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Ethernet Alliance Panel #2: Bandwidth Growth and The Next Speed of Ethernet

Moderator: Scott Kipp, President of the Ethernet Alliance, Brocade
Panelist #1: Vijay Vusirikala, Optical Network Architect, Google
Panelist #2: David Ofelt, Distinguished Engineer, Juniper
Panelist #3: Martin Pels, Senior Network Engineer, AMS-IX

DISCLAIMER

The views WE ARE expressing in this presentation are our own personal views and should not be considered the views or positions of the Ethernet Alliance.

AGENDA

- Introduction – The Ethernet Alliance and Ethernet Speeds
  - Scott Kipp – Brocade and President of the Ethernet Alliance
- Topic #1 – Bandwidth Drivers and Core Requirements – Large Data Center Perspective
  - Vijay Vusirikala - Google
- Topic #2 – Bandwidth Growth and the Next Ethernet Rate
  - David Ofelt – Juniper Networks
- Topics #3 – IXP Bandwidth Trends
  - Martin Pels – Amsterdam Internet Exchange (AMS-IX)
- Questions and Answers

The Ethernet Alliance

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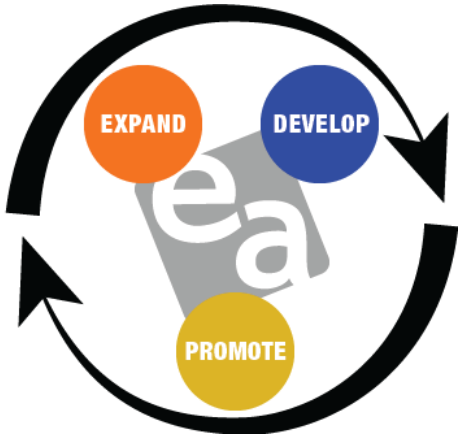
A global community of end users, system vendors, component suppliers and academia

- **Our Mission**
  - To promote industry awareness, acceptance and advancement of technology and products based on, or dependent upon, both existing and emerging IEEE 802 Ethernet standards and their management.
  - To accelerate industry adoption and remove barriers to market entry by providing a cohesive, market responsive, industry voice.
  - Provide resources to establish and demonstrate multi-vendor interoperability.
- **Activities**
  - Promote marketing and education awareness
  - Interoperability testing and demonstration
  - Industry consensus building
  - Technology and standards incubation
- For more information – see www.ethernetalliance.org



Ethernet Alliance Strategy

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Expand Ethernet Ecosystem

- Facilitate interop testing
- Expand the market
- Go global

Support Ethernet Development

- Support consensus building
- Host Technology Exploration Forums (TEFs)
- Team with other orgs

Promote Ethernet

Marketing Education

University of Ethernet

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- Completed and available online
- Planned
- Concept

Ethernet 101: Overview

Physical Layer x00 Series	Protocols x10 Series	Applications x20 Series	Informational x50 Series
Ethernet 102: The Physical Layer Of Ethernet	Ethernet 111: 802.1:Protocols Of Ethernet	Ethernet 121: The Applications Of Ethernet	Ethernet 151: Ethernet Alliance Plugfests
Ethernet 202: 10GBASE-T Revamped	Ethernet 211: Data Center Convergence	Ethernet 221: Ethernet Products	Ethernet 231: IEEE Projects
Ethernet 301: 40/100GbE Fiber Cabling and Migration Practices	Ethernet 311: Multi-tenancy	Ethernet 321: Industrial Applications	Ethernet 331: Ethernet Alliance Website

Bandwidth Assessment Report

- The IEEE quantified bandwidth growth in a new report that was released in July:
- http://www.ieee802.org/3/ad_hoc/bwa/index.html
- A basic equation for growth is:

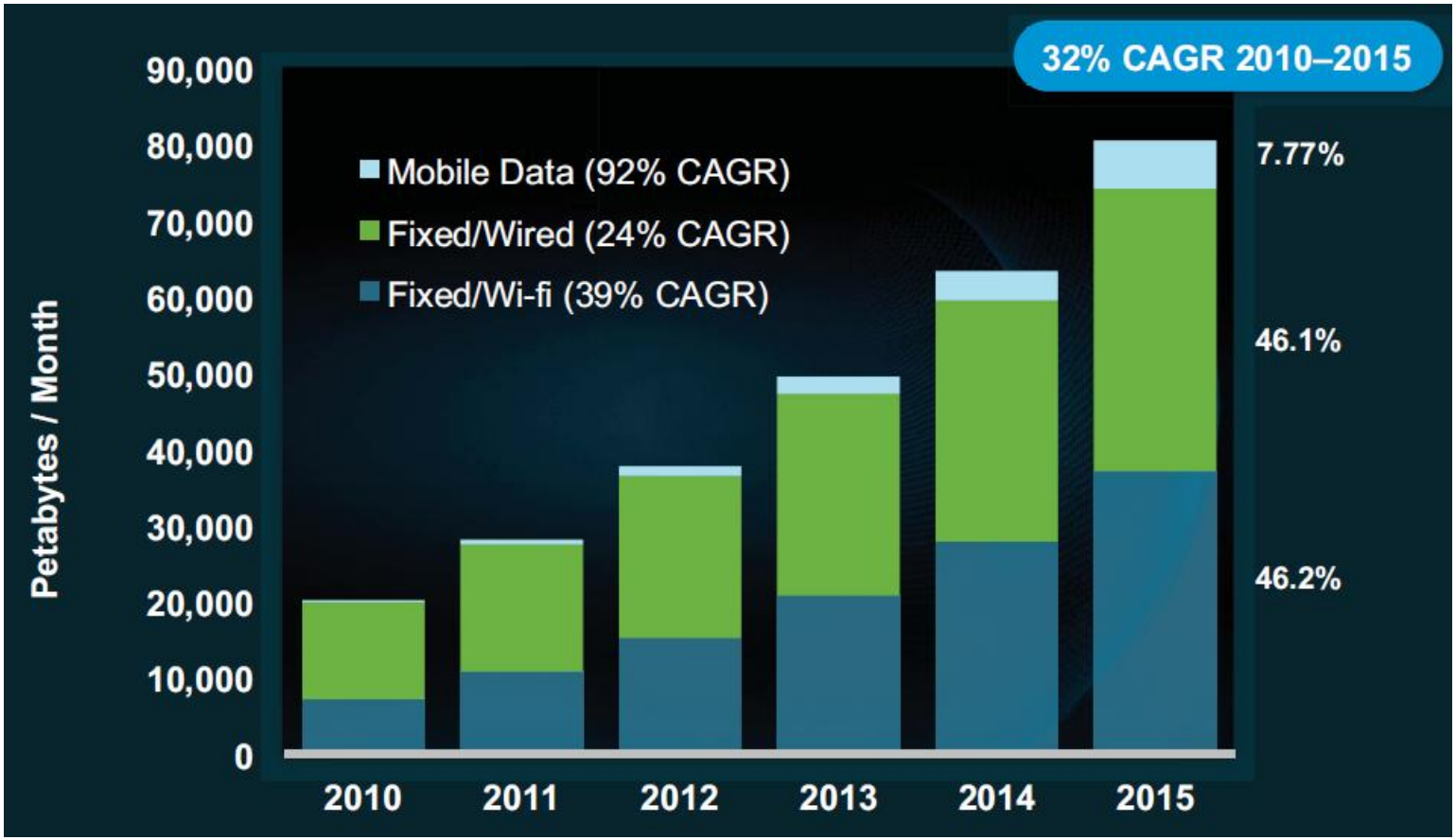
More Users X **More Devices** X **More Bandwidth** = **Bandwidth Explosion**

	Users	Internet Devices	Broadband Speeds	Total IP Traffic
2011	2.0 B	10B	9.1 Mbps	31 EB/ Month
2016	3.4B	19B	34 Mbps	110 EB/ Month

B = Billion, EB = Exabyte = A Billion Terabytes

Source: http://www.cisco.com/web/solutions/sp/vni/vni_forecast_highlights/index.html

IP Traffic Growth by Access Technology



Source: nowell_01_0911.pdf citing Cisco Visual Networking Index (VNI) Global IP Traffic Forecast, 2010–2015, http://www.ieee802.org/3/ad_hoc/bwa/public/sep11/nowell_01_0911.pdf

Data Center Growth

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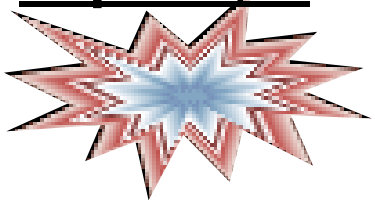
Increased Storage + **Increased Processing** + **Increased Bandwidth** = **Bandwidth Explosion**



Network

Entered the 100GbE era in 2010
Individual switches have Tb/s of bandwidth

Compute

First petaflop supercomputers in 2011
Individual servers delivering 10s of Gb/s of I/O
PCIe 3.0 supports 2 x 40GbE NICs now

Storage

Entered the zettabyte (1 billion terabytes) era in 2010
Individual disk drives over 1 terabyte
1000 disk drive storage subsystem equals 1 Petabyte

Energy Science Network Bandwidth Growth

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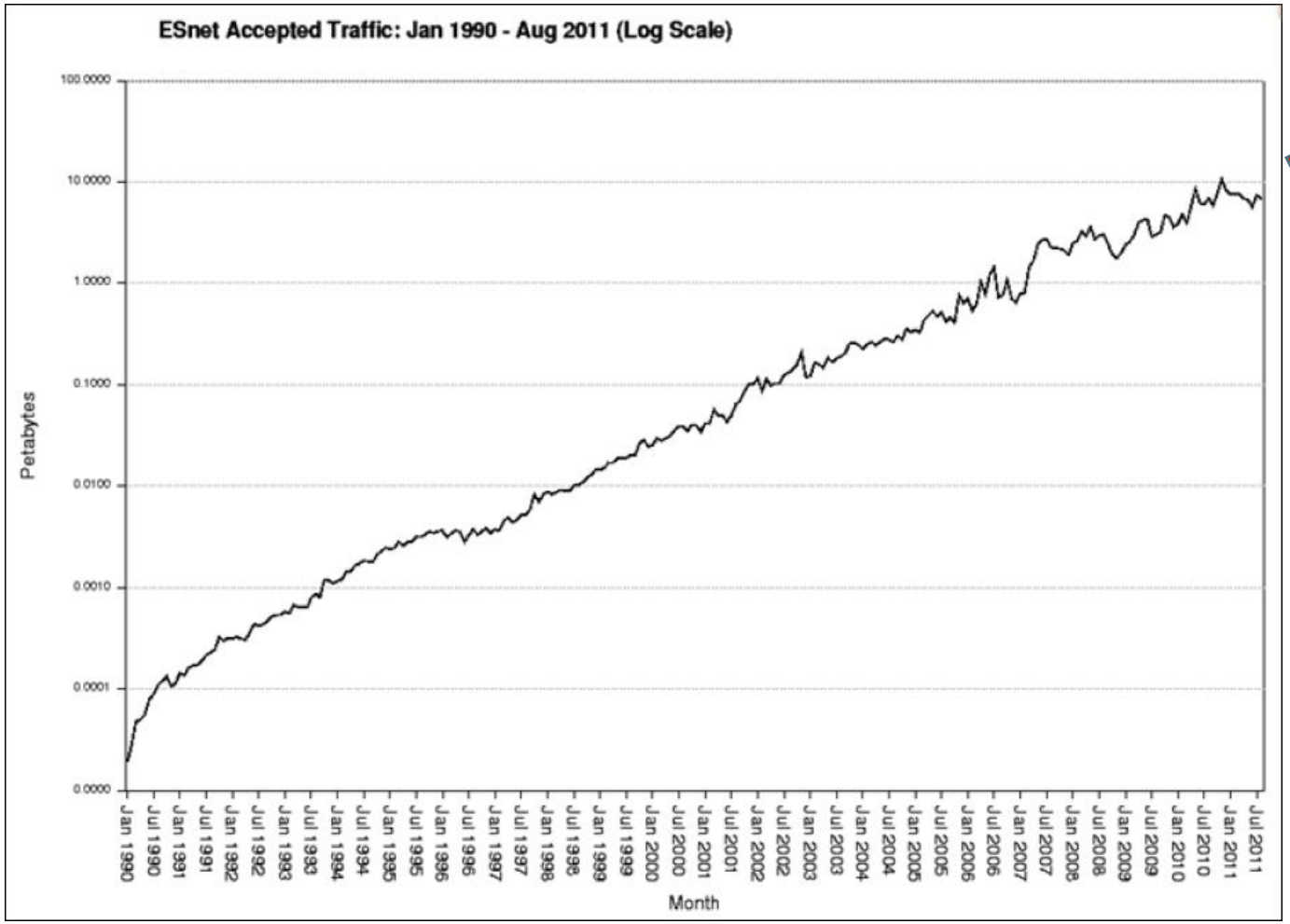
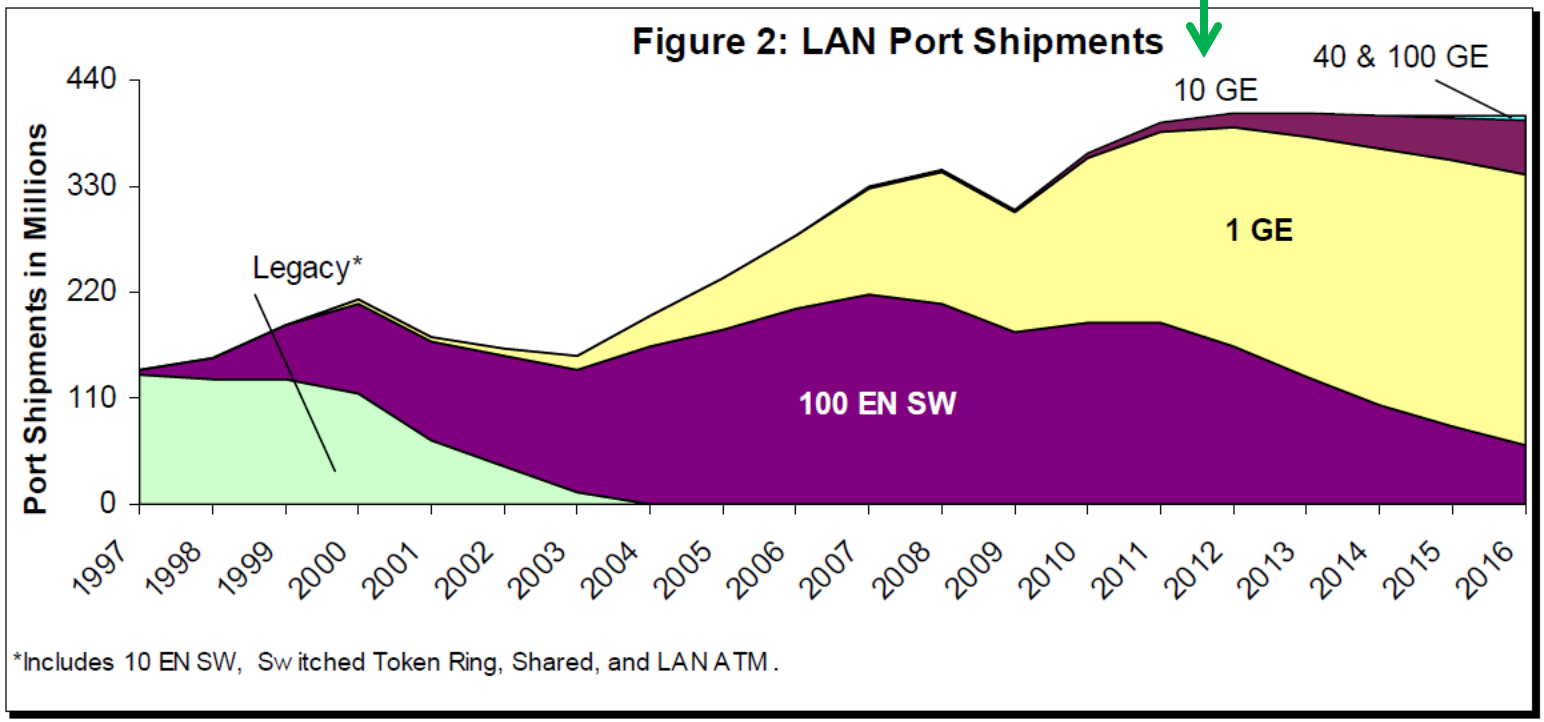
100 PB/ Month in 2015



Source: http://www.ieee802.org/3/ad_hoc/bwa/public/dec11/dart_01_1211.pdf

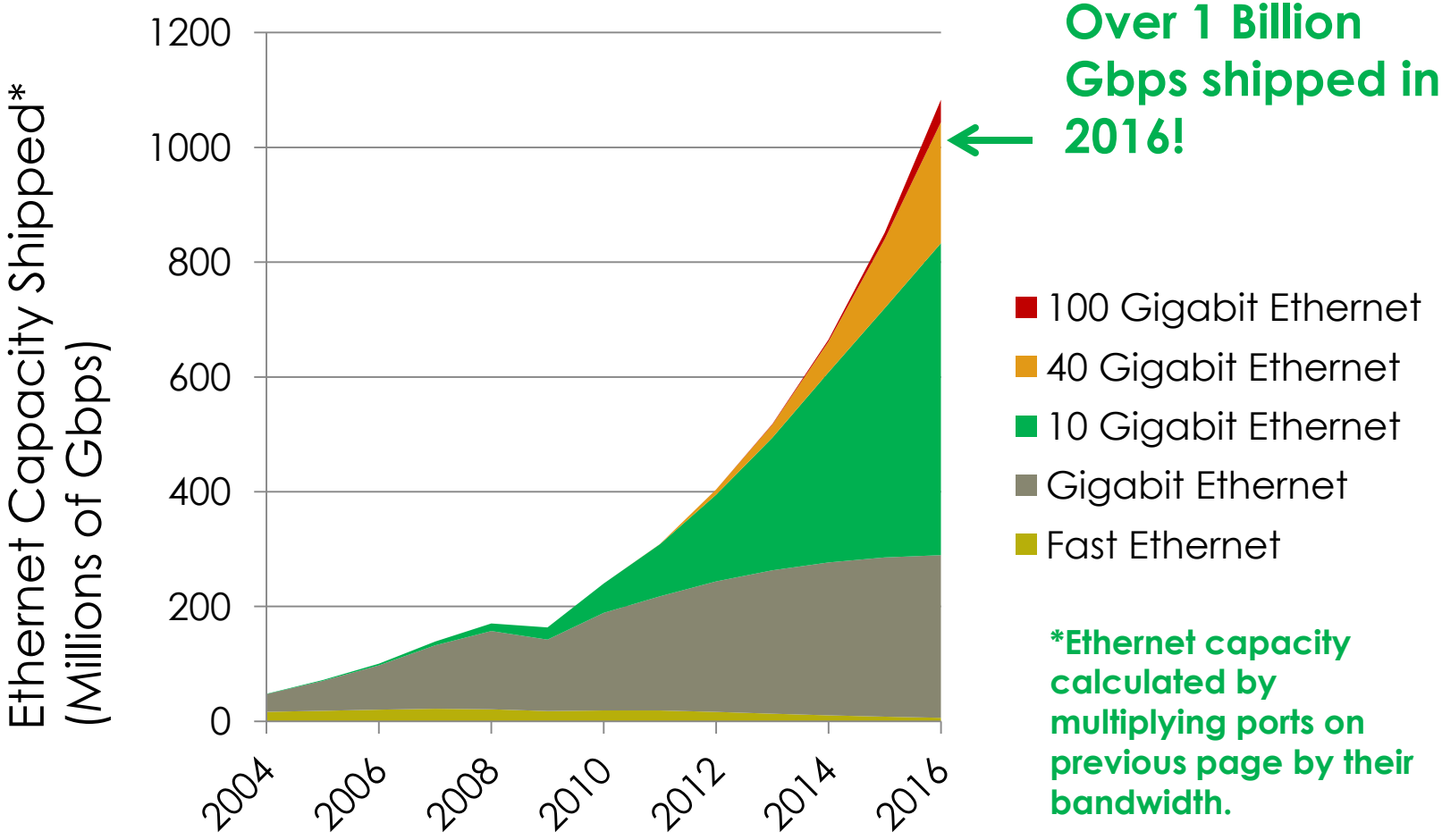
Ethernet Port Shipments

Over 400 Million Ports shipped in 2012 for the first time!



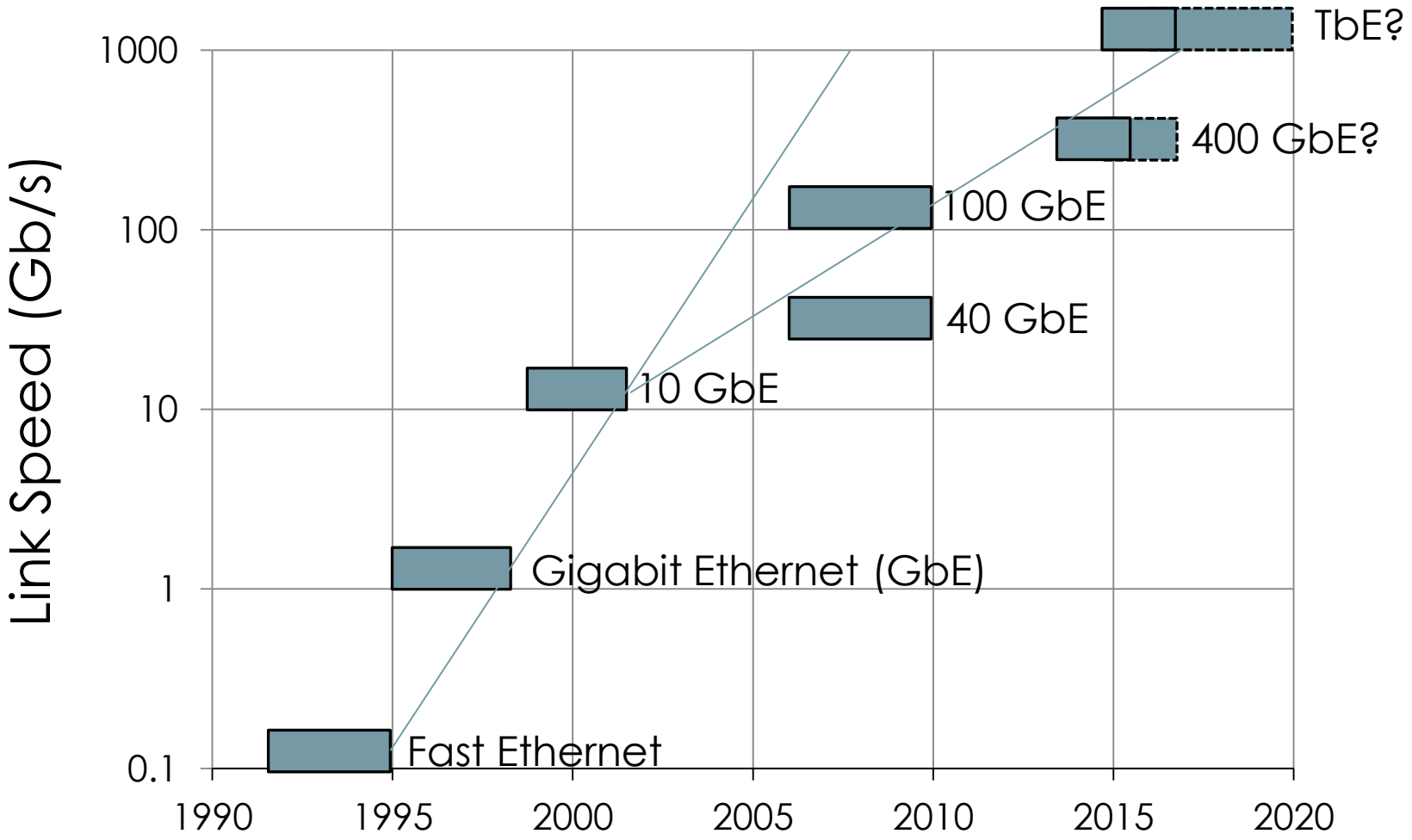
Source: Dell'Oro Ethernet Switch Forecast Report, July 2012

Bandwidth Capacity Projections



Source: Dell'Oro Ethernet Switch Forecast Report, July 2012

Standardizing Ethernet Speeds



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Bandwidth Drivers and Core Requirements – Large Data Center Perspective

Vijay Vusirikala
For Google Network Architecture

Ethernet Alliance – Sep 2012

Network Growth and Scale Drivers

- Growth and scaling at various layers
  - Datacenter connectivity, metro /edge and Longhaul/core
  - Different drivers and applications for different parts of the network
  - Overall growth across all segments → Driving need to higher capacity fabric, client connectivity and core capacity
- Growth drivers
  - Obvious ones – more users, more uses (User facing traffic)
  - More bandwidth intensive applications (User facing traffic)
  - Machine count and connectivity increases (M2M traffic)

More Bandwidth / Server X **More Servers / Data Center** X **More Data Centers** = 

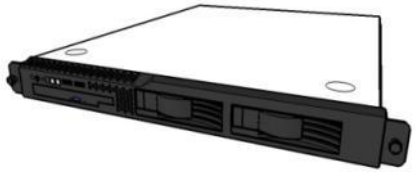
Bandwidth Explosion

Example of Applications Driving Scale

- You Tube Growth
  - 4 billion+ views a day - up over 30% in the last eight months
  - 800M unique users visit YouTube each month
  - 4B hours of video watched per month
  - More video uploaded to YouTube in a day than all 3 major US networks broadcast in the last 3 years
    - Over 72 hrs of video uploaded every minute--doubling y/y

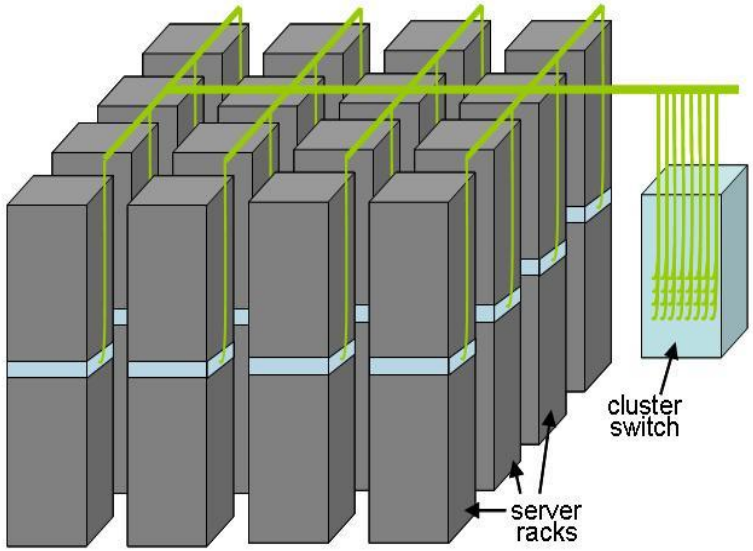
More users X **Longer views** X **More formats** = **Bandwidth Explosion**

Warehouse Scale Computers - Machinery



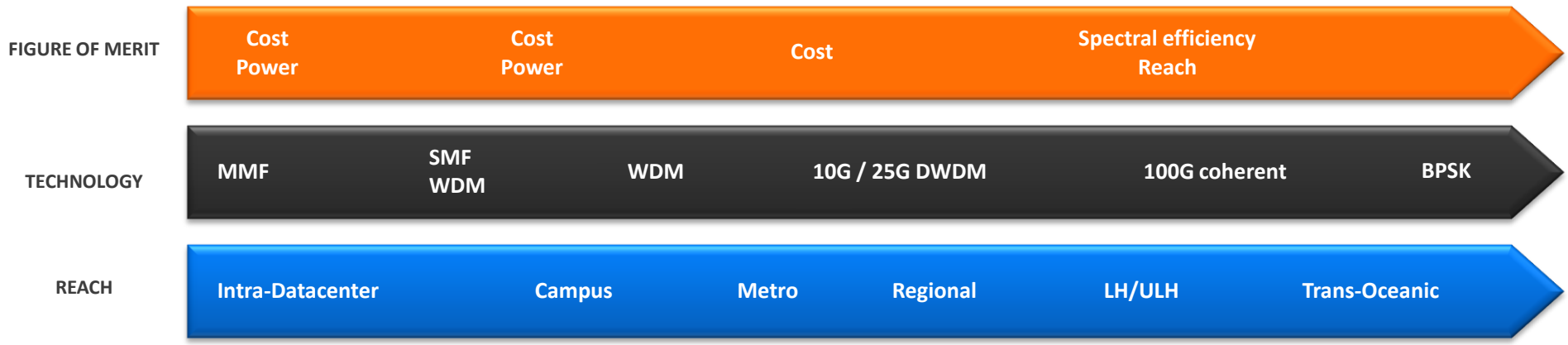
Servers
- CPUs
- DRAM
- Disks

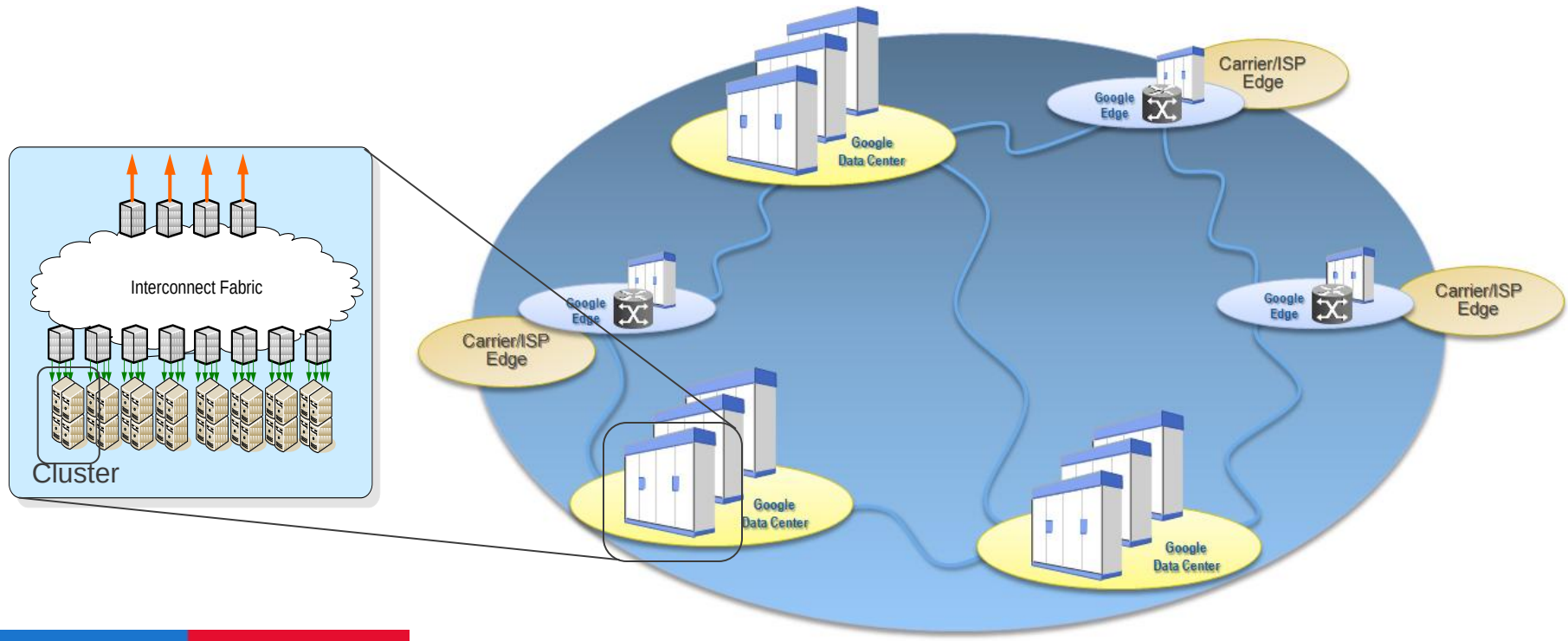
Racks
- 40-80 servers
- Ethernet switch



Clusters

Datacenter Optics - Overview



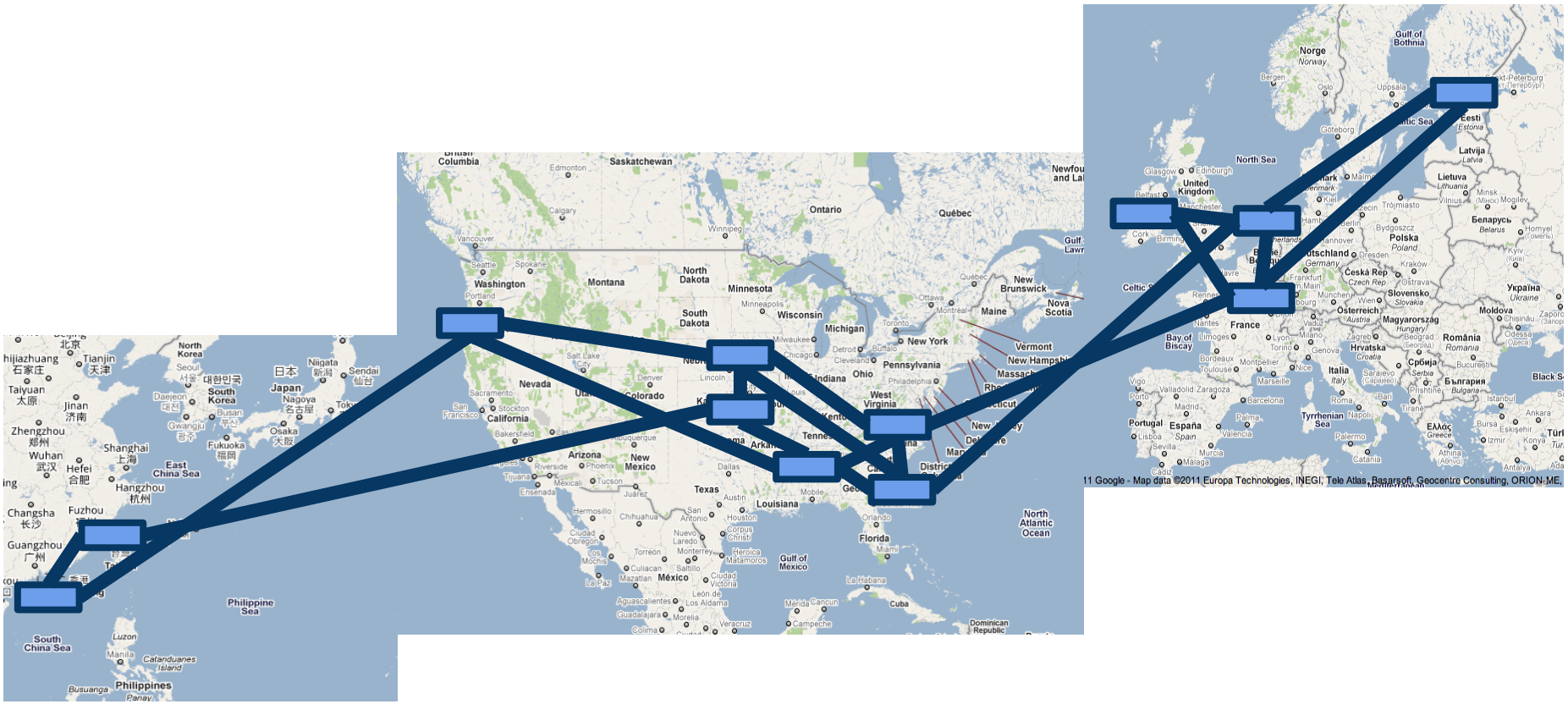


Google's WAN

- Two backbones
  - Internet facing (user traffic)
    - smooth/diurnal
    - externally originated/destined flows
  - Datacenter traffic (internal)
    - bursty/bulk
    - all internal flows
- Widely varying requirements: loss sensitivity, availability, topology, etc.
- Difference in node density, degree and geographic placement

  thus: built two separate logical networks
  - I-Scale
  - G-Scale

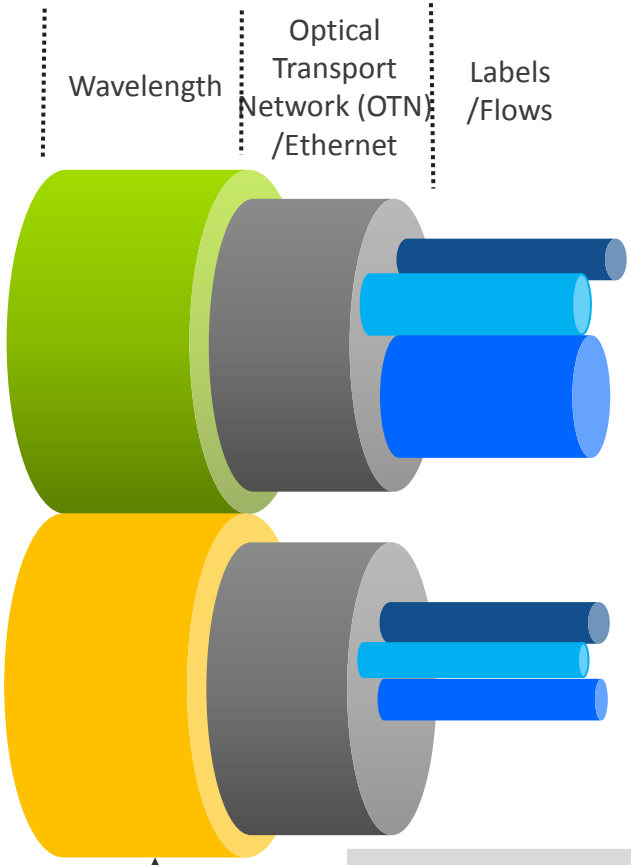
Google's Datacenter WAN



Software Defined Optical Network

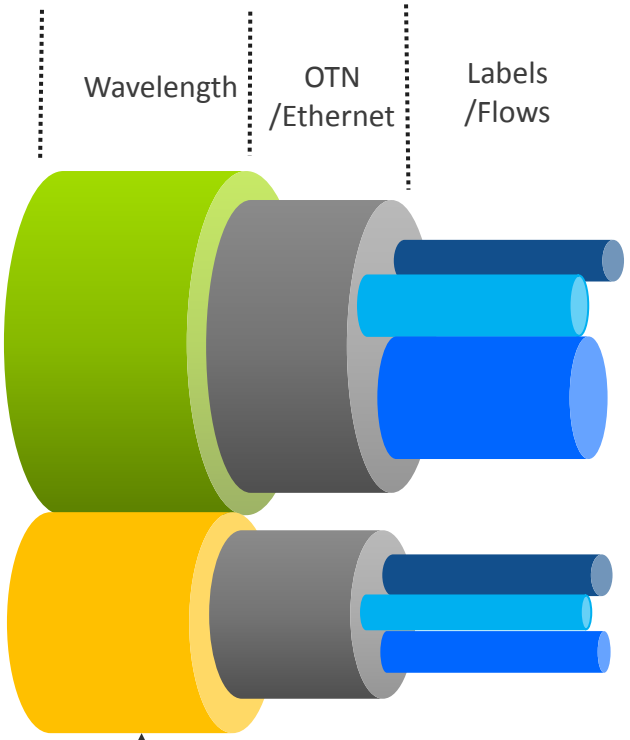
Google

Layer-cake Network



- **Static channel spacing**
- **Static optical channel bandwidth**
- **Static channel bit-rate**

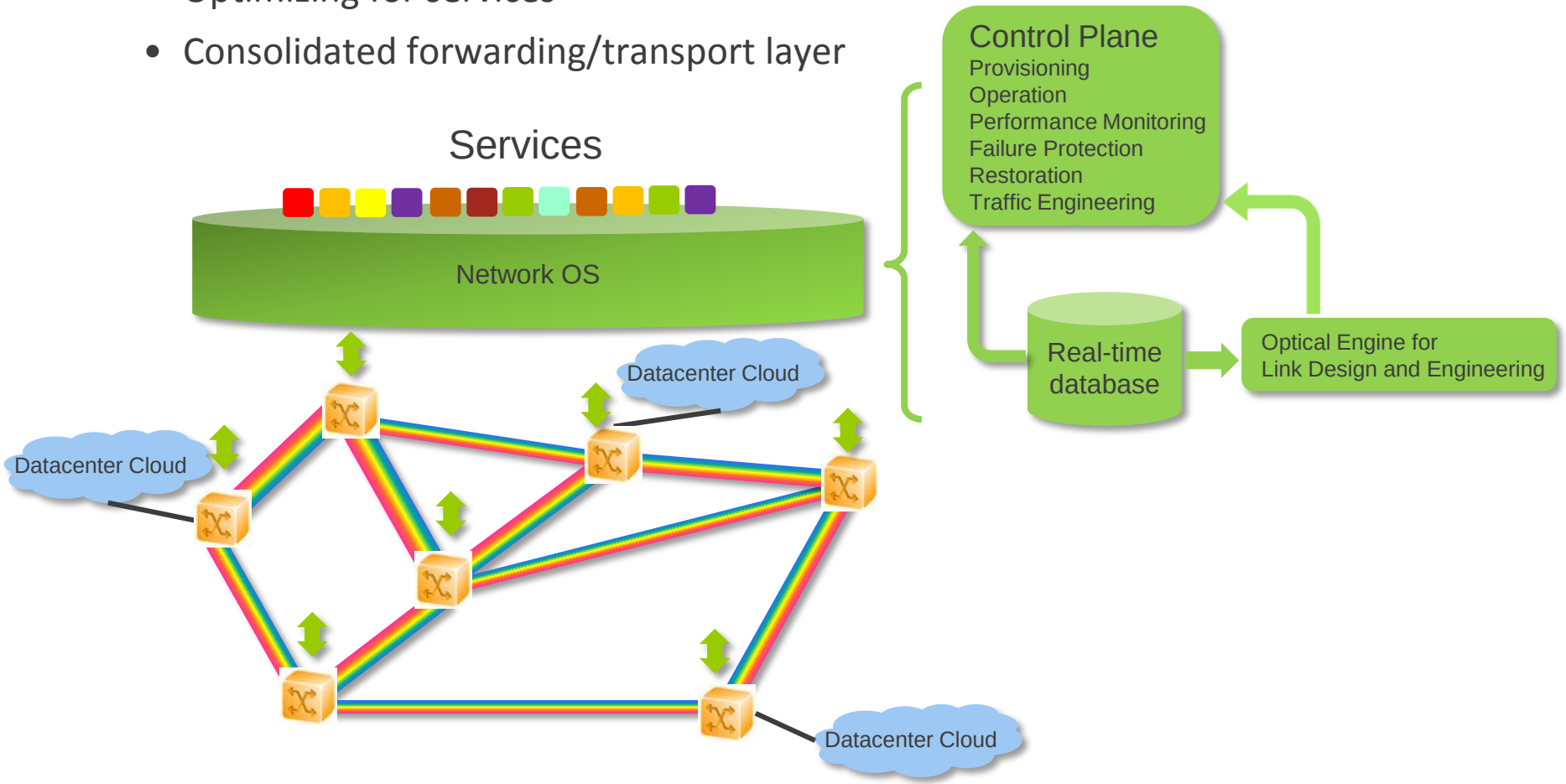
Software Defined Network



- **Dynamic grid spacing: Flex-grid Reconfigurable OADM (ROADM)**
- **Dynamic channel bandwidth: Super-carriers**
- **Dynamic channel bit-rate**

Software Defined Network Extending to Transport Layer

- Future – software-defined networking
  - Single network operating system with standardized interface
  - Global network view
  - Optimizing for services
  - Consolidated forwarding/transport layer



Thank You

Vijay Vusirikala

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or look me up on LinkedIn

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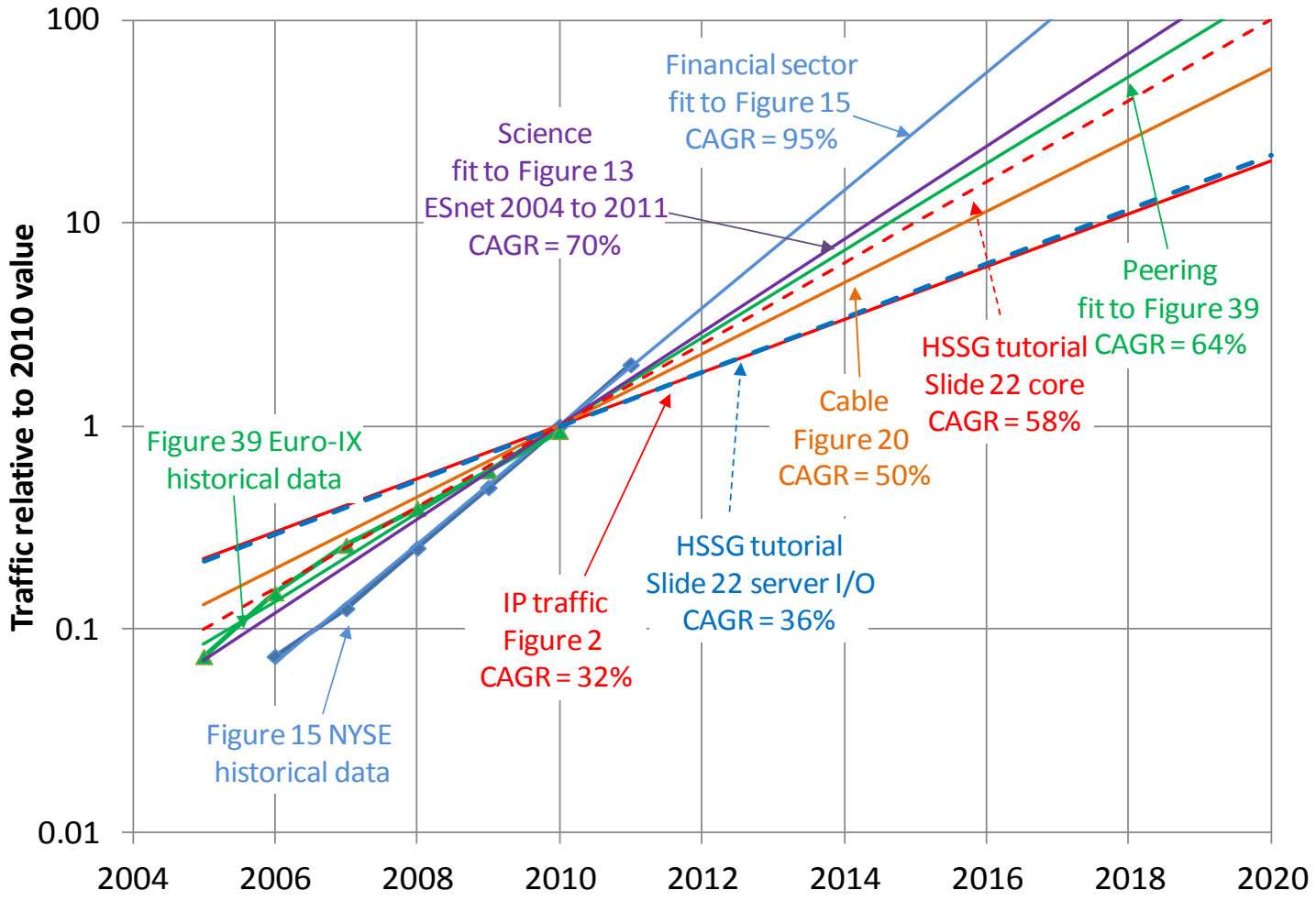
Bandwidth Growth and the Next Ethernet Rate

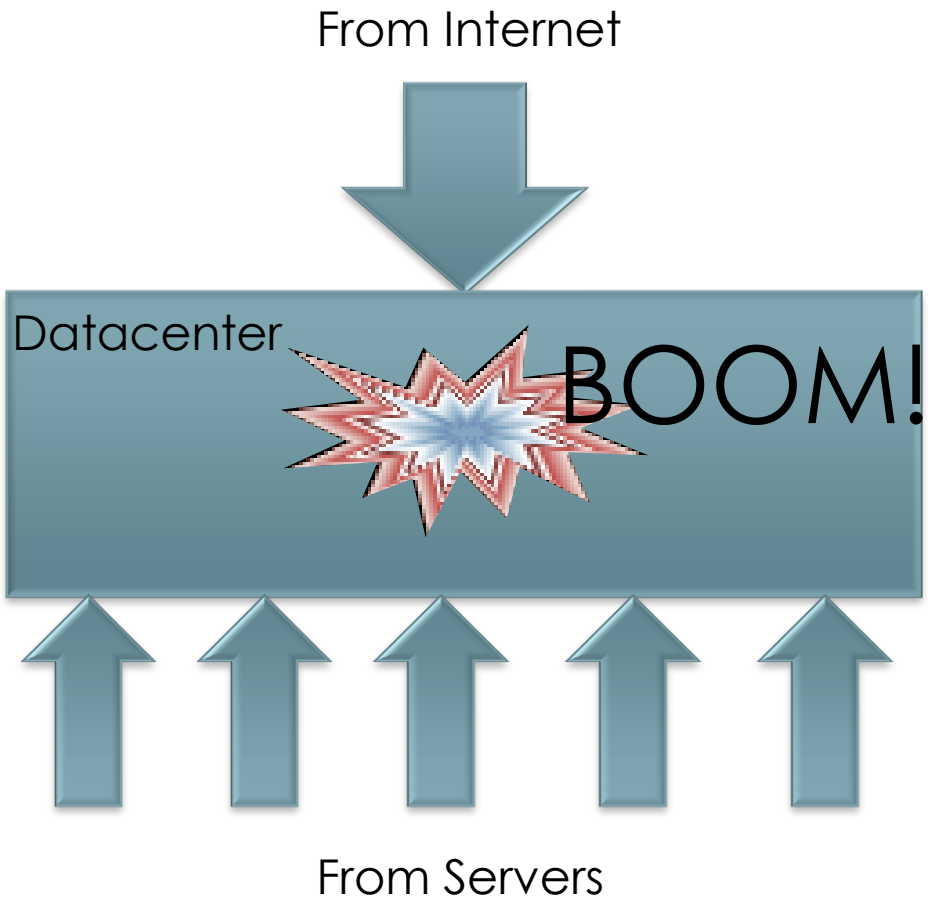
David Ofelt
Distinguished Engineer
Juniper Networks
2012-09-17

Bandwidth Growth

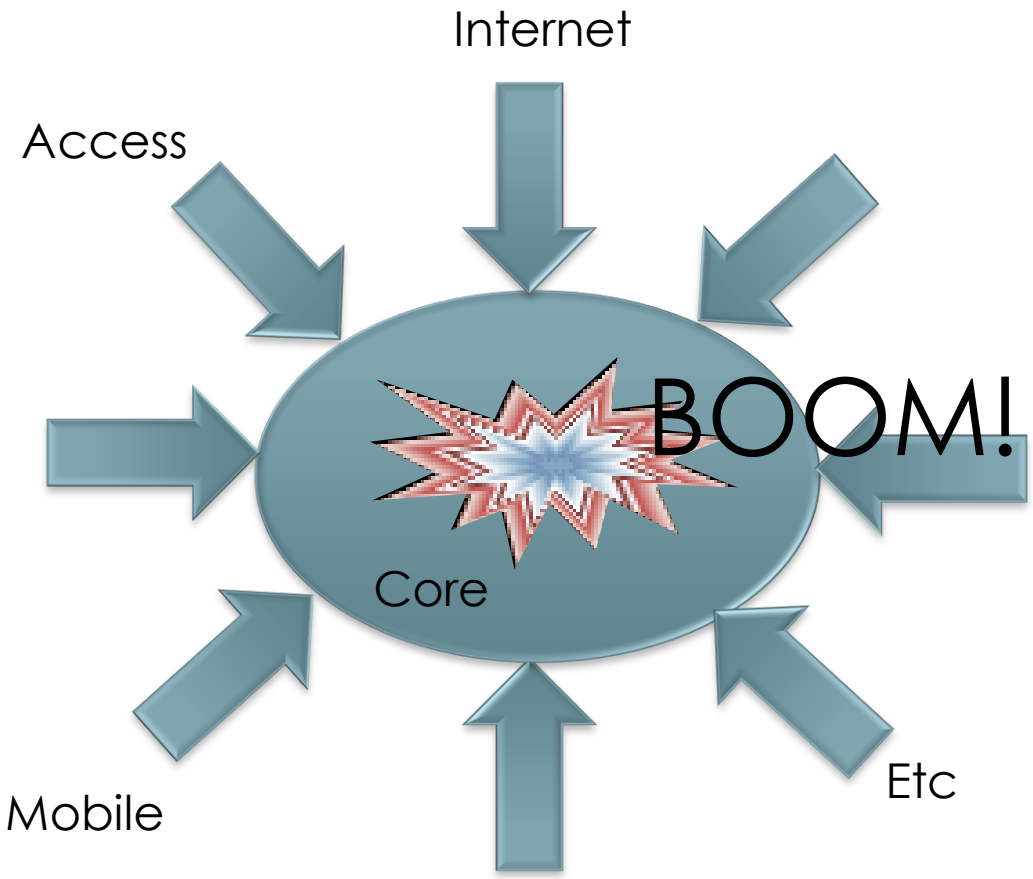


Bandwidth Assessment Ad-hoc (BWA) Summary

Datacenter Pressure



Core Pressure



Why not LAGs?

- Instead of faster links- why not just aggregate multiple links
- This is what everyone does but…
  - Exponential Bandwidth Growth means Exponential Growth in numbers of links
  - Inefficient due to imperfect load-balancing
    - Limited entropy
    - Flows are balanced ignoring bandwidth
  - Large flows exist
    - CDN
    - Encrypted traffic
    - Opaque trunks
- http://www.ieee802.org/3/hssg/public/may07/muller_01_0507.pdf

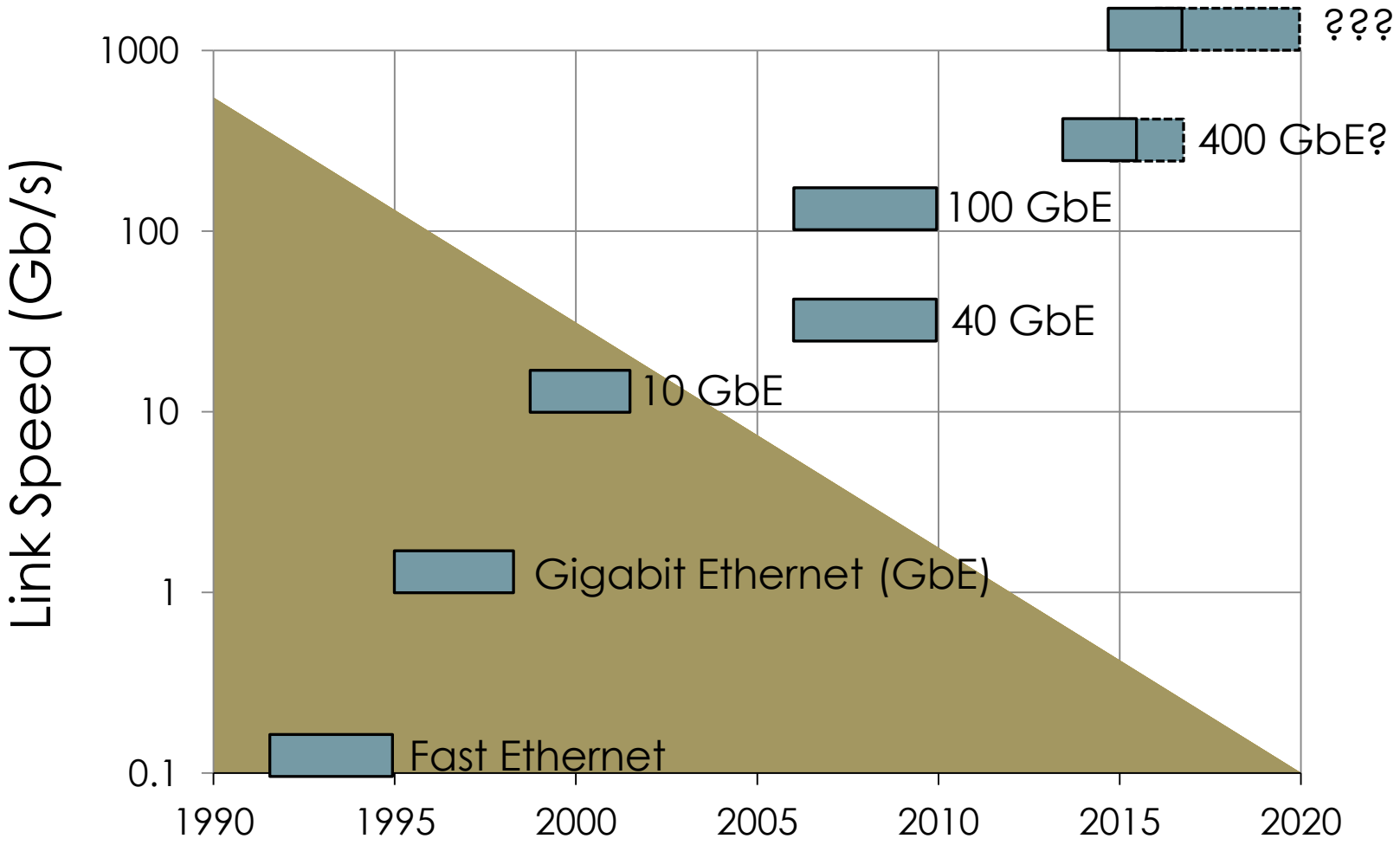
Constraints

- Need more bandwidth, but at what cost?
- Message from 100G is that new interface needs parity at introduction in:
  - Cost per Gb/s
  - Power per Gb/s
  - Density per Gb/s
- Customers were willing to compromise to save money
  - Ex: 10x10 "Ethernet" interface –vs- LR4

So… what speed?

- So we need a faster Ethernet, but what speed?
- Question is often phrased "400GbE or 1TbE"?
  - This ignores cost/power/density/physics
- Reality is that 1TbE is currently impractical
  - Forwarding Engine scales poorly
  - Module connector has too many signals
  - Practical optics not demonstrated

Standardizing Ethernet Speeds



400GE

- 400GbE looks practical and useful
- Industry producing dense 100GE engines
- Good building blocks
  - 802.3ba MAC and PCS
  - 802.3bj FEC and EEE framework
  - Potentially enhancements from 802.3bm
- Optical building blocks from 100GE roadmap

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IXP bandwidth trends

ECOC

Amsterdam, 17 September 2012

martin.pels@ams-ix.net

What is an Internet Exchange Point?

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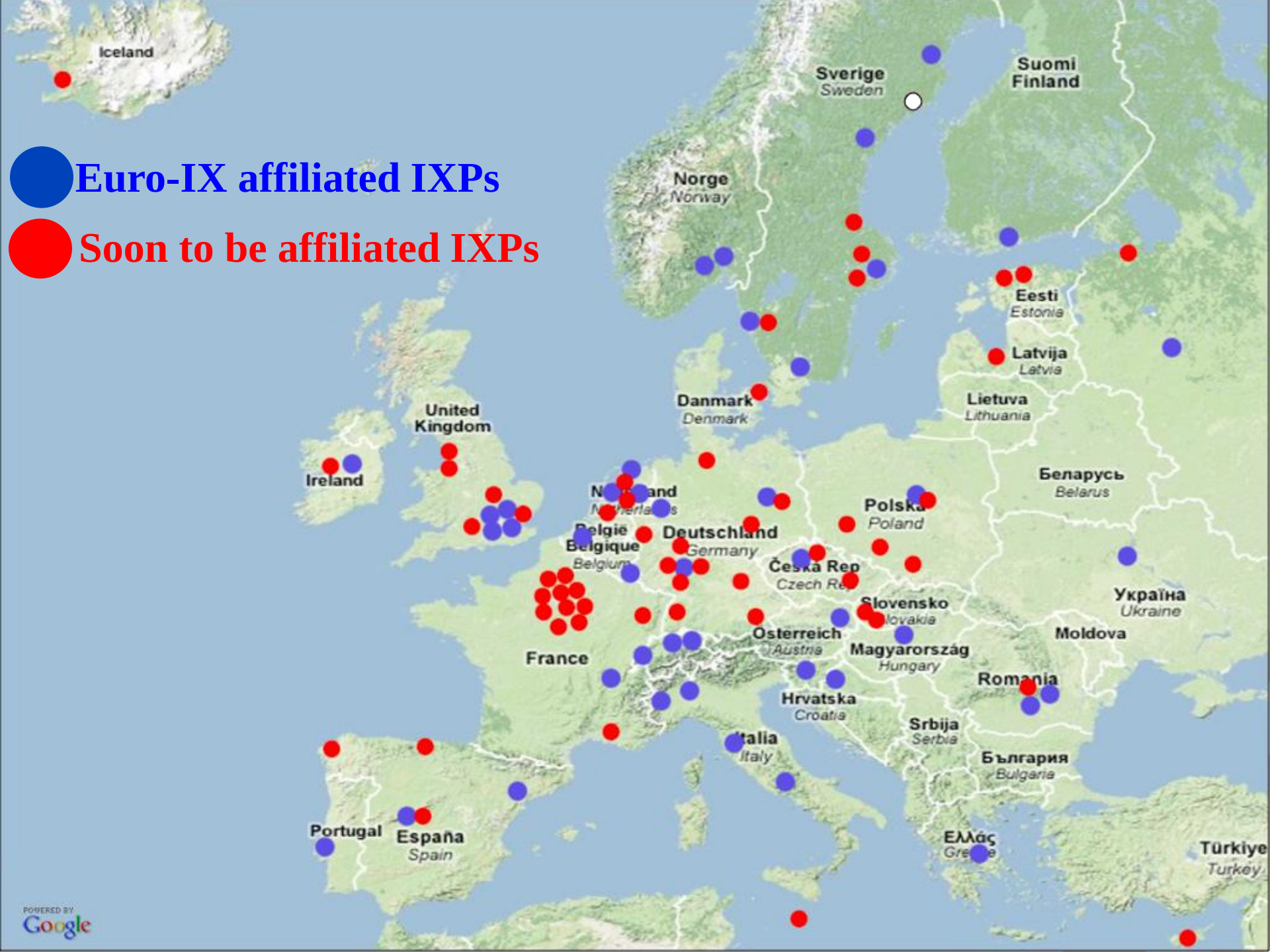
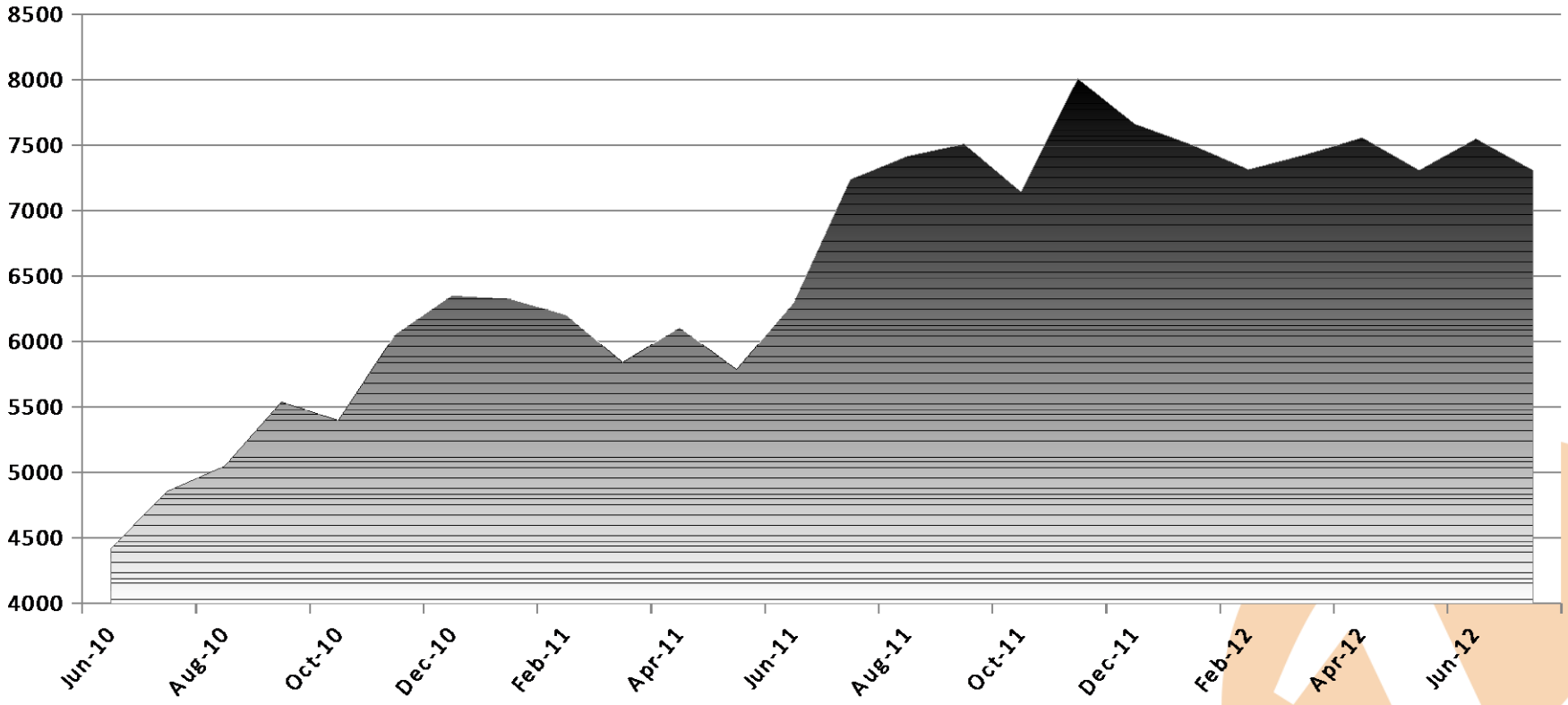
- Formal definition: “A physical (Ethernet based) network infrastructure operated by a single entity whose purpose it is to facilitate the exchange of internet traffic between Internet Service Providers. There must be a minimum of three ISPs connected.”
- Purpose:
  - Save on (transit-) cost
  - Optimize IP data path between providers

    (keep local traffic local)
  - Simplify interconnection between many providers

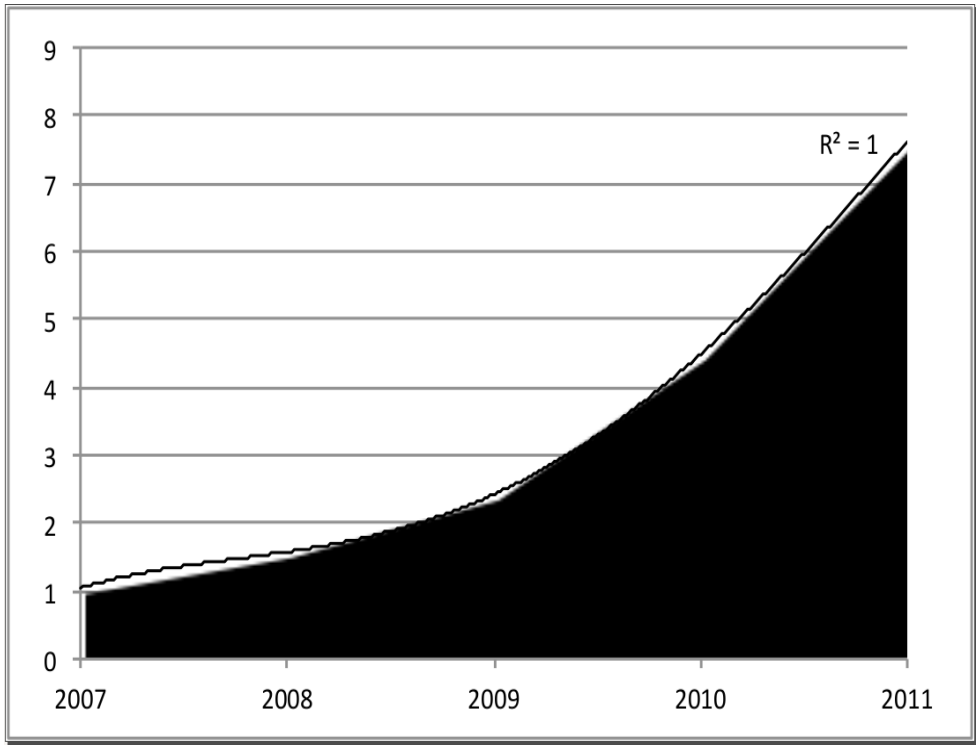

Euro-IX affiliated IXPs
Soon to be affiliated IXPs
Iceland
Sverige
Sweden
Suomi
Finland
Norge
Norway
Eesti
Estonia
Latvija
Latvia
Lietuva
Lithuania
Danmark
Denmark
United
Kingdom
Ireland
Беларусь
Belarus
Polska
Poland
Deutschland
Germany
België
Belgique
Belgium
Česká Rep
Czech Re
Slovensko
Slovakia
Україна
Ukraine
Moldova
Österreich
Austria
Magyarország
Hungary
Romania
France
Hrvatska
Croatia
Srbija
Serbia
Italia
Italy
България
Bulgaria
Portugal
España
Spain
Ελλάς
Türkiye
Turkey
Google

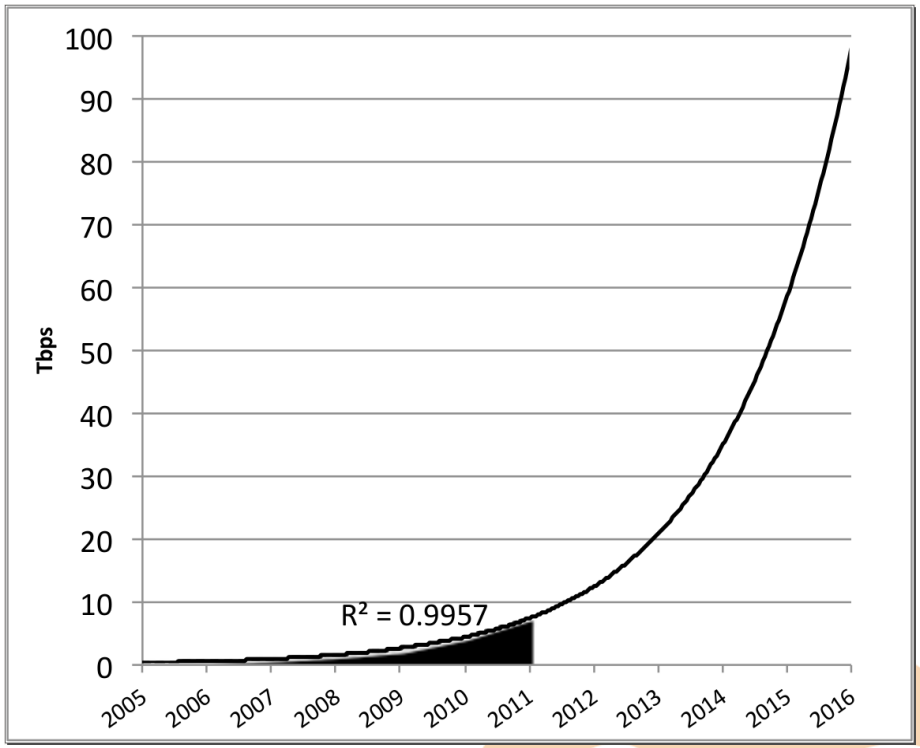
European IXP traffic



- Peak traffic increase of 33% per 12 months

5 year peak projection





- 12 times increase of IXP peak traffic between December 2006 and December 2011
- Exponential trend suggests 90 Tbps in 2016

About AMS-IX

- Non-profit association, founded in 1997
- 515 connected ASNs, 991 customer ports
- Metro Ethernet platform
- MPLS/VPLS architecture
- GE, 10GE, and 100GE connections
  - Aggregated links
  - Lower speed connections via resellers

Topology

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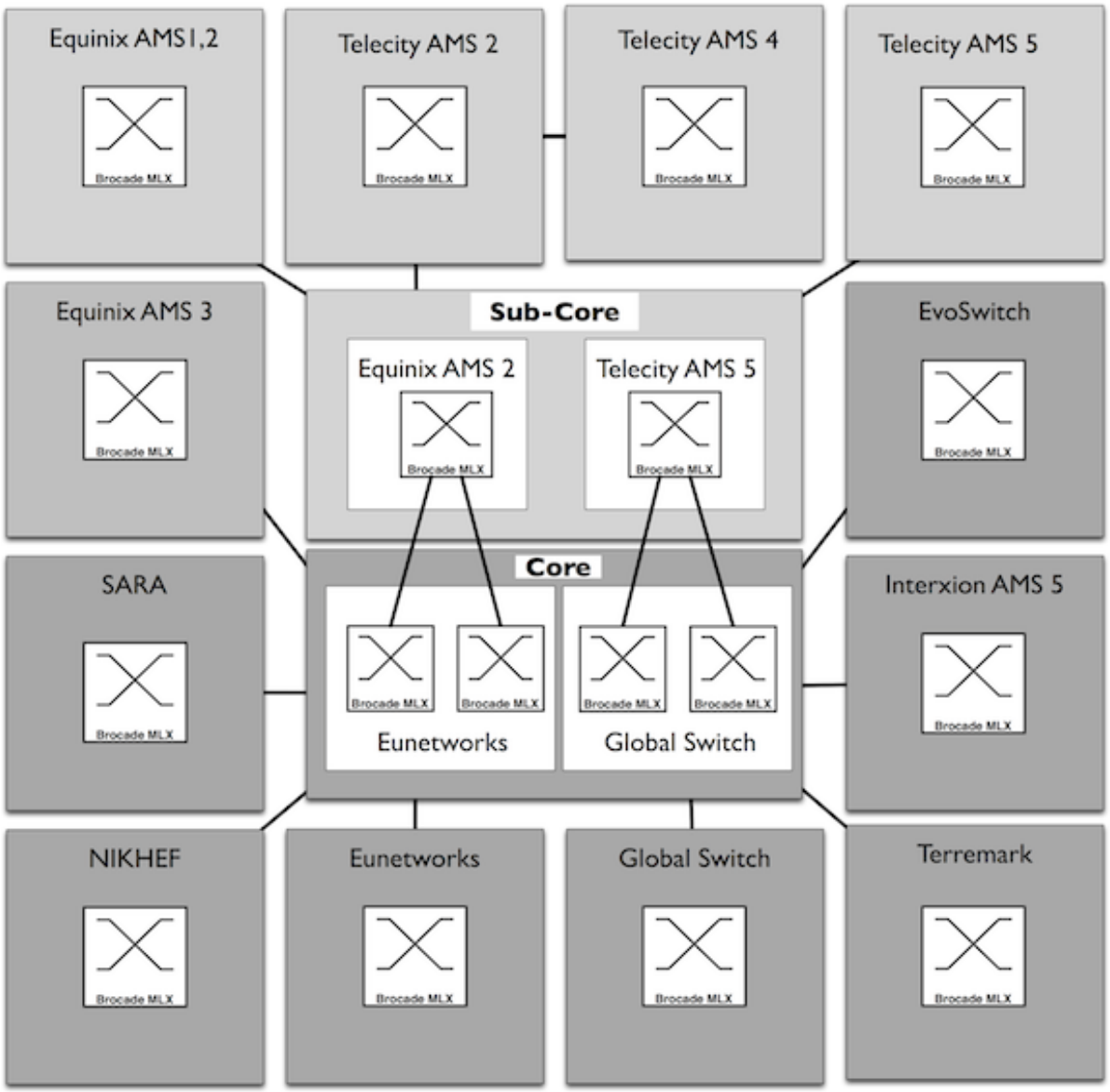

Traffic

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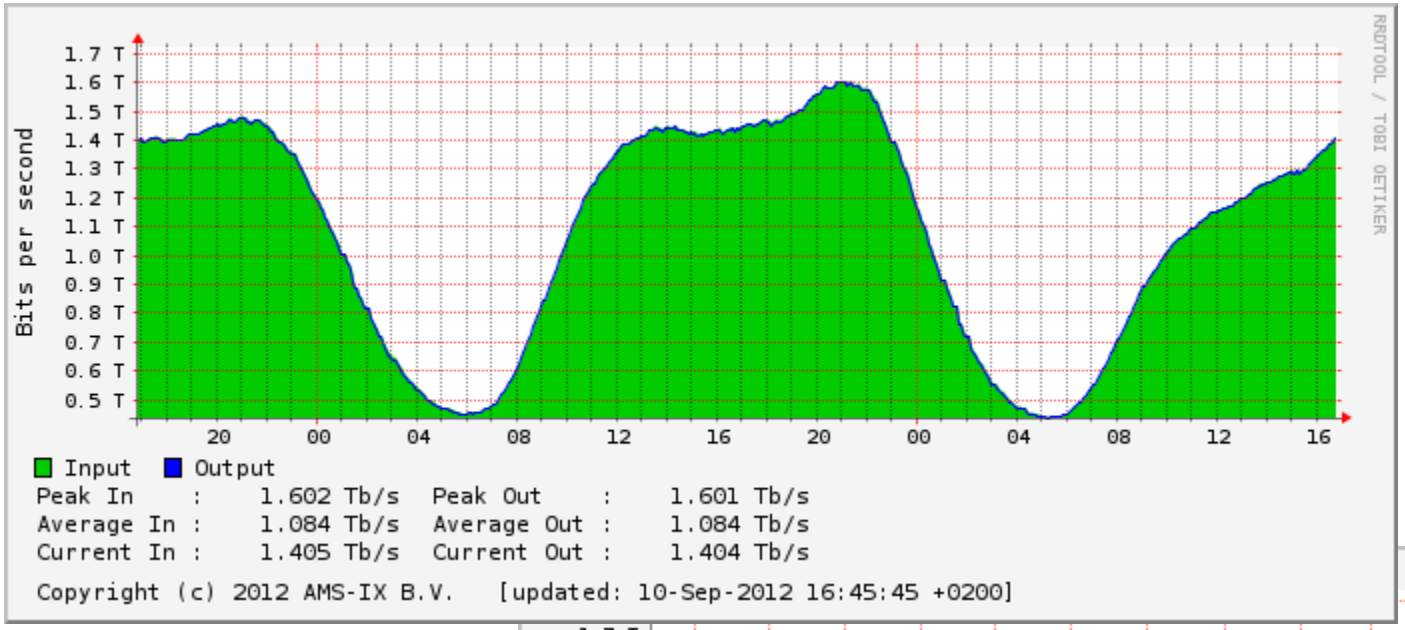
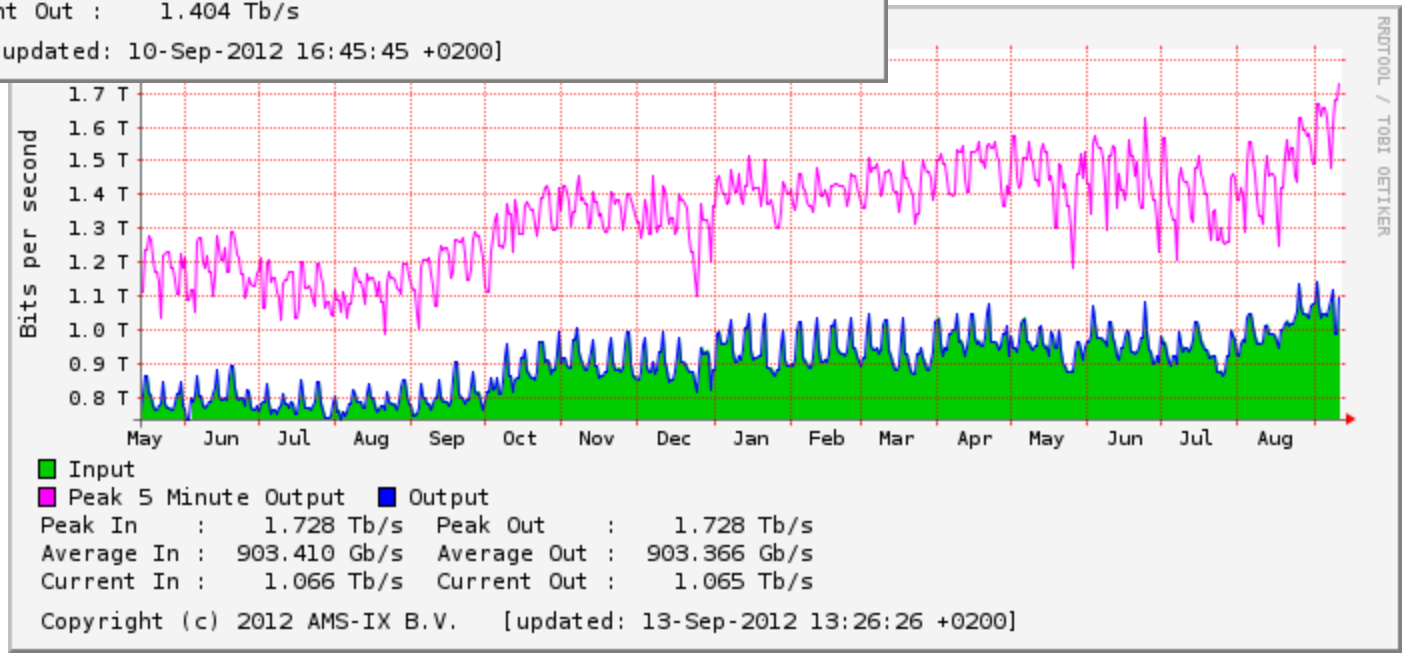
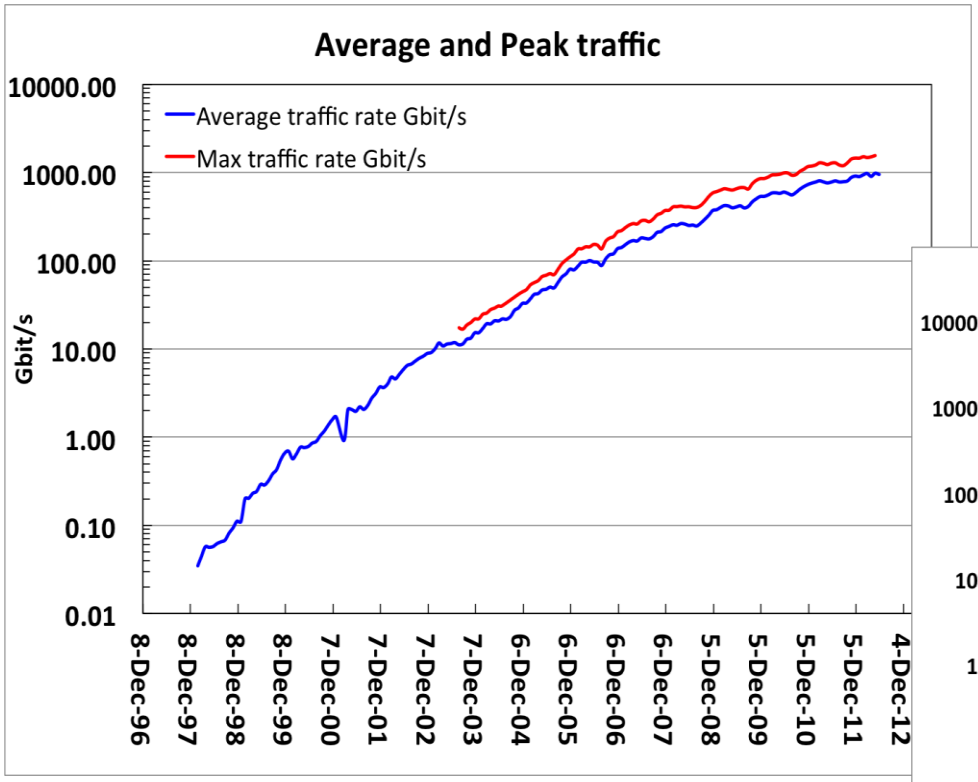
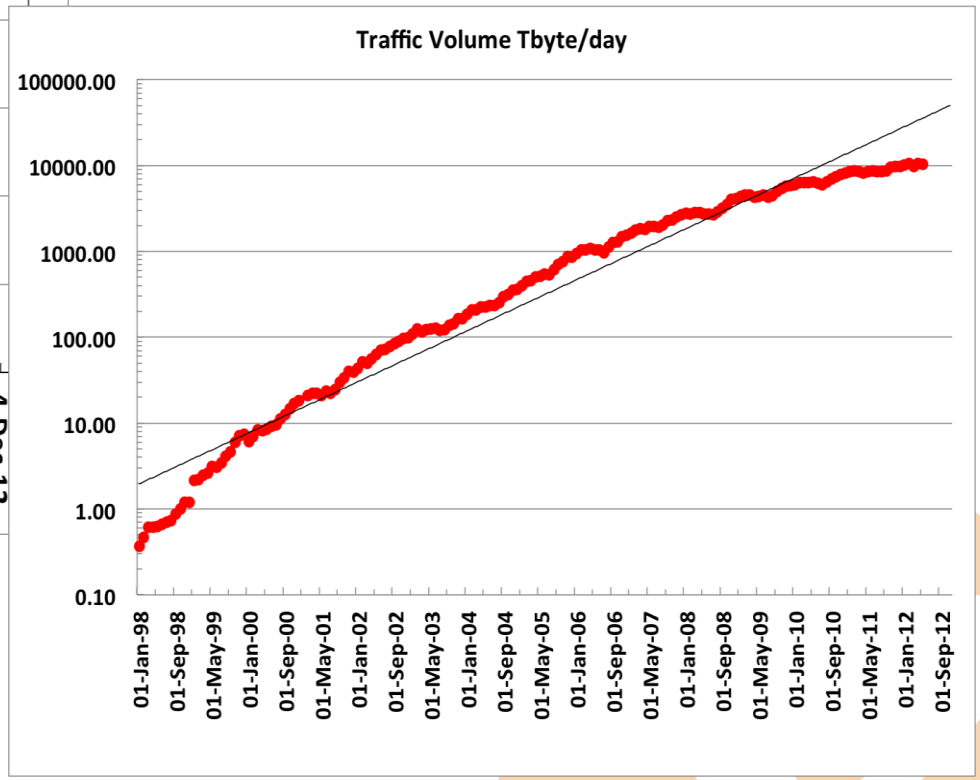




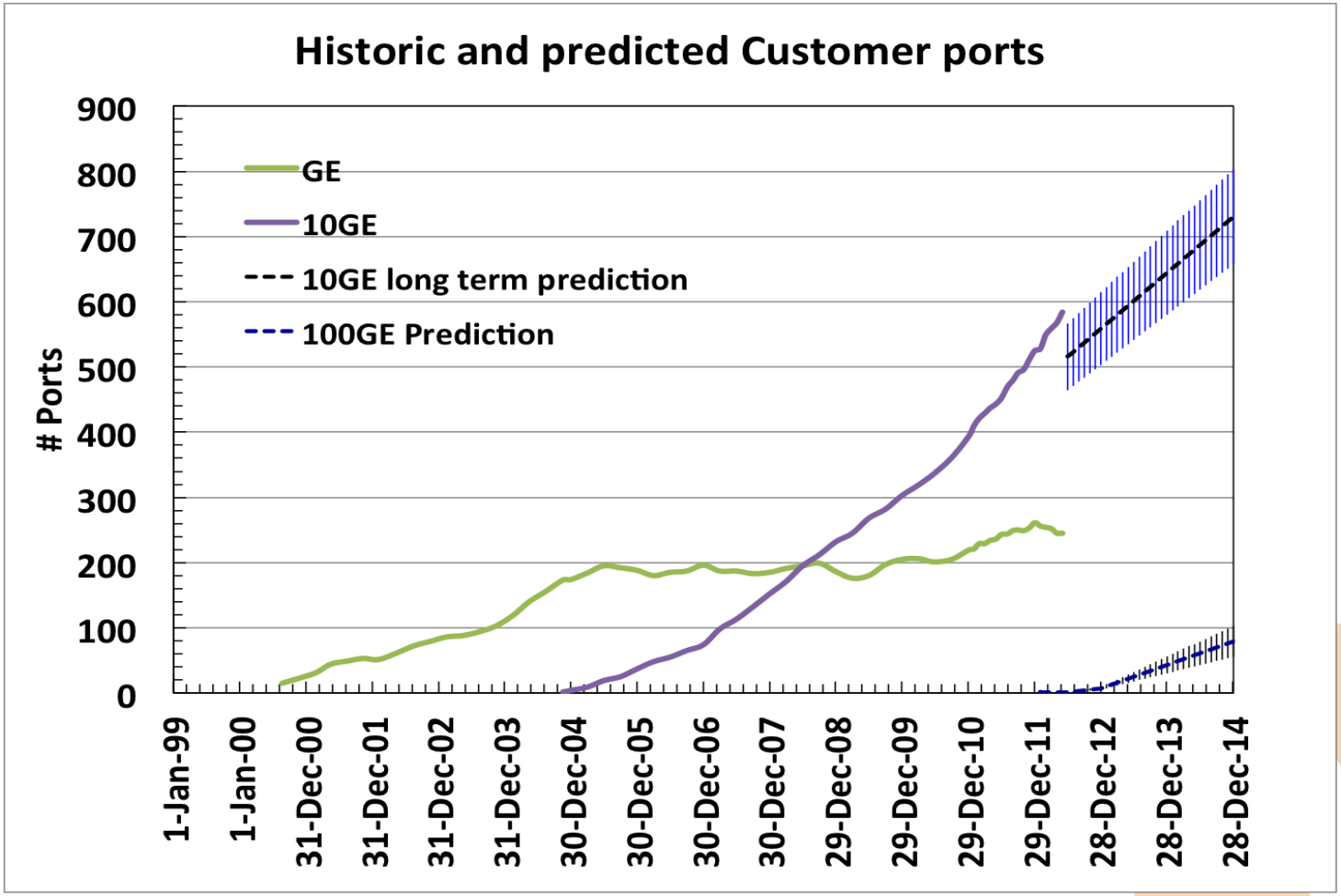
Traffic





- Peak traffic: 1.73 Tbps
- Daily traffic volume: 10.8 Pbyte/day
- Traffic doubling every ~2.5 years (30%/year)

Ports



- >70% of 10GE ports in aggregated links
- Largest aggregate: 16*10GE

100GE @ AMS-IX

- Two customers connected (using MSA 10x10-2km)
- 24 100GE connections in backbone
  - 16 of which in aggregates of 2x100GE
- Metro transport (<40km):
  - In-house design based on 100GE-LR4 + SOA
  - Proprietary solution: MSA 10x10 + ADVA WDM (4x100GE over single fiber)

Our wishlist

- Double density 100GE (CFP2/4) in 2013/2014
- 16*100GE over single fiber (<40km)
- 400GE in 2015
  - If economically feasible (max 2.5*100GE)
- Terabit Ethernet: ~2020

Summary

- IXP traffic is growing at a high rate
- 10GE aggregation > 10*10GE
- 100GE adoption slowly picking up
  - Link aggregation used almost from day 1
- 400GE desirable, but needs to be cost-efficient
- Need for Terabit Ethernet is expected

DISCUSSION/Q&A

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Thank you