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Communication Architecture For Distributed Interactive Simulation (CADIS): Rationale

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Rationale
Communication Architecture
for Distributed Interactive
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CHANGE 1
TO
COMMUNICATION ARCHITECTURE FOR DIS RATIONALE

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References: (a) Rationale - Communication Architecture for
Distributed Interactive Simulation (CADIS),
IST-CR-93-08, March 1993

This package contains the pages to be changed in the document
specified in reference (a). Please follow the directions below
for changing pages:

1. Insert this page into the document after the title page.
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the title page,
i,
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RATIONALE DOCUMENT

COMMUNICATION ARCHITECTURE

FOR

DISTRIBUTED INTERACTIVE SIMULATION

[CADIS]

1. INTRODUCTION

1.1 Foreward

The purpose of the communication subsystem for Distributed Interactive Simulation (DIS) is to provide an appropriate interconnected environment for effective integration of locally and globally distributed simulation entities. There are many diverse aspects of this integration, ranging from the nature of the entities represented within the common simulated environment, to the common communication interface used for receiving packets of information from other simulators. The standard addressed by this Rationale Document is concerned only with the necessary communication system standards which must be accepted and adopted for supporting the integrated framework.

The Protocol Data Units (PDUs) defined in the DIS Standard are the "lingua franca" by which any two simulation hosts can communicate. This includes simulators of different and unrelated design and architecture. No restriction is placed on what the participating simulator or site is, only on the way it communicates with the outside world.

Where the DIS PDUs define the information passed between simulators and simulation sites, this standard will define how those simulators, simulation sites, and other DIS entities can be connected in a modular fashion to facilitate the communication at the local and global levels. This will be done through the required use of communications standards which promote interoperability, such as the International Organization for Standardization (ISO) Open Systems Interconnection (OSI) reference model and the Government OSI Profile (GOSIP).

This standard describes the communication architecture subsystem that will support DIS exercises and activities. The DIS PDU standard describes the format of the application protocol data units that contain the entity, environment, and simulation management information that will be carried on the network. This standard describes the structure and use of the network to carry that information. This document describes the rationale behind the requirements and specifications in the communication architecture standard. The guidance document describes how to use the information in the standard and rationale to create a communication subsystem to support DIS activity by providing tutorial descriptions and sample prototypes as well as discussing unresolved DIS communication architecture issues.

1.1.1 Background

The current work on standards began in August 1989 with the First Workshop on Standards for the Interoperability of Defense Simulations. Using the work of SIMNET as a baseline and

4.2.1 Communication Service Requirements

Distributed simulation environment support requires various types of communication. The communication requirements encompass control and data. Data communications may be with or without real time requirements and will likely be augmented to include such things as voice, video and other forms of pictorial information. Upon the introduction of each of these forms of traffic, it is recommended that they share communications facilities instead of having disjoint facilities for each.

4.2.1.1 Service Requirements of PDUs

This section establishes DIS communication classes based on the application service characteristics for both the required DIS PDUs. Each DIS PDU requires certain service characteristics to make its communication practical. These characteristics are grouped into broad classes of operation for DIS.

4.2.1.2 Multicasting.

CADIS uses multicast communication services to address four key issues:

1. To permit multiple exercises to take place simultaneously on the same network.
2. To permit multiple applications (e.g. DIS and videoconferencing) to operate simultaneously on the same network.
3. To provide a mechanism for reducing the traffic load on a network.
4. To provide a mechanism for reducing the amount of traffic delivered to a given receiver on the network.

In today's practice, all simulators in an exercise are members of the same multicast group. Having multiple multicast groups, divided by exercise, permits simulators to receive traffic for the exercise in which they are participating and not others. The reasoning for supporting different applications is similar. Having multiple multicast groups allows a simulator to receive exercise traffic and not a videoconference that may be going on at the same time.

Multicast groups can provide a mechanism to reduce the traffic on a network. For example, it has been proposed that the virtual battlefield might be divided into areas, with multicast groups assigned to each area. A simulator would subscribe to only those multicast groups that were associated with areas it could sense or see. Each site would receive only the traffic for the union of the

areas of interest to its simulators. This could reduce the traffic load on the wide-area network that connects the sites. Similarly, allowing a simulator to subscribe to multicast groups that represented only the traffic of interest to that simulator could reduce the amount of traffic delivered to that simulator. The benefit of this would be fewer interrupts and/or reduced load on its network interface. The extent to which network traffic is reduced or the amount of traffic delivered to a simulator is reduced will depend on many factors, including the scenario, the exact design for the use of different multicast groups, and the way that simulators and the network topology are mapped into the geography of the virtual battlefield.

4.2.2 Performance Requirements

4.2.2.1 Bandwidth

There are a number of factors which have a major influence on DIS bandwidth. At the very highest level, they include:

- Total number of entities
- Mixture of entity types.
- Type of exercise or scenario
- Choice of dead reckoning algorithm (and positional/angular thresholds)
- Security requirements

For the current set of approved DIS PDUs, the majority of network traffic will be Entity State PDUs (ESPDUs). ESPDUs are required to be sent at some minimum rate (e.g. every 5 seconds) by every entity and may be sent much more frequently depending on entity dynamics. The start-up of a session will also see high traffic but that is deterministic. The PDUs used to initialize an exercise or entity (such as the recommended Activate PDUs) represent a significant amount of data to be sent via the net, but they can be transmitted at a controlled rate. In the near term, the inclusion of Emitter PDUs may add a significant traffic load to the network, depending on the degree of electronic warfare (EW) present in a given exercise. Similarly, the inclusion of simulated tactical communication links (both voice and data) will undoubtedly have a substantial impact on bandwidth.

There are also additional bandwidth requirements due to communications "overhead". A given PDU of "n" bits in length requires the addition of both headers and trailers in order to satisfy routing and data integrity requirements. The proposed UDP/IP protocols add 28 octets (8 for UDP and 20 for IP). The underlying media adds further overhead, such as FDDI's 20 to 28 octets of preamble, header and trailer information. A method to reduce this load is to concatenate PDUs at the application layer such that the overhead bits are applied to groups of PDUs rather

than to every PDU. This approach, however, imposes an additional computational load on each host.

Another source of "overhead" traffic are security measures. The degree of overhead depends on at what layer (of the OSI seven layer stack) the security measures are implemented.

Refer to the Guidance Document for an explanation of one method of estimating bandwidth.

Network bandwidth sufficient to satisfy performance requirements may be established administratively when a network is configured for a specific exercise, or bandwidth requirements on a shared network may be requested dynamically. Mechanisms for negotiating bandwidth requirements are for further study.

4.2.2.2 Latency Requirements

Some interactions between simulated entities are very tightly coupled in time. That is, the action of an individual controlling one of the entities may be a reaction to the activity of another. How tightly these interactions are coupled in time depends on the performance of the unit being controlled. High performance units, that is, those units that react quickly to a human controllers input, tend to be very tightly coupled. An example of this is one simulated fighter aircraft flying in close formation with another. Units that respond to control inputs less quickly, such as ships, are only loosely coupled.

The issue of communications latency is directly related to how tightly a simulated entity is coupled to the entity to which it is reacting. The more tightly coupled two simulated entities are, the less latency is permitted in the communications that carry the state data of each to the other.

4.2.3 Error Detection

PDUs currently have been identified as requiring either (1) Best Effort Multicast Delivery or (2) Reliable Unicast Delivery.

Best Effort Multicast Delivery should be implemented using UDP, with checksums computed by both the transmitting and receiving hosts. A corrupted packet must result in an indicator being passed up from the transport layer at the receiving host. Higher layers of the protocol stack will then determine if a corrupted packet can be processed (e.g. voice) or must be discarded (e.g. data, compressed or complex digitized analog traffic).

Retransmission is in effect for PDUs which require Reliable Unicast Delivery. TCP must be used for PDUs with this service requirement. Higher layers of the protocol (above transport) which request this

level of service can be assured of packets delivered in the proper sequence, without duplicates and without checksum detectable errors.

4.3 Approach to Communication Architecture.

The ISO Reference Model is probably the most widely referenced model for communication architecture, and we adopt its use here. Under this model, the communication interconnection problem is broken down into seven layers, each with specific responsibility in carrying out part of the overall communication integration. The development of this reference model was in large measure motivated by and patterned after the success of the DARPA Internet program, which was the pioneer of the general machine interconnection technology base. Along with the development of the reference model, ISO has developed a series of protocols which in some cases mirror comparable entities in the Internet, and in other cases extend and formalize concepts only primitively developed by the Internet program. Currently, there are two dominant suites of protocols (Internet and ISO) which fit within the Reference Model communication architecture and are instantiations of a solution to the general communication interoperability problem. These protocol suites differ in details, maturity, number of options, flexibility, performance, number of currently available commercial products, number of fielded systems, and organizational support, among other factors.

Functionality lies within level 3 of this reference model and is the key to a generalized interconnection model. This network level provides for packets of information to be transparently delivered from system to system across almost arbitrary interconnections of local and wide area networks. By adopting the low cost conventions of providing for remote delivery even when delivery is actually local, and through the provision of gateway processors linking the local and wide area networks, a single approach (from the application perspective) can handle both the local and global cases, as well as transparently handle any needed change from one to the other. Under this approach, any reasonable selection for the layers below will be perfectly acceptable and work. These decisions can be handled locally on a case by case basis or by policy over some administrative domain if deemed appropriate. Building to the level three interface admits a mixing and matching approach to all of the levels below without sacrificing interoperability. Levels above do need to be matched. However, in our immediate case, handling interoperability for these functional elements has already been subsumed into the current DIS PDU standard. This approach ensures the maximum interoperability with the minimum of specification and new development.

The Government Open Systems Interconnection Profile is the U.S. Government program for adoption of OSI across all Federal agencies. The purpose of GOSIP is to provide: networking connectivity,

through GOSIP network architecture; interoperability, through standard "profiles" of OSI protocols; and competition, through focus on small number of subnetwork technologies and interoperable applications.

DIS compliance with the OSI/GOSIP architecture provides the following benefits: reduced cost, increased interoperability, and increased application-level functionality. Efforts to ensure conformance to OSI/GOSIP standards and ensure interoperability between products of different vendors means that computer networking can be done as an integration of multi-vendor, commercial-off-the-shelf (COTS) components. Easy access to vendor interoperable COTS OSI/GOSIP products gives wider availability to networking capabilities at a reduced cost.

Not only will OSI/GOSIP standards provide interoperability between products, but international interoperability will also be increased. The OSI standards are international in scope and will be used by North Atlantic Treaty Organization (NATO) allies, among others. Using OSI standards opens the possibility that interoperation with our NATO allies will be accomplished within the framework of international standards.

4.3.1 The Communication Architecture Protocol Suites for DIS

There are a variety of existing protocols and interfaces which populate the functional areas for ISO Reference Model layers 1-4. The two most prominent suites of protocols which are collectively put forth as solutions to the interoperability problem are the DoD (Internet) suite and the OSI (GOSIP) suite. At this stage of evolution, the two are conceptually similar, but vary considerably in the details and in maturity. Both suites emphasize the network transparency from level 3 and above, as discussed previously. This means that one simulator is completely isolated from the selections made at levels 1 and 2 for every other simulator or collection of simulators, by adopting one of the "internetwork" layer standards as the base level for interoperability. This provides the freedom to delegate to local decision making the protocols used for the lower levels (assuming the selections conform with overall, real time performance objectives). The current real work of this document focuses essentially on levels 3 and 4. A plan which starts from the more mature Internet suite and evolves as appropriate over time toward the GOSIP suite is the most prudent path at this time. The three phased approach adopted by the standards effort is shown in detail in Figure 1.

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