OneSAF Implementation on High Performance Computing Systems

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ABSTRACT: *Implementing One Semi Automated Forces (OneSAF®) (Department of the Army) on massively parallel, distributed high performance computing (HPC) systems has the potential to create large-scale events. To achieve this, users have been exploring the scalability of OneSAF in the context of distributed multi-node, multi-core systems versus the traditional networked workstation model. Such implementations would allow OneSAF to support analysis, acquisition, planning, testing, training, and experimentation on a larger scale. This paper will highlight some of the OneSAF HPC implementations to date and provide a summary of lessons learned for other users who may be interested in the use of HPCs for their forces modeling and simulation (FMS) applications. Implementations include: OneSAF on the UCF Stokes system (work by Army Research Laboratory and the University of Central Florida's Institute for Simulation and Training (UCF IST)); Communications-Electronics Research, Development, and Engineering) Center's (CERDEC's) Command, Control, Communications, Computers, Intelligence Surveillance and Reconnaisance (C4ISR) and Network Modernization on Halle and Harold (U.S. Army Research Laboratory DoD Supercomputing Research Center, ARL DSRC); Space and Missile Defense Command (SMDC) and Redstone Test Center (RTC) implementations for laboratory and hardware–in-the-loop testing support.*

1. Overview of HPC and Challenges for Forces Modeling and Simulation

1.1 What are forces modeling and simulation (FMS) and high performance computing (HPC)?

Forces modeling and simulation (FMS) systems are simulations that represent interacting groups of entities. These entities are primarily associated with military-type forces, but they may also represent non-military entities that may be present within an area of interest. FMS may be represented by live, virtual or constructive simulation systems. [1]

The FMS systems have been developed using commercial-off-the-shelf (COTS) products such as personal computers, which are attractive because of their affordability. However, the need for higher fidelity, more complex representations with increased numbers of entities has made the use of highly parallel high performance computer (HPC) systems attractive.

Today's HPCs, sometimes referred to as super computers, are massive parallel systems using thousands of ordinary computational processing units (CPUs). These CPUs are connected together by a high speed network with several types of shared memory options. The operating system of choice is usually Linux® (Linus Torvalds) or some form of Unix® (X/Open Company). These systems are usually configured as shared systems, processing batch jobs submitted by the users.

1.2 Challenges for the FMS Community

The efforts of the High Performance Computing Modernization Program Office (HPCMPO) that provides HPC infrastructure (Defense Research and Engineering Network (DREN) and the Department of Defense (DoD) Supercomputing Resource Centers (DSRC)) and support (Productivity Enhancement Technology Transfer and Training (PETTT) program) has made HPCs more accessible to the FMS community, but many challenges remain before the community can take advantage of the full benefits that HPCs offer.

1.3 Hardware Architecture Issues

Most FMS applications have been developed for execution on uni-processor systems in a network of workstations mode. The highly interactive simulations are not well suited to take advantage of the highly parallel nature of HPC systems that almost always operate in a batch mode setting. Additionally, many of the HPC systems tend not to have multiple network connections necessary to support a large number of concurrent user interface sessions required for these interactive simulations. Constructive simulations are better suited for HPC systems, but they typically run as a single threaded process or are limited by the platform operating systems (OS) they support. Many of these simulations operate within the WinTel (Microsoft Corporation's Windows®, Intel Corporation's Intel®) platform, which utilizes standardized hardware architecture. In contrast, there is no universal architecture for HPCs. Software that is developed for, or installed and configured to run on, one HPC system will not necessarily run on another system.

1.4 Application Architecture Issues

As the FMS community grew, it sought to expand the capability and scope of FMS applications, particularly human-interactive simulations, through the use of distributed technologies such as distributed interactive simulation (DIS) and the high level architecture (HLA). The use of these technologies introduced the requirement to maintain simulation-state consistency across distributed systems and added network communications overhead and system complexity. Delays and bottlenecks were experienced from network transport. Even moving this paradigm to the HPC environment simply moves the bottleneck of communications from the network transport to inter-memory communication between processors. Similar limitations exist, even for HPC implementations. Probably a more significant concern is that this approach reinforces a high-resolution, entity-centric view of the world. The association of real-world vehicles and platforms (tank, plane, automobile, etc.) to simulation entities that operate on a single processor, while minimizing the inter-processor communication, requires that whole entities are simulated on a single processor.

This focus on platforms or physical entities does not take into account organizational or cognitive structures that have a significant impact on properly modeling the engagement environments found in the world today. To get around this limitation, the FMS community has resorted to constructive simulations with lower resolution than entity-centric models, but with greater representation of operational command and control behaviors. However, these applications have not been architected to support multi-threading within an HPC environment. In recent years, user requirements for increase scope and depth of representation have driven even these models to such detail that time required from scenario development to completed post-processing is a challenge. Such modeling requires much more computational power and needs to be performed within an architectural construct that is more adapted to the parallel environment offered by HPCs.

1.5 What Is Holding the FMS Community Back?

Given the hardware and application issues, the FMS community has been reluctant to move to HPC systems. The effort required to get things working is more than the community has been willing to invest. Some of the issues include the fact that:

- HPC user interfaces are not intuitive for the FMS community (still command line / terminal focused)
- There are many HPC systems with little commonality between architectures – lack of portability between systems
- A large number of FMS models exist:
    - Models built by model developers and analysts who are good programmers but unfamiliar with creating code that can implement parallelism
    - Many models have been built in the Windows domain and not easily portable to current DSRC HPC systems (which are primarily Unix-like)
- There is a lack of available off-the-shelf tools, best practices and documentation for the FMS community

1.6 Where Is FMS Making Advances?

FMS simulation has made progress in its implementation of HPC for a variety of applications to include test and evaluation, analysis, and training. OneSAF® (Department of the Army) has been used in several instances of FMS HPC applications. The rest of this paper will provide a brief overview of OneSAF and discuss several of those HPC implementations.

2. Overview of OneSAF

2.1 OneSAF Modeling and Simulation (M&S) Support

OneSAF is the Army's next generation entity-level simulation that provides a composable, distributed and scalable simulation of real-world battlefield situations using validated physical models and doctrinally correct behavior models. It can support analysis, acquisition, planning, testing, training, and experimentation. OneSAF allows users to compose a wide range of complete simulation systems from a set of component-based tools, develop new or extend existing tools, as well as compose new single or multi-resolution entities, units, and associated behaviors from existing physical and behavioral software components.

OneSAF also accurately and effectively represents activities within the Army warfighting functions to include:

- Intelligence
- Movement and maneuver
- Fire support
- Protection
- Sustainment
- Command and control

2.2 OneSAF Scaleability Dimensions

OneSAF hardware / system performance requirements are impacted by a number of distributed simulation-related factors. For this paper, we explore two dimensions of scaleability: fidelity and entity count. Increases in either dimension require additional hardware and communications resources to properly support the forces representation in the OneSAF model.

<u>Fidelity Dimension</u>
OneSAF supports variable levels of fidelity, making it possible to tailor the simulation in order to maximize satisfaction of diverse use cases. Here, fidelity refers to the faithfulness of the model to the real-world object being modeled. Often fidelity is equated to model detail and computational requirements, as they are typically, but not necessarily, related. For most entities, units, behaviors, and even terrain, OneSAF supports three levels of fidelity: low, medium, and high.

For example, low-fidelity dismounted infantries (DIs) move, sense and shoot, but they only move in a simple pattern along routes designated by the simulation operator and will not avoid obstacles. Medium fidelity OneSAF entities will also move, sense and shoot, but they have more sophisticated mobility, sensor and weapon models than their low-fidelity counterparts. So, for example, medium-resolution DIs will exhibit more realistic movement behaviors along routes and will avoid obstacles. High-fidelity entities have all the capabilities and attributes of medium-fidelity entities; however, they are enhanced in some way. They might have a high-fidelity missile fly-out model, rather than Army Materiel Systems Analysis Activity (AMSAA)-provided probability of hit/probability of kill (Ph/Pk) values. They might have sensor models that have greater detail, or they might have a higher-fidelity mobility model. OneSAF's composable architecture provides for complete fluidity among the various physical and behavioral models that can be instanced as a part of an entity. For instance, the medium-fidelity mobility model can be freely combined with the low-fidelity communication model and a high-fidelity acquisition model to create an entirely new, customized entity. There are no rigid rules that determine the fidelity of any given entity; it is up to the creator to assess and properly define them. For this reason, it is impossible to easily estimate global performance characteristics of entities based on their stated fidelity alone.

Entity Count Dimension
Entity count is tied more specifically to the size of the force being represented. However, entities may be used to represent more than just dismounted infantry or vehicles. When used to also represent communication devices (such as radios or cell phones) and sensors, the entity count dimension can quickly grow with increased fidelity in battle environment representation.

Different applications require different fidelity / entity count requirements. Staff training, course-of-action (COA) development and high-level COA analysis can be supported using low-fidelity, high-entity-count simulations. Medium-fidelity simulations are more suitable to support battlefield functional area (BFA)-specific training, detailed COA analysis, mission rehearsal, mission execution monitoring and some types of experimentation. They can also support concept definition and tradeoff analyses. High-fidelity, low-entity-count simulations, on the other hand, work well to support detailed analyses appropriate for research, system tradeoff analyses, etc.

OneSAF provides the option to support a mixture of entity fidelities in the same exercise. The user can select medium- or high-fidelity entities in areas where detailed modeling of battlefield conditions is needed, but use low-fidelity entities elsewhere as “wrap-around” to fill in the rest of the battlespace. This allows the computational resources to be focused on modeling items of interest in the simulation scenario. This composable approach allows users to tailor the simulation to meet their specific domain requirements.

High performance computing offers the OneSAF M&S community a chance to increase the simulation representation along both dimensions of scaleability, where workstation or network resources currently limit the simulation ability to scale and force the simulation architect to limit one dimension or the other.

3. HPC Implementations

OneSAF’s composable software framework makes it a prime candidate for implementation in the HPC environment. Although OneSAF out-of-the-box is not able to take full advantage of the HPC environment, recent work with its implementation has made the application more compatible with use on super computers.

3.1 OneSAF Performance Monitoring

The U.S. Army Research Laboratory (ARL) Simulation Training Technology Center (STTC) in partnership with the U.S. Army Program Executive Office for Simulation, Training and Instrumentation (PEO STRI) and the U.S. Army Space and Missile Command (SMDC) supported a research effort to explore the performance characteristics of OneSAF in massively parallel, distributed HPC environments to assess FMS support for training as a service. There were two primary technical components to this effort. The first component was to enhance OneSAF’s original benchmarking performance tool to collect more relevant performance parameters from OneSAF. The second component was to make modifications to OneSAF to allow key performance parameters to be accessible to the benchmarking tool (BMT). The result was the development of the Remote Distributed Performance Monitor. This tool provides an enhanced capability to the OneSAF community to measure simulation performance while providing the DoD community with access to a well-established tool for training and analysis activities.

3.1.1 OneSAF Installation on Stokes

To begin the research, OneSAF Version 3.0 was implemented on the Stokes HPC system located at the University of Central Florida’s (UCF’s) Institute for Simulation and Training (IST).

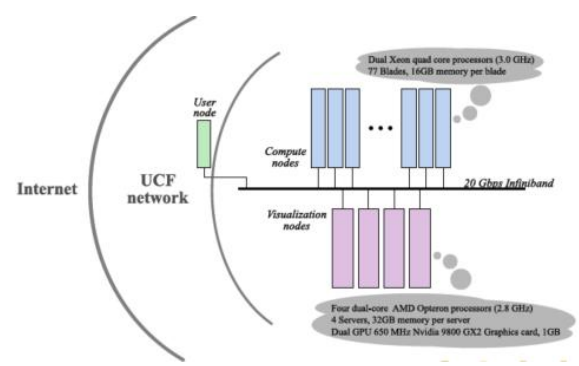

Figure 1. Access to Stokes is Similar to Other HPCs with Stokes a part of the UCF Network

STOKES has the following technical characteristics:

- Computational speed: ~7.3 trillion floating point operations per second
- Total cores: 848 at 3.06/2.93/2.8 Gigahertz (GHz)
- Total memory: 2.088 terabytes (TB) random access memory (RAM),
- Raw storage: 46+ TB
- 98 blades with Dual Xeon® Quad-Core Processor (3.06/9.93 GHz) (Intel Corporation)
- Four virtualization nodes with 4 Dual-Core AMD Opteron® processor, model 8220 (32 Cores at 2.8 GHz) (Advanced Micro Devices, Inc.)
- Fermi based NVIDIA® GTX 480 CUDA®-enabled graphics cards per node (NVIDIA Corporation)
- Operating system: Red Hat® (Red Hat, Inc.) Enterprise Linux® (Linus Torvalds) (RHEL™, Red Hat, Inc.) 5.0-5.4
- Interconnect: 1Gbps Ethernet and 2DDR/QDR (20/40) Gbps Infiniband™ (System I/O, Inc.)
- Network Storage: Dual Redundant Storage Node General Parallel File System (GPFS)

The Stokes system features a number of visualization nodes in addition to the traditional computation nodes found on HPCs. This allows for visualization directly on the HPC.

OneSAF on Stokes was executed from one of the visualization nodes to allow interaction via the OneSAF Management and Control Tool (MCT). This can be done remotely using a Virtual Network Connection (VNC). Once installed, the OneSAF BMT was evaluated.

3.1.2 Evaluation of the Original OneSAF BMT

The original OneSAF BMT was developed as a means to measure and evaluate the capabilities of the OneSAF system to support large entity-count scenarios. The tool was used by the OneSAF development team to gauge the effectiveness of software improvements in the OneSAF baseline as well as to estimate the necessary number of distributed OneSAF nodes needed to support a simulation scenario of a given entity count.

The original OneSAF BMT measured OneSAF performance "sufficiency." The BMT runs a single OneSAF node in "as fast as possible" mode and reports the average simulation scale that was achieved during the course of the simulation run. Typically, measurements are made with the BMT utilizing scenarios of increasing entity count, with the goal of reporting the relationship between entity count and the average simulation scale that is achieved by OneSAF. In this manner, the BMT was used to determine the entity load at which OneSAF could no longer keep up with real time on a simulation node.

Additionally, the original OneSAF BMT was integrated with the OneSAF system software and ran within the same Java® Virtual Machine (JVM®, Oracle America, Inc.) as the OneSAF instance it is monitoring. This affected the actual performance of the system since measurement may affect performance.

Although the information reported by the BMT is useful to understand the performance of the OneSAF system, it is difficult to gauge how well OneSAF was really making use of the computational power. This is due to the fact that the one measurement that is obtained is solely an average simulation scale for the course of a simulation run. That is, the BMT gives no indication of how the simulation scale varies during the course of the scenario. There are numerous operations that can occur during the course of scenario execution that affect performance, such as entity sensing, engagement, maneuvers through congested areas of terrain, and operations within buildings. The BMT provides no window into which of these events may have occurred and caused a direct impact on the system operations.

Additionally, as mentioned above, the BMT is limited to single node use and provides no information about how the performance of the OneSAF distributed cluster varies with increased entity count or model fidelity.

3.1.3 Development of the New OneSAF Benchmark Tool –- Remote Distributed Performance Monitor (RDPM)

Based on the evaluation of the original OneSAF BMT, it was determined that an independent tool was needed with the following features.

- The ability to separately assess OneSAF performance outside of the OneSAF processes. This mitigates the impact of the tool's operation on the performance of the simulation.
- Use Java® Management Extensions (JMX®) (Oracle America, Inc.) to monitor the state of the simulation, rather than embedding the monitoring within the running OneSAF application. This would affect the normal running system to a smaller degree. Allow monitoring of the performance of the OneSAF

cluster (distributed mode). Allow users to look at a variety of measures over time, preferably in an online fashion, instead of characterizing performance as a simple curve of entity count vs. simscale. Results might be aggregated over a run, or over steps across multiple runs, etc. It is important that standard measures used by the discrete event simulation community in general, such as average event rate and event queue size, are observable. But, more generally, this would allow users to be able to select and track the measures they find most salient for their performance analysis.

- Provide better flexibility in defining the scenario for measure. In the original OneSAF BMT, test cases were hard-wired into the tool itself. This limited number of automated tests does allow for a measurement of the performance of OneSAF for a number of valid use cases, but they also omit countless others. Although OneSAF allowed the loading of individual scenarios into the BMT, there was no way to parameterize the scenario to increase the entity counts. Users would have to explicitly code multiple scenarios and individually execute these.

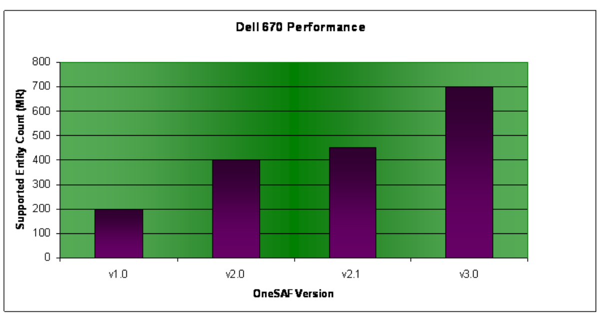

Figure 2. The OneSAF Benchmark Tool-measured average performance over the test run

3.1.4 The Remote Distributed Performance Monitor

The OneSAF Remote Distributed Performance Monitor (RDPM) is a lightweight tool designed to help users, developers, and co-developers monitor and analyze performance of multiple instances of OneSAF simulation engines running on a local network. The tool interacts with OneSAF remotely via JMX and is explicitly designed for very minimal interference with simulation operation. It can be run alongside any OneSAF simulation in almost any configuration. It can be configured to track a wide variety of information regarding the OneSAF simulation engine and can report such information directly to a file log for post processing and analysis or displayed online as the simulations are executing.

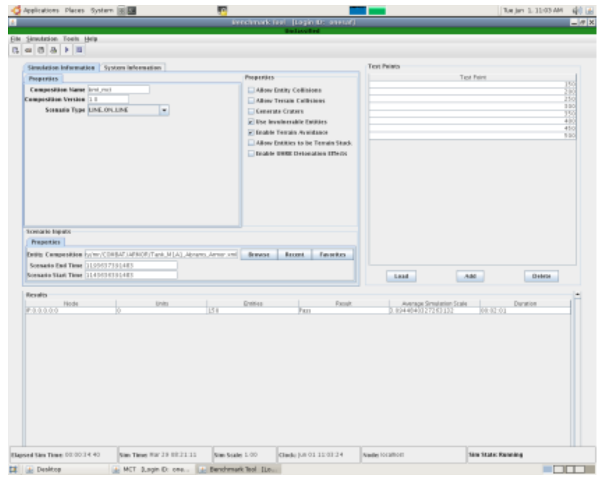

Figure 3. The interface for the RDPM makes it easy to select parameters to monitor during OneSAF execution

The RDPM distinguishes OneSAF simulation exercises based on the exercise ID, and it permits users to track data from simultaneously running simulations using exercise ID as a filter. This means that when a user asks the RDPM to track a particular attribute for a particular exercise, the RDPM will produce separate streams of data for each OneSAF simulation node on the network currently executing that exercise. Additionally, there is a mechanism by which the user can generalize the attribute to track that attribute on all running OneSAF simulation nodes in the network, regardless of exercise ID.

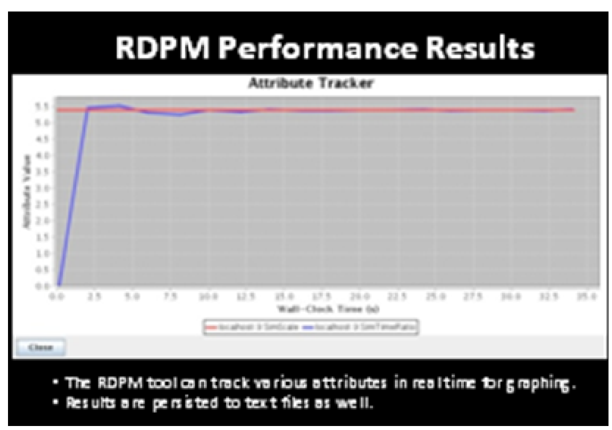

Figure 4. The RDPM tracks the values of attributes over time (vs. the average over total time like BMT), allowing observations regarding how simulation activities affect performance

3.1.5 Use of the RDPM

The RDPM tool has been used to evaluate how well OneSAF runs on an HPC. As a result of this preliminary evaluation, several functions have been added to the OneSAF baseline for version 5.0.

HPC features for OneSAF:

- The ability to run multiple instances of OneSAF from a single installation. Previous HPC installations of OneSAF required the software to be separately installed for each node on which it was executing. Although not a big deal for networked workstations, this is very impractical for HPCs. This new feature allowed OneSAF to be installed once and then instanced on multiple nodes.

- The ability to execute multiple OneSAF applications on a single node

- When OneSAF reduces the simscale to address network loading, it is able to reset the scale higher once network loading is reduced.

- OneSAF running in as-fast-as-possible mode when running in a distributed cluster

All of these OneSAF improvements help to make the application more HPC-friendly. As users become more experienced with OneSAF in the HPC environment, further improvements will be recommended.

3.2 OneSAF HPC Implementation

Several implementations of OneSAF on an HPC exist. These successful implementations affirm the suitability of OneSAF on an HPC, requiring minimal staffing. It also highlights the ability to use the HPC platform to conduct distributed operations. And, it allows for graceful scaling of performance with distribution of increased loads over multiple processors. It also introduces a framework that can be extended to incorporate any number of “hard” (e.g., high-fidelity physics) and “soft” factors (e.g., hunger, attention, etc.).

3.2.1 Army Constructive Training Federation (ACTF)

OneSAF was implemented on a Linux cluster, “Eagle,” at the AFRL DSRC. Eagle is an SGI International Corporation, Inc.’s Altix® 3700 consisting of four 512-processors nodes of Intel Corporation’s Itanium® 2 (1.6 GHz) processor.

One issue encountered was that OneSAF would hang at different locations on Eagle compute node. Both implementations were with early versions of OneSAF and executed in an HPC environment which was early in its support for interactive applications.

3.2.2 Physics-based Environment for Urban Operations (PEUO)

This effort used the OneSAF baseline, and previous work porting OneSAF to Linux-based HPCs to support an experimental simulation environment that combined physical, logical and behavioral models. This environment enabled the team to understand war and its consequences in context (e.g., improvised explosive devices (IEDs), urban combat, smoke, loss of signal), at high resolution and fidelity.

The effort focused on creating an operationally relevant urban combat test bed that integrated high-fidelity emulation of physical and electromagnetic environment with behavioral, organizational, and cultural simulation along with real-world sensors and events. Physics models included command, control, communications, computers, intelligence, surveillance and reconnaissance (C4ISR) and three-dimensional plume dispersion where OneSAF provided operational context. OneSAF entities were required to react to the parameters of the models by utilizing sensors and reporting detections based on sensing. Plume effects were also added.

OneSAF Version 1.0 was used with no modifications and installed on the ARL DSRC systems Powell and JVN (both which have since been retired). The user location was Orlando, Fla., but the experiment also supported users at the U.S. Army Communications-Electronics Research, Development and Engineering Center (CERDEC). They accessed the OneSAF code on Powell using a virtual network computing (VNC) connection. During the demonstration, OneSAF was integrated with SUNS (a communications simulation) and the Department of the Navy’s CT-Analyst® (plume generation). In some configurations, multiple instances of OneSAF were used.

The environment allowed for the simulation of entity reaction to smoke and nuclear, biological and chemical (NBC) clouds, going from mission-oriented protective posture (MOPP) level 0 to 1 with the smoke and from level 0 to 4 with the NBC cloud. Wind-shift effects on the smoke plumes were also represented with the high-fidelity physics model.

The resulting integrated environment demonstrated that OneSAF could be integrated with higher fidelity physics models in order to provide an enhanced environment for testing and training.

3.2.3 OneSAF Support for Space

The U.S. Army Space and Missile Defense Command / Army Forces Strategic Command (USASMDC/ARSTRAT) conducts space and missile defense operations and provides planning, integration, control and coordination of Army forces and capabilities in support of U.S. Strategic Command missions (strategic deterrence, integrated missile defense, and space operations); serves as the Army force modernization proponent for space, high-altitude and global missile defense; serves as the Army operational integrator for global missile defense; and conducts mission-related research and development in support of Army Title 10 responsibilities.

In 1981, USASMDC/ARSTRAT created the Simulation Center (SimCtr) for missile defense (MD) research design and analysis of complex MD systems with state-of-the-art computational and simulation resources by providing shared government-furnished property high-performance computational (HPC) assets. The vision of the SimCtr is to be the Army's premier center for air, space, and missile defense high-performance computational support. It works to provide the tools, technologies, and expertise needed to realize both the USASMDC/ARSTRAT and the Missile Defense Agency vision for delivering air, space, and missile defense.

USASMDC/ARSTRAT's has been exploring the implementation of OneSAF on HPCs for a number of years. Initially, OneSAF v1.5 was installed on an Altix 3700. But, with the OneSAF v1.5 upgrade to Java® v1.5 (Oracle America, Inc.), the Itanium processor did not support Java v1.5 in 2007. Another issue involved OneSAF use of X86-32 Bit Emulation, while the Itanium processor was 64 bit. To continue support, another Altix®-XE310 (SGI International Corporation) was explored and used for a technical event that generated about 21,000 entities during a side testing and about 3,500 during the event. OneSAF is currently hosted on one of USASMDC/ARSTRAT's HPCs. This machine has 12 Core AMD (Advanced Micro Devices, Inc.) Istanbul 2.2 GHZ processors and 16 GBs of memory per node. This effort is evaluating OneSAF for use on an HPC for future support of experiments.

USASMDC/ARSTRAT's experience highlights one of the challenges with hosting FMS software on shared HPCs – finding support for specific software requirements (in this case Java) while continuing to provide support to other HPC users. This effort also highlighted the expansion of HPC from strictly supporting scientific code to also hosting Java-based code.

3.2.4 C4ISR On the Move (OTM)

CERDEC C4ISR On-the-Move (OTM) Experiment 08-10 (E08, E09, E10) also used OneSAF on an HPC to support their experimentation efforts. This effort provides a relevant environment/venue to assess emerging capabilities in a C4ISR system-of-systems (SoS) configuration to enable a network-centric environment in order to reduce and mitigate risk for Future Force concepts and capabilities, accelerate technology insertion into the current force, and support Army Brigade Combat Team (BCT) Modernization and the Future Force.

This technology demonstration creates virtual world support using OneSAF on the HPC to support live range assets located at Fort Dix, N.J. OneSAF is used as a modeling and simulation driver for the experiments – providing a real-time, brigade-sized stimulation of live assets.

The 2008 C4ISR OTM demonstration ran OneSAF on C4ISR OTM's HPC called Halle. In this experiment, OneSAF version 1.5 was hosted on the IBM® PowerPC® (International Business Machines Corporation) HPC system. The most significant challenge for implementing OneSAF on a PowerPC architecture was the ability to support big endian architecture. Code and databases needed to account for the data requirements and byte swapping of database information required as OneSAF version releases were incorporated. OneSAF's ability to run simulation cores on different processors was used on Halle to help scale the number of entities. For the 2009 and 2010 experiments, OneSAF version 2.1 was used on Halle.

For the August 2010 C4ISR OTM demonstration, the same scenario and use of OneSAF on the ARL Halle was replicated on the ARL DSRC Harold system. The E10 activity used the Halle instance, but the duplicate on Harold was an experiment to explore the viability of using a shared resource to support experimentation events (Halle is a dedicated system).

The focus of the demonstration was to use a shared system to support live test and evaluation (T&E) events. The experiment made use of the DSRC reservation system, which allowed the team to reserve 10 nodes for exclusive use during the experiment. Networking was set up via the Defense Research and Engineering Network (DREN). One challenge for the exercise was the need to preserve the security of the tactical network used for the experiment. The team wanted to use a virtual private network (VPN) to make the 10 nodes a part of that secure network. Since this approach had not been used on a shared system, an alternative setup was used where OneSAF was executed and the data collected. Then the data was "manually" moved over the tactical network where it could be played. The C4ISR OTM team spent time post experiment exploring a direct connection from the DSRC to the OTM tactical network via VPN using an experimental system at the ARL DSRC. The development team was successful in demonstrating that DIS traffic generated on the test system at ARL DSRC can be seamlessly tied with the OTM architecture. They were able to get DIS traffic generated by OneSAF running on Harold to transmit through the VPN on the experimental system. This provides confidence that a direct VPN connection from Harold to the OTM architecture is possible for supporting future experiment activity. Another challenge was obtaining the proper security approvals at both the range for the experiment as well as at the DSRC for use of the shared systems. OneSAF was easy to install on the Harold system and performed extremely well, producing the required number of entities for the experiment.

3.2.5 Creating an Operationally Relevant Environment for Testing Ad Hoc Wireless Sensor Networks

The U.S. Army Redstone Test Center (RTC) Distributed Test Control Center (DTCC) / High Performance Computing (HPC) supports T&E and experimentation activities in the facilities. Full system life-cycle support is given to the RTC customers.

The DTCC/HPC facilities provide a complete live, virtual, constructive (LVC) environment to immerse test items so they perceive and respond to the stimuli just as they would in tactical environments. The DTCC/HPC facility has computing resources, simulations, network emulations, data acquisition systems, displays, virtual warfighter machine interfaces, and test control assets that operate in Unclassified and Secret configurations depending on the need. The capabilities are connected to high performance nationally/internationally distributed test networks operating from Unclassified to Top Secret / Sensitive Compartmented Information (TS/SCI).

The DTCC/HPC uses OneSAF on its HPC to provide an operationally relevant environment for realistic testing of wireless tactical networks. These include networked sensors and sensor fusion systems, which require the network environment to stimulate the system. Providing a real-time network emulation with interfaces to real systems forces perception and response as it would in the real world.

4. Conclusions

HPC provides a key capability to allow the DoD community to develop key technology concepts quickly and in a more robust, high-fidelity environment. FMS provides an operationally relevant context to support training, test and evaluation, and analysis activities, and OneSAF has been at the forefront of demonstrating the viability of FMS in this important role.

As the use of OneSAF on HPC grows, changes to OneSAF are being rolled into the baseline, allowing OneSAF's computational capabilities to grow as computational hardware advances toward more parallel, cluster-type systems. It also provides DoD engineers and researchers a valuable tool for scaling the simulation environment to meet a more demanding, higher fidelity environment.

5. Acknowledgement

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6. References

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6. Distribution Release

This paper has been approved for release by PM OneSAF, C4ISR OTM / CERDEC and SMDC / ARSTRAT. Release information is available upon request from the primary author.

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