# The future of Fibre Channel

**Mark Jones**

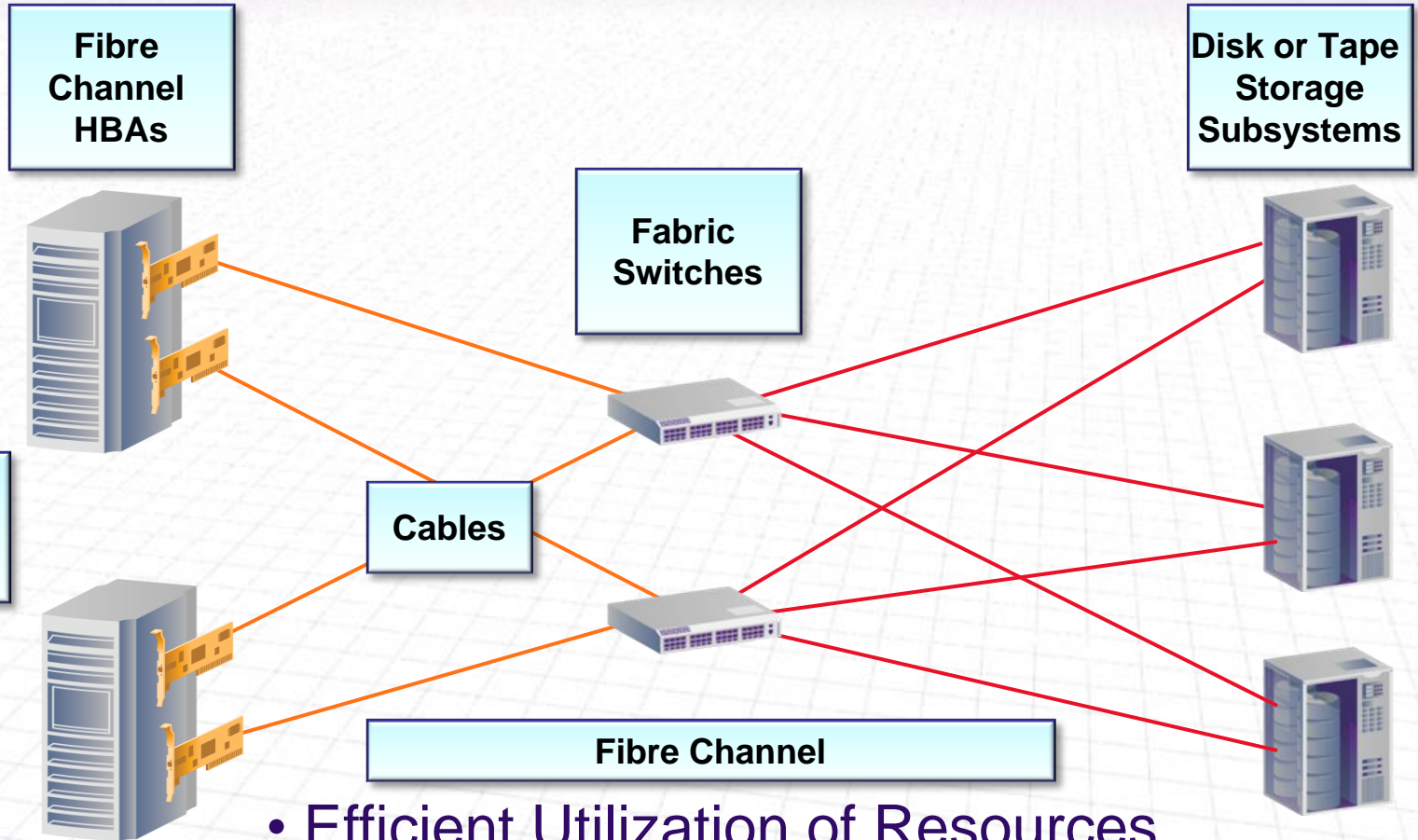**FCIA Vice Chairman**

**Emulex**
**Director Technical Marketing**

# Agenda

- Fibre Channel connects Storage Area Networks (SAN)
- Update on the Fibre Channel Industry
- The Fibre Channel Roadmaps
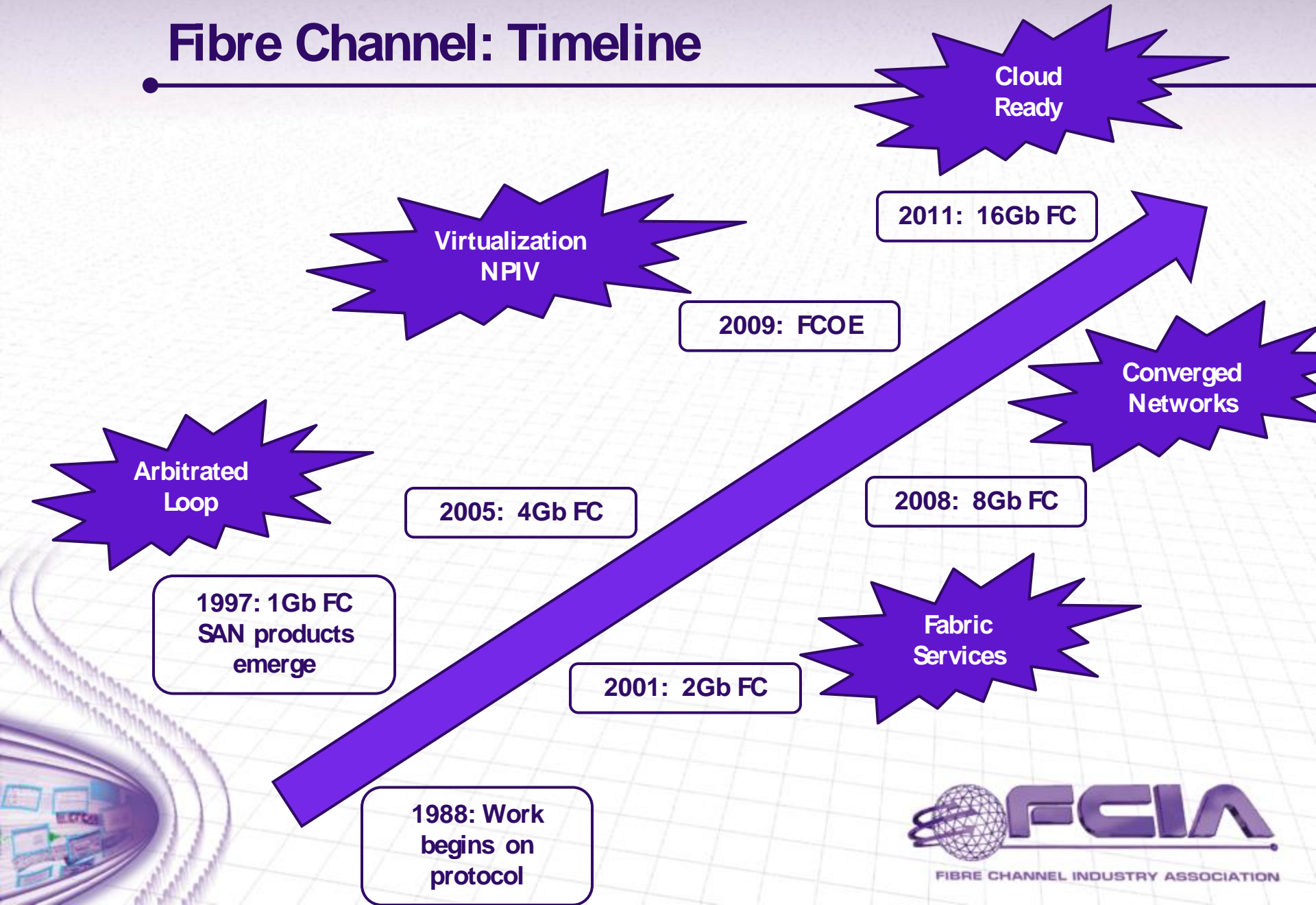- Innovations Abound
- Summary

# Traditional Fibre Channel SAN Fabric
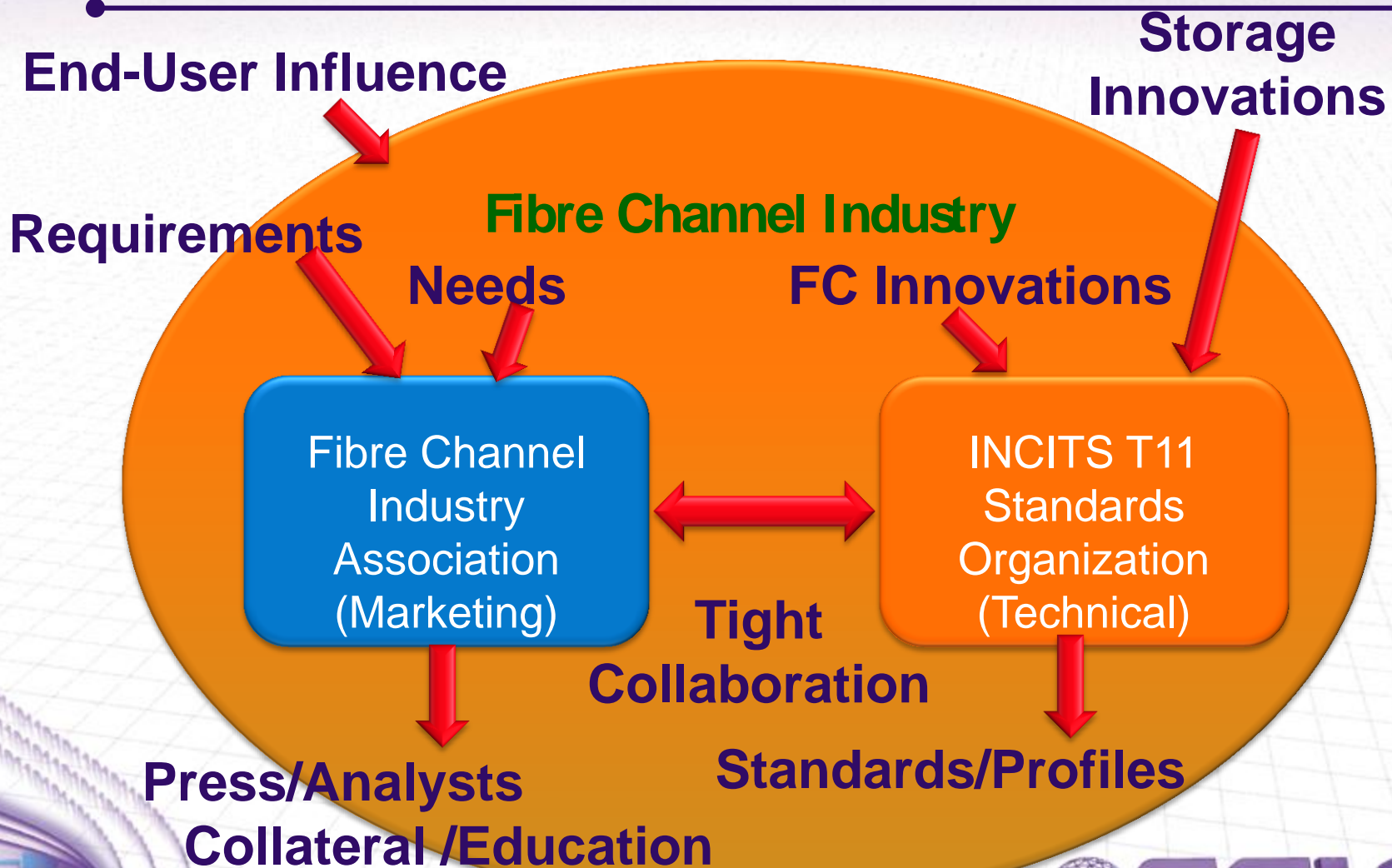


Fibre Channel HBAs

Disk or Tape Storage Subsystems

Fabric Switches

Application Servers

Cables

Fibre Channel

- Efficient Utilization of Resources
- Highest Storage Performance
- Scalable by Design

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# Fibre Channel: Timeline

**Cloud Ready**

**2011: 16Gb FC**

**Virtualization NPIV**

**2009: FCOE**

**Converged Networks**

**Arbitrated Loop**

**2005: 4Gb FC**

**2008: 8Gb FC**

**1997: 1Gb FC SAN products emerge**

**Fabric Services**

**2001: 2Gb FC**

**1988: Work begins on protocol**

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# Normalized Switch & HBA Port Count & Market



Source: Dell'Oro 1Q'11
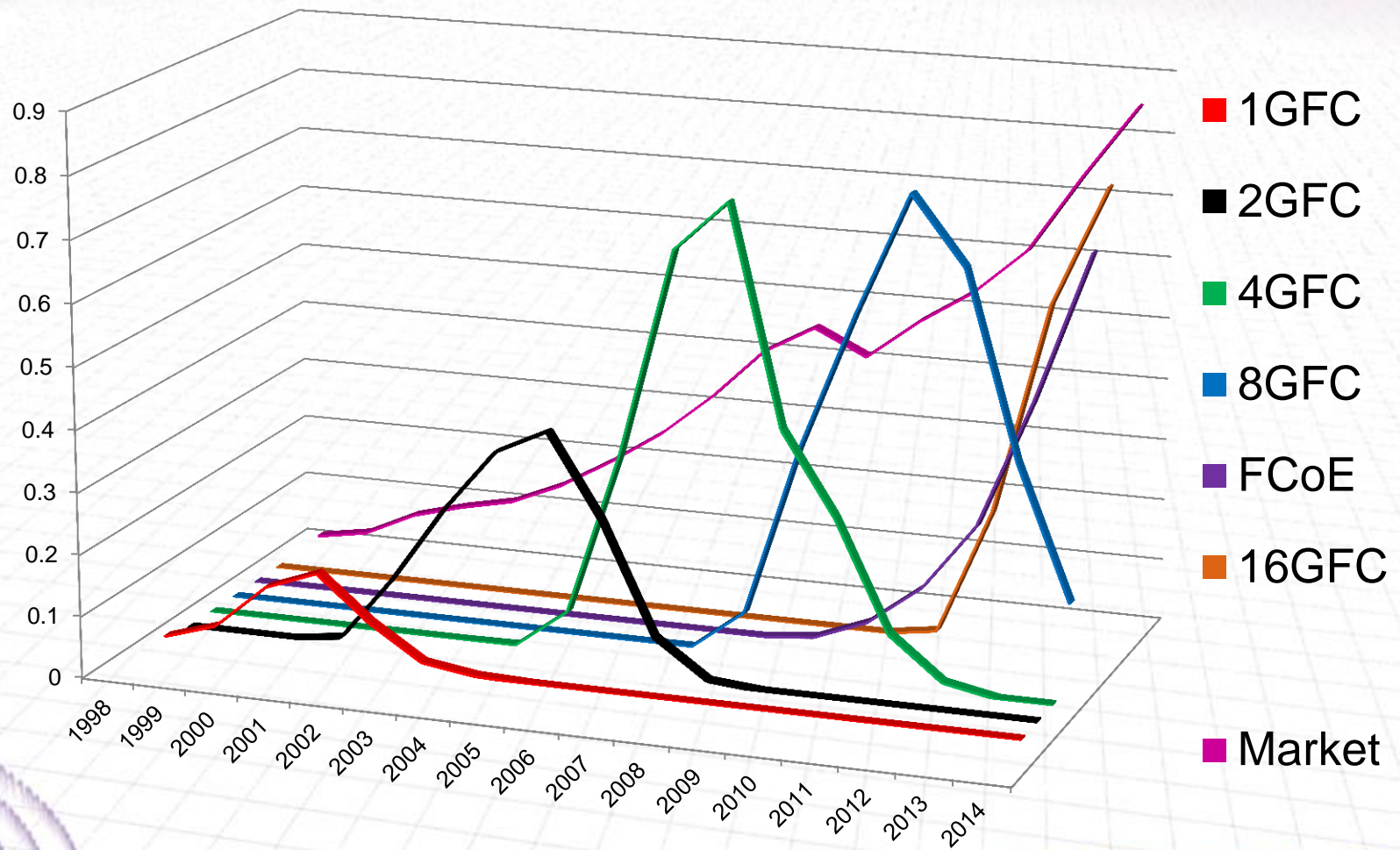
# Fibre Channel Speed Roadmap - v13 10/2011

FC

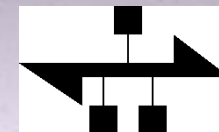| Product Naming | Throughput (MBps) | Line Rate (GBaud) | T11 Spec Technically Completed (Year)‡ | Market Availability (Year)‡ |
|---|---|---|---|---|
| 1GFC | 200 | 1.0625 | 1996 | 1997 |
| 2GFC | 400 | 2.125 | 2000 | 2001 |
| 4GFC | 800 | 4.25 | 2003 | 2005 |
| 8GFC | 1600 | 8.5 | 2006 | 2008 |
| 16GFC | 3200 | 14.025 | 2009 | 2011 |
| 32GFC | 6400 | 28.05 | 2012 | 2014 |
| 64GFC | 12800 | TBD | 2015 | Market Demand |
| 128GFC | 25600 | TBD | 2018 | Market Demand |
| 256GFC | 12800 | TBD | 2021 | Market Demand |
| 512GFC | 25600 | TBD | 2024 | Market Demand |

"FC" used throughout all applications for Fibre Channel infrastructure and devices, including edge and ISL interconnects.  Each speed maintains backward compatibility at least two previous generations (I.e., 8GFC backward compatible to 4GFC and 2GFC)
†Line Rate: All "FC" speeds are single-lane serial stream
‡Dates: Future dates estimated

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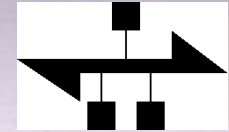# Fibre Channel Speed Roadmap - v13 10/2011

**ISL**
(Inter-Switch Link)

| Product Naming | Throughput (MBps) | Equivalent Line Rate (GBaud)† | Spec Technically Completed (Year) ‡ | Market Availability (Year) |
|---|---|---|---|---|
| 10GFC | 2400 | 10.52 | 2003 | 2004 |
| 20GFC | 4800 | 21.04 | TBD | 2008‡ |
| 40GFC/FCoE | 9600 | 41.225 | 2010 | Market Demand‡ |
| 100GFC/FCoE | 24000 | 103.125 | 2010 | Market Demand |
| 400GFC/FCoE | 96000 | TBD | TBD | Market Demand |
| 1TFC/FCoE | 240000 | TBD | TBD | Market Demand |

ISLs are used for non-edge, core connections, and other high speed applications demanding maximum bandwidth. Except for 100GFC (which follow Ethernet),
†Equivalent Line Rate: Rates listed are equivalent data rates for serial stream methodologies.
‡ Some solutions are Pre-Standard Solutions: There are several methods used in the industry to aggregate and/or "trunk" 2 or more ports and/or data stream lines to achieve the core bandwidth necessary for the application.  Some solutions follow Ethernet standards and compatibility guidelines.  Refer to the FCoE page 4 for 40GFCoE and 100GFC0E.

# Fibre Channel Speed Roadmap - v13 10/2011

FCoE

| Product Naming | Throughput (MBps) | Equivalent Line Rate (GBaud)† | Spec Technically Completed (Year)‡ | Market Availability (Year)‡ |
|---|---|---|---|---|
| 10GFCoE | 2400 | 10.3125 | 2008 | 2009 |
| 40GFCoE | 9600 | 41.225 | 2010* | Market Demand |
| 100GFCoE | 24000 | 103.125 | 2010* | Market Demand |

Fibre Channel over Ethernet tunnels FC through Ethernet.  For compatibility all 10GFCoE FCFs and CNAs are expected to use SFP+ devices, allowing the use of all standard and non standard optical technologies and additionally allowing the use of direct connect cables using the SFP+ electrical interface.  FCoE ports otherwise follow Ethernet standards and compatibility guidelines.

‡Dates: Future dates estimated

* It is expected that 40GFCoE and 100GFCoE based on 2010 standards will be used exclusively for Inter-Switch Link cores, thereby maintaining 10GFCoE as the predominant FCoE edge connection

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# Innovations – Compliments of Fibre Channel

- **The FCIA is helping to extend the FC protocol through close cooperation with the T11 Standards Organization through innovation in multiple areas:**

FCoE

16GFC+

FC-EE

Security

Configuration & Management
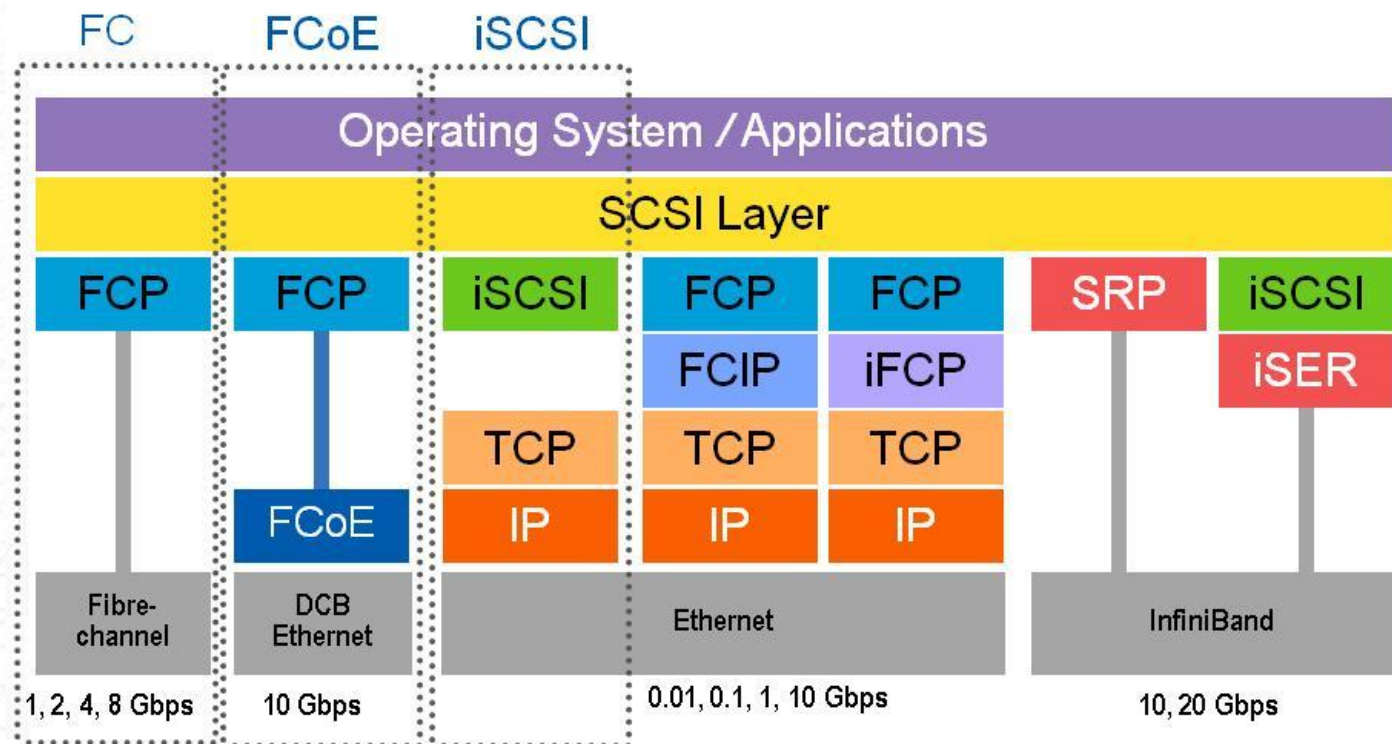
Virtualization Technologies

# Innovations – FCoE

- **Data Center Bridging (DCB)**
  - Set of IEEE Standards
    - Makes Ethernet more robust and enables lossless environments
  - Enables 10GbE I/O consolidation
  - Consists of Priority Flow Control, Congestion Notification, and Enhanced Transmission Selection

- **FC over Ethernet (FCoE)**
  - Ethernet encapsulates FC; another upper-layer protocol
  - Managed like FC at initiators, switches, storage systems
    - Central design goal for FCoE
  - Same cabling (SFP+ ) for 8GFC, 16GFC and 10G FCoE

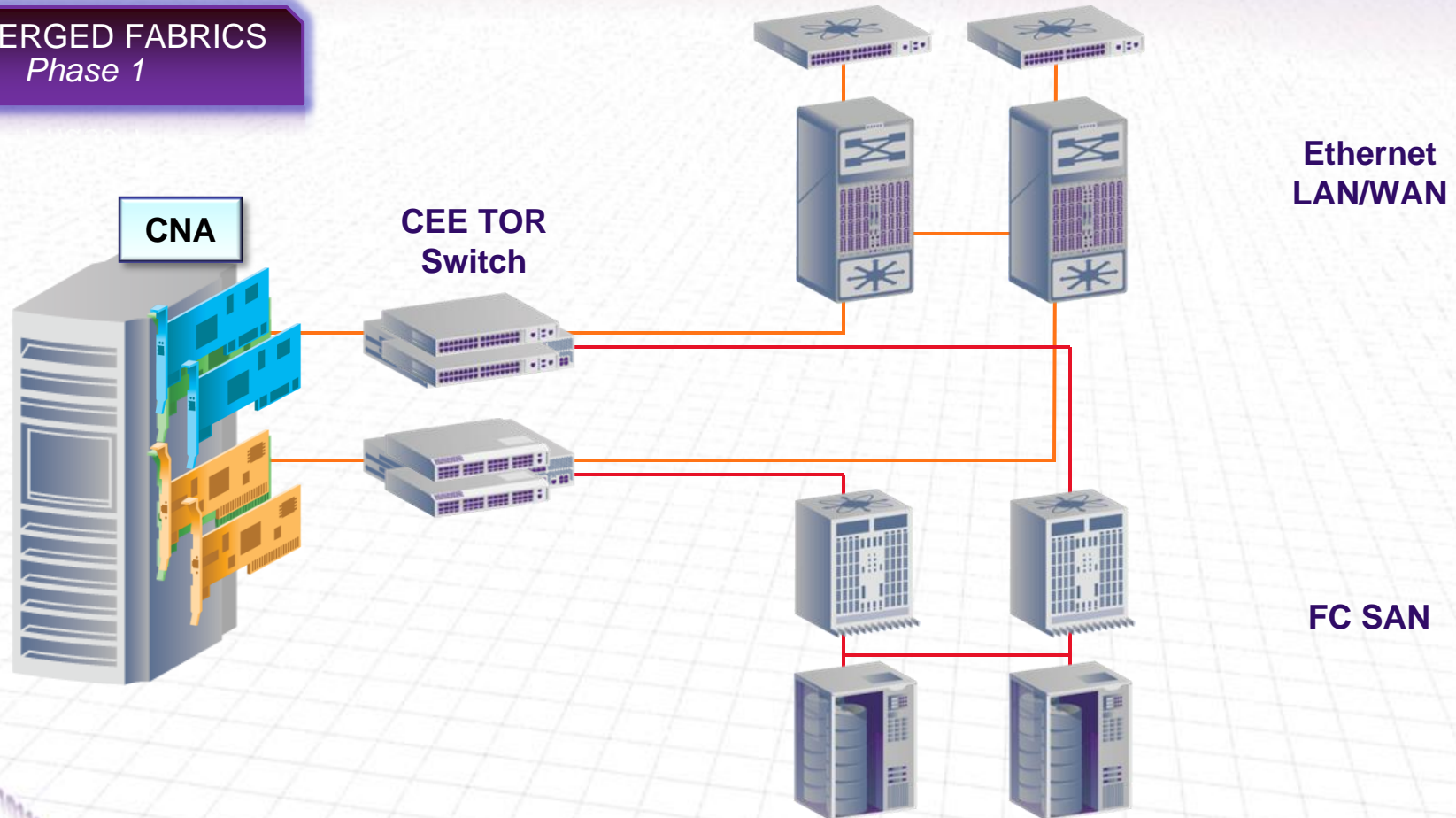FCIA

# Innovations – FCoE

## Fibre Channel over Ethernet

# Phase 1: Convergence in Server and Access Layer

**CNA**

**CEE TOR Switch**

**Ethernet LAN/WAN**

**FC SAN**

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# Phase 2: Convergence in the Core

**CNA**

IP
LAN

CEE
Core

FC
SAN
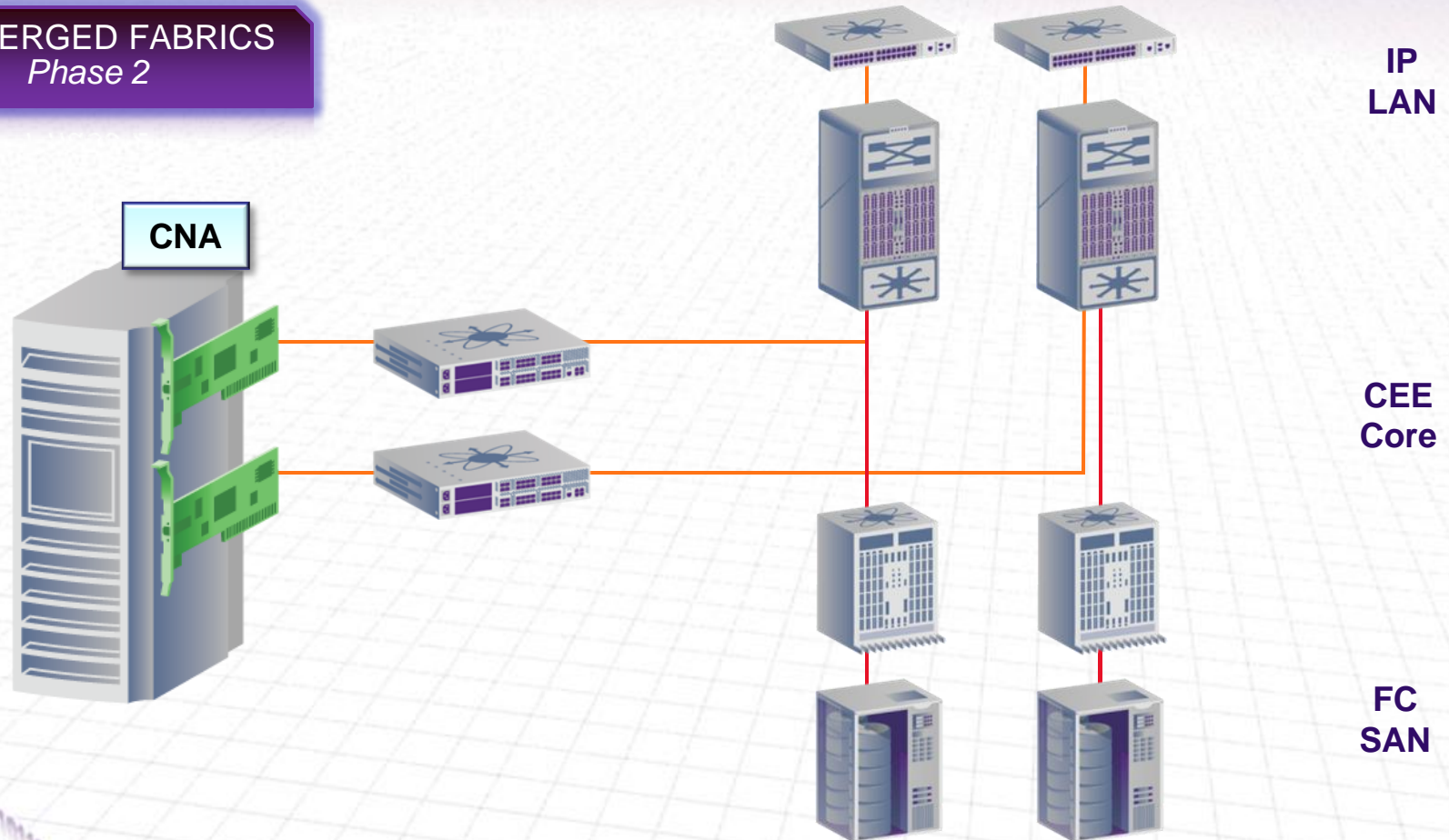
**The 2nd Phase will Consolidate TOR and IP Switching**

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# Phase 3: End to End Convergence

**CNA**

**IP
LAN**

**CEE
Core**
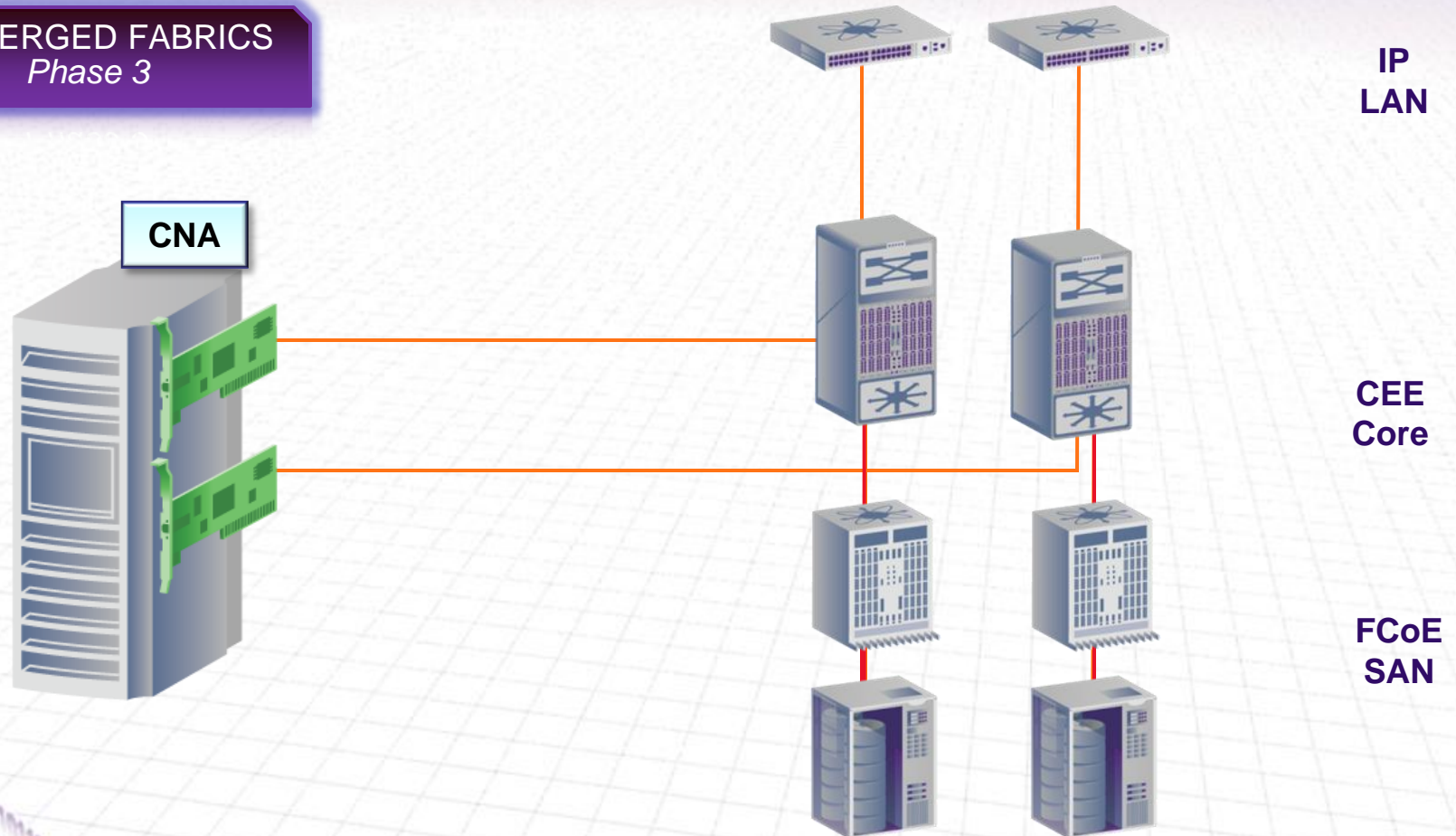
**FCoE
SAN**

**The 3rd Phase will Consolidate FC Switching and Storage**

16GFC+

16GFC+
Fibre Channel

# 16GFC Overview

- **What is driving 16GFC**
  - Prolific applications, server virtualization, multi-core processors, more memory, solid state drives, PCIe Gen 3, traffic aggregation, VDI

- **Benefits of 16GFC**
  - Higher performance leads to fewer links, easier cable management, less power consumption per bit

- **Defined by the following standards**
  - FC-PI-5, Standards completed spring 2011
  - FC-MSQS, Standards completed spring 2011
  - FC-FS-3, Standards completed spring 2011

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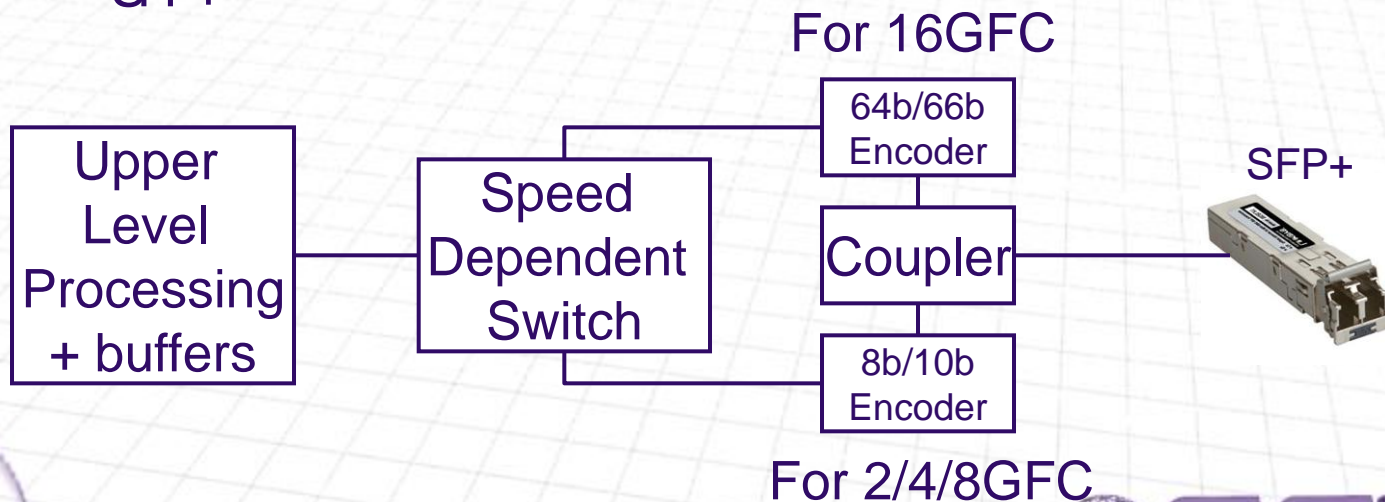
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# 16GFC Backward Compatibility

- **To improve the efficiency of the protocols, 16GFC only uses 64b/66b coding that is 98% efficient**
  - 8b/10b codes used for 2/4/8GFC are 80% efficient
  - 16GFC signals can not use the 8b/10b encoders
- **To be backward compatible with 2/4/8GFC, 16GFC ASICs need to support both 8b/10b and 64b/66b coder/decoders (codec) on each link**
- **During speed negotiation, the transmitter and receiver switch back and forth between the speeds (and the corresponding codecs) until the fastest speed is reached for a given link**

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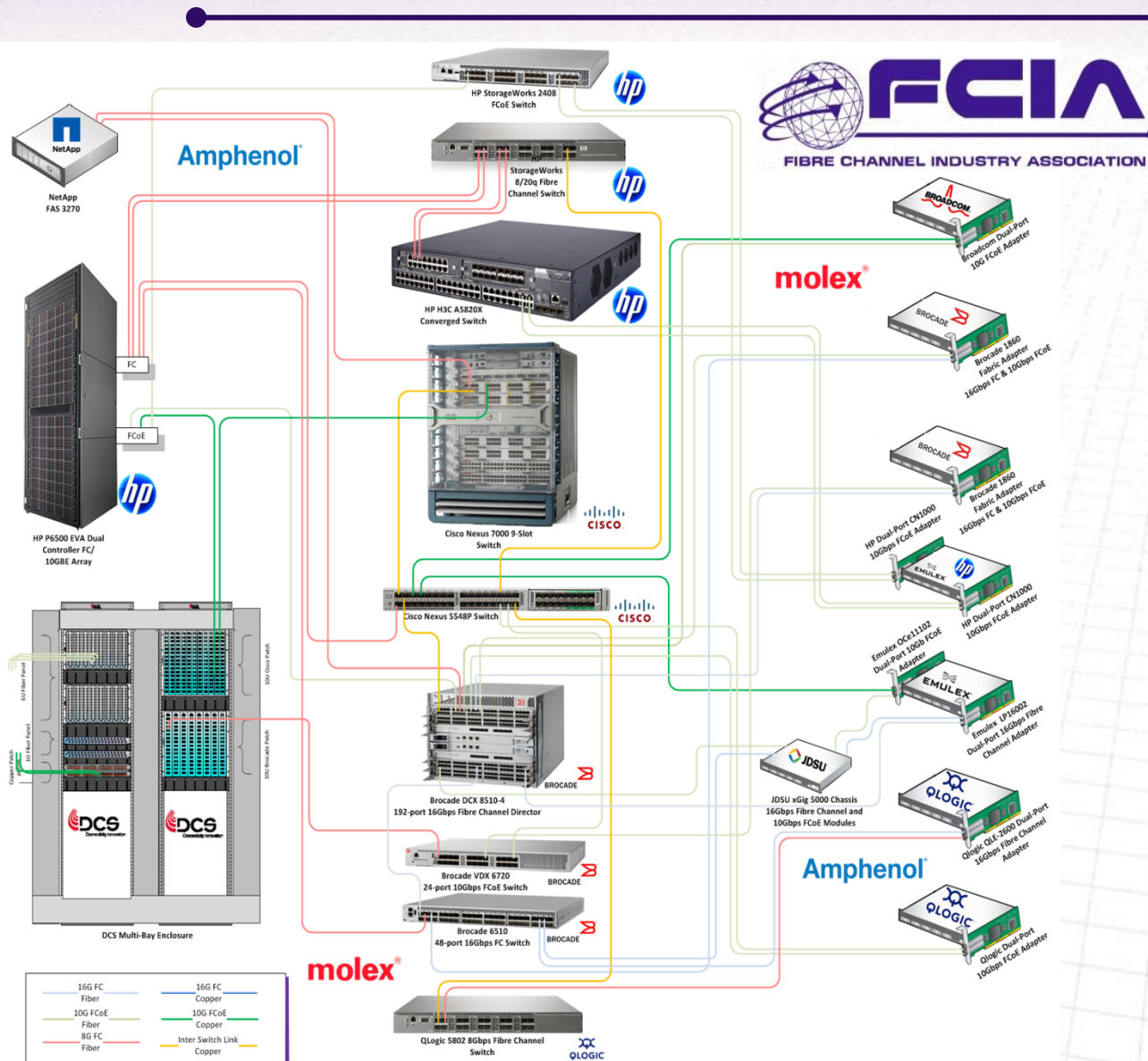
# 16GFC Speed Negotiation

- **During speed negotiation, the speed dependent switch routes the initialization sequence to the appropriate encoder**
  - 64b/66b for 16GFC
  - 8b/10b for 2/4/8GFC
  - The coupler sends the signals from one the encoders to the SFP+

For 16GFC

| Upper Level Processing + buffers | → | Speed Dependent Switch | → | 64b/66b Encoder |
| Coupler | → | SFP+ |
| 8b/10b Encoder |

For 2/4/8GFC

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# 1st 16Gb FC Plugfest (Oct '11)

- **1st plugfest for 16Gb FC devices**
- **Will test conformance of 16Gb FC physical layer**
- **Transmitter and return loss verification**
- **Test for backward compatibility 8b/10b speeds (4Gb and 8Gb)**
- **Interoperability amongst member company products**
- **Concurrent with FCOE plugfest tracks**

# 32GFC – The Next Step

- **32GFC MRD submitted to T11**
- **Work already underway in T11 on 32GFC**
  - FC-PI6 started 2010
- **Stay Serial and single-lane**
  - 28.05GBaud, 2x of 16GFC
- **Cost Effective**
  - Leverage work from multitude of other technologies
    - Ethernet 100G mandates a 25G/lane technology 2015
    - IB will have 25G per lane option in 2014/2015
  - < = 50% of comparable 40GE port in 2014/15 timeframe
- **Backwards compatible**
  - Same LC / SFP+ external connector – Existing 16GFC and 8GFC SFP modules will work in 32GFC-capable cages
  - Auto-negotiation with 16GFC and 8GFC
- **2014 Products ship**

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# Fibre Channel Powering Green Storage!

- **Tiered storage is an element of Green Storage**

- **Fibre Channel offers the high performance Green Storage requires to obtain the best Efficiency/Watt ratings**

- **The FCIA has a Green Initiative in place with the T11 Standards organization**

- **Work is under way on FC-EE, expect features in 2014**

Near-Online

Offline

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**Security**

# Fibre Channel Security Enhancements

# Innovations – FC-SP-2

- **FC-SP-2 enhances the existing FC-SP security model**
  - Threat Model drove PC-SP-2 Architecture work
- **Non-NULL DH-CHAP w/RSA-2048 mandatory to implement**
  - Original SP-SF required only NULL DH-CHAP
- **Key Management Services under active consideration**
  - KMIP Profile: FC-SP-2 Annex under consideration
- **Currently gathering technical input**
  - Current schedule: Ballot in 2012

# Simplified Configuration and Management (SCM)

- ## What is driving SCM
  - SMB Markets where simple installation, management, and operation is paramount

- ## Benefits of SCM
  - Devices compliant to this profile will provide streamlined functionality, be interoperable by default, and require little or no management

- ## Defined by the following standard
  - FC-SCM
    - Finished at T11 and at INCITS for final processing
  - A technical report rather than a standard that serves as a profile for FC configurations in SMB environments
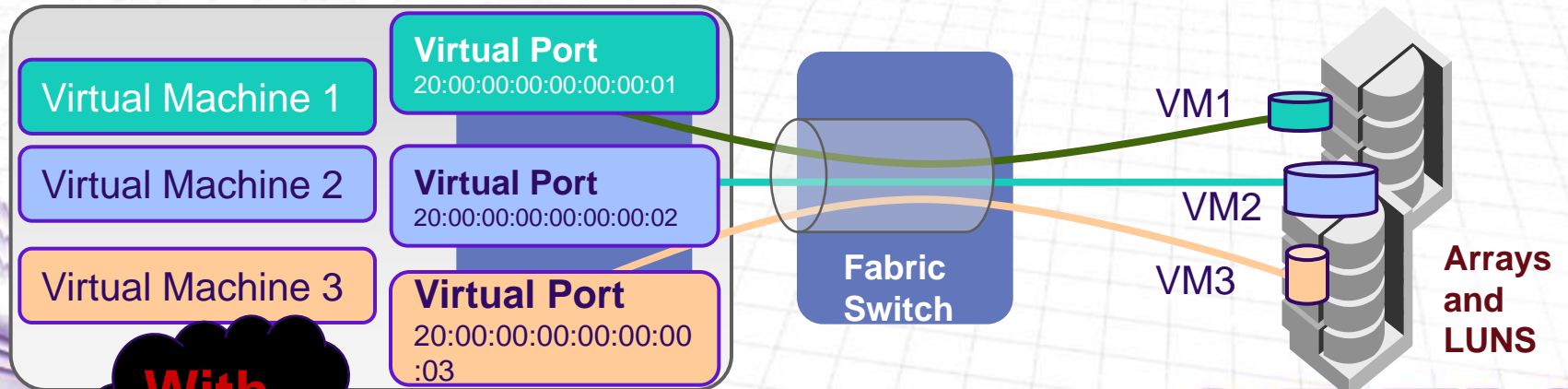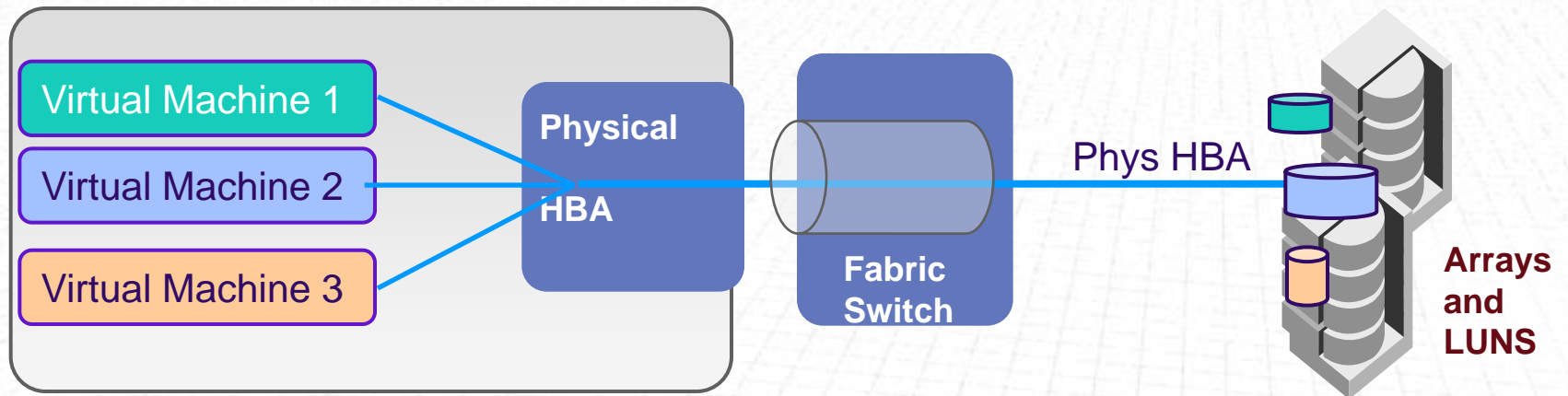
# N_Port ID Virtualization

- **Allows Multiple Virtual N_Ports to exist behind a physical N_Port**
- **Normal FLOGI Occurs for the first Login**
- **Subsequent Logins Request FC-IDs using the FDISC ELS**
- **Enables Virtual Machine Environments**
  - Each Virtual Machine is able to have its own WWN and FC_ID
- **Enables N_Port Virtualizers**

# NPIV – Virtual Server Example



Virtual Machine 1
Virtual Machine 2
Virtual Machine 3

**Physical HBA**

**Fabric Switch**

Phys HBA

**Arrays and LUNS**

Virtual Machine 1
Virtual Machine 2
Virtual Machine 3

**Virtual Port**
20:00:00:00:00:00:00:01

**Virtual Port**
20:00:00:00:00:00:00:02

**Virtual Port**
20:00:00:00:00:00:00:03

**Fabric Switch**

VM1
VM2
VM3

**Arrays and LUNS**

**With NPIV**

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# Relevant INCITS T11 Fibre Channel Standards

- ## www.t11.org
  - Published
    - FC-BB-5 Backbone, FCoE
    - FC-SW-5 Switch Architecture
    - FC-GS-6 Fiber Channel Services
    - FC-FS-3 Framing and Signaling Protocol
    - FC-PI-5 16GFC
    - FC-MSQS 16GFC Testing and Performance
  - Work In Progress
    - FC-BB-6 FCoE Enhancements
    - FC-PI-6 / MSQS-2 32GFC
    - FC-SW-6 Fabric Enhancements (Includes FCoE)
    - FC-GS-7 Management Enhancements (Includes FCoE)
    - FC-EE Energy Efficiency
    - FC-IFR Inter-Fabric Routing and Zoning
    - FC-SCM Simplified Configuration and Management, TR

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# Summary: Fibre Channel…

- *Dominates* the SAN market
- Well understood
- Easy to learn, use and implement
- Protects and future-proofs storage investments
- Provides comprehensive solutions
- Continuous speed & Bandwidth/$ improvements
- Listening to customer needs
- Aggressively pursuing Energy Efficiency

# FCIA Sponsored Plugfest

- **Oct 24-29, 2011 at UNH IOL**

- **1st Plugfest for 16GFC devices**
  - Physical layer and Protocol testing
  - Device interoperability
  - Backwards compatibility to 8GFC and 4GFC

- **The 7th FCoE Plugfest**
  - High Availability in converged network
  - Multi-Hop FCOE
  - Multiple FCF



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