Optical Impact on Architecture

Joint Techs
July 20, 2004
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Today’s Optical Technologies

• Point to point circuits which are:
  – Nailed up, with Little Flexibility
  – Have fixed (although very large) bandwidth
  – Sparse, connecting few end-points

• Networks built from them offer:
  – Poor scalability, with limited aggregation
  – Very expensive cost of entry
  – Very long deployment cycles
On the Other Hand - They Offer Light Paths

- What’s a light path? A Circuit with:
  - No jitter
  - No packet re-ordering
  - No drops due to congestion
  - Known (by definition) end points

- What good is a light path?
  - It supports arbitrary protocols
  - It can be explicitly parallel
  - It can bypass firewalls
The Well Known Problem

- Networks will soon offer 40 Gbs channels
- Typical single-stream throughput limited to 5-6Gbs
- Typical multi-stream (with tuning) yields 9–10Gbs
- Firewalls throw it away anyway
Science Applications - Bit Rate Budget
End-to-end

Bit-Rate

100 Gbps
DWDM
(One Lambda)

40 Gbps
OC-768
SONET
(One Channel)

10 Gbps
OC-192

5.0 Gbps
OC-48

2.5 Gbps

1.0 Gbps

.65 Gbps

Research Opportunities

TCP/IP
(One Flow)

ESnet

Site Security
Firewall

Apps

Cluster

GigE

One Host

Optical Backbone

IP Network Services

Host

End-to-end Performance Gap
Even Without Firewalls - We Have a Technology Problem

- This isn’t an opto-electronics problem -
- This isn’t a teleco problem -
- Nor is it a problem routers are going to fix -
- It is an opportunity for lightpaths

Teleco Circuit Clocking vs Max Router Interface

OAK RIDGE NATIONAL LABORATORY
U. S. DEPARTMENT OF ENERGY
So - We’re Building Ultra Science Net (DOE’s Roadmap Workshop)

- Three-tiered strategy
  - General Purpose network (ESnet today)
  - High-Impact Network (serve fewer sites with more bandwidth)
  - Research Network studying the next generation

- Research Network Should Provide
  - Maximum flexibility
  - Minimum investment
This is a Challenge -

• Lit-lambda Quotes from Qwest/Level(3)
  – $600k/lambda/yr ORNL-Chicago
  – $1M/lambda/yr Chicago-Sunnyvale

• Lit-lambdas constrain our research options

• Ideal research network should be dark fiber
Solution -

- Leverage DOE, NSF, TVA, and state resources (a portfolio of projects)
- ORNL buying dark fiber: Atlanta, ORNL, Chicago
  - Put up (and trade) lambdas to NLR
    - For charter-member pricing to Sunnyvale
    - For fall-back service between Atlanta and Chicago
    - For future access to JLAB and BNL
  - Leverage the way DWDM scales
- Lit-lambda service between Chicago and Sunnyvale
What will this let us do?

• Use switched-circuits and light-pipes to:
  • Bypass limitations of conventional networks
    – TCP/IP
    – Firewalls
    – Small-frame technologies
  • Take advantage of the real throughput available in optical networks today
  • Develop the techniques needed within 2-3 years for DOE Peta-scale science
The Physical View From 50,000 feet
But - Rick Wants a Crystal Ball (!)
Things That Aren’t Likely to Change

- No optical transistor
  - Electrons interact strongly
  - Photons interact almost not at all
- Limited range of design characteristics
  - Optics fit into a 2-1 frequency range
  - Compare with a 5,000 - 1 RF range
Things That are Likely to Change

- Agile lasers -> lambda routing
- Electro-dynamic filters -> nanosec switching
- Vacuum or gas-core fiber
  - Reduced non-linear effects and signal to noise
  - Allow eight x eight (level and phase) modulation
- Small-scale integration
- Hybrid and nano-optics
What Will This Mean?

• Fast Provisioning
  – Time Scale = Today’s Layer-2 Convergence
• 100G Lambdas
• End of Monolithic Component Design
  – Infinera leading the way here
  – Other hybrid technologies in the pipe
    • Better monitoring
    • Better control
• Cost
  – Fiber up
  – Components down
But what does that REALLY mean?
I Don’t Know!