HIGH LEVEL ARCHITECTURE AND THE PLATFORM PROTO-FEDERATION

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ABSTRACT

The High Level Architecture (HLA) is a simulation infrastructure designed to promote interoperability between simulations. The Defense Modeling and Simulation Office (DMSO) organized several experimental applications of HLA in 1996 to test and refine the architecture. One of those experiments was performed by the Platform Proto-Federation (PPF), a group of virtual real-time (i.e. DIS-type) simulations assembled to test HLA applicability to that domain. The PPF consisted of four member programs: BDS-D, BFTT, CCTT, and JTCTS. Each member program implemented an HLA federate that simulated one or more combat entity objects and interoperated with the others via HLA. That interoperation was tested in an experimental scenario that included land, sea, and air entities and a range of combat interactions. The PPF experiment showed that HLA provides the requisite functionality to support DIS-type distributed simulation, and is a promising component of future simulation development, but the run-time performance of production HLA software must be substantially improved over that of the prototype HLA software used for the PPF experiment.

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HIGH LEVEL ARCHITECTURE

This section provides background information on the goals, components, and basic concepts of the High Level Architecture.

The HLA Concept

Under Management Directive 5000.59, the Department of Defense (DoD) established requirements and responsibilities for the development of a comprehensive Master Plan for the "... strengthening, improvement, coordination, and management of modeling and simulation within DoD." The major goals of that effort included promoting interoperability between simulations and facilitating reuse of simulations and their components. The scope of this vision encompasses a broad range of simulations, including categories of simulations not previously included in the Distributed Interactive Simulation (DIS) community, such as simulations which utilize a different time management scheme or a different level of resolution or aggregation. The intent is that simulations of different types could be combined to interact and interoperate in meaningful ways.

The High Level Architecture (HLA) addresses those goals. It is a DMSO-initiated simulation framework intended to facilitate interoperation between a wide range of simulation types and to promote reusability of simulation software. If it is successful, HLA will encompass virtual, constructive, and live simulations, from training, engineering, and analytic domains.

HLA Components

HLA consists of a number of interrelated components. The three that specify HLA are: (1) the HLA Rules, which define interoperability and what capabilities a simulation must have to achieve it within HLA; (2) the Object Model Template, which is a semi-formal methodology for specifying simulation and federation object classes, attributes, and interactions; and (3) the Interface Specification, a precise specification of the functional actions that a simulation may perform, or be asked to perform, during an HLA exercise. Documentation of the HLA Rules, Object Model Template, and Interface Specification are available from DMSO.

The HLA Run-Time Infrastructure (RTI) is a software embodiment of the Interface Specification that implements the actions defined therein to be invokable by a simulation, provided as a set of services. Perhaps most important among those services is the transport of data between interoperating simulations. The RTI services fall into five categories: federation management, declaration management, object management, ownership management, and time management. Federation management refers to the creation, dynamic control, modification, and deletion of a federation execution. The declaration management services provide the mechanism for simulations to declare their desire to generate and/or receive object state information. The object management services are the means by which federates create, modify, and delete objects and the interactions they produce. The ownership management services allow simulations to transfer ownership of an object and/or its attributes. Finally, the time management services provide different categories of message delivery service as well as the mechanism for time advancement during an execution. A full description of the RTI services are available in the Interface Specification; they are summarized in (Calvin,1996). A prototype RTI implementation was developed in versions by MIT Lincoln Laboratory and the Mitre Corporation. The prototype RTI was used for the initial HLA experiments, including the one described in this paper.

Though HLA is still under development a number of published descriptions of various aspects of it are available. For more information, see the several papers in the proceedings of the last two DIS Workshops (IST,1996a) (IST,1996b).

Federations and Proto-Federations

A core HLA concept is the federation, which is a group of simulations that intend to interoperate to achieve some specific objective. A federation consists of a named set of interacting simulations, called federates, a common federation object model (FOM) which documents the object classes and interactions that will be mutually understood by the federates, and supporting RTI software and data files.

DMSO organized four prototype federations (or "proto-federations") to test the HLA concept and its initial specification and implementation. The proto-federations included a wide range of simulation types and implemented a diverse set of applications using the initial HLA specifications and RTI. The proto-federations were charged with the task of addressing the technical issues raised by the HLA specification and with the assessment of the applicability of the HLA to their application domains. Each member of a proto-federation was a major simulation program; the members were supported by technical teams assembled from government, industry, and academia. The experiences of the proto-federations were used to modify the initial HLA specification so as to establish a baseline version of HLA.

The grouping of member programs into the four proto-federations was based on the characteristics of the member programs, their shared mission interests, and their key technical issues. The four initial proto-federations were the Analysis, Engineering, Joint Training, and Platform proto-federations. The Analysis proto-federation was composed of member programs JWARS and MIDAS, a deployment prototype. The federation was based on faster-than-real-time, closed form analysis simulation. Their key technical issues were time management, data filtering, exercise repeatability, and run-time efficiency. The Engineering proto-federation was composed of member programs JMASS, T&E-EW, SBD, and IADS. That federation was based on validated, detailed, high fidelity simulations for test and evaluation, acquisition support, and concept evaluation. The key technical issues of that federation were object ownership management and performance. The Joint Training proto-federation was composed of member programs JSIMS, Eagle, NASM/AP, NSS, and DEEM, which are distributed discrete event simulations. Time management, object ownership, and environmental representation were their key technical issues. The fourth federation, the Platform proto-federation (PPF) is the topic of this paper and is defined in the next section.

THE PLATFORM PROTO-FEDERATION

This section presents the Platform Proto-Federation, including its goals, members, federates, object model, RTI integration, and common software. Some of the material in this section is based on (TASC,1996), where it is presented in more detail.

PPF Overview

As mentioned earlier, the PPF consisted of four member programs; in alphabetical order, they were: Battlefield Distributed Simulation-Developmental (BDS-D), Battle Force Tactical Training (BFTT), Close Combat Tactical Trainer (CCTT), and Joint Tactical Combat Training System (JTCTS). These members are all real-time distributed simulations that are based on DIS or DIS-type network protocols. The PPF's HLA experiment was organized to determine if HLA can effectively provide the necessary interoperability and performance for DIS-type real-time simulation. Each of the members implemented an HLA federate to participate in the PPF experiment. Table 1 summarizes the PPF.

Program	Federate	Simulation Type	Government Sponsor	Support Agency
BDS-D	Crewed SIMNET M1 Simulator	Crewed virtual	STRICOM	IST
BFTT	BFTT Training System	Crewed live	NSWC	ARL UT
CCTT	CCTT Semi-Automated Forces	CGF virtual	STRICOM	SAIC
JTCTS	JTCTS Engineering Model	Analytic virtual	NAWC	Raytheon

Table 1. PPF summary.

Three goals were identified for the PPF effort: (1) assess the developmental impact on legacy simulation programs of HLA compliance; (2) assess the performance issues associated with the HLA specification and the implementation of the prototype; and (3) determine the extent of commonality achievable in the development of a common software framework to support HLA implementation. The main PPF experimental scenario (to be discussed later) was designed to test aspects of HLA crucial to DIS-type simulations, including typical DIS classes, attribute updates, and interactions. HLA capabilities new to DIS, such as object and attribute ownership transfer, were also tested by the PPF. Data gathered during the PPF experiment helped to determine if HLA can effectively provide the necessary interoperability and performance for DIS-type real-time virtual simulation. The results of the PPF's experience can be used to guide procurement of new systems and upgrades of existing systems which must comply with the HLA.

Not all HLA technical issues were taken up by the PPF. Some of those not specifically tested were federation initialization, the effects of the synthetic environment on interoperability, data filtering, and time management.

PPF Members and Federates

The BDS-D is the Army's keystone program for continued advancement of distributed simulation technology in support of stated Army Training Research and Development Operational Capabilities Requirement and the Office of the Secretary of Defense's Joint Warfighting Capability Objectives for Joint Training Readiness. The BDS-D federate was a crewed SIMNET M1 simulator. The M1 simulator was the only human-in-the-loop simulator involved in any of the proto-federations. As such, the BDS-D federate provided unique insight into how HLA is perceived by human users in an HLA-supported exercise. BDS-D connected the existing M1 simulator to the HLA network using an HLA Gateway, developed at IST. The HLA Gateway performs protocol translation, converting SIMNET protocol data units into RTI service invocations and vice versa. The gateway approach was chosen for BDS-D to test the feasibility of integrating legacy simulations into HLA in that manner. The HLA Gateway is described in full detail in (Cox,1996). Figure 1 is an overview of the BDS-D federate.

The BFTT system provides training opportunities for fleet personnel to achieve and maintain combat readiness within the surface and subsurface naval forces. The BFTT program's PPF federate was based on a DIS-compliant simulation model. The BFTT federate simulated several sea vessels which included subsystems such as sensors and weapons. BFTT operates in an embedded computer environment which will support the evaluation of the portability issues relative to the HLA.

The CCTT is the first of the Combined Arms Tactical Trainer (CATT) family of virtual trainers. The CCTT system was the first fully DIS compliant training system and consists of networked vehicle simulator manned modules, as well as Semi-Automated Forces (SAF), combat support, and after-action review workstations. The CCTT SAF served as CCTT's PPF federate. The CCTT SAF has the ability to generate a large number of entities and their behavior. The PPF experiments utilized the flexibility and capacity of the CCTT SAF to fill out the PPF experimental scenario and to generate sufficient entities to drive performance testing of the RTI. The CCTT federate's overall design is shown in Figure 2.

The JTCTS is a joint USN/USAF program to develop the next generation Tactics Combat Training System. JTCTS will interface with and augment existing combat system capabilities in the areas of tactical training and data collection. The JTCTS Engineering Model was used in the PPF experiments to simulate aircraft, aircraft sensors, and munitions. The JTCTS federate provided a means to investigate the performance of the RTI for "fast movers", such as aircraft and missiles, as well as testing the RTI's ownership transfer services. Figure 3 shows the JTCTS federate's overall design.

PPF Object Model

As a part of the federation development phase within the federation development and execution process, the PPF developed a FOM. The FOM documented the common simulation functionality and data needed to support the PPF scenario. The FOM identified the objects, attributes, associations, and interactions that were important to the PPF and were supported by the PPF. The PPF began with a draft scenario which was refined prior to FOM development. The PPF members reviewed the scenario in detail in order to understand the interactions between federates. The scenario description was then used to extract the FOM classes, attributes, and interactions, which were documented as in the Object Model Template format. This process produced a FOM which was exercise specific, because the FOM development was driven by the experimental scenario, and reminiscent of DIS, because of the DIS origins of the PPF federates. Table 2 is a subset of the PPF's FOM class structure table. The classes of objects actually instantiated by the PPF are italicized.

PPF RTI Integration

For the PPF members, a crucial design decision in the implementation of their federates was how to integrate the RTI into their simulation. The approaches to RTI integration can be categorized into three general levels. In the first level, the RTI services are directly implemented into a simulation's basic structure to produce a federate; this is the most difficult. The second level involves interfacing a simulation with a separately developed RTI service package. The third level, and simplest to implement, is to use a protocol translator. All three levels of integration were tested by the PPF. BFTT and JTCTS employed the "services package" approach, based on the PPF Component Service Framework (presented later). The BDS-D HLA Gateway used a protocol translator, which itself included the CSF services package. Finally, the CCTT SAF implemented the RTI directly into their simulation, providing the third perspective in the evaluation of implementation levels of the HLA RTI. Figure 4 displays the different RTI integration approaches used by the PPF federates.

PPF Common Software

Seeking to leverage the available resources for the PPF experiments, a common services package was designed and developed for the PPF by TASC. The Component Service Framework (CSF) is a software services package that reorganized and extended the set of RTI services. Designed from an HLA simulation developer's perspective, and in particular a PPF developer's perspective, it was intended to simplify PPF federate development. The CSF provided a layer of abstraction and encapsulation between the federate developer and the RTI. Instead of invoking the RTI services directly, a PPF federate's software could interface with the CSF. This benefited the PPF developers because the CSF's feature set was more specific to the needs of the PPF and because the individual PPF developers were to some extent insulated from changes in the RTI. Furthermore, capabilities developed for one federate within the CSF could be utilized as appropriate by other federates.

Entity	Platform	Ground_Vehicle	Wheeled	Truck	
			Tracked	Tank	*M1*
					T72
				Armored_Fighting_Vehicle	*M2*
					BMP
		Air_Vehicle	Fighter	*F1*	
			Attack	*FA18*	
		Sea_Vehicle	Carrier	*CV64*	
			Missile_Cruiser	*CG47*	
			Gunboat	*Nanuchka*	
		Human	*Infantry*		
	Munition	Guided	Anti_Ground	*TOW*	
				AT5	
				HARM_Anti_Ground	
				LGB	
			Anti-Air	*SM2*	
				SA16	
				SA_N_4	
			Anti_Sea	*Exocet*	
				HARM_Anti_Sea	
		Unguided	Anti_Ground		

Table 2. A portion of the PPF FOM class structure table.

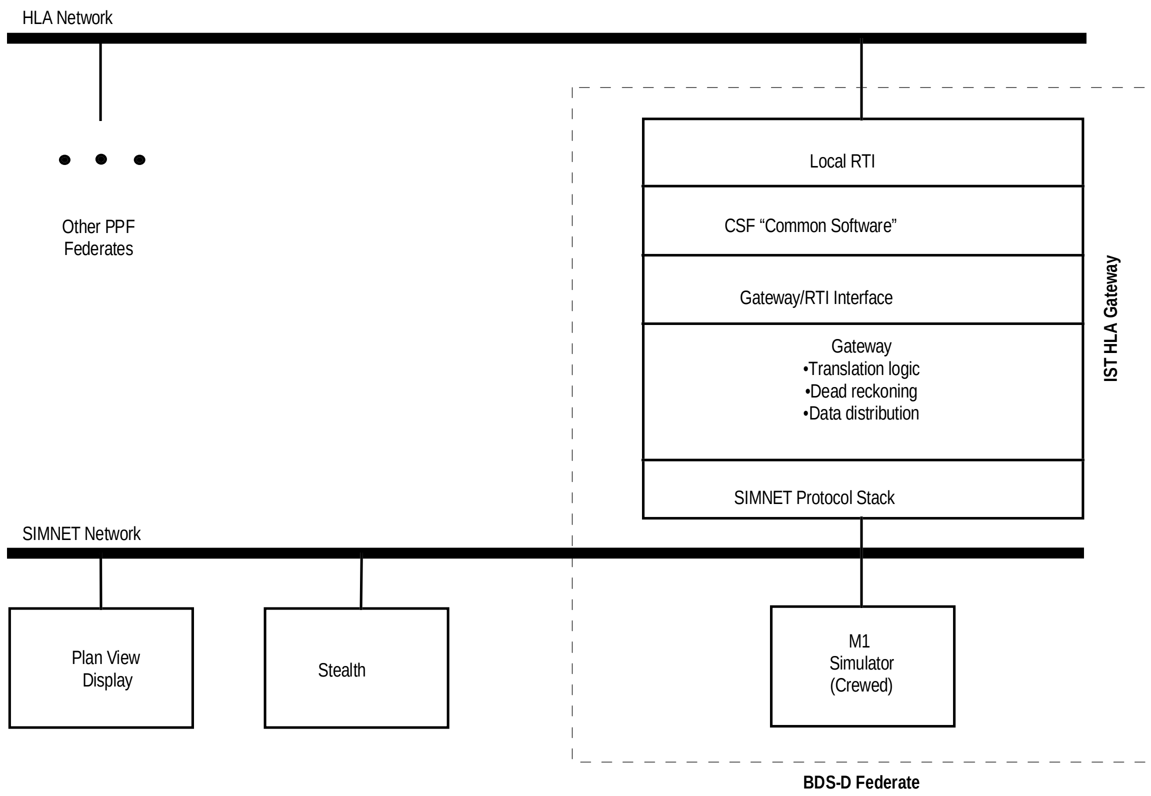

Figure 1. BDS-D federate design overview.

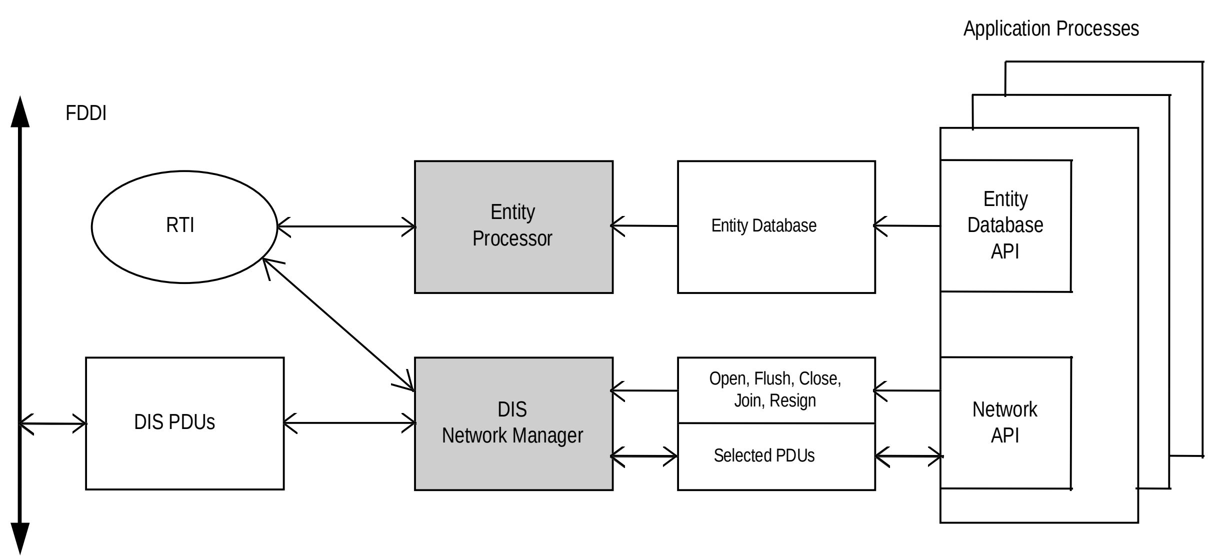

Figure 2. CCTT federate design overview.

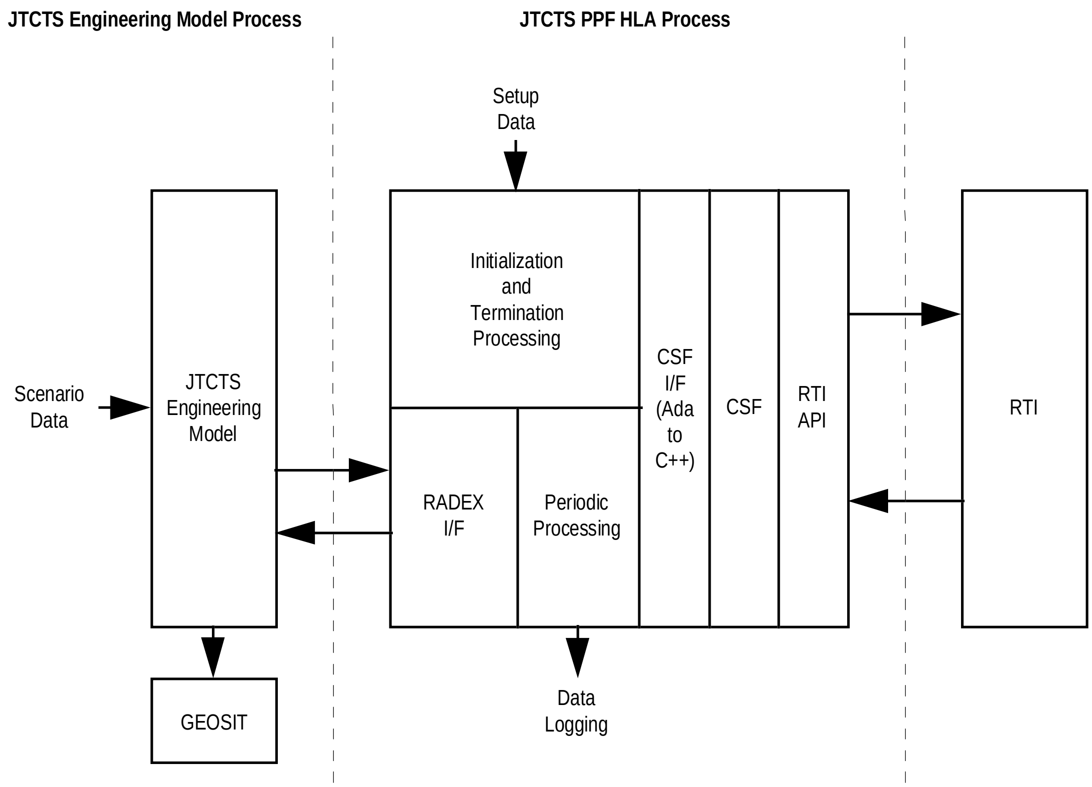

Figure 3. JTCTS federate design overview (Rattey,1996).

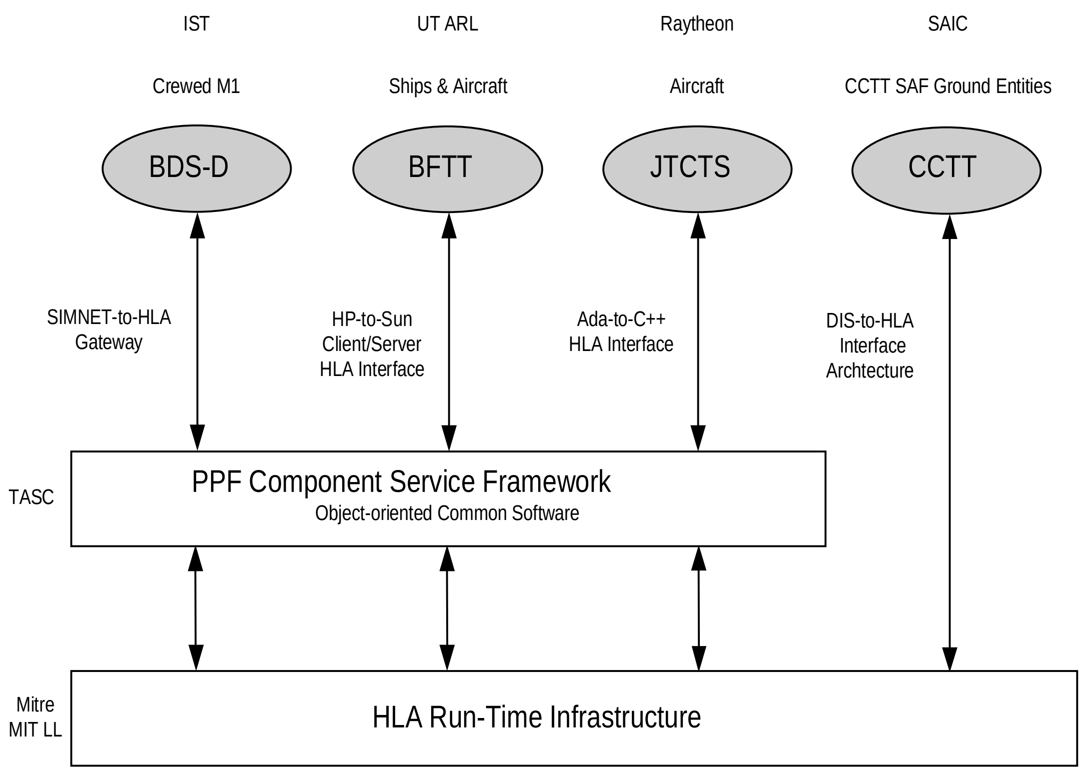

Figure 4. PPF RTI integration.

THE PPF EXPERIMENT

This section presents the PPF's experiment, including its plan, scenario, and results. See (TASC,1996) for more detail on the plan and scenario.

PPF Experiment Plan

As mentioned, there were three main issues to be addressed by the PPF: (1) assess the developmental impact on legacy simulation programs of HLA compliance; (2) assess the performance issues associated with the HLA specification and the implementation of the prototype; and (3) determine the extent of commonality achievable in the development of a common software framework to support HLA implementation. Lessons about issues (1) and (3) were learned during the process of developing the PPF FOM and the individual PPF federates. The motivating force for that development, and the mechanism for addressing issue (2), was the PPF experiment. The PPF experiment centered on an experimental scenario which exercised all of the HLA functions that were of interest to the PPF members.

For the PPF, HLA performance was of interest in four areas: (1) general performance; (2) stress; (3) ownership transfer; and (4) "fast movers" performance. The first area included general RTI performance factors, such as processor loading and communications latency, as a function of the experimental scenario conditions. The stress aspect focused on the behavior of the RTI under heavier loading conditions. The RTI's ownership transfer mechanism was examined for reliability and efficacy. Finally, the fast mover tests identified the performance of the RTI in terms of supporting simulation entities that have high dynamics (i.e., rapidly changing state).

PPF Experimental Scenario

For the PPF experiments an experimental scenario that involved all of the federates was required. Working from a well defined scenario facilitated the Federation Object Model development process, identified information that could be captured for analysis of the RTI performance, and provided structure and characterization to the experiments.

The PPF experimental scenario consisted of multiple phases. Each phase involved two or more interoperating federates. Each phase was designed to specifically address one or more of the PPF's HLA assessment areas. The individual phases operated independently, and had specific initialization parameters that did not depend on the execution of any of the other phases. The separation of the scenario into phases enabled interoperability testing with only two federates, reducing complexity and mitigating risk.

The PPF scenario begins with Blue and Orange forces separated by a geographic border. Ground, air, and sea entities exist and are simulated on both sides. Table 3 details the PPF experimental scenario.

PPF Experiment Results

The PPF experiment was conducted in July 1996. Though various problems and obstacles disrupted the testing schedule, the PPF members were able to execute all of the planned experimental scenario phases. At this writing a detailed analysis of the results are still underway, but several findings of the PPF can be reported. Recall that the primary goal of the PPF was to determine if HLA can effectively provide the necessary interoperability and performance for DIS-type real-time simulation. The results of the PPF experiment indicate the following:

(1) *HLA has sufficient functionality to support DIS-type simulation.* The PPF scenario was designed to exercise as many as possible of the HLA services that might be needed by a DIS-type federation. Those services exercised by the PPF worked as specified. Other services that might be needed by DIS-type simulations that were not exercised in the PPF scenario are present in the definition of HLA.

(2) *HLA provides capabilities beyond those currently found in DIS that are likely to be very useful to DIS-type simulations.* Class-based interest management, to reduce the load imposed on a federate by incoming network traffic, and ownership transfer, to permit more flexible and specialized distributed simulation models, are examples of HLA functions exercised by the PPF that have obvious value for DIS-type simulations.

(3) *At present the run-time performance of the current prototype implementation of the RTI is not sufficient for DIS-type real-time simulation.* In particular: (3a*) Latencies for data communication via the RTI exceed the DIS threshold.* Throughout the PPF experiment trials, the overall average RTI latencies for attribute updates and reflections of 400-500 milliseconds were observed, well above the 100 millisecond threshold often stipulated for real-time simulation (DIS, 1994). Interactions, which in the current RTI were sent via Reliable transmission (as opposed to Best Effort for

Phase Number and Description	Force	Unit	Objects	Federate(s)	Goals
Phase 1: Border Crossing Blue Tank Platoon in fixed position. Orange Tank Company crosses border into Blue territory. Orange Tank Company assaults Blue Tank Platoon. After attack, Orange forces assume defensive position.	Orange	Tank Company	10x T-72	CCTT	Test interoperability of CCTT, BDS-D.
		Motor Rifle Platoon	3x BMP	CCTT	
		Anti-aircraft Squad	1x BMP	CCTT	
	Blue	Tank Platoon	3x M1 1x M1	CCTT BDS-D	
Phase 2: Blue Ground Airstrike Orange forces in defensive position, with infantry from Motor Rifle Platoon and Anti-aircraft Platoon dismounted. Blue F/A-18s attack Orange T-72s with GBU-12 laser guided bombs. Orange Anti-aircraft Platoon dismounted infantry engage Blue F/A-18s with SA-16 SAMs.	Orange	Tank Company	10x T-72	CCTT	Test interoperability of CCTT, JTCTS. Test RTI run-time performance for "fast mover" objects (aircraft and missiles).
		Motor Rifle Platoon	3x BMP 18x Dsmntd Inf	CCTT CCTT	
		Anti-aircraft Squad	1x BMP 2x Dsmntd Inf 1x SA-16	CCTT CCTT CCTT	
	Blue	Division	4x F/A-18 4x GBU-12 LGB	JTCTS JTCTS	
Phase 3: Blue Counterattack Orange forces in defensive position, with infantry from Motor Rifle Platoon and Anti-aircraft Platoon dismounted. Blue F/A-18s attack Orange T-72s with GBU-12 laser guided bombs. Orange Anti-aircraft Platoon dismounted infantry engage Blue F/A-18s with SA-16 SAMs. Blue Tank Company assaults Orange forces.	Orange	Tank Company	10x T-72	CCTT	Test interoperability of CCTT, BDS-D, JTCTS. Test RTI run-time performance with increased entity and interaction counts.
		Motor Rifle Platoon	3x BMP 18x Dsmntd Inf	CCTT CCTT	
		Anti-aircraft Squad	1x BMP 2x Dsmntd Inf 1x SA-16	CCTT CCTT CCTT	
	Blue	Division	4x F/A-18 4x GBU-12 LGB	JTCTS JTCTS	
		Tank Company	12x M1 1x M1	CCTT BDS-D	
		Mech Infantry Platoon	4x M2	CCTT	
Phase 4: Orange Sea Airstrike Orange F1 detects CG-47 with radar, then attacks it with Exocet missile. Blue CG-47 intercepts Exocet with SM-2 missile.	Orange		1x F1 1x Exocet	JTCTS JTCTS→BFTT	Test interoperability of JTCTS, BFTT. Test object ownership transfer services.
	Blue		1x CG-47 1x SM-2	BFTT BFTT→JTCTS	
Phase 5: Blue Sea Airstrike CV-64 launches F/A-18. F/A-18 detects Nanuchka with radar, then attacks it with HARM missile.	Orange		1x Nanuchka	BFTT	Test interoperability of JTCTS, BFTT. Test object ownership transfer services.
	Blue		1x CV-64 1x F/A-18 1x HARM	BFTT JTCTS JTCTS→BFTT	
Phase 6: Complete Scenario All events from Phases 1-5.		All units.	All objects.	All federates.	Test interoperability of all PPF federates. Test RTI run-time performance with full scenario.

Table 3. PPF experimental scenario summary.

attribute updates) were slower, with average latencies of 800-1200 milliseconds observed. Latencies for network pings along the same routes averaged 1-10 milliseconds. (3b) *The RTI may be cyclically delaying data communications.* During several PPF experiment trials, an update batching phenomena was observed, where some attribute updates were not received with the same time distribution as they were sent. Typically, one federate's attribute updates would be sent approximately uniformly distributed in time, but they would be received by (reflected to) another federate in clusters or "batches". As one would expect, the first update received in a batch was the longest delayed from its send time, with the delay declining for each successive update received in a batch. The observed behavior suggests that the attribute updates were being buffered somewhere in the transmission sequence. It is not all certain that the batching is taking place in the RTI, but the batching was observed in several different trials with quite different network configurations. This problem is especially important in a DIS-type federation with an independent time advancement scheme. (3c) *The RTI performance was highly sensitive to network configuration.* Some configurations tested by the PPF resulted in interactions being delivered by the RTI with latencies in the range of 10-150 seconds. Relative to this finding as a whole, please note that these comments are relative to the prototype RTI available for our experiment; the PPF expects the run-time performance of the RTI to improve in future versions.

A secondary goal of the PPF was to evaluate the utility of a common software "middleware" layer between federates and the RTI to simplify RTI integration.

(4) *Common software middleware can be very helpful in federation development.* The PPF found that it eased the task of interfacing federates with the RTI and helped to insulate the federates from changes to the RTI, at least for simulations as homogenous as the PPF's DIS-type federates. The PPF's middleware (the CSF) did a good job relative to its goals, especially given its prototype status. However, the particular set of functions implemented in the PPF CSF was not necessarily optimum for all of the PPF federates.

CONCLUSIONS

A hazard of proving the efficacy of a concept is the volatile nature of the concept itself. HLA is a concept in flux, with many objectives and goals. All the components of HLA were in development throughout the PPF development and experiment period, thereby compressing the PPF's development schedule and confounding the production of lasting results. Nevertheless, the PPF found that HLA does meet its objective of promoting interoperability between simulations and is a promising component of future simulation development.

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REFERENCES

Calvin, J. O. and Weatherly, R. (1996). "An Introduction to the High Level Architecture (HLA) Runtime Infrastructure (RTI)", *Proceedings of the 14th Workshop on Standards for the Interoperability of Distributed Simulations*, Orlando FL, March 11-15 1996, pp. 705-715.

Cox, A. and Wood, D. D. (1996). "Design and Implementation of the BDS-D/HLA Gateway", *Proceedings of the 18th Interservice/Industry Training Systems and Education Conference*, Orlando FL, December 3-6 1996.

DIS Steering Committee (1994). "The DIS Vision: A Map to the Future of Distributed Simulation", *Technical Report IST-SP-94-01*, Institute for Simulation and Training, May 1994.

IST (1996a). *Proceedings of the 14th Workshop on Standards for the Interoperability of Distributed Simulations*, IST-TR-96-02, Orlando FL, March 11-15 1996.

IST (1996b). *Proceedings of the 15th Workshop on Standards for the Interoperability of Distributed Simulations*, IST-TR-96-01, Orlando FL, September 16-20 1996.

Rattey, P. A. (1996). "JTCTS Federate Design and Status", *Briefing at PPF8 meeting*, May 23 1996.

TASC (1996). "Platform Proto-Federation Experiment Plan", Technical Report, June 6 1996.