Operational Challenges of Communication Networks

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Outline

- Introduction to SURFnet
- The SURFnet network and some generic operational challenges
- New trends in ICT, their consequences on the SURFnet network and the resulting challenges

SURF

SURF

SURF is the collaborative ICT organisation for Dutch higher education and research. SURF offers students, lecturers and scientists in the Netherlands access to the best possible internet and ICT facilities.

SURF NET

ensures that researchers, lecturers and students can work together in a simple and robust manner using ICT. To enable the most effective use of ICT, SURFnet supports, develops and operates advanced, reliable and interconnected ICT infrastructure networks.

SURF MARKET

negotiates with ICT providers on behalf of institutions connected to SURF, offering them a selection of software, cloud services, digital content, ICT services and hardware, and all at competitive prices.

SURF SARA

is the Netherlands' national supercomputing centre. SURFsara supplies high-performance computing (HPC) services, data storage, network research and visualisations to the academic and business communities.

SURFnet

Mission

To improve higher education and research by promoting, developing and operating a trusted, connecting infrastructure that facilitates optimum use of the possibilities offered by ICT.

Vision

We make a unique contribution by ensuring that researchers, instructors, and students can work together simply and effectively by linking individuals and teams seamlessly together and by giving them access to services, data, and tools and by encouraging and developing new ICT applications.

Results

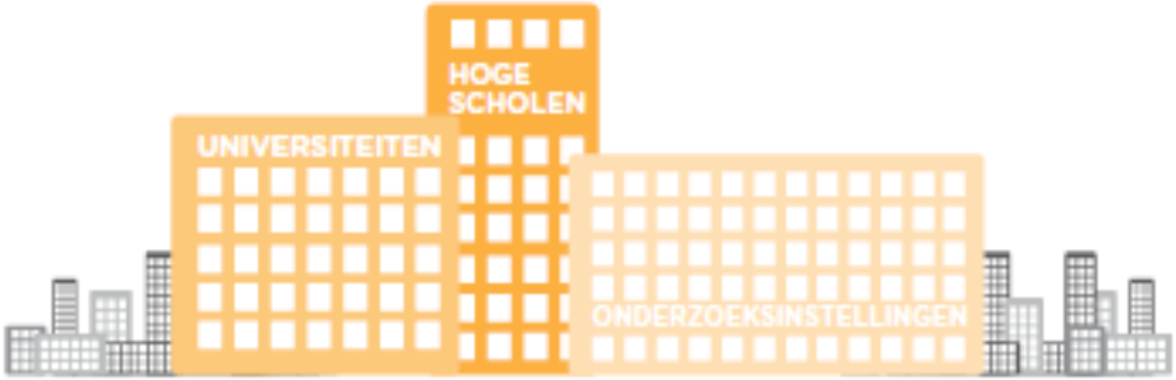
Network infrastructure
a hybrid fixed-wireless network as the basis for all collaboration, providing efficient, unlimited data transport.

Collaboration infrastructure
a pioneering collaboration environment that seamlessly connects systems, services, tools, and people

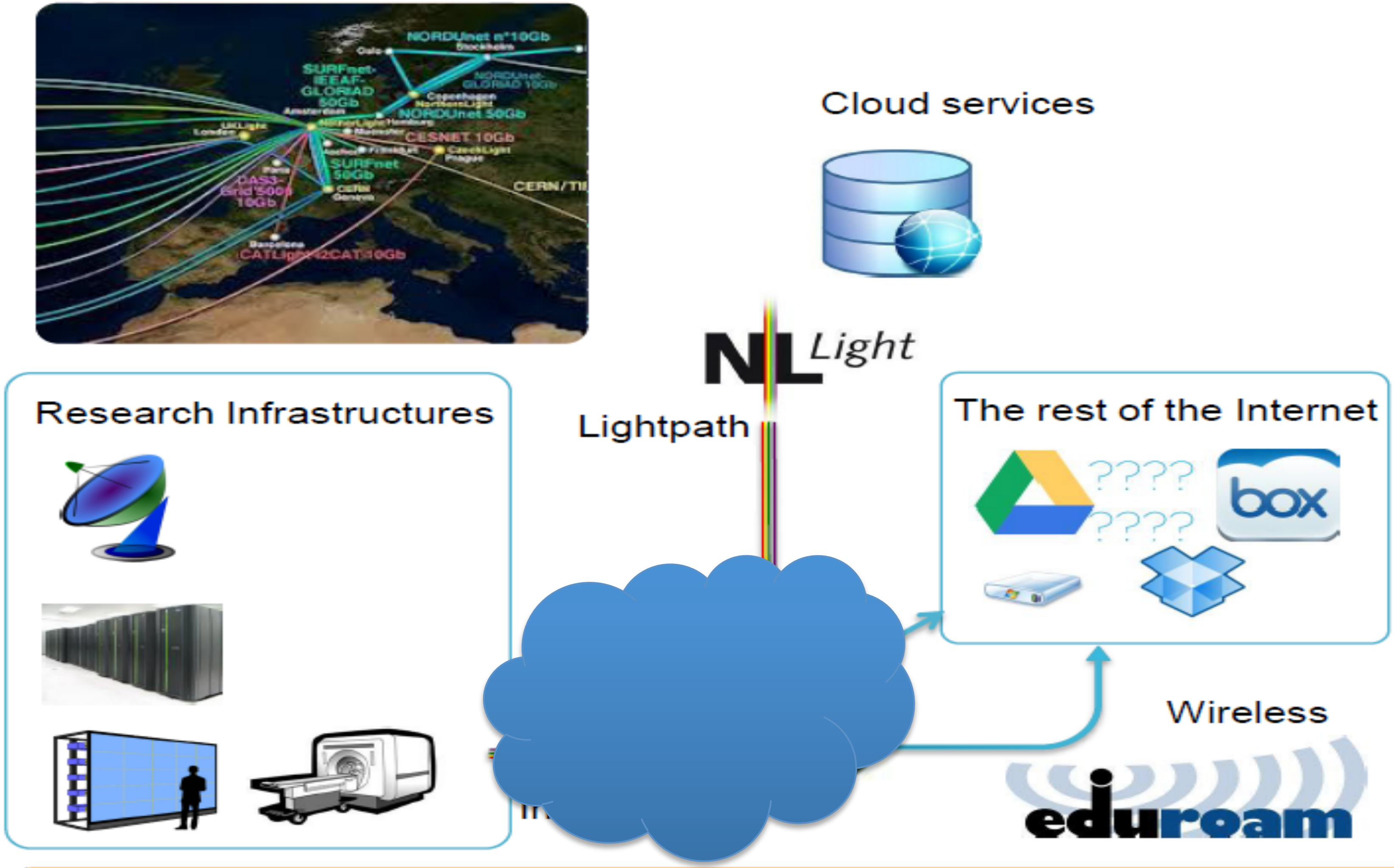
SURFnet

- 14 research universities
- 42 universities of applied sciences (*hogescholen*)
- 8 academic hospitals
- 40 professional education institutions (*MBO*)
- Research Institutions such as
  - Astron, Nikhef, AMOLF, CWI
  - National Library of the Netherlands (*Koninklijke Bibliotheek*)
  - Netherlands Organisation for Scientific Research (NWO)
  - Royal Netherlands Academy of Arts and Sciences (KNAW)
  - TNO, Novay
- Commercial R&D institutions
- International cooperation

SURF is a partnership of and for institutions for higher education and research



State of the art network infrastructure



- Unlimited data transport supporting big data
- Connecting users and services to each other and to the world
- Optimal use of cloud services via Netherlight
- Wireless and mobile (LTE) access through eduroam
- On demand connectivity

Fixed Network Services

SURFinternet

SURFlichtpaden

Multi
Service Port
Vs Single
Service port

NetherLight

On demand

Who are our users??

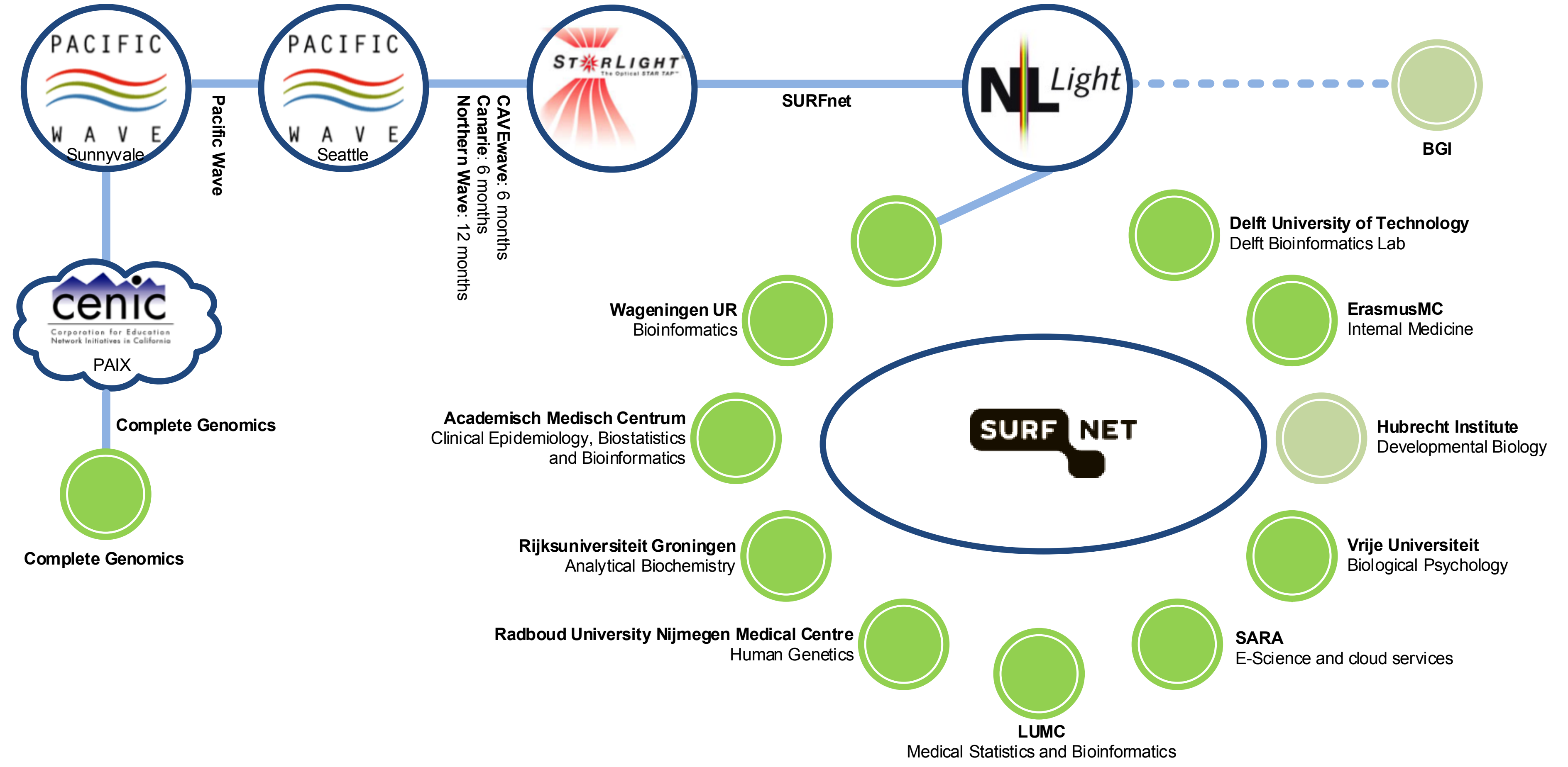
Big Data

- Large/complex/rapidly changing datasets used by researchers require large-scale computing, advanced visualization, high-speed networking, combined with high-quality user support.
- Need for highly advanced e-infrastructure.

https://www.esciencecenter.nl/project/esalsa

But also Internet connectivity for about 1 million end-users

Genomics



PACIFIC WAVE
Sunnyvale
Pacific Wave
PACIFIC WAVE
Seattle
CAVEwave: 6 months
Canarie: 6 months
Northern Wave: 12 months
STARLIGHT
The Optical STAR TAP
SURFnet
NL Light
BGI
cenic
Corporation for Education Network Initiatives in California
PAIX
Complete Genomics
Complete Genomics
Delft University of Technology
Delft Bioinformatics Lab
Wageningen UR
Bioinformatics
ErasmusMC
Internal Medicine
Academisch Medisch Centrum
Clinical Epidemiology, Biostatistics and Bioinformatics
SURF NET
Hubrecht Institute
Developmental Biology
Rijksuniversiteit Groningen
Analytical Biochemistry
Vrije Universiteit
Biological Psychology
Radboud University Nijmegen Medical Centre
Human Genetics
SARA
E-Science and cloud services
LUMC
Medical Statistics and Bioinformatics

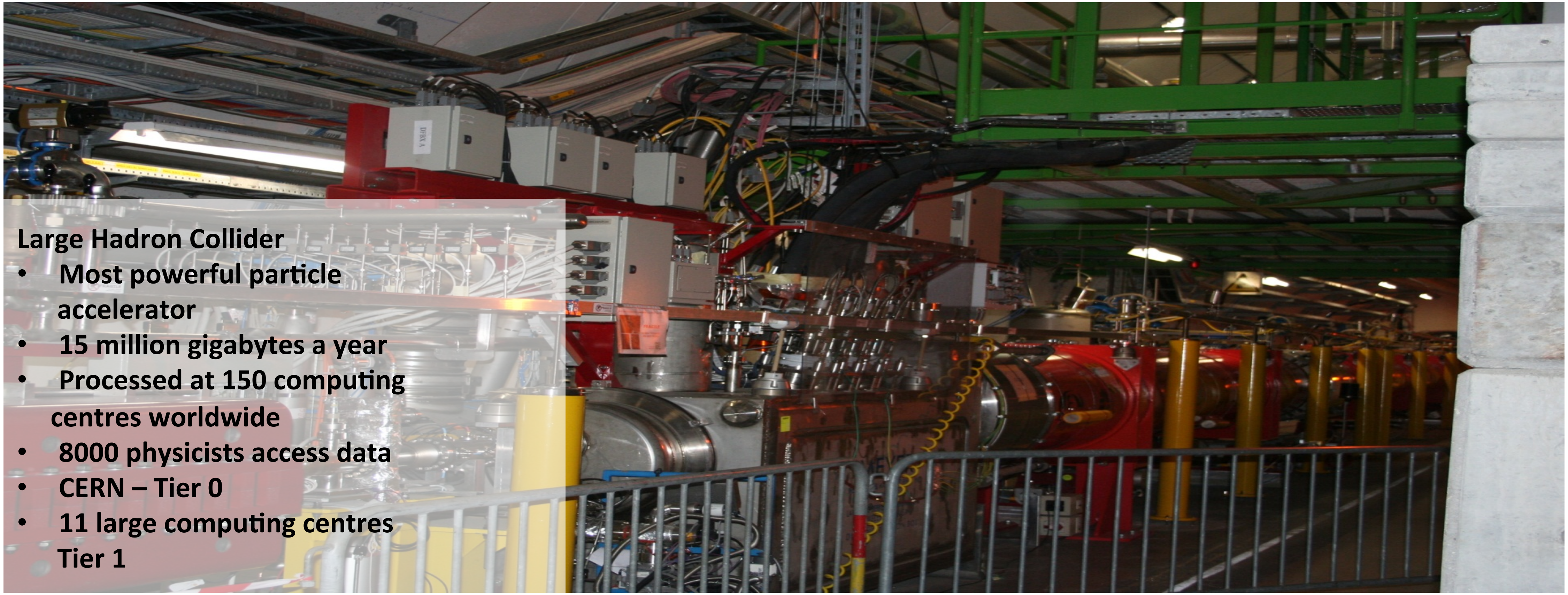
Astronomy

- Array of radio telescopes
- High resolution observations
- Multiple Gbps
- Point-to-point connections to correlator and data processor

- Future
  - Higher resolution
  - Larger arrays
  - Increased data rates

Network status as per 2007-08-21. Image created by Paul Boven <boven@jive.nl>. Satellite image: Blue Marble Next Generation, courtesy of Nasa Visible Earth (visibleearth.nasa.gov).

Particle and high-energy physics



Large Hadron Collider

- Most powerful particle accelerator
- 15 million gigabytes a year
- Processed at 150 computing centres worldwide
- 8000 physicists access data
- CERN – Tier 0
- 11 large computing centres Tier 1

Challenge for the SURFnet network

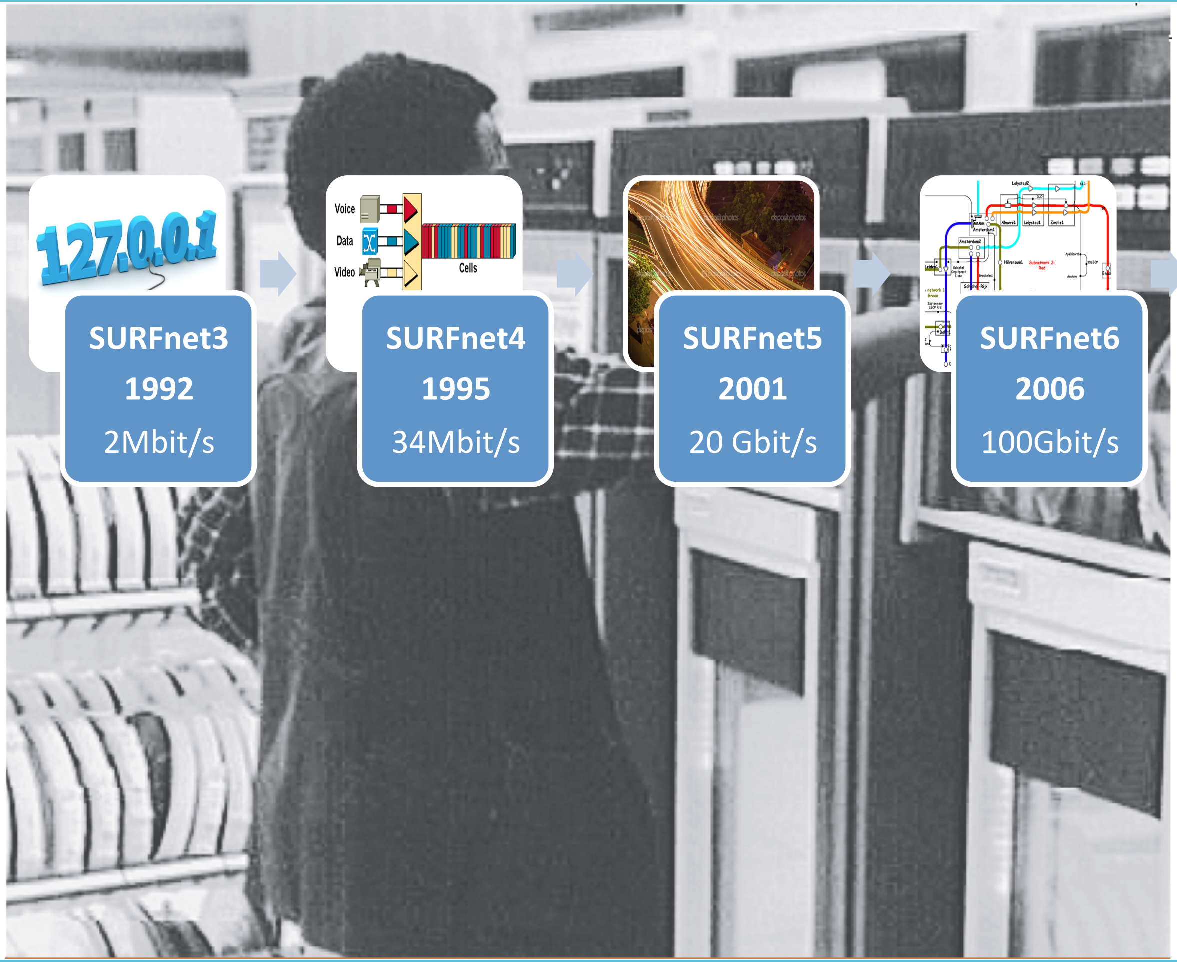
High-end data intensive research
Tailor made implementations
Lot of specialized support needed

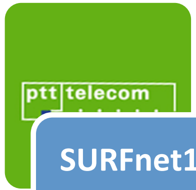
SUPPORT

Reliability and performance is critical
Commodity

0 # end-users 1 million

The SURFnet Network -- The “flow” of innovation!





SURFnet1
1986
9,6Kb/s

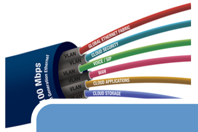
SURFnet2
1989
64Kb/s

SURFnet3
1992
2Mbit/s

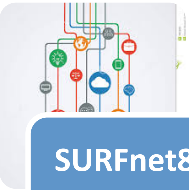
SURFnet4
1995
34Mbit/s

SURFnet5
2001
20 Gbit/s

SURFnet6
2006
100Gbit/s



SURFnet7
2012
100Gbit/s



SURFnet8
2017/2018
100Gbit/s+

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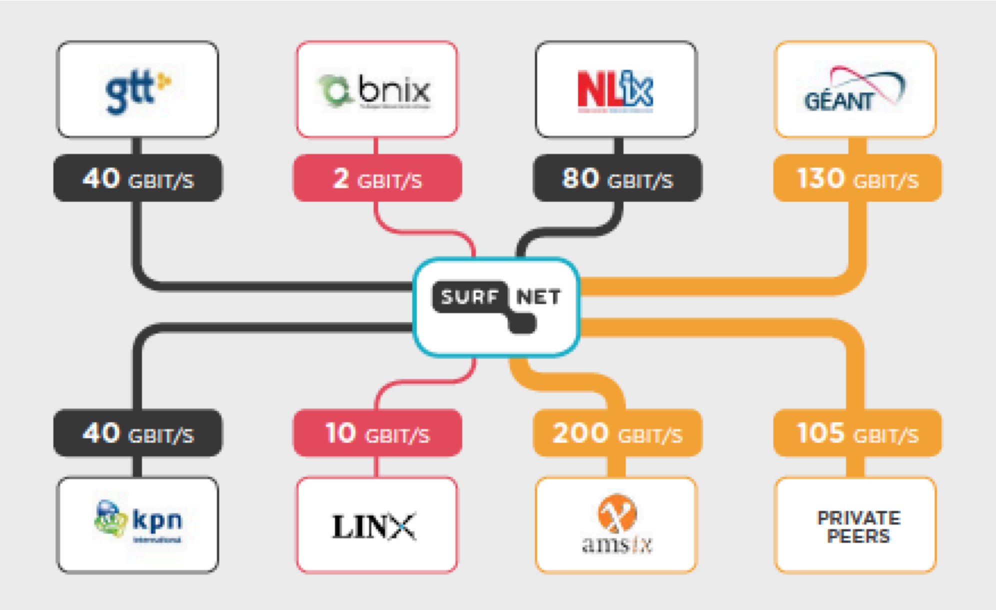
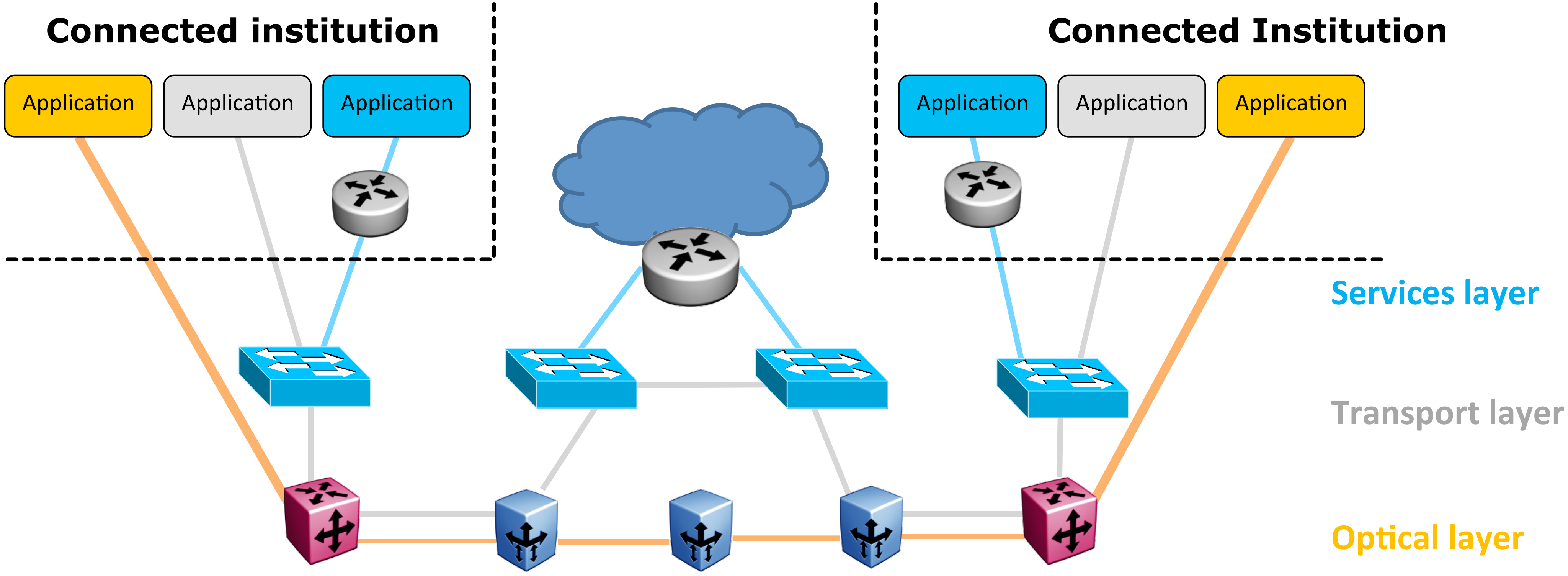
SURFnet – traffic timeline

- IP traffic volume
  - In 2000, 543 TB in and 635 TB out
  - In 2005, 17707 TB in and 11515 TB out
  - In 2010, 45212 TB in and 34918 TB out
  - 2015, 57948 TB in and 93552 TB out
- External connectivity
  - 2000, 1.6 Gb/s
  - 2005 41.6 Gb/s
  - 2015, 607 Gb/s



SURFnet network: Layered and scalable



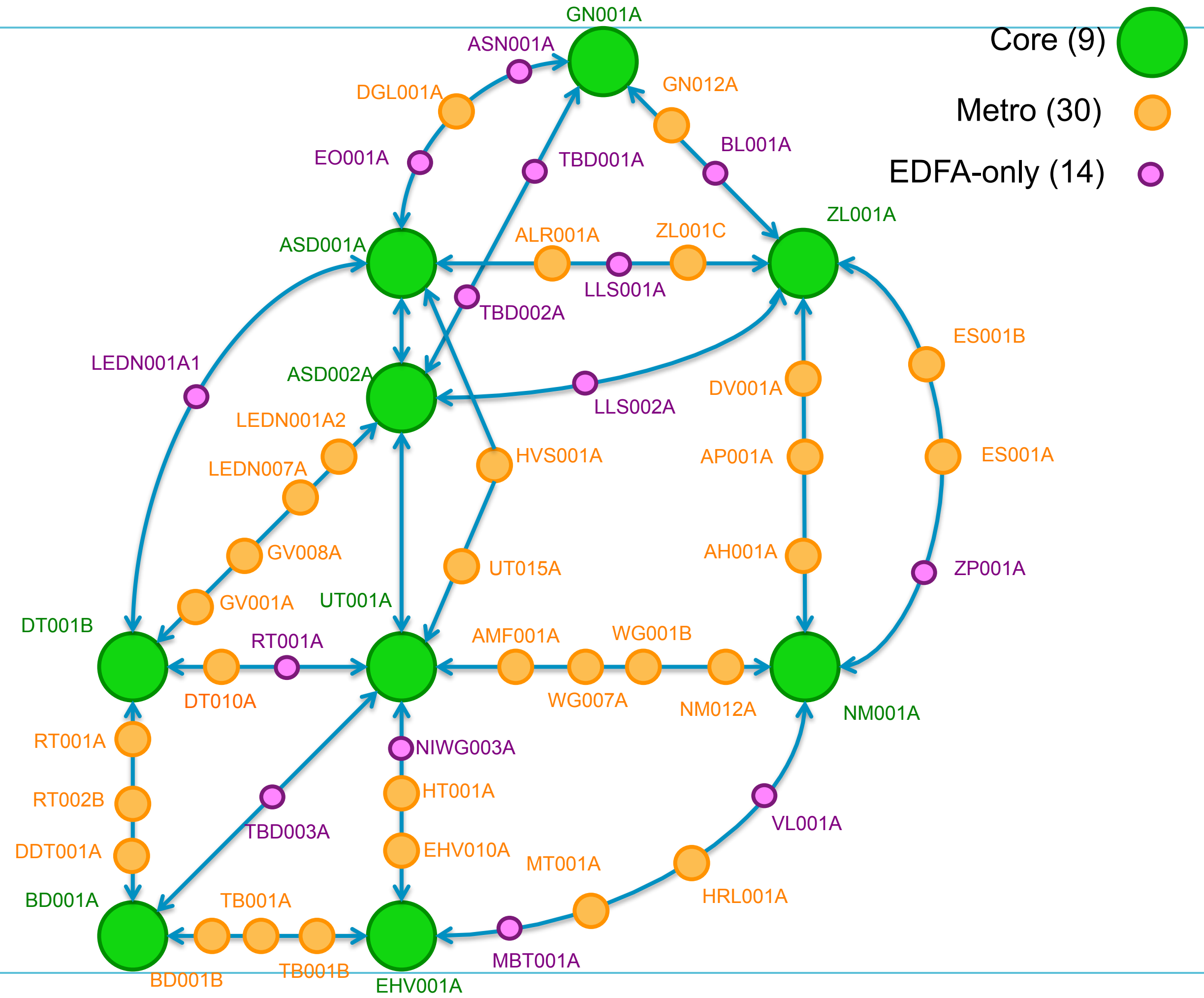
Fiber infrastructure

2015 based on
11.000 km of dark fiber

In 2005 this was
only 6000km

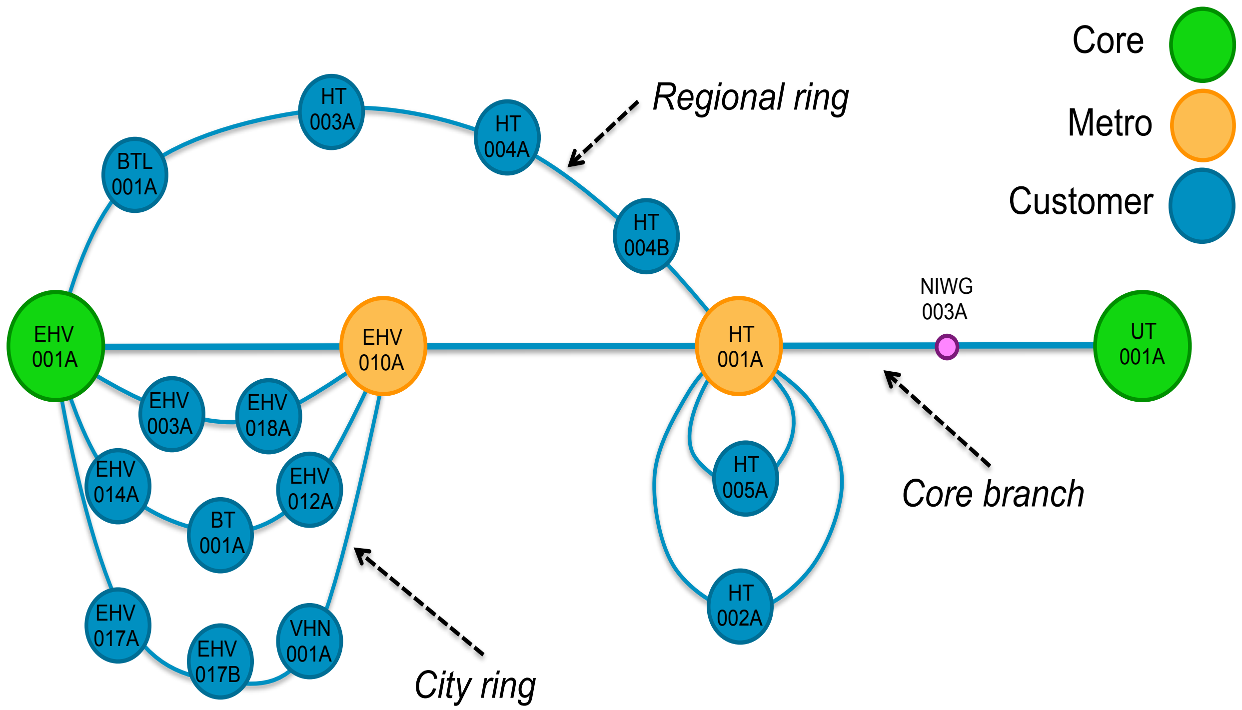
SURF NET

SURFnet network topology: Photonic Layer



- Metro sites: nodal degree is 2
- Core sites: nodal degree >3 (more traffic, better power arrangements and available rack space)

SURFnet network topology (2)

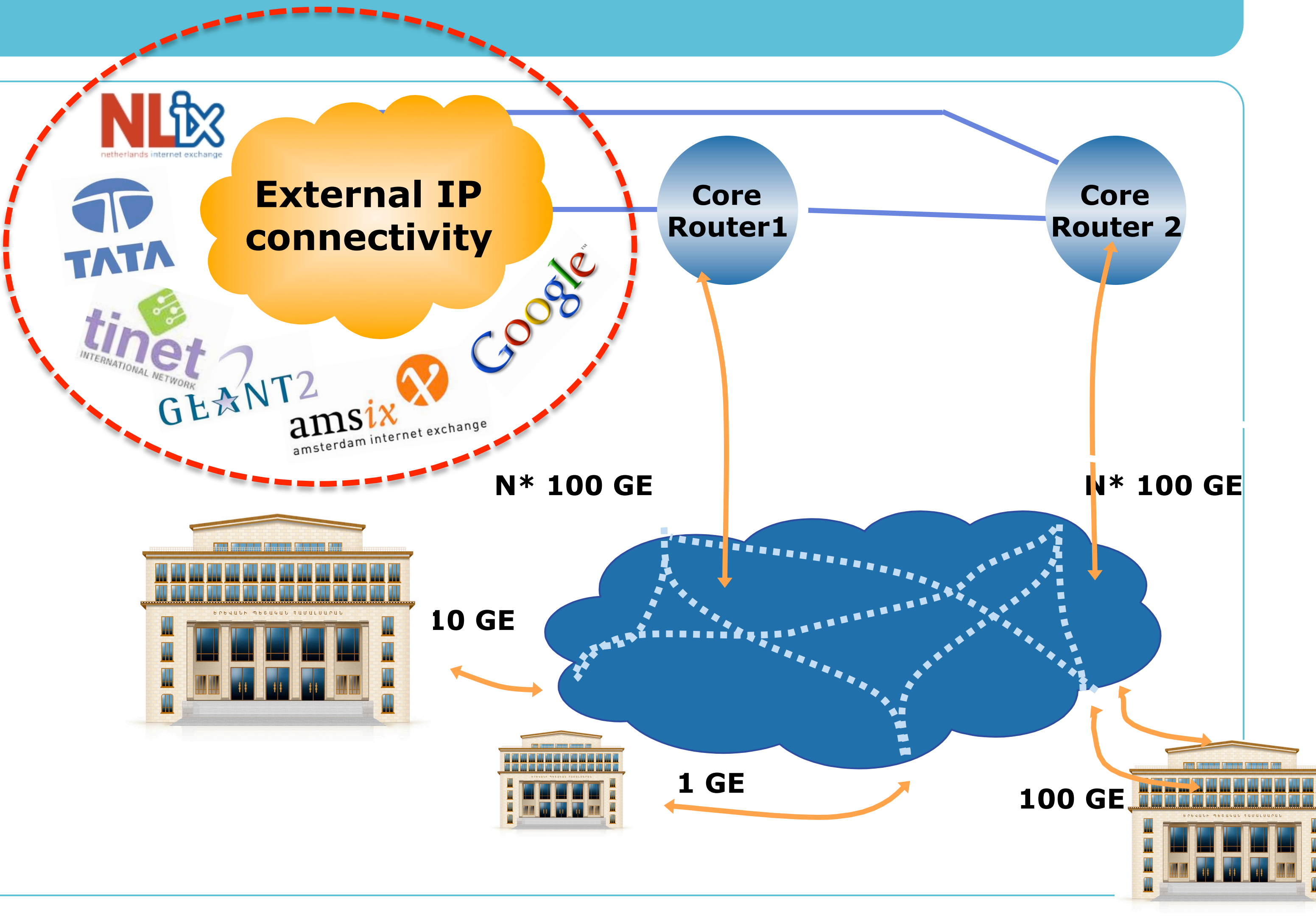


Switching Layer

	#	Customer ports	Switch Fabric
Access nodes	250	1G to 10G	10 to 40Gb/s
Regional nodes	80	Multiple 1G and/or multiple 10G	100 to 240Gb/s
Core nodes	50	Multiple 10G	1Tb/s

Routing Layer

	#	Router 1	Router 2
IP Routers	2		
10GE ports	122	60	64
100GE ports	12	7	5



Some generic operational Challenges

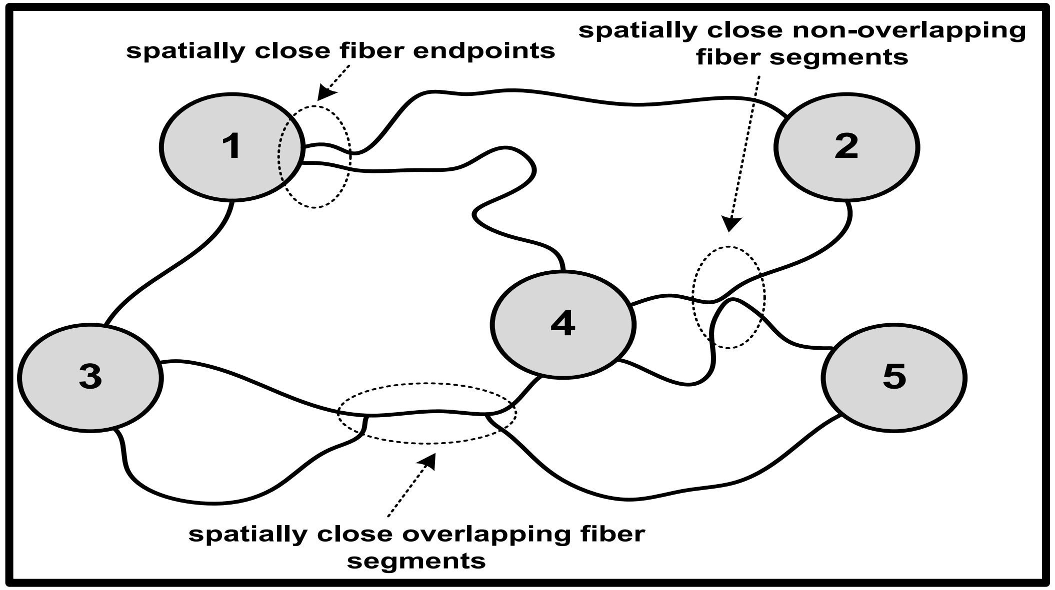
- Capacity or resource planning
- Reliability

Reliability

- Network downtime is not acceptable anymore
- Non optimal interaction between network and application layer
- Numerous potential failure points
  - Multiple layers
  - Fibers (Single point of failures)
  - Each layer has numerous equipment
  - Each equipment has multiple ports/connection points
- Network architecture and graph can also be upgraded to improve reliability

Reliability problems solved in
Collaboration with TUDelft

- SPoF-disjoint paths
- Spatially-close fiber segments have a high chance of failing simultaneously in the event of disasters

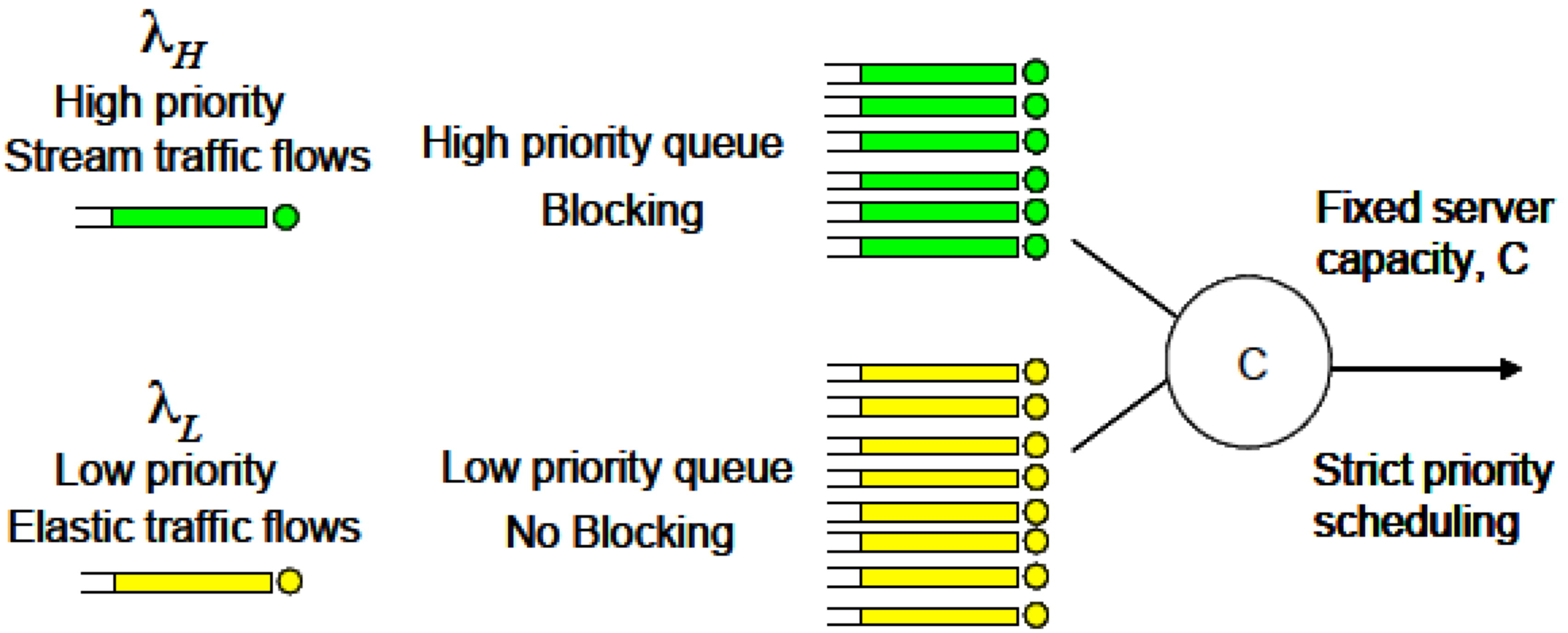


Capacity and Resource planning

- Given a traffic matrix for a existing network topology
  - How should traffic be routed such that latency experienced by delay-sensitive traffic is minimized or SLAs are met
  - Traffic grooming is maximized
- How should the network topology be improved to increase reliability of network services (given a traffic matrix)?
- How to deal with dynamics in the traffic matrix? First model the traffic matrix itself?
- How much capacity (on all layers- photonic, switching and routing) should be planned as reserve and on which locations?
- When to upgrade?

Capacity and Resource planning (traffic types)

- Different traffic types in network with different service level agreements

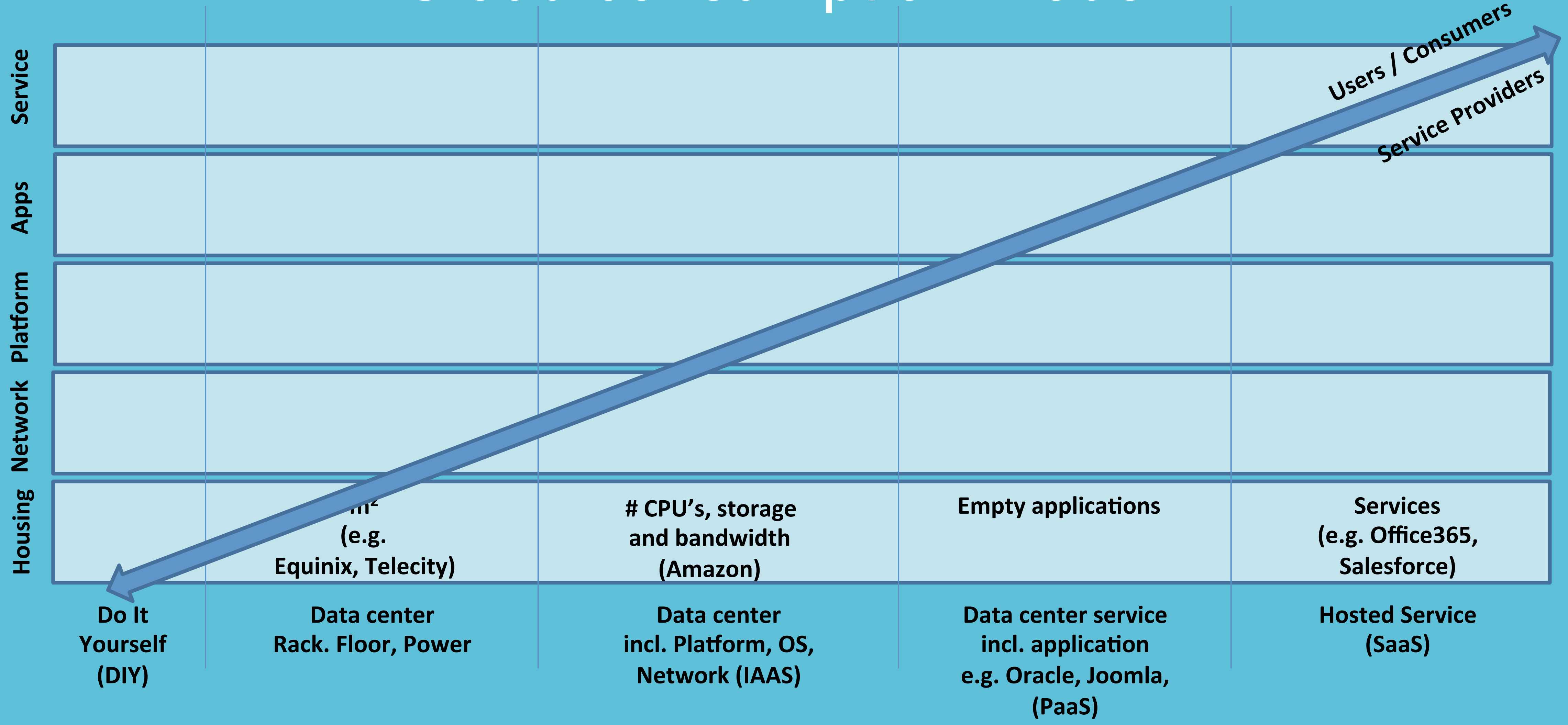


New trends in ICT

- Virtualization in the datacenter of connected institution
- Datacenters in external locations
- Move to Infrastructure-, Platform- and Software-as-a-Service
- Outsourcing ICT

https://www.surf.nl/en/knowledge-base/2015/best-practice-utrecht-university-greater-flexibility-with-the-multi-service-port.html

Cloud consumption model



Source: Routz (www.routz.nl)

Datacenter virtualization

- Virtualization
  - Agility and speed in datacenter needs to be matched on network level as well
  - Agility in network requires complete automation
  - Full potential can be realized through orchestration
- SURFnet network has to match the service agility as well
- Also relevant for e-infrastructure for researchers

Datacenters

- Datacenters outside campus
  - Pros
    - Disaster recovery
    - Better facilities such as power supply etc
  - Challenges for networks
    - Longer network chain, multiple parties
    - Performance problems and troubleshooting
    - Interaction between network and application layer

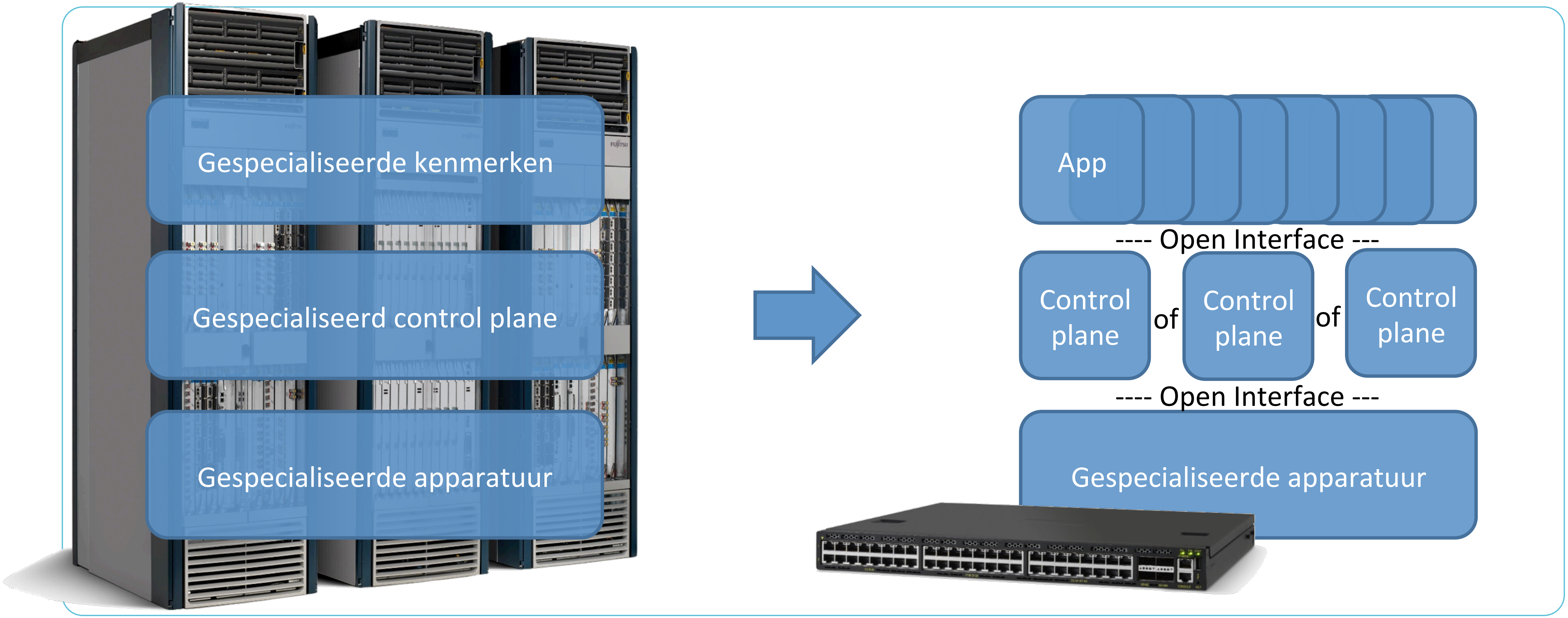
Cloud Services

- Pros
  - Lower costs through competition
  - Flexibility
- Challenges for network
  - Agility
  - Flexibility
  - On-demand connectivity
  - Adjust to cloud service requirement

Outsourcing ICT/network operations

- ICT not core business of educational institutions
- Especially smaller institutions are outsourcing the operations
- Challenges
  – Specialized network functions might move from the campus network of institutions into the SURFnet network
  – Need for Network Functions Virtualization

What’s next in networking?
Software Defined Networking



Some existing challenges become more critical

- Reliability is becoming more important
- Interdependency between multiple connections of a single customer
- From point-to-point to multipoint-to-multipoint
- Longer network chains: Performance monitoring and interaction with higher layers

New challenges

- Greater flexibility, service agility and on-demand connectivity required from the network
- Integration with Cloud services and e-infrastructure through orchestration

→ Models for capacity planning, traffic modeling become more important as provisioning in the long run will be automated

Problem: performance guarantees vs efficiency

- Lightpaths
  - 100% Gauranteed bandwidth
  - Minimal delay and jitter
- Capacity planning for multiple lightpaths on a link
- Dynamic algorithm needed to estimate the (dynamic) traffic profile of the lightpath with the help of monitoring techniques
- Ensure almost lossless performance

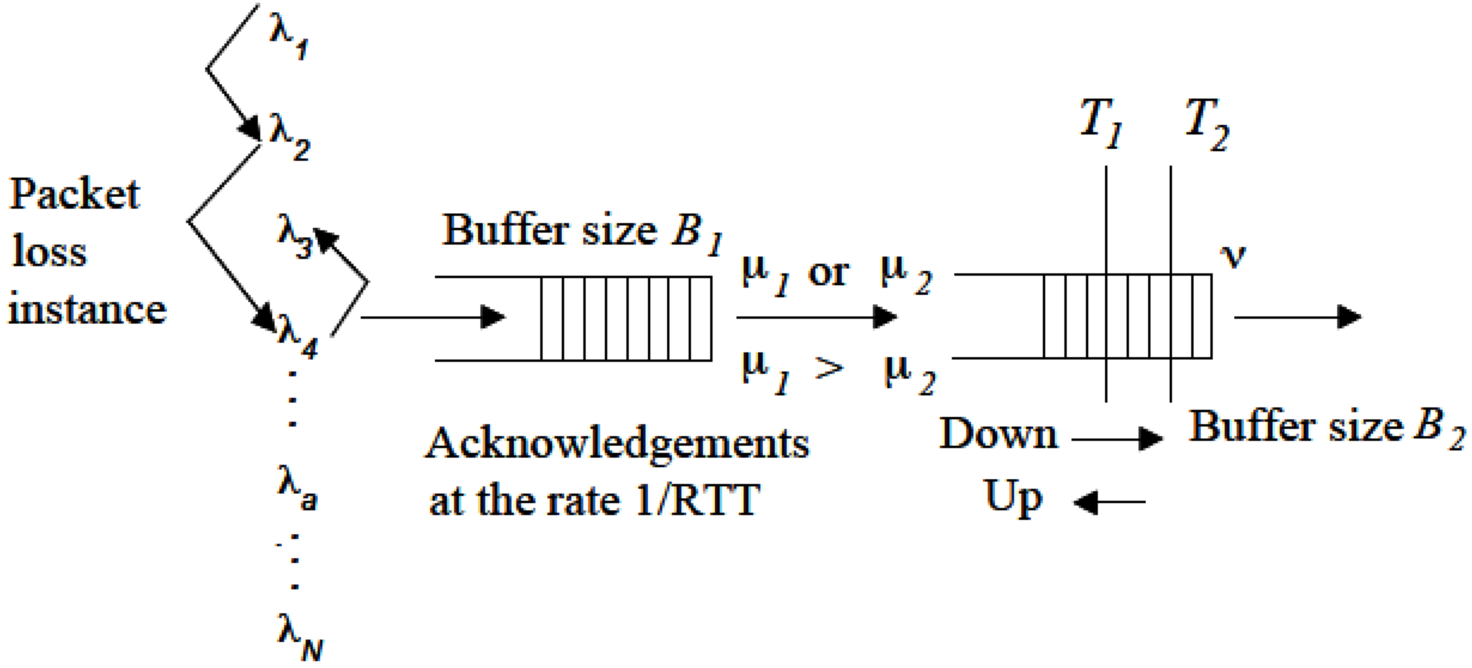
Problem : interaction application and networking layer

- Network chains are longer
- Monitoring within a single domain is not sufficient
- Monitoring and troubleshooting over multiple domains is required

- Furthermore interaction with higher layer applications is critical to success, perception of performance on network layer
- Therefore, modeling the interaction with higher layers and generic guidelines for configuring parameters optimally is essential

Problem: performance interaction application and networking layer

- For example, previous work on TCP and Ethernet congestion control



Problem: performance interaction between application and networking layer

- Research required on interaction of higher layer application layer protocols with
  - network protocols or settings such as buffer lengths
  - Network latency and jitter
  - Very short outages
- For example
  - Storage and compute applications

Problem: traffic modeling for Internet of Things

Internet of Things

- Sensors everywhere
- Generate and transfer data
- How much data would stay within a local network
- How much would need to be transported over a wide area or backbone network?

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