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INTERFACING LOW COST NETWORKED FLIGHT SIMULATORS IN A SIMNET ENVIRONMENT

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ABSTRACT

In this paper we present a discussion of research being carried out at the Institute for Simulation and Training/University of Central Florida which focuses on the interconnection of dissimilar networkable simulators. Specifically, we describe the results of our efforts to interconnect two dissimilar simulation networks, namely, the Perceptronics Avionics Situational Awareness Trainer (ASAT) networkable F-16 training device and the DARPA developed SIMNET simulation network.

INTRODUCTION

The advent of direct computer to computer communications (computer networking) opened the possibility of interconnecting many different types of computer based systems. Until recently, most devices used in Simulation and Training (S&T), which usually contained an embedded computational resource, operated in a stand alone mode. Today there is a major emphasis being placed on the development of distributed S&T systems which are **networkable**. In this context, *networkable* implies the S&T systems are capable of communicating (transmitting and receiving), in real-time, information relative to their simulation which can be understood by other networkable devices tied to the network, thus allowing for interaction between the devices. However, due to the lack of a standard network protocol, the interconnection of multi-vendor simulators on the same network presents some interesting problems.

Institute for Simulation and Training (IST) is presently under contract to DARPA and the Army's PM TRADE to develop a low cost Aviation Test Bed to investigate issues in low cost aviation simulators for training and the networking of these types of devices. IST has procured two commercially available F-16 ASAT devices from Perceptronics. The ASAT is a PC based (MS-DOS) training device developed to teach beyond visual range (BVR) target acquisition and engagement. The simulator can be operated in a stand-alone mode or networked with other ASATs to provide a multi-ship, interactive training environment. In addition, IST has two M1 Tank SIMNET modules, along with other SIMNET support modules. Currently in the research and development stage, SIMNET is a networked simulation environment made up of armor, mechanized infantry and aircraft (rotary and fixed wing) simulators linked together such that actions of one vehicle can be observed by the

crews of the other vehicles. Both the ASATs and the SIMNETs utilize ETHERNET local area networks to communicate vehicle state information between the simulators engaged in the training exercise.

In fulfillment of the requirements of the research being performed by IST, the task of interconnecting the ASAT network with the SIMNET network was undertaken. This task centers around the design and development of a device referred to as a Network Protocol Translator (NPT). The NPT device will act as an interpreter between the ASAT and SIMNET networks; receiving data from the ASAT network, transforming it into the appropriate SIMNET format, and then retransmitting it onto the SIMNET network, and vice versa. In order to do this task correctly under real-time constraints, a detailed knowledge of the exact workings of each simulator's network is required.

Although both the ASAT and the SIMNETs are networkable and use ETHERNET as a communications medium, the information (packets) transmitted by one simulator is totally unrecognizable by the other in its native form. Simply stated, the task of providing interoperability between the two simulators involved the translation

of information contained in the ASAT ETHERNET packet into the appropriate SIMNET ETHERNET packet format and vice versa.

APPROACH

To achieve networked communications between the two simulators, a protocol translator was placed as an additional node on the ETHERNET network (see Figure 1). Functionally, the translator monitors the network traffic and copies packets which are transmitted by the ASAT trainer into its local memory. Every packet copied by the protocol translator is converted to the proper SIMNET format and transmitted onto the ETHERNET. The SIMNETs can now receive these packets as they would any other standard SIMNET packets, and act on it appropriately (i.e., display aircraft on local simulator's visuals).

A similar approach for SIMNET to ASAT protocol translation can be envisioned. However, due to the nature of the ASAT hardware/software configuration, packet translation in this direction would not have been possible without some modifications to the ASATs themselves. Since one of our goals was to provide a passive protocol translation system this translation was not fully implemented.

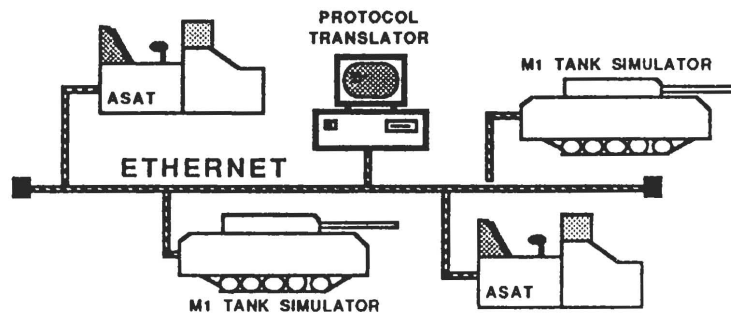


Figure 1. ASAT/SIMNET Network

PROTOCOL TRANSLATOR

The protocol translator was developed on a 20 Mhz 80386 IBM/AT compatible PC. To connect it to the ETHERNET network, the PC was outfitted with a 3Com Etherlink II Network Adapter. This adapter was configured to operate in promiscuous mode such that it would be able to capture all packets transmitted onto the network. The translator would filter all unwanted packets, taking only the properly addressed packets into its memory for processing.

ASAT PROTOCOL

There are four different types of packets that the ASAT uses to initialize and execute an exercise:

- Packet Type 1: is used during initialization of an exercise.
- Packet Type 2: activates the vehicles with their proper parameters (e.g., position, orientation, speed, weapons' capabilities)
- Packet Type 3: provides information regarding the aircraft's location, elevation, orientation, airspeed, and other state variables.
- Packet Type 4: provides information regarding the aircraft's location, elevation, orientation, airspeed, and other state variables for all computerized targets.

The information contained in Packet Type 3 (i.e., location, elevation, orientation, airspeed) were the main parameters used in the ASAT to SIMNET protocol translation algorithms.

SIMNET PROTOCOL

The communications protocol used by the SIMNET network is the SIMNET Protocol Version 6.0 which is described in [1]. The SIMNET protocol has three subprotocols: Data Collection Protocol, Association Protocol, and the Simulation Protocol. The only protocol of interest in the translator experiment was the Simulation Protocol.

The Simulation Protocol provides the necessary tools for allowing a simulator to describe any of its actions that may affect other nodes participating in the same exercise. Several of the functions that are furnished by the simulation protocol are:

- Activation and Deactivation
- Vehicle Appearance Updates
- Vehicle Status
- Weapons' Effects and Interactions
- Detection and Reactions to Vehicle Collisions
- Service and Repairs to Vehicles

The Vehicle Appearance Updates are provided by the SIMNET Vehicle Appearance Protocol Data Units (VA PDUs) and were used to provide the ASAT information to the SIMNETs.

TRANSLATOR PROCESSING

The translator creates a template of the SIMNET VA PDU for each ASAT packet that is to be translated. This template is supplemented by translated ASAT data to create a complete VA PDU for the ASAT. The fields which are supplied by the ASAT packet are:

- Source Address
- Vehicle Location
- Vehicle Speed
- Orientation (roll, pitch, and yaw angles)

Mapping the ASAT supplied information into the SIMNET VA PDU format required the following:

Source Address - ASAT 6 byte ETHERNET source address mapped directly into the SIMNET VA PDU source address field.

Vehicle Location - Coordinate transformation required to provide proper unit matching and a compatible location in the SIMNET terrain database.

Vehicle Speed - Manipulation required to convert ASAT airspeed data into SIMNET normalized velocity components (x, y, z velocity). Unit conversions were also required.

Orientation - Manipulation required to transform ASAT pitch, roll, and yaw angles into a nine element SIMNET rotation matrix.

(Note: A detailed description of the translation algorithms can be found in reference [2].)

SIMNET TO ASAT TRANSLATION PROBLEMS

In trying to network the ASAT and SIMNET simulators, several complications prevented their complete interfacing. The first problem resulted from the inability of the SIMNET vehicles to be properly initialized in the ASAT environment. Upon activation, the ASAT trainers undergo a handshaking process. From this

process each ASAT creates a list of all participants in the exercise. If a vehicle is not involved in this initialization procedure, it will not be a participant, and ASAT simulators which are a part of the exercise will ignore any packets received with the source address of that vehicle.

The inability to perform the required handshaking and thus be placed on the ASAT players list made it impossible for the SIMNETs to be initialized into the ASAT exercise via the Protocol Translator. In the SIMNET environment, it is not critical for this function to be performed. If a vehicle is not activated properly, the other vehicles on the network will proceed to acknowledge the vehicle's existence in the exercise and allow it to interact with other players.

Other complications arose because the ASATs were designed to train pilots in air-to-air BVR techniques. One of the most prominent problems was that the ASATs do not support vehicles which have zero velocity. Because the SIMNET MIs are ground vehicles, they operate at low velocities and are static in many situations (i.e., zero velocity). These scenarios could not be duplicated in the ASAT environment without modifying the ASAT source code. The design requirements of the ASATs did not call for the existence of ground vehicles. Therefore, no models for vehicles such as tanks are provided in the ASAT environment. The only moving models that are provided by the ASAT visual system are an F-16, a Mig21, a Mig29, and a generic missile.

Another problem was the ASAT addressing scheme: its protocol is not of a standard IEEE 802.3 format.

The ASATs begin their packet with the source address immediately followed by data. This deviation from 802.3 format caused difficulty in data analysis using standard ETHERNET LAN Analyzers.

TRANSLATOR PERFORMANCE TESTS

There are several considerations when translating a simulator's packets through a protocol translator. Two factors which are of importance are the amount of increase in traffic on the network, and the transmission delay due to processing the ASAT packets.

The increase in network traffic must be considered a factor in networks which have a limited bandwidth/simulator ratio. The increase in traffic is proportional to the number of simulators which are dissimilar to the standard network. In our experiment, we had one simulator anomaly (ASAT) which was connecting into the SIMNET network. The increase in traffic was given by the simple formula:

$$\text{Increase in traffic [one-way translation]} = N_{pt}(R_a)$$

$$\text{Increase in traffic [two-way translation]} = N_{pt}(R_s + R_a)$$

where N_{pt} is the number of protocol translators on the network, and R_a and R_s are the rates of transmission for the ASATs and the SIMNETs, respectively.

In our experiment we had a single protocol translator performing a one-way translation. We are assuming that one translator will translate the traffic of a single ASAT simulator. The increase in traffic is equal to adding another ASAT module onto the network.

This means that on the average the increase will be:

$$(1 \text{ translator})(113 \text{ bytes/pkt})(12 \text{ pkts/sec}) = 10.848 \text{ Kbits/sec}$$

This increase in traffic is merely 0.15% of the usable network bandwidth, based on 7 Mbits/sec as the usable ETHERNET bandwidth. However, it must be kept in mind that the ASATs are selective fidelity simulators and do not have as rapid an update rate as most flight simulators.

Transmission delays are a critical factor in the implementation of a protocol translator. In a distributed simulation environment, the systems can ill afford an extra delay produced by a protocol translator. In this light, we have conducted timing tests on the translator. These tests have produced statistics about the total translation delay introduced by the ASAT/SIMNET translator. The translation of the ASAT packet to a format which the SIMNETs can recognize caused an average network delay of 29 ms. This included time of packet processing at the board level.

CONCLUSIONS

Herein we have discussed the various aspects of IST's research involving the networking of dissimilar distributed simulation and training devices: specifically, interconnecting the ASATs and the SIMNETs. Impacts on network loading and increases in network delays were discussed and experimental results were presented. Insight gained from this research will provide the basis for the development of a Generic Protocol Translator device which would be able to translate data packets between various types of dissimilar simulators. However, the

problems stemming from the interconnection of high and low fidelity simulators, aside from basic communications issues, are beyond the scope of this work and need to be addressed in full detail.

ACKNOWLEDGEMENTS

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