CRITICAL ISSUES IN C4I
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DEVS Unified Process for Web-Centric Development and Testing of System of Systems

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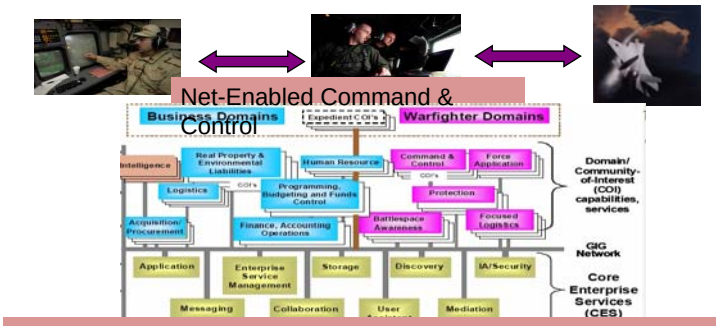
Outline

- Why an M&S-Based Integrated Development and Testing Framework?
- Today's Model-Driven Architecture (MDA) Software Engineering
- Background: Discrete Event Systems Specification (DEVS) M&S Framework
- Proposed: DEVS Unified Process (DUNIP)
  - Application to Web-centric Environments
- Evolution of DUNIP
- Comparing MDA and DUNIP
- Summary

Why an M&S-Based Integrated Development and Testing Framework?

- Need new development and testing paradigm for web-centric systems of systems (SoS)
- Examples
  - Distributed C4I
  - Global Information Grid (GIG)/Service Oriented Architecture
  - Collaborative Unmanned Autonomous Systems



Example: Testing DISA's Net-centric Enterprise Services (NCES)

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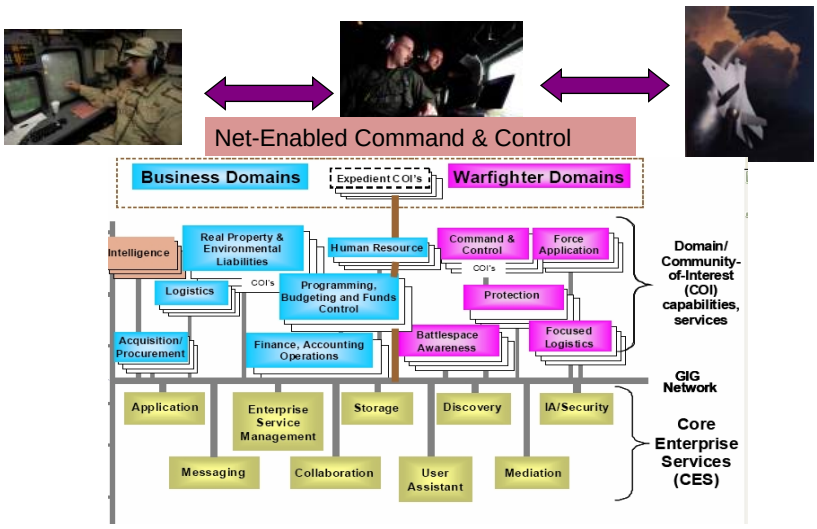
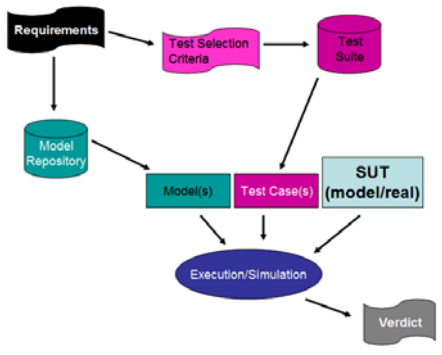


Today's Model-Driven Architecture (MDA) Software Engineering

- Model Driven Architecture (MDA) by OMG in 2001
- Defines system functionality using Platform Independent Model (PIM), using an appropriate domain specific language
- Entails various standards like UML, MOF, XMI, CWM
- Suffers from many shortcomings
  - UML bounded by UML meta-model itself
  - Executable UML not a standard yet
  - Modeling and Simulation not well integrated

Model-Based Testing

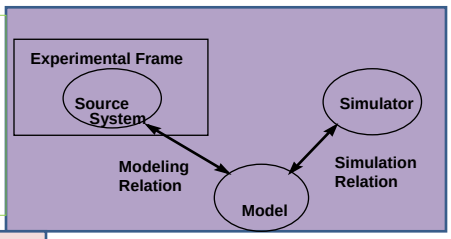
- A variant of testing that relies on explicit behavior of models
- Pairs of input-output are interpreted as test-cases
- Output of model is the expected output of System Under Test (SUT)
- Must take into account the required abstractions and lumped behaviors and parameters.



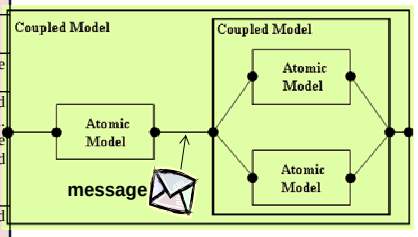
Background: DEVS M&S Framework

Discrete Event Systems Specification (DEVS)

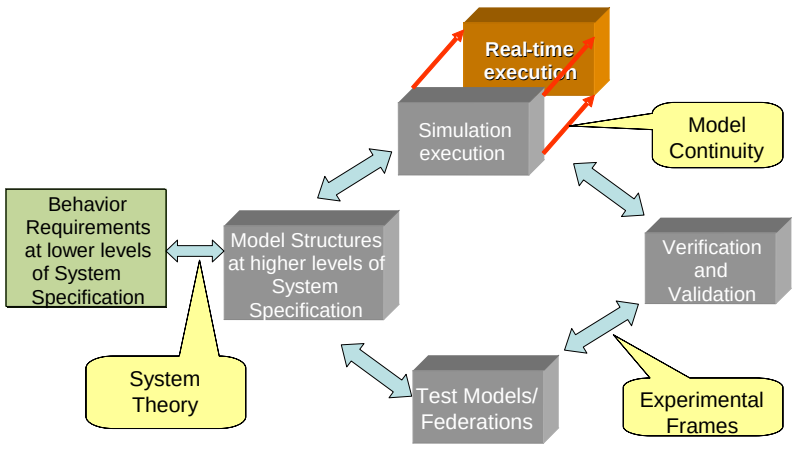
- Based on mathematical formalism using system theoretic principles
- Separation of Model, Simulator and Experimental Frame
- Atomic and Coupled types
- Hierarchical modular composition



Level	Name	System Specification at this level
4	Coupled Systems	System built from component systems with coupling recipe.
3	I/O System Structure	System with state and state transitions to generate the behavior.
2	I/O Function	Collection of input/output pairs constituting the allowed behavior partitioned according to initial state of the system. The collection of I/O functions is infinite in principle because typically, there are numerous states to start from and the inputs can be extended indefinitely.
1	I/O Behavior	Collection of input/output pairs constituting the allowed behavior of the system from an external Black Box view.
0	I/O Frame	Input and output variables and ports together with allowed values.



Integrated M&S-Based System Development and Testing Methodology



Provides Foundation for DEVS Unified Process (DUNIP)

DEVS Unified Process (DUNIP)

Supports

- Automated DEVS Model Generation from PIM to PSM (Platform Specific Model)
- Collaborative Development using DEVSML (XML representation)
- Automated Test Model Generation

Simulation Services provided by DEVS/SOA:

- Web-centric Execution of DEVS models
- Distributed, logical, and real-time modes

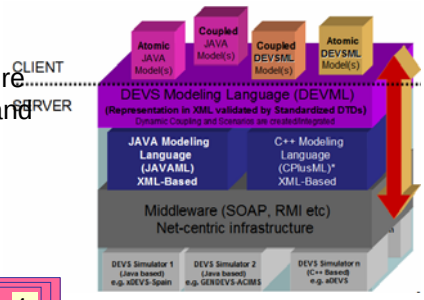
Automated DEVS Model Generation

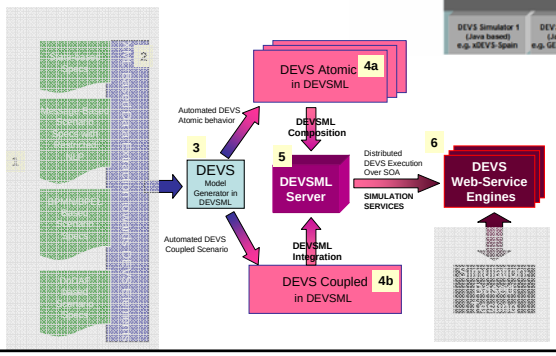
- State-Based System specifications
- Rule-Based System specifications using Natural Language Processing (NLP)
- BPMN/BPEL Based System Specifications
- DoDAF-Based requirement specifications

Refer www.acims.arizona.edu Publications page

DEVSML Collaborative Model Development

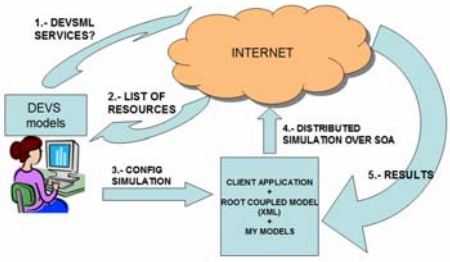
- DEVS PSM (Java) in XML language
- Based on JavaML Layered architecture
- Cross-transformation between XML and Java
- Server farm and Simulation services





DEVS/SOA: DEVS on SOA with Simulation services

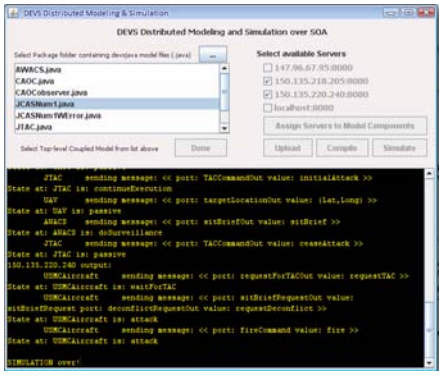
- Client-Server architecture (based on layered architecture of DEVSML)
- Two layer service framework
  - User layer
    - Upload, Compile, Simulate (centralized or distributed)
  - Engine layer
    - Initialize, DEVS-protocol relation services, exit, console output retrieval service

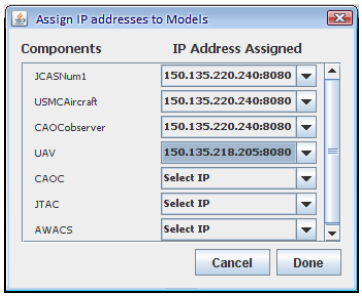


Run Example

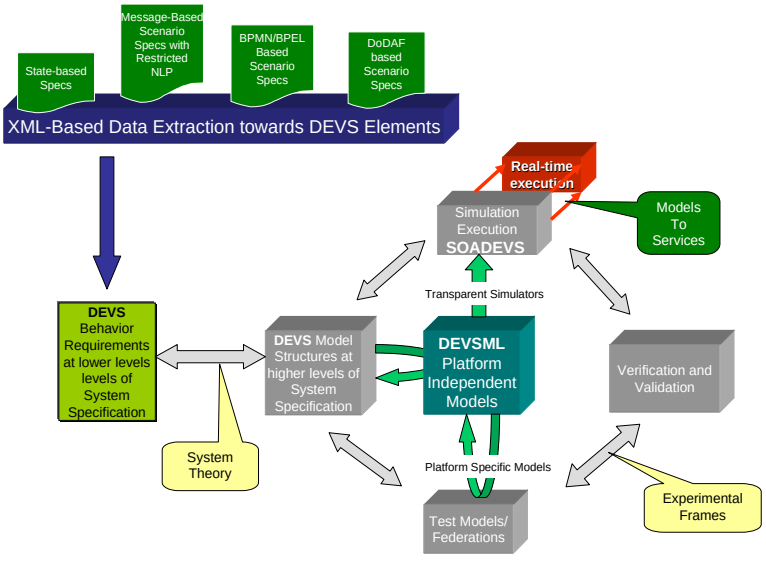
DEVS/SOA Client

- Model partitioning, deployment and simulation initialization
- Invoking simulation services from DEVS/SOA Server farm





The Complete DUNIP

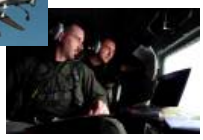


Evolution of DUNIP

Project / DUNIP Elements		JCAS model	DoDAF-based Activity Scenario	ATC-Gen Project	GENETSCOPE Project
Requirement Specification Formats		X			X
	State-based Specs	X			
	Message-based Specs with restricted NLP	X			
	BPMN/BPEL based Specs	X			
	DoDAF-Based Scenario Specs		X		X
XML-based Data Extraction		X	X	X	
DEVS Model Structure at lower levels of Specification		X	X	X	
DEVS model structure at higher levels of System specification			X		X
DEVSML Platform Independent Models		X			
Test Model Development		X		X	
Verification and Validation using Experimental Frames			X	X	X
DEVS/SOA net-centric Simulation		X			

DEVS/SOA Infrastructure for GIG Mission Thread Testing

- Test agents are DEVS models and Experimental Frames
- They are deployed to observe selected participant via their service invokations



1. MAJ Smith tasks Intell to reconnoiter objective area and provide threat

2. Posts taskings using Discovery and Storage

3. Intell Cell initiates high priority collection against objective, and collectors post raw output

4. Intell posts products via Discovery and Storage

5. Intell Cell issues alert via messaging

6. MAJ Smith pulls estimate from Storage

NCES GIG/SOA

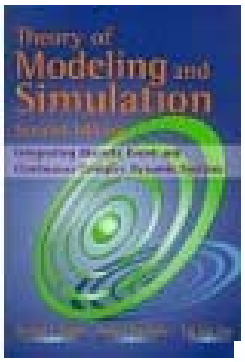
Comparing MDA and DUNIP

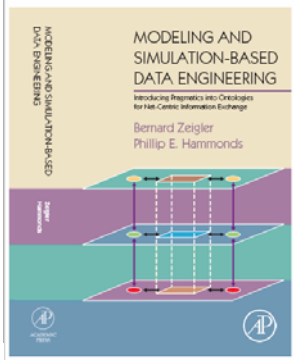
Desired M&S Capability	MDA	DUNIP
Need for executable architectures using M&S	Yes, although not a standard yet	Yes
Applicable to GIG/SOA	Not reported yet	Yes
Interoperability and cross-platform M&S using GIG/SOA	--	Yes, DEVSML and DEVS/SOA provides cross-platform M&S using Simulation Web Services
Automated test generation and deployment in distributed simulation	--	Yes, based on formal Systems theory and test-models autogeneration at various levels of System specifications
Test artifact continuity and traceability through phases of system development	To some extent, model becomes the application itself	Yes, supports model continuity
Real time observation and control of test environment	--	Model Reconfiguration and run-time simulation control integral to DEVS M&S. Enhanced MVC framework is designed to provide.Dynamic capability

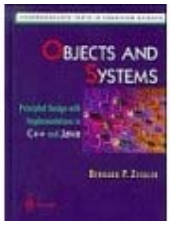
Summary

- DUNIP supports web-centric development and testing of SoS
- Advantages of several inter-related concepts
  - DEVSML, DEVS/SOA, M&S framework, Model-Continuity
  - Separation of model with the simulators
  - Real-time execution
  - Testing at multiple levels over wide range of platforms
  - Collaborative model development
  - Additional SoS architectural views
- Web-centric SoS can be specified by UML, DoDAF, or systems engineering methodologies
  - DUNIP provides an integrated development framework supporting these approaches

Books and Web Links







devsworld.org

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