Advanced Systems Engineering Methodologies and Tools for Gateway Selection and Configuration

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Introduction

- System – a combination of interacting elements organized to achieve one or more stated purposes (Systems and Software Engineering - System Life Cycle Processes - ISO/IEC 15288)

- Under this definition, a model or simulation is a type of system
  - Modular standalone M&S tools are composed of multiple software components interacting through well-defined interfaces
  - Distributed M&S environments use modern simulation architectures, middleware, and various infrastructure elements to allow multiple simulations to share information at runtime and interact coherently for some defined purpose

- While system and software engineering principles are certainly relevant to M&S, much work has been done in recent years to tailor these principles to the M&S domain
Distributed M&S Process Models

- Distributed interactive Simulation (DIS) - Exercise Management and Feedback (IEEE 1278.3)
- High Level Architecture (HLA) – Federation Development and Execution Process (IEEE 1516.3)
- Test and Training Enabling Architecture (TENA) – Logical Range Concept of Operations (TENA Architecture Reference Document)

- Distributed Simulation Engineering and Execution Process – DSEEP (IEEE 1730)
  - Published in January 2011
  - Reconciles differences among the architecture-specific process models and describes distributed simulation lifecycle process in architecture-neutral terminology
Step 3 – Design Simulation Environment

Objectives

1.2

Conceptual Model

2.2

Member Application Documentation

Scenario(s)

2.1

Simulation Environment Requirements

2.3

Select Member Applications

3.1

Design Simulation Environment

3.2

Design Member Applications

3.3

Prepare Detailed Plan

3.4

List of Selected (existing) Member Applications

4.3,5.2

Simulation Environment Design

4.1,4.2,4.3,4.4

Member Application Designs

4.3

Simulation Environment Development and Execution Plan

4.1,4.2,4.3,4.4, 5.1,5.2,5.3,6.1

Initial Planning Documents

1.3

Augmented Planning Documents

List of Requirements Gaps

M&S Repositories

Gateway Selection
Step 4 – Develop Simulation Environment

Supporting Resources
- Other Resources
- Data Dictionaries
- Existing Simulation Data Exchange Model Libraries

Simulation Environment Design
- Simulation Environment Development and Execution Plan
- Conceptual Model

Develop Simulation Data Exchange Model
- Data Dictionary Elements
- Existing Simulation Data Exchange Models

Establish Simulation Environment Agreements
- Simulation Environment Agreements
- Scenario(s)

Implement Member Application Designs
- Member Application Designs

Implement Simulation Environment Infrastructure
- Simulation Environment Infrastructure
- Modified/new Member Applications

Simulation Data Exchange Models
- Scenario Instance(s)
- List of Selected (existing) Member Applications

Supporting Databases
- Supporting Databases

Implemented Simulation Environment Infrastructure

Gateway Configuration
Gateway Challenges

- Despite the many documented success stories associated with the use of gateways to facilitate LVC interoperability, there are also some significant issues that impact technical, schedule, and cost risk

  - No central “marketplace” of gateways
    - Few mechanisms for user to determine what reuse opportunities are available
    - No mechanisms for direct comparisons of gateways

  - Gateways built for specific needs
    - Not built for reuse/not built for extensibility
    - Extensive duplication of existing gateway capabilities

  - Broad proliferation of gateways
    - Redundant maintenance costs

  - Many gateway configuration tasks are very time consuming and error-prone
    - Development of mappings (i.e., translations) among simulation data elements
    - Filters
Live-Virtual-Constructive Architecture Roadmap (LVCAR)

- The Live-Virtual-Constructive Architecture Roadmap (LVCAR) was established in the Spring of 2007, continuing for approximately sixteen months
  - Intended to examine the differences among the major simulation architectures from a technical, business, and standards perspective, and to develop a time-phased set of actions to improve interoperability within multi-architecture simulation environments in the future
  - Resulted in a final report and supporting documentation that collectively totaled over a thousand pages

- LVCAR technical recommendations included numerous actions to create new products that help to increase the efficiency and effectiveness of LVC simulation environment developments
  - Spanned many areas, including needed improvements to gateway selection and configuration practices

- The implementation of LVCAR recommendations began in the Spring of 2009
Systems Engineering Approach to Gateway Selection

1. Create metadata files describing gateway products and configurations using Gateway Description Language (GDL) based on Gateway Capabilities List

2. Search database via tool that allows selection of gateway requirements via high priority capabilities

3. Best Matches from Search Gateway 1: 
   Gateway 2: 
   Gateway 3: etc.

4. Discussion with Community of Interest: Gateway Developers & Vendors, and other Gateway Users

5. Select gateway to deploy based on meeting exercise capabilities, configurability, licensing, and user feedback

Selected Gateway

Reevaluate

Searchable metadata files describing reusable gateway configurations using Gateway Description Language (GDL)
Step 1: Create Gateway Descriptions

- **Gateway developer describes the capabilities the gateway provides in a common file format and stores the file in an on-line repository**

- **Supporting gateway products:**
  - **Gateway Capability Description (GCD)** - Delineates the various capabilities that individual gateways can offer to user programs, along with specific levels of implementation for each unique capability.
  - **Gateway Performance Benchmarks (GPB)** - Identifies specific gateway performance measures, along with use cases that describe how and where these measures should be applied.
  - **Gateway Description Language (GDL)** - A common XML-based, machine-readable format/syntax for describing both user gateway requirements and the capabilities that individual gateways can offer to users.
Step 2: Identify User Requirements

- Gateway user defines the gateway requirements for their LVC application in a common file format (GDL)
- Supporting gateway products:
  - GDL Editor – Software tool for creating and editing a GDL file
Step 3: Match Requirements to Capabilities

- Gateway user employs GDL Editor to match requirements to gateway capabilities stored in GDL Repository

- Supporting gateway products:
  - GDL Repository – Gateway-specific element of a larger LVCAR Asset Reuse architecture which includes the Enterprise Metacard Builder Resource (EMBR) Portal. Provides search and discover capabilities
Step 4: Select Gateway

- Gateway user leverages matching results and other relevant information to make informed gateway decision

4. Discussion with Community of Interest: Gateway Developers & Vendors, and other Gateway Users

5. Select gateway to deploy based on meeting exercise capabilities, configurability, licensing, and user feedback
Systems Engineering Approach to Gateway Configuration and Use

1. Define/Reuse Mapping using SDEM Mapping Language (SML) Editor

2. Store mapping information in a common DB format using Common Components Tool (CCT Tool)

3. Initialize Gateway

Gateway Configuration Information (e.g., data file, code stubs)

GW-Specific Plug-in

Simulation Architecture to Exercise-wide Mapping written in SDEM Mapping Language (SML)

For Each

Gateway Configure Information

Simulation

Searchable SML Local Library

Searchable SML Remote Repository Library

All Files Stored
Step 5: Define Simulation Data Element Mappings

- Gateway developer describes the capabilities the gateway provides in a common file format, and stores the file on an on-line repository.

- Supporting gateway products:
  - **SDEM Mapping Language (SML):** An XML-based, machine-readable format/syntax for describing architecture/SDEM element mappings and any necessary transforms (e.g., units, coordinate systems).
  - **SML Editor – Software tool for creating and editing an SML file**
Step 6: Perform Gateway Configuration

- **Gateway developer describes the capabilities the gateway provides in a common file format, and stores the file on an on-line repository**

- **Supporting gateway products:**
  - Gateway Filtering Language (GFL): Common XML-based language for describing gateway message traffic filters
  - Common Components Tool (CCT): Software Tool that ingests gateway configuration information (SDEMs, GFL files, SML files) and stores in a common database format
  - Gateway-Specific Plug-ins: Converts CCT data into the format needed for configuration of specific gateways (e.g., files, code)
Gateway Configuration Tools

SML Editor Interface

CCT Architecture

- SML Loader
- GFL Loader
- ANDEM Loader
- ASF Loader Plug-in
- Gateway Specific Writer Plug-in
- Gateway Developer API
- CCT Database
- ASF Loader API

CCT

SML Editor Interface
LVCAR-I Gateways Effort – Summary

- LVCAR identified a general need for systems engineering rigor in the way LVC environment developers select, configure, and employ gateways.

- LVCAR-I has produced a process model for gateway selection/configuration that streamlines the development of LVC environments (particularly multi-architecture LVC environments).

- Numerous products have been produced to enable this process for practical use:
  - Specifications (e.g., language specifications, performance benchmarks)
  - Tools (e.g., GDL Repository, SML Editor, CCT)

- LVC community outreach will be a strong emphasis in 2013 to engage developers in product revisions and to help gateway users take advantage of this work.

- Many LVCAR-I gateway products produced to date are available via this website:
  - [https://msenterprise.jhuapl.edu/drupal/?q=node/37#overlay-context](https://msenterprise.jhuapl.edu/drupal/?q=node/37#overlay-context)