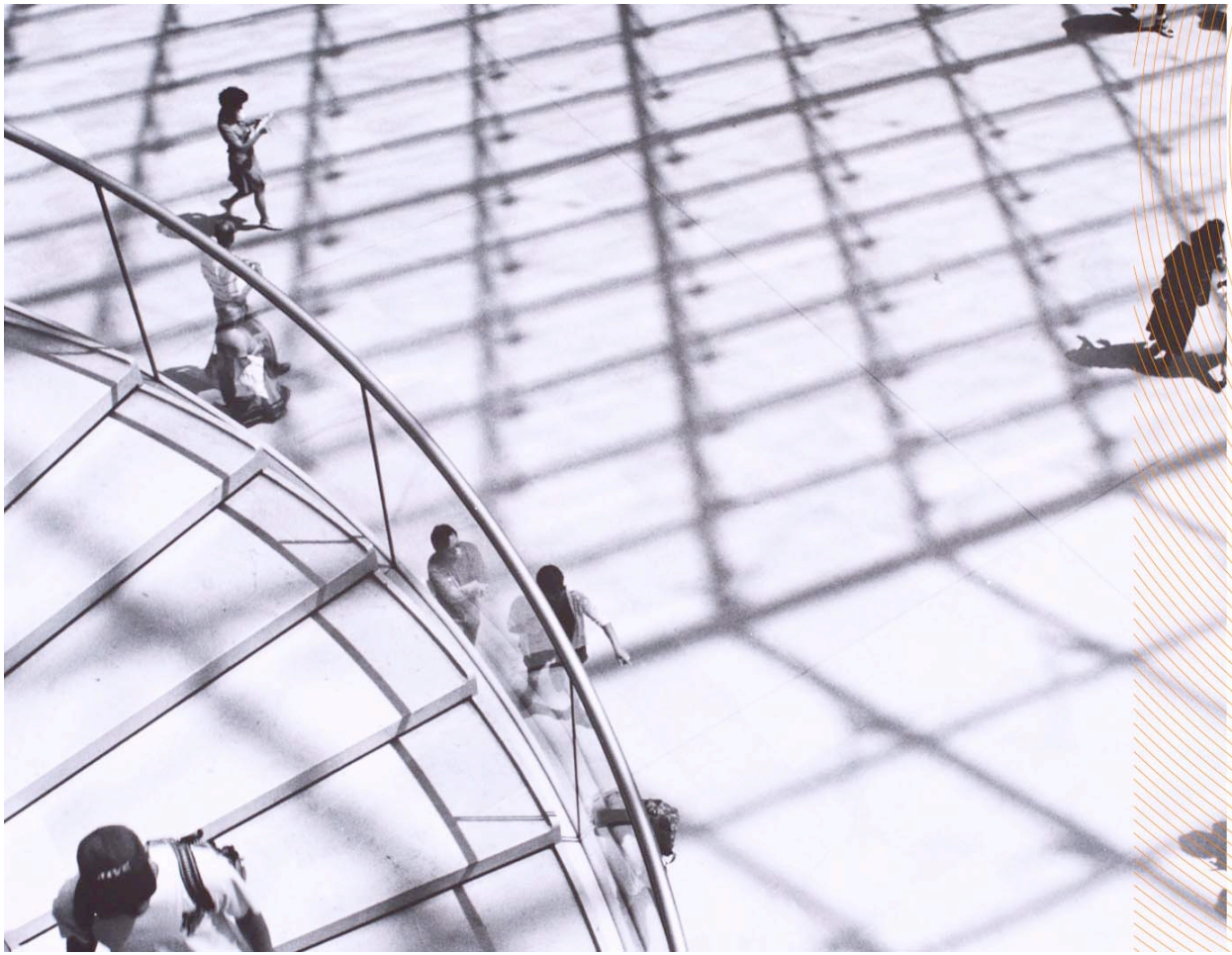


Research networks: Engines for Innovation

by Kees Neggers

Networking Research Challenges Workshop, September 28, 2008

Networks: enablers for progress

- The Roman empire: a road system to enable conquest

- 18th – 20th centuries: enabling the industrial revolution:
  - Canals, roads en railroads
  - Post-Telegraph-Telephone

- 20th century: driving the Digital Economy:
  - Internet

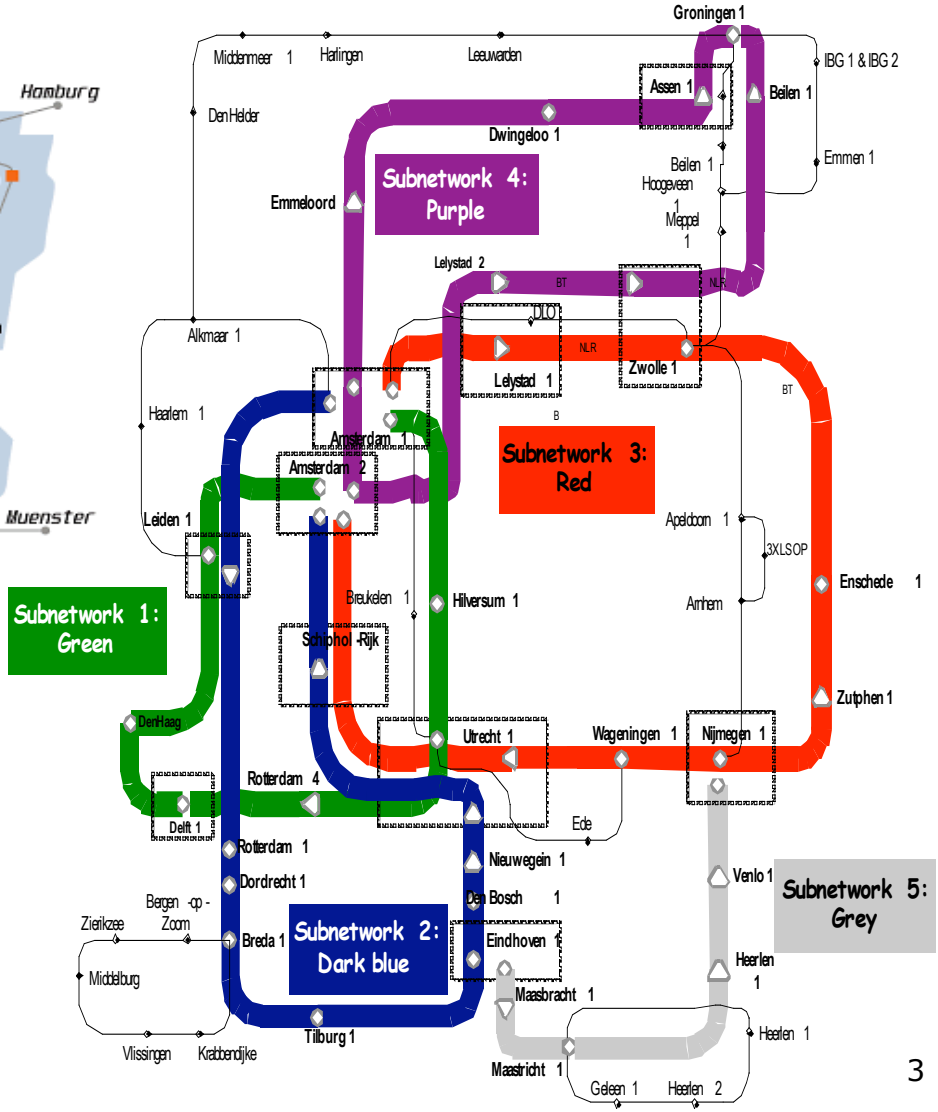
'New networks' will remain important enablers for economic and social developments

Who is SURFnet?

- Dutch National Research & Education Network (NREN)
  - Not-for-profit organization, 65 employees
  - Owned by the research and education community
  - >900.000 end-users from 160 connected institutions

- SURFnet provides advanced services to the research and education community
  - High performance networking
  - Authentication and authorization services to provide secure access to the network and other resources
  - Advanced multimedia collaboration tools, including high quality audio/video communication

SURFnet: Dutch Research and Education Network



The importance of Research Networks

Three trends in research

- System level science
  - *the integration of diverse sources of knowledge about the constituent parts of a complex system with the goal of obtaining an understanding of the system's properties as a whole* [Ian Foster]

- Multidisciplinary research
  - Each discipline can solve only part of a problem
  - Collaboration between different research groups
  - Distributed across states, countries, continents

- Research driven by (distributed) data
  - Data explosion, both volume and complexity
  - Simulation and experiment combined
  - Exploring data-sets with no up-front hypothesis

New research means new networking requirements

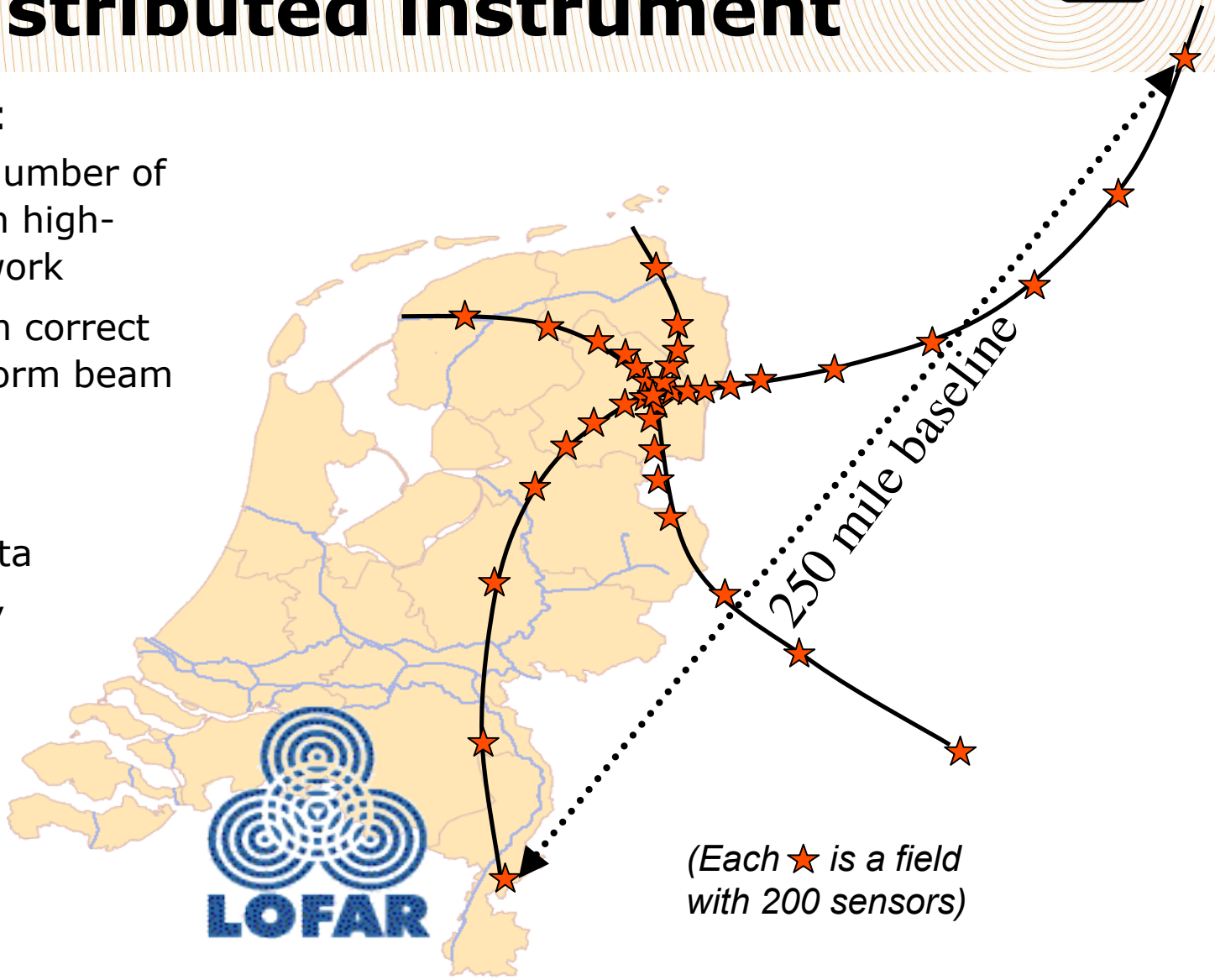
- Explosion in the *amount* of data from experiments and simulations
  - Examples: LHC, LOFAR, e-VLBI
- Need for *near real-time* processing of very large datasets
  - Example: LHC Atlas trigger
- Increase in *remote* collaboration
  - Distributed sensors
  - Shared computing and storage, grids
  - Virtual teams

Example: distributed low frequency array LOFAR

- A distributed multibeam array for radioastronomy
- Large number of very simple antennas, with very high bandwidth connections

LOFAR: a distributed instrument

- Guiding principle:
  - Connect large number of sensors through high-bandwidth network
  - Add signals with correct phase shift to form beam
- Data flows:
  - 37 Tbps raw data
  - 2500 Tbyte/day distributed data
  - 250 Tbyte/day correlated data

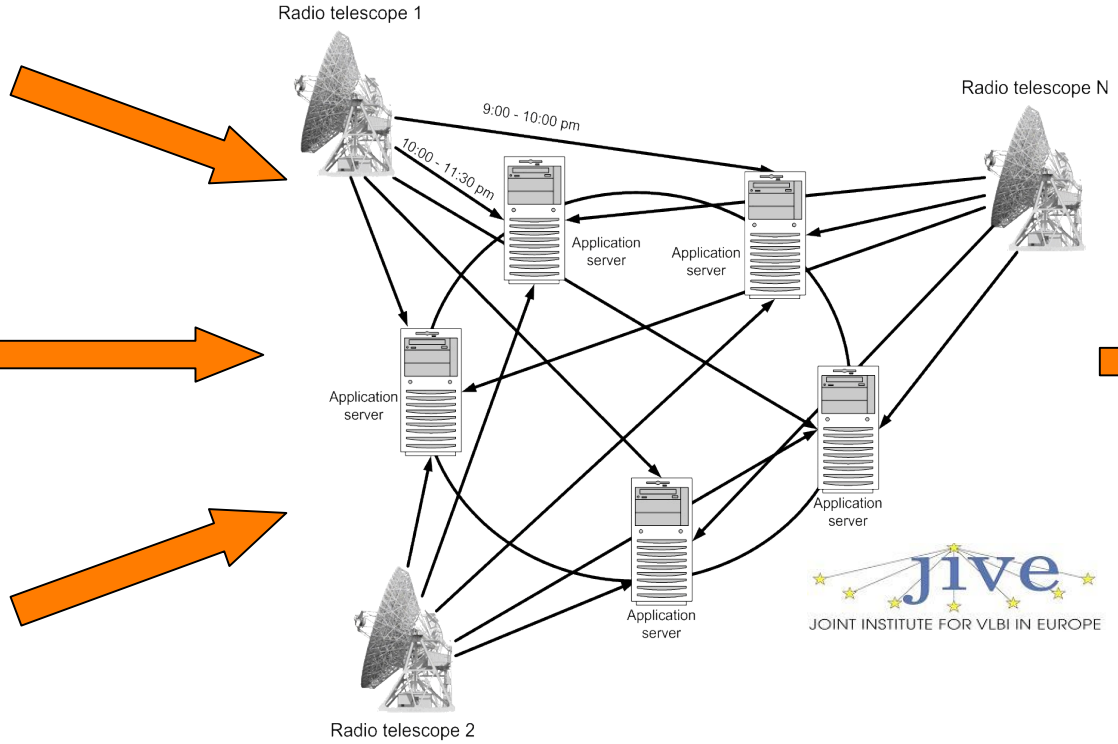


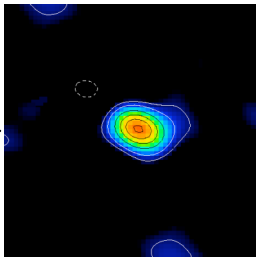
Example: e-VLBI, a global radiotelescope

JIVE
JOINT INSTITUTE FOR VLBI IN EUROPE

e-VLBI: global distributed radiotelescope

- Very long baseline virtual radiotelescope, created by correlating outputs of multiple actual radiotelescopes (e-VLBI)





Results

Constant evolution of networks is needed

- Satisfy evolving connectivity requirements
  - Very large data streams (>10 Gigabit per second for a single experiment)
  - Very large numbers of sensors in various environments
  - Collaborating users in various locations

- Provide flexible configuration
  - Lightpaths controlled by user or application
  - Fast configuration change
  - Secure access

Trends in networking

Optical networking is still improving

- More bandwidth at lambda level
  - 10G now standard
  - 40G and 100G coming soon

- More flexibility at lambda level
  - From static configurations to tunable lasers and filters
  - WSS and MEMS devices for flexible re-routing of entire lambdas
  - Alien waves?

- Dynamic configuration
  - Allows control plane systems to alter lambda routes “on the fly”

Next generation Ethernet offers new flexibility

- Build on existing technology
  - Ethernet is everywhere
  - Expanded from LAN, to WAN edge, and now to WAN core

- Next generation Ethernet now being standardized
  - Carrier grade Ethernet network with PBBTE (802.1Qay)
  - Separates network layer from control plane
  - Provides scalable and flexible Ethernet-based architecture

Mobile, wireless and ubiquitous networking

- The ubiquitous network is becoming a reality
  - Cellular networks implementing “high-speed” data
  - WiMAX networks, WiFi hotspots providing alternatives
  - Wireless technology available at home and in the office

- Wireless is complementary to fixed networks
  - Bandwidth will increase, but will always be less than fixed
  - Provides mobility and access in difficult places

Services and applications will have to take different access methods into account

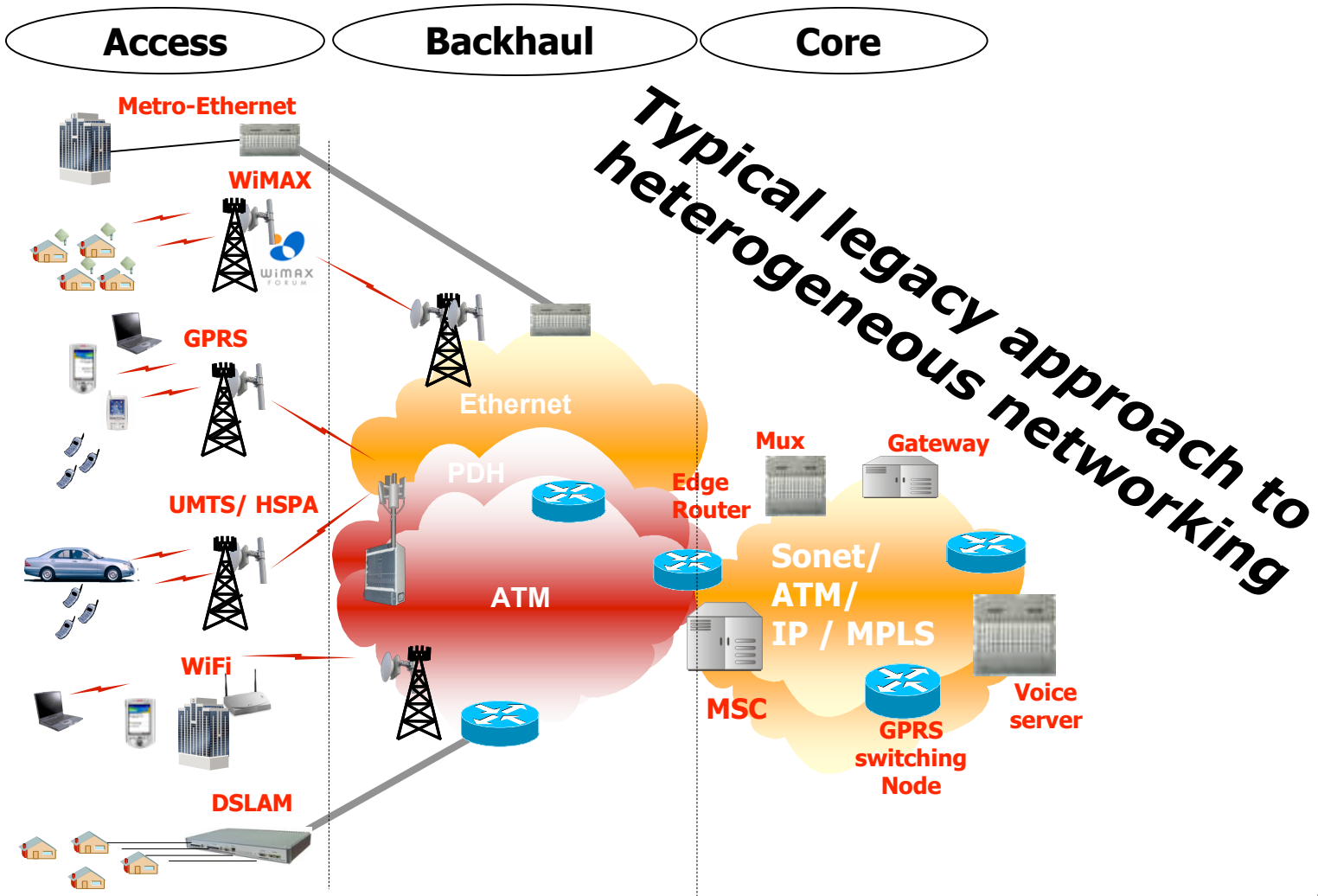
Challenges and issues

Commercial operators stick to outdated models

- Operators with legacy business model:
  - Attempt to retain traditional telephony model
  - Assume that network resources are scarce
  - Attempt to move as high as possible in OSI stack to "create value"

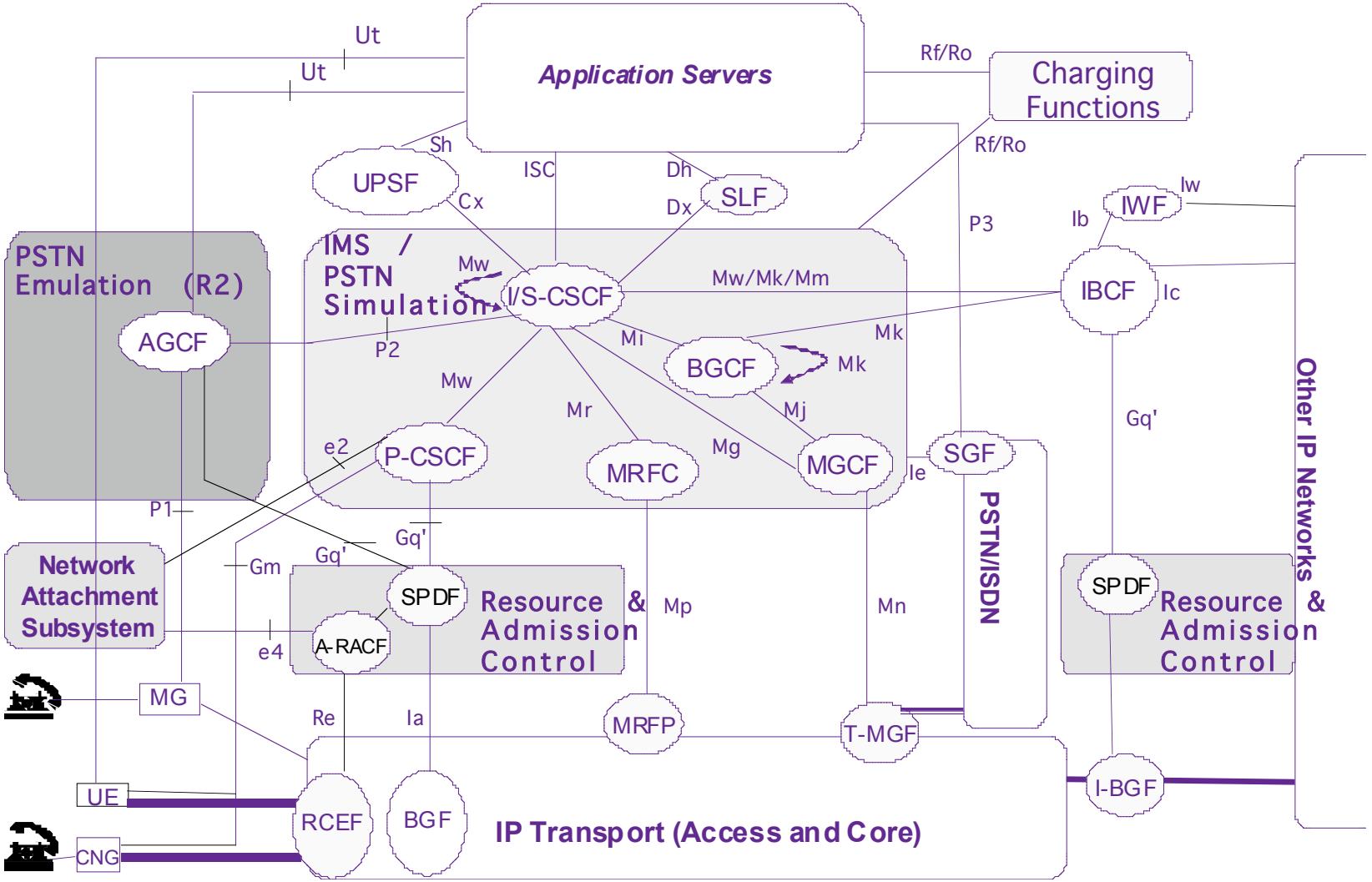
- Operator driven standardization efforts are based on this model
  - MPLS used to create IP-VPN's where lightpaths would be better
  - UMA (Unlicensed Mobile Access) attempts to integrate WiFi in cellular business model
  - IMS tries to put the operator in charge again

Integrating heterogeneous networks is not effective

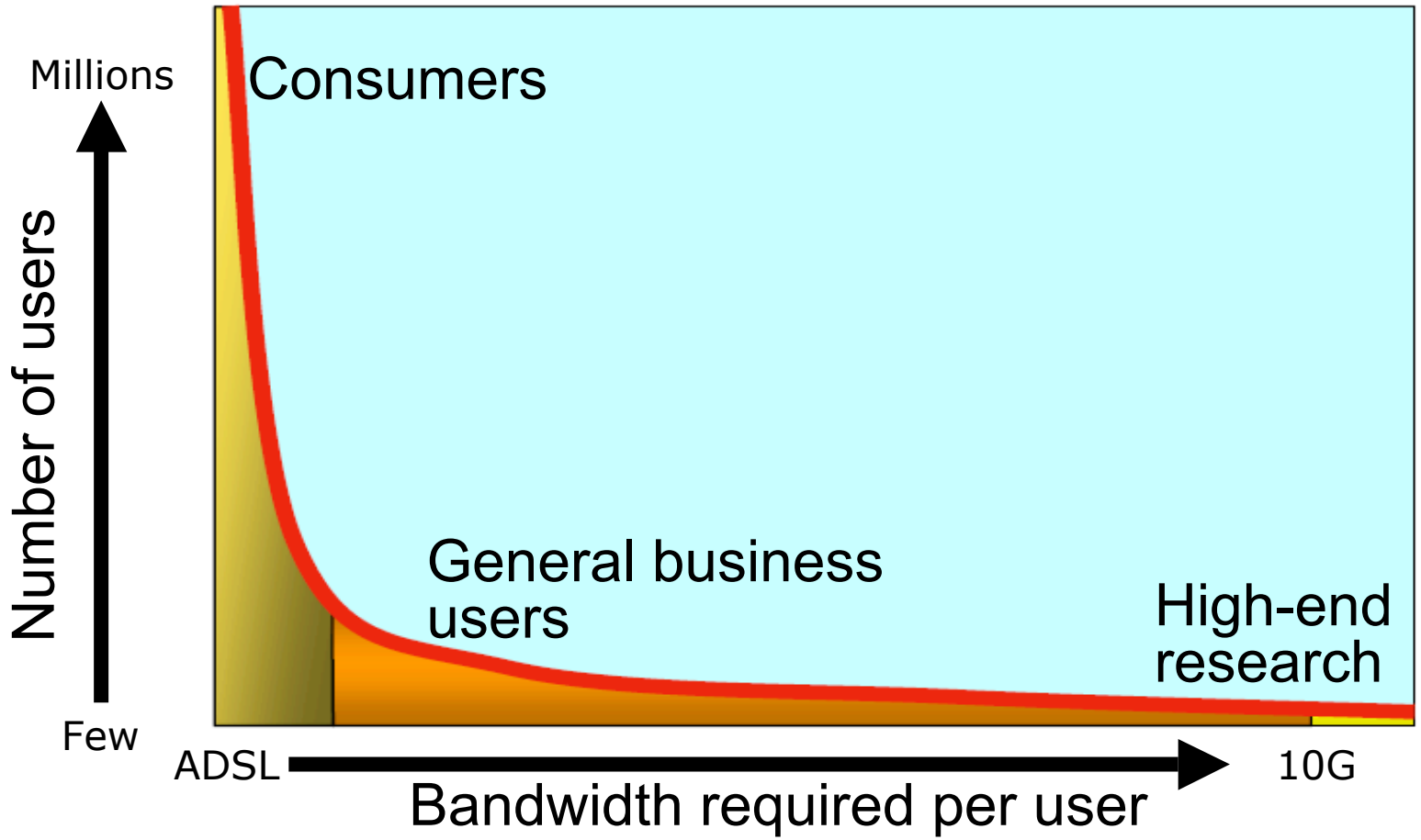


Operator solutions such as IMS are too complex

ETSI TISPAN IMS Architecture



Not all users are equal



SERENATE Study Final Report, 2003, *Cees De Laat, David Williams* et. al.

Research network challenges

- Internet is not the solution to everything
  - Can not implement guaranteed services on “best effort” network
  - Fine for delay tolerant, many-to-many communication

- Research networks will have to do better...
  - Provide guaranteed performance for large data flows and time-critical applications
  - Support increasingly heterogeneous access methods
  - Take into account security and environmental issues

- … while keeping the successful end-to-end model of the internet

Approaches in future networking

What made the internet successful?

- Focus on the endpoint, not on the path
- Independent of the physical medium
- Topology is irrelevant to the end-user
- Inherently robust
- Application agnostic
- No need for a central management function
- Innovation driven by the advanced requirements of the science community

- *So let's stick to these principles*

The SURFnet approach

- Business philosophy:
  - Requirements of scientific applications are ahead of the general network markets
  - Research networks are driving network innovation
- Architectural principles:
  - Keep It Simple!
  - Bandwidth is not scarce
- Financing approach:
  - Operations paid by connected institutions
  - Innovation paid through subsidies and industry contributions

Keep it simple and clean

- Avoid unnecessary complexity
  - Don’t add more functionality than needed
  - Don’t implement functionality at the wrong layer
  - Don’t expose a layer to the problems in the layers below

- Keep it simple
  - Every layer does what it needs to do, and no more
  - Every service on one layer can run on every version of the layers below it

Build your own network

- Incumbents operators are reluctant to provide the services required by Research networks
  - Try to sell leased line or IP-VPN, instead of dark fiber or lambda
  - Impose limitations on transparency and performance

- Therefore:
  - Use a commercial operator willing to go lower in the stack (e.g. a carrier's carrier) or build your own fiber
  - Implement neutral exchanges

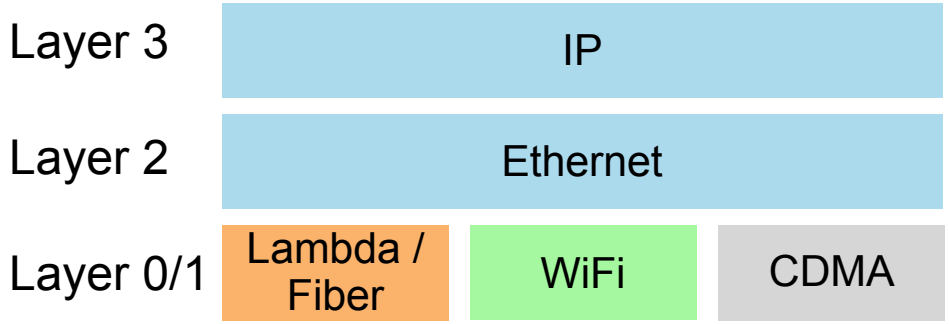
Resource sharing and collaboration

- Capacity for research networks can be created effectively
  - Build on dark fiber (including cross-border fibers) or lambdas
  - Purchase sufficient capacity
  - Share resources with research networks or other users

- Share resources at the fiber or lambda level
  - Allows each partner to build out his own network at his own pace
  - No need for a ‘big bang’ approach

A better approach to heterogeneous networking

- Don’t attempt to build a single, complex network from different access, backhaul and core networks
- Hide the differences between technologies inside the relevant layers
- Give the users the freedom to use the network at each layer in any way they want



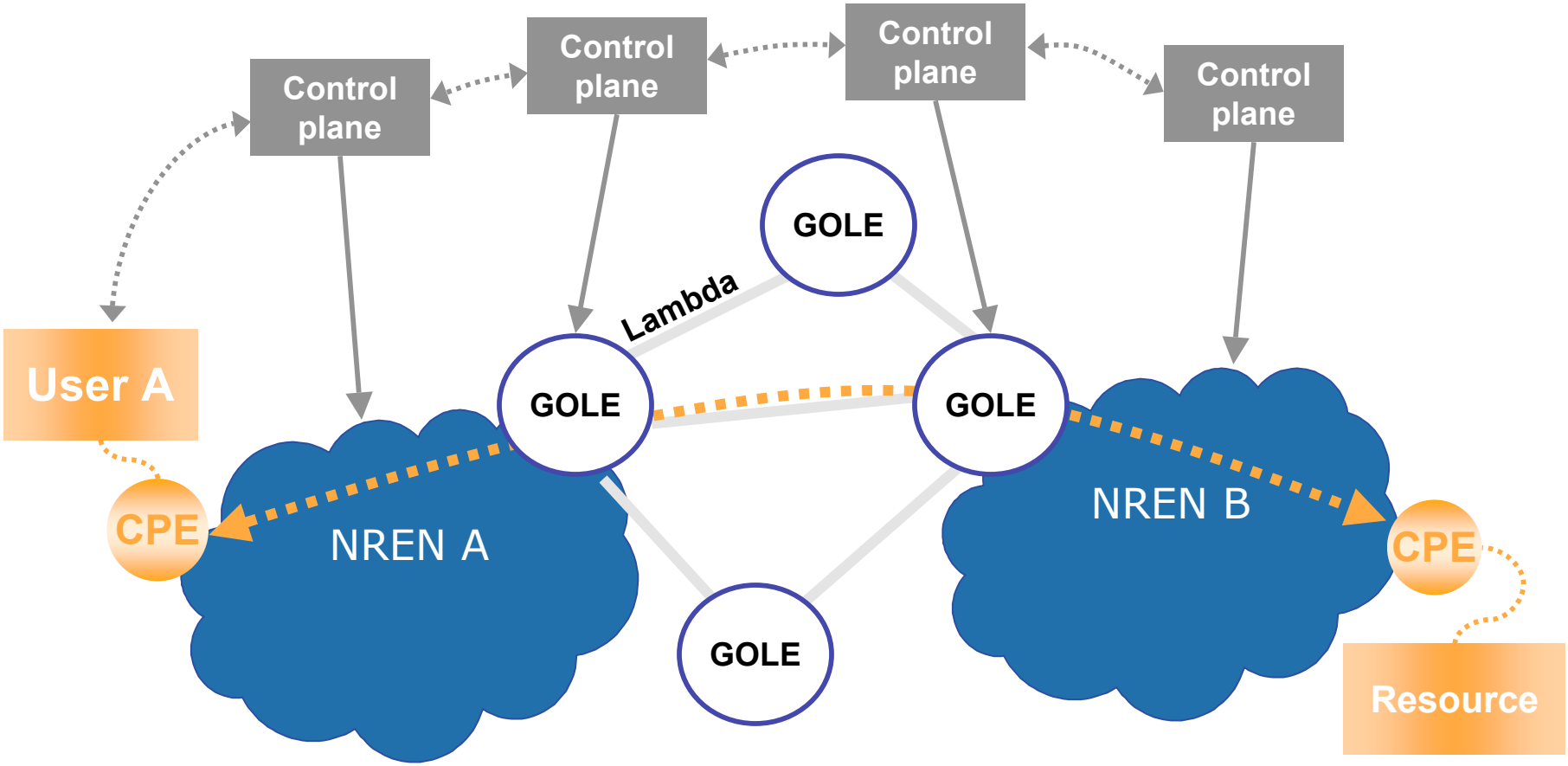
Multi-domain control planes

- Cooperation between networks requires a shared control plane

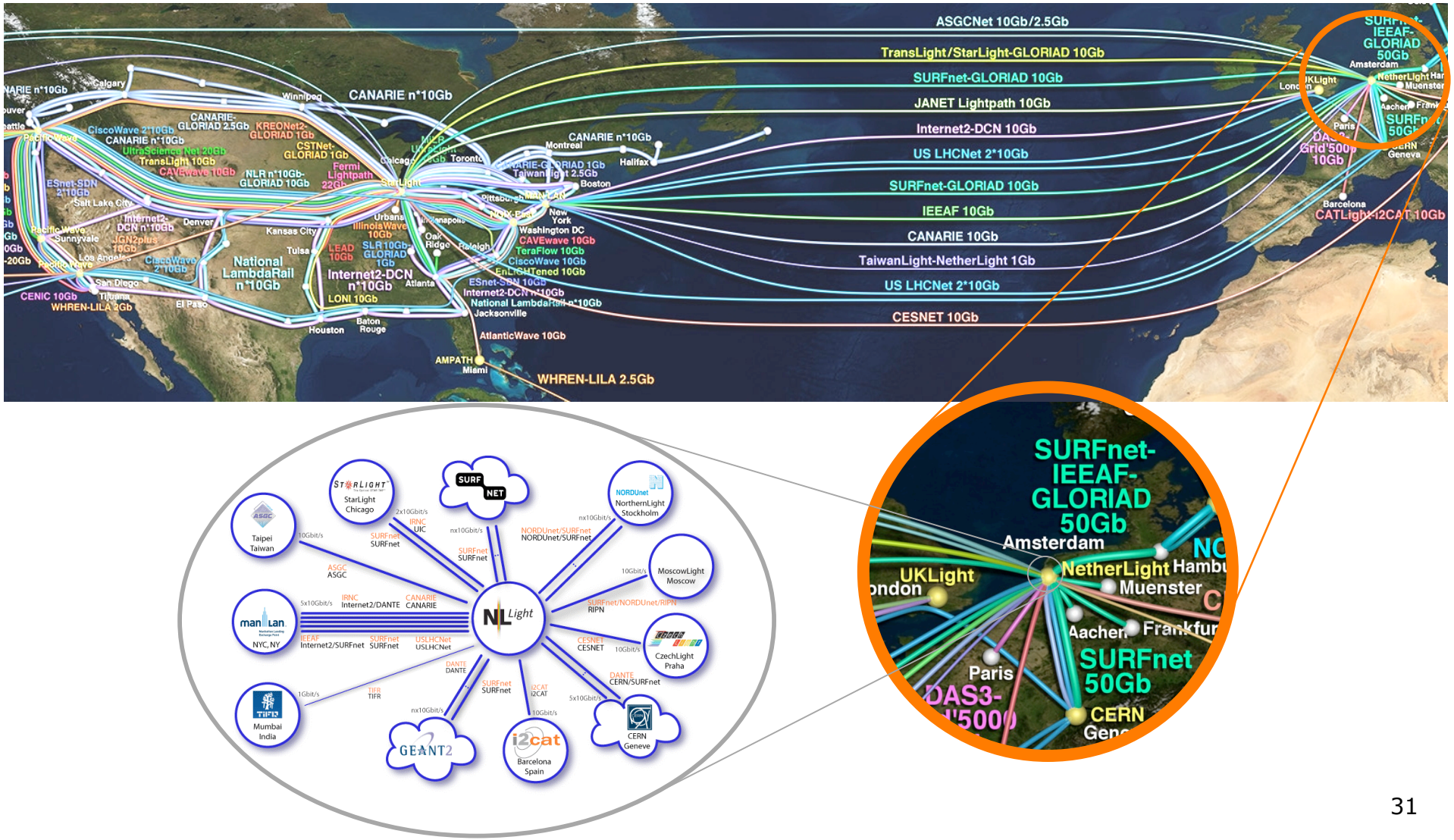
- Centralistic models won’t work
  - Complex to implement
  - Not scalable

- Create a loose cooperation between domains
  - Each domain creates its own solutions
  - Standardized interfaces between domains

The GLIF approach to lambda networking



GLIF: global multi-domain lambda networking



Hybrid networking

- Hybrid networks
  - Offer services at multiple layers (OSI)
  - While maintaining only one optical network as a substrate
  - Each layer uses the services provided by the layers below it
  - Don’t go higher in the stack than needed (saves energy, too)

- Hybrid networking is getting easier
  - New devices allow several layers to be provided through one device
  - Optimal use of such devices requires direct access to the fiber

Next generation ethernet simplifies the network

Current

Future

Layer 3

Layer 2

Layer 1

Layer 0

IP Routing

Ethernet aggregation

Sonet framing (GFP)

Lambda (10G)

Fiber

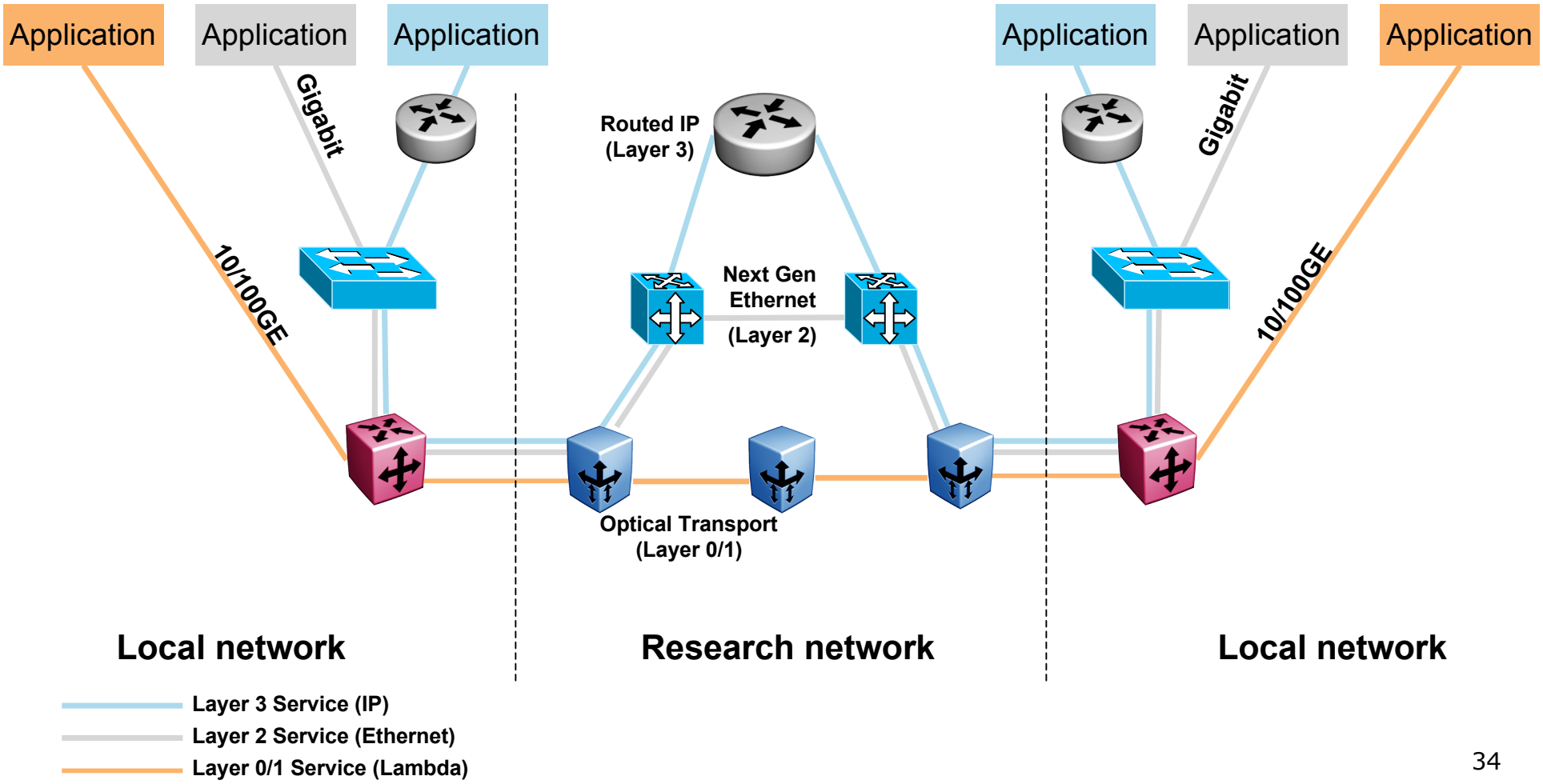
IP Routing

Next Generation Ethernet

Lambda (100G)

Fiber

SURFnet7: the next hybrid network



The user in charge

User controlled lightpaths made easy

"Create schedule"

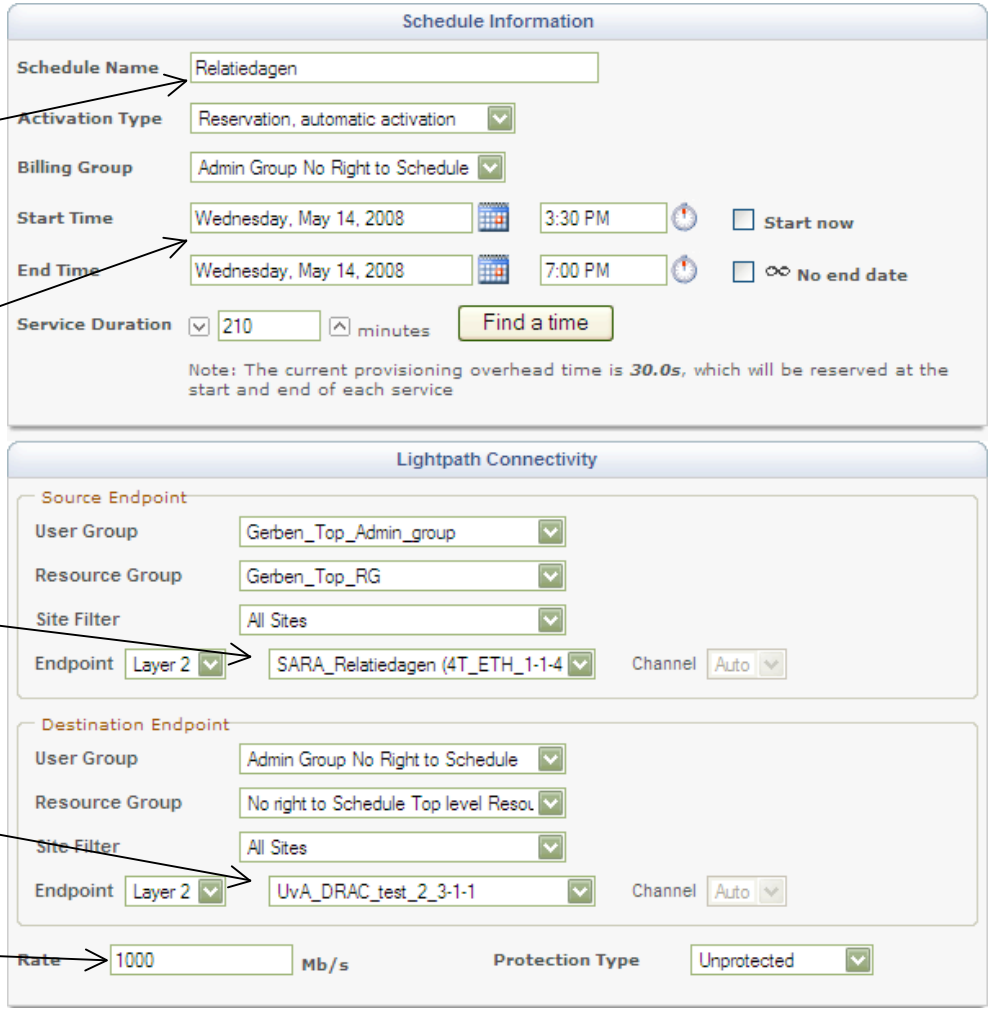
Name

Start and end time

Origin

Destination

Bandwidth



Contest to stimulate dynamic lightpath use

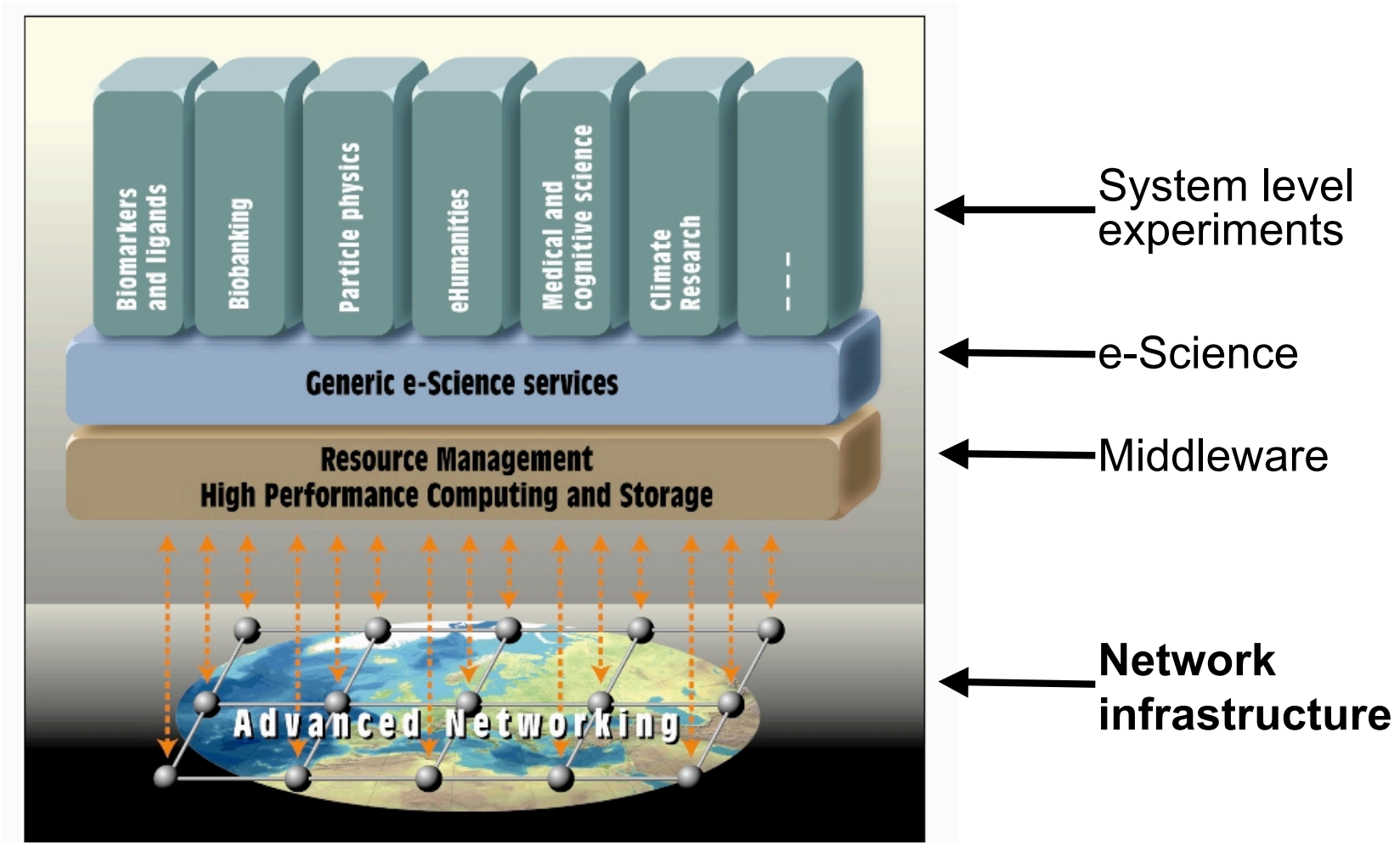
enlighten your research

e-Science needs an integrated infrastructure

- An e-Science infrastructure provides access to:
  - Computing and storage facilities
  - Generic application services
  - Sensors and instruments
  - Network resources

- A generic middleware layer is needed to provide user-friendly access to these resources
  - Allow application or user to combine facilities as needed
  - Hide the complexity of resource allocation from the end-user

e-Science in context

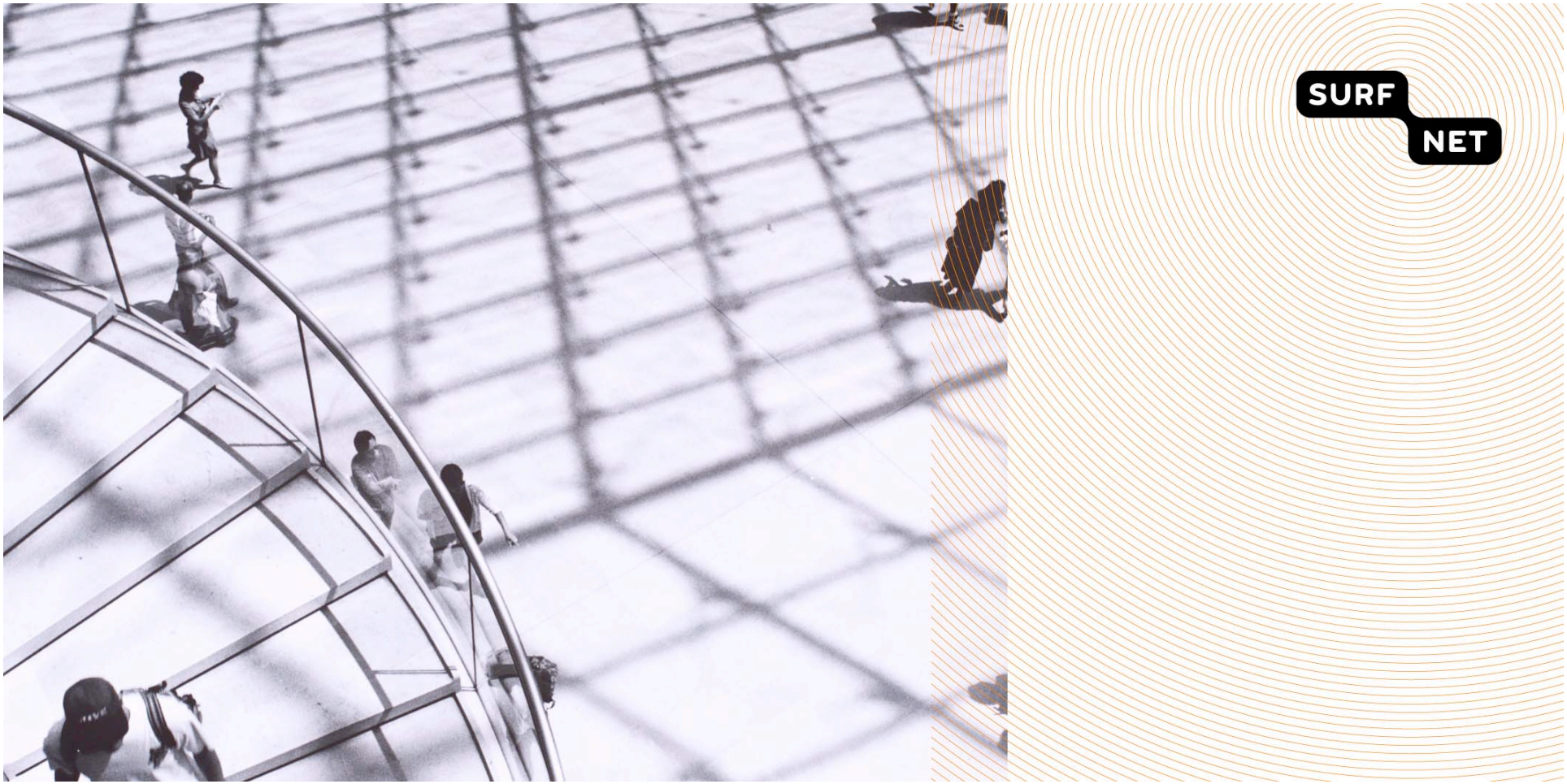


Virtual laboratory for e-Science, *Bob Hertzberger, Henri Bal* et. al.

Strategic impact of Research Networks

- Breeding place for innovative use of networking and advanced applications
- Create a focal point for international cooperation in data intensive science projects (e-VLBI, LOFAR, LHC)
- Create broad demand pull in society for advanced products and services
- Challenge industry players to develop innovative products and services

Research Networks:
Engines for Innovation



Thank you for your attention