A Conversation About Ethernet

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Q: Ethernet has become a trending technology concerning EMSO/EW systems. What do you believe is driving the adoption of this "household-name" technology?

A: First, you're correct that the average person you'll meet is at least familiar with the name of this 40-year-old IEEE 802.3 standard—a physical and data link layer specification for wired networks. However, don't be surprised if you hear some people associate the word "Ethernet" with the phrase "the internet," for which there's good reason.

In some places, an Ethernet cable is still used to connect home computers to an Internet Service Provider's modem and, therefore, a gateway to the Internet. In most cases, your personal electronic device's path to the Internet is via a wireless Ethernet router (an IEEE 802.11 standard). All said, Ethernet is well-known, and it's utilized in places worldwide, from data centers to self-driving passenger vehicles.

High-speed Ethernet is also quickly becoming the preferred

network technology for implementation within many modern EMSO/EW systems. It is a low-cost yet capable alternative to high-speed buses or data transport systems, such as AURORA, Interlaken, PCIe, serial front-panel data port (sFPDP), Fibre Channel, and InfiniBand®.

Q: What is Ethernet's practical role for EMSO/EW systems?

A: Without being overly simplistic, the architectures of various combat platforms with capabilities such as advanced radar, ultra-wideband radio sensing for ELINT, and other such systems typically have many radio frequency sensors (or antennas) that feed a set of RF front-end receivers that are coupled to a bank of analog-to-digital converters. This setup is also seen in an all-encompassing product called a software-defined radio (SDR) unit.

In nearly all cases, the digitized RF data must quickly reach some digital signal processing (DSP) section or distant DSP backend for solutions calculations. Ethernet easily fulfills this application and utility requirement.

Q: Is Ethernet as robust as, for example, InfiniBand® for EMSO/EW systems?

A: Absolutely. Ethernet was once a non-starter for some critical defense applications, as it was slow and unreliable. It was also known to be susceptible to data loss during transmission and have unacceptably high latency characteristics. However, Ethernet has come a long way, with massive gains in speed and improved transmission schemes.

Q: How fast is Ethernet?

A: Practically speaking, we typically find customers utilizing 100GbE-links for 100Gb/s speeds. However, a beautiful feature of Ethernet is its simple scalability, with minimal software development effort and systems integration required. For example, a systems architect could install twice the number of

100GbE interface ports with matching cable sets to achieve 200Gb/s—and the same scheme works for achieving 400Gb/s, 600Gb/s, and so forth. Although to reach a host's "total throughput" potential, engineers should also check for "bottlenecks" in the data paths before and after the 'xGbE' interfaces.

Q: What Ethernet speeds can we expect to see in the future?

A: The IEEE 802.3 working group's approach to accelerating Ethernet's performance development cycle is to reuse legacy standards and implementations whenever possible. For example, in the case of the latest 200GbE technology and the "QSFP56" interface design, they've simply quadrupled the use of the older SFP56 (Small Form-Factor Pluggable), a 50GbE technology to achieve 200Gb/s in a single connector.

We're also beginning to engage customers who plan to utilize 400Gb/s Ethernet technology—that's right, "QSFP56-DD" (Double Density)!

Our product developers are also excited to see the IEEE P802.3df Task Force blazing its way to a Terabit Ethernet (1.6 Tb/s) standard, with new definitions and parameters for its Media Access Control (MAC), physical layers, and other technical specifications in progress.

Ethernet will remain relevant for many years, allowing EMSO/EW producers and our company to chart a clear product-development roadmap to meet the capability demands of our shared research and defense customers.

Q: What do Ethernet packet recorders bring to the "EMSO/EW Table"?

A: An EMSO/EW or SIGINT system with a "DC-to-daylight" operations scope will have some number and combination of wide-band RF-to-digital receivers or software-defined radios. Nearly all digital radio and SDR products will feature

Ethernet encapsulation techniques to transport their I-Q data reliably to other digital systems.

Moreover, EMS researchers and EMSO system developers utilizing the newest Radio Frequency System-on-Chip (RFSoC) technologies are compelled to almost exclusively implement Ethernet to accommodate RFSoC products that can produce hundreds of Gigabits per second data to support wider RF instantaneous bandwidths or higher RF channel counts. Whatever the case, a protocol-agnostic, zero packet-loss Ethernet recorder is a must-have instrument for EMSO/EW systems design, development, test and evaluation (T&E), and even combat mission deployments.

Q: Can a software tool like Wireshark® accomplish the same thing?

A: While Wireshark® is a widely used software tool for capturing Ethernet packets for analysis, it is limited in its capability to sequentially record fast data rates to the computer host's disk-based storage. At best, this popular software can capture snapshots of data that can be retrieved later.

Our packet recorders can be ordered off-the-shelf to perform effortlessly up to 400Gb/s through our unique software engine and hardware architecture and design expertise that ensures each inbound bit at our product's network port(s) makes its way to the onboard enterprise-grade solid-state drives (SSD). This originates our core phrase and value proposition, "Zero Packet-Loss." The data is packed in a sequence of smaller recording files in a PCAP format whose files can be accessed and analyzed by tools like Wireshark®.

Our Ethernet recorders are also application protocol-agnostic, which means we can interface with the network just before the physical layer, "Layer-2" of the OSI Model. This is important because many producers and manufacturers of digital/computer

systems implement a variety of network application protocols and produce unique data payloads. Since we're a passive Ethernet capture and record technology, we can handle it all as long as it's encapsulated within standard IEEE 802.11 packet frames. This flexibility truly sets our capabilities apart from others, benefiting customers with multifunctional cases.

Q: Is there a case for Ethernet packet recorders outside of the laboratory environment?

A: Certainly. First, our recorders are size, weight, and power optimized. You will be hard-pressed to find another COTS, 1U by 19-inch rack-mountable Ethernet recording instrument that sustains 400Gb/s data capture and up to 720TB of storage in the marketplace. We are also beginning to deliver 100Gb/s recorders that are ½ ATR in size, which has been an incredible achievement and milestone for our engineering and fabrication teams. These products within our portfolio are easily hand-transportable and operate successfully "in the field."

In 2023, we entered a new product development phase, tasked with bringing our 100Gb/s Ethernet recording capabilities to airborne combat and mission platforms. After successfully delivering our first article (the XDR TITAN100 model) to the U.S. government in the Spring of 2024, we've been asked to propose bringing onboard 200Gb/s (2 x 100GbE) to 600Gb/s (3 x 100GbE) recording capabilities to support future 6th-generation fighter aircraft activities. As our company can already deliver conventional environment solutions with these explosive data rates, we're embarking on a journey to design suitable mechanical enclosures and mounting fixtures so that our higher-speed solutions can also endure the extreme temperature and vibration conditions these combat platforms may experience during flight operations (e.g., MIL-STD-810, MIL-STD-461, DO160, etc.).

Q: As a "turnkey," commercial-off-the-shelf manufacturer of

data recorders, do you offer custom solutions?

A: Of course! We have customers with truly extraordinary Ethernet recording requirements. As we've discussed before, where appropriate, we can increase 'xGbE-link' channel counts, total data throughput, and data storage beyond the capacity of a single-unit model by "stacking" additional units. For example, we've delivered 8x 100GbE (800Gb/s) recording capabilities in a rack solution consisting of four 2x 100GbE recording units (DDR HYPERION200 model).

We also utilize onboard FPGA technology, where we've created and loaded custom, in-line packet filtering IP capabilities that enable a particular customer to "thin out" hundreds of Gigabits per second of raw inbound Ethernet traffic.

Q: Can you name customers or the type of end-user that acquires your technology brand and why?

A: To name a few places where our business activities are often announced publicly, some by law, the U.S. Air Force Research Laboratory, the U.S. Naval Research Laboratory, Johns Hopkins Applied Research Laboratory, the University Corporation for Atmospheric Research, and The MITRE Corporation were early adopters of our COTS technology. As you can imagine, their work with our products is like that of other well-known national and private defense organizations. A quality Ethernet packet recorder is essential for developing EMSO/EW systems and deployment for special combat operations. For stakeholders who don't have this capability in their inventory, our first job is to introduce them to it!