Making the decision to convert to a switch-fabric backplane can be daunting. In this increasingly mechanized world, backplanes must also keep up with increasing bandwidth demands. This challenge of meeting bandwidth demands has spurred several backplane technologies, including multi-point and point-to-point, and now switch fabric has joined the lot as the newest system in the industry. Although fabrics will indeed be the heart of network switches and routers in the near future, it might or might not be timely for designers to make this change. This article will provide system designers with an overview of the costs and rewards of making this paradigm shift and will aid them in facilitating the decision-making process, ultimately determining whether such a change is truly necessary.

Existing architectures
Bandwidth has been, and will continue to be, a key issue when working with backplane technology. The constant demand for high performance has pushed bus-based systems to the limit. Backplanes are often serviced by one of several bus systems, including multi-drop, parallel bus and shared bus, shared memory, and point-to-point systems. Multi-drop backplanes are ones in which the driver sends the data to more than one receiver, whereas point-to-point systems are ones in which the driver sends data to only one receiver. Parallel or shared bus architectures were once the workhorse of the industry for a number of reasons. For example, parallel backplanes can provide higher throughput over relatively short distances, albeit at relatively slow speeds. Additionally, although loading on the bus increases by adding parallel data lines, data throughput can be increased with relative ease. However, this comes at a cost. Due to the number and size of devices needed for a parallel system, power requirements are often prohibitive. Shared bus systems are confined to low-bandwidth applications because a data packet can be blocked from transmission by another transition taking place on the bus. Since the driver card communicates with all receiver cards, it allows only one data packet to be transmitted at a time. The widely used Peripheral Component Interconnect (PCI) standard is an example of a bus-based architecture, which is limited to 64 bits at 133 MHz.

In order to combat this initial bandwidth problem, multi-port shared memory systems arrived on the scene in the late 1980s. This type of architecture allows for...
Simultaneous memory access for each output sending data. Although it would appear that these systems were the answer to the ever-demanding problem of bandwidth, shared memory systems, too, are both difficult and expensive to implement.

Throughput requirements demanded a solution to the limitations of a parallel, multi-point backplane. Hence, in the late 1990s, serial point-to-point backplanes became a popular method for data transmission. The ease of design, combined with faster transmission frequency, seemed to be a solid answer to the pitfalls of other bus systems. However, the popularity of point-to-point systems was short-lived as technology quickly passed the practicality of such systems in favor of switch fabric systems.

Overall, the bus architecture itself places limits on:

- Operating frequency
- Signal propagation delay
- Electrical loading

Propagation delay limits the physical distance a bus can span, while electrical loading limits the number of devices it can connect. Pragmatically speaking, cables cannot increase physical distances.

Since many of these architectures are riddled with pitfalls, the industry has begun to turn to switch-fabric architecture. In fact, many would argue that both the present and the future of the industry are in this protocol. Before jumping on the switch-fabric bandwagon, however, it is first important to introduce many of the topologies of switch fabric and the benefits and disadvantages of each.

**Switch-fabric architecture**

Although all switch fabrics are not equal, they generally provide both the power and flexibility needed to build cutting-edge communications equipment and offer a degree of scalability and reliability not found in the previously mentioned bus-based ICs.

The term “fabric” is accurate in describing this architecture, as any single node can connect to any other node through data paths that resemble the woven fibers of cloth material (Figure 1). End points function as a type of bridge to existing components. Thus, open-switch architecture allows many devices to engage in the transactional process of communication, meaning the components simultaneously act as both a sender and receiver of information. Many existing topologies can support ever-scalable bandwidth. With switch fabric, when one route fails, traffic is redirected onto an alternate route. Using point-to-point connections, a single endpoint failure does not affect the rest of the system. Contrasted with a bus model, in which a single poorly functioning device can diffuse the entire bus, the advantages of a switch fabric seem obvious. Furthermore, the point-to-point connection with many switch fabrics facilitates device addition and removal.

Star topology is centralized and supports only one fabric slot on the backplane (Figure 3). The dual star supports two fabric slots on the backplane, providing redundancy. This system is generally easy to control, as all traffic originates from the hub of the star. Similar to other structures, however, the star network is susceptible to data backlog and bottlenecking, as well as failure problems at the central site. Star topologies have lower bandwidth than mesh topologies but are more cost effective to design and maintain.

Mesh topology takes the star concept a step further (Figure 4). As interconnects are added to eliminate dead branches in a star network, a point is reached when all nodes have connections to all other nodes. At this point, the hierarchy disappears and each node can become an end point.

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a router, or both. Each node switches its own traffic, and all nodes are equal in a peer-to-peer system. Many in the industry argue that mesh topology fabrics are the topology of choice.

**Figure 4**

**Transitioning to switch fabric**

At face value, it appears that all signs point to yes when deciding to transition to a switch-fabric architecture. However, there are several factors to take into consideration before making such a paradigm shift. The first and possibly most important issue deals with design complexity. Jumping from a traditional parallel or point-to-point backplane to a switch fabric requires massive design efforts that often take months or even years to perfect. One key concern facing designers is the complexity associated with the layout of the switch matrix itself. One must consider matters of protocol dependencies, control and overhead requirements, and redundancy in case of failure.

Additionally, cost may indeed prove prohibitive when implementing a switch fabric design. Large chipsets and complex hardware combined with sizeable design teams and expensive design tools can add up to an unrealistic cost-to-throughput ratio. These costs can be slightly diminished, however. Interconnect speeds can be user-definable – scalable from 10 Mbits/sec to 2000 Mbits/sec per node. Thus, it is possible to start with lower-cost components and then upgrade as needed. Obviously, these lower-cost pieces are also lower speed. As a result, this cost-cutting measure might not solve the initial problem of speed.

Moreover, time to market may be a factor. With competition always increasing, transitioning to switch fabric may force a company into a non-competitive standpoint. It might, therefore, be more advantageous to redesign existing architecture to create additional generations, and thereby generate increased revenue with minimal R & D cost.

Finally, as with any backplane design, signal integrity is a primary concern. The more complicated the design, the harder it is to control crosstalk, reflections, and power-supply noise. Thus, sophisticated routing techniques must be adhered to in order to ensure a clean, error-free environment. Since bus-based backplanes are commonplace and have been so for some time, expertise in the form of design, personnel, and support is ubiquitous and available to all in the industry.

**To switch or not to switch**

Current bus systems have likely reached their maximum potential. Additional improvements to these aging, bus-based systems will run headlong into the physical limitations set forth by voltage slew-rates and transmission-path characteristics. Switch fabrics are quickly becoming the heart of network switches and routers, as multiple advantages exist with this architecture. However, these advantages come at a cost, and not just a financial one. Transitioning to switch fabric may not be the most practical choice for all organizations. It is, therefore, incumbent on the designer to consider all factors before taking on a challenge of this intensity and magnitude.

Jeffrey Small is currently a systems engineer in Fairchild Semiconductor’s corporate marketing department having worked for the previous seven years as a senior applications engineer in the company’s Interface Products Group in South Portland, Maine. Jeff earned his B.S.E.E.T. from the University of Maine at Orono.

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