Re-engineering Legacy Simulations for HLA Compliance

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ABSTRACT: Simulation proponents are driven to replace existing simulations as a result of several factors. These include obsolete and inefficient source code, maintenance costs to upgrade aging hardware, need for expanded capability, and the requirement to be compliant with the DoD mandated High Level Architecture (HLA). Good business practices argue against the wholesale replacement of simulations due to the enormous cost of developing entirely new systems. TRADOC, faced with the need to maintain a entity-level simulation despite increasing maintenance costs and limited expansion capability, reengineered the Janus simulation with a new architecture, re-hosted on personal computers, and modified to meet the HLA mandate. The reengineered simulation is known as HLA Warrior. The paper addresses the policy management decision process to modify and adapt simulations rather than replace them. Using Janus/HLA Warrior as a case study, the paper details a non-technical process for re-hosting a legacy simulation with modern technology, to include achieving HLA compliance. The paper also discusses in-house versus outsourced tasks, budget management considerations, and modern architecture capabilities.

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1. Introduction

Simulation proponents are faced with the decision to either upgrade legacy models or replace them due to inefficient source code, aging hardware, and the need for improved functionality. Also, as a result of technical limitations to Distributed Interactive Simulation (DIS) standards, DoD implemented High Level Architecture (HLA) standards under a September 1996 DoD directive, known informally as the Kaminski Memorandum. The directive instructs all DoD activities to either make existing simulations HLA compliant or retire them. Funding limitations and mandatory retirement dates were imposed on all legacy simulations not pursuant of HLA compliancy. Although certain stand-alone simulations were waivered for compliance, and others waivered for retirement pending fielding of replacement systems, the directive effectively required all existing simulations to either be HLA compliant or replaced by 1 Oct 2000. However, DoD provided no resources to meet compliancy requirements. This paper addresses policy management decisions and cost considerations to upgrade, rather than replace, legacy simulations with modern technology and achieve HLA compliance.

2. Background

The Army initiated a plan to replace a majority of the legacy constructive simulations used in the Advanced Concepts and Requirements (ACR) domain and the Training, Exercises, and Military Operations (TEMO) domain. WARSIM, OneSAF and COMBAT XXI are programmed to replace most of the existing constructive simulations and meet HLA compliancy requirements. However, since fielding dates for these new simulations are well into the future and HLA compliancy options are still being assessed, TRADOC forged a technology demonstration, known as HLA Warrior, to determine the level of effort to upgrade a legacy simulation with modern technologies and achieve HLA compliance. The Janus legacy simulation, used in both ACR and TEMO domains, was selected for the HLA Warrior demonstration.

The TRADOC Analysis Center (TRAC) initiated the HLA Warrior project in 1998. Project guidance was to complete development within 18 months with a relatively limited budget. The technology demonstration includes porting Janus from a UNIX-based workstation to a Personal Computer (PC) running Windows NT (WinNT), and making the simulation both DIS and HLA compliant. Other requirements include improved graphical user interfaces (GUIs), object-oriented source code, and a modern modular architecture. The paper uses HLA Warrior as a case study to assess technical considerations and policy management decisions when upgrading a legacy simulation.

3. Technical Considerations

This section describes technical considerations for re-hosting a legacy simulation. The HLA Warrior project serves as a case study to evaluate each concept.

3.1 Architecture

Determining the simulation architecture is the first technical consideration in the re-host process. Legacy simulations tend to follow a standard three-tiered architecture: interface, application, and storage mechanism. The application is linked to the graphical user interface (GUI) through established protocols while a database provides persistent storage. Future simulations must have open, modular architectures in the sense that new functionality can be added with minimal impact to existing code and easily supported by the GUI.

HLA Warrior uses a commercial of the shelf (COTS) architecture developed by Tapestry Solutions, Inc. The Tapestry kernel provides the architecture backbone which isolates the simulation core from the operating system, supporting platform independence. The open architecture easily supports future enhancements and distributed capabilities. Additionally, the kernel development environment allows code writers to develop classes and algorithms using a scripting language. These scripts can be invoked directly from the user interface. This powerful, time saving technique relieves the code writer from the burden of recompiling source code to verify results. Once invoked, the code writer can immediately verify intended object behavior from model output. The debugged script can subsequently be replaced by compiled code. The development environment also permits independent GUI and source code development without the lengthy process of defining numerous protocols required for reliable model-interface interaction.

3.2 Modify vs Rewrite Source Code

The decision whether to modify or rewrite source code depends on the degree to which the simulation will require modifications and adaptations in the future. Many existing simulations are monolithic in design, meaning they have a single massive software program that performs all functions in a procedural order. Modifying existing source code tends to be less expensive in terms of cost and time in the short run versus rewriting the entire simulation. However, numerous modifications to monolithic simulations often result in 'spaghetti code' as well as clumsy lockstep processing, adversely affecting implementation of future enhancements in the long term. Rewriting the simulation in modern, object-oriented source code facilitates future enhancements due to code modularity. Also, object-oriented source code will arguably execute faster than procedural code if written efficiently. Costs of rewriting source code include extended development times and money for skilled code writers.

The HLA Warrior project elected to rewrite Janus source code as opposed to modification. Janus' procedural source code has evolved over two decades, resulting in over 200,000 lines of code developed by numerous code writers. As a result, project managers determined that a complete rewrite in an object-oriented language would benefit future enhancements and documentation.

3.3 Language Decisions

If project managers decide to re-write existing source code, the next decision is selecting an appropriate language. The availability of programmers may impact the decision. For instance, SIMSCRIPT (the language of the Corps Battle Simulation) programmers may be in shorter supply than more popular language programmers such as FORTRAN or C/C++. Also, programmer cost may be based on language. For example, although Java is well suited for simulation, Java programmers may be cost prohibitive since they are currently among the highest paid programmers of modern languages.

Although HLA Warrior project managers considered several major object-oriented languages, Java and C++ were the prime candidates. Java was considered given future web-based applications and platform independence. However, project managers selected C++ as the programming language primarily due to programmer availability, which reduced overall development costs.

3.4 Graphical User Interfaces (GUIs)

When re-hosting a legacy simulation, the project manager should assess the following areas prior to selecting the GUI. GUIs should be easily re-configurable, particularly if the simulation serves multiple domains. If the simulation is used in multi-national training exercises, buttons should be available in multiple languages. Also, the GUI should be configured to allow the user quick access to scenario development, execution, and post processing functions. Finally, users should participate in GUI development, specifically in the layout of menus and naming conventions.

The HLA Warrior user interface consists of a windows-based GUI that displays simulation data for scenario development, order entry, simulation

monitoring, analysis, and after action review. The GUI is developed using the COTS REVUE graphics environment developed by Tapestry Solutions. REVUE provides a high level scripting language for GUI construction. Most of the user interface is defined using scripts. These scripts are interpreted at runtime allowing the user to dynamically re-configure the interface during execution. The REVUE graphics environment and the Tapestry kernel development environment are integrated to link the GUI to the simulation.

3.5 Hardware & Operating Systems

Many existing simulations, including Janus, operate on workstations rapidly reaching the end of their effective lifespan. The decision to maintain existing, obsolete, workstations past their effective lifespan may result in degraded simulation performance once new functionality is added to the model. The trend in DoD is towards simulations operating on PCs. The increased computing power of PCs, combined with their low cost and flexibility, makes them a logical platform for future simulations.

The hardware platform selection impacts the target operating system. Many legacy simulations execute on a UNIX-based operating system. If a PC is the selected hardware platform, the simulation can operate on a UNIX-based or WinNT operating system. The program manager should consider the end user when selecting an operating system. Simulations used by individual soldiers may benefit from WinNT because of wide familiarity and maintainability. Whereas simulations maintained at analysis centers manned by trained systems administrators may benefit from UNIX-based operating systems.

HLA Warrior will execute on a PC running WinNT. PCs, particularly laptops, provide the flexibility needed to reach soldiers at all levels. Previously, Janus was only available at analysis centers or large training sites equipped with powerful workstations. Now, soldiers can load HLA Warrior onto their personal machines and benefit from simulation training at their convenience. Also, WinNT's wide familiarity and acceptance enables all soldiers, regardless of computer-skills, to execute HLA Warrior.

3.6 HLA Compliancy Options

Three general HLA compliancy options exist [1]:

- Gateway Option. DIS-compliant simulations can integrate Gateway software to achieve HLA compliance. Gateway is an adapter that transforms DIS packets into a format usable by the HLA Runtime Infrastructure (RTI). Gateway also converts incoming information sent via the RTI to DIS formats, enabling the simulation to interpret attribute updates and interactions.

- Standard Implementation. All simulation functionality is defined and implemented in source code. The Simulation Object Model (SOM) is a model of simulation functionality written in HLA Object Model Template (OMT) format. The SOM includes only those public attributes and interactions of potential interest to other federates. The simulation makes calls to the RTI and receives attribute updates and interactions from the RTI during simulation execution.

- HLA-based (Native) Implementation. All simulation objects are defined and implemented in the HLA OMT format. The Comprehensive Object Model (COM), written in OMT format, matches the simulation implementation [2]. The SOM is derived from the COM and contains all public data and interactions. (The COM contains additional information/functions not required in the SOM such as static data). The simulation engine is designed to recognize and update data types (attributes) and execute interactions defined in the SOM. The simulation makes calls to the RTI and receives attribute updates and interactions from the RTI during simulation execution. One major benefit of this option is that HLA tools, such as the Object Model Development Tool (OMDT), can be used for simulation development.

HLA Warrior uses the Standard Implementation option to achieve HLA compliance. Although the Gateway option is the least expensive, this option increases latency and is limited to passing attributes and interactions previously developed in DIS. The native HLA option was not selected because the HLA Warrior development environment and architecture do not support the OMT format directly. A future enhancement to HLA Warrior is to automate SOM generation directly from source code; thus the SOM will not be a model of the code implementation but a translation into OMT format.

4. Management Considerations

This section describes management considerations for re-hosting a legacy simulation. The HLA Warrior project serves as a case study to evaluate each concept.

4.1 In-House vs Outside Contract

After the project manager assesses technical considerations for re-hosting the legacy simulation, the next major issue is to determine whether to perform tasks in house, or contract out. The main factors bearing on this question are cost and expertise. When military and civilian government employees perform in-house general contracting tasks, project costs can be significantly reduced. Also, in-house contracting supports effective project oversight. However, in-house expertise and competence in advanced simulations is often not available, requiring outside contracting. The main benefit of outside contracting is the expertise civilian contractors contribute to the project. Generally, civilian contractors are experts in their field and have experience completing assigned tasks. Also, civilian contractors may implement tools that speed development, although these tools may incur proprietary costs. The main drawback to outside contracting is cost. Profit motive and overhead increase costs significantly when hiring civilian contractors. Additionally, the contract award process often takes months to complete if an existing contract is not already in place. Such delays could adverse affect project timelines.

HLA Warrior combined both in-house expertise and civilian contractors to complete the project. Given that TRAC-Monterey is located at the Naval Postgraduate School (NPS), project managers were in the unique position to benefit from professors' and postgraduate students' research. NPS Computer Science students and professors teamed to develop a class design of Janus functionality, derived from Janus source code and documentation. Once the coding began, the class design enabled code writers to build Warrior classes. Additional in-house expertise came from TRAC-Monterey analysts. Specifically, analysts developed an HLA Warrior SOM required for HLA compliancy.

The HLA Warrior project hired two civilian contractors to support the project. One contractor (Rolands & Associates) implemented source code, while another contractor (Tapestry Solutions) developed the GUI, provided the architecture, and supplied the development environment. More than one contractor involved in a project creates coordination issues and risks, particularly when one contractor develops source code while another develops the interface. To facilitate coordination, the project managers and contractors established a secure system at one location for registering daily updates to the simulation. The system was successful and the two-contractor concept significantly reduced overall development time.

4.2 Use of GOTS/COTS

The HLA Warrior team reviewed available GOTS and COTS during market and design analysis. The team made a deliberate decision to utilize available GOTS/COTS to the greatest extent possible to reduce both cost and development time. In fact, one conclusion from the HLA Warrior project is that future simulation developers should use GOTS/COTS products to the fullest extent if initial cost benefit analysis justify life cycle costs. Incorporating Tapestry's COTS architecture and development environment proved highly beneficial to the project. Although proprietary software involves licensing fees, the long-term benefits afforded by the leading-edge technology and time saved during the development phase far outweighed the licensing costs. Janus code, written in FORTRAN, was treated as a GOTS product. Janus functionality and algorithms were re-used in the HLA Warrior architecture, although rewritten in C++. Using existing functionality and algorithms enabled HLA Warrior to be completed at a fraction of the cost otherwise required to develop these functions from scratch.

4.3 Verification and Validation

Project managers must also address verification and validation (V&V) issues when re-hosting a legacy simulation to ensure customer confidence. The benefit of re-hosting a legacy simulation is that the simulation has likely undergone V&V. To preserve V&V integrity, the re-hosted simulation should incorporate existing legacy functionality, particularly all validated algorithms. Additionally, project managers should develop a formal V&V plan, implemented throughout the duration of the project.

HLA Warrior incorporates all Janus functionality and algorithms to support V&V. Additionally, code writers and selected test sites will perform verification procedures to ensure the code performs as intended. Subject matter experts at the test sites will also support validation measures by providing face validity assessments of combat scenarios. TRAC-Monterey

analysts will complete a quantitative statistical validation of HLA Warrior by comparing the results of an HLA Warrior scenario with the results of the same scenario executed in Janus (acting as the baseline).

5. Summary

Re-hosting legacy simulations with modern technologies is a cost-effective method to develop a new simulation incorporating state-of-the-art software. To ensure success, program managers must clearly assess technical considerations prior to development, particularly simulation architecture. Most technical tasks will require civilian contractor support, although military personnel can be trained to complete required tasks. For instance, the Defense Modeling and Simulation Office sponsors free HLA training workshops where analysts can learn the SOM development and federation development processes. Also, program managers should research COTS products and tools that could expedite simulation development.

This paper also described options to achieve HLA compliance. Despite a lack of funding for further developments, the Gateway option provides a cost-effective method to achieve compliance, given the legacy simulation is DIS compliant. Additionally, free HLA online help, technical assistance, and tools (such as the OMDT) exist to support HLA development.

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