



Physical layer switches ready for deployment

Once exclusively the preserve of the development laboratory, Physical Layer Switches (PLSs) now have the performance and packaging to operate in the severe environments found in deployed weapons platforms and vehicles. In VMEbus format, they are ideally suited for applications requiring high performance and deterministic routing. They can also be used with many different high-speed technologies such as Ethernet, Serial RapidIO, PCI Express, Sonet, high-resolution digital video, Firewire, Serial FPDP, and Fibre Channel. Fibre Channel is already in widespread use by the military, particularly in avionics applications. Although most of these today use only 1 or 2 Gbps signaling, the next generation of PLS will already operate at the latest commercial standard of 8.5 Gbps, easily able to support the military's anticipated advance to 4.25 Gbps.

A PLS switches only at the physical level and is independent of a network's type or protocols. Unlike a managed switch that makes routing decisions based on a packet's address and the switch's local routing tables, a PLS switches the physical connection through a crossbar ASIC that has its topology changed via routing commands received from an out-of-band port. The PLS has minimal latency (10-20 ns) as all packets are passed straight through the crossbar with no processing overhead.

Network nodes are connected directly to the switch, which can then set up different routing topologies for each of these physical connections. A PLS allows point-to-point (A routed to B), multicast (A routed to B and C and D), and loop (A routed to B to C to A) topologies to be created from only one set of physical connections. A PLS cannot change the protocol or physical characteristics of its connections, always offering, for example, Fibre Channel *in* and Fibre Channel *out* or Serial FPDP *in* and Serial FPDP *out*. This is illustrated in Figure 1, where four nodes are connected to a PLS configured as a loop (Node 1 connected to 2 to 3 to 4 to 1). The lower half of the figure shows

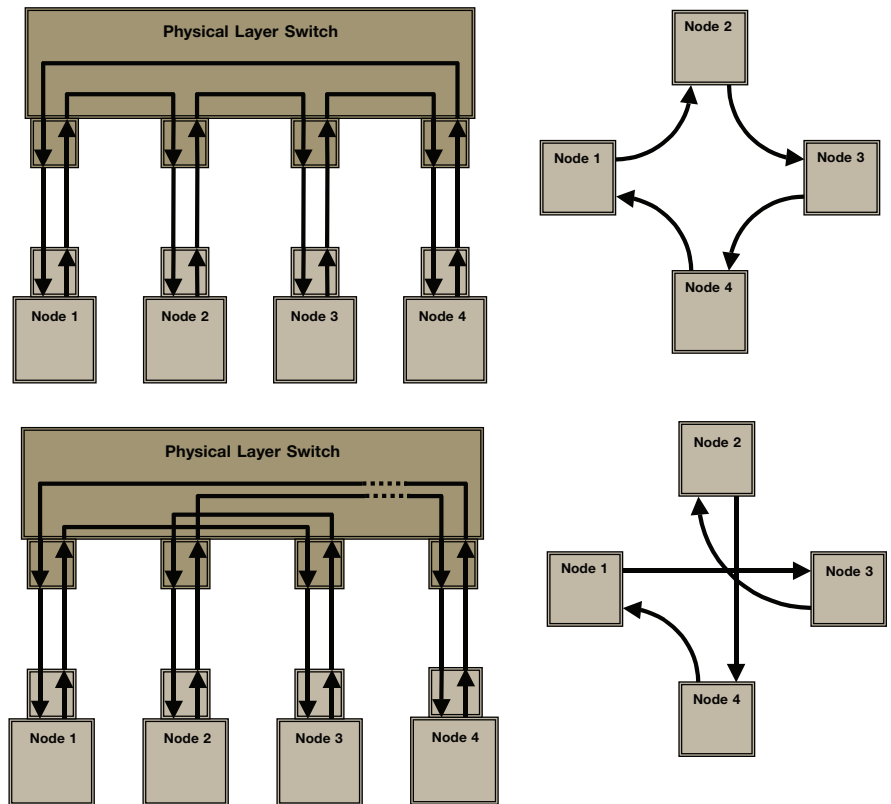


Figure 1

the loop reconfigured (Node 1 connected to 3 to 2 to 4 to 1) by the PLS without changing any of the cabling.

These characteristics of a PLS make it ideally suited for use in an avionics systems integration laboratory environment where Fibre Channel is to be the deployed platform's network medium. In the laboratory, frequent changes are made to a system's network configuration as equipment is modified and new equipment is inserted or pieces of equipment removed. A PLS enables every piece of equipment to be connected just once to the switch and the current network topology to be created via its configuration port like an electronic patch panel. If cables were frequently moved and reconnected, damage could result and considerable time will be spent reestablishing the network's integrity each time it is disturbed. In addition to the reconfiguration time saved, new network

topologies can be created easily to test for potential bottlenecks and system robustness by routing traffic to saturation on certain parts of a network in controlled experiments. Response times and overall system performance can also be optimized and characterized in a similar way for final testing prior to deployment.

Using fixed or infrequently changed routing through a PLS offers more stable network characteristics than the potentially dynamic environment of a managed switch, offering many advantages to the integrators of avionics platforms or ground-based semi-autonomous surveillance vehicles with multisensor or weapons payloads that can be varied from mission to mission. An integrated avionics and mission system for an Unmanned Aerial Vehicle (UAV) might be a good example of this type of application. This system would be responsible for the flight

management of the vehicle, as well as management of its mission, sensors, and weapons payloads. Traditionally, flight control and mission avionics systems would be totally separated in order to meet safety criticality requirements. But when overall vehicle cost, weight, and power are at such a premium, it is advantageous to share some of these resources where possible. Fibre Channel is often the network of choice for avionics applications, and a PLS allows it to be used in such a way that sensors and weapons can be changed freely between missions without affecting any of the onboard fabric's safety-critical characteristics.

This is analogous to the way that AFDX (ARINC 664) works. AFDX is a form of switched Ethernet designed for similar applications where many levels of criticality can coexist in the same system. AFDX uses restricted packet sizes and predetermined routing to ensure that critical parts of the network operate deterministically (at frame rate) under all conditions. In the multisensor UAV example mentioned, a PLS can be used in a similar way, providing fixed routing for critical functions while giving flexibility to accommodate various payload types as mission requirements vary. For enhanced overall reliability, multiple redundancy is easily achieved by adding extra switches with the ability to reroute signal paths quickly in the event of a failure.

8.5 Gbps signaling

Commercial applications of Fibre Channel such as Storage Area Networks (SANs) and server farms are already making the transition to the new 8.5 Gbps standard. Obviously, at these signaling rates, optical fiber is used as the transmission medium; hence, current 8.5 Gbps embeddable PLS products incorporate fiber connections via the front panel. This is apparent from Figure 2, which illustrates the VLX8000 PLS in VMEbus format, developed by Curtiss-Wright Controls Embedded Computing (CWCEC).



Figure 2

Deployed military applications are now at the stage to consider using 4 Gbps Fibre Channel due to component maturity and proof that commercial products at these speeds are totally reliable in operation. However, current VMEbus or CompactPCI packaging and connector technology limits signaling rates to 1 Gbps when using a copper connection through the backplane. This is about to change with the introduction of the new VPX standard (VITA 46) with its connector pairs rated to 6.25 gbaud. This makes 4 Gbps Fibre Channel a reality for the harshest environment deployed military applications, even those incorporating conduction cooling.

"The next generations of PLS appear set to make the transition from the development laboratory to deployment in many types of military applications, from the benign command center's SAN to the harshest environment critical avionics systems."

New applications emerging

But potential applications of an embeddable PLS in military applications are not just limited to harsh environment deployed avionics systems where Fibre Channel is in regular use today. There are many unique application areas emerging that may easily eclipse this market segment:

- Cooperative war fighting in the emerging digital battlefield will require vastly increased computing power to assimilate the amount of information collected from multiple sensor platform types and to disseminate a filtered tactical situation back to individual units on the ground or in the air, with directions for

engagement. This extra computing power will be located in mobile command posts, command centers, and communications centers with their own embedded SANs making extensive use of Fibre Channel storage technology.

- Other forms of high-speed serial connections can be used with a PLS, even those not normally associated with a switch for routing. Serial FPDP is a good example of this. Serial FPDP with its very high ratio of payload to protocol is used extensively to link high-speed sensors to their DSP systems. Sensors may have multiple elements or DSP systems may, in some instances, share multiple sensors, resulting in a number of connections within a platform. Using a PLS to control these connections provides much greater flexibility of routing, can provide multicast capability, and can be used to tap additional paths into the established routing without disturbance. A typical use would be recording raw sensor data where just a single connection to a recorder can be switched by the PLS between multiple sensor data streams.
- Digital video distribution is another military application area for an embeddable PLS. Currently most video sensor systems use regular TV standards, but High Definition Television (HDTV) technology is now readily available and could be used instead. Digital HDTV has a nominal data rate of 1.5 Gbps plus emerging standards for 3 Gbps using dual link and, in the near future, a single 3 Gbps link. This makes it an ideal candidate for routing, recording, and multicasting through a PLS.

The next generations of PLS appear set to make the transition from the development laboratory to deployment in many types of military applications, from the benign command center's SAN to the harshest environment critical avionics systems. The introduction of 8.5 Gbps signaling, VPX packaging, and connector technologies will further extend its life and embedded application flexibility.