Integrating the Portal into the Distributed Mission Operations Network (DMON)

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ABSTRACT

The United States Air Force has embarked upon an ambitious long-term strategy to enhance the training of its operational crews through the Distributed Mission Training (DMT) program. The DMT Operations and Integration (O&I) Team has deployed Portals as part of its operational network. The Portal provides an architectural mechanism for interoperability between Distributed Interactive Simulation (DIS) protocols and various versions of the High Level Architecture (HLA) run-time-infrastructures (RTIs) as well as performing other functions.

The approach we have used with the Portal is to divide the large and complex (N^2) problem of overall DMT System interoperability into parts; the first of which is the single Portal-to-Portal interoperation problem over the WAN. The other parts are the "N" simpler Portal to Mission Training Center (local simulators) interoperation problems on the local MTC LAN. Deployment of the Portal is underway with the associated performance testing required to ensure quality operational training.

This paper will discuss the test results and lessons learned to date of implementing the Portal into the Distributed Mission Operations (DMO) network. Analysis will include the integration impacts experienced during lab testing at Northrop-Grumman, between Air Force Research Laboratory (AFRL) and the Distributed Mission Operations Center – DMOC (formerly the Theater Aerospace Command and Control Simulation Facility –TACCSF) and during operational training between sites on the DMO network.

ABOUT THE AUTHORS

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DISTRIBUTED MISSION TRAINING/OPERATIONS

The United States Air Force (USAF) has embarked upon an ambitious long-term strategy to enhance the training of its operational crews through the Distributed Mission Training (DMT) program. DMT is the foundation for revolutionizing training for the USAF. The purpose of the DMT Program is to allow warfighters to train in the full spectrum of team combat skills. DMT supports inter-team and intra-team composite force training for warfighters located in geographically separate locations. Mirroring current doctrine, DMT will provide warfighters the ability to train as a team, while supporting the enhancement of individual proficiency.

The current training focus is on the operational and strategic training of the warfighter. The characteristics that distinguish DMT include:

- Primary components are state-of-the-art, high fidelity man-in-the-loop virtual cockpits for pilots, and C2ISR (Command, Control, Intelligence, Surveillance, and Reconnaissance) crew stations provided at Mission Training Centers (MTCs)
- MTCs are located at home bases of aircrews
- Supports manned threat stations that provide man-in-the-loop friendly/adversary forces
- DMT availability is 24/7
- Provides rapid mission execution in support of user training. Lead-time is 1 hour for archived scenarios
- Provides an integrated scheduling system in support of coordinated multi-site AEF training and rehearsal

Northrop Grumman is the DMT Operations and Integration (O&I) contractor and provides the DMO Network (DMON) that contains the DMT Portal and leads the DMT Standards Development effort.

DMO Network (DMON)

The DMON is a high-bandwidth, low latency, real-time, secure network engineered to deliver maximum training capabilities and minimal limitations. It is robust, scalable, secure, and highly reliable. The network is built on a worldwide Asynchronous Transfer Mode (ATM) Wide Area Network (WAN) backbone provided by Global Crossing, with local loop access provided by the Local Exchange Carrier (LEC) for each MTC.

The ATM WAN provides the MTCs with steady connections, predictable throughput, minimal delay, and high Quality of Service (QoS) for data delivery. In addition, the ATM WAN provides the means for continuous monitoring and control of DMON, while Virtual Circuits provide the reliable connectivity to any combination of participating MTCs.

The LEC drops the multiple DS1 ATM circuits off at the Military Point of Presence (MPOP) on the base where the MTC is located. A router located at the MPOP interfaces to the LEC circuits, and provides the ATM to IP (Internet Protocol) Ethernet translation. A pair of 10/100 Base FX/TX media converters are used to drive the fiber used to bring the DMON to the building that houses the MTC. This media converter pair has a maximum spanning distance of 28 km.

At the MTC, Northrop Grumman installs a Portal Kit in a certified IPS Container (which is an equipment rack built into a safe, and when full weighs approximately 2000 pounds). Figure 1 shows the typical MTC configuration for the Portal Kit. This kit contains several items including: 1) the aforementioned media converter, 2) a rack mounted UPS, 3) a Cisco 2950 switch ("the black switch"), 4) two KG-175 TACLANE E-100 encryption devices, 5) two Cisco 2950 switches ("the red switches"), 6) two Dell PowerEdge 2650 dual-processor Windows 2000 servers ("the Portal computer"), and two Dell PowerEdge 1650 single-processor Windows 2000 PCs. Figure 2 shows a

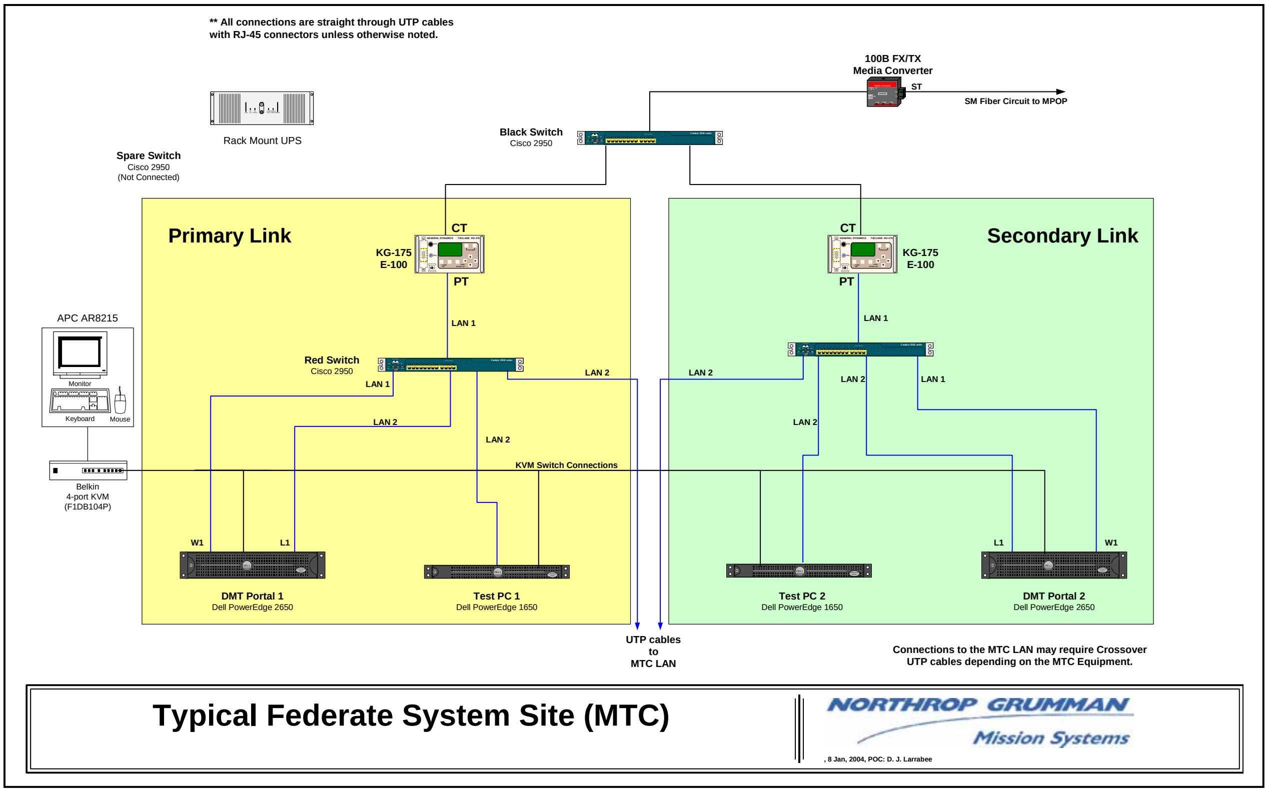

Figure 1. Typical MTC Configuration

picture of the components installed in the IPS container (with an extra TACLANE installed just for testing).The Initial Operational Capability (IOC) of the DMON went online to support warfighter training in May 2000 (without the Portal Kits). The Portal Kits were added at the MTCs in 2002.

DMT Portal

The Portal provides an architectural mechanism for interoperability, and was created for three primary reasons: 1) To adapt to an MTC on a local basis, 2) To provide whatever protocol conversions are required to allow MTCs to interoperate (i.e., between Distributed Interactive Simulation (DIS) protocols and various versions of the High Level Architecture (HLA) run-time-infrastructures (RTIs)), and 3) To provide isolation and insulation of MTCs from each other.

A key part of the local adaptation/integration with the MTC is that the Portal implements DMT Standards (which will be discussed at length in the next section).

The isolation/insulation is required because of the constantly changing nature of the MTCs, which are required by contract to maintain concurrency with the aircraft at that base. Another factor introducing change is the modifications that are required to maintain compliance with the DMT standards. By insulating the MTCs from each other, it greatly limits the ripple effect of changes of one MTC from spilling over into other MTCs and inducing further problems.

An important desired side effort of the isolation/insulation is that it simplifies the integration of the DMT System. The approach with the Portal is to divide the large and complex problem of overall DMT System integration and interoperability into several parts. The first part of the problem is a simpler Portal-to-Portal integration/interoperation over the WAN. The other parts of the problem are “N” simpler and isolated Portal-to-MTC integrations/interoperations over the LAN.

The DMT System (and the Portal) supports a training cycle which has three parts: 1) Mission Brief, 2) Simulator Execution, and 3) Mission De-brief.

For simulation data (produced during Simulator Execution), the Portal in essence implements a hierarchical federation comprised of a single federation among the Portals, with a set of federations among the MTC assets with the individual Portal at that MTC (see Figure 3). Each of the lower federations can have an implementation paradigm (i.e., DIS or HLA, etc) that is required for that installation.

Figure 2. Operational Portal Kit

The RTI Interoperability Study Group [Myjak, Clark, and Lake 1999] introduced the concept of a hierarchical federation to the larger Modeling and Simulation community at the Spring and Fall Simulation Interoperability Workshop (SIW) Conferences in 1999. Subsequent research discussed details of how hierarchical federations could be implemented [Myjak, and Sharp 1999] [Magee, Shanks, and Hoare 1999]. Later work by a group in Australia on a Virtual Ship architecture also employed hierarchical federations [Cramp and Oudshoorn 2002] [Cramp, Best and Oudshoorn 2002].

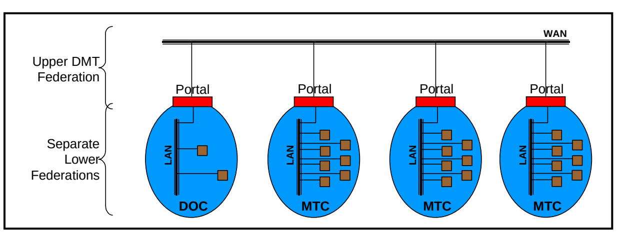

Figure 3. Portal Hierarchical Federation

DMT SYSTEM STANDARDS

DMT can best be described as a "System of Systems", each developed by different contractors with different objectives. Each MTC has been developed to support their specific intra-team training needs (i.e., the training needs of the warfighters within the single platform type at that MTC).

The MTC development results in highly efficient simulator systems that achieved Air Combat Command (ACC) defined training objectives. From the DMT "System of Systems" perspective, this resulted in an outcome which was unacceptable since these systems were not compatible and thus not capable of supporting inter-team training. These systems lacked the interoperability required for inter-team training due to 1) The various FSP approaches executed in implementing this functionality, and 2) the need for additional MTC functionality to support inter-team training needs.

The O&I contractor's approach to achieving interoperability among the disparate Federate Systems connected across the DMT System network is through the DMT System Standards. Participation in the DMT Standards Maintenance Process provides stakeholders a voice in determining the focus and content of upcoming DMT standards. Through this participation, future DMT participants are provided with information to assist in the integration of their Federate Systems into DMT.

The DMT Standards Development Working Group (SDWG) and Standards Implementation Working Group (SIWG) were established to get the DMT Standards developed and implemented. The SDWG is the technical working group, whose primary purpose is to assess the merits of proposed standards modifications in support of the evolving DMT system. Tiger Teams are tasked by the SDWG as necessary to validate proposed standards modifications. Tiger Team participation is open to government and industry stakeholders and interested community members. The SIWG's primary purpose is to evaluate the programmatics associated with a proposed standards change.

Each of the DMT standards is categorized under one of three categories. Standards in the first category, Interface Standards, address the network connectivity, software and hardware interfaces, and protocols necessary for federate systems to exchange information. Integration Process Standards, document common processes and procedures that facilitate coordinated operation of individual simulator systems as a harmonized DMT system. The third category, Federate System Performance Standards, address consistency, fidelity and performance factors ensuring a fair fight among training participants. As a whole, the set of standards is intended to ensure an interoperable, distributed, simulated battle-training environment.

The Portal plays a key role in the implementation of DMT Standards. It traffics and exchanges the battlespace that is described in the Reference Federation Object Model (RFOM) Standard (in an HLA or DIS manner), while supporting the event control processes described in the Event Control Standard.

PORTAL SOFTWARE ARCHITECTURE

Each portal operates as a "peer" in the upper federation and shares/exchanges a common battlespace that is designed to be sufficient for the needs of inter-team training (as dictated in Standards, as described earlier).

The Portal Software Architecture is depicted in Figure 4, which shows the major functions implemented in the Portal.

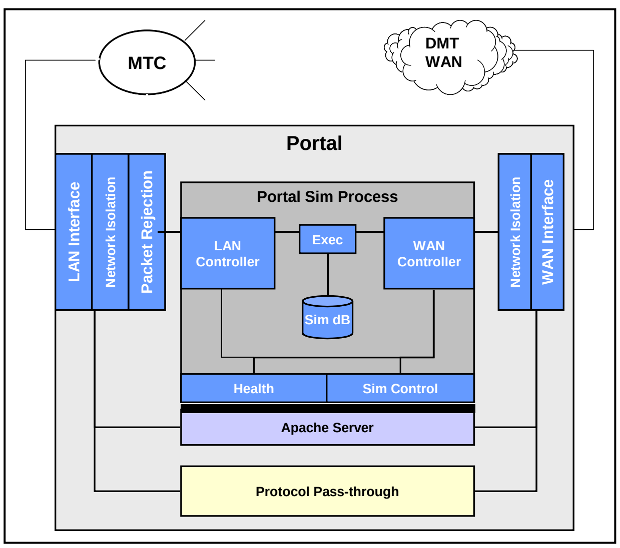

Figure 4. Portal Software Architecture

The protocol pass-through is required in the software architecture to support the Mission Brief and De-brief phases. The primary tools for accomplishing the briefing /debriefing is Desktop Video-Teleconferencing (VTC), accompanied by FTP, Telnet, ETC. These tools use protocols for carrying data that are point-to-point in nature and require a pass-through to get to their destination MTC.

Future Portal Directions

The current Portal software shares and collaborates on the implementation of a single shared battlespace among all the MTCs in a DMT/DMO exercise. In the not to distant future this will not be sufficient. The Portal software will need to evolve to route streams of data in addition to (or an amplification of) the shared battlespace.

Examples of these kinds of data streams are: 1) Instructor/Operator traffic that only needs be shared among MTCs of the same type and manufacturer, 2) external secondary modeling information that might only be shared among a couple of MTCs that are interested (or need) a greater level of expression on a single aspect of the battlespace (e.g., a more detailed signals model of a threat Surface to Air Missile emplacement), 3) data link information that is only communicated to selected participants/MTCs in the battlespace (that mirrors the real world where not every system has every capability).

Another aspect of the Portal that will need to evolve is the capability to manage the WAN traffic and load (including traffic shaping and buffering). The Portal will need to eventually be able to adjust traffic among Portals be able to maximize the utilization of the communications network. It also will likely need to be able to deal with asymmetrical topologies (in speed, capacity or cost) for WAN connections.

INTEGRATION AND TEST RESULTS

DMT System in IOC configuration occurred without portals because 1) Portal software wasn't fully implemented yet, and 2) the IOC MTCs only used DIS (therefore no protocol conversion or local adaptation was envisioned). As it actually turned out, the MTCs involved in the IOC configuration spoke two different dialects of DIS; which required one of the implementations to be altered to make a "compatibility mode" of operation for that MTC. This problem was overcome when Portals were installed in the IOC configuration in 2002. The MTCs that used a mutant variation of DIS (V6 body with a V4 header) could continue to do so, while the other MTC used a standard DIS (IEEE 1278.1a).

After the initial deployment, several MTCs have been brought online and interfaced to the various DIS implementations with minimal integration effort.

Two DMON MTCs have been activated that use an HLA RTI implementation. The first is a brand new from-the-ground-up design; the other is a new infrastructure implementation of an existing Network Interface Unit (NIU) that interfaces with the internal bus of the simulator.

Integration and Test with the newly designed MTC have met with mixed success. The MTC was not quite ready when we started integrating the Portal; as a result even though we were having successes with the Portal integration, the overall experience for the warfighter was not positive. There were stability issues in the MTC that had nothing to do with the Portal that had to be worked out.

After pulling back for a while (during which there was no further DMON integration/interoperability/testing), these issues were resolved, which allowed integration and testing to begin again and complete.

As an example of the variety of integration issues that arose from this integration, the MTC vendor had based his design on an assumption that any attribute update passed to the RTI would only contain changed values (i.e., every attribute update would only update attributes that had actually changed). While this was an ideal assumption to make, it was not one that the Portal was initially designed to handle correctly (since this is not the default interpretation).

The NIU implementation (while an HLA infrastructure) is still very close to (and grew out of) a DIS implementation. As a result integration and test were mostly straightforward.

As an example of the integration issues that arose from this integration, the NIU designer had assumed that the HLA objects would be published on a Heartbeat time schedule. (Under a traditional HLA implementation there is no Attribute update until a predictive contract is broken.) The Portal allowed easy accommodation of these simulation specific differences

LESSONS LEARNED

Because the conceptual models behind most DIS simulator implementations are closer together (or more alike), it is more straightforward to bring a DIS implementation into the shared battlespace.

Unfortunately the same cannot be said about HLA implementations. The conceptual models for HLA implementations are wide open (i.e., as a simulator designer you can make just about any modeling assumption you want on how your simulator will/should function). As a result 1) it is much more difficult to anticipate the potential issues that may arise with interoperability with an HLA implementation, and 2) it will likely take more time and effort to actually make interoperation happen.

SUMMARY AND CONCLUSIONS

The DMO Network is alive and well, and supporting training on a daily basis. The Portal is the onramp to the DMON, and has proven its worth in both adaptation and isolation.

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