Technology trends in terrestrial and subsea networks to cope with ongoing Internet growth

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Global Crossing® Think Ahead

Presentation Overview

- **Global Crossing – who we are and what we do**
- **Looking back and looking forward: exploding traffic growth…**
- **Transport technology trends to address the challenges for global Internet backbones – Ultra Long Haul**
- **Different market / same services: how the Financial Trading market exploits “our” transport technology trends – Ultra Low Latency**
- **Summary and conclusions**

GLOBAL CROSSING
WHO WE ARE AND WHAT WE DO

Global Crossing at a Glance

Unparalleled global sub-sea & terrestrial network

Core Network self built / self operated / fully owned

Team of over 5000 professionals in North America, Latin America, Europe and Asia

Global Crossing's global solution sets

A totally integrated and interoperable suite of IP and legacy services that support a customer's migration path to a fully converged environment.

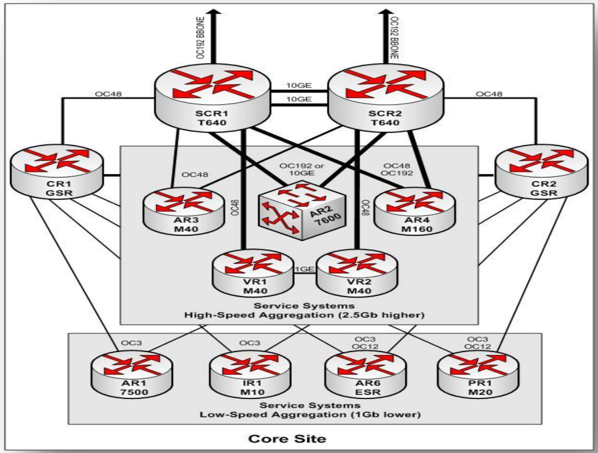
Converged IP Services	Collaboration Services	Traditional Voice Services	Data Transport Services	Managed Solutions	Data Centers	Genesis Video Solutions
IP VPN	Video Conferencing IP Video and iVideo	Outbound	EtherSphere	Professional Services	Secure Housing	Video Transport Solutions
SIP Trunking •On-Net Plus •Outbound •Local Service •Toll Free •Community Peering	Ready Access Audio	Toll Free	Ethernet Private Line	Managed Network	Hosted Managed	Full Time Point to Point
IP Video	Event Call	Local	Co-location	Managed Security	Virtual Housing	Portable Bandwidth
IP Transit	Web Conferencing •Live Meeting •eMeeting •Web Meeting		Wavelength	Managed VoIP		Occasional Feeds
Remote VPN Access	Communications as a Service (CaaS)		Private Line	Video Endpoint Management		Commercial Insertion
Mobile IP Connect				Applications Performance Management		Managed Monitoring
CDN Services				WAN Optimization		

IP Transit

Recognized Tier 1 ISP with extensive global private and public peering reaching 100% of the Internet

One seamless global IP network (AS#3549) with end-to-end control

- Over 4.5 Tbps peering capacity
- Present not only in North-America and Europe, but in Latin America, Asia and Australia as well
- Strong focus on network security and keeping malicious traffic off the network
- First to deploy native IPv6 globally (2006)
- BGP Automation (RADB)
- Warsaw IP Node in PLIX-DC (LIM building)

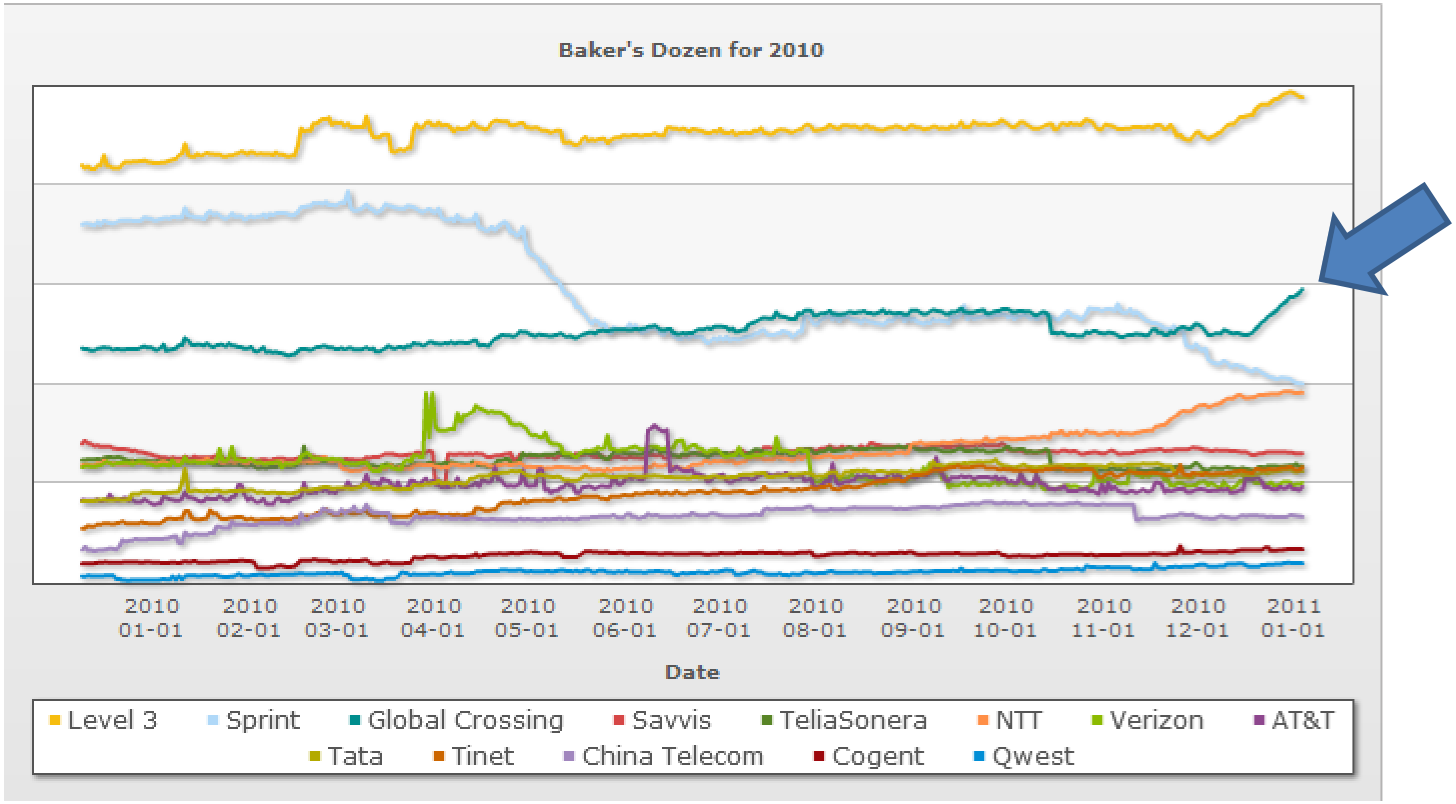


Direct connectivity with top Internet destinations

- Content: Google, Facebook, Youtube, Yahoo, Live, Blogspot, MSN, Amazon
- CDN's: Akamai, Limelight, nLayer, CD-networks, EdgeCast
- Major access networks and other Tier1's

Renesys reports Global Crossing as 2rd most connected backbone Tier 1 ISP, globally

Top 13 Providers of 2010



"The rankings are a rather crude measure of *size*, as they are based entirely on the quantity of IP space ultimately transited by each provider. However, it's the ranking *trends* that are more revealing than any absolute number"
(source: Renesys Blog 2011)

Tier 1?.... Second in Renesys Ranking?.... Coverage of LatAm, Asia, Australia?.... So what?

- 40-50% of our traffic stays On-Net
- End-to-end transport across 5 regions

means

- Maximum control of latency and packet loss
- Independent from peering capacity with other networks
- Best security against malicious traffic
- Better end-user experience and lower total cost of operation to run your network

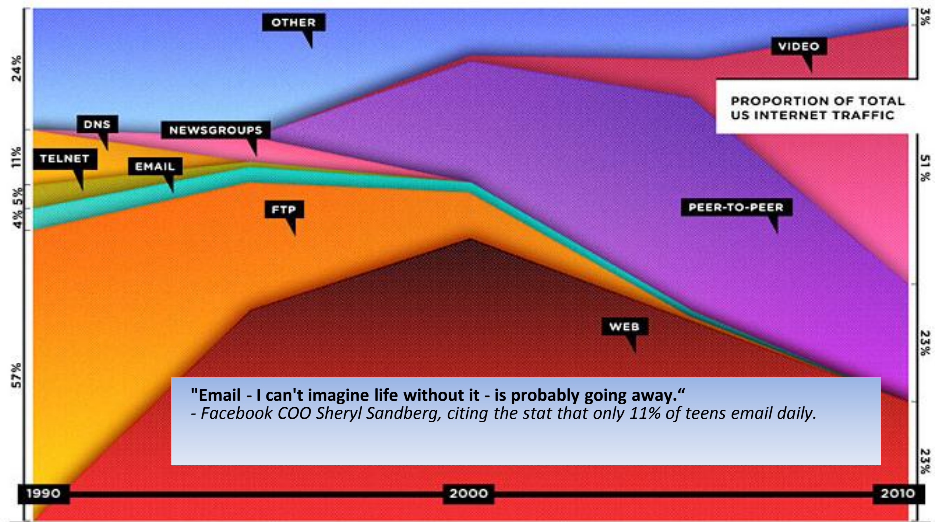
Central & East European POP expansion

- Providing Tier1 connectivity in 4 additional cities
  - Bratislava, Slovakia, Sitel building at Kopèianska
  - Bucharest, Romania, NXData Feper Building (NXDATA-1),
  - Sofia, Bulgaria, Neterra in the Sofia Teleport/Data Centre
  - Kiev, NewTelco
- Already present in
  - Budapest, Hungary, BIX/Interware building
  - Warsaw, Poland, at LIM Building (PLIX)
  - Helsinki, Finland at Kvaidankatu 2
- All pops are diversely connected to the GC IP backbone with multiple 10G uplinks
- Connected Istanbul, Turkey on diverse STM4 providing SDH and Ethernet services
  - Pantel PoP location

LOOKING BACK AND LOOKING FORWARD

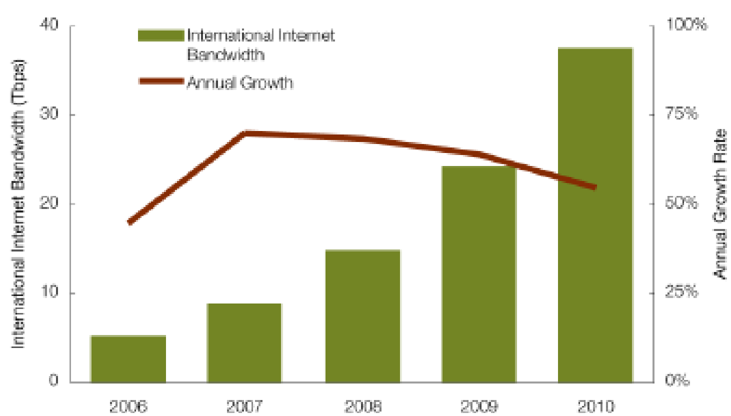
Internet Growth Continues

- Traffic continues to grow driven by user demand
- Underlying international bandwidth grows at >50% annually
- Utilization rate Traffic vs Capacity is at around 50-60%
- Global Crossing's IP traffic in 2010 increased 72.6% YoY from 4Q09.



Sources: Cisco estimates based on CAIDA publications, Andrew Odlyzko

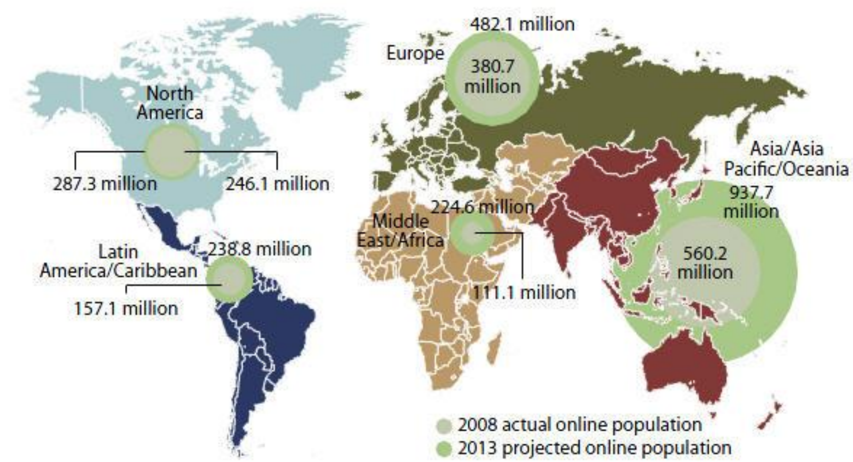
International Internet Bandwidth Growth, 2006–2010



Notes: Data represent Internet bandwidth connected across international borders as of mid-year. Domestic routes are excluded.

Source: TeleGeography research

Figure 1 Growth Of The Global Internet Population By 2013



Source: Forrester Research Internet Population Forecast, 4/09 (Global)

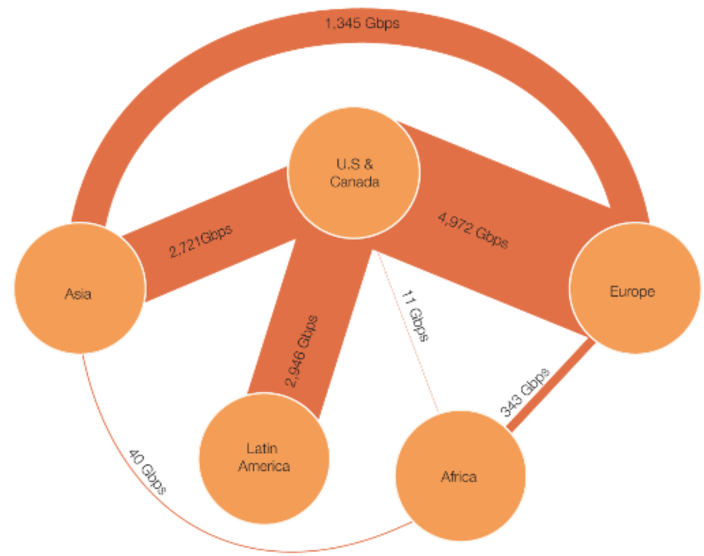
53355

Source: Forrester Research, Inc.

International Internet Bandwidth

- ~30% of all international capacity is in use by Top 5 Internet carriers
- 12Tbps Interregional capacity mainly subsea (compared to 4.3Tbps in 2007)
- Subsea grows faster then terrestrial, US-Latam and Europe to Asia are fastest growers. Europe to Africa picking up

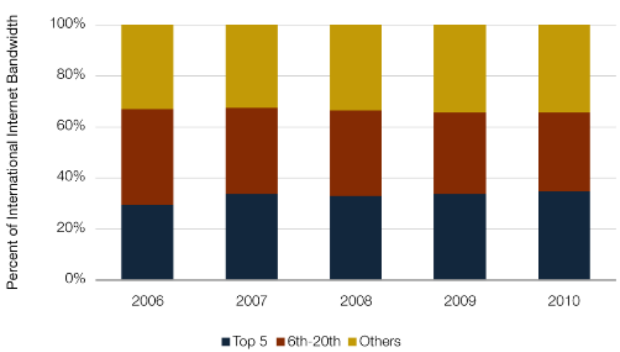
Interregional Internet Bandwidth, 2010



Notes: Data as of mid-2010. Interregional bandwidth below 10 Gbps not depicted.

Source: TeleGeography research

Concentration of International Internet Bandwidth by Carrier, 2006–2010



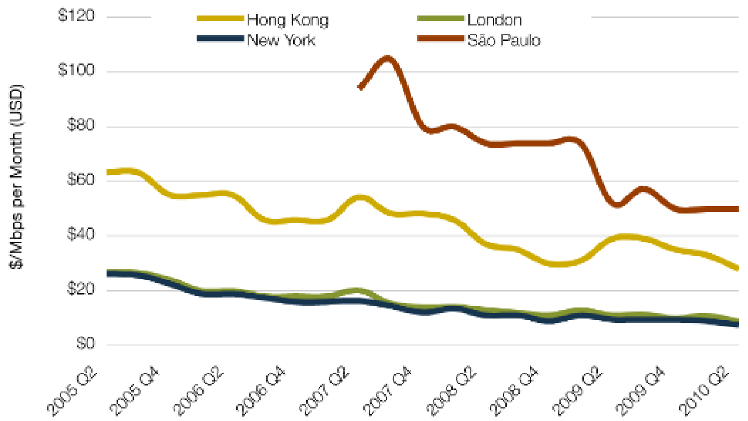
Notes: Data represent percentage of total international Internet capacity held by the Top 5 carriers the 6th-20th ranked carriers, and all other carriers with international capacity in the given year. Data as of mid-year. Domestic links excluded.

Source: TeleGeography research

Price per Mb evolution

- As traffic continues to grow and ARPU per user remains flat. Price per Mb needs to come down
- Traffic x Price/MB shows growth
- Costs/Mb needs to follow this trend

Median GigE IP Transit Prices in Major Global Cities, Q2 2005-Q2 2010



Notes: Each line is the median monthly price per Mbps in that city. Data exclude installation and local access fees. Gigabit Ethernet (GigE) = 1,000 Mbps.

Source: TeleGeography research

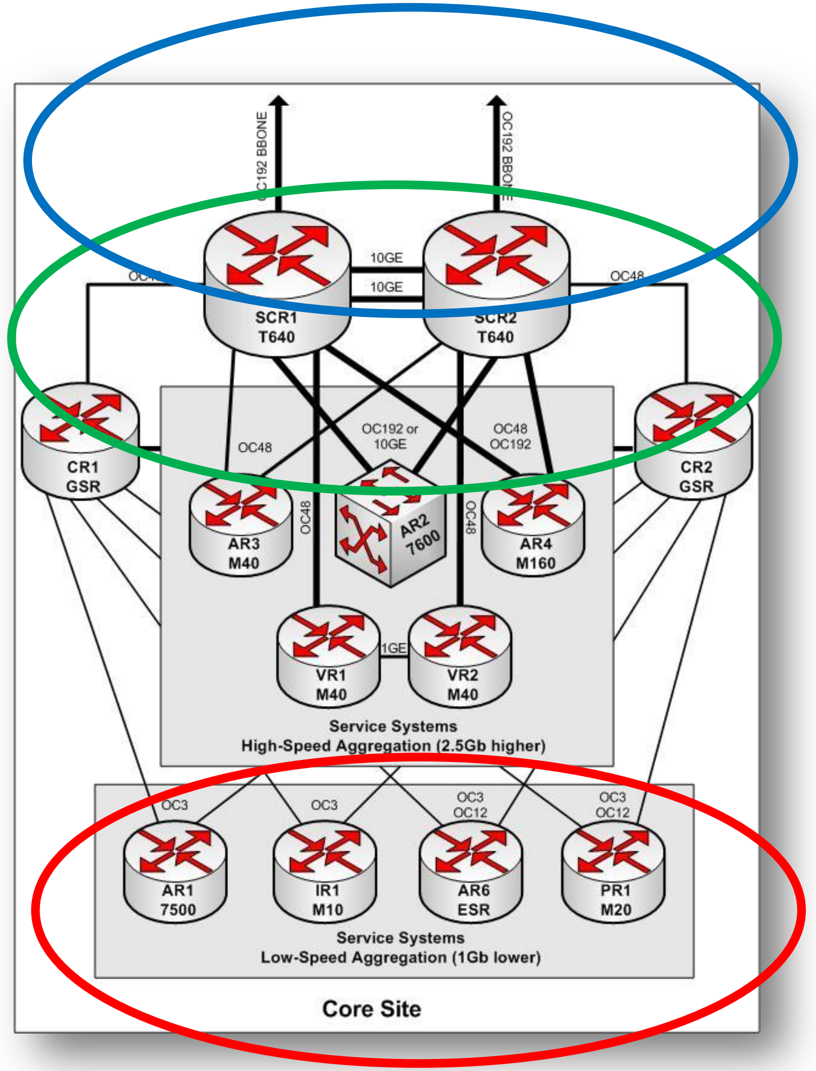
TRANSPORT TECHNOLOGY TRENDS TO ADDRESS THE CHALLENGES FOR GLOBAL INTERNET BACKBONES

DESIGNING YOUR TRANSPORT ARCHITECTURE

Understanding the Costs of an IP Backbone

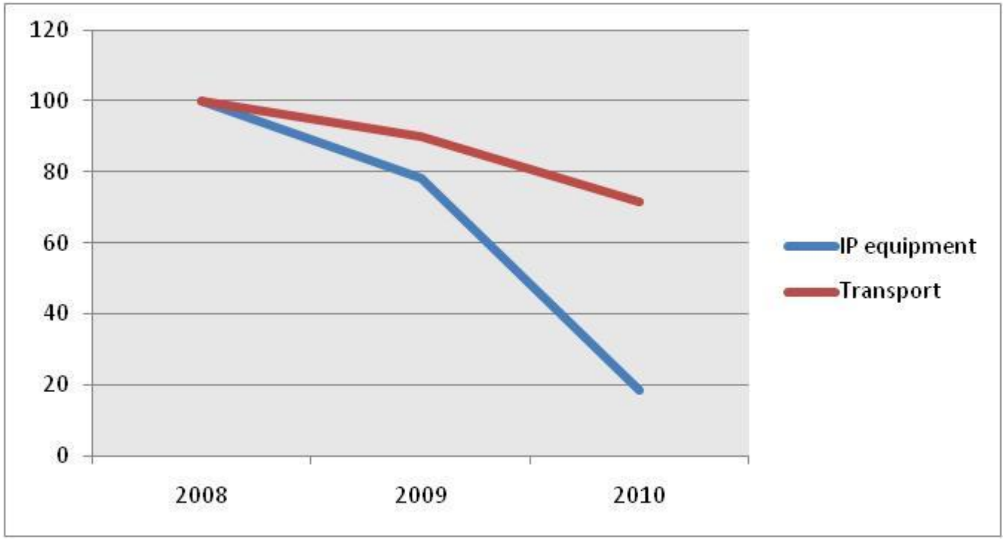
- Edge routers
- Core/Aggregation routers
- Backbone capacity
  - Fiber
  - Transmission equipment
- Space and power
- Peering interconnects
- People

- For a new customer interconnect; costs attributes are in Edge, Core and Backbone

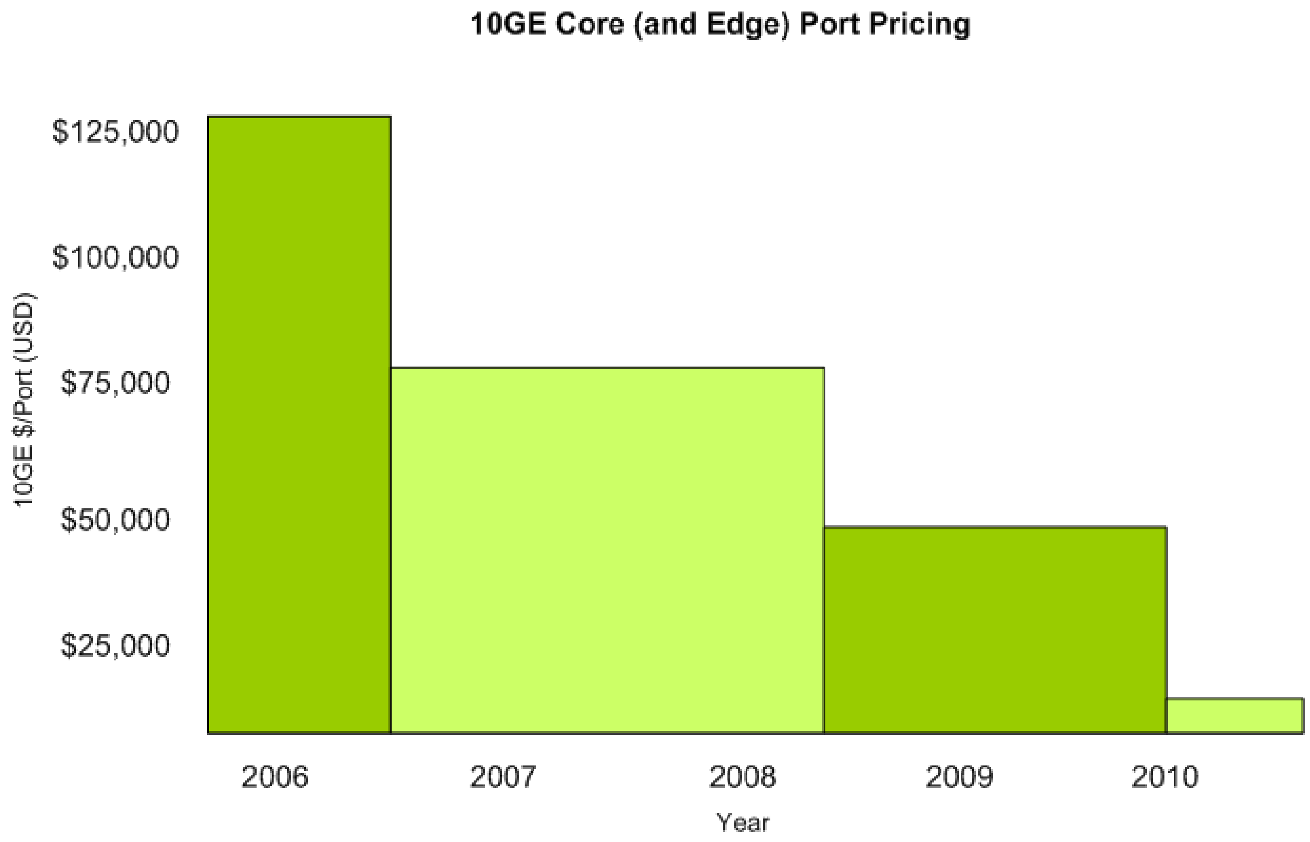


Global Crossing Cost Evolution

- Increased router port density drove down costs for edge and core routers

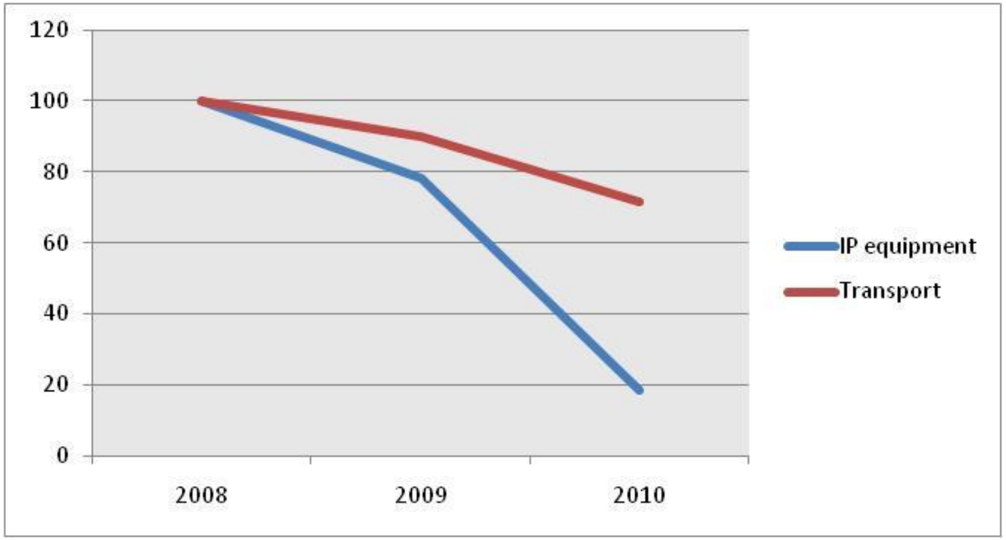


Cost trends Core and Edge routers



Global Crossing Cost Evolution

- Increased router port density drove down costs for edge and core routers
- Transport cost didn't not follow the same path and was not in line with market price erosion
- New Transport equipment and new architecture is needed



Considerations for backbone architecture/technology

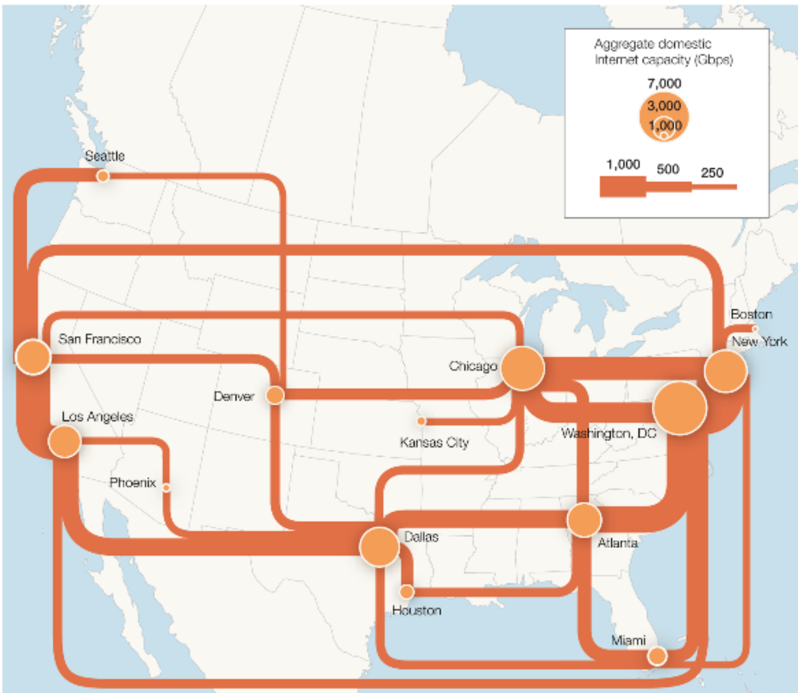
- 10GE transport costs MUST support IP Transit market price erosion
- Base transport architecture for US and Europe based upon Gen1 technologies
  - Average wavelength services is US(2000Km), Europe (1000 Km)
  - Built to support "Tier 1 City" to "Tier 2 City" requirements, but selling Tier 1 to Tier 1
- Gen1 technologies getting to the end of their technology and economical life cycle. New architectures must focus now on clever ways to scale the core while keeping cost down.
- Future proof. You can't change your network architecture every year.
- Scaling approach: We must scale not only technologically, but economically ("pay as you grow" versus "big lump sum investments")

Architecture challenges

- Increase flexibility – add cities or metro sites
- Meet new market requirements
  - Protected wavelength at small incremental cost
- Reduce provisioning time
  - Faster time to revenue
  - Flexible scaling of capacity
- Latency garantuees and monitoring

Optimize Network to align with major peering ports

Major Domestic Internet Routes in U.S., 2010

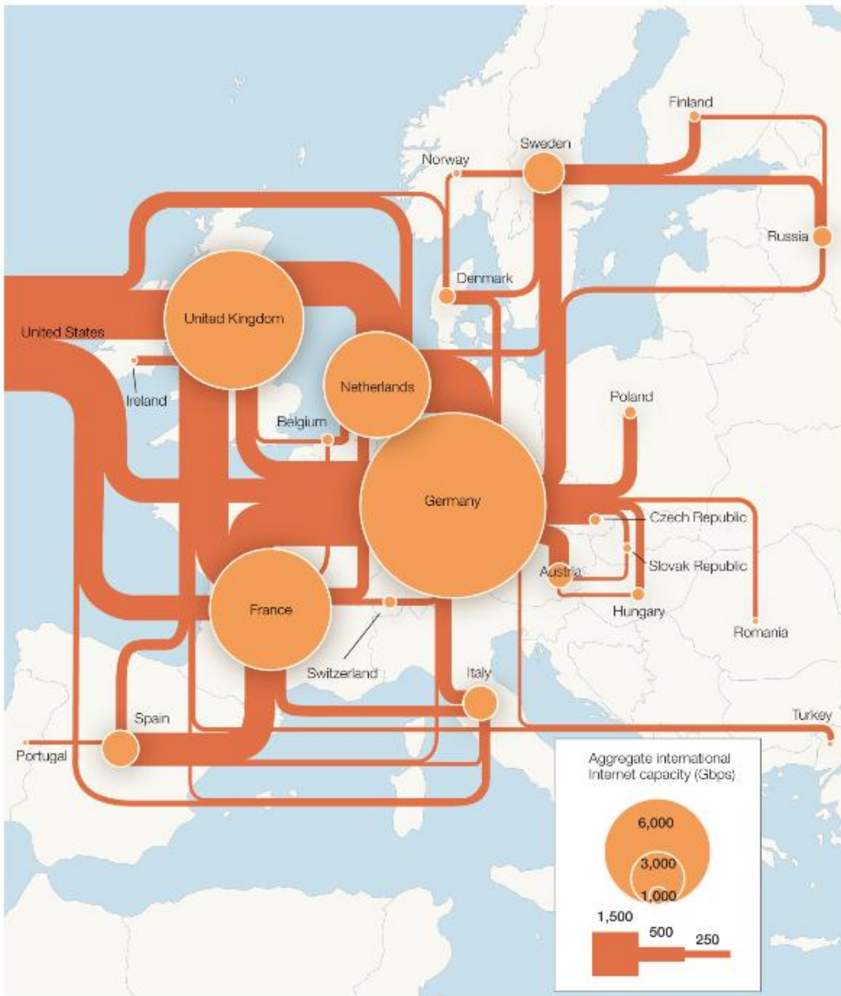


Notes: Map includes domestic Internet routes with at least 320 Gbps of aggregate capacity. Figures represent Internet bandwidth connected between Consolidated Metropolitan Statistical Areas. International routes are excluded. Data as of mid-2010.

Source: TeleGeography research

Need to optimize costs for Tier1 cities while maintaining flexibility for Tier2 cities

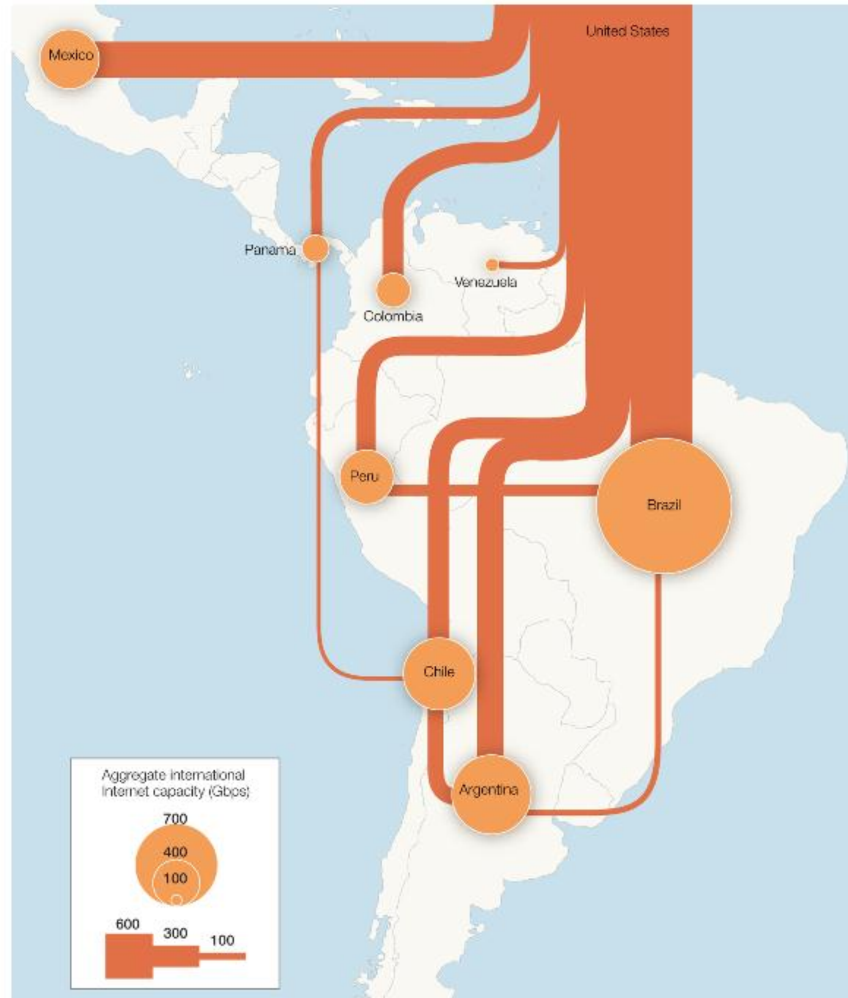
Major International Internet Routes in Europe, 2010



Notes: Map includes international Internet routes with at least 115 Gbps of aggregate capacity. Figures represent Internet bandwidth connected across international borders. Domestic routes excluded. Data as of mid-2010.

Source: TeleGeography research

Major International Internet Routes in Latin America & Caribbean, 2010



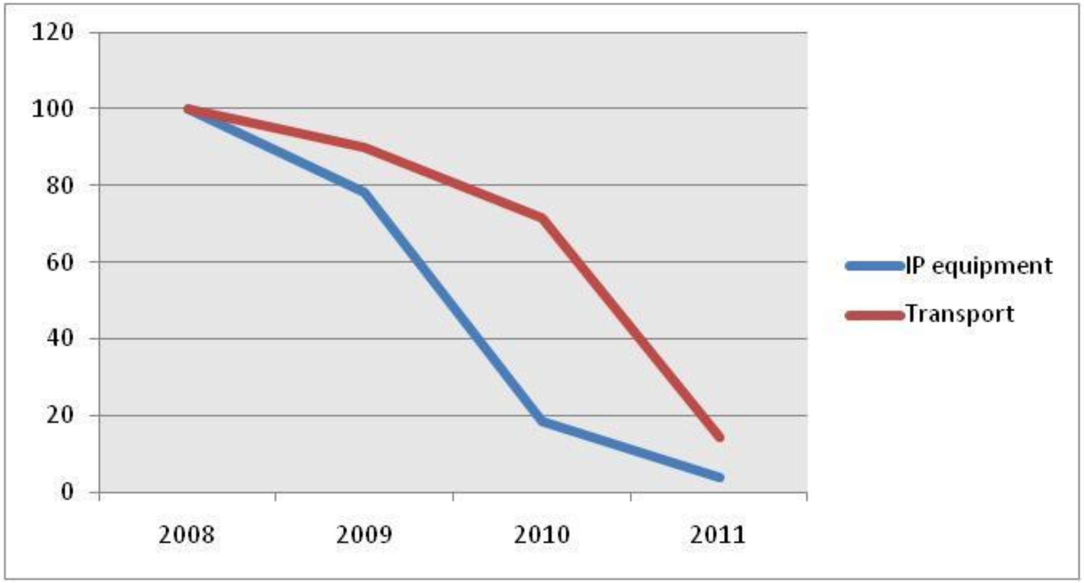
Notes: Map includes international Internet routes with at least 25 Gbps of aggregate capacity. Figures represent Internet bandwidth connected across international borders. Domestic routes excluded. Data as of mid-2010.

Source: TeleGeography research

Planned architecture

Deploy Ultra Long Haul technology in addition to existing solution

- ULH targeted at Tier1 cities – supporting 40G and 100G
- Keep flexibility and local drop capability in Tier2 cities with existing infrastructure
- This will bring the needed cost reduction for the transport part of the IP network



What does ULH mean?

Ultra Long Haul is a combination of advanced technologies that allow optical services to be travel longer distances than previous technologies, provide more flexibility in provisioning, creates near-zero touch provisioning , and allows for end-end circuit monitoring.

It's NOT just one thing.

It's building a seamless network.

It's supported by new Transponder and new Amplifier technology

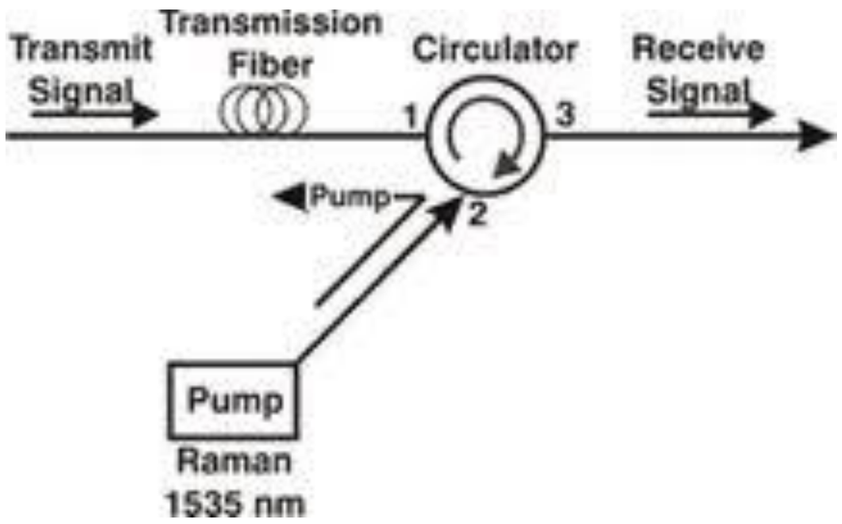
Transponder and Add/Drop/Switch Enhancements

- Modulation Schemes
  - Phase-shift keying (PSK) is a digital modulation scheme that conveys data by changing, or modulating, the phase of a reference signal (the carrier wave).
  - BPSK, QPSK, DQPSK (Binary/Quadruple/Differential Phase Shift Keying) - minimizes optical power inserted into fiber, minimizing non-linear effects of fiber
- Coherent Detection- Uses digital signal processing to compensate for line impairments.
- Error Correction - SDFEC (Soft Decision Forward Error Correction) algorithms are able to correct for higher error rates and allow systems to have lower OSNR (Optical Signal Noise Ratio).
- Photonic Integrated Chips (PICs) – Perpetuating Moore's Law and help to drive the costs down at regeneration sites

- ROADM (Reconfigurable Optical Add/Drop Multiplexer) – Allows flow thru provisioning at sites where no add/drop is required
- Wavelength Selectable Switches (WSS)- Allow multiple directions of traffic to be managed cost effectively. Small incremental optical switches.

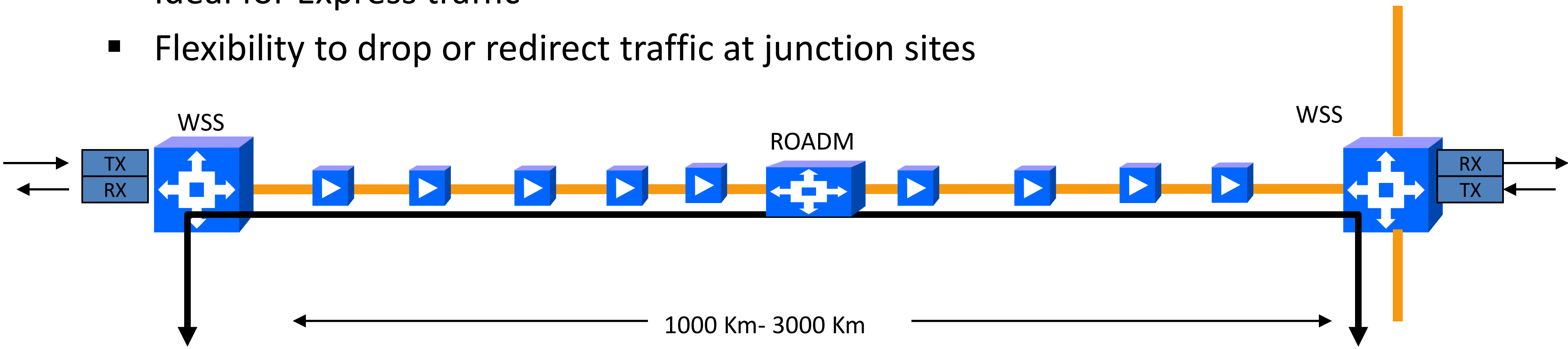
Low loss Raman Amplification

- In a Raman amplifier pump lasers are connected to the fiber and transmit optical energy down the length of a fiber. As it passes along the fiber this extra energy interacts with the optical signal increasing its strength.
- Low Loss Optical Amplifiers offer minimal ASE noise (“Amplified Spontaneous Emission” - lower noise floor) and allows more amplifiers to be cascaded.
- Lower power usage, fast, in-line amplification, larger distances without regeneration (…lower cost), robust



ULH-LH Systems

- Optical parameters support much longer distances between OEO (Optical-Electrical-Optical)
- Drastically reduces space and power at low density sites.
- ROADM / WSS technology allows for selective add/drop
  - ROADM not required for optical signaling, but placed in line to accommodate only if low-density drop location was required.
- Ideal for Express traffic
- Flexibility to drop or redirect traffic at junction sites



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40GE Ratified!

June 21, 2010

40/100 Gb Ethernet Standard Ratified; First Interoperability Event November 2010

The IEEE Standards Board this month approved IEEE 802.3ba – a new version of the Ethernet standard which includes a single architecture capable of supporting both 40 Gigabit Ethernet (40GbE) and 100 Gigabit Ethernet (100GbE), along with physical layer specifications for communication across backplanes, copper cabling, multimode fiber and single-mode fiber.

Standards Watch Blog

http://blogs.netapp.com/standards_watch/2010/06/40100-gb-ethernet-standard-ratified-first-interoperability-event-november-2010.html

IEEE ratifies 40-, 100- Gigabit Ethernet standard

MOUNTAIN VIEW, Calif. -- The Ethernet Alliance announced its congratulations to the IEEE Standards Association (IEEE-SA) and the IEEE P802.3ba Task Force on the ratification of the IEEE Std. 802.3ba - 2010 standard. As an amendment to IEEE 802.3 base standard, IEEE Std. 802.3ba specifies the technology and requirements for the development of higher speed Ethernet components and systems that operate at 40 and 100 gigabits per second.

The new standard describes a single architecture capable of supporting both 40 Gigabit Ethernet (40GbE) and 100 Gigabit Ethernet (100GbE), along with physical layer specifications for communication across backplanes, copper cabling, multimode fiber and single mode fiber.

Interconnection World

http://www.interconnectionworld.com/index/display/article-display/2367085283/articles/connector-specifier/standards/2010/june/ieee-ratifies_40-.html

Future of Ethernet 40GE and 100GE

IEEE HSSG 802.3ba interfaces

- Focus on 40GBASE-LR4, offices are not set up for multi-mode.
- CFP Interfaces

40GBASE-SR4 supporting 40 GbE over 100 meters of Multi-Mode Fiber (MMF) using four parallel 10 Gbps lanes;
40GBASE-LR4 supporting 40 GbE over 10 km of Single-Mode Fiber (SMF) using four 10 Gbps CWDM channels;
100GBASE-SR10 supporting 100 GbE over 100 meters of MMF using ten parallel 10 Gbps lanes;
100GBASE-LR4 supporting 100 GbE over 10 km of SMF using four 25 Gbps WDM channels; and
100GBASE-ER4 supporting 100 GbE over 40 km of SMF using four 25 Gbps WDM channels.

- Do not expect the initial deployments of 40GE to meet the (3 x 10G) cost points!
- Full 40GE will take still quite some development
- 100GE with 4x25G might be more economical sooner then 40GE

- Expect to give cost effects 2013-2014

Sub-Sea Challenges (Transatlantic, Pacific, LatAm)

- Many Trans-Atlantic systems are over 10 years old
  - Typically 4-fiber-pair systems – enabling different technology per fiber pair
  - Suboptimal amplifier performance for newer higher rate services
  - These systems have non-linearities that must be overcome, requiring additional electronics or higher cost electronics must be used to compensate
  - Current Trans-Atlantic bandwidth prices are too low to justify a new cable build (>500 mln Euro)
- Often fiber pairs are already in use, so upgrades must either:
  - Migrate traffic to other fiber pairs
  - Clear enough spectrum to put in newer technologies (guard-band requirements)
- Limitations on using 40G and 100G modulation
  - Longer spans or spans with high non-linear properties
  - This may ease as SD-FEC becomes commercially available (2012-2013)

How we handle those challenges – augment principles

- Deploy higher rate modulation schemes to defer “Sub-sea” augments
- Minimize Latency
- Minimize impact of upgrade on existing customer base
  - Try to clear fiber pairs, or ample spectrum

- How can we achieve these goals?
  - Look at newer modulation schemes: PM-QPSK, PM-BPSK, DPSK
  - Use Coherent Receivers or Fiber Bragg Gratings
  - Proper annual Forecasting
  - Continuously work with vendors to develop technologies that will increase our overall capacity per fiber pair

AND NOW SOMETHING COMPLETELY DIFFERENT:

HOW THE FINANCIAL TRADING MARKET EXPLOITS “OUR” TRANSPORT TECHNOLOGY TRENDS

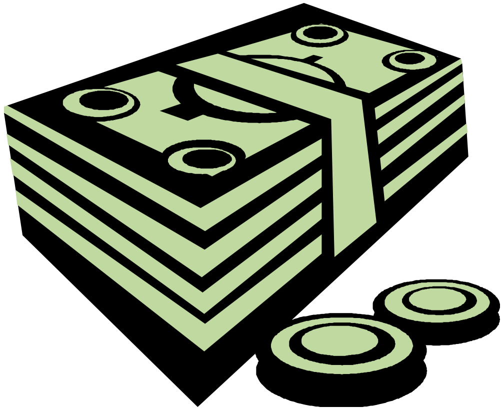
ULTRA LOW LATENCY TECHNOLOGY

High Frequency Trading

High-frequency traders buy and sell thousands of shares every second

Over the past 10 years, algorithmic trading has overtaken the industry.

- By some estimates, computer-aided high-frequency trading now accounts for about 70 percent of total trade volume.
- The TABB Group estimates that 10 milliseconds of latency could impact revenues negatively by 10%.
- Another study estimates a 1 millisecond advantage in latency can be worth $100M/year to a financial institution (InformationWeek, April 2007)



The financial industry's obsession with minute differences in latency between different fiber routes has triggered a wave of telecom network optimization, with service providers going so far as to lay new fiber, if needed, to shave miles—and milliseconds—off of key trading routes.

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High Frequency Trading – Direct Market Access Strategies

- Electronic trading facilities give investors a way to interact with the order book of an exchange.
- Investment companies and other private traders utilize information technology infrastructure to control the way a trading transaction is managed.
- Infrastructure is combined with algorithmic trading to create a high performance trading platform – we are part of that platform.

Traders in New York or Chicago

Global Crossing Transport

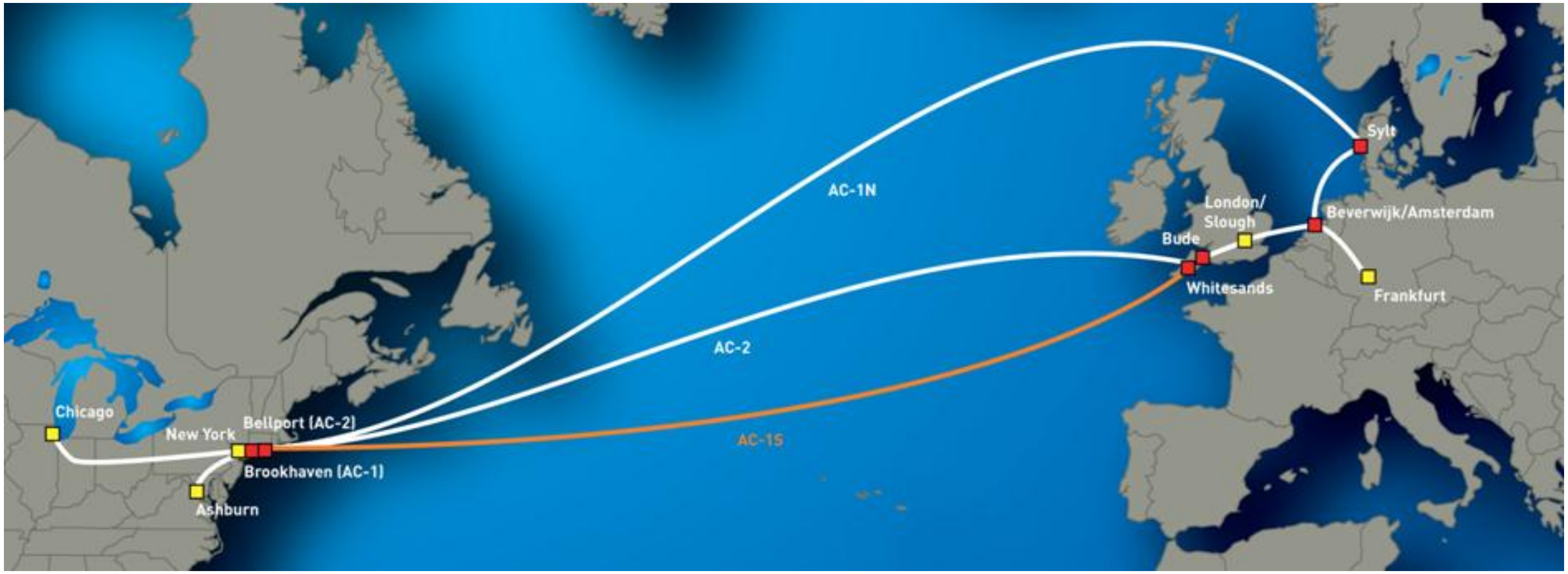
Low Latency Wavelengths

Financial Exchanges in London or Frankfurt

Buying decision is based on Speed!

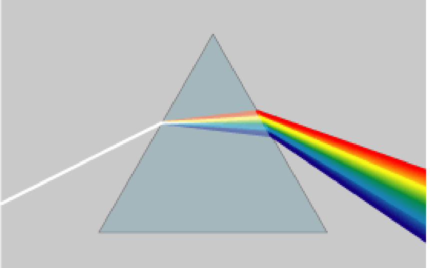
What contributes to latency ?

- Fiber Distance
- Dispersion



Dispersion & Compensation methods

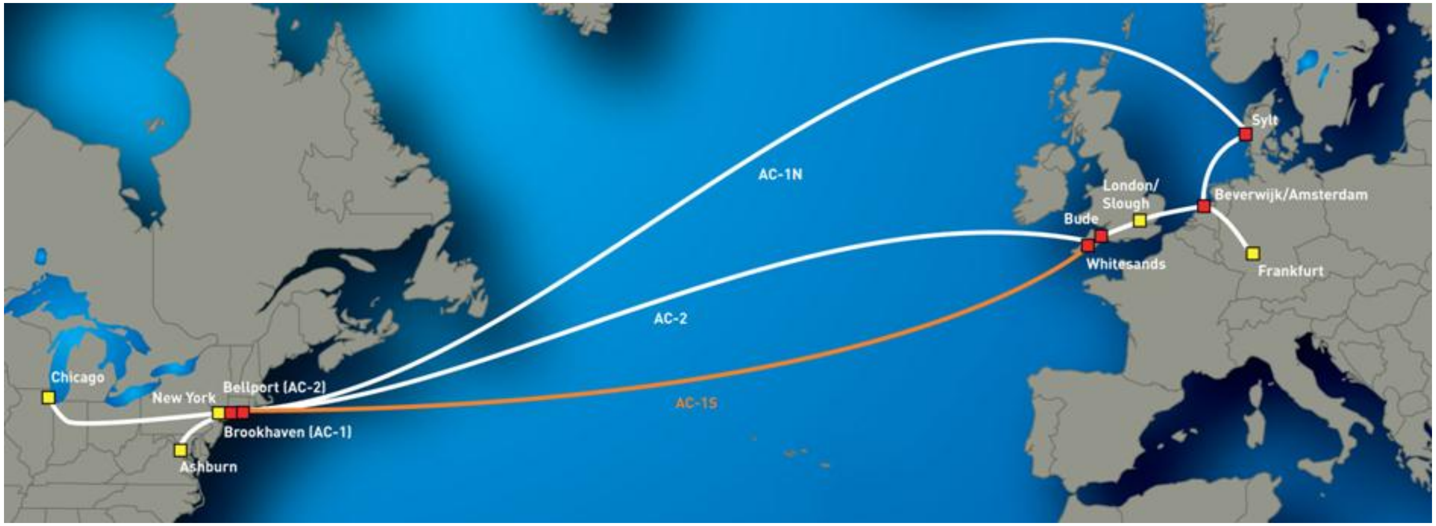
- Dispersion is the phenomenon in which the phase velocity of a wave depends on its frequency.
- The most familiar example of dispersion is probably a rainbow, in which dispersion causes the spatial separation of a white light into components of different wavelengths (different colors).
- Dispersion causes pulses to spread in optical fibers, degrading signals over long distances;
- To compensate for dispersion additional fiber (on coils) can be inserted – sometimes up to 50km on a coil – adding latency
- A fiber Bragg grating (FBG) is a type of distributed Bragg reflector constructed in a short segment of optical fiber that reflects particular wavelengths of light and transmits all others.



What contributes to latency ?

- Fiber Distance
- Dispersion Compensation Methods
- System processing Time-
  - Transponders
  - Muxing methods
  - FEC

- How can we minimize it?
  - Shortest route selection
  - Use technologies that minimize discrete dispersion compensation
    - Coherent Detection
    - Fiber Bragg Gratings



Global Crossing Ultra Low Latency Routes

Summary

- Trends in Ultra Long Haul technology and 40G/100G Ethernet will continue to support traffic growth and cost reduction, supporting flat end-user pricing at growing bandwidth
- Trends in Subsea Technology support growth on existing cable systems, but new construction is unavoidable over time
- High Frequency Financial Traders apply the same services to different applications – driving investments in faster and new routes

Making it Even Easier To Connect….

Come to our booth, talk to Roland Vrijheid or Boleslaw Kraus

Or use our fully integrated social media presence ….

twitter

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Thank You

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