Advanced Switching Interconnect (ASI) sets new benchmarks in networking over the backplane

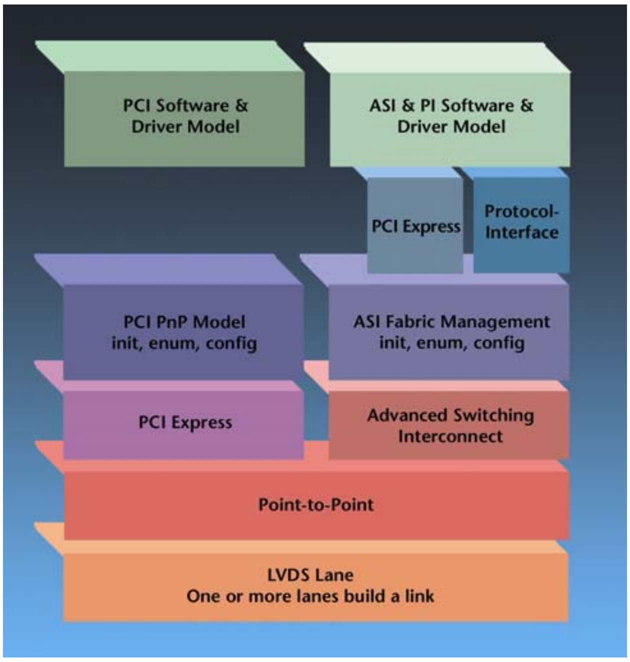
New PCI Express-based expansion technology reduces system complexity and allows the combination of different networks through protocol tunneling

By Claudia Bestler

The data and telecommunications industry's search for ever faster connections between chips, boards, and chassis goes hand in hand with the rapidly increasing demands on the bandwidth of future systems. In order to meet this challenge over the long term, innovative connection technologies that implement high speed data transfer at low cost are needed, thus smoothing the way for the next generation fabrics [1] of the telecommunications world.

But just what constitutes optimum networking in the world of (data) communication? Ideally, it offers high scalability and a high degree of availability, a high quality of service level at low latency and minimal jitters, and last but not least cost-effectiveness. The PCI Express (PCIe)-based expansion technology Advanced Switching Interconnect (ASI) combines exactly these advantages, and thus has all that it takes to position itself, in this respect, as a future-oriented alternative, alongside Gigabit Ethernet. Together with the hardware specifications for ATCA and AMC, ASI sets the trend for flexible, economic, and high-performance "commercial off the shelf (COTS)" systems in the data and telecommunications industries.

The ASI transmission format specified by the ASI-SIG is an innovative network enhancement of the recently launched PCI Express connection technology. Development and market introduction are led by the Advanced Switching Interconnect Special Interest Group (ASI SIG, www.asi-sig.org). ASI brings important innovations for telecommunications servers and network infrastructure devices: based on PCIe, the various data and telecommunications protocols are transmitted efficiently, and are transparent for the applications (protocol agnostic tunneling). In addition, priorities and defined data transfer rates can be predetermined for certain connections (Quality of Service – abbreviated QoS). Both unicast and multicast modes are supported, which means that data packets can be targeted to one receiver, or to several at the same time. The primary focus is on backplane connections, that is board-to-board communication within a single chassis, as opposed to chip-to-chip or chassis-to-chassis connections. Thus, ASI offers a lot of innovative potential for this area of use. Unlike Ethernet, ASI not only allows connections between processor assemblies, but also complex connections from several processors to several I/O assemblies. The special advantage: ASI is transparent for operating systems, and can thus be used like PCIe.



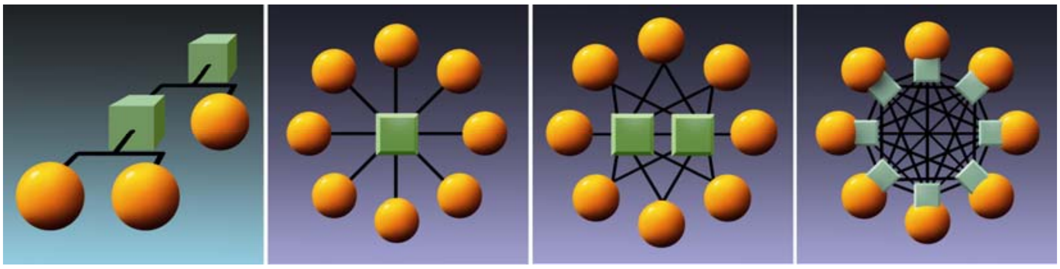
Layer model of PCIe and ASI

[1] fabric = communication network

PCIe and ASI – a strong common base

Specified by the PCI SIG as an economical, highly scalable, serial all-purpose I/O connection technology, the PCI-Express (PCIe) basic specification offers a uniform standard for consolidating a wide variety of I/O solutions within one platform. The architecture of PCIe and ASI is defined by three layers: the physical layer, the link layer, and the transaction layer. The level above that is not specified, and is broadly described as the software layer. ASI uses the same physical and link layers as PCIe and is therefore able to reuse important functions and existing developments of the established high-tech standards PCI and PCIe (PCI transparency). This includes Internet protocol (IP), tools, and services from the comprehensive PCI and PCIe ecosystems. The decisive difference in PCIe is in the superordinate transaction layer, specially optimized for ASI. It adds the relevant, ASI-specific protocol parts and replaces the CPU- and RAM-centric PCIe architecture with a peer-to-peer network architecture with virtual channels (VCs). Thus, ASI offers the optimum prerequisites for device connections from processor to processor, or processor to I/O in board-to-board or backplane architectures.

The ASI transaction layer allows source-based path routing in comparison to the RAM-addressed routing of PCIe. By dropping the hierarchical structure of RAM-addressed routing, flexible topologies, such as star, dual star, and full mesh, can be created. Furthermore, the path routing process offers system immanent security mechanisms using the unique route signature.



Representation of the path routing process with the different topologies

Furthermore, as a serial point-to-point connection architecture, ASI for PCIe offers new, economical switching functions on the platform level, and increased expansion of the bandwidth, which is not available in shared bus architecture. The serial architecture allows simultaneous communication between several node pairs via separate transmission paths in a peer-to-peer environment, as well as multiple node connections. In addition, queues and QoS arbitration functions are made available by these switching functions, which optimize the overall use of the bandwidth while, at the same time, taking into consideration the priority requirements of transmitted data streams.

Protocol tunneling

One of the technically most significant functions of ASI is protocol tunneling: ASI encapsulates the data packets from other levels such as Ethernet, FibreChannel, or ATM, and adds a header that guides the data packets through the network, independent of the packet format, as though through a tunnel. The header contains a PI field (protocol interface) which is used by the receiver to determine the data format encapsulated in the packet. Thus, almost any transport, network, and link layer protocol can be transmitted via the ASI network. In this way, several divided networks, each for a specific protocol (Ethernet, FibreChannel, or ATM), can be combined into a single common network. The tunneling mechanism reduces the complexity of the system to a minimum. The reliability of the entire system is thus increased massively, while at the same time the corresponding administrative and monitoring expenses (OAMT Operation and Maintenance) are reduced.

PCIe packets are an especially important format for systems developers, where ASI serves as a central switching exchange for the connection of the PCIe end points. Using the PCIe plug and play software, PI-8 offers the possibility of transparent connections between several PCIe-capable CPUs and several PCIe-capable I/O nodes within the ASI structure. Moreover, the tunneling capabilities of ASI contribute significantly to the investment security of the software.

Improved scalability

Scalable platform architecture avoids the cumbersome and costly exchange of system components, or even the entire system, if the system requires expansion. Functional enhancements are simply added later, thus reducing the overall costs of operation and support. With ASI, the architecture can be scaled from simple to complex, based on the optional capabilities of the specification. PCIe can already integrate several lanes (x1, x4, x8, ...) in order to assign the specifically required bandwidth to any given function. Other important functions are different QoS levels, messaging procedures, and mechanisms for avoiding congestion. These functions contribute to the standardization of the system architecture in next generation systems and, at the same time, guarantee wide acceptance in the target markets, the key factor in the ultimate success of any technology.

ASI versus Gigabit Ethernet

When looking for a “better or worse” technology there is essentially no general distinction between ASI and Gigabit Ethernet. As is (almost) always the case, the specific requirements of an application determine which connection technology is preferred, or in which cases GbE and ASI should be used as complementary solutions. Interesting applications for ASI present themselves, for example, in telecommunications servers, security platforms, enterprise routers, and media gateways. The advantages of ASI vary with the application: in telecommunication servers, PCIe compatibility, low latency time, and simple load/store data communication are the most significant advantages, while a security platform benefits above all from the high bandwidth and the NPU-CPU connectivity of ASI. ASI is likewise very well suited for enterprise routers through its PCIe compatibility and multi-protocol support. Because many enterprise routers today use PCI and PCIe for CPU-I/O connections, ASI, which is compatible with PCI and PCIe, is a logical economical enhancement in this case. It provides more flexibility with, at the same time, moderate costs, which lie within the PCIe range. The key criteria for ASI in media gateway applications are multi-protocol support, flow control, lower overhead, and QoS. ASI allows the routing of any protocol at a high QoS level. With mechanisms such as congestion management and virtual channel flow control, ASI is more attractive than Ethernet through absolute high-level QoS. Ethernet also has QoS possibilities – however, mostly not in the form of integrated hardware. It requires additional protocols (e.g. DiffServ).

In the link layer of PCIe, and therefore also in ASI, data packets are tested and, in the event of error, are automatically prompted for repeat transmission, while Ethernet transmits data packets without testing and rejects defective data packets. Missing data packets are only noticed at the very top of the protocol hierarchy, and only then is a new transmission prompted, with considerable delay in comparison to a similar ASI connection. With the ASI connection via 8 lead pairs in the fabric interface currently specified in PICMG 3.4, a theoretical bandwidth of 16 Gbit per second can be achieved for communication between two ATCA assemblies.

By encapsulating upper level protocols, ASI allows a significantly simpler system design, because it is not necessary to convert protocols within multi-protocol systems and architecture. Ethernet has only limited options here, which leads to a correspondingly increased system complexity.
ASI also shows advantages over Ethernet in scalability: while, with Ethernet, connections with 100 Mbit, 1 Gbit, or 10 Gbit (scaling factor of 10) can be created, ASI offers bandwidths of 2.5 Gbit, 5 Gbit, 10 Gbit, 20 Gbit, etc. (scaling factor of 2) through the combination of several lanes with 2.5 Gbit each. Low latency time and good jitter control – especially important in transmitting video and voice data – also argue in favor of ASI.
ASI demonstrates other advantages over Ethernet in the event of failure, thus, for example, in a break in the pathway. While, in Ethernet, the network topology must be relearned by the redundant switch (spanning tree), transfer to the redundant ASI switch, which already knows the topology, takes place much faster.
In terms of cost, 10 Gigabit Ethernet is still quite expensive at a few hundred US dollars per channel, while its “baby brother” Gigabit

Ethernet is roughly in the price range of ASI at a few US dollars per channel.

According to unanimous expert opinions, Ethernet technology is very well suited to chassis-to-chassis connection on the system level and in local networks. If sophisticated, scalable QoS, bandwidth, multiprotocol environments, and fabric convergence are required on the backplane, ASI has the edge.

Nevertheless, even if the capabilities and possibilities of ASI sound very promising and innovative, Gigabit Ethernet is currently still state-of-the-art when it comes to high-speed connections in the data and telecommunications market. The established technology is broadly supported worldwide by leading hardware companies such as Kontron. ASI will have to work to gain this level of acceptance by the industry. Experts assume that, in the future, both technologies will exist in parallel in a "best of breed" fashion, complementing one another.

Three in one: ATCA, AMC, and ASI

A technology leader and pioneer in ATCA and AMC, and a member of the ASI SIG, Kontron is actively committed to the market introduction of ASI to provide its customers with the greatest possible flexibility in high-speed networking. Along with the established Gigabit Ethernet, which Kontron has implemented in all of its products, the company now also offers hardware for ASI technology with the recently introduced ATCA Hub Board AT8901.

With the introduction of the ATCA (Advanced Telecom Computing Architecture, PICMG 3.x) hardware specifications, the telecommunications market has had a technical concept for standardizing telecommunications infrastructure since 2003. In addition, the corresponding mezzanine concept AMC (Advanced Mezzanine Card, likewise defined by PICMG at the beginning of 2005) ensures the widest variety of application possibilities, and expands the ATCA standardization. The new AMC specification essentially enhances the PMC model (PCI Mezzanine Card) with hot swap capability, remote management via IPMI, frequency synchronization signals, more circuit board area, and a higher power dissipation. Thus, mezzanine modules also achieve "five nine" high availability at the carrier level. While PMC modules are still based on the parallel PCI or PCI-X interface, AMC modules can be addressed via PCIe. AMCs are flexible, efficient, and ideal for integration into the ATCA concept. They are also suitable for a range of application on proprietary platforms. Together with ATCA and AMC, ASI now allows another step towards more flexible, more economical, and higher performance commercial-off-the-shelf (COTS) standard systems. Thus, TEMs (Telecommunication Equipment Manufacturers) obtain an innovative architecture for the high-speed networking of new, demanding telecommunications systems based on ATCA and AMC.

Summary

The future belongs to standards-based next generation fabrics – primarily because many major telecommunications facility manufacturers will adapt their backbone systems developed in-house to the ATCA standard in the future, according to the relevant predictions of the pundits. Therefore, it is equally to be expected that ASI's high speed networking technology will primarily establish itself in the backplane area as an alternative to Gigabit Ethernet. It reduces system complexity by being able to "tunnel" a variety of protocols, and is particularly well suited for enhancing PCIe designs because of its transparency to existing software. With its advantages over purely proprietary solutions, wide acceptance and support by industry, and the steadily growing ecosystem of compatible products, ASI promises cost efficiency and innovation potential – particularly as a connection technology on the backplane. Kontron, the leading manufacturer of embedded computer systems for telecommunications infrastructure, was a pioneer in recognizing the necessity of and trend towards standardization in this segment from the very beginning with ATCA and AMC, and has played a decisive role in the definition of both standards. The company was one of the first to develop a production-ready, compatible, and integrative family of products for ATCA and AMC. Once again, Kontron takes the lead: with the AT8901, the company combines all three advanced technologies in one product and proves its leadership as an innovative partner for the data and telecommunications industry.

ATCA Hub Board AT8901

In Kontron's AT8901, the integrated 10-port ASI switch "Merlin" from StarGen supports ASI connectivity with eight ATCA assemblies and two AMC slots.
For PICMG 3.1-based ATCA systems, the AT8901 is also available in a Gigabit Ethernet version. Moreover, the AT8901 offers two AMC slots for flexible expansions, such as for a processor AMC assembly in the role of the high availability system manager, for a SETS assembly (Synchronous Equipment Timing Source) for frequency synchronization in telecommunications applications, or for the AMC Interlink module with two 10 Gigabit Ethernet interfaces for connections among several ATCA systems.

ASI SIG – the "cradle" of Advanced Switched Interconnect

The Advanced Switching Interconnect Special Interest Group (ASI SIG) is a non-profit board, with currently more than 55 member companies from the embedded hardware and semiconductor industries, as well as telecommunications equipment suppliers. The goal and mission of ASI SIG is the (further) development, support, and market introduction of the Advanced Switching Interconnect technology as a standards-based high-speed connection technology in the field of data and telecommunications. The technical requirements of ASI are set out in the ASI Core Specification. Moreover, the PICMG 3.4 specification of March2003 defines the use of ASI as a fabric interface in ATCA systems. All of the member companies involved in ASI SIG, including Kontron, actively support the continued technical development of the ASI specification, and an industry-wide standardization and adaptation of ASI. They support and promote this through training programs and the development of appropriate technical parameters and systems.

About Kontron

As global leader in embedded computer technology and mobile rugged solutions, Kontron supplies a diversified customer base of OEMs, system integrators and application providers in the communications, automation, test and measurement, transportation, medical, military, aerospace and energy markets. The company helps its customers to considerably reduce their time-to-market and to gain a competitive advantage with products including high-performance open computer platforms and systems, single board computers, human-machine interfaces and mobile rugged computers. Kontron employs more than 1,900 people worldwide and has manufacturing facilities in Europe, North America and Asia Pacific. The company is listed on the German TecDAX 30 stock exchange under the symbol "KBC". Kontron is the only European based Premier member in the Intel ® Communications Alliance which means earliest access to leading-edge Intel technologies and privileged engineering support.
For additional information on Kontron, please visit: www.kontron.com.