2012 NDIA GROUND VEHICLE SYSTEMS ENGINEERING AND TECHNOLOGY SYMPOSIUM
VEHICLE ELECTRONICS AND ARCHITECTURE (VEA) MINI-SYMPOSIUM
AUGUST 14-16, MICHIGAN

OPEN SYSTEMS COMMON HBCT ELECTRONICS VICTORY ARCHITECTURE APPROACH

Dr. Shubhagat Gangopadhyay
Mr. David Jedynak
Curtiss-Wright Controls Defense Solutions
Santa Clarita, CA

ABSTRACT

Commercial Technology, coupled with open standards and the US Army's VICTORY Standard present a strong opportunity to create Open Systems Common Electronics Architectures. The paper describes the COTS approach, the relevant open standards, application for ground combat platforms, and references the previously presented intra-vehicle network reference architecture. A candidate LRU, the TPUIII, is presented as a first step towards a common building block in HBCT. Next steps for common architecture development and analysis versus VICTORY are provided.

INTRODUCTION

Curtiss Wright is a committed industry partner for the US Army's VICTORY Architecture initiative. We are continuing development of new products to address Heavy Brigade Combat Team (HBCT) needs (such as VICTORY-enabled network switch) as well as augment our standard COTS products to be able to communicate over the VICTORY Databus. For the past several years, we have been performing research into network centric approaches specifically for HBCT vehicle electronics. We have presented papers describing open architectures and distributed network architectures for VICTORY-inspired Army platforms (D. Jedynak, et al, 2010; D. Jedynak, 2011).

This approach has now matured to the point of illustrating specifically how such an intra-vehicle network architecture can be synthesized using Open Standard COTS products, even spanning over multiple security levels. The paper will present an open standards based intra-vehicle network design approach applicable to multiple HBCT platforms using a common set of vehicle agnostic components, leveraging OpenVPX slot profiles and VICTORY Standards. Furthermore, this approach will clearly define and segment vehicle specific interfaces from the common architecture.

We will demonstrate how the approach uses line replaceable modules to support the US Army's 2-level maintenance concept, is highly scalable, modular, and provides an affordable path to rapid technology refresh. This is accomplished using standard components (computers, network switch, and data storage modules) which can be procured from multiple vendors.

As part of the HBCT vehicle electronics research activity, Curtiss-Wright has developed a common fire control computer solution, which integrates and bridges the highly optimized vehicle specific fire control loops with a common OpenVPX based C4ISR/EW infrastructure. The common intra-vehicle network design approach will highlight how the TPU III computer hosts the Fire Control Processor and Fire Control Communications Processors used in multiple HBCT platforms. In addition, the TPU III provides growth slots that can host OpenVPX cards with specific profiles that can provide mission processing, situational awareness, and additional C4ISR/EW capabilities for the Warfighter.

Upon completion of our presentation, the audience will have an understanding of the common design approach, the open standards utilized, commonality of components, and low logistics footprint required to support multiple HBCT platforms.

LEVERAGING COMMERCIAL TECHNOLOGY

As commercial technology progresses exponentially, and time-to-market shrinks, there is a growing expectation by military users to be provided with the similar performance that they are accustomed to from their private lives. For example, while using a software application for situational awareness that is relying heavily on graphics, users have a performance expectation from what they have seen in the gaming industry.

This expectation of being able to use the latest technology is an antithesis to the most important constraint, especially for ground combat systems: SWaP-C (Size Weight and

Power – Cooling/Cost). Other constraints such as meeting DoD-level security, minimizing logistic support, and need for high reliability and ruggedness only make the situation more challenging.

Leveraging Commercial Off The Shelf (COTS) technology is a proven approach to inject commercial technology into the military industry quickly and efficiently. However, COTS does not mean supplying the users with a gaming hardware from the local store as this approach will surely fail all the other needs of a deployed infrastructure. 'COTS' implies leveraging commercial technology at the most fundamental level – think commercial semiconductors embodying the latest functionalities – and making it suitable for military deployment.

IMPLEMENTING COTS

To meet the requirement for deployed systems, COTS suppliers for military industry at a high level do three things:

- Packaging: Use the commercial electronic semiconductor integrated circuits (IC) such as microprocessors and data storage, but package them in such a way to be able to withstand extreme environmental conditions. This is accomplished by the COTS supplier using special thermal and mechanical designs either at the module level and/or at a system level.
- Security: DoD policies are decomposed to security requirements throughout the system including the COTS hardware/software. An example may be that to prevent a covert channel for leakage of classified data, there is a requirement to write-lock all unencrypted non-volatile memory in the system including the one the commercial Operating System uses for writing during its normal operation. As a COTS supplier to the military, we need to provide a solution to this apparent contradictory situation. Another requirement could be anti-tamper to prevent reverse engineering of critical technology.
- Functional/Software: There are unique needs in military deployment for managing assets. To limit the costs associated with logistic support, there are often significant requirements for embedded diagnostics and prognostics. Also, to enable some of the security features, the system needs to behave in a specific way enabled by the embedded software. A COTS-based system integrator needs to provide the necessary functionalities via embedded software to construct a system capable of military deployment.

From a programmatic perspective, there are other value-add services a COTS supplier needs to provide such as management of obsolescence parts through end-of-life (EOL) mitigation processes, guaranteed traceability of ICs to their manufacturing source to prevent counterfeit parts propagation, and performance based logistic (PBL) support.

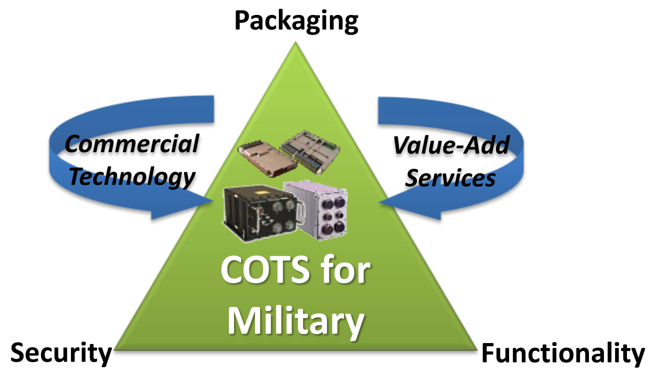

Figure 1: The "COTS" paradigm.

OPEN STANDARDS

To keep downward pressure on prices, and to enable rapid deployment of commercial technology for military systems, open standards are encouraged by the DoD procurement agencies. In fact, we notice that maximum utilization of open standards is now a de-facto "requirement" for all major military procurement. Open standards enable interoperability that reduces integration effort and risks, and maintains competition amongst the COTS suppliers throughout the lifecycle of the program.

There are several levels where open standards are invoked:

- Hardware interoperability: By specifying electronics modules such as single board computers, switches/routers, data storage modules, to be compliant to standards such as VME, cPCI or VPX ensures that modules can be inter-changed amongst products from different suppliers. The need to support higher electronic bandwidth and interface density has made the VITA standards currently the "state of the art" and the next generation standards. These set of standards enable high speed communication (VITA 46, also known as VPX) along with support for various communication fabrics (VITA 46.x), environmental standards (VITA 47), and packaging (VITA 48) and the way it is implemented (VITA 48.x). To make the standard a truly interchangeable one, OpenVPX has been introduced and matured by the COTS industry itself, and readily accepted by the military procurement agencies.
- Sub-systems interoperability: The VICTORY standards enable previously disparate subsystems to communicate with each other sharing information

such as environmental data, diagnostics/status and threat. For example, a platform may have many GPS receivers that were part of individual sub-systems, but they all do the same work. VICTORY enables sharing of the GPS information across all subsystems so that redundant receivers can be eliminated thus reducing SWaP-C. The VICTORY initiative, even though initiated by a military agency, is being increasingly accepted by the industry.

- Software interoperability: The Future Airborne Capability Environment (FACE) Consortium, established as a government and industry partnership to define an open avionics environment for all military airborne platform types, has released the FACE Technical Standard, a specification that establishes a common computing architecture supporting portable, capability-specific software applications across DoD avionics systems. The end result will be faster software development time and reduced costs, enabling developers to create and deploy a catalog of applications for use across the entire spectrum of military aviation systems through a common operating environment. For example, the standard ensures that application software shares a common infrastructure, and that they can communicate with each other via a common set of APIs.

There are many other open standards that are leveraged as well, but for a COTS supplier these are the salient ones.

GROUND COMBAT PLATFORMS

With an urgent need to modernize electronics in ground combat platforms for enhanced network presence and C4ISR/EW capabilities on one hand, but with severe SWaP-C constraint on the other, relying on use of COTS and open standards is imperative. SWaP-C issues in current vehicles are so severe that procurement objectives are not just to acquire systems with the lowest SWaP, but even drive to collapse platform SWaP if possible.

By consolidating functions occupying previously fielded "silo" systems into fewer pieces of hardware is an obvious way to shrink SWaP-C. Two important developments help: one, increasing use of COTS in the military programs enable quick adaptation of the latest commercial technology – so the hardware can host more functions. Two, interoperability initiatives such as VICTORY standards eliminate more efficient use of existing assets avoiding duplication in the platform.

Another driving force in procurement is of fostering commonality. Many types of vehicles and configurations, multiplied by many mission objectives, have a potential to proliferate many unique parts and systems to stock and support. This situation exponentially affects the logistic footprint needed to sustain a deployed military. Again, open standards become important tools: for example, a single computer card, based on open standard VITA 48.2 that adequately specifies a Line Replaceable Module (LRM), already qualified to run FBCB2 or JBC-P, and capable of interoperability with other platform systems using VICTORY, is all any vehicle of the Heavy Brigade Combat Team (HBCT) might ever need to stock – one single board computer, one application.

INTRA-VEHICLE NETWORK ARCHITECTURE

A high-level network architecture is shown in Figure 2. The data communication network is Ethernet which is the VICTORY data bus (VDB).

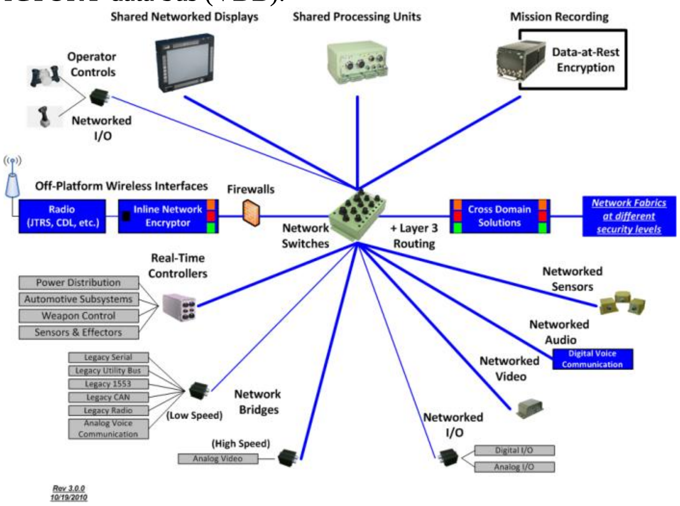

Figure 2: A notional Ethernet-based intra-vehicle communication network.

At the center of the network is the Ethernet switch. Not only it facilitates data communication amongst subsystems, it is also a convenient place to bridge VICTORY messages to legacy protocols, thus enabling the system to be VICTORY-friendly. Note that there is no intention of the VDB to be part of any real-time servo loop: the VDB communicates with a real-time controller only for health and status messages.

The VICTORY-enabler switch is either a standalone unit (such as CWCDS's Digital Beachhead) or a switch module housed in a system chassis (a switch LRM such as VPX3-683/-5). This is a COTS solution, and based on open standards from both hardware and software perspectives.

This networking notion is generic by design. Depending on the needs of the platform, the building blocks – the subsystems – can be used accordingly. The only criteria to be an ideal citizen of this network is: (1) able to communicate via the platform VDB over Ethernet, and (2) be able to communicate with VICTORY messages and protocols.

VICTORY has already ensured that the services and protocols that is expected any subsystem to support is 100% COTS. For example, the VDB itself is generic Ethernet. Any services that a subsystem is expected to provide are also typical. The subsystems could be a processing asset, a network switch, direct or network attached storage, firewall, router, assets for both data-at-rest and inline encryption etc. Management of these assets, as well as exchanging health and status information, are accomplished using COTS and open standard based services.

The specific vehicle-related services and subsystems are kept at the periphery of the VDB network, via a gateway that bridges vehicle-specific uniqueness to the VICTORY environment in the C4ISR/EW area.

THE TPU III

The Turret Processing Unit (TPU) is a suitable case study on implementation of open standards. As part of the HBCT vehicle electronics research activity, CWCDS has developed a common fire control computer solution. The Fire Control Processor (FCP) is a VME-based module that is housed in the TPU. Significant amount of effort had to be spent to qualify the FCP, especially as it hosts a critical functionality.

Figure 3: The 3rd generation Turret Processing Unit (TPU III) for Bradley showing hosting the VME-based Fire Control Processor and empty slots capable of hosting OpenVPX modules.

We have integrated and bridged the highly optimized vehicle specific fire control loops with a common OpenVPX based C4ISR/EW infrastructure: the growth slots are designed for insertion of LRMs. As the TPU III (3rd generation) hosts the Fire Control Processor and Fire Control Communications Processors used in multiple HBCT platforms, the growth slots can host OpenVPX cards with specific profiles that can provide mission processing, situational awareness, and additional C4ISR/EW capabilities for the Warfighter. This enables the fielding philosophy of "one single board computer, one application."

OVERALL SYSTEM COMPOSITION

In order to develop a full common HBCT Architecture approach, the approach of the TPU III must be further developed. The computing and network infrastructure of the vehicles must be modularized into a set of building blocks which are common and a set of building blocks which are vehicle specific. The TPU III is an example of one part of this approach.

Ideally, the common architecture will be broken down into the following major items:

- Common Network Infrastructure building blocks to establish the VICTORY Databus
- Common VICTORY Shared Processing Units, standardized to the VITA 48 LRM form-factor and a well selected OpenVPX (VITA 65) Module Profile
- Common VICTORY Mission Recording components
- A subset of common LRUs with slots for common LRMs and critical vehicle specific connections (such as the TPU III)

The items which are unique to each vehicle will most likely be:

- Vehicle optimized enclosures with slots for common LRMs
- Vehicle specific I/O Modules, preferably built from common I/O Concentrators and Legacy Network Bridges
- VICTORY compliant equipment specific to each vehicle's capability requirements (e.g. cameras, threat-detection systems, etc.)

The next steps in developing the common architecture are to design the overall network architectures with common versus distinct building blocks and identifying a set of common slots / module profiles.

ANALYSIS VERSUS VICTORY

The above approach correlates with the VICTORY Architecture (1.2) in the following ways:

- Network specifications
- General approach to interoperability

VICTORY does not, however, specify the following:

- Form Factors (e.g. 3U)
- Module / Slot profiles (e.g. OpenVPX)

- LRM specifications (e.g. VITA 48)

Nothing in the Open Systems Common HBCT Electronics approach contradicts VICTORY Specifications, nor are any required elements a proprietary standard. It is recommended that the missing items be added to the VICTORY Specification given the potential benefits in further standardization.

CONCLUSION

The COTS approach using Open Standards provides a significant benefit to HBCT. In conjunction with VICTORY, COTS becomes lower risk and more interoperable. The COTS module form-factor, with the ability to remove and replace in favor of newer technology significantly reduces the logistics burden of supporting sophisticated electronics. It is highly recommended that the COTS approach be embraced by VICTORY in order to create a well-defined subset of COTS modules and form-factors for use, and just as importantly, draw the proper divisions between common building blocks and truly vehicle specific systems.

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