Backplane fabric topologies

Switched fabrics not only allow far superior speed and bandwidth capabilities, but also inherently support high-availability (HA) designs and system scalability. The switched fabric backplane topologies come in several forms: Star and Dual Star, Ring, and Mesh. Many of these topologies have their own subsets. This article describes these architectures, how they work, and how companies can implement them now and in the near future.

Star, Dual Star

Star and Dual Star are centralized configurations where one (Star) or two (Dual Star) fabric slots control the switched fabric on a backplane. A Dual Star offers redundancy – a key element to achieve 5-nines high availability.

Backplane-based fabrics use the Star configuration (Figure 1) such as in Compact Packet Switching Backplane (PICMG 2.16) and StarFabric (PICMG 2.17) standards products. Usually, these are smaller slot size, eight slots or less, applications where the CompactPCI bus operates as the control bus. As the CompactPCI bus is limited to eight slots, without bridging, one slot is often the fabric slot with the rest of the slots acting as node slots with CompactPCI. Figure 2 shows 6- and 8-slot PICMG 2.16-compliant backplanes with the Star topology design.

A key strength of PICMG 2.16 and PICMG 2.17 is that the system can use standard CompactPCI line cards while integrating the fabric. The specifications allow use of CompactPCI bus and H.110 bus cards in various configurations. When using CompactPCI, the CompactPCI bus acts as the control plane on P1 and P2, with P3 and P5 acting as the data plane. P4 is reserved for optional H.110 bus implementation for computer telephony. The CompactPCI bus width can be 32-bit or 64-bit. Also, one can forego the CompactPCI bus and use the area for custom signals. There are fabric board-pin assignments (unused areas on core PICMG 2.0 specification) on P3 and P5 and node board-pin assignments on P3 for the PICMG 2.16 specification. StarFabric also uses the available unused pins and allows for PICMG 2.16 implementation within PICMG 2.17, creating a Dual-Dual Star configuration.

Dual Star configurations also commonly use PICMG 2.16 and PICMG 2.17. The backplanes are often nine slots or more, but not necessarily. Usually, with a large backplane system in a 19-inch rack, the designer will not want to take the chance of using one fabric slot. Therefore, the designer will commonly use a Dual Star fabric topology to provide redundancy and to help achieve high availability (Figure 3).

PICMG 2.17 was recently ratified, and development backplanes are currently available. One example is a 17-slot Dual Star version that features 10 basic node slots, two fabric slots, two node slots with H.110, a StarFabric system slot with CompactPCI and H.110, and two standard CompactPCI with H.110 slots. This topology allows ample testing of system designs in various configurations with a separate segment for CompactPCI and H.110.

The VXS (VITA 41) backplane also uses a Dual Star configuration. VXS adds a high-speed connector over the center row of connectors on the VME64x backplane (P0) for serial data traffic. Designers often use P0 for custom signaling and user I/O.

Designers will have the flexibility to:
- Plug in standard VME64x cards for parallel bus use
- Integrate new payload and switch cards for parallel bus and switch fabric transport
- Use switch fabric transport only
The VXS specification allows for four differential serial pairs per direction link over PO and supports up to two such ports on each VMEbus card.

Designers also will commonly integrate Advanced Telecom Computing Architecture (AdvancedTCA) in Dual Star topologies. The specification does not have provisions for single Star, as high availability and redundancy are key parameters of the specification’s positioning. The base interface of the AdvancedTCA backplane core specification requires a Dual Star topology that uses Ethernet, while the fabric interface section of the backplane could be Dual Star, Dual-Dual Star, or Mesh.

Star and Dual Star configurations are the most common right now for today’s switched fabric backplanes, as they are the easiest to implement. As the product life cycle continues and designers become more familiar with these technologies, they will likely adopt Mesh topologies.

**Mesh**

For higher bandwidth and advanced Quality of Service (QoS) applications, Mesh fabrics allow each node slot to act as a fabric slot with multiple interconnections to the other slots using point-to-point links. In other words, each node is an end point that manages its own traffic without a central resource. The data rates and protocols are not dependent of other data transfers in other slots. Therefore, this configuration is highly scalable, foregoing latency and determinism problems. Each node switches its own traffic, so each node can be an end point, a router, and so on (see Figure 4).

The fabric technologies and supporting architectures are moving toward implementing Mesh configurations. AdvancedTCA (PICMG 3.x specification) is one example where the specification outlines detailed provisions for a Mesh topology. The AdvancedTCA is a major effort by PICMG to develop a next-generation telecom architecture. The form factor includes an 8U x 280mm card that plugs into a backplane spaced at 1.2 inches. The larger cards allow more space for more components, while the wider space between slots allows for taller components. In addition, the backplane allows for 48VDC input from an external source to be distributed to the individual slot cards. PICMG chose the 2D connector from ERNI and Tyco, which is capable of up to 5-Gbits/sec speeds. Aggregate bandwidth performance will vastly improve with this setup.

In a 19-inch rack, there is room for 14 slots on the AdvancedTCA backplane. However, 14 slots in a Mesh configuration where each slot has many lines linked to every other slot would be a routing nightmare, and layer counts would get very high. Alternatively, the Mesh configuration is ideal for smaller slot counts. Replicated Mesh is another possibility, having duplicate node links with double the interconnections between each slot link.

By the time this article is published, a 14-slot AdvancedTCA backplane and 19-inch rack-mount chassis design will be available. It will have a Dual StarFabric interface, using Ethernet as the traffic vehicle, based on the draft specification of PICMG 3.1. The chassis will have rear I/O mounting, dual 48VDC input, front-to-rear dual redundant cooling (dissipating 200 watts/slot), and an ESD terminal on the front. The system management interface would comply with the PICMG 2.9 specification. Figure 5 shows the AdvancedTCA concept unit with a 14-slot backplane and Dual Star topology.

Figure 4

VITA 34, a similar effort from VITA, with aggressive shielding and cooling options, also uses a Mesh fabric topology. StarFabric will also have Mesh versions. A PICMG 2.17 system with a small slot count could have a distributed topology. Designers can integrate each node card into the system with a fabric chip on it. Each node card links to the others via the Mesh fabric. This method eliminates the use of the CompactPCI bus, therefore providing very high performance.

The Ring topology is a bidirectional set of controllers acting as nodes on a Ring throughout the backplane. The GigaBridge technology (see Figure 6) from PLX Technology Inc. is a good example. It is capable of managing up to four bus segments connected to other controllers via a dual-counter-rotating ring, thereby forming a vast network of bus segments. It is similar to a Mesh topology in that each backplane slot can have a switch controller. However, the signals are bound by the Ring via two 16-bit-wide, point-to-point, low-voltage-differential links that are clocked at 400 MHz. With two Rings, the system offers redundancy, and special high-availability software helps detect errors and reroute signals without losing a step in the transaction.

Designs with the Ring topology are available now. GigaBridge has a devel-

Figure 5

dopment system for the high-availability version of the backplane developed by Bustronic. It consists of a chassis, backplane, bridge-enabled card, and a switch module. See Figure 7 on the following page for an interconnect diagram of an HA backplane, switch modules, and GigaBridge-enabled cards. The bridge-enabled card converts the PCI bus to the switched-PCI bus via a GigaBridge Switched-PCI Controller (GBP) device. A cell-based fabric, with independent PCI bus segments connected to each port, enables each device to drive up to four PCI slots and interoperates with other devices as ports on the fabric. Two 16-bit-wide, point-to-point, low-voltage-differential links clocked at 400 MHz link each controller. The developer’s CompactPCI board plugs into the bridge enabled card.
In turn, the bridge-enabled card plugs into the backplane. The switched-PCI network is contained on the backplane. Developers do not have to alter the CompactPCI boards to test a switched-PCI architecture. They can plug the CompactPCI boards into the development system chassis and run hardware and software to prove the switched-PCI concept. Once the developer has completed the proof-of-concept phase, they can design the switched-PCI bridges into the boards and design a backplane for the application.

The Ring topology offers a creative way of integrating several nodes without the routing complexity and duplication in Mesh topologies. Designers can add or subtract switch cards, thereby offering scalability even in high-slot-count backplanes where Mesh topologies may have logistical problems.

**Choice considerations**

Choosing a switch fabric design has many considerations. The viability of the technology, open or proprietary solution, compatibility, and performance are just some of the criteria. Hopefully, this topology point-of-view provides a different perspective of things to consider when choosing a fabric technology.

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*Bustronic* is a manufacturer of standard and custom-design backplane applications. The company’s standard product portfolio includes VMEbus, VME64x, CompactPCI, H.110 CTEL, VME320, VXI, and ISA and switched fabrics. Application engineers also develop custom backplanes to meet customer specifications from initial concept to finished product.

Bustronic designs serve a wide array of industries, including aerospace, military, industrial automation, telecommunications, medical, and high-performance computers. Bustronic is an Elma Electronic company with facilities and representatives in more than 22 countries.

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