Contents of this talk

- This space is intentionally left blank
Purpose of this talk

• You can do:
  – Research on Lambda’s
  – Research with Lambda’s
  – Research because of Lambda’s

• This talk is about the first two points
What is a Wave?

What are some examples of waves?

- Radio/TV microwaves
- Infrared waves
- Visible light
- X & _-rays

What is the wavelength range for each type of wave?

- Radio/TV microwaves: 300m
- Infrared waves: 300µm
- Visible light: 300nm
- X & _-rays: 300pm

What is the THz Bandwidth and its significance?

- THz Bandwidth: 50 THz
- Bandwidth: 500 channels with 100 GHz spacing

What are the wavelengths for 1440 nm + range?

- 1310 - 1625 nm

What is the EDFA and its use?

- EDFA: 4.5 THz
- Channels: 45

What is the attenuation and its impact on loss?

- Attenuation: 50 dB/km
- Loss too high

Sheet from Gert Nieveld, Global Crossing

*) S-Band is planned for the 1440 nm + range
C and L-band \(\lambda\)ambda overview (terrestrial applications)
So, what’s up doc

Suppose:
- Optical components get cheaper and cheaper
- Dark (well, dark?) fibers abundant
- Number of available λ/user -> ∞
- Speeds of 10, 100, 1000 Gbit/s make electrical domain packet handling physically difficult

Then:
- λ provisioning for grid applications becomes feasible
- Long term view ---> full optical
Current technology + (re)definition

• Current (to me) available technology consists of SONET/SDH switches
• DWDM+switching coming up
• Starlight uses for the time being VLAN’s on Ethernet switches to connect [exactly] two ports
• So redefine a λ as:

  “a λ is a pipe where you can inspect packets as they enter and when they exit, but principally not when in transit. In transit one only deals with the parameters of the pipe: number, color, bandwidth”
Possible STAR LIGHT configuration

10 Gbps (8 x GbE)
2.5 Gbps (2 x GbE)
1 GbE
STS mapped to GbE

I-wire: 4 x GbE CWDM
Optical Mux/Demux

GbE transceivers

DTF: 4 x 10 Gbps SONET DWDM
CA*net 4: 8 x 10 GbE DWDM

10 Gbps SONET to GbE Demux
10GbE to GbE Demux

STS to GbE Demux

SURFnet 5: 1 x 2.5 Gbps SDH DWDM
Layer 3 Router to connect to smaller networks

Courtesy Bill St.Arnaud
Basic phase 1

2.5 Gbps SONET/SDH “Lambda”

1 Gbps Ethernet

Chicago

CISCO 15454

Teleglobe domain

Amsterdam

CISCO 15454
Amsterdam 1st phase

- 2.5 Gbps SONET/SDH “Lambda”
- 1 Gbps Ethernet

SURFnet 5 → TBD → R → GIGA cluster
Multi domain IP controlled

Administrative boundary

BGP

IP-environment

Administrative boundary

R

Multi domain IP controlled
Optical networking, 3 scenarios

• **Lambda switching for internal ISP bandwidth provisioning**
  – An ISP uses a lambda switching network to make better use of its (suppliers) dark fibers and to provision to the POP's. In this case the optical network is just within one domain and as such is a relatively simple case.

• **Lambda switching as peering point technology**
  – In this use case a layer 1 Internet exchange is build. ISP's peer by instantiating lambdas to each other. Is a N*(N-1) and multi domain management problem.

• **Lambda switching as grid application bandwidth provisioning**
  – This is by far the most difficult since it needs UNI and NNI protocols to provision the optical paths through different domains.
2.5 Gbps SONET/SDH “Lambda”
10/100/1000 Mbps Ethernet

Amsterdam

GSR

AMSIX

VLAN SARA

AMSIX

R

GIGA cluster

SurfNet5

Amsterdam 2nd phase

Almere

VLAN SARA

AMSIX

R

DASHII

SARA
Other architectures - L1 - 3
Other architectures - Distributed virtual IEX’es

Problem: vlan tag distribution ==⇒ gmpls
Distributed L2

Layer 2 VPN

Univ A

Univ B

SN5
CHICAGO

lambda

Univ X

Univ Y

SN5
A'DAM

lambda
Lambda/GbE exchange

CERN

AMS

GbE Switch (Layer 2)

SN5

454

Lambda 2.5G

C/DWDM

e.g. Dwingeloo: research GbE

production GbE (from router)

e.g. Jordel Bank

UK

connection management system

connection management system

454

454

454

454
research on λ’s

• how to get traffic in and out of lambdas
• how to map load on the network to a map of lambdas
• how to deal with lambdas at peering points
• how to deal with provisioning when more administrative domains are involved
• how to do fine grain near real time grid application level lambda provisioning
Research with \( \lambda \)'s

- High speed TCP (high rtt and BW)
- Routing stability
- Routing responsibility
- Extremely multihomed Networks
- Roles, organizational issues
- SLA’s
- Models (Connection less versus oriented)
- Discreet versus continuous in time
The OSI Reference Model

Host A

7 Application → ah data ← Application
6 Presentation → ph data ← Presentation
5 Session → sh data ← Session
4 Transport → th data ← Transport
3 Network → nh data ← Network
2 Data link → dh data dt ← Data link
1 Physical → bits ← Physical

Host B

= data path
← → = protocol path
- lambda for high bandwidth applications
  - Bypass of production network
  - Middleware may request (optical) pipe
Revisiting the truck of tapes

Consider one fiber

- Current technology allows for 160 $\lambda$ in one of the frequency bands
- Each $\lambda$ has a bandwidth of 40 Gbit/s
- Transport: $160 \times 40 \times 10^9 / 8 = 800$ GByte/sec
- Take a 10 metric ton truck
- One DLT contains 50 Gbyte, weights 200 gr
- Truck contains $(10000 / 0.2) \times 50$ Gbyte = 2.5 PByte
- Truck / fiber = $2500000 / 800 = 3125$ s $\approx$ one hour
- For distances further away than a truck drives in one hour (50 km) minus loading and handling 50000 tapes the fiber wins!!!