Meeting Military Data Signal Analysis Imperatives

Embedded Tech Trends
January 2018

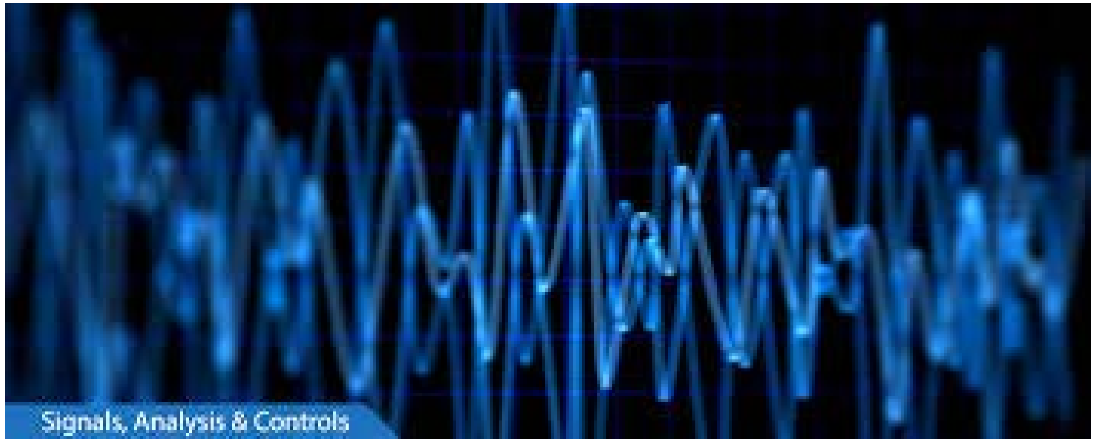
Roy Keeler, Sr. Product and Business Development Manager Aerospace & Defense

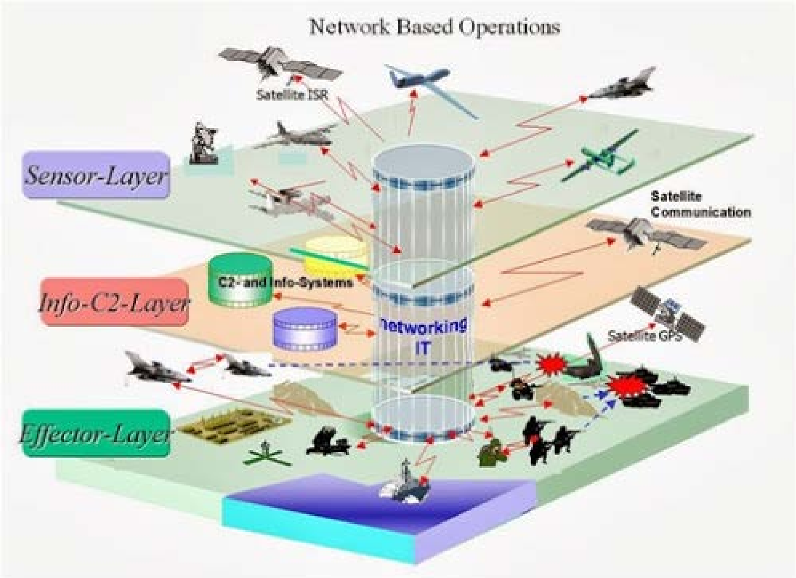
ADLINK

Leading EDGE COMPUTING

Meeting Military Data Signal Analysis Imperatives Solutions

In 21st century electronic warfare, one of the most decisive factors behind victory is the ability to aggregate massive amounts of data and process those streams into insightful, actionable outcomes. Data processing can distinguish between noise and a viable target, and the speed of that processing can mean the difference between real-time intelligence and missed opportunities.



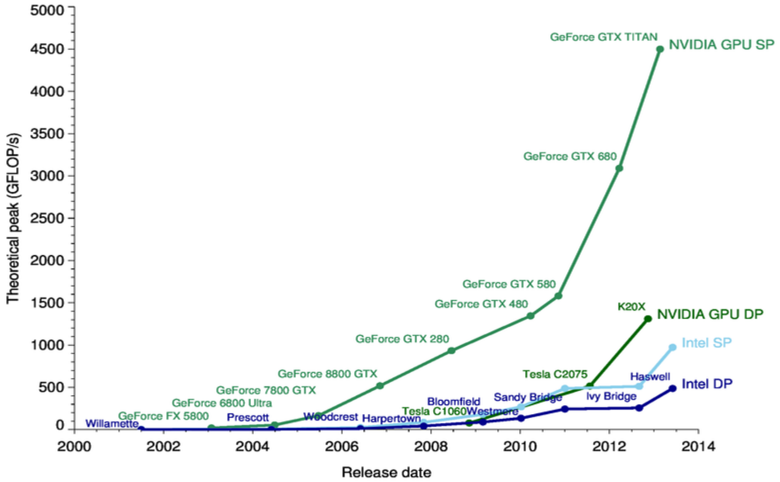


Obstacles in Military Signal Processing

Speed Bump

Over 15 years ago, Intel and other CPU manufacturers realized that the race for raw speed, as measured in megahertz, was destined for failure. At roughly 4 GHz, processors encountered a ceiling at which heat began to cripple performance. Multi-core processors arose to address the problem, essentially harnessing multiple smaller engines that could collectively outperform a single large engine.

"…we hit the era of what I'm calling Peak MHz in about 2004. That's the point when processor speed effectively peaked as chip manufacturers began competing along other dimensions."
—Mike Kuniavsky, http://sta.mn/5cm



Not surprisingly, GPU chips soon followed CPUs in the shift to efficiency over speed, with NVIDIA starting around 2010 to discuss performance in terms of gigaFLOPS (floating point operations per second) per watt.

Obstacles in Military Signal Processing

Size does matter

- Size considerations are also inextricably tied to power. Throughout the military, missions increasingly revolve around command, control, communications, computers, intelligence, surveillance, and reconnaissance (C4ISR) capabilities being stuffed into vehicles from bombers to scouts

- Demands for nimbleness and mobility dominate field work, and the weighty rack mounted, generator-driven systems of yesterday are quickly giving way to small form factor (SFF), battery-optional solutions able to fit under a seat

- This leads to additional concerns with designs being able to withstand the shocks and vibrations of field use

- Military solutions for signal analysis must address all of these variables within the context of given applications. Taking GPGPU as the most efficient solution available today for signal analysis, both in terms of raw performance and power dynamics, we will now examine four particularly promising areas for military GPGPU adoption: radar, communications, sonar, and image processing

The Demand for Increase Process Power

WESCAM's MX-25D imaging sensor for airborne targeting

- Simultaneously supports six sensors
- HD imaging resolution from Electro-Optical (EO) and Infrared (IR) cameras
- Real-time image enhancement for EO day, EO night & IR
- Long-range target Illumination
- Pointing and Range-Finding
- Automatic video-Tracking and GEO-Tracking
- 720p and 1080p cameras

Imagine the data load from next-generation pods based on 4K imaging or 360-degree virtual reality capture systems that might incorporate well over a dozen cameras per pod. Depending on the application and situation, several such sensor clusters might be pooled into a central data pool for analysis, compounding the analysis load by many times.

Picking the Processor

Generally speaking, processors for such tasks fall into three groups:

- Central processing units (CPUs), also known as general-purpose processors (GPPs). In the server arena, Intel’s Xeon processor family has long dominated the field. CPUs excel at tackling a broad range of task types in an ad hoc or randomized fashion
- Graphics processing units (GPUs) arose from 1970s arcade gaming roots. In the early years of the 2000s, NVIDIA and then ATI developed methods for running small on-GPU programs for individual pixel computations. This quickly evolved into parallel “stream processing” across many logical cores within the GPU
- Field-programmable gate array (FPGA) processors are designed to be configured by customers or integrators subsequent to manufacture (thus being “field-programmable”). The many logic blocks within FPGAs can perform complex combinational problems, tackling virtually any problem

GPGPU

Why GPGPU?

All three of these processor types are used extensively throughout the military, but for real-time signal processing and analysis, GPGPU solutions offer the best combination of value and benefits in an increasing diversity of scenarios. Other GPU advantages include:

- Large video memory bandwidth for keeping large problem computation closer to the main processor
- Comparatively strong floating point computation performance
- A multi-core architecture in which most chip silicon is devoted to computing units, not cache, which further aids highly parallelized data processing
- Relatively easy programming via high-level languages (CUDA, C, C++, Python, etc.)
- OpenACC and OpenCL support for shorter iteration cycles in algorithm transplants
- Higher computing power efficiency relative to CPU-only computing

In short, GPUGPU architectures excel for applications that benefit from massively parallel processing of large data volumes and/or arithmetic-intensive computing, particularly involvir multiple calculations based upon a single memory visit.

Radar Processing

- Synthetic aperture radar (SAR), phased array radar, and hybrid radar systems pervade military information gathering
- Applications include:
  - air-defense systems
  - antimissile systems
  - marine radars to locate landmarks and other ships
  - aircraft anti-collision systems
  - ocean surveillance systems
  - outer space surveillance and rendezvous systems
  - altimetry and flight control systems
  - guided missile target locating systems

Radar Processing

ADLINK GPGPU-based products provide high tech radar systems with digital signal processing and machine learning capabilities able to extract useful information from very high noise levels. These products include:

- **VPX3010** - The VPX3010 processor blade features three CPU options: the Intel Xeon D-1559 (12-core, 45W TDP), Intel Xeon D-1539 (8-core, 35W TDP), or Intel Pentium D-1519 (4-core, 25W TDP)

- **VPX3G10-R/A** - The 3U VPX3G10 GPGPU blade embeds 2GB of dual-channel GDDR5 memory alongside the NVIDIA GeForce GT 745M GPU

- **VPX3G20** - The 3U VPX3G20 is the next gen GPU blade from ADLINK utilizing the NVIDIA Quadro GPGPU with 6GB DDR5 memory and Gen 3 16-lane PCIe interconnect

- **cPCI-6630** - For various reasons, including legacy investment support, some solutions may fare better using CompactPCI rather than VPX. Like the VPX3010, the ADLINK cPCI-6630 offers a high-performance foundation for radar processing systems

Sonar Processing

- Within the sonar sphere, digital signal processing can extend to analysis of signals from towed and fixed acoustic arrays, sonobuoys, torpedo guidance, and other systems
- Applications include the MK-48 torpedo, the Poseidon P-8, and autonomous underwater vehicles (AUVs)
- ADLINK's broad range of GPGPU products provide sonar receiver designers with multiple processing options based on size, weight, and power consumption (SWaP) considerations. A sampling of these include:
  - **VPX6000** - When SWaP priorities allow for more leniency in form factor, the 6U VPX form factor tends to deliver the most compute performance per rack unit for GPGPU applications. ADLINK's VPX6000 harnesses up to two Intel Core i7-4700EQ (4-core, 47W TDP), providing significant processing horsepower that remains within the bounds of conduction-based cooling
  - However, as the Core i7 only provides integrated Intel graphics, a companion GPU card is still required for a full GPGPU solution in the **XMC-G1050TI**. ADLINK's **XMC-G1050TI** features 4GB of surface-mounted GDDR5 memory around an NVIDIA GeForce GTX 1050Ti GPU (Pascal architecture, 768 CUDA cores)

Image Processing

High Power Embedded Real-time Computing (HPERC)

HPERC-MH

HPERC-MC

Image processing methods perform operations to enhance an image and/or extract useful information from it. Applications include pattern of life analysis, surveillance, reconnaissance, target identification, and geolocation in GPS-denied areas

ADLINK's HPERC (highly ruggedized, MIL-SPEC SFF systems) and GPGPU products, coupled with NVIDIA's CUDA graphics processing and the OpenGL API, provide solution engineers with powerful COTS (commercial off-the-shelf) products with which they can design the next generation of image processing systems.

Sample products include the aforementioned VPX3G10, XMC-G1050TI,

and others, including:

- **HPERC-IBR-C** - Designed for Extreme Rugged temperatures from -40˚C to +85˚C, the HPERC-IBR-C measures only 223.65(L) x 177.8(W) x 68.7(H) mm with mounting brackets and weighs just over 3 kg
- Via the MXM, users can opt for ADLINK's NVIDIA GT 745M GPGPU with 2GB of GDDR5, making this a remarkably compact, highly versatile option for fast image analysis, particularly in remote and/or mobile settings

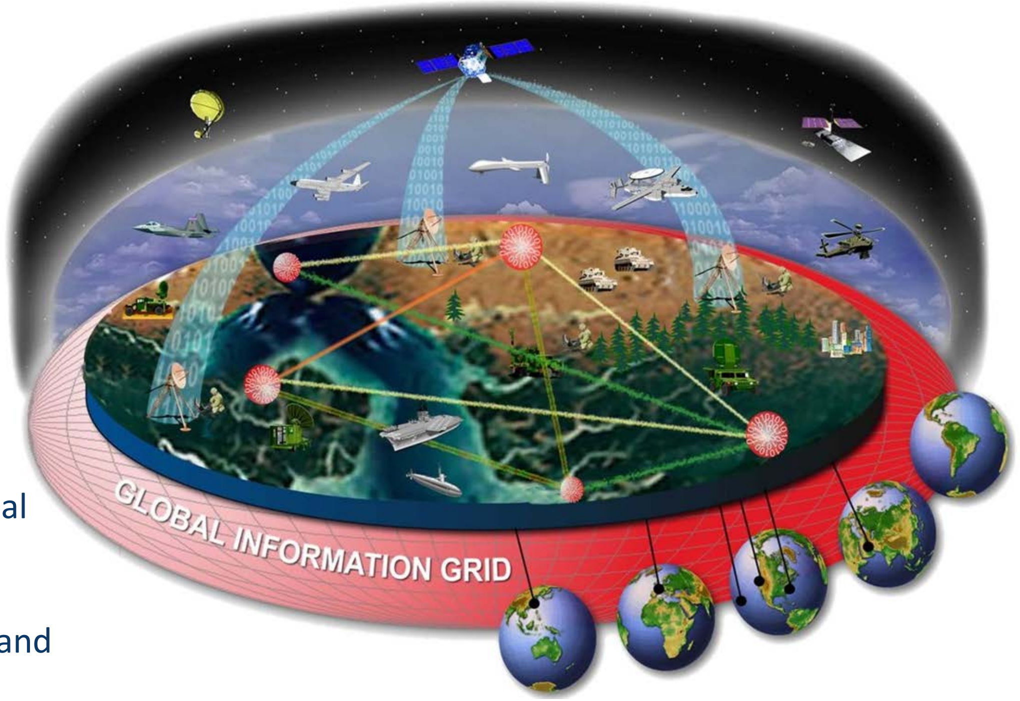
Communications Systems

Network-Centric Warfare

- **Net-Centric Warfare (NCW) is driving shift in military culture towards interconnected units operating cohesively**

- **Global Information Grid (GIG) is an all encompassing DoD communications projects**

- **The GIG and NCW tenets:**
  - Robustly networked force improves information sharing
  - Information sharing enhances the quality of information and shared situational awareness
  - Shared situational awareness enables collaboration and self-synchronization and enhances sustainability and speed of command
  - Speed of command, in turn, dramatically increases mission effectiveness

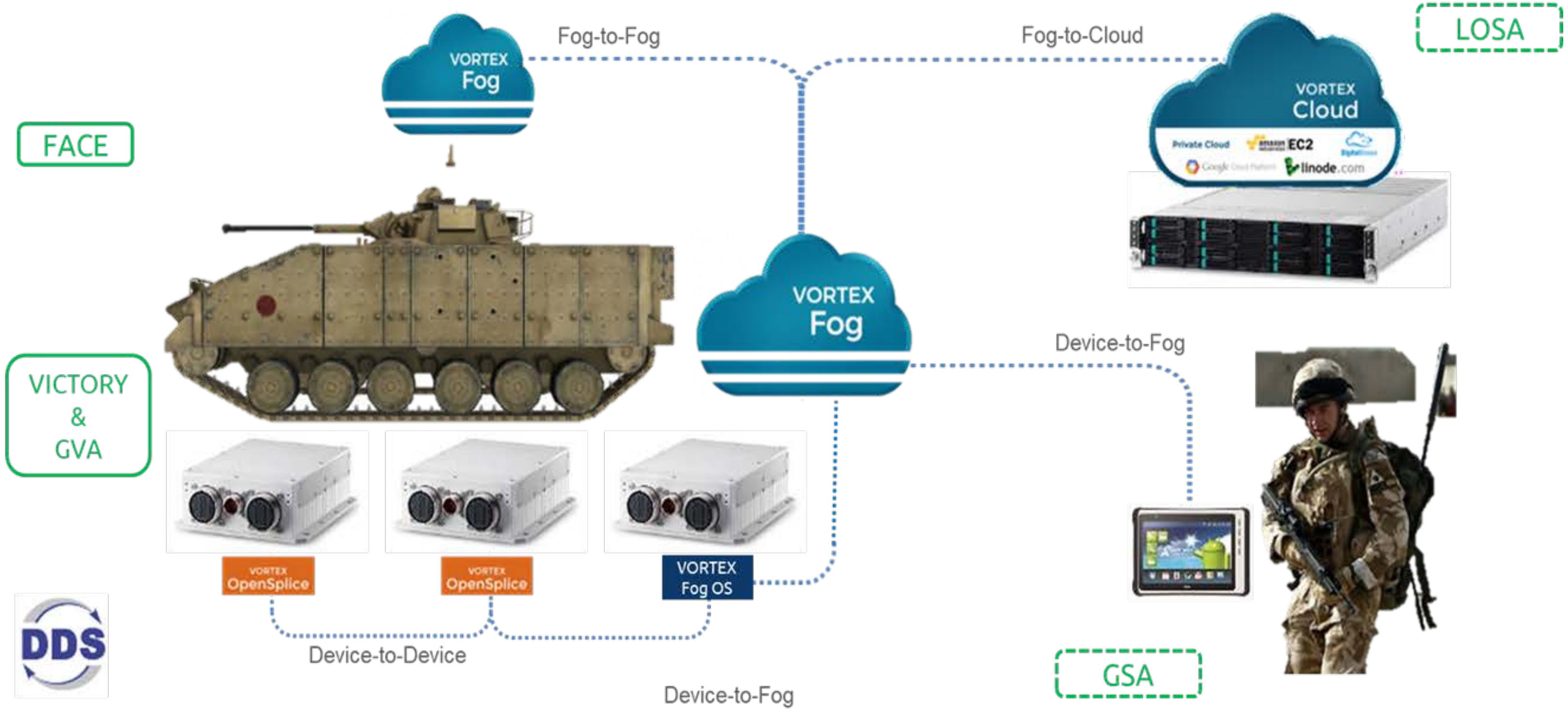


"The right data, at the right place at the right time"

Communications Systems

The Key Elements of Cloud Architecture include:

- **Forward Deployed**
- **Discoverable**
- **Users are able to access applications**
- **VM Machine based**
- **Can operate disconnected**
- **Middleware for Data-connectivity**

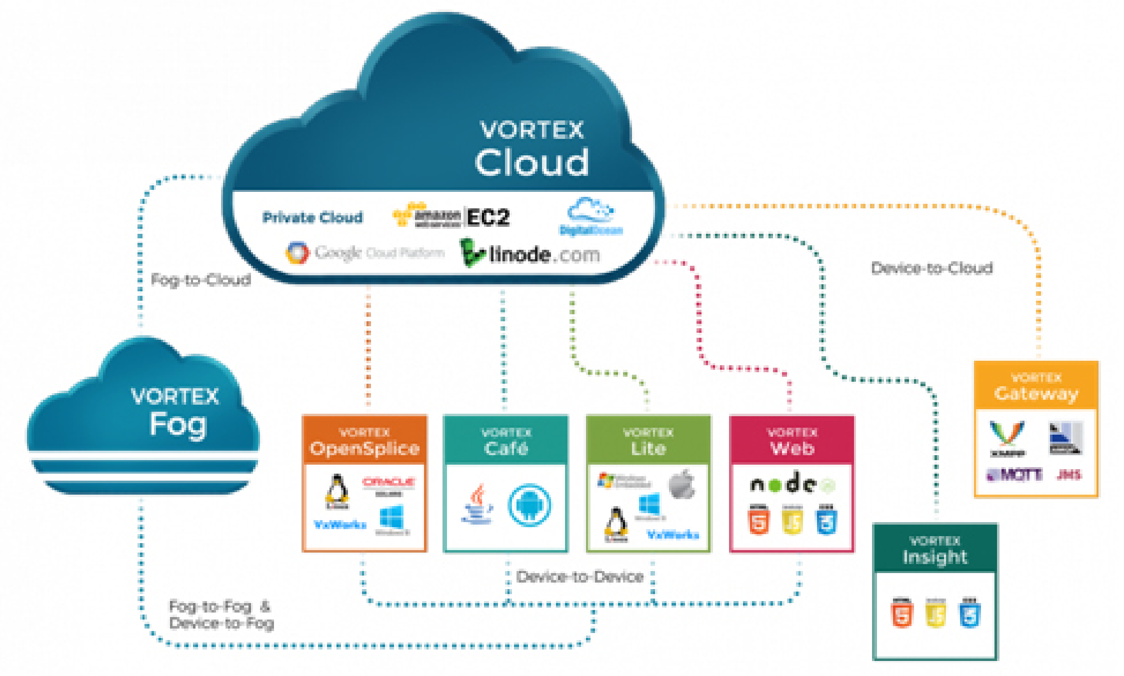


ADLINK DDS for Communications Systems

Vortex from ADLINK IST(IoT Solutions and Technology)

Vortex is the intelligent data sharing platform for mission-critical applications

- **End-to-end QoS providing**
  - Superior performance & scalability, reliability, determinism, interoperability, security and network efficiency
- **Dynamic discovery**
  - Devices find each other automatically
  - Peer-to-peer connections
  - Decentralized data space with no single points of failure
- **Temporal decoupling**
  - Late joiners can subscribe to historical data if required
- **Operating System and programming language independent**
- **Built on Open Standards (DDS)**



Conclusion

Radar, communications, sonar, and image processing may be some of the highest-growth niches for GPGPU within the military, but there are many more applications. Deep learning, artificial intelligence, gaming and simulation, cryptography, and others can benefit from GPU assistance in similar measures. By pairing NVIDIA GPGPU advances with proven, reliable computing hardware and middleware from ADLINK, engineers can craft military solutions able to deliver reliable, actionable analysis results with unprecedented speed.

Commanders have more data to assess than ever before. Fortunately, the technologies exist to turn that deluge into real-time intelligence accessible in any theater, no matter how small or remote and ADLINK is there to support them.