The Case for 10G Ethernet in Embedded Processing

Texas Instruments

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Ethernet, one the cornerstones of today's interconnect technologies, just turned 40 years old (**www.netevents.org/ethernet-innovation-conference**), and is not slowing down. Challengers like Token Ring and ATM have come and gone, but Ethernet has prevailed. Very few technologies or standards in the electronics and computing industries can match this track record. There is no single reason for its success, but one of the important technical reasons is the approach to raw bandwidth. While other technologies focused on adding features from different levels of the networking stacks, and trying to maximize the utilization of the bandwidth available, Ethernet has kept its focus and added an order of magnitude bandwidth. If it is simple, it can be developed quickly and deployed ahead of more complex standards. 10Mbit/s to 100Mbit/s to 1Gbit/s to 10Gbit/s and beyond, the steps are typically an order of magnitude and the bit rates are real, not baud rates as in most other technologies.

In the embedded space, SoCs have integrated Ethernet interfaces for a decade, where the integration is almost the defining factor that makes a processor an SoC. The need for bandwidth increase has been driven for different reasons in different applications. HDTV pushed the raw display bandwidth requirement above 2.9Gbit/s. A single ARM® Cortex™-A15 can provide 500Mbit/s of network traffic in a real application, a quad-core processor is already often bottlenecked by 1Gbps. Typically the most valuable commodity in the SoC is the performance the processor is able to provide, and the system architect does not want the networking or interconnect bandwidth to become the bottleneck. This is definitely the case for high-performance multicore processors such as 66AK2H14 SoC.

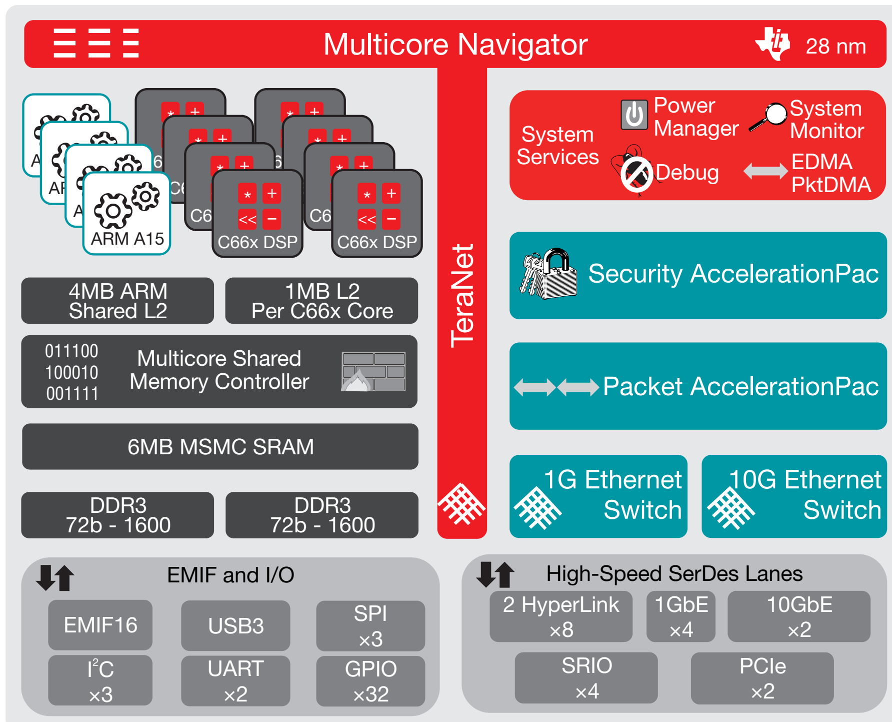

Figure 1. TI's KeyStone™ 66AK2H14 SoC

The 66AK2H14 SoC shown in Figure 1, with the raw computing power of eight C66x processors and quad ARM Cortex-A15s at over 1GHz performance, enables applications such as very large fast fourier transforms (FFT) in radar and multiple camera image analytics where a 10Gbit/s networking connection is needed. There are, and have been, several sophisticated technologies that have offered the bandwidth and additional features to fill this role. Some such as Serial RapidIO® and Infiniband have been successful in application domains that Gigabit Ethernet could not address, and continue to make sense, but 10Gbit/s Ethernet will challenge their existence.

The only area where Ethernet use might be perceived to decrease is in data centers with technology trends like Software Defined Networking (SDN) and architectures like Open Compute. SDN might be a major change at several levels, but underneath at layer 2, it is just Ethernet. Approaches like Open Compute move the border between memory mapped and message-based connectivity one level of hierarchy. Between racks or chassis it is still just Ethernet.

Deterministic behavior has been a traditional angle which Ethernet's competing solutions have challenged. Historically, Token Ring and ATM, and more in the embedded space Serial RapidIO, sometimes with the power of a dominant corporation or an industry, and sometimes with less muscle, have provided guarantees of quality of service (QoS), while pointing out the lack of those in Ethernet. Bandwidth provisioning and enforcing the use of Ethernet features such as IEEE802.3 Qav shaping have allowed Ethernet to be used in real-time applications like audio and video (Ethernet AVB). In addition, applications driven by raw bandwidth can provide lower latency and reduced jitter by reducing the head of line blocking and transmission time of a packet.

Texas Instruments Keystone™ II devices introduce 10G Ethernet to a whole new class of devices. XFI interface, utilizing a single SERDES lane, reduces the power consumption of an integrated 10G to a few hundred milliwatts compared to older four-lane XAUI at over a watt. There are several different application scenarios where 10G Ethernet is relevant in both computationally heavy processing with the 66AK2Hxx devices with multiple >1-GHz C66x processors, or data movement dominated applications with AM5K2E multicore ARMs.

For example, when the application, such as radar signal processing, is based on calculating FFTs, the computational power of the 66AK2H14 SoC exceeds 1G Ethernet by a significant margin, moving to 10G will remove that bottleneck and allow it to fully utilize the computing power.

On the other end of the application spectrum, AM5K2E02 and AM5K2E04 multicore ARM Cortex-A15 SoCs, shown in Figure 2, are often tasked with moving data from a couple of the integrated interfaces, such as multiple USB3s, PCIes and/or multiple 1G Ethernet ports, to an aggregated IP/Ethernet connection. Traffic from each of these can be at the 1Gbit/s level or above. So for the aggregated traffic, 10G Ethernet fits perfectly.

In both of these cases the supporting XFI interface and the ability to switch at wire rate with 10G Ethernet allows glue-less daisy chaining of a couple of Keystone II SoCs. This allows getting rid of a separate switch chip, or in the case of larger systems with dozens of SoCs, a lower port count switch can be used for better power and cost efficiency. Keystone II 10G Ethernet switching supports IEEE 1588-2008 and IEEE 802.1AS precision timing and IEEE 802.3Qav shaping, for real-time applications such as Ethernet AVB.

The last discussion point is software performance and 10G Ethernet. The situation where the raw rate of packets the I/O can deliver can overwhelm the software is not uncommon in Ethernet's history. Keystone II SoCs are addressing this in a couple ways. First by making sure the hardware supports coherency for the packets coming in and out from 10G Ethernet. This has a significant performance impact almost regardless of the software architecture chosen, i.e., full Linux™ TCP/IP stack, something more networking focused like TI's Transport Netlib on the ARM Cortex-A15s, or a traditional RTOS in either ARM or C66x DSP. An important consideration is that the goal of the application, unless one is building a router, is not to fully utilize the Ethernet link, but rather to not make it the bottleneck. The value add comes from the full solution. With 10G Ethernet there is one thing less to hold back the performance of the system.

For more information on TI's devices enabled with 10G Ethernet, visit **ti.com/dsp**.

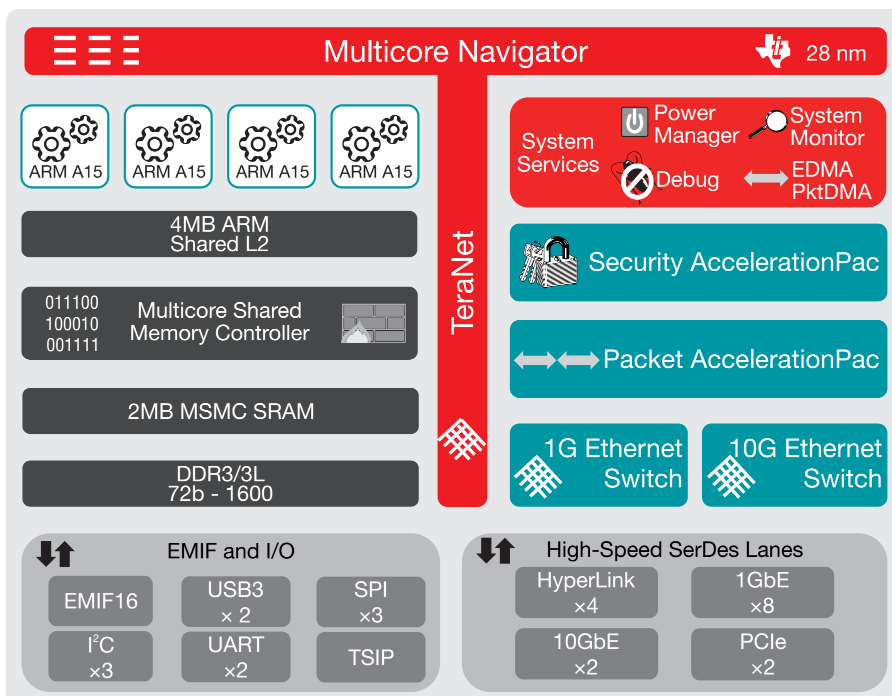

Figure 2. TI's KeyStone AM5K2E04 SoC

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