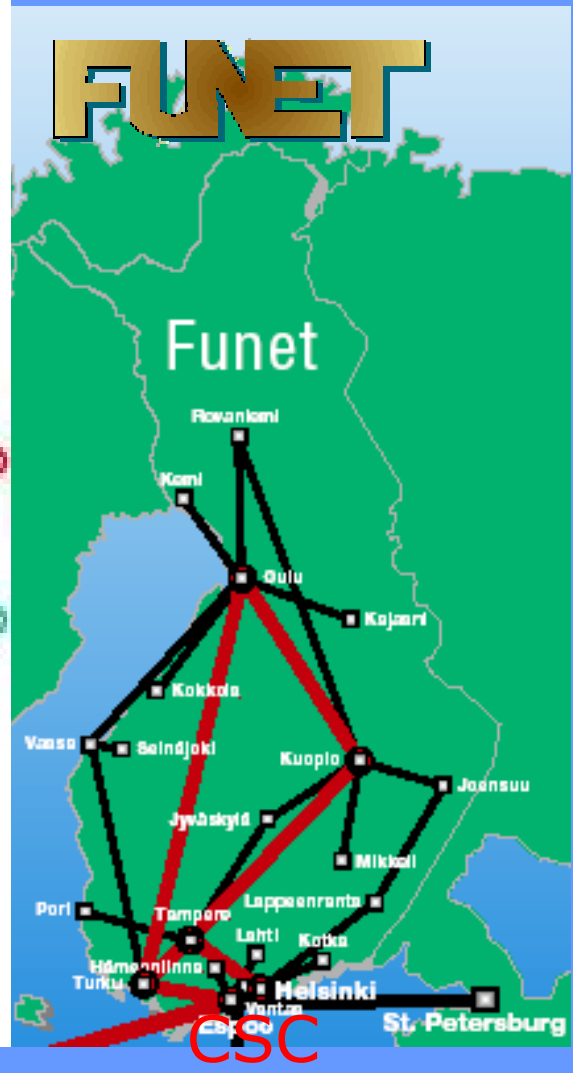

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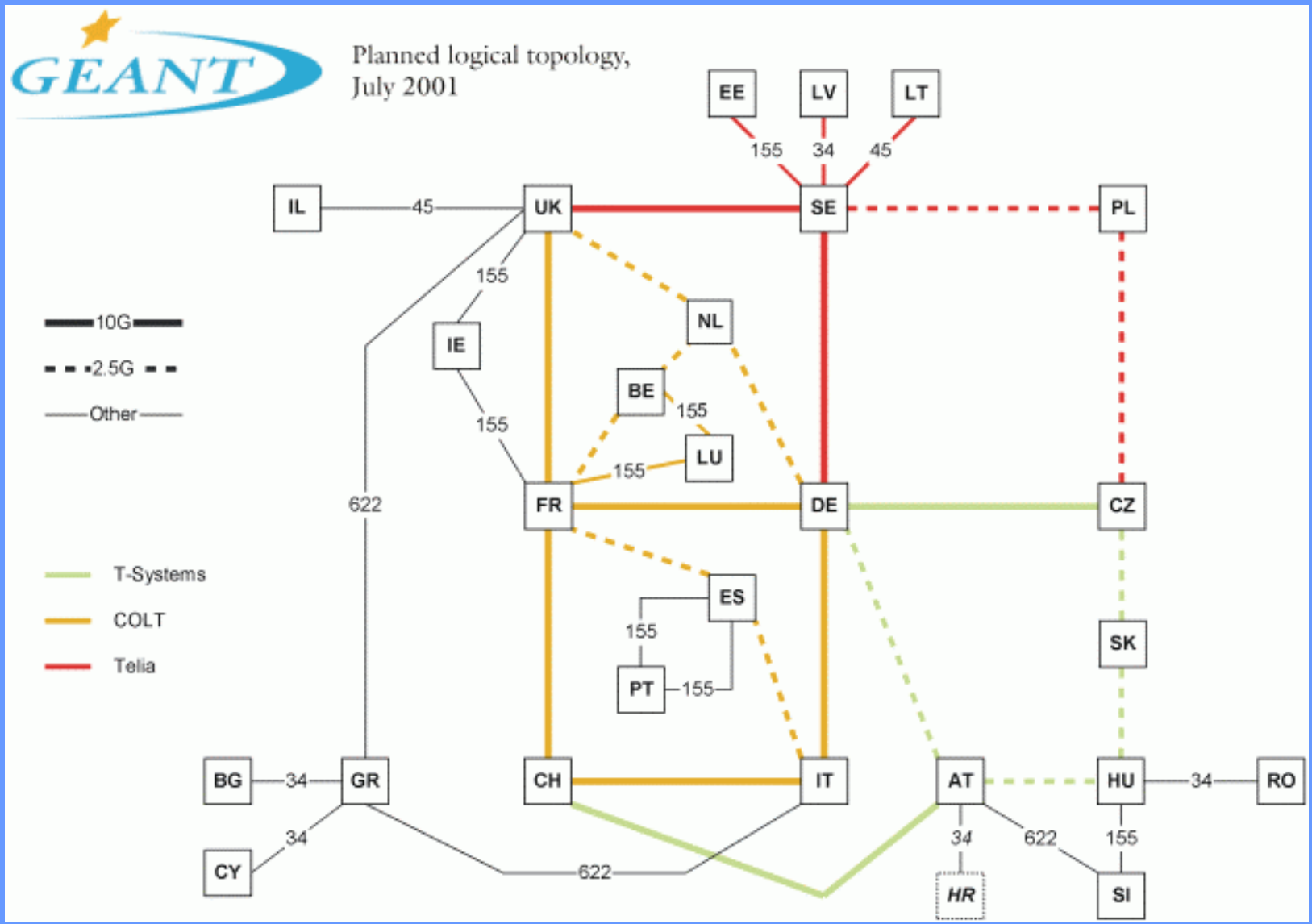

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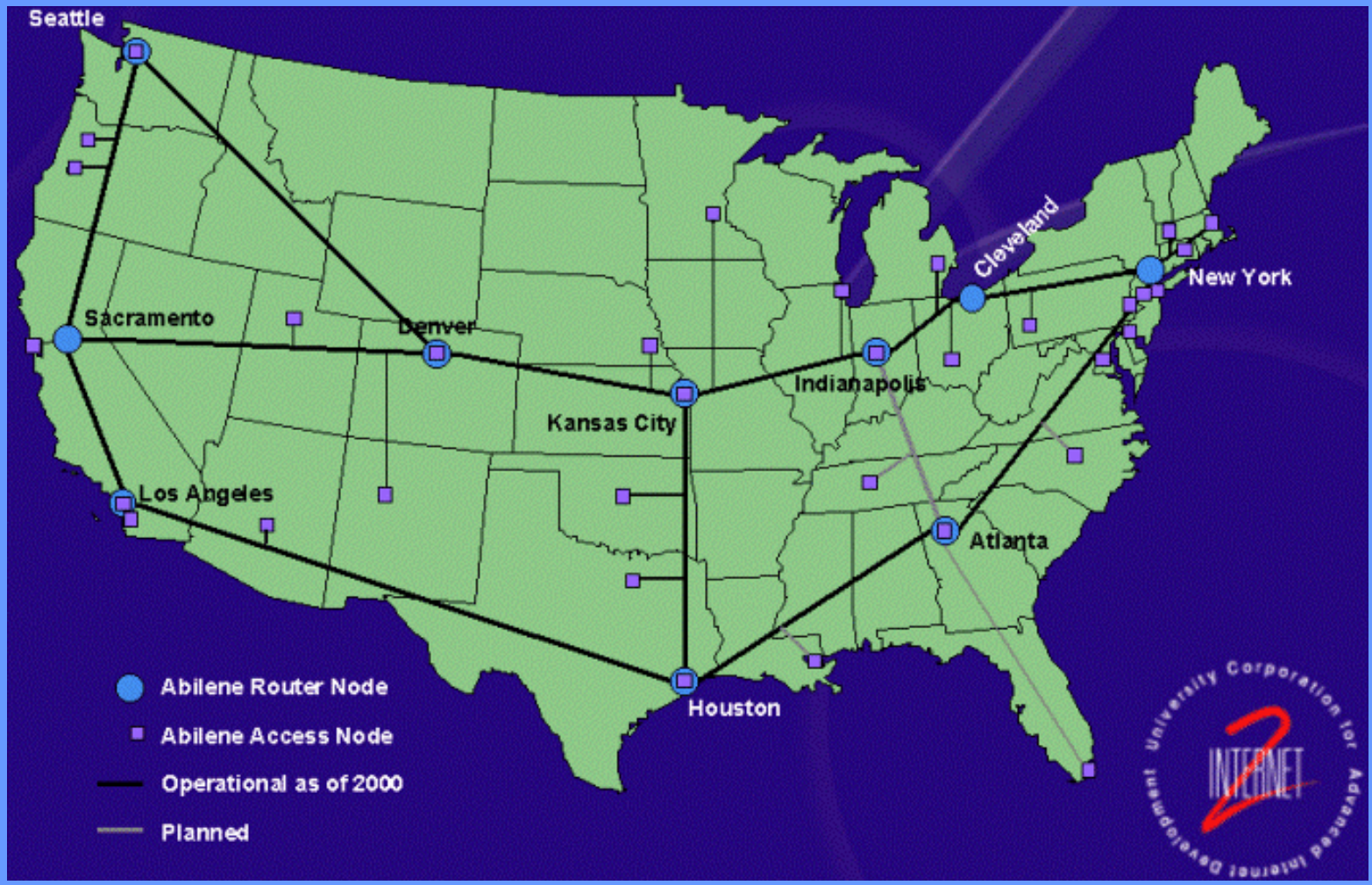
Internet2 - Abilene



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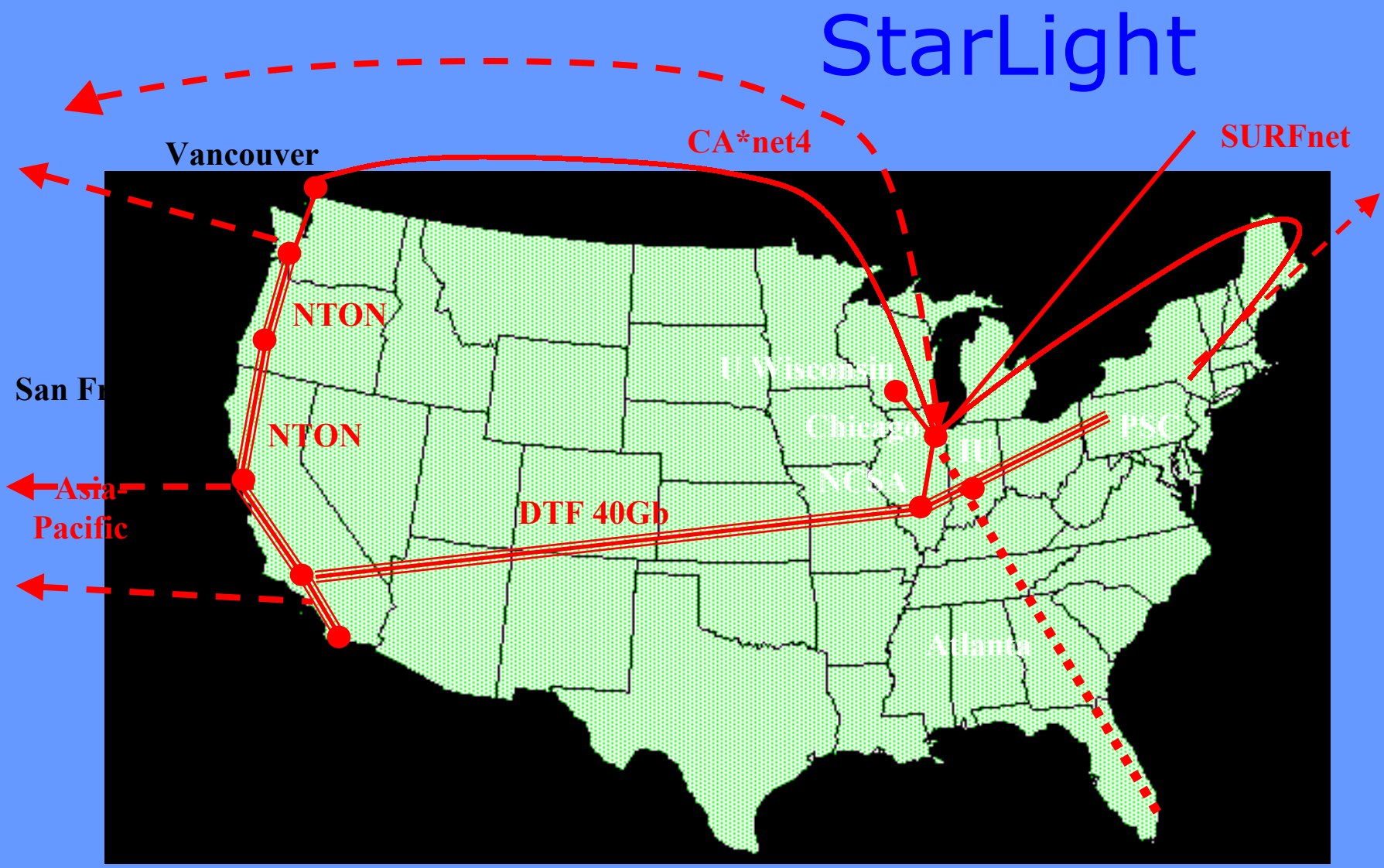

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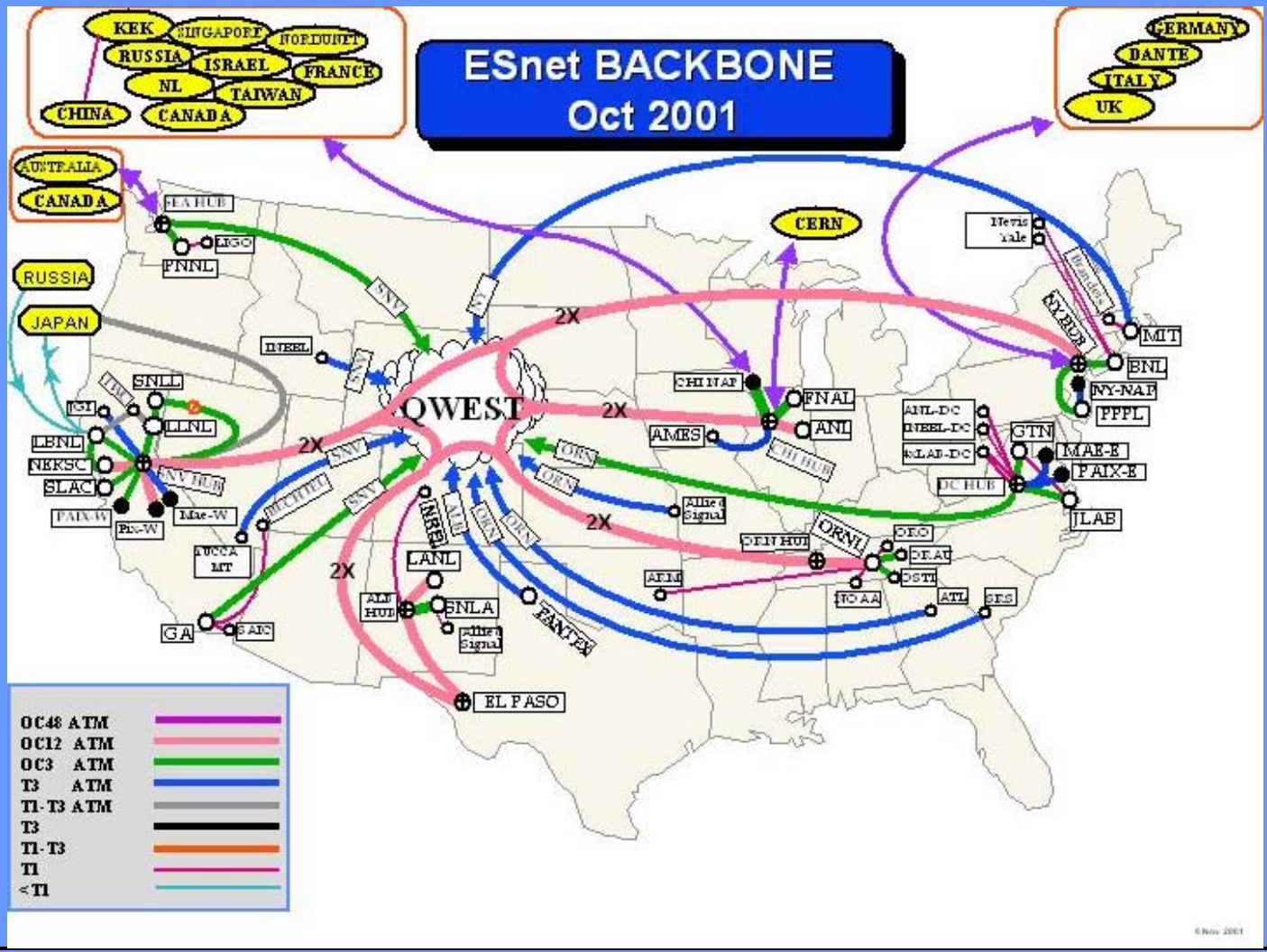
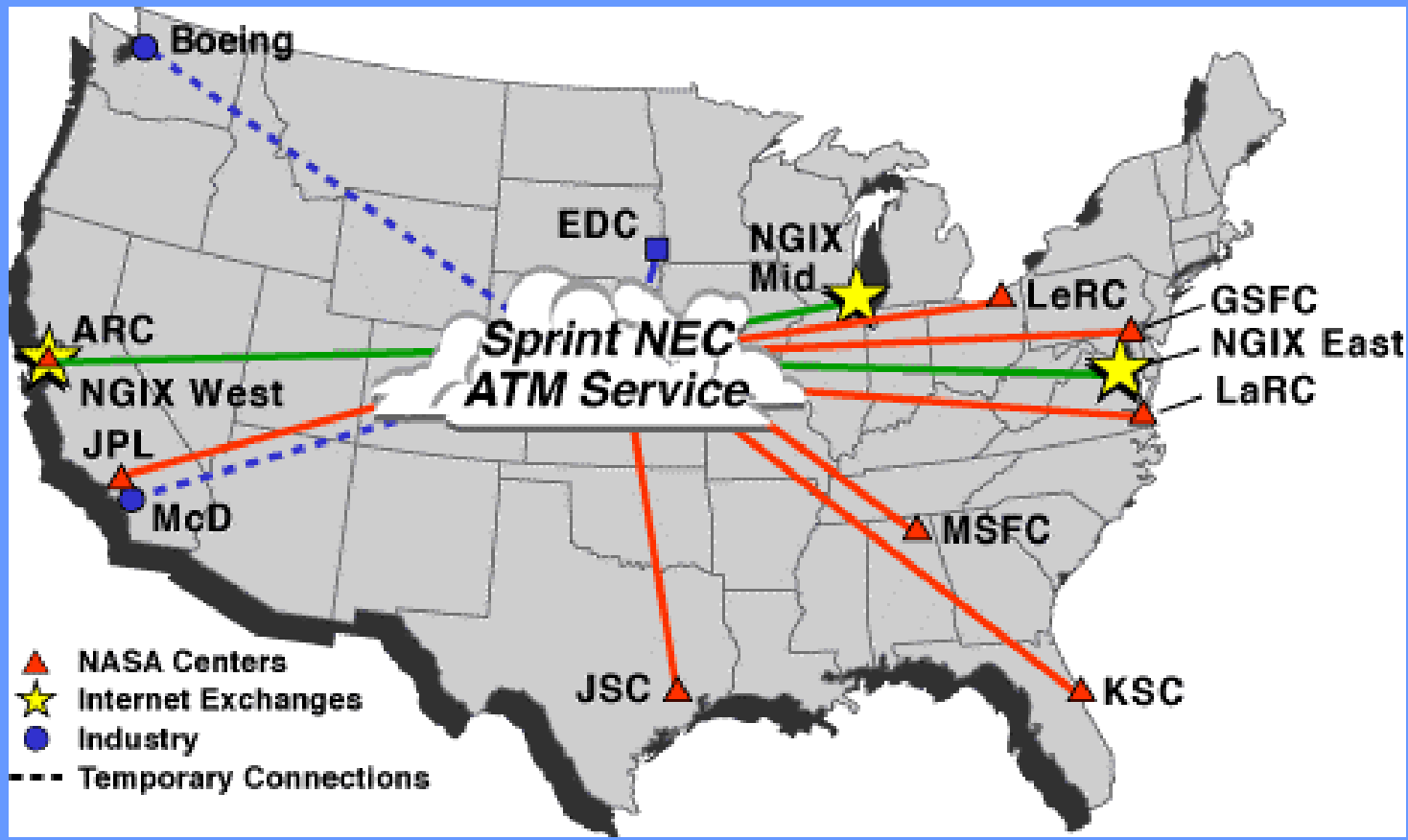
DoE Energy Sciences Network



NASA Research and Education Network (NREN)



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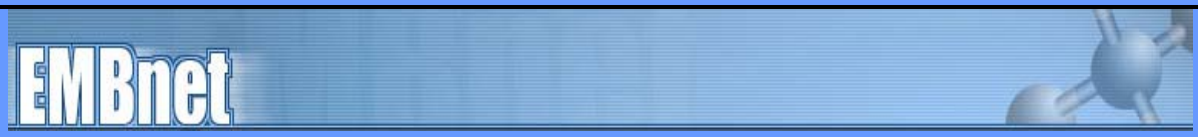

GrADS
Grid Application Development Software Project

6NET

EUROMAP
LANGUAGE TECHNOLOGIES

HPCN TTN
network

N'S³
ENScube

JaCo3

Sharing the future
nedlib

enacts

DataTAG

NPACI

CAVERN
互

EUROGRID

NeuroGenerator NG
- a databasegenerator for the neuroimaging community

Data GRID

Nordic Testbed for Wide Area Computing and Data Handling

ALLIANCE

FINNOVA
TECHNOLOGY TRANSFER NODE AT CSC

VIRTUAL FIRES

Nordic Grid Consortium

Plans

- Work with sponsoring agencies to facilitate resource sharing
- Set up a NGC portal
- First edition shared software environment by end of April (Globus)
- “Friendly” users in summer of 2002
- Account and user access managment
- Limited service in accordance with sponsor policies by the end of 2002

Acknowledgements

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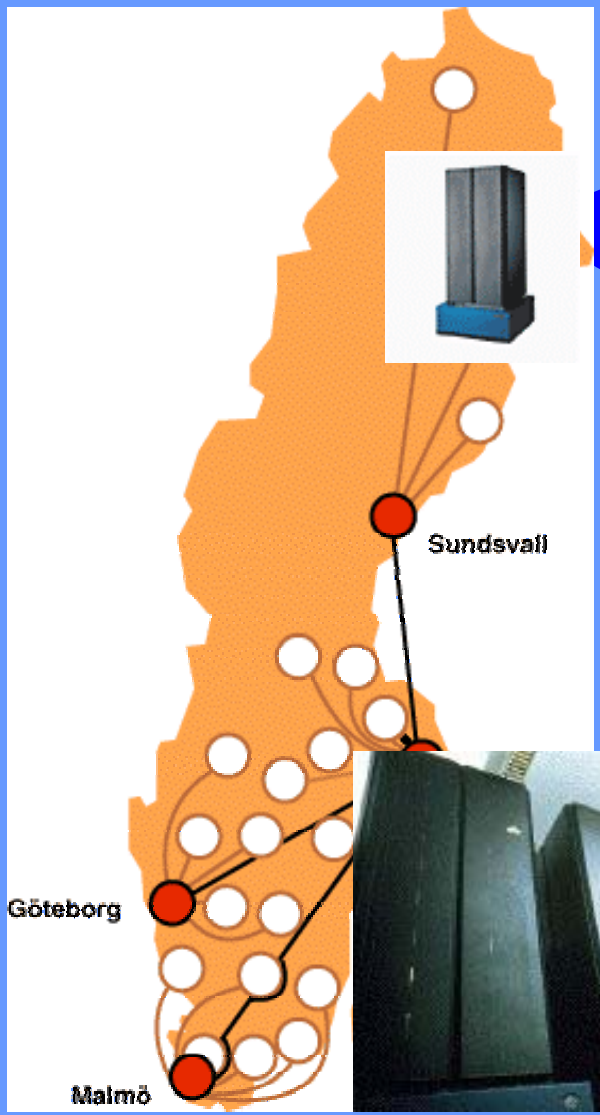
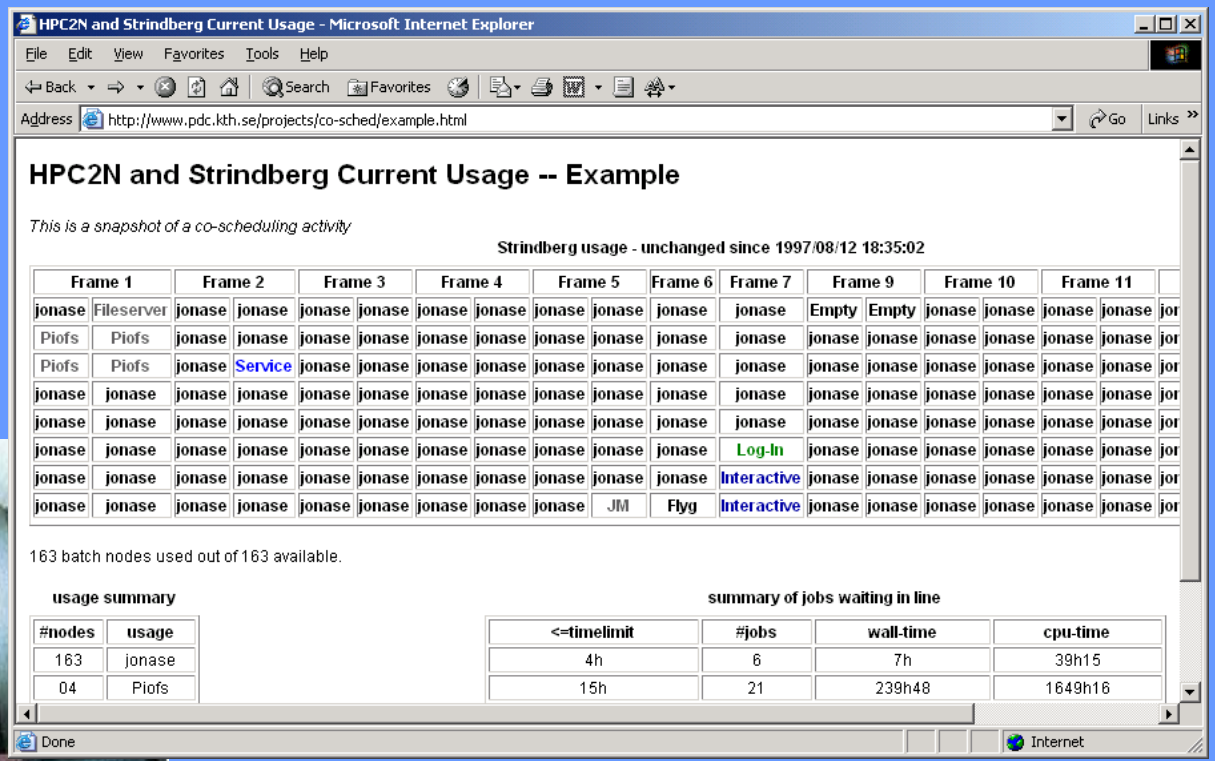
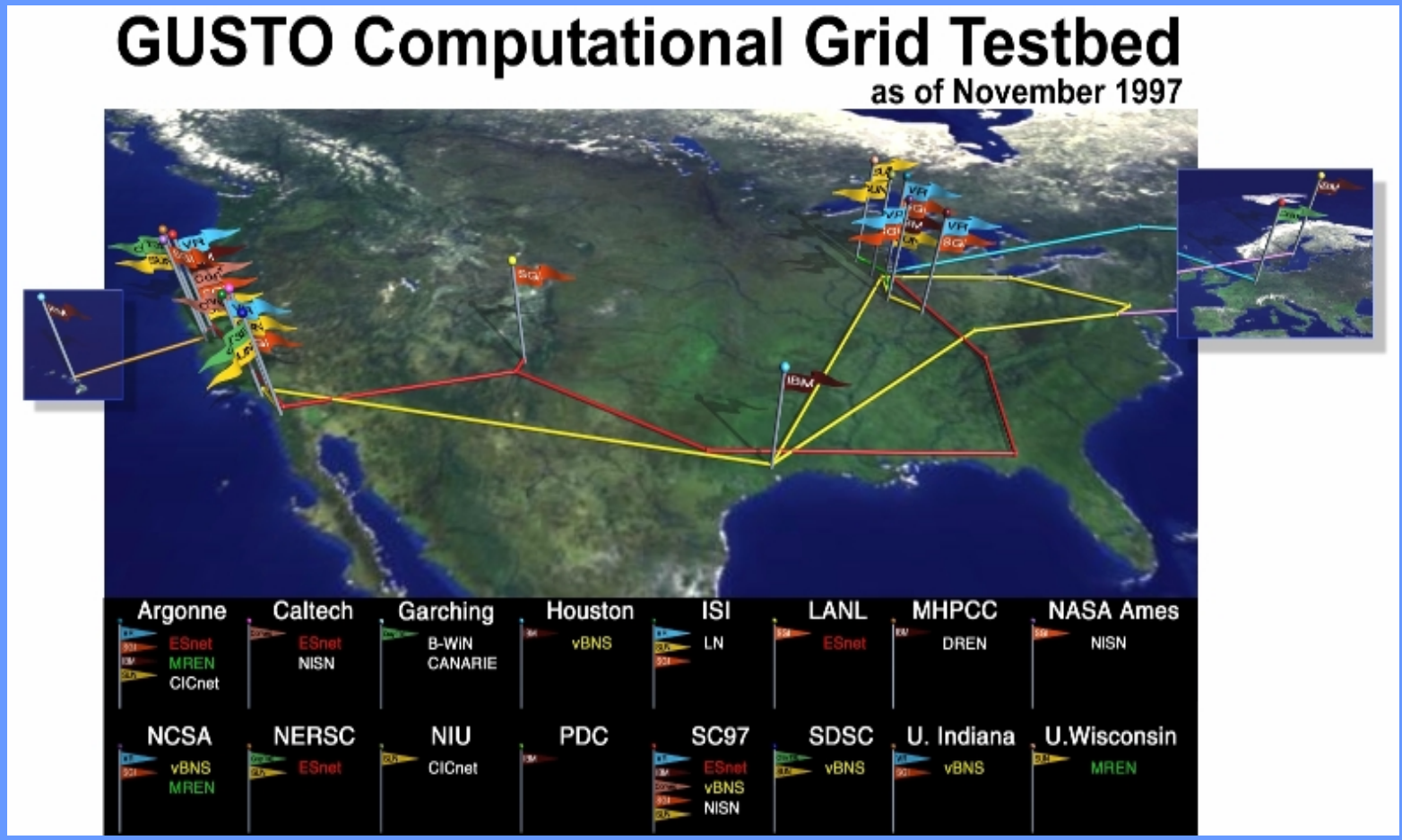


Co-Scheduling of jobs between HPC2N and PDC



http://www.pdc.kth.se/projects/co-sched/

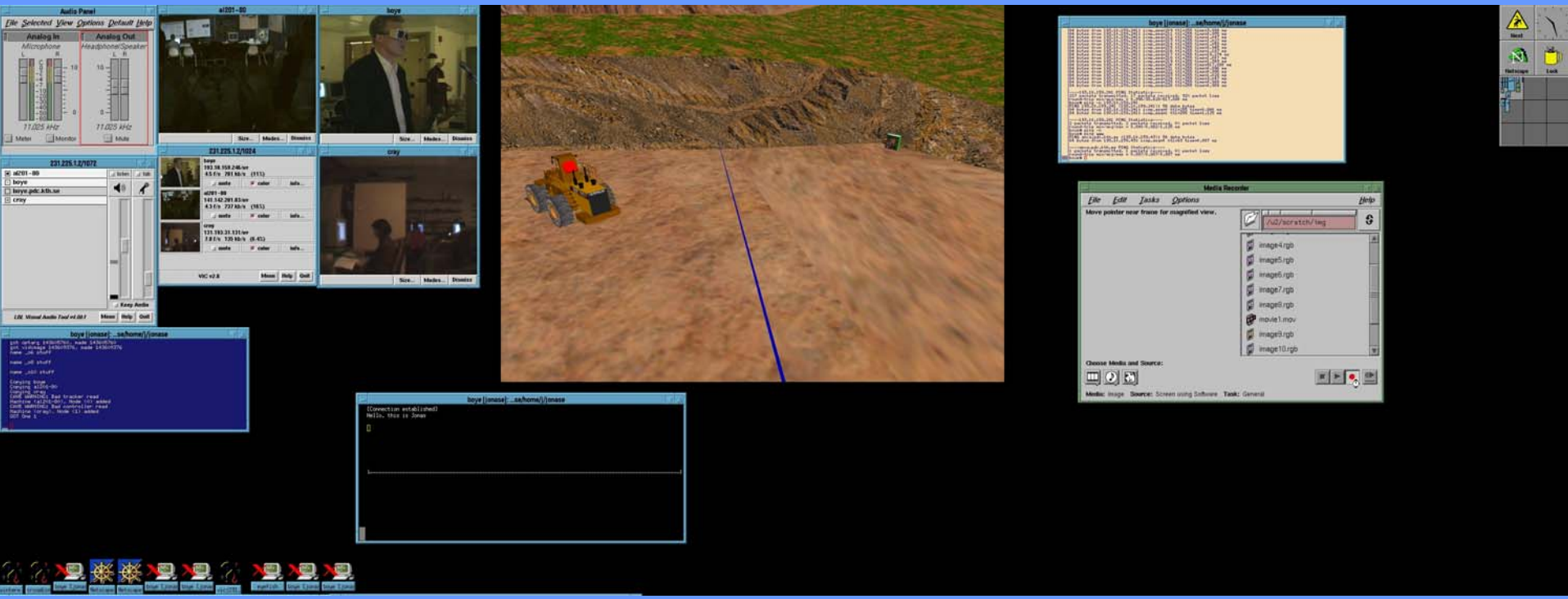
Nordic Grid Consortium



GUSTO tesbed for Grid applications demonstrated at Supercomputing97 exhibition

Nordic Grid Consortium

Alliance98

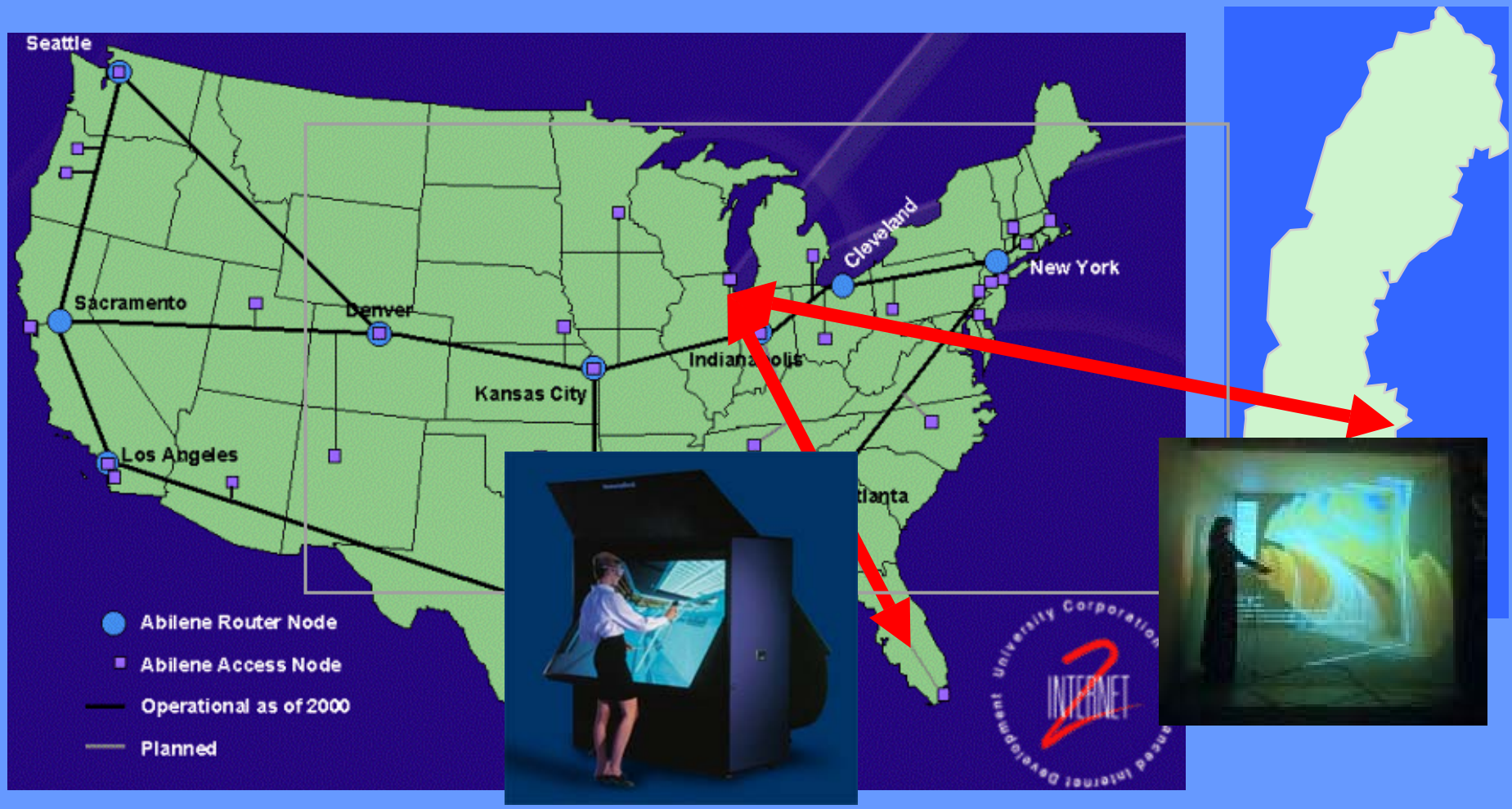


Interactive Collaborative Virtual Environment

http://www.pdc.kth.se/projects/alliance98/

Nordic Grid Consortium

EnVis@SC98



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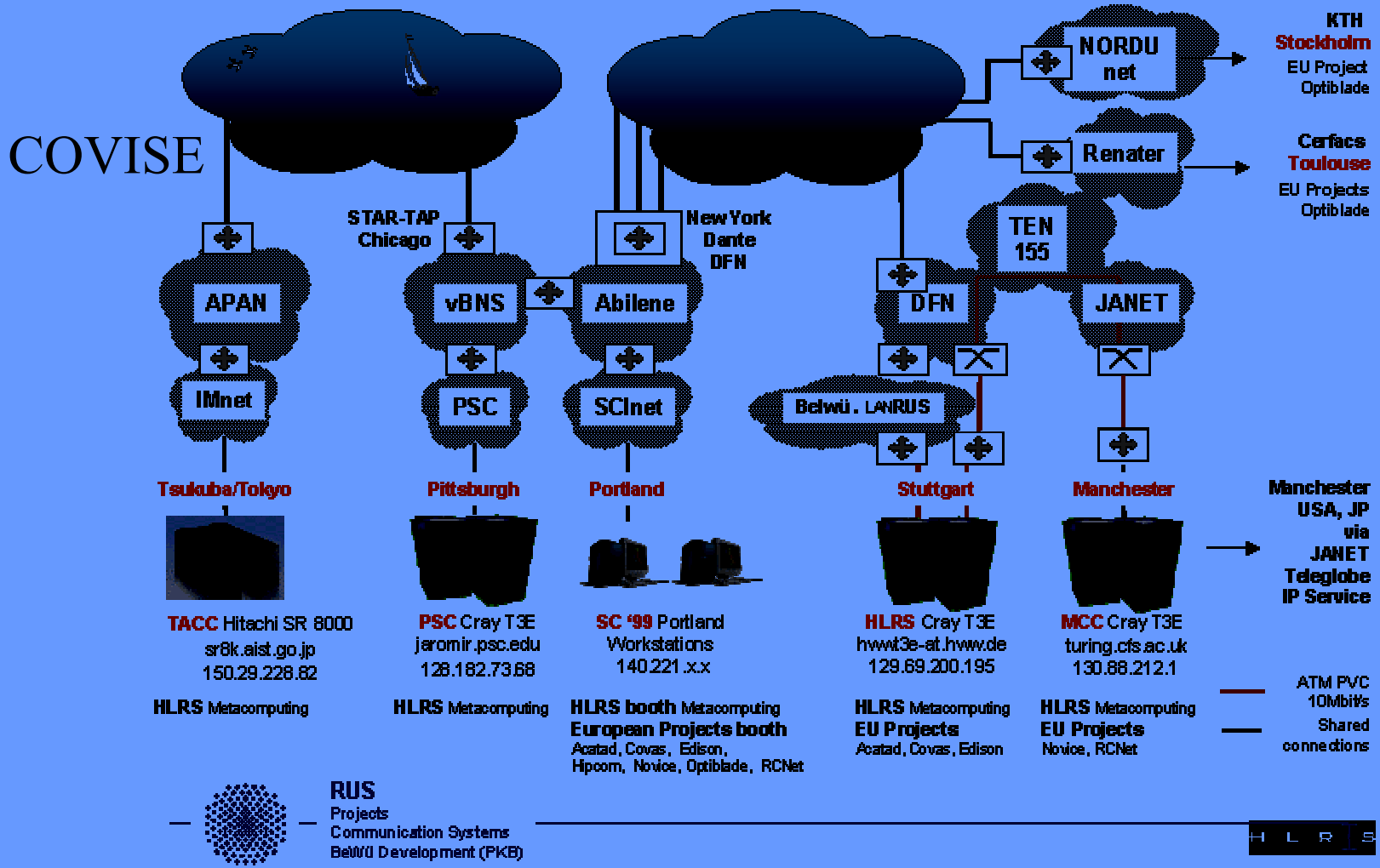
SC '99



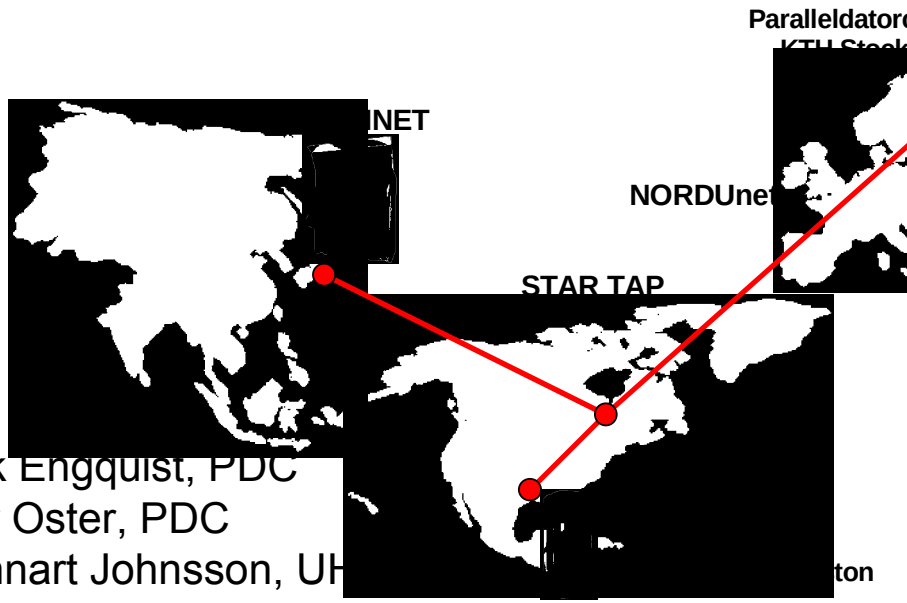
Nordic Grid Consortium

Computational Steering

the globus project
www.globus.org

GEMSviz at iGRID 2000

NORDUnet



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