3rd IFIP/IEEE BoD Workshop
Osaka, Japan, April 2010

University of Zurich

Investigating the Economic Feasibility of Bandwidth-on Demand Services for the European Research Networks

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DFN

FNSNF Swiss National Science Foundation

COST 605

ftw.

SURFNET

Introduction

Use of network connections by-passing the network layer may be desirable

- User perspective
  - Avoids packet loss and unforeseeable jitter behavior
  - Provides higher security level
- Provider perspective
  - Allows dedicated network pipes with lower costs (no expensive router ports)
  - Cost and power consumption per bit of optical layer devices is 1/3 to 1/5 of IP layer devices

Diversity of technologies for provider-internal realization

- SDH/SONET
- Native Ethernet
- Ethernet over MPLS

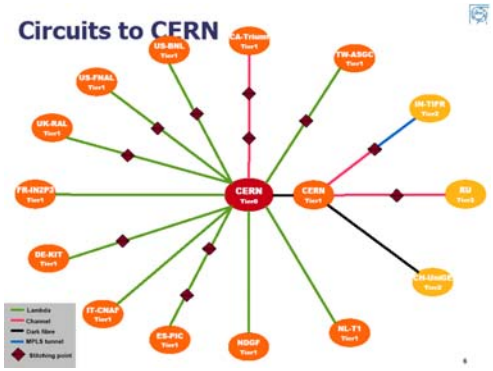
Realization and Example Projects

Two variants of dedicated network paths

- Static manually configured
- Dynamic automatically configured („Bandwidth-on-Demand“)

For permanent high data volumes (e.g. 1-4 years) with known and constant paths of flows, E2E links can be configured manually

- E.g. Tier0 and Tier1 connections for the CERN LHC experiment (needs to send large amounts of data to processing and storage centers around the world)



For temporary (e.g. few hours to months) or dynamic flows E2E links need to be established on demand

- E.g. e-VLBI (Very Long Baseline Interferometry) connects radio telescopes over high speed network

Picture sources:
Edoardo Martelli (CERN), Paul Boven (JIVE)

Current Status of Bandwidth-on-Demand

Technical feasibility of Bandwidth-on-Demand (BoD) solutions demonstrated on several occasions, e.g.

- Dynamic VLAN Service in NLR
- Dynamic Circuit Network (DCN/ION) in Internet2
- BoD Service in SINET3
- AutoBAHN in GEANT2

Challenge: Design of suitable allocation policies and business models, especially in multi-domain cases with independent providers

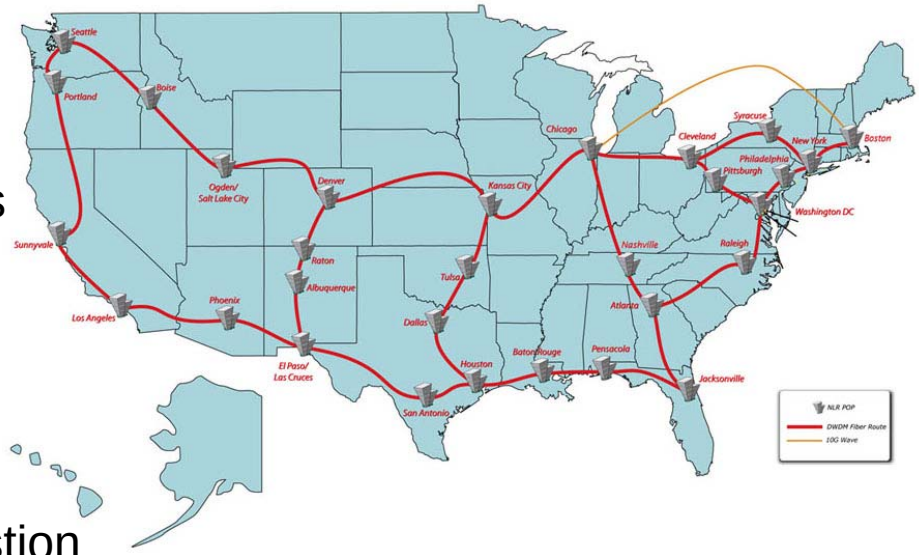
Example 1: National Lambda Rail (NLR) Dynamic VLAN Service (FrameNet)

BoD service based on Ethernet

User configuration tool called Sherpa
- Designed for intra-domain networks

Service can be reserved ahead of time

Bandwidth can be dedicated in 100M increments, from 100M to 10G (subject to availability)
- No overprovision to prevent congestion

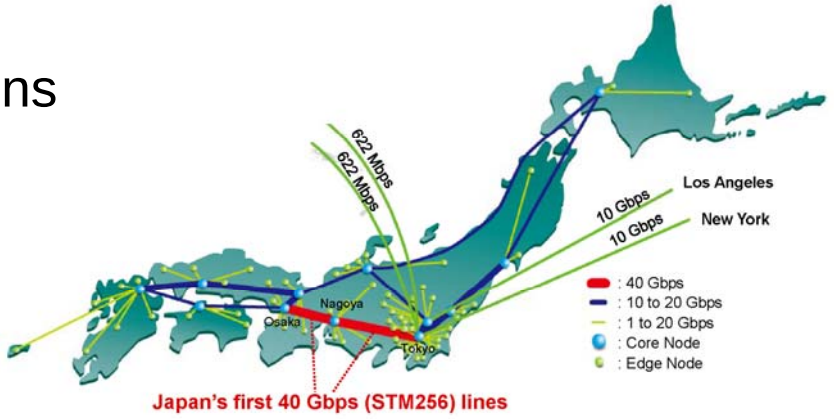


Source: www.nlr.net

Bandwidth below reserved limit marked as priority traffic, above best effort
- Dedicated traffic is never over-provisioned (will not exceed capacity)

Cost per hour per segment per 1 Gbps is $1.60 (or $2 depending on member type)

Example 2: BoD Service in SINET3 (Japanese Research Network)



Support for data-intensive applications
- E.g. Remote backup, HDTV

Layer-1 paths using GMPLS

Web-based reservation interface
- Users can select:
  - Source/destination, start/end time (15 min interval),
  - Bandwidth (150 Mbps interval), route preference (e.g. „min delay“)
- Path setup/release time: ~1-5 minutes, based on path length

Available bandwidth for BoD differs based on L2/L3 traffic pattern
- BoD services allocated in a first-come-first-serve manner
- Fair admission control scheme currently under study

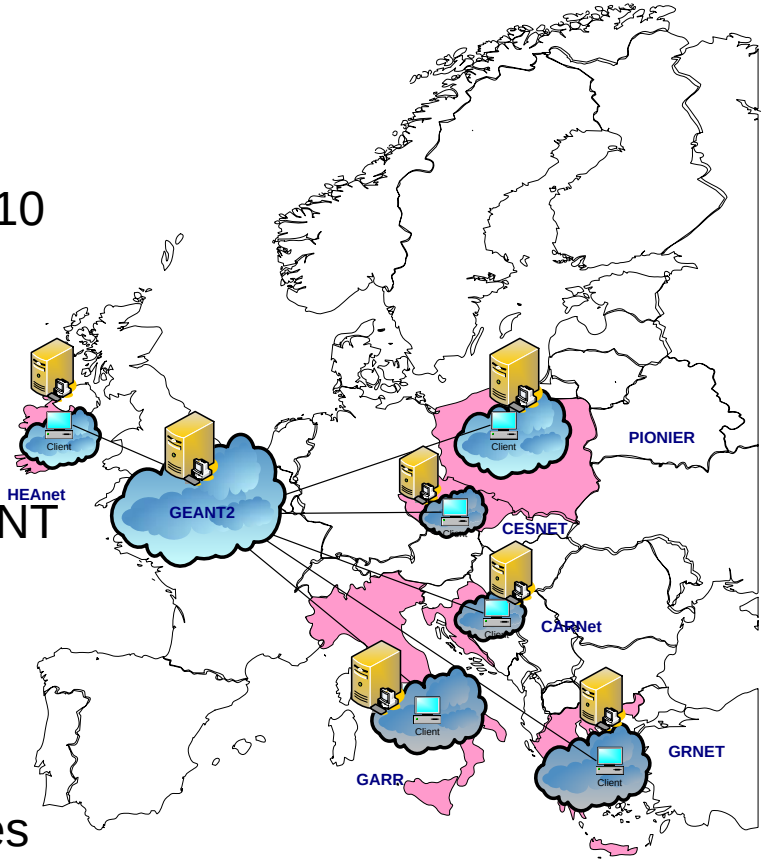
Source: Shigeo Urushidani, National Institute of Informatics (NII)

Example 3: Automated Bandwidth Allocation across Heterogeneous Networks (AutoBAHN)

Research activity in GN2 project (2004-2009)
Service activity in GN3 project (2009-2013)
- Rollout to five NRENs in second half of 2010

End-to-end paths with guaranteed capacity
- Layer-1 or 2 switched circuits

Multi-domain approach
- Inter-domain BoD provisioning within GEANT
- Proxy to intra-domain solutions, e.g.
  - BLUEnet (HEAnet)
  - ANSTool (GRNET)
  - Nortel DRAC (SURFnet)



Complements existing control plane capabilities
- Authentication and authorisation, allocation policies
- Inter-domain path finding, monitoring, advance reservation

Source: A. Sevasti, TNC 2008

BoD Dimensions

On-demand versus scheduled bandwidth allocation
- On-demand dynamic allocation: e.g. ISP-to-ISP, ASPs
- Scheduled fixed allocation ahead of time: e.g. Sporting events, research

What time-scales matter for setup and duration?
- Once a year, month, week, day, hour, minute …

What is the requested item? Quantity vs quality, guarantees necessary?
- Bandwidth, delay, jitter, error-rate, availability, single link vs end-to-end
- Strict QoS requirements may make provisioning too hard

Resource association
- Circuits/light paths (lambdas), IP packets (queues), ports, ...

Interacting roles
- ISP-to-ISP versus ISP-to-end user

Source: BoD Seminar, Dagstuhl, Germany, February 2009

GEANT

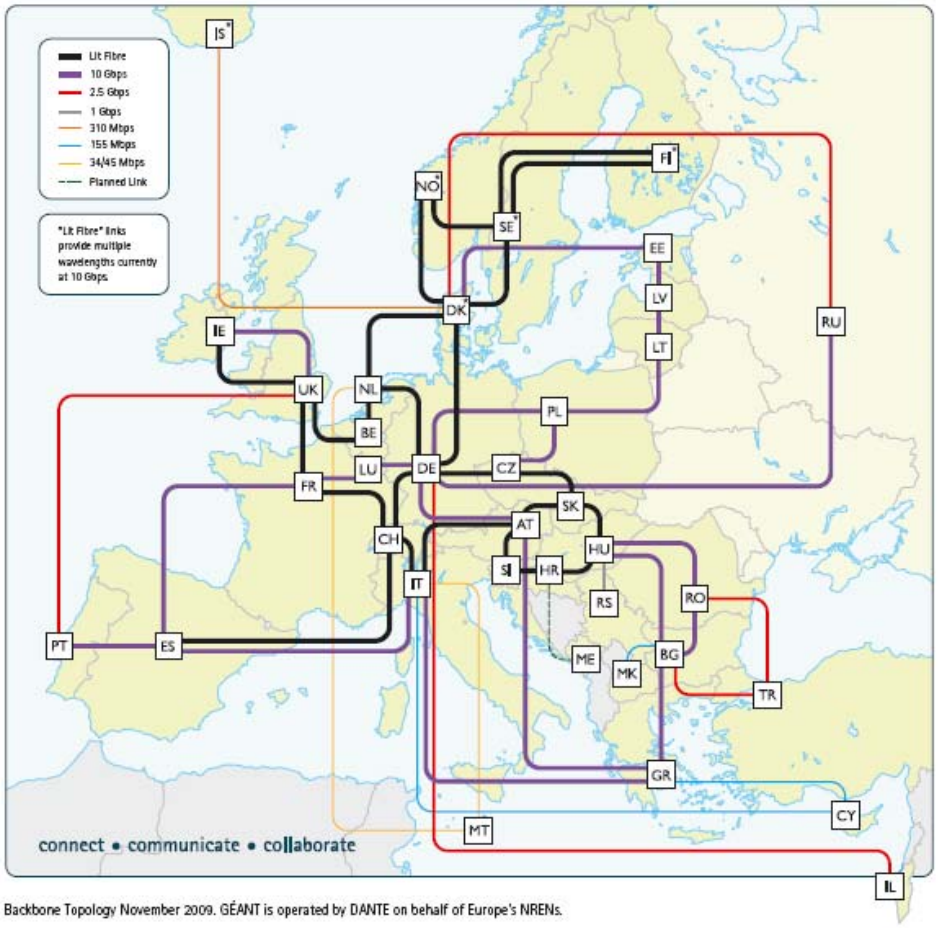
European academic network for research and education

Interconnects national research and education networks (NRENs)

Co-funded by the European Commission (EC) and NRENs

Operated by DANTE (owned by EC and NRENs)

Connects 40m users across 40 countries



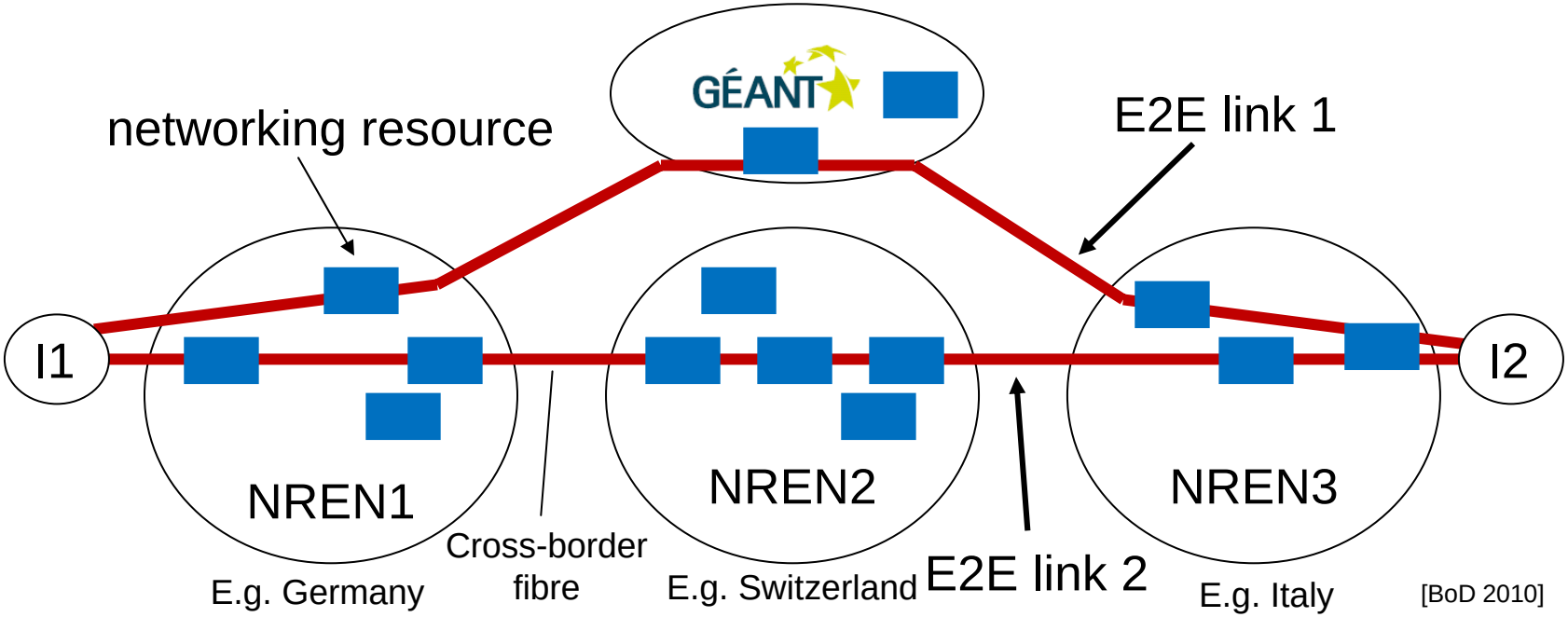
Backbone Topology November 2009. GÉANT is operated by DANTE on behalf of Europe's NRENs.

Source: www.geant.net

BoD Scenario for GN3

Europe‘s case: joint service offer by independent providers

- End-user sites are always connected via their NREN
- Two BoD options: (1) DANTE only, (2) DANTE and NRENs
- (2) may be beneficial for redundancy purposes (1+1 protection)



[BoD 2010]

Key Economic Research Challenges

End-site pricing

- Economically viable pricing model on the long term, maximizing overall social welfare (beneficial both for users and providers)
  - Needs to show a benefit for providers (investing in new technology) and users (switching to the new service)

Cost sharing

- Providers take a risk by investing in resources for on-demand use
- Costs will be partly refunded by revenues (based on estimates only)

Revenue distribution

- Distribution of revenues received from end-users among providers involved, based on used resources

Accounting

- Consider implications of cost/pricing models on accounting effort

End-site Pricing Alternatives

Flat-rate model

- End-site has a certain access bandwidth (e.g. 2 Gbit/s)
- Any other subscribed end-site can be accessed
- Simple and often preferred by end-users due to predictability
- End-site has no incentives to allocate bandwidth efficiently
- Higher cost than usage-based scheme if bandwidth is not used

Usage-based model

- Based on bandwidth and duration (e.g. x Euros per 1 Gbps per hour)
- May be based on number of segments as well
- There may be a penalty if scheduled bandwidth is cancelled too late

Other models

- Market-based model (e.g. auction-based)
- Congestion-based model (chargeable only during times of congestion)

Cost Sharing Options

Scenario 1 (service only provided by DANTE)

- Less challenging with regard to cost sharing
- Every organization pays its costs

Scenario 2 (service offered jointly by DANTE and NRENs)

- Not clear how many and how resources must be allocated in the NRENs and DANTE, or by whom they are paid
- Single NREN may harm the reputation of the overall service if too few resources are purchased, causing a bottleneck
- Static cost sharing
  - Providers have no incentives to use resources efficiently
  - Providers may not be transparent about their costs
- Usage-based cost sharing may be necessary

Revenue Sharing Options

Scenario 1 (DANTE only)

- Simpler since end-user site is a customer of both the NREN (for the static access service) and DANTE (for the BoD service)
- Fees are paid to both organizations for the respective service

Scenario 2 (DANTE and NRENs)

- Distribution of revenues based on resources made available
- Or related to resource use
  - Incentive to allocate resources efficiently
  - But path selection determines which NRENs will have a revenue

Scenario 3 (DANTE and NRENs, but only DANTE offers service)

- DANTE acquires fibers and wavelengths from NRENs
- End-users become DANTE customers (may not be politically desired)

Additional Scenario Modeling Parameters

- Service parameters (e.g. granularity of bandwidth units offered, start-time, duration)
- Details of service specification (in particular QoS guarantees, penalties)
- Number of end-sites and NRENs wanting to participate (related to the pricing selected)
- Service usage behavior of the end-sites (high use/low use per end-site, predictability of use)
- Service quality expectations of end-sites (tolerance of network bottlenecks, etc.)
- Provisioning policy (degree of over-provisioning in the networks)
- Equipment costs (e.g. fiber costs, transponder costs, DWDM and switching devices' costs, energy, cooling, space rents, etc.)
- Operations staff costs

Existing Resources

Cost calculation alternatives for re-use of existing resources (e.g. unused fibers allocated for IP services):

- Fibers regarded as available without charge
  - I.e. costs are completely compensated by the IP services
- Fiber costs proportionally shared between BoD and IP services
  - E.g. if five wavelengths are used by the BoD services and 10 for the IP services, then the cost splitting ratio will be 5:10.
- Costs are compensated by the BoD service
  - BoD service fully independent from IP services

Applicable also to devices, energy, cooling, space rents, and operations staff

Preliminary Conclusions and Future Work

Finding a sound economic basis for BoD services is challenging

Efficient bandwidth allocation is difficult, since BoD with deterministic QoS may lead to under-utilization

Multi-provider/multi-domain case increases complexity

New EU FP7 project „ETICS“ including European telecoms aims to show challenges not only relevant to academic world

Thank you for your attention!
Questions?