Lucent Technologies
Bell Labs Innovations

System Vendor Requirements for 10 Gb/s Backplane

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Evolution Towards "Carrier Grade" Ethernet

- Ethernet has long been the technology of choice for Local Area Networks (LAN)
- Ethernet-based technologies and services expanding to a regional or national transparent wide-area interconnection and interworking network (Wide Area Ethernet)
- Achieving carrier-grade interoperable services becoming increasingly important
  - Some concerns with deployment of Ethernet services today
    - Limited ability to provide guaranteed QoS
    - Achieving carrier-grade 99.999% reliability
  - Supporting specifications under development within standards & industry forums
    - Ethernet OAM including fault and performance management
    - Fast protection mechanisms
    - Performance metrics in support of service level QoS

➢ Trend suggests more demanding metrics for 10G backplanes

Applicability of 10G Backplanes beyond Ethernet

1. Migration of backplane electrical interconnections to 10 Gb/s is inevitable!
2. Interest in 10G backplanes goes beyond Ethernet applications
   - Multiple market segments: datacomm, telecomm, computers (desktop, servers, workstations)
   - Multiple data protocols
   - Other standards: OIF-CEI, RapidIO, NPF, FibreChannel 8G-FC, UXPi …
3. All 10 Gb/s applications share common physical layer and electrical interconnection issues
4. General requirement that backplanes not be the weakest link in a hardware element
5. Electrical interoperability of silicon devices benefits system vendors and ASIC vendors alike

Questions for IEEE 802.3ap Backplane Ethernet Task Force:

- ***Is the task force interested in defining next generation Ethernet backplane technology that can have broader applications?***
- ***Does the task force want to avoid technology or economic fragmentation in the 10G backplane ASIC market ?***
- ***Does the task force believe that interoperability is <u>important</u> to the wide scale acceptance and penetration of 10 Gb/s I/O into system designs?***

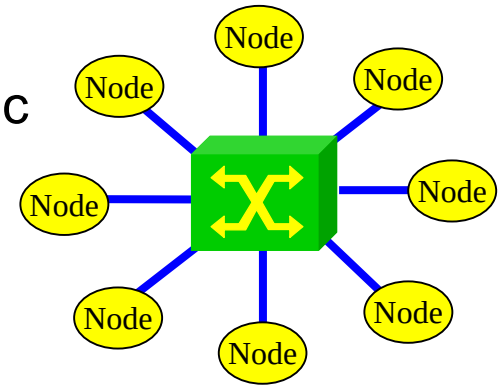
If the answer is YES to any of the above, then different industry organizations, system vendors and ASIC vendors must work together to find solutions we can all take advantage of.

Telecomm/datacomm system vendor requirements for 10G backplanes

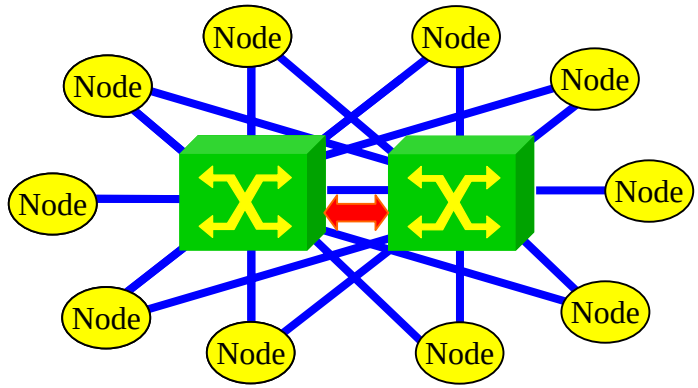
- Network element architecture examples
- Legacy versus non-legacy issues
- Electrical interface functional requirements
- Link and overall system metrics

Network Element Architecture Examples

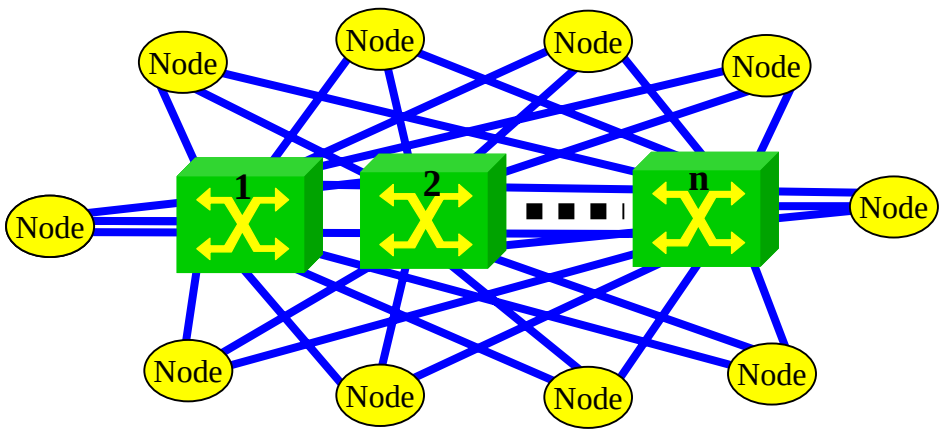
Star Fabric



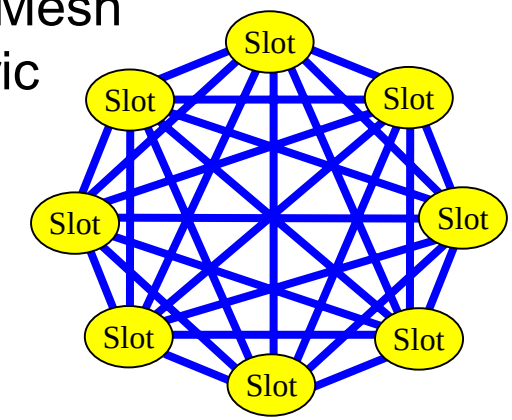
Dual Star Fabric



Multi-Star Fabric



Full Mesh Fabric



Legacy versus Non-Legacy issues

DEFINITIONS:

Non-Legacy: 10G interfaces deployed using new PCB technology, materials and associated components

Legacy: deployment preserves existing PCB technology such as backplane boards and associated components which were originally designed for data rates and reaches <10G NRZ

Why address legacy applications?

Next Gen Systems often include an upgrade path

- Retain customers' investments in hardware such as port cards
- Feasibility???
  2.5/3.125G ⇒ 10G? Or 2.5/3.125G ⇒ 5G and 5G ⇒ 10G?
- Many scenarios and specific design issues to consider!

BUT….Economic considerations are too important to ignore

Electrical Interface Functional Requirements: *Must be compatible with other data formats*

- Key datacomm/telecomm data protocols over backplanes:

  SONET/SDH scrambled code, G.709, Ethernet

- **FEC**:
  - Electrical signaling should not depend on added FEC to achieve carrier grade backplane link performance
  - FEC and other error detection codes should be optional part of framing layer so can be application specific

- Training patterns; other out-of-service states:

  Not allowed once traffic is established for telecomm/datacomm with carrier grade QoS

Electrical Interface Functional Requirements: *Signal Characteristics*

- **Reach:**
  - Some backplanes have signal paths exceeding 1000 mm
  - Most backplanes actually have signal paths under 700 mm
  - Need to be able to achieve the longer reach. But from the standpoint of cost and power optimization, the focus should be on the shorter reach—at least for non-legacy applications.

- **Signal coding:**

  Don't care per se, care about performance ***while optimizing for low power and low cost***

Electrical Interface Functional Requirements: *Signal Characteristics, contd*

- **AC versus DC Coupling:**
  - Must support both AC and DC coupling options up to 700 mm
  - Over 700 mm: support AC coupling, DC coupling needs further study.
- **For DC coupling option:**
  - Fix termination voltage at 1.2V to be compatible with other interface standards (e.g. SxI-5, TxI-5).
  - Rest of ASIC can use other voltages.
  - Set limits on ground level shifts between boards to be supported.
- **Differential pair:**

  Differential impedance of 100Ω ± 10% (PCB trace)

Link and Overall System Metrics
BIT ERROR RATE

- System vendors favor BER < 10^{-17} as a system requirement across the backplane of a network element

Consider the implications for a 10 Tb/s dual star backplane (1000 lanes of 10 Gb/s. Half are for protection)

BER of 10^{-12} *per link* ⇒ **5 errors per second** on the backplane

BER of 10^{-15} *per link* ⇒ **8 errors per hour** on the backplane

BER of 10^{-17} *across the NE* ⇒ Gives **4 errors/day** on the backplane

- 802.3ap BER objective is 10^{-12} per lane. ***Need to achieve Bit Error Ratio of better than 10^{-15} per lane with an objective of 10^{-17}.***

Link and Overall System Metrics
COST (both at link and system level)

COST for *Non*-Legacy Applications

- **<2.5X** relative to FR-4 based backplanes+connectors designed for ~same number of 2.5/3.125 Gb/s lanes
- Includes ASICs, boards and connectors

COST for Legacy Applications

- **<1X** relative to FR-4 based backplanes+connectors designed for ~same number of 2.5/3.125 Gb/s lanes
- Does not include added cost of upgrading the ASICs
- Legacy — so boards and connectors are preserved while I/O and central switch/router cards are upgraded

Link and Overall System Metrics
POWER (both at link and system level)

- **Power consumption (thermal dissipation) of 10G link**
  - **NON-LEGACY: must be < 1.2X power of 2.5/3.125G link**
  - **LEGACY: <1–1.2X *at the system level; implications for link***
  - Includes functions in reference 2.5/3.125G link
  - Must include power allocation for any additional encoding, equalization, emphasis, synthesized clocks, etc.
  - For non-NRZ signaling, must include power allocation for data conversion/reconversion macros
- **Power consumption of reference 2.5/3.125G link**
  - Calculated for single Rx/Tx channel at max. frequency of 3.125 Gb/s
  - Includes I/O buffer, 1:16 MUX/DEMUX, PLL power (divided by maximum no. channels if shared)
  - **Average value is 150 mW/link**

Link and Overall System Metrics
DENSITY

- **Need to support dense board-to-board interconnections**
  - Full mesh: up to 4000+ lanes (diff)
  - Dual star: up to 1000+ lanes (diff)
  - Card edge connector densities are at least 1 diff pairs/mm for I/O cards; 1.5-2 diff pairs/mm for central switch/router cards
- **High board density, especially on switch/router cards**
  - Must include backplane I/O electrical Tx/Rx in system ASICs
- **Must support live card insertion/removal with no damage**
  - No impact on existing traffic (e.g. bit errors)
  - Must allow keeping a newly inserted card in power-down mode

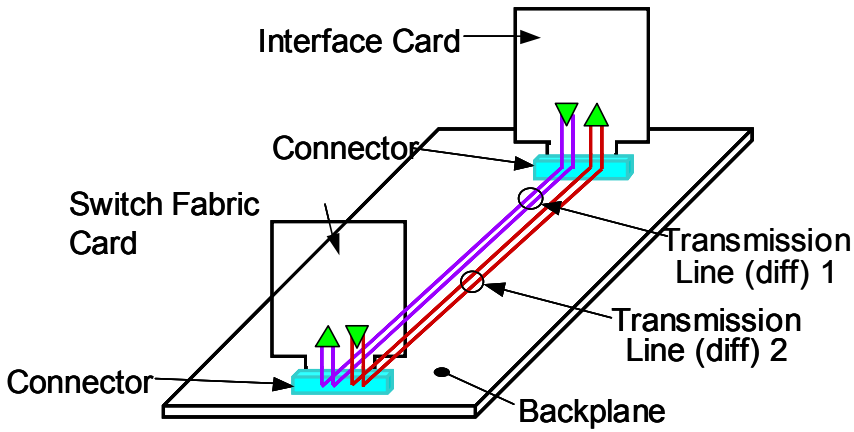
Link and Overall System Metrics
Additional considerations

- **Data DC Balance and Transition Density Requirements**
  - DC balance/average transition density should not assume 8B/10B coding; link receivers should handle this for worst case (SONET/SDH)
- **Robustness of BER and Crosstalk to Data Pattern**
  - Support use of worst-case test pattern per TFI-5 and ITU-T G.957
  - PRBS31 not worst case test for cross talk. Recommend cross talk tolerance include testing at PRBS23 and lower
- **Backchannels for equalization control information**
  - Should not require feedback communication between transmitter and receiver link when optimizing for low power
- **EMC is critical issue**
  - Substantial reductions in emissions can be achieved by using scrambled code

Channel/Link Characteristics

Channel models

- Needed—key aspect of interoperability!
- Define using realistic and measurable S parameters for major subsystems.



Example major subsystems:

Interface card

Backplane

Switch fabric card

- Specify informative/normative losses for legacy and nonlegacy applications
- Need additional specifications for max. allowable resonances (e.g. from vias)
- Need common method for verifying channel compliance
- Need common method for measuring and reporting crosstalk

Broad Application of 10G Backplanes

1. Ethernet has specific needs
2. Other applications in telecomm/datacomm have specific needs
3. Electrical specifications should and could be common for multiple applications
4. Economies of scale outweigh any cost advantage of "cheaper 10G components" designed for one niche

- **Suggest that IEEE 802.3ap task force consider 10G Ethernet backplanes in larger context of 10G I/O**
- **Converged solution for 10G I/O benefits System and ASIC vendors alike**