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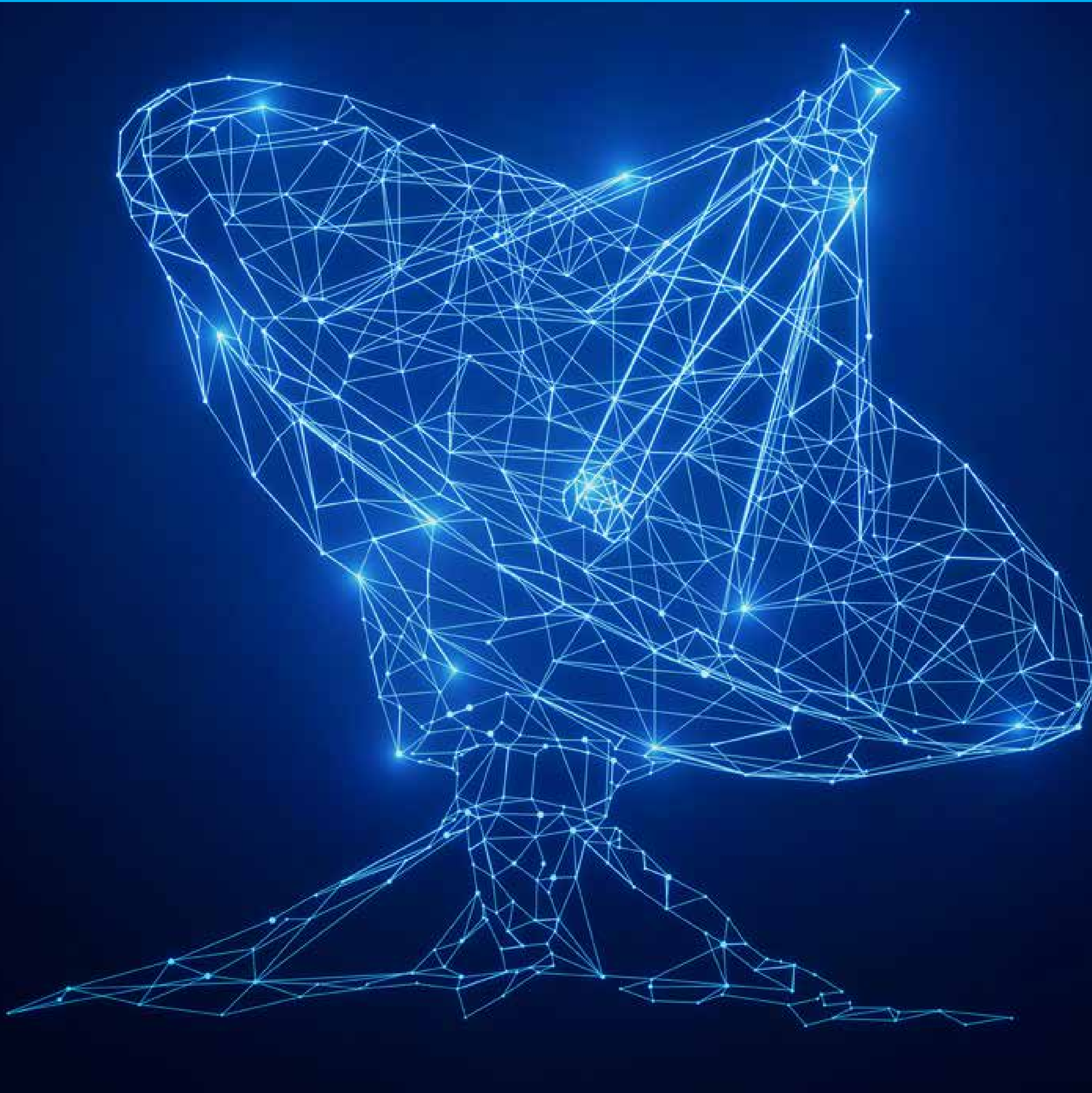
ETHERNET PACKET CAPTURE • RECORD • PLAYBACK

TECHNICAL BRIEF

Packet-based digital radios and Ethernet recording

Digital radios and the case for high-speed
Ethernet packet recording before signal processing

"There's an army of advanced wideband RF receiver manufacturers in the world and most of them feature streaming digital radio packet output capabilities."



Contents

The RF-digital receiver

There is no surprise that the end-to-end analog receiver (i.e, analog RF-in to analog IF-out) would necessarily evolve and feature digital frequency-output capabilities (i.e., analog RF-in to digital IF-out)

Figure 1. A typical VPX digital wideband receiver

Therefore, the development of the modern digital receiver as an integrated RF tuner and digitizer combination. These products effectively brought the analog world into the digital domain for reliable signals transport and advanced signal processing-scheme opportunities.

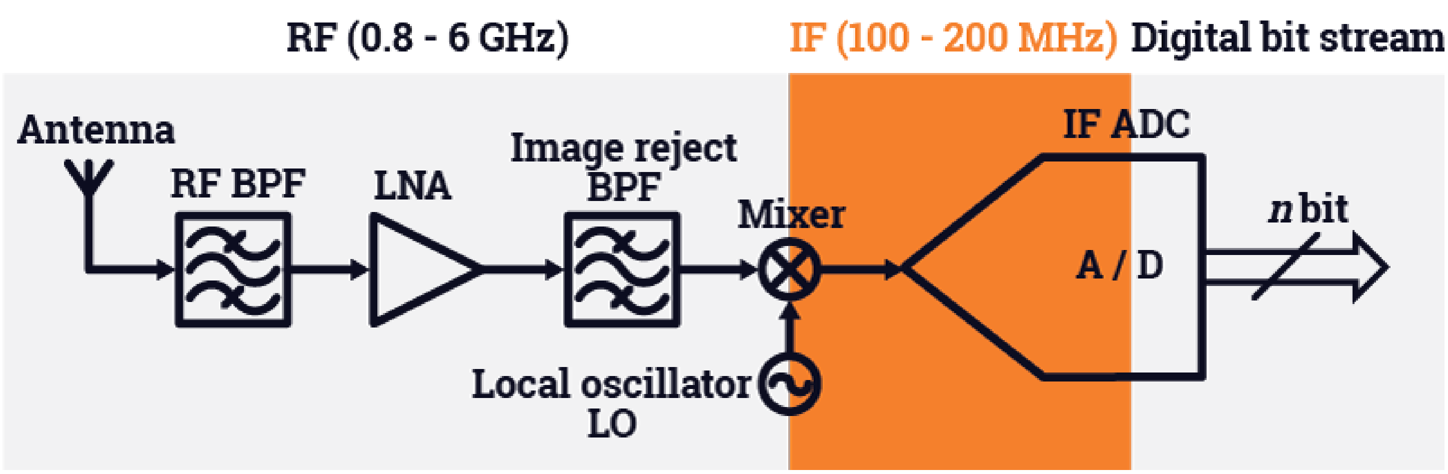


Figure 2. General architecture of wideband RF receivers

Digital radio
+ digital signal processor
= software-defined radio

The average consumer enjoys the power of the software-defined radio (SDR) in their pockets or as a technology that's embedded within their home entertainment systems.

Figure 3. Software-defined radio examples in common consumer electronics

SDRs enable both smart phones and cable television appliances to offer advanced personal communication and entertainment experiences from the information the devices receive by radio. This is because the information encoded upon these signals can be easily manipulated within the digital domain, as opposed to dealing with radio signals in their respective analog formats. There is also the reliable nature of digital communication systems, in that data can be transmitted over long distances with a very high level of accuracy and nominal precision.

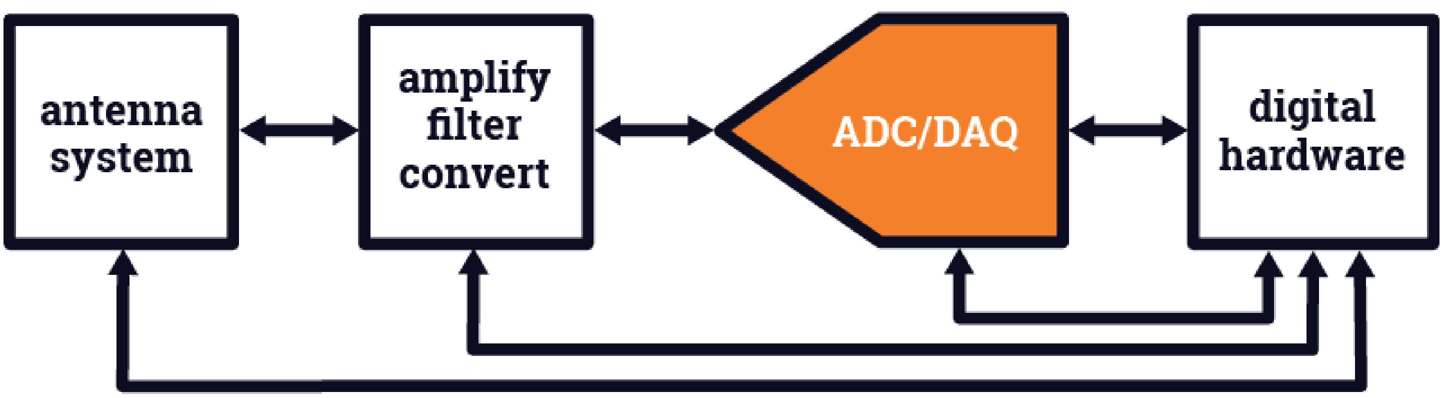


Figure 4. Software-defined radio transceiver diagram

The central component responsible for this technical wizardry is called a digital signal processor or DSP. It is a type of computing device/system that is relevant to many industry applications, including the development and production of military and security systems. A DSP system may be utilized to turn digitized RF spectrum information into critical, real-time intelligence that can give a security force a tactical operational advantage against lethal threats. In other cases, signal processing is a near-real-time or post information collection process that can be used for strategic defense planning and operations.

Digital radio with IF/baseband output, VITA 49 and Ethernet

Analog receivers feature RF inputs and circuitry that facilitate signal mixing, tuning, filtering, and RF-IF conversion. The signal output from these receivers is typically a set of analog components that are manipulated and centered around a manageable frequency; otherwise an Intermediate Frequency (IF) or a signal at baseband is employed. It is then the job of a high-speed digitizer – external or integrated – to convert the analog signal into a digital format.

There's an army of advanced wideband RF receiver manufacturers in the world and most of them feature streaming digital radio packet output capabilities. The steaming data they produce is transmitted in various formats and over a handful of data input/output interfaces with their associated physical transport layer-types. Examples include legacy Serial Front-Panel Data Port (sFPDP) and Serial RapidIO (sRIO) network technologies. The problem with many of these data transport schemes is they were often expensive and featured proprietary and exotic data formats.

A universal digital radio transport standard

Enter the VME bus International Trade Association (VITA) and the VITA Radio Transport standard (VRT/VITA 49.0 or VRT) that includes a packet-radio protocol for use across many digital receiver and signal processing products. VRT effectively provides system interoperability and sustainability (e.g., maintenance and upgrades) through packaging and transporting both RF signal information and context metadata in a uniform data structure.

Standard VRT/VITA 49.0 metadata examples.
Device Identifier
Bandwidth
IF Reference Frequency
RF Reference Frequency
Gain
Sample Rate
Formatted GPS (Global Positioning System) Geolocation
State and Event Indicators

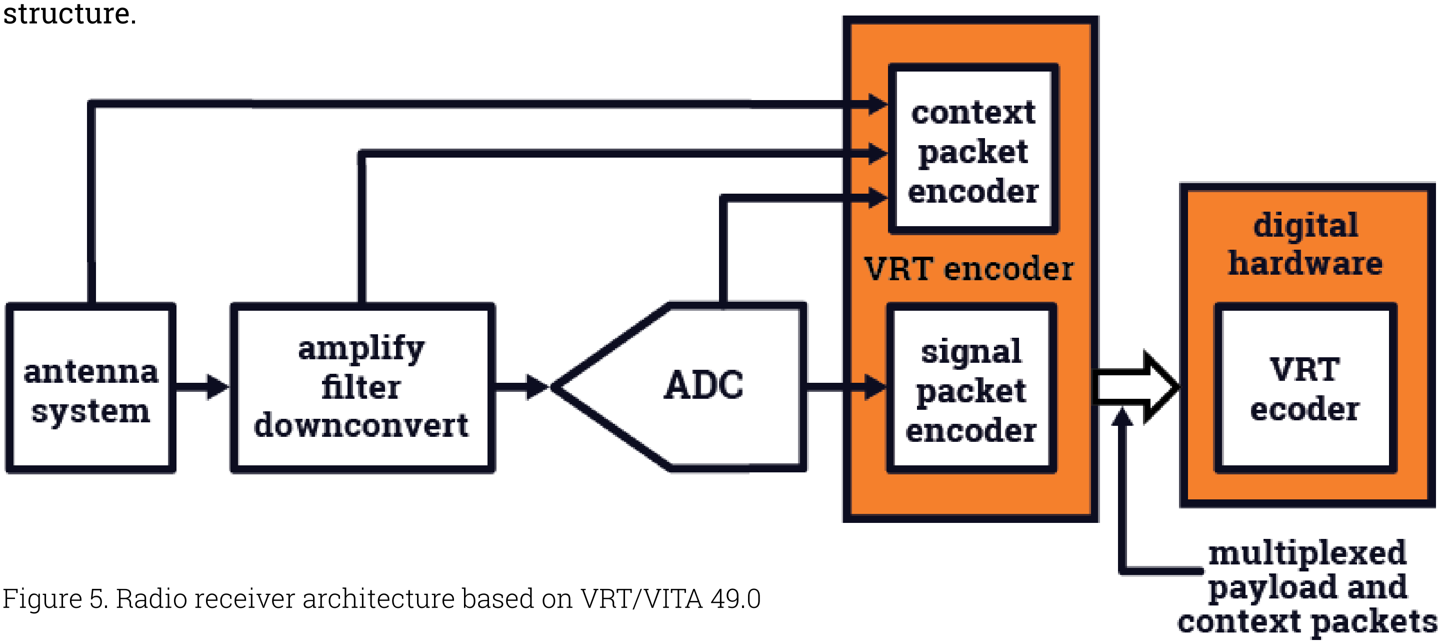


Figure 5. Radio receiver architecture based on VRT/VITA 49.0

But the VITA 49 standard does not specify a technique to carry VRT packets. As a result, most digital radio and peripheral manufactures have opted to implement inexpensive but very capable Ethernet technologies for radio packet transmission.

Signal process now, a little later, or much later: the case for Ethernet-enabled digital radio recorders

The obvious opportunity Ethernet brings to both digital receivers and software-defined radios at large, is the ability to dynamically route radio packets to processing systems via commercially available Ethernet equipment. In most cases, standard Ethernet protocols such as TCP, UDP, Multicast, and other schemes are utilized. And with more digital radio vendors producing products with larger spectrum bandwidths and RF channel densities, today's Ethernet is ready with the ability to handle radio data-throughput rates up to 100Gbps.

A consequence of the greater data-rate capacities is that it produces very large data sets that computer systems will ultimately be required to crunch. But throwing a "bigger wrench" at this problem is neither a clear nor practical solution. A DSP system's processing power is nominally proportional to its size, weight, power-consumption, and cost (SWaP-C) specifications.

Signals recording and archiving for post-processing

Be assured that given any supercomputer, large amounts of In-phase and Quadrature (I-Q) signal-data can be processed and then produce the most mathematically intensive real-time Falling Raster spectrum displays. But in most cases, installing a supercomputer aboard a SIGINT aircraft becomes impractical. Using this case-example, a better solution alternative is to integrate and deploy a low-cost Ethernet recording system for off-location, signal post-processing (e.g., long-term or archive data storage).

Near-real-time signals processing

In sticking with the airborne signals collection platform example; there is also a near-real-time processing opportunity where onboard DSP resources are limited. A recorder can have its recently stored radio data drawn when signal processors are either busy or temporarily offline. The recorder effectively functions as a very large circular buffer, enabling "radio spectrum time machine-like" capabilities.

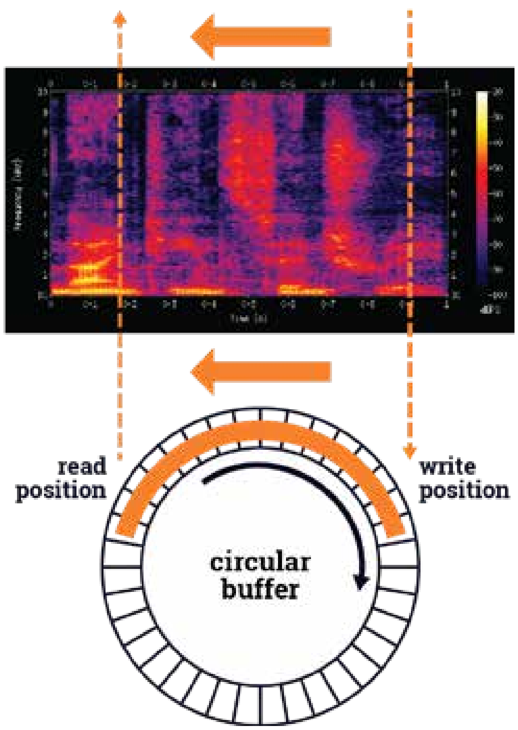


Figure 6. A "spectrum time machine" enabled by a circular buffer with dynamic data reading

Figure 7. VITA 49 recorder between digital radio source and back-end processor

Agnostic Ethernet packet radio recording from Layer-2

The utilization of a protocol agnostic Ethernet recorder would also be wise to assure compatibility with any digital radio manufacturer utilizing either proprietary or VITA 49 data formats.

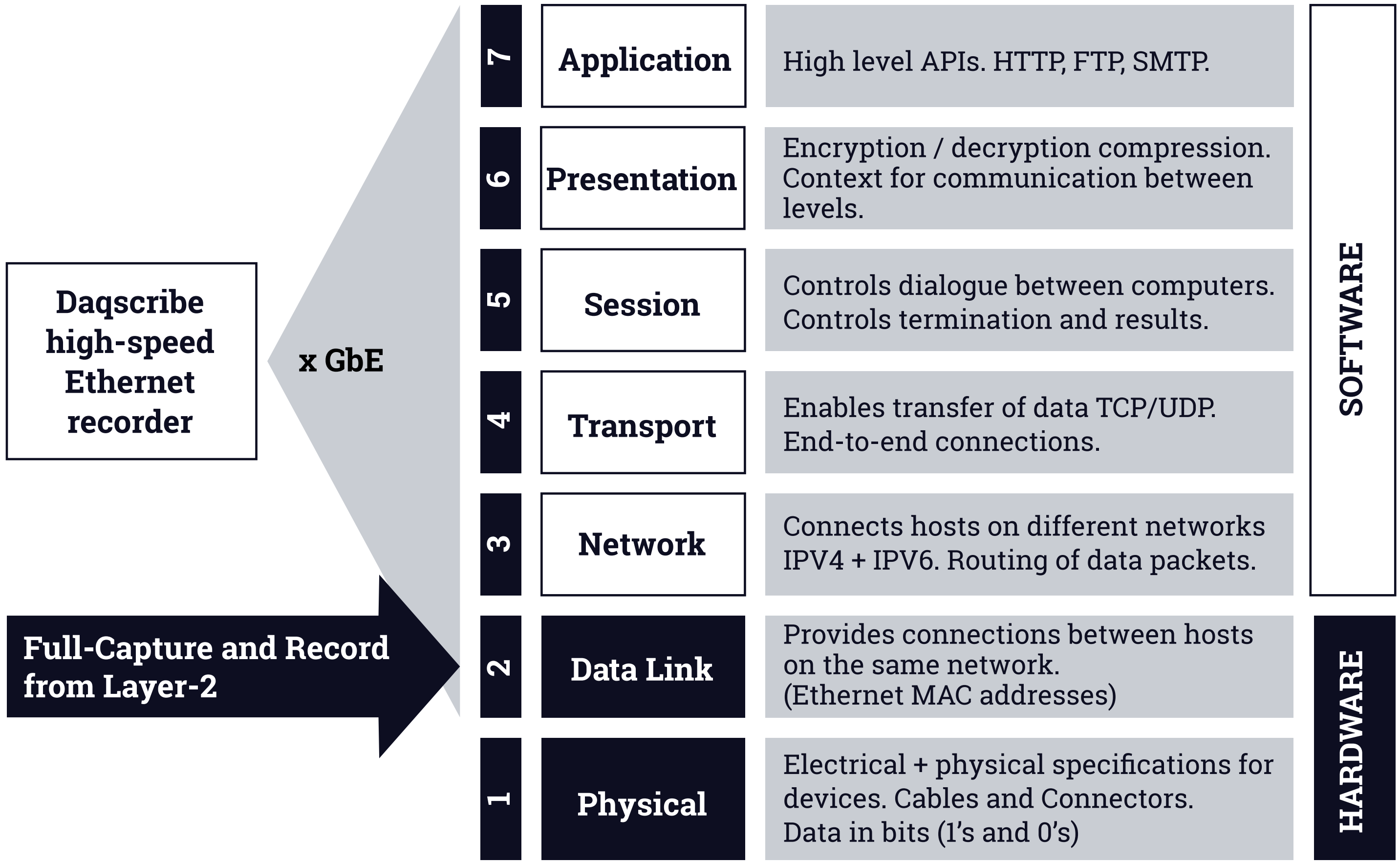


Figure 8. protocol agnostic digital radio recording from **Layer-2**

In the case of proprietary radio packet recording, the system should grab Ethernet data from Layer-2 (closest to the hardware layer) of the Ethernet stack, as opposed to just capturing specific application or protocol layers. In all, an Ethernet recording solution should assure 100% packet capture and recording of the streaming data at the full-rate of the radio's data-ports.

Storage and data offload

A robust and reliable Ethernet packet recording system should recruit the best data storage options available. This often means using enterprise solid-state drives (SSDs) with a significantly higher performance than the common commercially available SSDs and HDDs.

A well-designed high-speed recording system will also need to monitor and manage the use-cycles of its storage devices. For example, it is important to assure that data is written evenly across both the logical storage volume and its individual SSD devices. The goal is to effectively optimize and extend the life of the otherwise expensive storage devices. A periodic status check of the drive's temperature and read/write history is also useful in determining the readiness of the recorder's critical storage system.

Today's Ethernet recorders offer scalable storage capacities in the hundreds of terabytes; petabyte storage recording systems have recently become available on the market. But the obvious problem in the real-time and continuous data recording world is the transferring of large amounts of data from the system.

Many high-speed recording manufacturers accomplish this with one or two options.

- Removable Storage (e.g., removable disk packs)
- Incorporated high-speed network interfaces featuring 10GbE, 40GbE, and 100GbE-links

Another alternative most recorder manufacturers make available to systems engineers is the ability to mount the recorder's standard file system (i.e., NFS) for limited, but direct access to data that external processors demand.

Data processing choices

In typical cases, data is transferred or removed from the recorder to external data processing systems. However, advanced Ethernet recorders now feature onboard, user-available data processing resources. Systems architects and engineers wishing to implement relatively simple data processing schemes closer to the radio/sensor interfaces will find value in options for additional CPUs, GP-GPUs, FPGAs, and memory on the high-speed packet recording platform.

Figure 9. A full rate 40GbE Ethernet record and playback system by **Daqscribe**

Ethernet packet radio playback

A digital radio recorder should also have an option to accurately playback data to peripherals that could benefit from the direct injection of previously recorded packet data. For example, digital RF transceivers that feature DACs and/or up-conversion capabilities could be utilized to create unique RF stimulation and simulation systems.

Conclusion

Modern wideband receivers and radios have implemented RF-to-digital output capabilities. Manufacturers implemented various data transport schemes, including VITA 49 and they have wisely chosen Ethernet as the best physical data interconnect technology.

Faster digitizers and high-speed Ethernet links have created opportunities for both wider instantaneous bandwidths and increased channel capabilities. But It is not always practical to have large and expensive computer systems onboard SWaP constrained platforms.

A relatively low-cost, high-speed Ethernet recording system is a reasonable alternative when and where near-real-time or post signals processing can be implemented in the information operation production process.

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Release: 08/10/2020

Innovated and produced in the U.S.A

Daqscribe is a provider of high-performance computers (HPC) and full-rate Ethernet packet capture, record and playback solutions, without any loss of data, compression or filtering.

From the defense to automotive industries, from aerospace to atmospheric science research, and from LTE to 5G, you can rely on high-speed network recorders by Daqscribe.