Part 1 - Enabling Technologies

Introduction

Modems for RF communications have traditionally performed their analog and signal processing in custom hardware and firmware. New technologies are enabling software modems to replace these legacy point-solution modems.

In the 1970s and 1980s, modems for satellite telemetry, ranging, and commanding were implemented as multiple hardware boxes. There were separate physical units for the RF converters, receiver, demodulator, bit synchronizer, frame synchronizer, command formatter, baseband modulator, and IF modulator.

In the 1990s and 2000s, the 70 MHz Intermediate Frequency became standard, and modems consolidated many of these functions into a single box. Hardware boards replaced the hardware boxes. They performed the signal processing with analog circuit cards, backed by FPGAs that implemented the digital signal processing. The modem's software provided little more than the user interface and the network connection for data, monitor, and control.

As more and more of the functionality migrated to the FPGAs under control of the software, these modems became known as software-defined modems, where the software "defined" what FPGA functions would be used to implement the modem.

Today digital IF, waveform-agnostic signal converters, multi-core processors, and waveform-specific applications are making possible true software modems.

Digital IF

Digital IF allows the majority of that hardware and FPGA firmware processing to be replaced with software. This has key advantages, but first let's explore what Digital IF is.

IF is short for Intermediate Frequency. Rather than having an RF or 70 MHz analog signal as the intermediate frequency, Digital IF provides a digitized sample representation of that same signal. The digitized samples can then be processed entirely in software.

In addition, transport of the digitized samples can be over a much longer distance than a traditional RF or baseband analog signal. A Digital IF interface can flow via Ethernet, whether that be a local area network or possibly even a wide area network. Fiber optic cabling and network routing can replace RF cabling and switching.

There are some important reality checkpoints. The digitized samples must be at a frequency and resolution that is sufficient to reliably perform the digital signal processing. For example, 40 Msamples/second at 12-bits each may be required to processing a 5 Mbps telemetry downlink with 10 MHz of bandwidth. So, there's high throughput and high network loading that most often requires the network connection carrying the Digital IF be dedicated.

Signal Conversion

With Digital IF, there's still hardware that performs the analog signal to digital sample conversion for received links and the digital sample to analog signal conversion for transmitted links. The Signal Converter has RF or IF signals on one side and Ethernet interfaces on the other.

With a true software modem, the Signal Converter is "waveform agnostic." Waveform agnostic means that it requires no knowledge of the type of modulation and demodulation. To it, all signals are the same. Any waveform-specific processing is performed in the software that's across the network.

Signal converters that are waveform agnostic can be deployed in any satellite ground system, supporting the waveforms of current and future unknown satellites.

Multi-Core Processors

Processing MBytes of sample data every second and doing the complex computations needed for a software modem is no small task. It's one that would swamp most computer systems prior to a few years ago. But the multi-core processors in today's high-performance, low-cost servers have changed all that.

Multi-core processors are advantageous for signal processing in several areas. First, there's their sheer performance when doing floating-point arithmetic. Second, the multi-core processors include instruction primitives that speed up the sophisticated math even more. Third, processing tasks can be assigned to a core and that core dedicated to that task. This is important for tasks that require near real time execution and/or have high throughput requirements. GPUs enable even more high performance processing.

Getting all of this power and functionality in a commercial, low-cost server has enabled the software modem.

Part 2 - Implementation Benefits

Waveform-Specific Applications

Many previous generation modems combined FPGA firmware and software. These modems are configurable in that the modem's processing can be configured for the waveform, data rates, data formats, and other parameters. But they are essentially a monolithic firmware/software implementation that has all of the features and functions in one hard-to-manage configuration. These are software-defined modems and they necessitate a long regression test period with each new release.

True software modems are implemented with separate software applications for each unique waveform. In other words, there's an application specific to a type or family of spacecraft. This has the advantage of allowing customers to only deploy the waveform applications they need and update them as needed. An App is started and stopped for each contact.

These "smaller" Apps are independent, and thus more reliable, more mature, and easier to manage. Plus, adding a new waveform-specific App does not invalidate any of the existing Apps.

Reduced Life Cycle Costs

True software modems are dramatically reducing the up front and on-going costs of the modems used for satellite telemetry, ranging, and commanding.

Hosting the Apps on commercial servers has two cost benefits. First, the initial cost is much lower than the custom industrial computers that are often used with point solution modems. Second, the software Apps can be easily migrated to new server platforms, eliminating the need to replace/repurchase the full modem.

The up-front costs are also lower because the vendor cost to produce and support the products are lower. They may also be lower because the satellite operator only needs to purchase the waveform Apps specific to their satellites.

Can we help? AMERGINT's expertise is available to assist in your systems engineering and design

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