[New optical interface standard aims at 5G]

[Larry Desjardin] - October 03, 2017

By now, you may have seen the [announcement] from the AXIe Consortium, the VITA trade organization, and six companies endorsing a new standard called the [Optical Data Interface] (ODI).

ODI is a new high-speed interface for instrumentation and embedded systems. It breaks speed and distance barriers by relying on optical communication between devices, over a standard pluggable optical fiber. With speeds up to 20 GBytes/s from a single optical port, and speeds up to 80 GBytes/s through port aggregation, ODI is designed to address challenging applications in 5G communications, mil/aero systems, high-speed data acquisition, and communication research.

Figure 1 shows a storage and playback system using ODI, the Optical Data Interface standard. Since ODI is a pluggable interface, any product can become ODI-enabled, regardless of form factor. A test system controller configures each device to enable ODI transmission through its standard interface. In the figure above, data is streamed over the ODI link from the digitizer to the storage unit. Alternately, it could stream to a DSP processor. The recorded data may be played back by sending the recorded data stream to the AWG over the second ODI link.

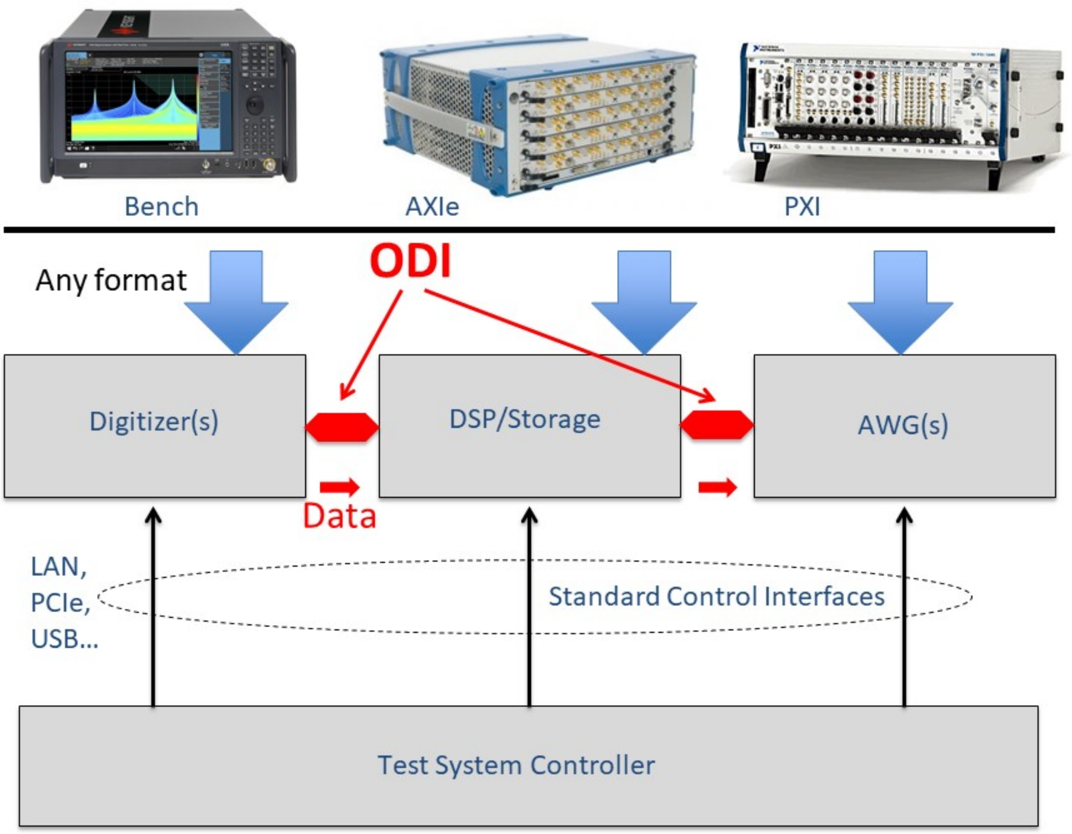

Figure 1. ODI provides a high-speed optical link between test instrumentation and DSP or storage devices. Source: Modular Methods.

How ODI works

Let me explain how ODI works. But first, it’s time for full disclosure. I’m not an unbiased observer when it comes to ODI. In fact, I’m the chairman of the AXIe Technical Committee that created the standard. I’m an unapologetic advocate of open systems, and I believe this standard is the right standard at the right time to address a multitude of vexing instrumentation and embedded system challenges.

Here's the problem.

When you take a look at a number of emerging applications, such as 5G communication or phased-array radar, the aggregate bandwidth needed to transfer IQ data grows very rapidly. Whether you are creating or testing these applications, the solutions require very high data bandwidths between measurement and processing blocks. It is easy to calculate 15 GBytes/s needed, and that's just for a single channel. At these speeds, electrical communications links can't extend across a backplane, mush less a racked system. The electrical signals quickly dissipate, and the connectors create large reflections, creating signal-integrity problems that make interoperability difficult. Plus, the speeds are only going to get faster.

With optical links, the interoperability, bandwidth, and distance issues simply disappear. You can connect instruments 100 meters away if needed, so there is no issue of interconnect distance within a rack.

That is what the ODI standard delivers—an open system method of connecting a fiber-optic data link between two devices, regardless of their physical format, regardless of manufacturer. The ODI standard is designed around a standard optical connector, which may be placed anywhere on any device. Therefore, ODI works equally well with all product formats, whether AXIe, PXI, LXI, VPX, or a traditional bench instrument design. It works equally well with instrumentation and embedded systems, such as those found in mil/aero applications. Through the standardized ports, ODI enables high-speed continuous communications between instruments, processors, storage, and embedded devices. Though the standard itself is sponsored by the AXIe Consortium, it is open to all vendors, without license fees or royalties.

Let’s take a look at the technology.

ODI Technology

The name Optical Data Interface was carefully chosen. First of all, *Optical* refers to the multimode fiber-optic transmission medium that connects from one device to the other. *Data* implies that the standard is aimed at data transmission, not control. Control plane communication is performed over a product’s standard interface, such as LAN or PCI Express, to set up the optical connection, which then runs independently until a “stop” event. Interface refers to the concept of a pluggable port, which can be placed anywhere on a product. ODI is high-speed point-to-point optical data connection, not a traditional parallel bus. It is not specific to backplanes at all, though ODI ports may be placed on backplanes.

Figure 2 shows the three key technologies behind the Optical Data Interface standard. The physical medium is 12-lane multimode fiber optics, delivering more than 160 Gb/s per port. The protocol layer is the Interlaken protocol, which delivers packet data between devices. Finally, the packets and their content are defined by the VITA Radio Transport protocol.

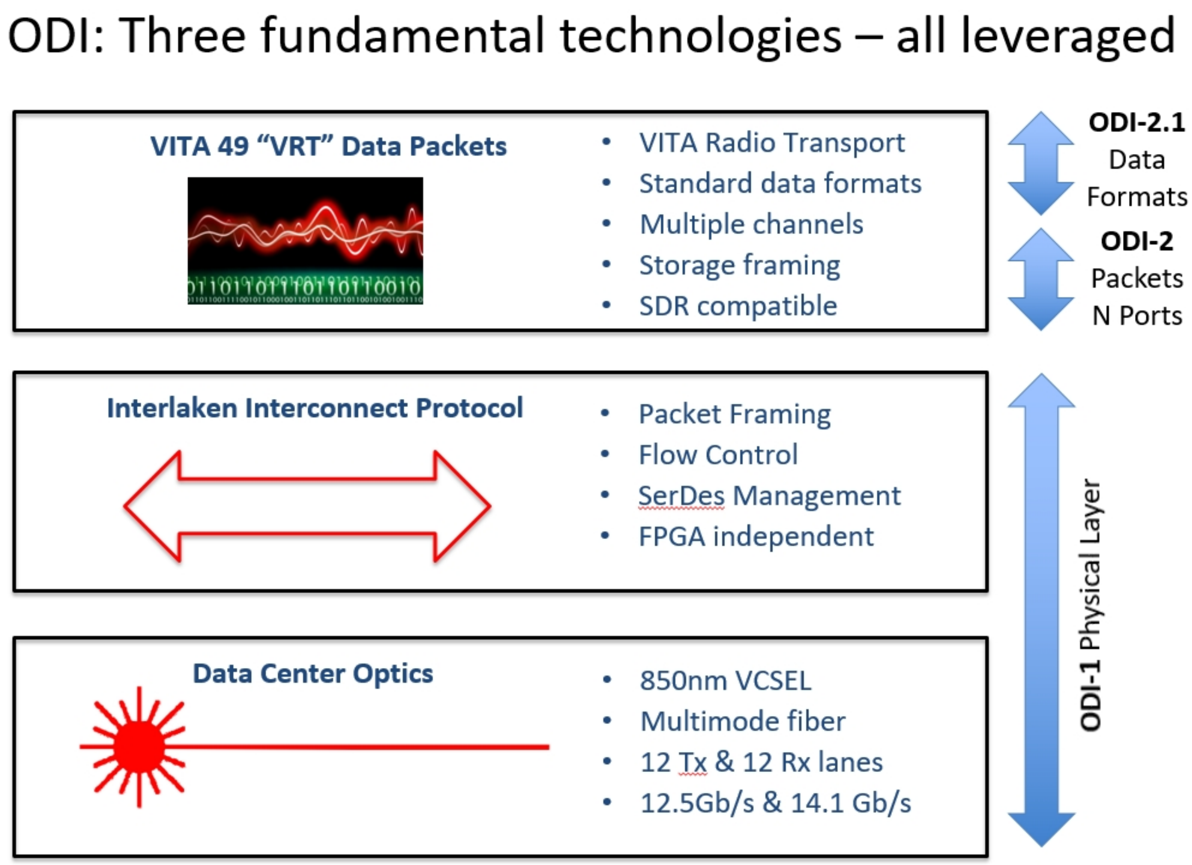

Figure 2. ODI incorporates physical-layer optics and Interlaken Protocol combined with VITA 49 data packets. Source: Modular Methods and the AXIe Consortium.

The ODI standard leverages three layers of technology, as shown in Fig 2. The physical layer is defined as optical technology consisting of 12 lanes of 14.1 Gb/s each, enabling 20 GBytes/s per optical port. Multimode fiber cables connect ports together, using the standard MPO (Multi-fiber Push On) connector. Ports may be aggregated, with four ports delivering 80 GBytes/s. Samtec announced immediate support of the ODI standard, with ready-made optical engines and cables based on its FireFly Micro Flyover System.

The protocol layer is defined by the Interlaken standard, a chip-to-chip interconnect standard common in data centers, conceived by Cortina Systems and Cisco Systems. Interlaken is supported by the major FPGA suppliers, and is managed by the Interlaken Alliance. It delivers packets of data over any number of serializer/deserializer (SerDes) lanes, at any speed. Interlaken doesn't define the packets, only their boundaries as a block transfer. Intel and Xilinx have both announced their intent to offer ODI-compliant Interlaken cores for their FPGAs.

Packets play a critical role in ODI. They envelope the data payload that contains single channel or multi-channel sample data. Consecutive packets are sent to stream data. Data is stored as packets. Packets enable error recovery from an outage, such as could be caused by an electrostatic discharge. Packets allow port aggregation, the combining of ports to achieve proportionally higher data rates.

ODI has adopted the VITA 49 family of standards for packet definition. VITA is a trade and standards organization well known for its VME and VPX standards, common in many mil/aero embedded applications. VITA 49.0 is titled as the VITA Radio Transport (VRT) specification. VRT defines common packet formats and protocols for software defined radios, but is applicable for sending any sampled data or block data.

You can see how the three layers map into the three ODI specifications. ODI-1 is the physical layer, which combines the optical layer and the protocol layer. ODI-2 introduces packets and port aggregation. With ODI-2, block data of any format may be sent between devices. Finally, ODI-2.1 defines the actual data formats for the sampled data. ODI-2.1 focuses on 8-bit to 16-bit real and complex binary data, the most practical resolutions for high-speed transfers.

VRT packets on top of optics create a remarkable opportunity. According to VITA Executive Director Jerry Gipper, the VITA Radio Transport standards define packet structure and formatting for a wide set of software defined radio and mil/aero applications. With its adoption by the test-an--measurement industry, VRT has expanded its reach, which sets up numerous opportunities for synergy. Gipper also noted that there is no apparent reason that ODI couldn't be adopted by the embedded industry as well. Thus, ODI could be as applicable to operational systems as to instrumentation systems. ODI delivers high-speed sampled data in an industry standard software defined radio packet structure, so why not?

Imagine the possibilities for synergy. Instruments and operational systems sharing the same interfaces and data formats. Don't have the RF front end yet for your embedded design? Don't wait. Grab your ODI-capable digitizer or oscilloscope and stream the data into your prototype. Have an embedded processor design, but no RF output stage? Connect your embedded processor to your ODI-capable arbitrary waveform generator (AWG) and generate the signal. Need some real-world signals to test your design? Record them from a RF digitizer to a storage array using ODI, and then play them back using an ODI-capable signal generator.

Speaking about applications, let's review a few.

Applications

ODI may be used whenever fast real-time data needs to be transferred from one device to another. But what are the applications driving it?

Figure 3 is a map of all electronic measurement and embedded system applications. The horizontal axis denotes industry of the end user, while the vertical axis denotes the life cycle of the application. The center "gray" region is traditional test and measurement market. Red indicates areas directly addressed with ODI. Orange indicates segments with upside potential.

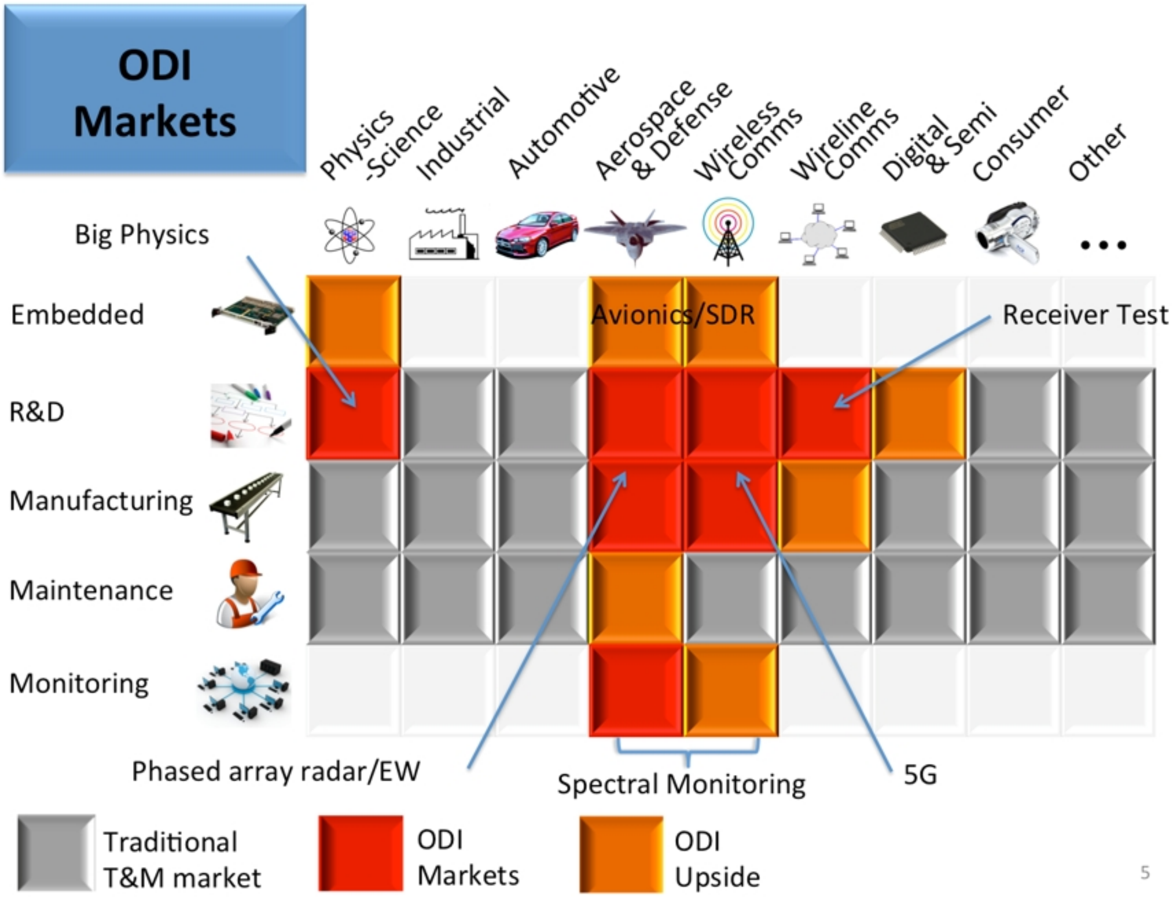

Figure 3. ODI has the potential for use in applications beyond test and measurement. Source: Modular Methods.

Fig. 3 is a template I've used before, segmenting the embedded and test industries. The red areas show ODI's principal markets, whereas the orange areas show applications with significant upside potential. The key applications are:

- **5G.** If there is a single application driving ODI, it is 5G wireless communications. With 20 GBytes/s of bandwidth, ODI can easily transport 5G IQ (in-phase/quadrature) signals, real or complex. VRT packets are optimized for radio communication, including timestamps, RF-oriented context packets, and event signals. Instrument architectures are morphing to data streams driving sophisticated signal processors. ODI has the bandwidth to enable that transition. Signal generators can use the flow control features of ODI to modulate the speed of the incoming data, allowing the generation of a continuous low-phase-noise signal.
- **Phased-array radar.** In many ways, phased-array radar mimics the issues of 5G multiple channels at high-bandwidth. Multiply the number of channels by their individual bandwidths, and the data link restraints become apparent. In fact, anything with beamforming can benefit from ODI, as the parallel signal channels are kept time-aligned through the ODI packet structure, even if sent over different ODI ports.
- **Wireline receiver test.** Looking for long patterns to send to a digital receiver under test? Typically, this is done through BERTs and AWGs. Now, with ODI, data may be streamed continuously from a storage device to an AWG to create very long test patterns, even patterns that have been recorded.
- **Big physics.** High-energy physics continues to be a massive generator of data during an experiment. The high speeds of the data acquisition, combined with the number of channels, collude to challenge electrical interface designs. ODI's bandwidth solves this problem. VRT packets are just as applicable to any sample data as they are to radio applications. With just 32 bytes of overhead for packets as long as 256 Kbytes, the VRT overhead is miniscule.

- **Spectral monitoring.** Whether you are a regulator of spectrum, or monitor the airwaves for any number of other security reasons, continuous spectral monitoring key. Most applications involve streaming real-time spectral data to a storage system continuously, until an event occurs. As in the applications above, electrical interconnects are doomed to deal with the necessary bandwidth. With ODI, data is streamed optically to the storage unit. Embedded timestamps can give the precise time of day of an event.
- **Embedded designs.** As stated earlier, VRT packets were invented for embedded designs. Now, instead of cobbling together some 10GbE links or custom interfaces, there is an open system interface that can transport at the speed required.

ODI equipment manufacturers
The ODI announcement included three instrument vendors declaring their intent to build ODI capable devices- Conduant, Guzik, and Keysight. The announcement serves as an invitation to others to join the standard.

Figure 4 shows the first ODI products to be announced. The [Guzik ADP7104](#) AXIe digitizer, on top, has four ODI ports shown in the lower right corner of the module. The product can stream two channels, each at 10-bits and 32 Gsamples/s, continuously to the DP7000 digital processing modules shown underneath. The entire system is integrated into a Keysight AXIe chassis. Total bandwidth: 640 Gb/s.

Figure 4. Guzik is the first company to announce a test product with an ODI interface. The AXIe module has four ODI ports for data and one for control signals.

The Guzik ADP7104 AXIe digitizer's 640 Gb/s matches nicely with the four ODI ports. The digitizer can stream continuously to the two digital processor units underneath. Applications include direct RF sampling, 5G test, radar test, and advanced communications research.

The ODI standard is in a great place to be considered by other vendors. It leverages common industry technology, such as the optics, Interlaken, and VITA 49. It is open to all vendors, without license fees or royalties. There is no equivalent standard it is competing against. The early timing of the announcement gives none of the current vendors a significant head start.

As the chairman of the ODI Technical Committee, I invite all interested organizations to join and develop ODI products. Whether you build bench instruments or modular products, embedded systems or instrumentation, ODI is a way to break through the tough data bandwidth issues that are plaguing you now, and will be in the future. Our combined customers want a single, easy to use solution.

The light at the end of the tunnel truly is light. Please join me in welcoming the Optical Data Interface.

Larry Desjardin *is a regular contributor to EDN's Test Cafe. He served in several R&D and executive management positions with Hewlett-Packard and Agilent Technologies, and current manages a consulting company, Modular Methods. He is chairman of the AXIe Technical Committee that specified the ODI standard.*

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