HLA INTERACTION IN LVC SIMULATION ENVIRONMENT

Mariana Wong Yoshikawa
Atech Negócios em Tecnologia S/A
Rua do Rocio 313, 5o andar, São Paulo, SP, (11)3103-4600, myoshikawa@atech.com.br

Fabio Seiti Aguchiku
Atech Negócios em Tecnologia S/A
Rua do Rocio 313, 5o andar, São Paulo, SP, (11)3103-4600, faguchiku@atech.com.br

Valter Heitor Cadore
Atech Negócios em Tecnologia S/A
Rua do Rocio 313, 5o andar, São Paulo, SP, (11)3103-4600, vcadore@atech.com.br

ABSTRACT

The environment consists of a platform that integrates Live, Virtual and Constructive (LVC) elements. It was developed in order to allow participants to enter and leave the simulation scenario without degrading it. The HLA (High Level Architecture) is a simulation pattern mainly in military simulators. The main focus of this paper is to present the simulation tools integration process that utilizes HLA in LVC environment and possible simulation scenario given this integration.

Keywords: Simulation, LVC, HLA, Integration, Interoperability.

RESUMO

O ambiente consiste em uma plataforma que integra os elementos Reais, Virtuais e Construtivos (LVC). Foi desenvolvido com o objetivo de permitir os participantes ingressar e desligar-se da simulação sem degradar o ambiente de simulação. A arquitetura de HLA (*High Level Architecture*) é um padrão de simulação utilizado principalmente em simuladores militares. O principal foco deste artigo é apresentar o processo de integração de uma ferramenta de simulação que utiliza a arquitetura HLA no ambiente LVC e o cenário de simulação dado esta integração.

Palavras-chave: Simulação, LVC, HLA, Integração, Interoperabilidade.

1. INTRODUCTION

Due to great and complex demand for complex simulations for military exercises, solutions like the Defense Advanced Research Projects Agency (DARPA) Synthetic Theater of War (STOW) are presented for training and mission rehearsal (Tiernan, 1996). This environment created by the STOW is ideal for developing decision-making, planning and execution capabilities. It was developed in a simulated distributed context using Distributed Interactive Simulation (DIS).

In order to solve scalability problems, the United States Department of Defense (DoD) developed an architecture for exercises in large scale – High Level Architecture (HLA). This architecture became a standard for military simulations. Aguchiku et al. (2018) presented a simulation environment capable of integrating with real and simulated systems. In this paper, the simulation environment is developed to become compliant with HLA.

HLA is a common technical architecture specification to be used by all simulation classes, creating a basic structure for simulation interoperability (Dahmann, Fujimoto, Weatherly, 1998). Based in the premise that no simulation can satisfy all uses and user requirements, the architecture use the concept of federations. The federation is composed by simulation groups that interact with each other.

In a LVC simulation, there are three domains: Live, Virtual and Constructive (Aguchiku et al., 2018). The live domain is represented by the operating systems used in the simulation and their operators. The virtual domain is composed by simulation tools used to execute the scenarios. Finally, the constructive domain is achieved by systems that simulate the human behavior through system simulation, and infrastructures that allow the integration between the virtual and the real domain. In this scenario is possible to add, remove, substitute simulated elements to change the fidelity of the exercise perspective.

In the scenario constructed, the virtual domain is represented by the X-Plane flight simulator (X-Plane, 2018), the simulated flight data from the Flyback (Aguchiku et al., 2018). The real domain is represented by the pilots controlling the X-Plane simulators, and by the operating systems: SAGITARIO air traffic control system and AMAN (Arrival Management). Finally, the constructive domain is represented by the LVC Server, Radar Simulation and HLA Integration. A basic simulation scenario is shown in Figure 1. The paper goal is to validate the HLA integration in order to create a complex simulation environment for training and simulating in air traffic control.

This simulation environment can be used to familiarize operators with new systems on a controlled environment; to calibrate systems; to validate new operational scenarios. With HLA, it is expected different simulations, so an increase on the number use cases with the LVC solution is expected accordingly.

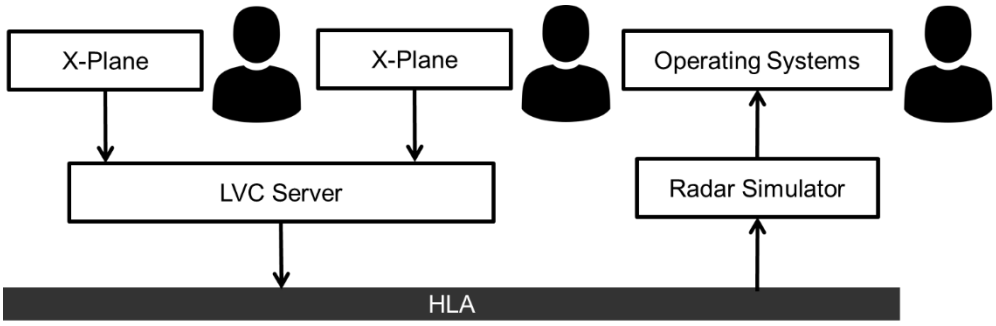


Figure 1: Basic simulation scenario example

2. METHODOLOGY

In this section, the components of the solution will be better explained.

X-Plane

The flight simulator developed by Laminar Research has a vast collection of aerodromes and airplanes models. Also, new models can be imported to the simulation. Depending on the model, it is possible to train the pilot in the same model he will use. Models provided by Laminar research have a highly detailed in 3D models of the inside and outside. In the eleventh version is possible to interact with the 3D cockpit and integrate it with Virtual Reality (VR) hardware, such as, Oculus Rift, HTC Vive and WMR). X-Plane was used on Aguchiku et al. (2018) because of its high-fidelity simulation. Depending on the configuration, X-Plane is a FAA (Federal Aviation Administration) certified training platform.

The HTC Vive VR System was used to provide a more immersive experience to the pilot. The system is composed by the VR headset, two movement sensors and two controllers. Besides the 360 degrees' field of view, the pilot can move freely inside the area marked by the two motion sensors. In order to integrate with the LVC, is recommended to set the camera to first person setting and set the instruments and panel to be interactive. The pilot can configure the SSR (Secondary Surveillance Radar).

In X-Plane configuration panel is possible to configure the flight data to be sent to the Server LVC via UDP as shown in the Figure 2.

Other simulators could be used replacing or together with the X-Plane simulator. There are simulators that are HLA compliant, for example, Titam.IM (war simulation sandbox), Steal Beasts (tank simulator) and Prepar3D (aviation, marine and land simulator). These human-in-the-loop simulators provide simulation with greater interaction.

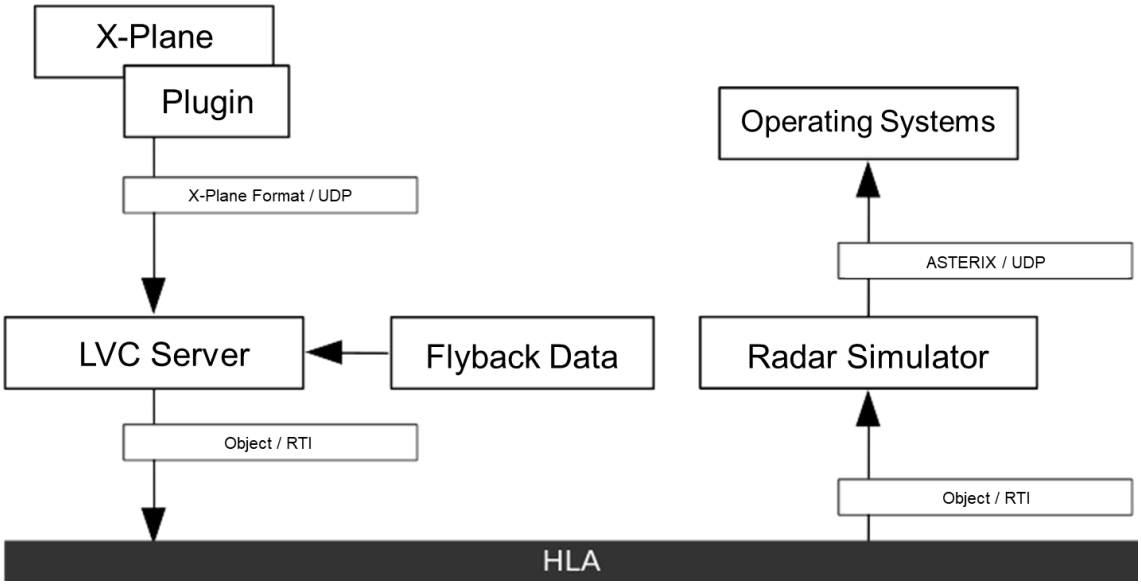


Figure 2: LVC Simulation network architecture

Server LVC

The LVC Server has two functions: process flight plan data received from X-Plane via UDP and simulate flight data collected from the Building Block used in Flyback. Both are published in the HLA integration.

Radar Simulator

The Radar Simulator receives the data transmitted by the LVC Server via HLA and sends it to the operating system via UDP as ASTERIX. The operating systems receives the data as a real signal, which means, it is possible to integrate real radar signals with simulated ones, creating a mixed environment.

HLA Integration

The integration provides a library to the LVC Server and the Radar Simulator to publish and receive data via RTI (Run-Time Infrastructure) using Portico (Portico, 2019) implementation. The HLA is formally composed by three components: the interface specification, Object Model Template (OMT) and HLA rules.

The interface specification describes six services provided during execution from RTI to federation and form federation to RTI: federation management, declaration management (managing data to be provided and needed by the federation during execution), object management, object ownership and attributes management, time management and data distribution management.

The OMT is composed by element descriptions or essential objects. Due to the goal of interoperability in the HLA, there are no restrictions to the content of the model. However, it is necessary to document the objects on both the federation and the federate. There are two types of objects, the Federation Object Model (FOM) and the Simulation Object Model (SOM). The FOM describes objects, attributes and interactions that the federate can offer.

The HLA rules specify important principles to the federation and the federate. Federations must contain the FOM in OMT format. During the execution, all objects must be represented by the federates and only one must have ownership at a time. The exchange of information between federates occur through the RTI and the interface

The HLA federation (Figure 3) is composed by three elements: the federation, the RTI and the RTI interface. The federate can be a computational simulation, human operated simulation or a support utilitarian (data collector or simulator display). The RTI provides interaction services between the federations, interaction management and support functions. Also, the RTI interface provides an interaction standard between federate and RTI, inquiry and respond to RTI interaction support services.

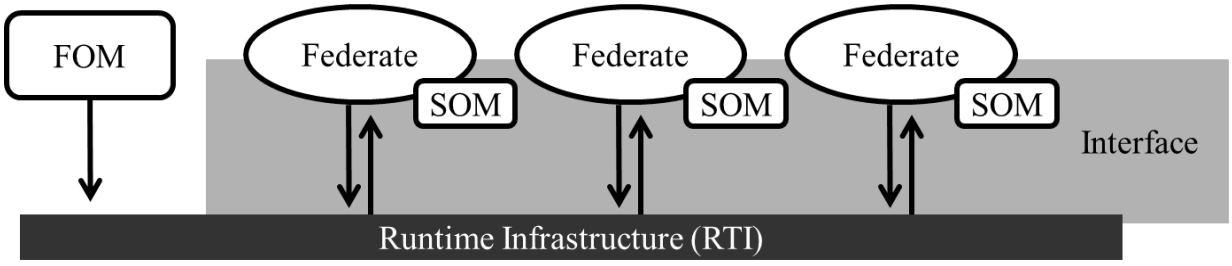


Figure 3: Federation and Federate

The HLA Integration manages federations and federates. The federate can create a federation where the simulation will be executed and joint it. If the federation name already exists, it just joins the created one. The federation awaits all the other federations to join, and when all are connected, the federate that created the federation register the sync point "ReadyToRun", communicating that the simulation will start. RTI announces the sync point to all federates when is the sync point and all federates. RTI confirms that all federates are in sync.

The federates can enable the time constraint and regulation. The regulation allows the federate to generate time-stamped-ordered (TSO) events and permits it to coordinate the time advancement. The time restriction allows a federate to receive TSO events. Those that didn't enable time restriction, receive the TSO events but without the timestamp information (HLA-Group, 2018).

The federate must register an object described in FOM and obtain its identifier before publishing it. The FOM used has the object Aircraft with the attributes: timestamp, latitude, longitude, altitude, axis X aircraft speed, speed axis Y aircraft, roll, pitch, and yaw and transponder information.

The HLA is more efficient than DIS in the in dispatch of data. DIS sends all data through the Protocol Data Units (PDUs) that transmit redundant data, while HLA only sends data that was updated (Ryan, 2003).

The solution from Portico broadcast the data through Jgroups library. It is possible to operate the HLA in LAN or WAN by setting the RTI.rid configuration file.

Operating Systems

The operating systems are used to visualize the data generated, providing a situational awareness of the simulation and the LVC simulation can be used to familiarize and train operators with these systems. For this solution two systems were used, SAGITARIO and V3D. AMAN consume the same data as SAGITARIO though the diffusion mode. Other systems could be integrated if they could receive ASTERIX messages via UDP or integrated through a federation in the RTI. The system SAGITARIO has the diffusion module that receives the message. The V3D receives the track through DDS (Data distribution Service), therefore it was necessary a driver to parse the message. The Simulation Radar integration is shown in the figure 4.

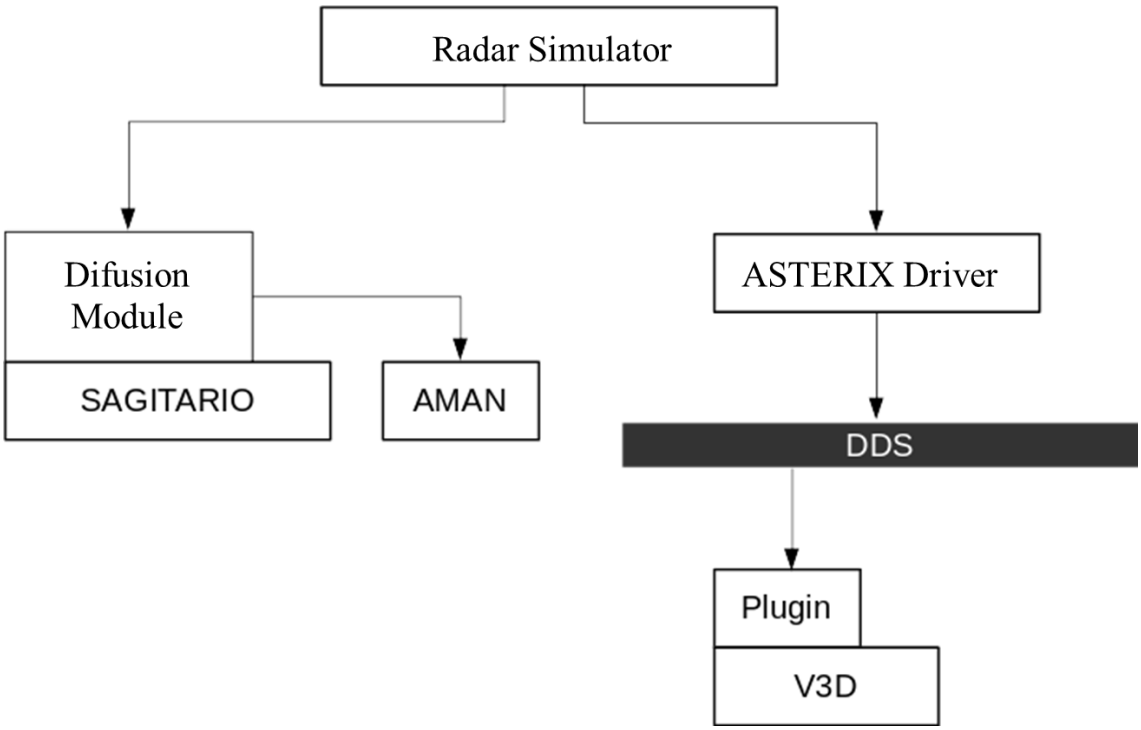


Figure 4: Operating Systems structure

3. RESULTS

The Solution presented in this article was implemented with success. The information from the transponder configured at X-Plane (Figure 5) simulator is seen in the SAGITARIO (Figure 6) and V3D (Figure 7). The result presented in Aguchiku et al. (2018) was achieved with HLA. Therefore, the simulation environment is currently able to readily integrate more systems in the simulation, thus providing different, more complete and complex scenarios than Aguchiku et al. (2018).

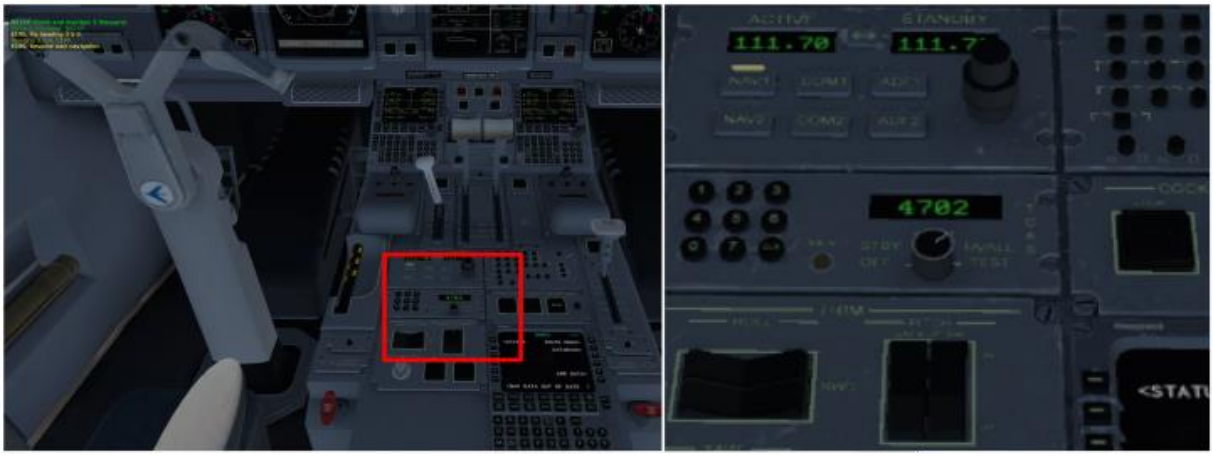


Figure 5: X-Plane Simulator Transponder

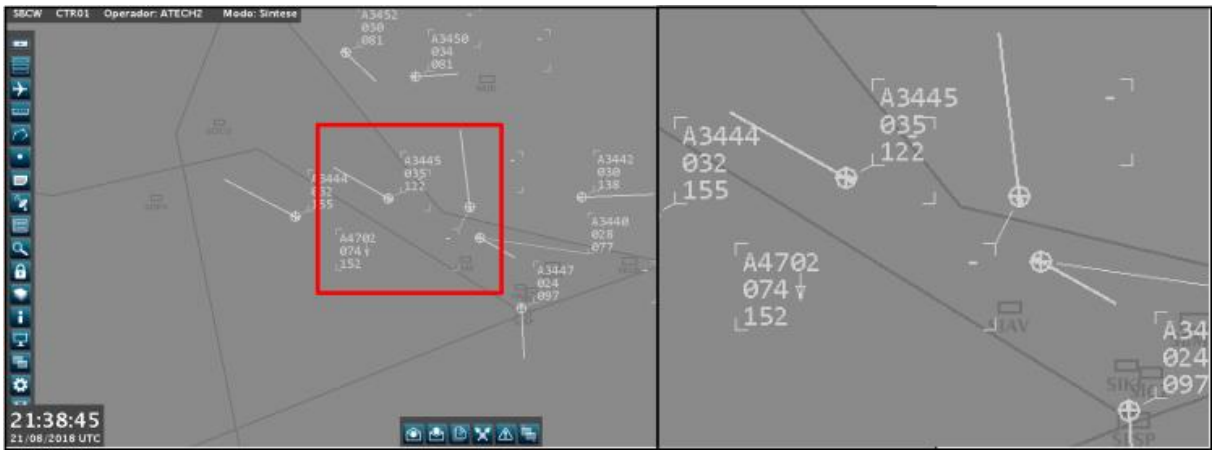


Figure 6: Track in SAGITARIO



Figure 7: Track in V3D

4. CONCLUSION

Some limitations were found in the HLA, once the sync point "ReadyToRun" is achieved, it is not possible to add federates that can receive object attribute updates to the federation. DIS allows to sync new elements during the exercise, however it does not have a time management, its use is focused in real time or near real time scenarios.

It is possible to have a scenario that operate with both DIS and HLA, using a gateway. Moreover, the RTI (Real-Time Innovations) developed an integration via DDS. In RTI (2019), it is mentioned as advantageous the flexibilization to developers to integrate: legacy systems architecture, embedded training operating systems, decision support and simulations that do not have defined open-wire standard.

Regarding the pilot experience, HTC Vive provide a higher immersive one compared to conventional screens or others VR hardware's with a joystick. Since pilot can interact directly with the panel through the controllers and move inside the cockpit.

In this solution it was possible to validate the construction of a complex simulation that can be used for training. The architecture allows other simulators to be integrated, for example, Microsoft Flight Simulator or other aircraft simulators, for example, X-Plane simulator, which can also simulate helicopters.

5. REFERENCES

AGUCHIKU, F. S. et al. Live, Virtual & Constructive simulation for pilot and air traffic controller training. In: SITAER Air Transportation Symposium, 2018, São J\São Paulo. XVII SITRAER Air Transportation Symposium, 2018.

DAHMANN, J. S. FUJIMOTO. R. M. WEATHERLY, R. M. The DoD High Level Architecture: An update. Proceedings of the Second International Workshop on Distributed Interactive Simulation and Real-Time Applications (DIS-RT '98) IEEE Computer Society Washington, DC, United States, 1998. p 32-40.

HLA-GROUP—Carnegie Mellon University. RTI Synopsis. Available at: <http://www.cs.cmu.edu/afs/cs/academic/class/15413-s99/www/hla/doc/>. Accessed at 28/01/2018.

PORTICO. The Portico Project. Available at: <http://www.porticoproject.org>. Accessed at 30/01/2019.

RTI. Can DDS help solve the distributed simulation integration challenge? Available at: <https://www.rti.com/blog/can-dds-help-solve-the-distributed-simulation-integration-challenge>. Accessed at08/03/2019.

RYAN, P. ZALCMAN, L. The DIS vs HLA Debate: What's in it for Australia? SimTect 2003. Simulation Industry Association of Australia. 2003.

TIERNAN, T. R. Synthetic Theater of War (STOW) Engineering Demonstration-1A (ED-1A) Analysis Report. Technical Report 1722. Naval Command, Control and Ocean Surveillance Center. 1996.

X-PLANE. X-Plane 11 Flight Simulator. Available at:<http://www.xplane.com>. Accessed at: 02/02/2019. 02/02/201902/02/2019s 14:00.