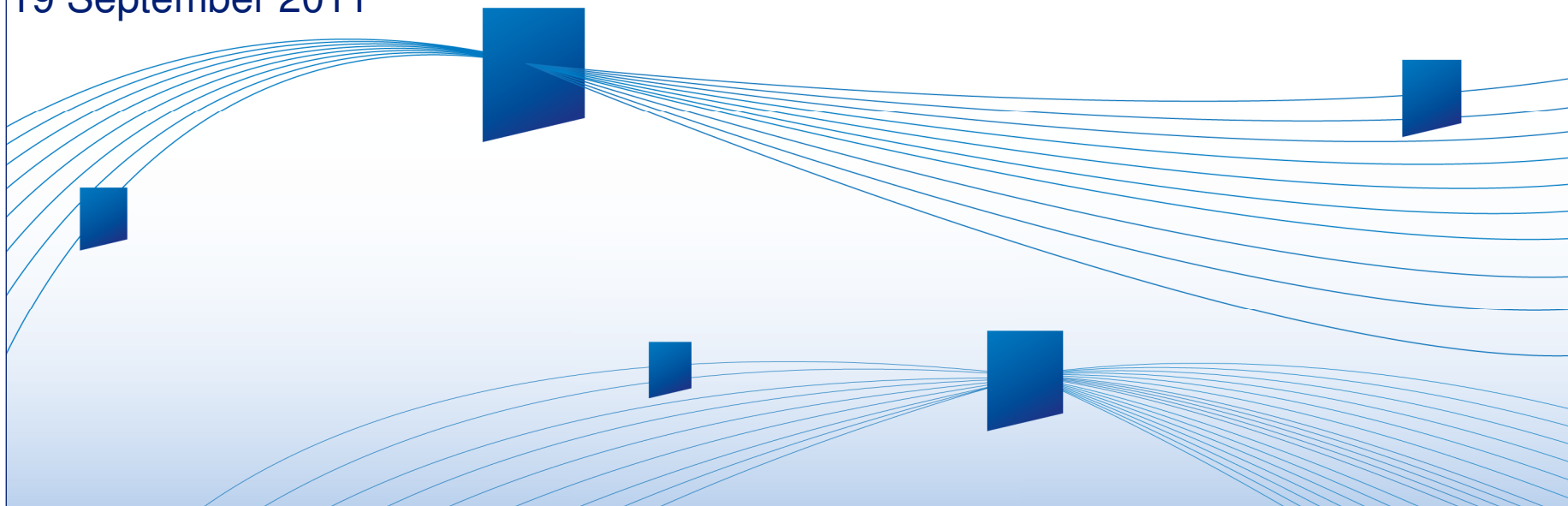


# Optical Communication in a Trading Data Center

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19 September 2011



# Agenda

- The business and the needs that drive the technology
- What we deployed
- What technology we need next



# **THE BUSINESS NEEDS THAT DRIVE THE TECHNOLOGY**

# 400+ years of business and technology firsts

We are the inventors of financial exchanges...

- Amsterdam, founded 1602, is the world's oldest exchange
- Our markets in Brussels, Lisbon, NY and Paris and trace their roots to the 18<sup>th</sup> and 19<sup>th</sup> centuries
- We have over 16 centuries of combined experience running financial exchanges



And we have a rich history of innovation in markets...



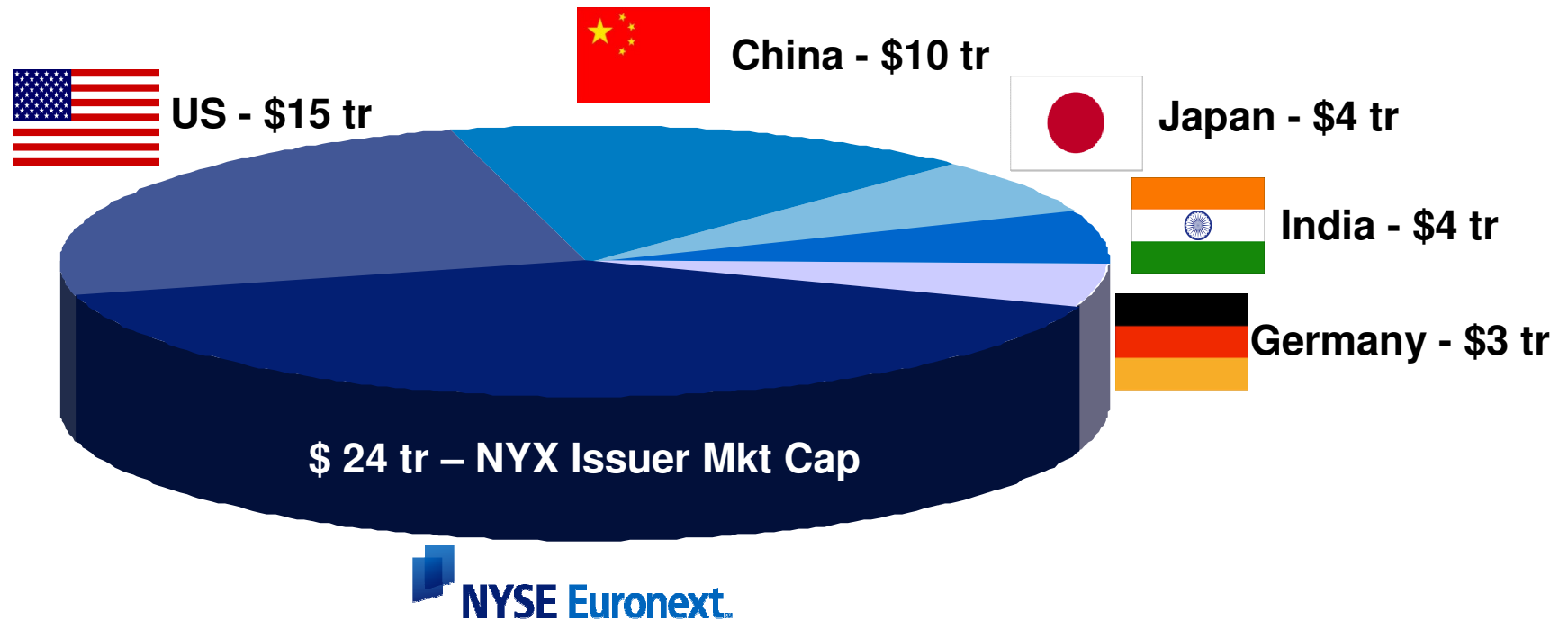
- NYSE was the first exchange to use a stock ticker to disseminate data (1867)
- NYSE was the first to have telephones on the trading floor (1878)
- We had automated quotation services 18 years before Nasdaq was founded (1953)
- First electronic ticker display board (1966)
- First options exchange in Europe launched in Amsterdam (1978)
- Amex pioneered the Exchange Traded Fund (1993)
- Wireless handheld devices on NYSE's floor 15 years before iPad invented (1995)
- Euronext becomes first pan-European equities market (2000)
- SFTI was the industry's first network offering global connectivity (2008)

# Scale of the Business

The total market cap of all our listed companies is over **\$24 Trillion....**

...Compared to country GDPs, that would make us the largest economy in the world.

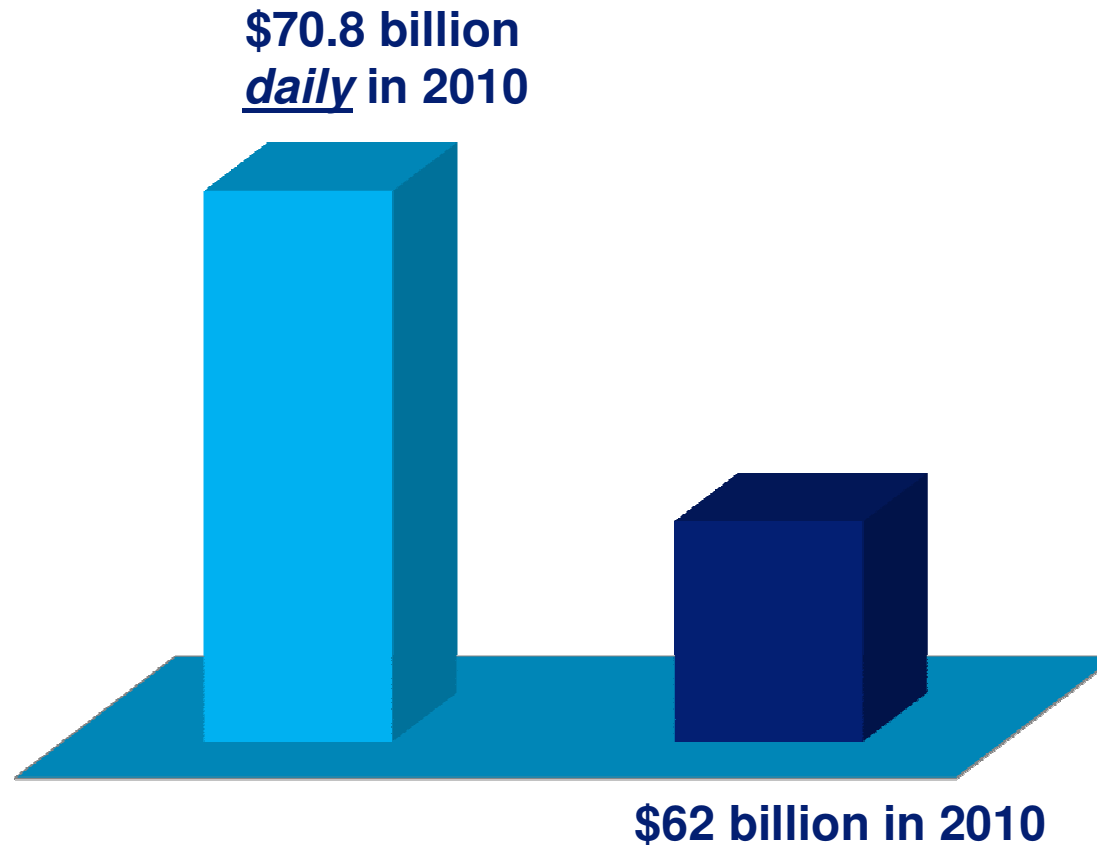
**Largest Economies by GDP (in Trillions of \$)**



# Scale of Transactions

In the U.S., NYSE Euronext exchanges execute **\$70.8 billion** in financial transactions every day...

...eBay handled **\$62 billion** all of last year.

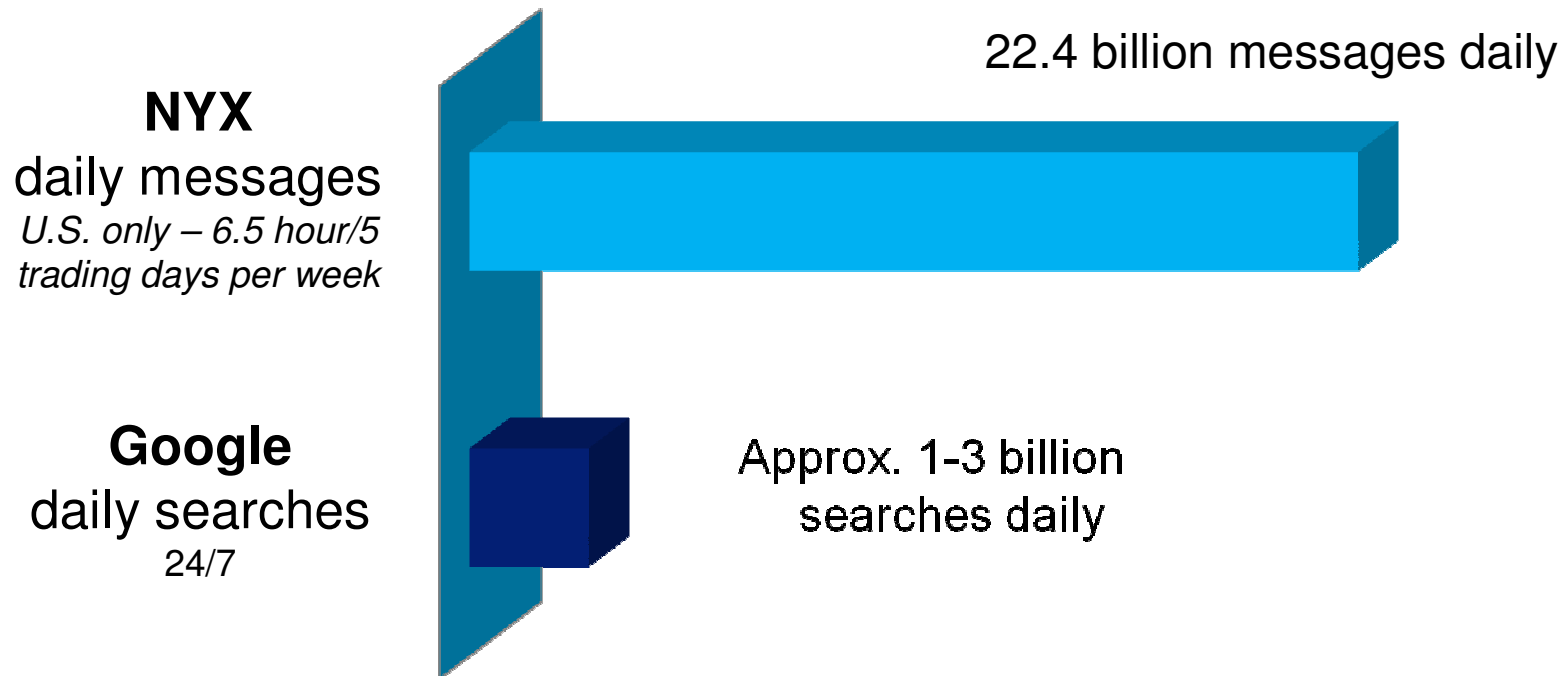


# Message Activity

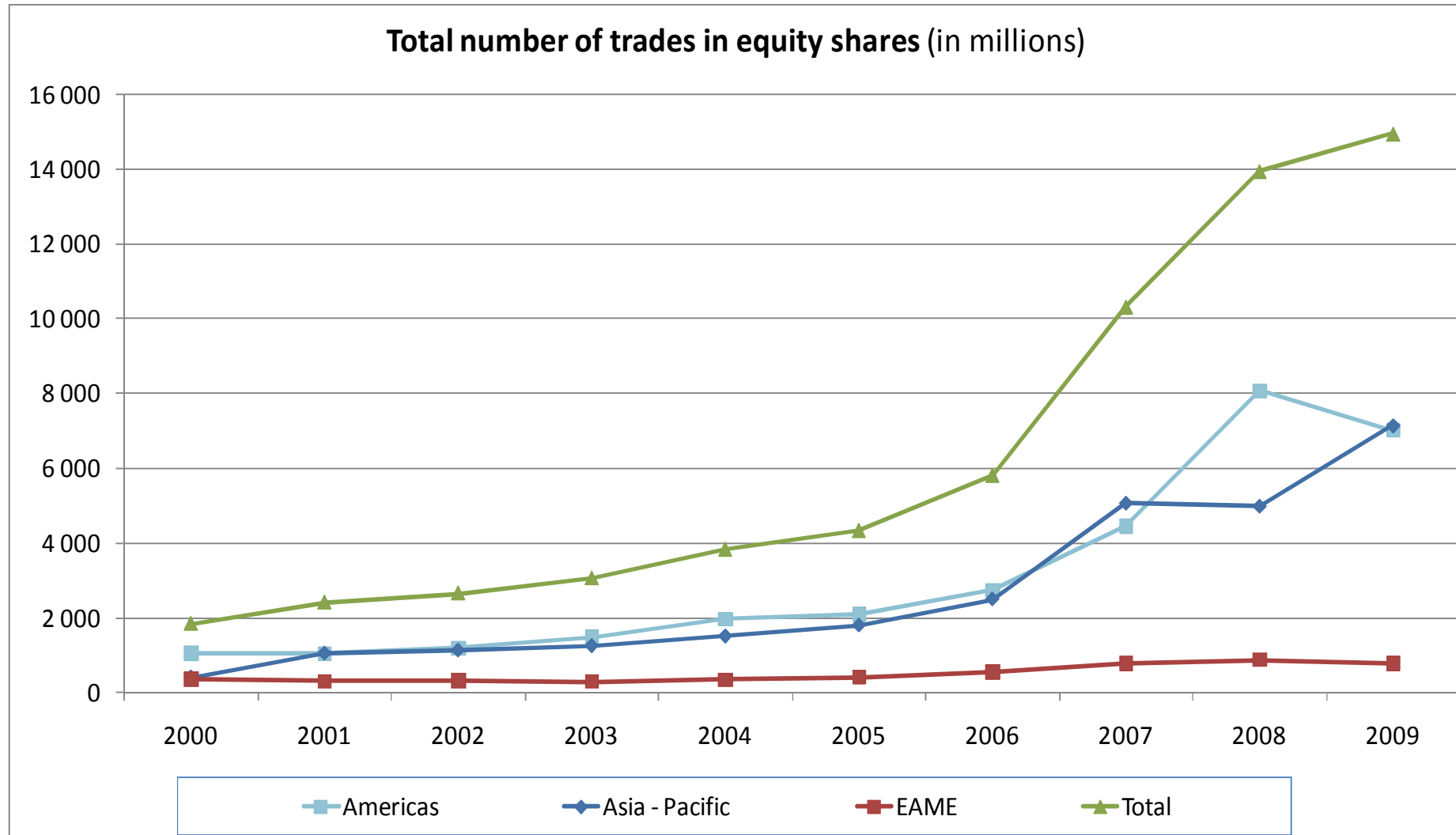
In the U.S. alone, NYSE Euronext process more than **22.4 billion messages** each day...

...That's **7.5** times more than the number of internet searches Google handles daily.

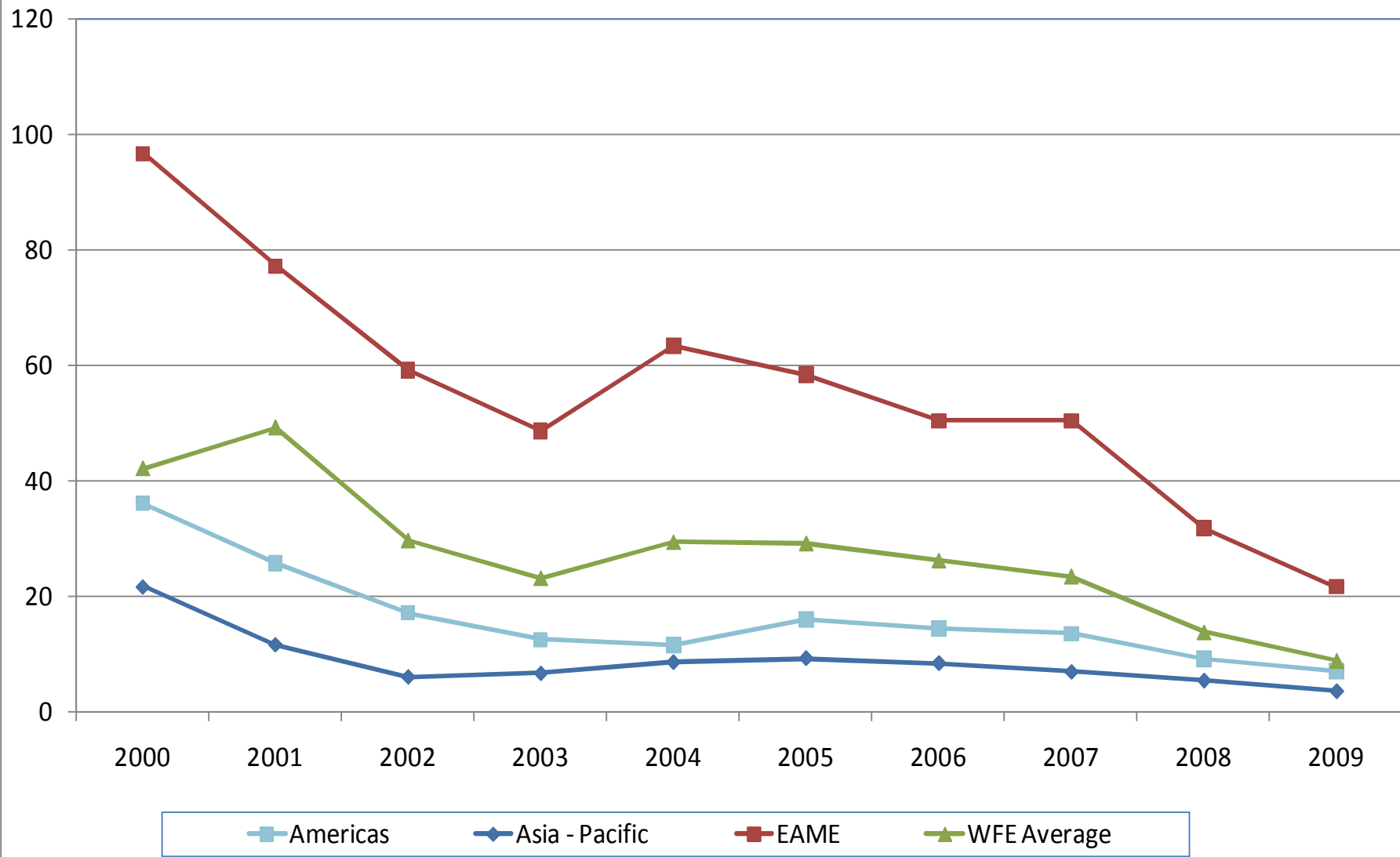
## Number of Messages/Transactions per day



# Total number of Trades in Equity Shares **+700%**

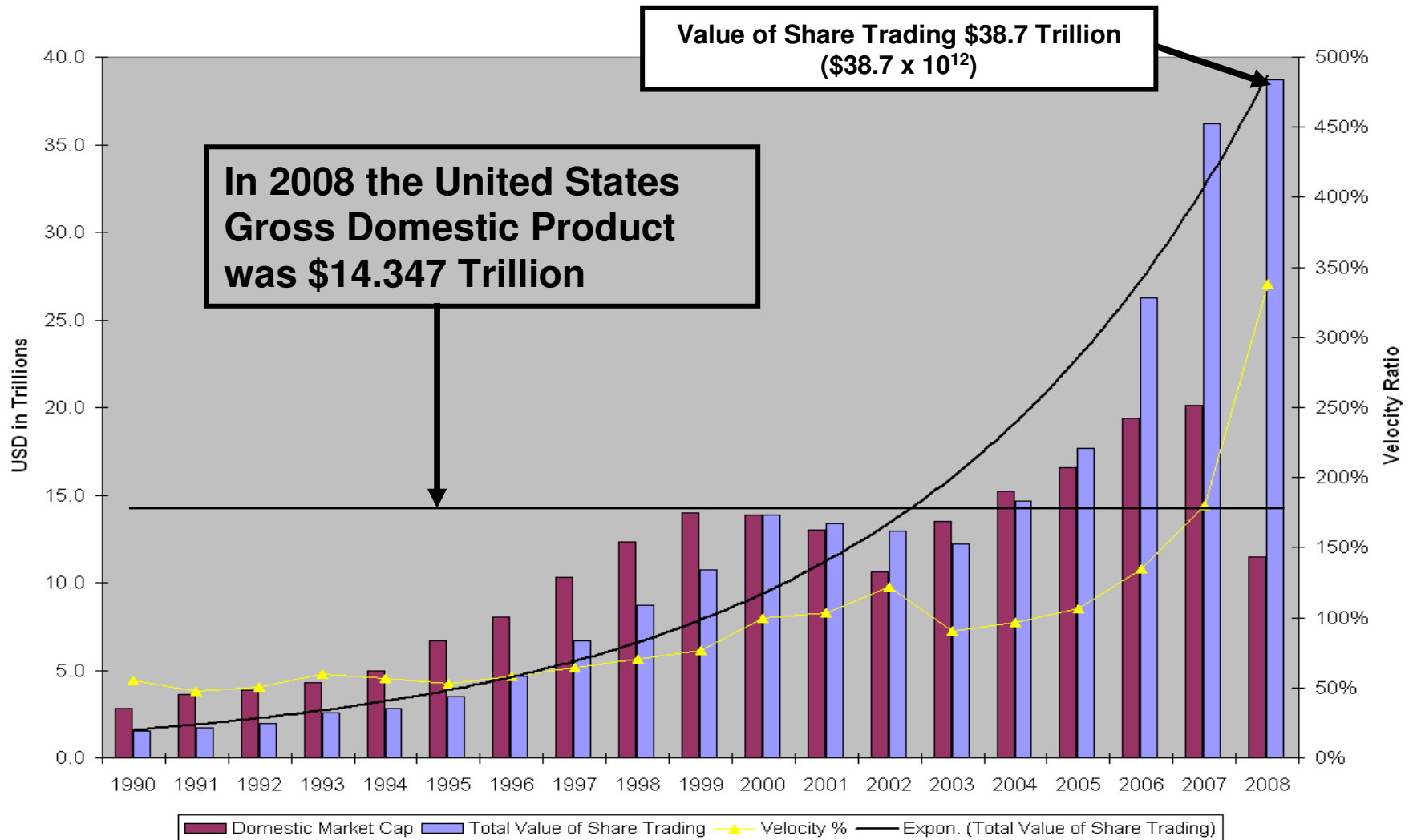


Average value of trade - USD thousands (weighted by share value trading)



Data Source: World Federation of Exchanges ([www.world-exchanges.org](http://www.world-exchanges.org))

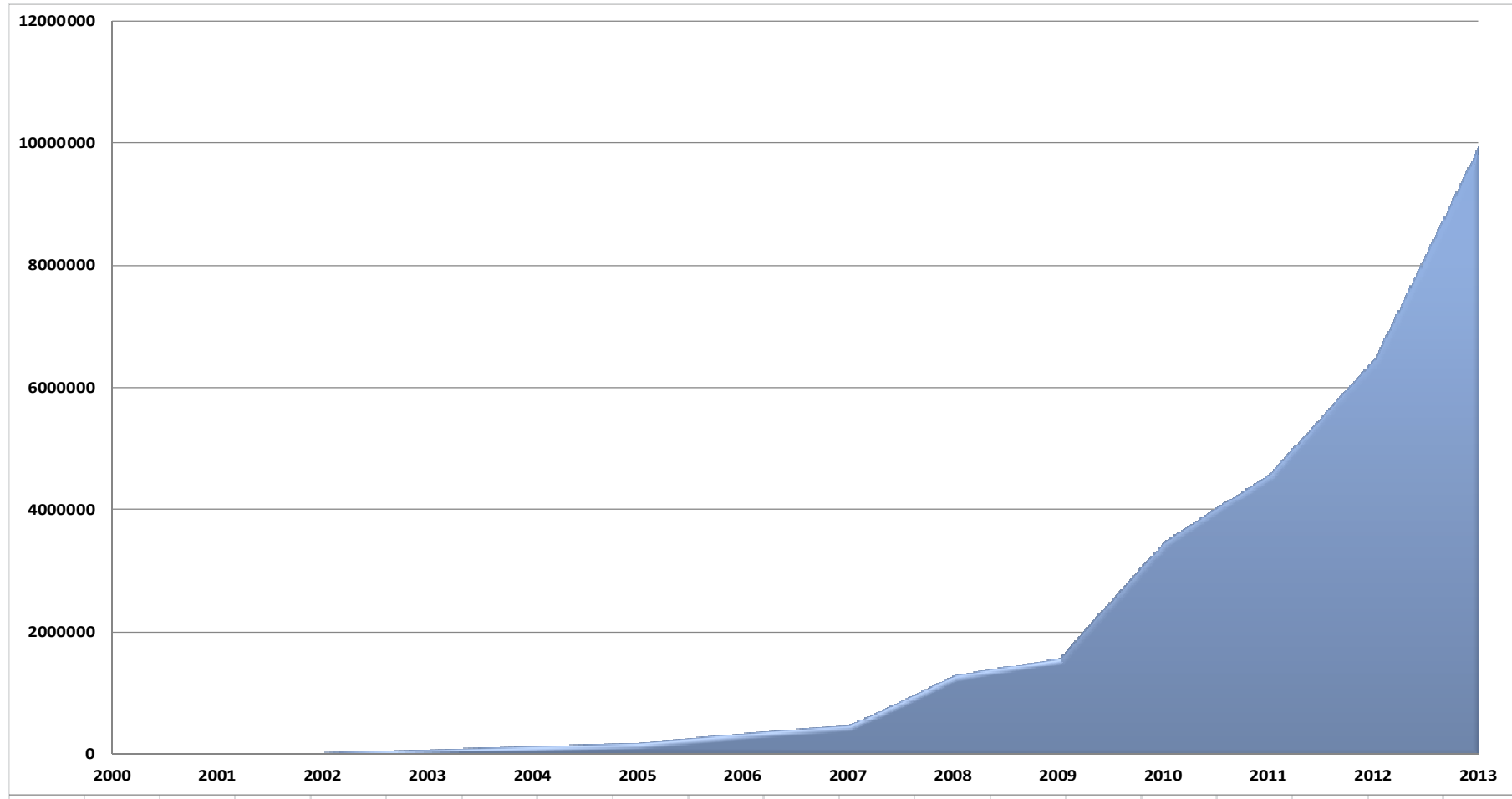
# Market Capitalization and Value of Share Trading



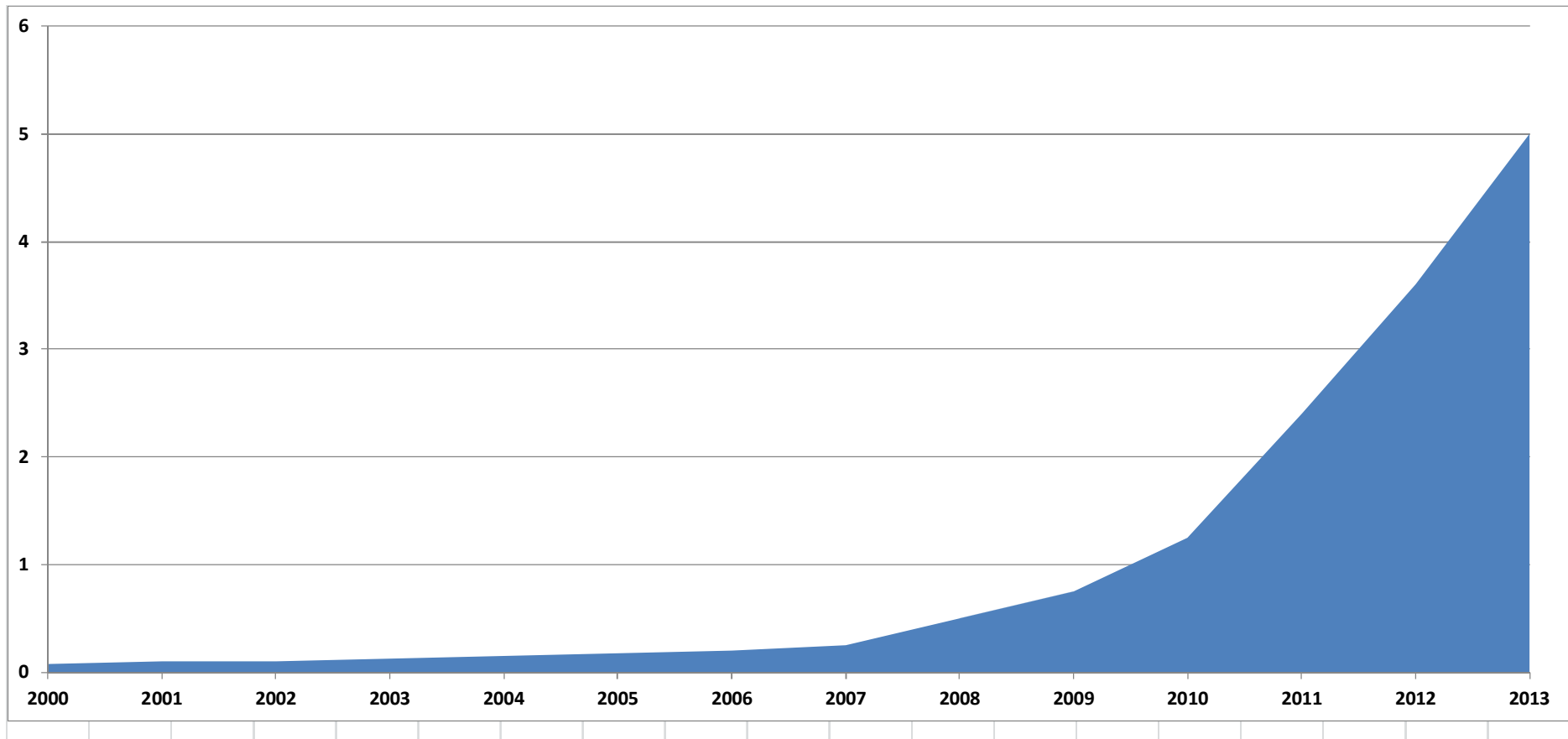
# Latency and Market Data

- Low latency market data is uncompressed, requiring more bandwidth
- Competitiveness of the market is no longer measured in milliseconds (ms), but in microseconds ( $\mu$ s)
- Any delay or queuing inserted into the trading path must be eliminated
- Delaying market data wreaks havoc on trading applications and is significantly worse than discard

# Approximate North American Options Data (Messages per Second)



# Bandwidth Distributed to the Financial Community (Terabits/Sec)



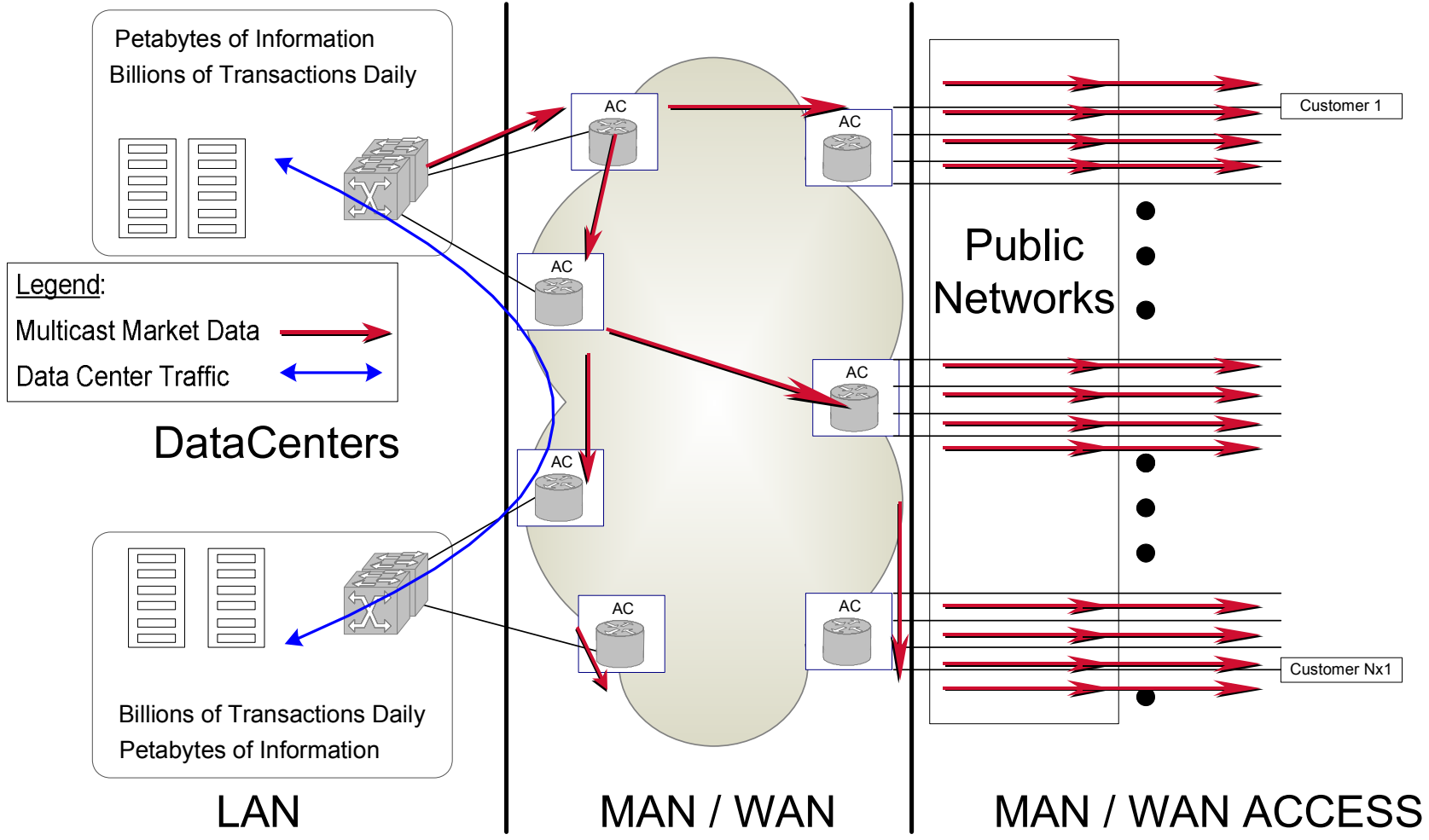


# THE TECHNOLOGY THAT WAS DEPLOYED

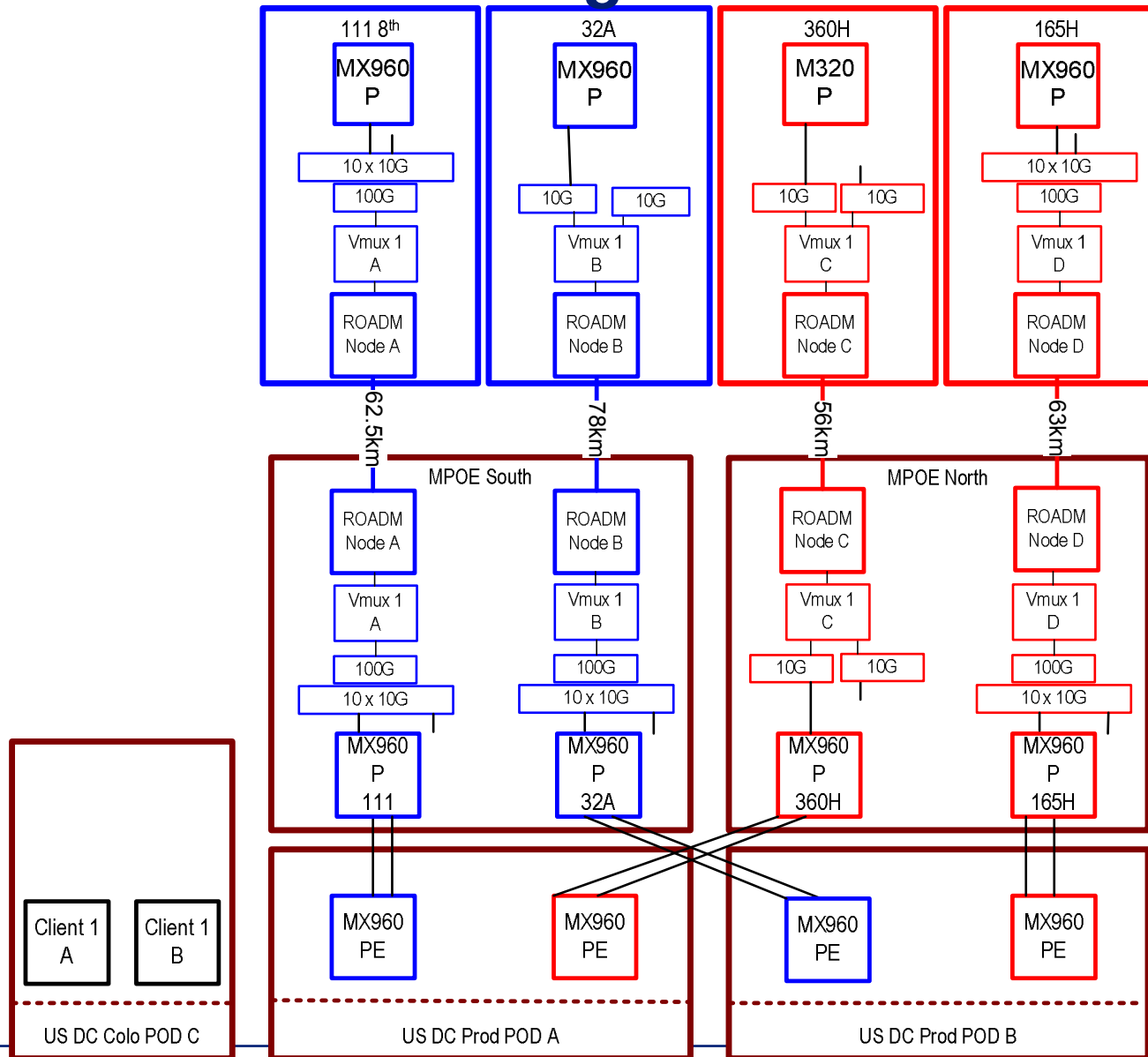
# Technology Foot Print

- Network
  - Network devices (Routers, Switches, etc) 6,000
  - 1G Ports or below 200,000
  - 10G ports 10,000
  - Route table 500,000
  - Entitlements 40,000
  - Telco Circuits 20,000
  - Data Center Core Bandwidth 18,350,000,000,000
- Processing
  - Servers  $\approx$  10,000
  - Cores  $\approx$  60,000
  - Storage  $\approx$  10 PB

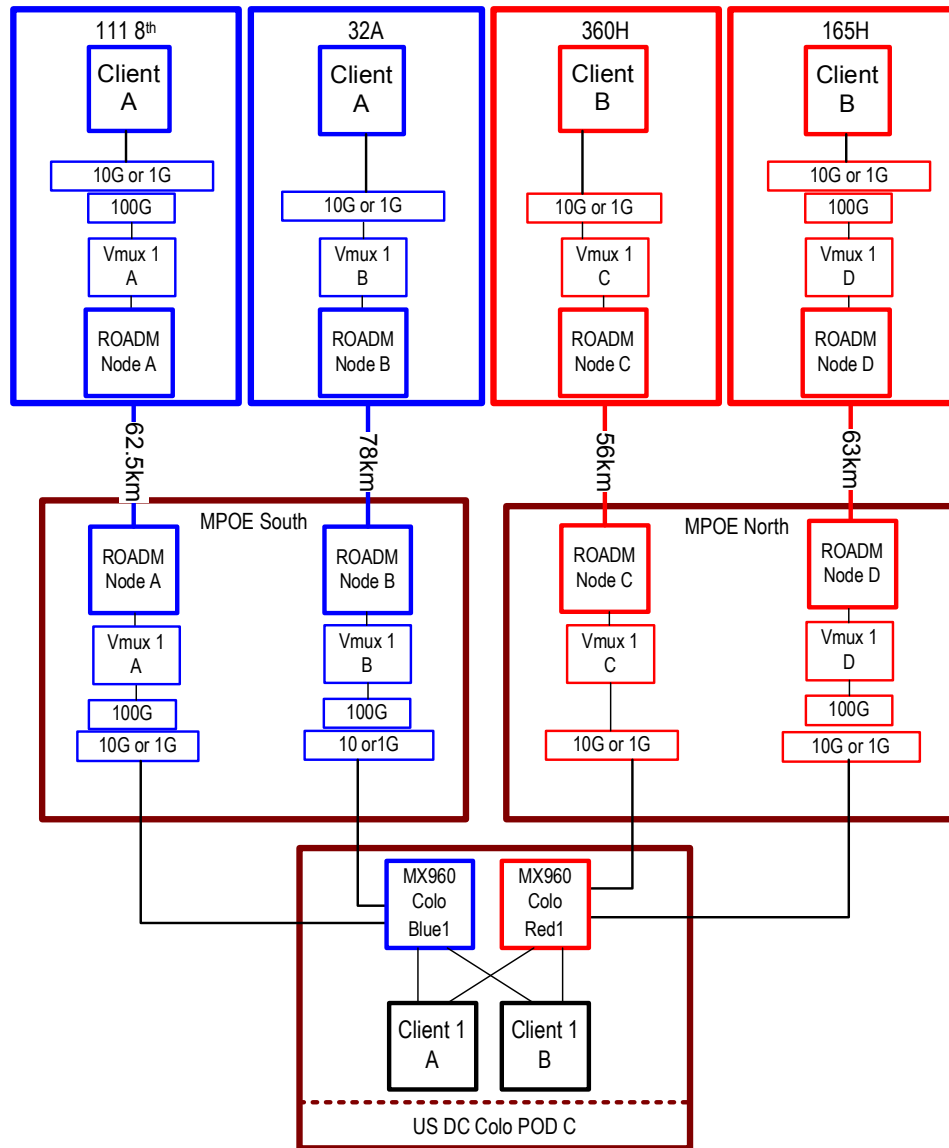
# Exemplar External Network



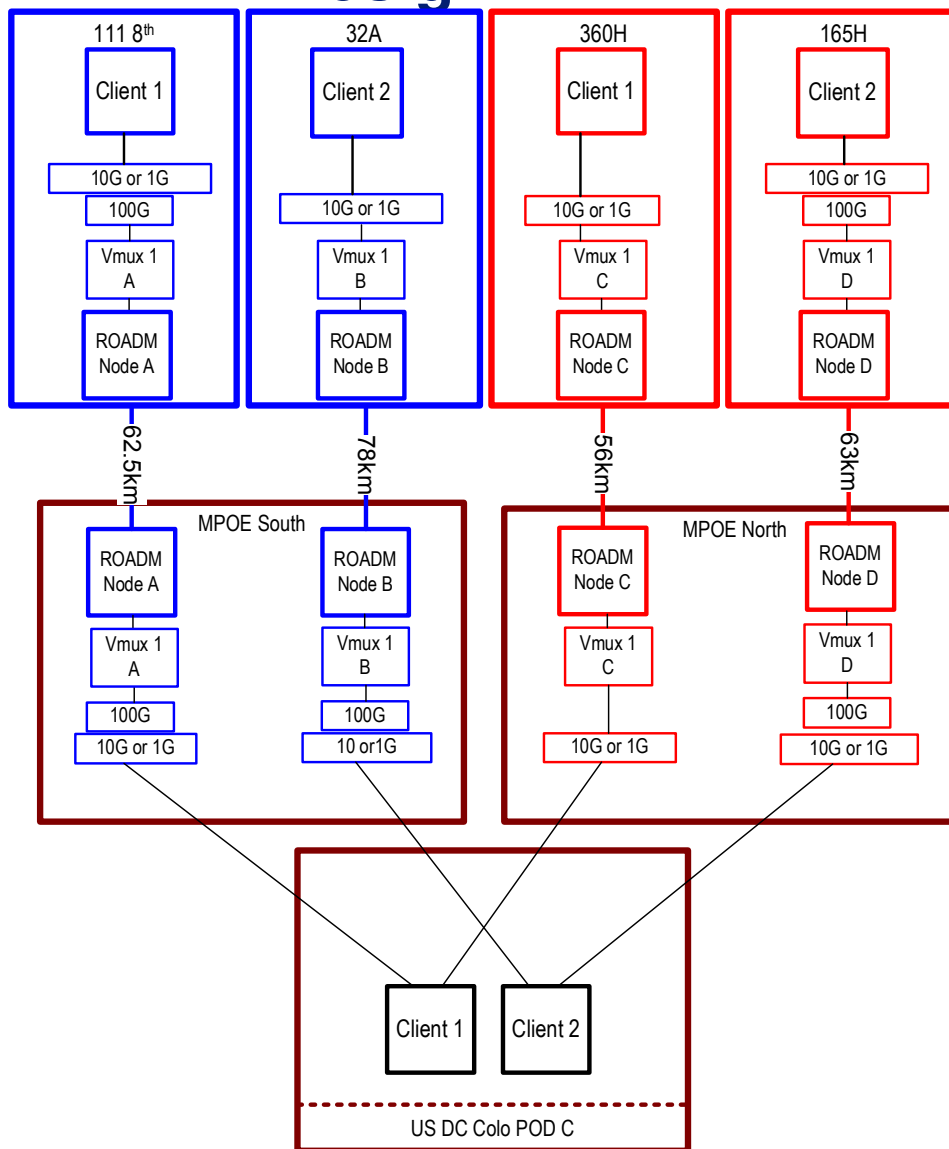
# US DC - Core DWDM Design



# US DC - Colo – SFTI Client Design



# US DC - Colo - DWDM Design



## Optical Footprint (one data center only)

- First Plan:
  - 4 -100G wave delivering 40 - 10G Ethernet circuits (0.4Tb)
- Currently Deployed – North America:
  - 13 - 100G waves delivering 130 – 10G Ethernet circuits (1.3Tb)
  - 27 – 10G waves (0.27Tb)
  - 88 –  $\lambda$ 's (0.88Tb)
  - Total 128  $\lambda$ 's delivering 2.45Tb/S
- Currently Deployed - EU:
  - 26 – 10G waves (0.26Tb)
  - 16 – 10G waves delivering 160 -1 G Ethernet (0.16Tb)
  - Total 42  $\lambda$ 's delivering 0.42Tb/S
- Grand Total 170  $\lambda$ 's delivering 2.87Tb/S

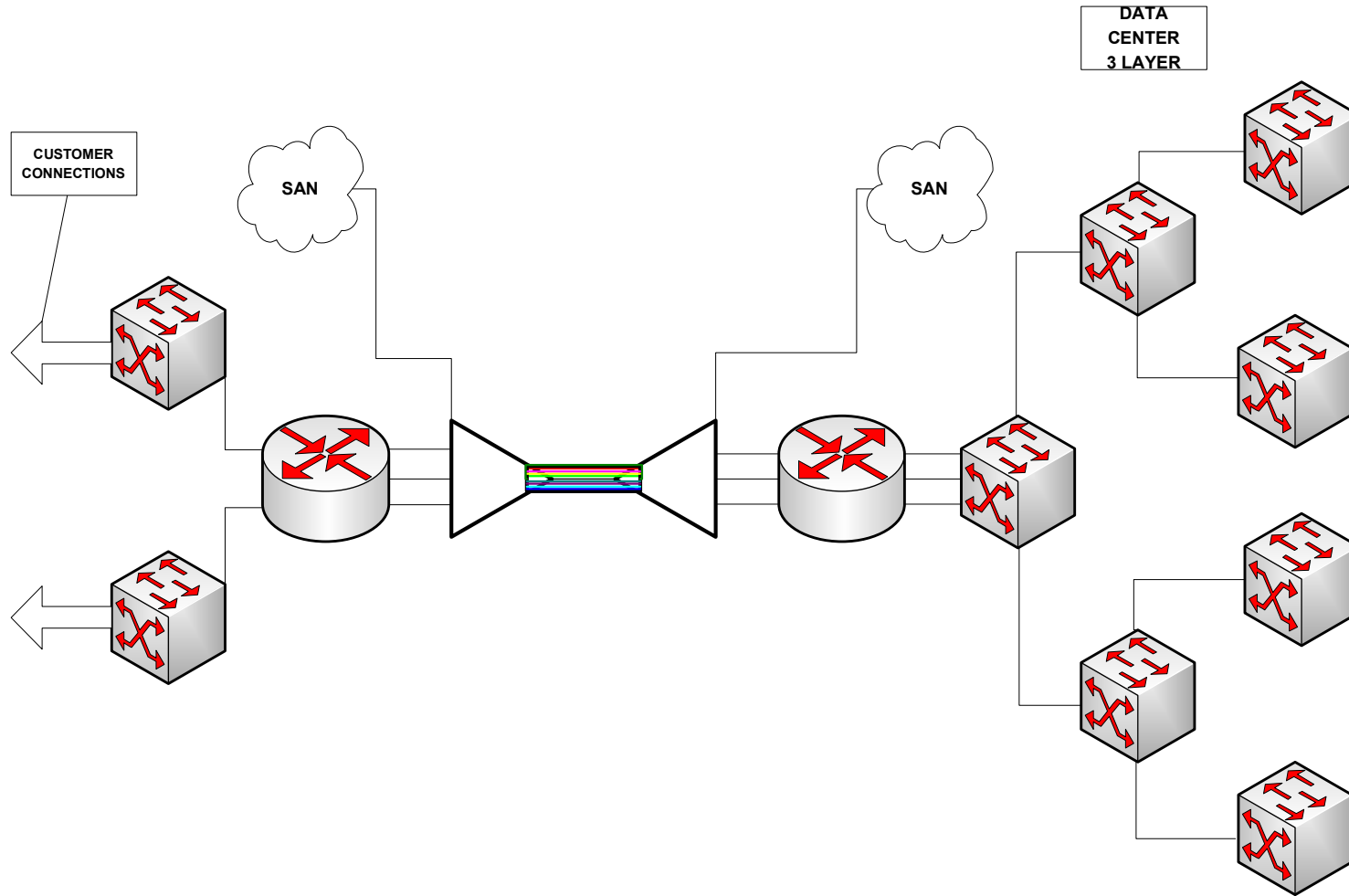


# WHAT TECHNOLOGY WE NEED NEXT

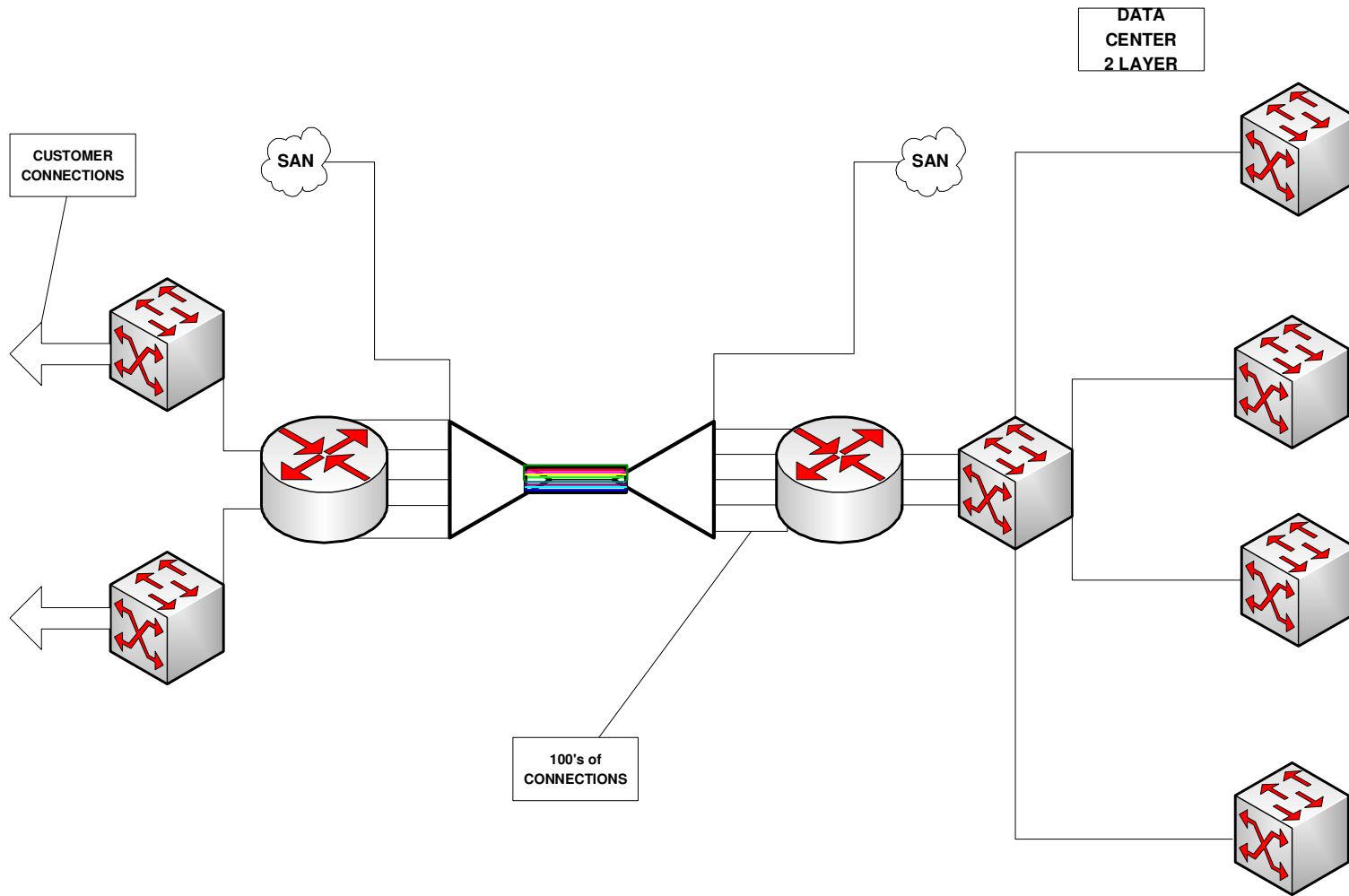
# Pushing the Technology Edge

- Flat “cloud” network within the four walls of the data center
  - Will fully support storage
  - Will support bandwidth on demand
  - Ultra low latency and jitter
  - Very reliable – without adding layers of redundant switches
  - Scalable to 10,000’s of ports at 10G/40G and beyond
  - Core interconnect will need to support/exceed 1T
- Seamless view and operation independent of location
- Fully extensible to the local wide area (about 50 miles diameter)
  - DWDM integrated into the data center Router
  - GMPLS fully controlled and managed from the data center routers
- Limited by speed of light in a vacuum only

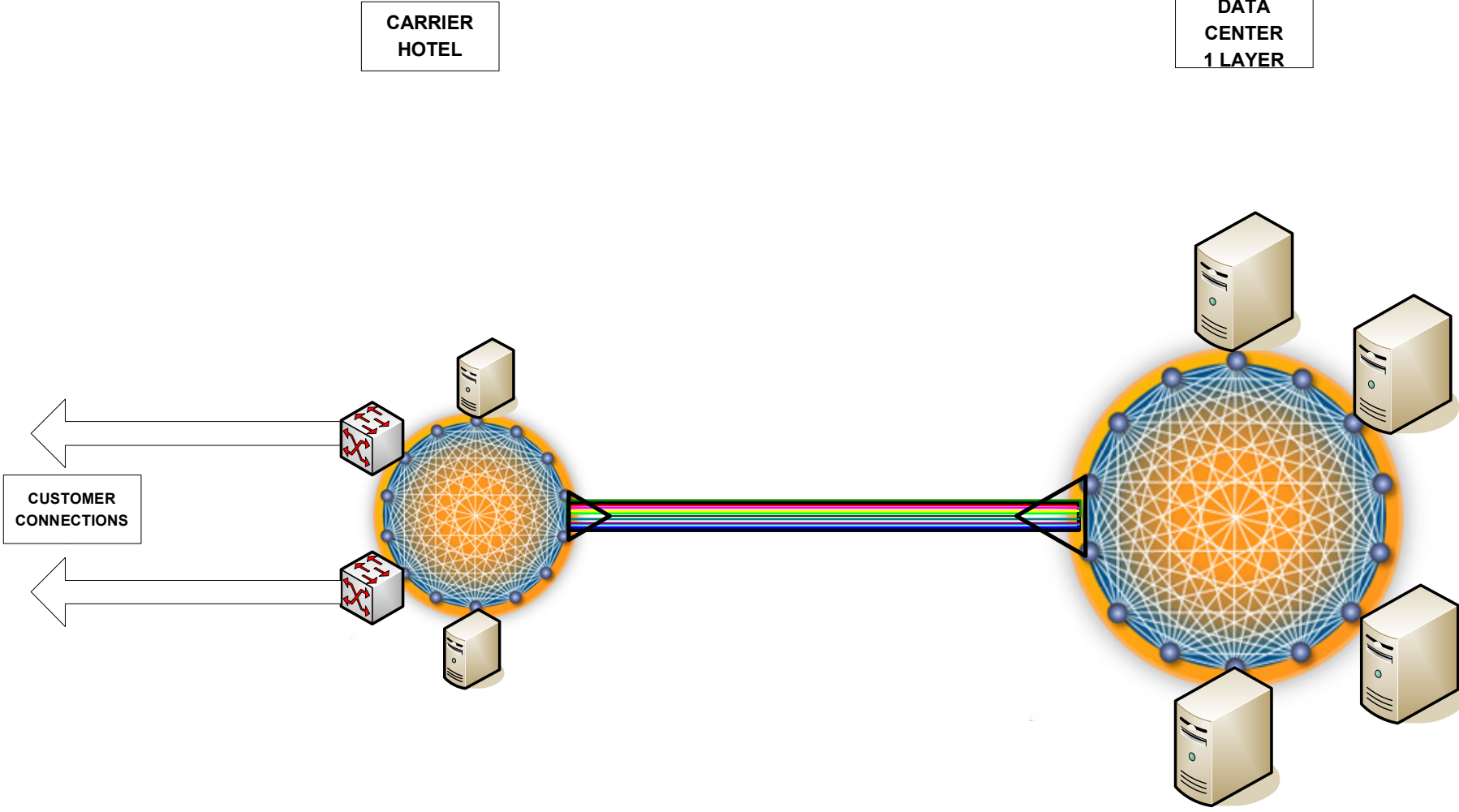
# Classic Data center



# Current Data Center



# Future Data Center



# Closing Comments

- Technology race accelerating
- Bandwidth Demand continues to grow at 30% - 50% per year
- Fundamental new architectures are required