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AN-CASE NET-CENTRIC Modeling and Simulation

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ABSTRACT

The objective of mission training exercises is to immerse the trainees into an environment that enables them to train like they would fight. The integration of modeling and simulation environments that can seamlessly leverage Live systems, and Virtual or Constructive models (LVC) as they are available offers a flexible and cost effective solution to extending the "war-gaming" environment to a realistic mission experience while evolving the development of the net-centric enterprise. From concept to full production, the impact of new capabilities on the infrastructure and concept of operations, can be assessed in the context of the enterprise, while also exposing them to the warfighter. Training is extended to tomorrow's tools, processes, and Tactics, Techniques and Procedures (TTPs).

This paper addresses the challenges of a net-centric modeling and simulation environment that is capable of representing a net-centric enterprise. An overview of the Air Force Research Laboratory's (AFRL) Airborne Networking Component Architecture Simulation Environment (AN-CASE) is provide as well as a discussion on how it is being used to assess technologies for the purpose of experimenting with new infrastructure mechanisms that enhance the scalability and reliability of the distributed mission operations environment.

Keywords: Distributed Modeling and Simulations, Distributed Mission Operations, Net-Centric

1. INTRODUCTION

Today's Military Operations are composed of varying information enclave types that may be part of or employ a fixed infrastructure or a mobile network with limited connectivity. The systems that make up these enclaves are architected to provide a set of capabilities that contribute to the mission of the warfighter. Department of Defense (DoD) transformation endeavors such as Corporate Enterprise Systems, the Defense Information Systems Agency (DISA) Global Information Grid-Bandwidth Expansion (GIG-BE) and Net-Centric Enterprise Services (NCES), are networked-based Systems of Systems (SoS) developed to reduce the proliferation of redundant capabilities and provide a set of common services to maximize information sharing and assure the right information and only the required information is available where it is needed.

The DoD vision continues to focus on the development of a network-centric enterprise information environment that improves warfighter capabilities and ensure horizontal integration across DoD joint services, coalition, and homeland defense efforts. The objective is to expand warfighter capabilities and ultimately the mission and campaign effectiveness by extending the enterprise, the required services and information, across platform boundaries. In essence, it's about breaking down stovepipes and getting the right information to the right command and control (C2) node or platform at the right time, in the right format. Traversing multiple legacy software and information systems, communication infrastructures, classification levels, domain boundaries and policy directives are some of the many items that must be considered when creating a network-centric enterprise across multiple military forces.

The development of a modeling and simulation environment that can seamlessly leverage Live systems, and Virtual or Constructive models (LVC) as they are available offers a flexible and cost effective solution to evolving the development of the net-centric enterprise. More over, the C2 systems, virtual cockpits, threat models, and communications assets within the environment can be applied to the "war-gaming" environment for a near real-time realistic mission experience. From concept to full production, the impact of new capabilities on the infrastructure and concept of operations, can be assessed in the context of the enterprise, while also exposing them to the warfighter. Training is extended to tomorrow's tools, processes, and Tactics, Techniques and Procedures (TTPs).

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Section 2 of this paper addresses the challenges of a net-centric modeling and simulation environment that is capable of representing a net-centric enterprise. Section 3 highlights the Air Force Research Laboratory's (AFRL) Airborne Networking Component Architecture Simulation Environment (AN-CASE) and how it is being used to assess technologies for the purpose of experimenting with new infrastructure mechanisms that enhance the scalability, security, and reliability of the distributed mission operations environment. The infrastructure mechanisms, including information transport protocols, time management and information assurance mechanisms, being evaluated and assessed are addresses in Section 4.

2. NET-CENTRIC MODELING AND SIMULATION CHALLENGES

A Modeling and Simulation (M&S) environment supporting all facets of enterprise network research, development and employment needs to provide an analysis capability enabling the user to answer questions related to projected performance, mission effectiveness and cost of the eventual fielding and employment of the network and information management capabilities, in the context of meeting the requirements of both the tactical and strategic warfighter.

To achieve these goals, the ability to experiment with new technologies and architectures in a realistic end-to-end mission thread, supported by a flexible, user-friendly, near-plug-and-play environment and infrastructure that provides timely, assured information exchange is needed.

The technical challenges that need to be addressed in defining this infrastructure include:

- Interoperability of validated models with the appropriate (focused) fidelity
- High performance, scalable "best-of-breed" alternative network communication protocols for large scale real-time distributed simulations that can provide better:
    - Scalability in network settings where transport protocol limitations pose serious issues.
    - Performance in WAN settings where TCP collapses.
    - Time-critical, reliable delivery for UDP multicast, stabilizing applications that will otherwise face disruptive collapses in performance and reliability.
- Efficient and effective solutions to meet security needs in an open, multi-domain Wide Area Network (WAN) environment, as well as other cross-cutting issues such as Information Assurance, Quality of Services (QoS), and fault tolerance.
- Enterprise and Interoperability services that help to eliminate the need for translators between architectures and enable "plug-n-play" and the joining and departing of individual simulation systems over wide or local area networks.
- Information management services that improve performance and load balancing,
- Effective time management mechanisms for distributed simulations that provide consistency, repeatability and resolution of time anomalies.

There has been a significant investment in Commercial Off The Shelf (COTS) or Government Off The Shelf (GOTS) M&S capabilities and applications (e.g., HLA, DIS) that can be leveraged while focusing on the development of new capabilities that support improved communications and network infrastructure development as well as advanced visualization, and engineering analysis and evaluation tools. To properly simulate a distributed system of systems it will be necessary to integrate components capable of simulating the functional, logical and physical behavior of selected C2 players, policy, and network components and devices that may be required for mission and engineering analysis.

The M&S environment must be a set of services and tools that provide the mechanism for quickly evolving and instantiating new capabilities (e.g., technology or models) as a means to define and rapidly generate the "as-is" and alternative "to-be" concepts of operation, network topologies, connectivity options, alternative message protocols and processing threads to be simulated, as well as to instantiate static and dynamic routing concepts to be represented. This needs to be done in a manner that accurately represents military and intelligence community operations and defines the Measures of Effectiveness and Performance (MOEs, MOPs) to provide a valid assessment of the enterprise or networking capability.

The M&S environment also must provide the mechanisms for managing the various models but more importantly provide a flexible means for mapping network options to the defined entities of a mission scenario whether they be constructive or live. Hundreds of mobile nodes needing to collaborate using a dynamic RF environment will significantly challenge a tactical network. Capturing the symbiotic relationship between the nodes, their RF links, and the distributed network services in the simulation environment will go a long way in establishing what will work and what won't for a given tactical environment.

3. AN-CASE CAPABILITIES AND FRAMEWORK ARCHITECTURE

AN-CASE is both an extensible modeling framework and a base set of tools selected specifically to enable simulation and evaluation of communication architectures (e.g. airborne networks) and new technologies intended to improve C4ISR capabilities for the Air Force and DoD in general. AN-CASE is designed to support distributed, heterogeneous simulations over a local and/or wide area network. Heterogeneous simulation refers to the AN-CASE capability to provide interoperability and seamless integration of LVC models with Hardware-in-the-Loop (HWIL), Software-in-the-Loop (SWIL), or Human-in-the-Loop (HIL) node configurations.

Complimentary to the distributed military operational mission needs, AN-CASE supports a configurable set of services that can be architected to support complex training scenarios or mission rehearsals as well as experimentation and evaluation of proposed technologies against realistic mission scenarios in order to: a) validate architectures and topologies; b) benchmark product performance and capabilities; c) assess the technology or capability impact on mission effectiveness; d) investigate the effects of various failure types on force and communications architectures; e) do trade analyses on QoS and Quality of Information Assurance (QoIA) mechanisms and their impact on the mission; f) evaluate mission effectiveness given a degraded set of resources; and g) assess the time it takes to load balance an enclave given different operational and threat constraints.

By design, AN-CASE is architecture and application (e.g. model) agnostic and enables the integration and interoperability of existing and emerging heterogeneous models and modeling tools by leveraging the "Best of Breed" features from the High Level Architecture (HLA), Distributed Interactive Simulation (DIS), Common Component Architecture (CCA) and Service Oriented Architecture (SOA) domains. It is an open and scalable, standards-based framework that facilitates system evolution from concept to deployment.

As seen in Figure 1, the AN-CASE Vision recognizes a development process that enables a concept or prototype to evolve from phase to phase throughout its lifecycle and the role that a flexible, enterprise level M&S environment can play. AN-CASE provides the context for evaluating the capability in the modeled environment or using it in a training exercise. The AN-CASE vision is to provide an M&S environment that supports the seamless transition from R&D to Deployment - from technology development and mission effectiveness trades to mission rehearsal and training.

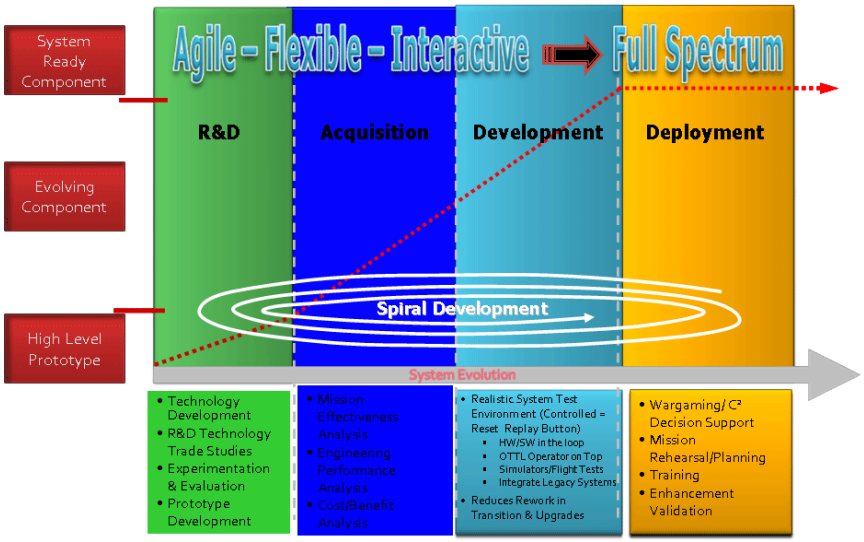

Fig. 1. AN-CASE Vision for a Model-Based Development Life Cycle

The AN-CASE environment provides a means of investigating different architectural alternatives to determine the impacts that result from selecting among them. Tools such as AN-CASE's NetSim, or QualNet and OpNet can be used for injecting packet streams into the simulated networks. The environment provides the means to gather large volumes of network performance data to provide insight into the exact impact that a new mechanism will introduce on the overall network architecture. When an experiment is established, we are able to translate the results into metrics of network performance and metrics of mission success. This answers the question of how much benefit is actually achieved operationally if some aspect of the network architecture is modified.

The AN-CASE Architecture is illustrated in Figure 2 below. AN-CASE provides the messaging transport and services that enable the interoperability of different modeling applications and tools over a distributed network. The grey boxes represent simulation applications or models that are COTS or GOTS software currently integrated on the framework. The colored boxes represent the toolset available on the AN-CASE Framework that supports the capabilities to add applications and to build, run, and analyze experiments.

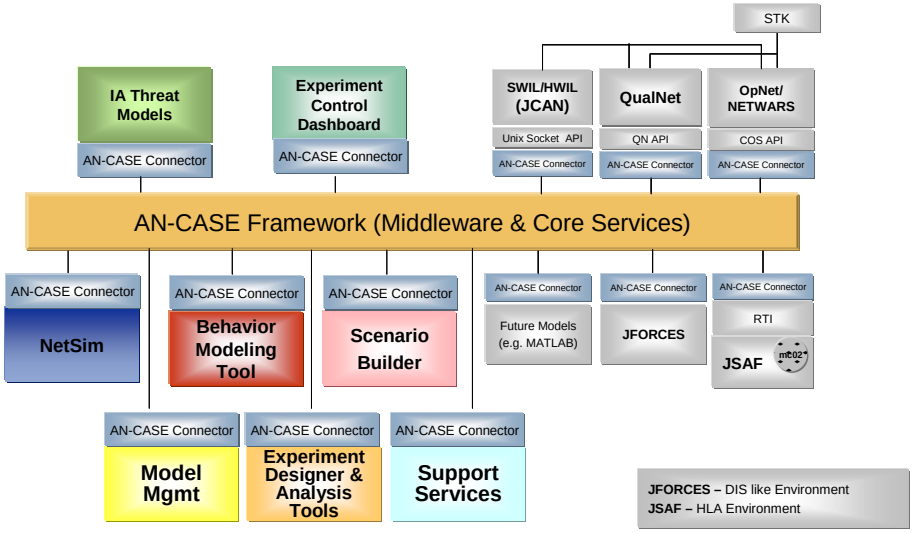

Fig. 2. AN-CASE Architecture

Integrating AN-CASE Simulation Applications

An AN-CASE testbed can be configured to emulate small scale exercises, e.g. 10 locations, 10 simulations and a few dozen participants to much larger scale exercises or experiments. DIS, HLA or any C4ISR system or application can be integrated to create war gaming experiences to facilitate training and mission rehearsal objectives. Currently AN-CASE has integrated a number of DIS and HLA applications and can be configured to simulate various tactical and Global mission scenarios.

The AN-CASE model componentization mechanisms can be used to add any applications required to support new experimentation in the testbed. The AN-CASE Componentization Tool and process reads in an application and creates an application xml-based interface description and data specification that collectively act as an application "wrapper." The wrapper enables tool interoperability between different architectures such as DIS and HLA so that comprehensive scenarios of interest can be defined. The wrapping mechanism reduces model integration time but more importantly it supports the interoperability of legacy mission & network simulation applications so that we can build on existing experience.

AN-CASE Scenario Builder

Setting up an experiment or training exercise, involves integrating a number of assets including high fidelity man-in-the-loop virtual cockpits, C2ISR crew stations, manned threat stations, environment generators and instructor-operator stations with the communications and network capabilities that emulate an operational environment. The communications capabilities may be real (e.g. PRC117 UHF Radio, T3 Link) or simulated using tools like OpNet and QualNet. The AN-CASE Scenario Builder is used to develop the mapping required for tool interoperability. In

particular, the Scenario Builder provides the cross layer model mapping of force entities to the appropriate behavior, network and communications capabilities.

AN-CASE Experiment Management and Control

The AN-CASE Web-based Management and Control Dashboard provides a view of the network and the resources that have been configured for an experiment. Using the Service Location Protocol (SLP), the automatic resource discovery mechanisms provide real-time feed back on the status of the services and applications that are running at each of the distributed nodes. Applications and services can be started, stopped or paused from the Dashboard. The user can also subscribe to the data being sent or received by all the applications, services and networks on the framework making diagnostics of a remote node or communications link only a click away.

AN-CASE experimentation definition, analysis and evaluation

The objective of experimentation and analysis is to address application and protocol configuration and deployment options, and to provide configuration guidance for integration of mechanisms in future distributed mission operations environments.

Using AN-CASE, the Measures of performance (MOP) metrics that serve as resource and network health indicators such as CPU load, bandwidth utilization and latency can be defined and recorded such as throughput (messages/sec, bytes/sec), latency, and dropped messages.

Experiments can also be defined to assess QoS, QoIA and fault tolerance mechanisms that can enhance the delivery of data to the right person or tool at the right time and in the right format for a large exercise or training event with diverse and geographically distributed participants. Measures of Effectiveness (MOE) metrics such as those related to security, content based routing and filtering (e.g., delivery of right data and delivery of only required data), can also be defined and collected.

The AN-CASE data collection, data logging and time stamping functions support monitoring the infrastructure and application message traffic as well as logging the messages that change states of all object entities for subsequent analysis. The infrastructure MoPs are assessed in the context of meeting the experiment or training objectives. The MoPs allow analytical routines to be applied to the data logged from each experiment execution to generate MoEs including such metrics as Probability of Correct Message Receipt (PCMA), Latency, Security and Life-Cycle Cost.

Example experiments under investigation include:

- TCP versus Multicast and other connection methods
- Binary versus text based protocols
- Reliability, QoIA, and QoS testing, examining the network of Information Brokers and Broker clustering for dropped or delayed messages in response to an induced failure or incident
- Topology Testing – Test local clusters on a local area network (LAN) verses the interconnection of clusters over a variety of wide area network (WAN) configurations
- Inclusion of Tactical Edge players with wireless or low bandwidth connectivity.

AN-CASE Data Collection and Reporting

The AN-CASE environment includes mechanisms that will reach out to the executing applications and automatically collect the data specified for a given experiment. All data collected is stored in a repository for future access as well as normalized and stored in the ANCAR database where report generation tools are used to easily produce network performance and/or training effectiveness reports.

4. NET-CENTRIC M&S INFRASTRUCTURE ENHANCEMENTS

Distributed mission operations and the supporting enterprise architecture present a number of challenges which are also present in a net-centric M&S infrastructure. Below we discuss three research and development areas that we are addressing using the AN-CASE environment.

4.1 Message-Oriented middleware and transport protocol alternatives

The requirement to support anytime, anywhere, anyone training and mission rehearsal implies that exercise participants may be connected by high-latency disadvantaged links. This infrastructure needs to be scalable and reliable to support the management and timely flow of information between the exercise participants. The information flow must be managed and controlled using QoS mechanisms such that the right information in the right format is delivered to the right tool or player to prevent wasting bandwidth and information processing resources. AN-CASE supports a number of tools and mechanisms that can be used to evaluate the overall performance of the communication infrastructure as well as its effectiveness within the larger context of providing realistic training and mission rehearsal for the warfighter.

AN-CASE currently supports a standards-based publish and subscribe transport middleware. It is an instantiation of Apache ActiveMQ, a message broker which fully implements the Java Message Service 1.1 (JMS) and is a highly configurable, flexible messaging mechanism. JMS messages are asynchronous requests, reports, or events that are consumed by the enterprise applications. AN-CASE also supports TCP, UDP, HLA and DIS Plug-ins such that disparate tools can easily connect and interoperate on the AN-CASE Framework.

Interconnection of the simulation applications in AN-CASE is through the AN-CASE software abstraction of "Platform", which relies on the application's Object Model (description of all that is produced or consumed by the application) and the Pub/Sub API, which is implemented as either a JMS API for communication to the message bus, an HLA API for connection with an HLA federation RTI, or TCP for direct connection to a socket based application interface as seen in Figure 3.

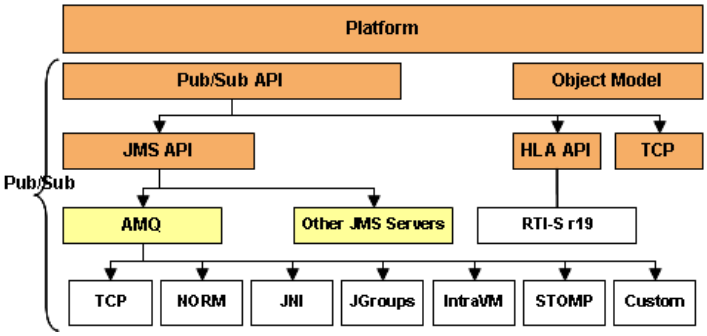

Fig. 3. AN-CASE Platform Interconnection Abstraction

The JMS API, as stated earlier, is implemented using the ActiveMQ message broker. To date, ActiveMQ brokers in AN-CASE have used the TCP protocol for communication. We are also currently evaluating alternative protocols that provide low-latency and reliable transport for message brokering and interconnection..

Connection Topology

Using an AN-CASE connector each simulation application, software or hardware in the loop, or virtual or live asset, is connected to the AN-CASE Framework. The flexible configuration options of the framework are ready to adapt to the characteristics of network and communicating applications. AN-CASE has been used with a single broker with all AN-CASE servers communicating in a hub and spoke topology. Each server advertises its features communicating within the hub. Although a spoke could easily be extended outside of a local cluster or local network, network communications that are only intended for the consumers in the local network should not be spilled outside of that scope. An alternative is to use multiple brokers that communicate with each other. The ActiveMQ message broker is built to support multiple topologies to support local and wide area networking, passing messages in an efficient manner as directed by the subscribers within the message bus.

Using the AN-CASE servers and messaging protocols, configurations of different deployment topologies, protocols, and wire formats can be evaluated. An experiment may include one or many applications on a single LAN communicating with a remote network with one or more applications, and also communicating with live assets. A cluster of simulation applications and AN-CASE servers may be configured as clients to a broker, or network of brokers, and in turn, may be connected by a LAN or WAN to another simulation cluster and broker, or network of brokers. Thus, configurations may be adjusted to suit the nature of a particular experiment and combination of constructive, virtual and live assets.

4.2 Time Management in Distributed Simulation

For the results of a distributed simulation to be "correct," time must be consistent across all simulations. The purpose of any time management scheme should be to ensure temporal causality among simulated events. Time management in a distributed simulation can be based on:

- synchronized system clocks,
- sending a time sync signal from a central clock,
- dividing time into discrete periods and not proceeding to the next time period until all calculations for the current time are complete,
- and several combinations of the above.

Methods by which time can be managed in a simulation model include time-stepped, event driven and independent time advance. In a time-stepped simulation, time is advanced in steps of a pre-determined length. In an event driven simulation time is advanced to the next event. In independent time advance simulations, time advances independently of the events occurring in the simulation. Usually in such simulations time advances in line with wall clock time or as a multiple of wall clock time, either faster or slower.

Problems that can arise in time management when a simulation model is distributed over two or more machines include network latency causing temporal anomalies and variability causing non-repeatability.

If time anomalies are caused by network latency, then they will occur randomly and scenarios will not be repeatable. Non-repeatability is a problem when a scenario is re-run with a change made for Analysis of Alternatives (AoAs). If the results of the two scenarios are different it would be very difficult to analyze if the difference was due to the change or due to the non-repeatability caused by time anomalies.

While time management is especially important in distributed simulations used for AoAs, the time management requirements for training may be less stringent because in general there is no need for repeatability. Also minor time anomalies, particularly if of a very short time period, are either difficult for a human to detect, or have minimal impact on human players in interactive simulations.

Distributed Interactive Simulation (DIS) and High Level Architecture (HLA) each have their own method or methods of dealing with time. DIS provides no time coordination between the independently running real-time simulators participating in a DIS simulation. The HLA Run Time Infrastructure (RTI) provides sufficient time management functions so that Real Time, Time Stepped, Event Driven, and Optimistic Time Warp simulations can all run in the same confederation.

The command to start or resume a DIS simulation contains both the simulation time and the actual time at which the simulation is to start. DIS simulation time is the reference time within a simulation exercise. Simulation time is established ahead of time by the simulation management function and is common to all participants in a particular exercise.

The major functional components of the HLA are federates, the Run Time Infrastructure (RTI) and the interface between the federates and RTI. Federates are the simulations participating in an HLA federation. The RTI acts as a distributed operating system for the federation and provides mechanisms for object data exchanges between federates and time management.

The HLA time-management structure also supports interoperability among federates using different internal time-management mechanisms. To achieve these goals, HLA provides a single, unifying approach to time management interoperability among disparate federates. Different categories of simulations are special cases in this unified structure, and typically use only a subset of the RTI's full capability. Federates need not explicitly indicate to the RTI the time-flow

mechanism (time stepped, event driven, independent time advance) being used within the federate, but utilize the RTI services, including time management, that are appropriate for coordination of data exchange with other federates.

Currently, we are investigating the features of the HLA hybrid time management mechanisms for inclusion in AN-CASE to support the simultaneous operation of live, virtual and constructive entities. Specifically, AN-CASE time management will be extended to incorporate these hybrid time management mechanisms in order to extend these mechanisms to all simulation applications on the framework as appropriate. Currently, the AN-CASE server provides time and process control to the local applications through the SimAgent interface. These APIs provide interfaces for the local applications to receive start, pause, resume, forward and similar time controls from the experiment dashboard.

A more robust means of synchronizing all clients to a master clock at pause and resume commands is also being developed in AN-CASE. This procedure will include sending advanced notice of a pause to all players and managing synchronization at pause points by using this advanced notice to guarantee the simultaneous pausing and restarting of all applications. The value of this will be to support the possible incorporation of optimistic time management algorithms (i.e. "look-ahead") on selected applications in the future. The intent is not to insert optimistic time management into AN-CASE in general, but to provide this support to candidate applications as appropriate.

AN-CASE also supports the employment of time management through the Behavior Model. A behavior can be developed to deliver a message to another instance or application and hold it until a specified time, when it then delivers that message to the destination. Under the current implementation, the delivery time is based upon the simulation clock, not the real time clock, however, the AN-CASE Behavior Model is also being extended to permit applications to pre-schedule message delivery based on the real-time clock as well. This will be implemented through a real-time threaded basis to invoke the execution of the event at the designated time regardless of the simulation clock's pause/resume state. This capability will be enhanced to incorporate any required updates to implement all remaining germane HLA time management functions.

4.3 Distributed M&S supports enterprise IA analysis

The DoD enterprise is composed of enclaves needing to share information of varying levels of security. The systems that make up these enclaves are architected to provide a set of capabilities that contribute to the mission of the warfighter. The systems and the information produced and/or consumed at an enclave, whether it be a platoon of foot soldiers, an airborne platform, a ship, a forward deployed asset (e.g. Air Operations Center) or a national asset such as the Pentagon, must be protected in the context of mission assurance.

Today our adversaries are very sophisticated and recognize that attacks on our communications infrastructure, our information or the timeliness of a service can have a significant effect on mission success. Everyday new threats are challenging our systems and networks. The ability to react, protect, defend and/or defeat them all is a very challenging and probably unachievable task.

Each enclave in the enterprise can be viewed as a layered set of services and capabilities that touch each layer of the OSI stack: from the physical connection to the network via a wired or wireless device to the applications that include Firewalls, Intrusion Detection Systems, Routers, Domain Name Services, Email Servers, DBMSs, Email Clients, Chat or Mission Applications (e.g. Blue Force Tracking). Evolving operational requirements, and a dynamic operational environment dictate an enclave, its systems and services, must be fault tolerate such that they can gracefully degrade and preferably, adapt whether experiencing a systemic problem or malicious attack.

There are three ways in which security and information assurance come to play and need to be assessed in the distributed M&S environment:

1) In order to assess the effectiveness of new capabilities in realistic mission scenarios and to support the requirement for warfighters to ***train as we fight***, enclaves will have capabilities with information sharing requirements that cross security and domain boundaries. The guard technologies, multiple levels of security (MLS) and multiple independent levels of security (MILS) devices, and information assurance mechanisms that need to be integrated and supported will significantly increase the complexity of the M&S environment and corresponding infrastructure.

2) The enterprise M&S infrastructure needs to be protected from any intentional or unintentional compromise. Current defense systems focus on strong boundary protection mechanisms such as firewalls and Intrusion Detection Systems (IDSs) that are applied in a layered architecture to provide more defense-in-depth modes.

However the solutions are often ad hoc or hard wired with little ability to manage and control such that they can only adapt to a small finite set of situations (that are expected not unexpected).

3) The distributed enterprise M&S environment can be used to develop and assess new security and IA mechanisms against the growing and evolving threat. Mission critical systems need to shift operational capabilities to the most important functions, while degrading others to a lower, yet acceptable level of service whether there is a system or bandwidth overload, physical failure (e.g. jamming, hard drive crash) or attack. Attacks must be assessed for their ability to disrupt or make a service inoperable or alter the information being transmitted - undermining the confidence of the information received and uncertainty in the decision making process.

A significant factor that affects the survivability and trust of systems, networks and the services they provided is that most legacy systems either do not adapt or have ad hoc hardwired mechanisms to accommodate only a small, predefined, set of reconfigurations. Subsequently, next generation IA architectures must include proactive evaluation and reconfiguration mechanisms to keep pace with emerging threats. The distributed M&S environment can support the development of the tools and mechanisms that will enable dynamic load balancing of the systems, the services and the networks within and between enclaves.

AN-CASE supports the analysis of the QoS & QoIA posture of various enclave types given different operational conditions. The objective is to identify the mechanisms and conditions that influence QoIA and how they complement or interfere with QoS requirements. Collectively, AN-CASE's Threat, NetSim and Behavior Models together with the SWIL/HWIL capability provide a very powerful toolset for instantiating threats, designing and incorporating IA mechanisms to avoid or survive the threat, and subsequently analyzing the ability of various defense and IA mechanisms to eliminate or mitigate the threat.

AN-CASE can be used to instantiate force and network (fixed and airborne) architectures that can be subject to various attacks (e.g., Denial of Service, Worms, etc). The knowledge gained from the resulting attack enables the development and evaluation of new mechanisms that can be used to neutralize the threat. This capability can be used to assess the impact of the IA enhancements on both mission assurance and mission effectiveness.

Not only can AN-CASE be used to develop the mechanisms that enable the applications and infrastructure to be more stealthy and deceptive through avoidance mechanisms, the collective results will enable users to morph information and communication architectures into secure, reliable enterprise solutions for our distributed military operations.

5. SUMMARY

The design and fielding of military communications systems capable of enabling Network Centric Operations remains one of the greatest challenges facing military institutions today. Demanding security requirements and the need for interoperability among disparate systems, including legacy systems and those of our allies, make it difficult to leverage commercial technology to meet the needs and expectations of military users.

A distributed M&S environment capable of performing technology analysis and mission effectiveness to answer questions related to the eventual fielding and employment of net-centric enterprise solutions is key in addressing the technical challenges associated with distributed communications and information management problems that arise as experiments and exercises progressively scale up the number, diversity, and geographic dispersal of participants. These challenges are exacerbated by the goal to “train warfighters as they expect to fight” because it requires Command, Control and Intelligence (C2I) systems and real-world data to be linked together with realistic, high quality distributed simulations over an open WAN such as the Global Information Grid (GIG). The Air Force Research Laboratory's AN-CASE system is leading the challenge to address these issues.

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