

DEVS Background

for Model-Based System Engineering

Bernard P. Zeigler
Emeritus Professor University of Arizona

RTSync Corp.
6909 W Ray Rd STE 15-107
Chandler, AZ 85226 USA

Overview

RTSync Corp. Arizona and Maryland

Focus:

Model-based System Engineering (MBSE), Discrete Event System Specification (DEVS) modeling and simulation methodologies and software toolset

Research and Development products

- ***Automated Test Case Generator (ATC-Gen)*** : tactical data conformance testing
- ***MS4 Modeling & Simulation Environment (MS4 Me)***: DEVS IDE
- ***Automated Scenario Selection/Construction (ASC)*** : SES-based Simulation generated search
- ***Collaborative Architecture for Model-level Integration (CAMLI)***: DEVS-based Re-usable Component Development

Related Contract Support and Grants:

Missile Defense Agency, SBIRs,

Korean Advanced Defense Development

DoD Info Sys Agency JITC, Dept of Homeland Security, National Science Foundation, NASA,

Collaborations:

- **Business:** Prime Group Solutions (Arizona: MBSE), nSi (Huntsville: Missile Defense M&S)
- **FFRDC:** Oak Ridge National Lab, M&S Group
- **University:** Arizona Center for Integrative Modeling and Simulation (ACIMS) (<https://acims.asu.edu>) Arizona State Univ, Univ of Arizona, Georgia State Univ, Univ of Corsica, Univ of Nice and CNRS in France, Univ of Wismar, Germany

Books :

“Model Engineering for Simulation”, Editors: L. Zhang, B. P. Zeigler, and L. Lian

“Theory of Modeling and Simulation Third Edition”, B. P. Zeigler. Alexandre Muzy, E. Kofman, 2018

“Guide to Modeling and Simulation”, B. P. Zeigler and H. Sarjoughian , 2nd Edition, 2017

“Modeling and Simulation-based Data Engineering Introducing Pragmatics into Ontologies for Net-Centric Information Exchange”, B. P. Zeigler and P. Hammonds, 2007

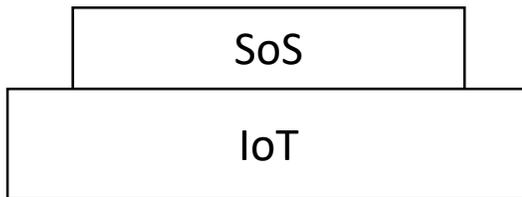
Contacts

For more information , contact info@rtsync.com or POCs ;

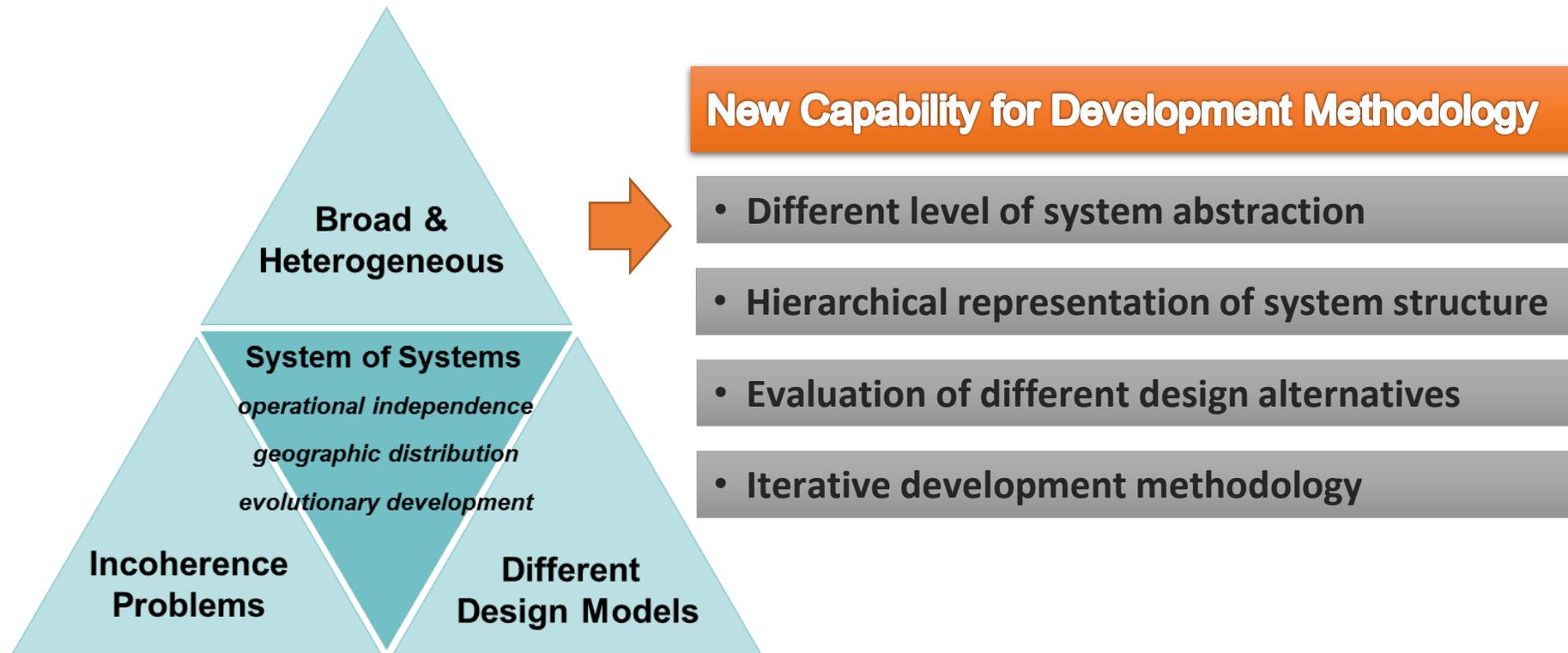
Dr. Bernard P. Zeigler	Chief Scientist	zeigler@rtsync.com
Dr. Doohwan Kim	President & CEO	dhkim@rtsync.com

System of systems (SoS) is a collection of task-oriented systems that pool their resources and capabilities together to obtain a new, more complex, 'meta-system' which offers more functionality and performance than simply the sum of the constituent systems (from Wikipedia)

- Energy : Smart grid system, nuclear power plant infrastructure,
- National Infrastructure : intelligent transportation infrastructure
- Defense : C4ISR, Net-centric warfare
- Security : Homeland Security, Boarder Surveillance
- Space : Planetary colonies



- System of Systems(SoS) contains high degree of complexity and current methodology is not capable of designing and development as well as operating the SoS.



Theory of Modeling and Simulation

Levels of System Specification

Level	Specification Name	What we know at this level	Example: A Person in a Conversation
0	Observation Frame	How to stimulate the system with inputs; what variables to measure and how to observe them over a time base;	The person has inputs and outputs at the usual cognitive level, such as streams of words
1	I/O Behavior	Time-indexed data collected from a source system; consists of input/output pairs	For each input that the person recognizes, the set of possible outputs that the person can produce
2	I/O Function	Knowledge of initial state; given an initial state, every input stimulus produces a unique output.	Assuming knowledge of the person's initial state when starting the conversation, the unique output response to each input.
3	State Transition	How states are affected by inputs; given a state and an input what is the state after the input stimulus is over; what output event is generated by a state.	How the person transits from state to state under input words and generates output words from the current state
4	Coupled Component	Components and how they are coupled together. The components can be specified at lower levels or can even be structure systems themselves – leading to hierarchical structure.	A description of a person's I/O behavior in terms of neural components and their interaction by spikes is at this level.

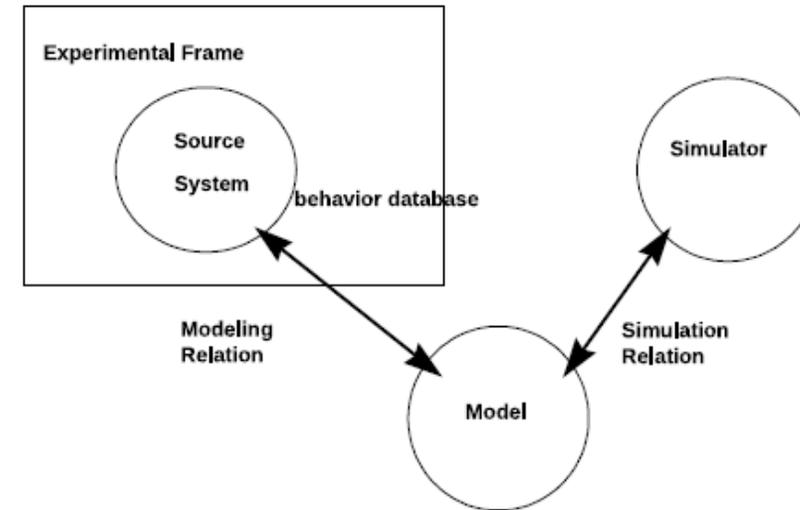
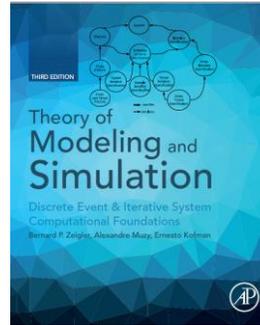
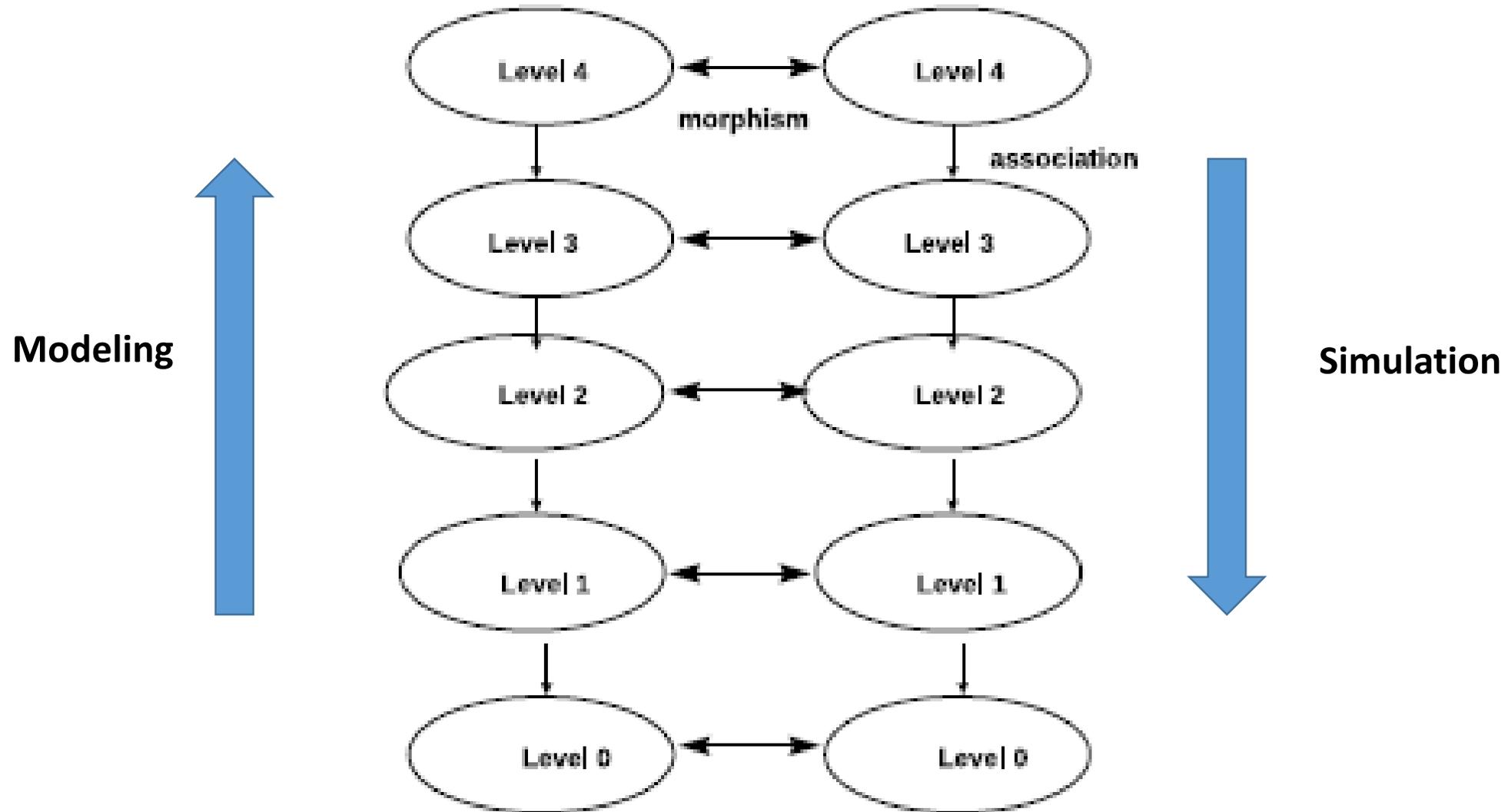


FIGURE 2.1

The Basic Entities in M&S and Their Relationships.

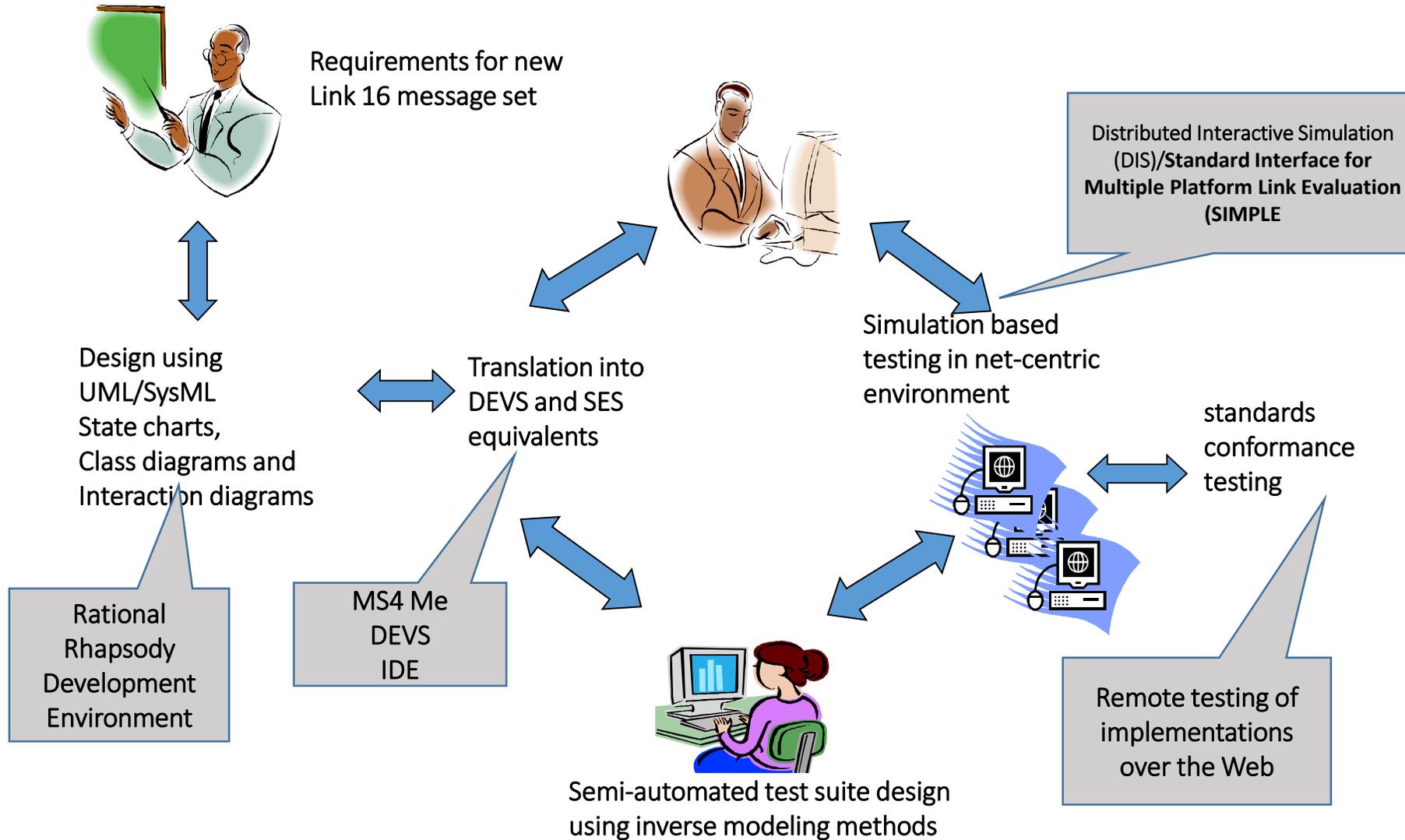
Equivalences at each Level of System Specification



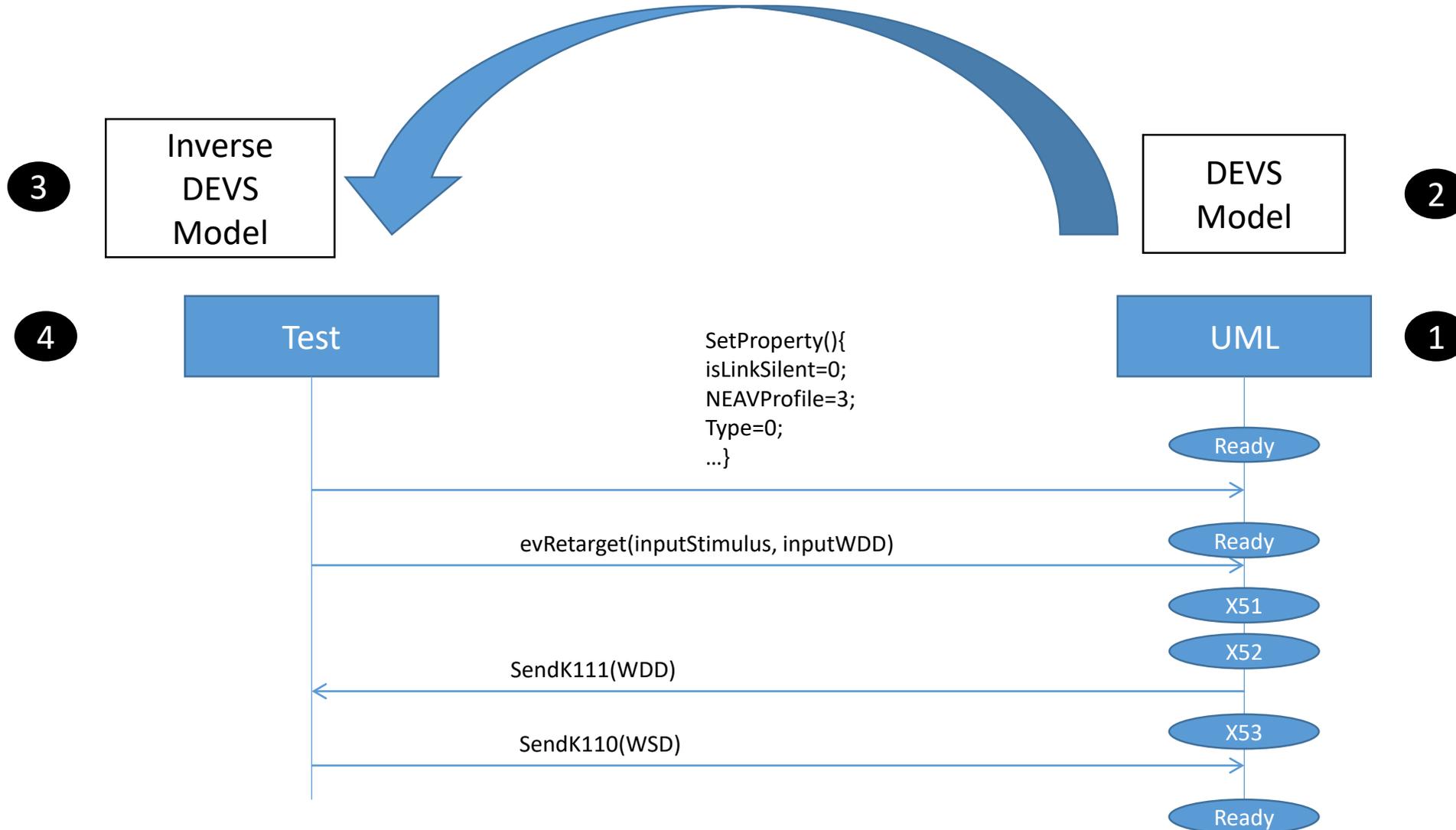
DEVS Systems-based Simulation is applicable to wide spectrum complex systems

- Theoretical – supporting application
 - Closure under coupling, universality, uniqueness, relation to other formalisms
 - Hierarchical Model Construction supports complex system development
 - Supports the correctness of the algorithms and validation of the executing models, e.g., time management is rigorously defined
 - Discrete Event System Specification (DEVS) formalism can be easily expanded beyond discrete-event world to continuous characteristics of system. (Hybrid-DEVS)
- In Application
 - Models, Simulators and Experimental Frames are distinct entities with their own software representations
 - Precise and well-defined mathematical representation
 - Models/Experiments are developed systematically for interoperability
 - Repositories of models/experiments created and maintained systematically
 - Components can be easily reused for constructing new models
 - Discrete-event basis improves performance (e.g. no need for a global clock to control timing)
 - DEVS software can be deployed on distributed computing environments and interact with heterogeneous M&S system.

DEVS Model-Based Systems Engineering



DEVS-Based Test Development

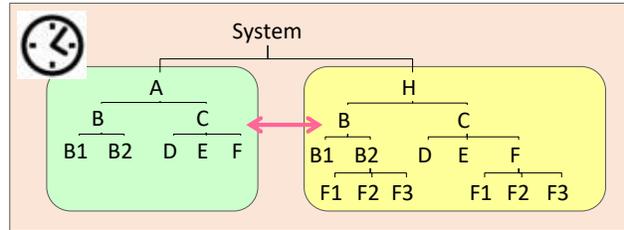


Transform models for real time application

- Same DEVS models can be designed, evaluated and transformed to operating system for actual real application.

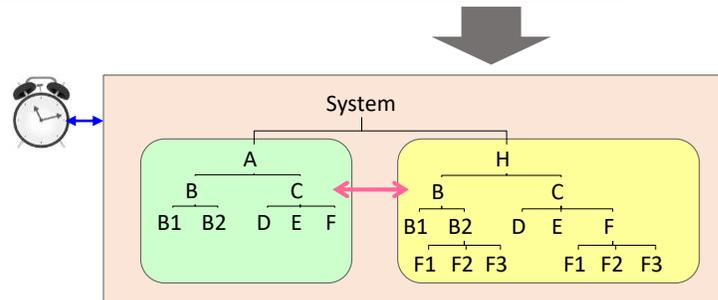
Monitor & Control System
(ex.. SCADA)

System under test
(ex.. Plant, Power System)



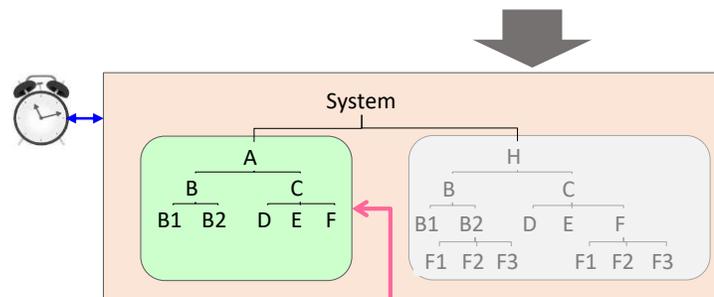
Phase 1: Simulation by simulation clock

- Simulate models and SES with simulation clock
- Evaluate various design specifications and performance



Phase 2 : Simulation by real-time clock

- Continue to use same models of phase 1
- Run simulation with real-time clock
- Evaluate real-time characteristics of system

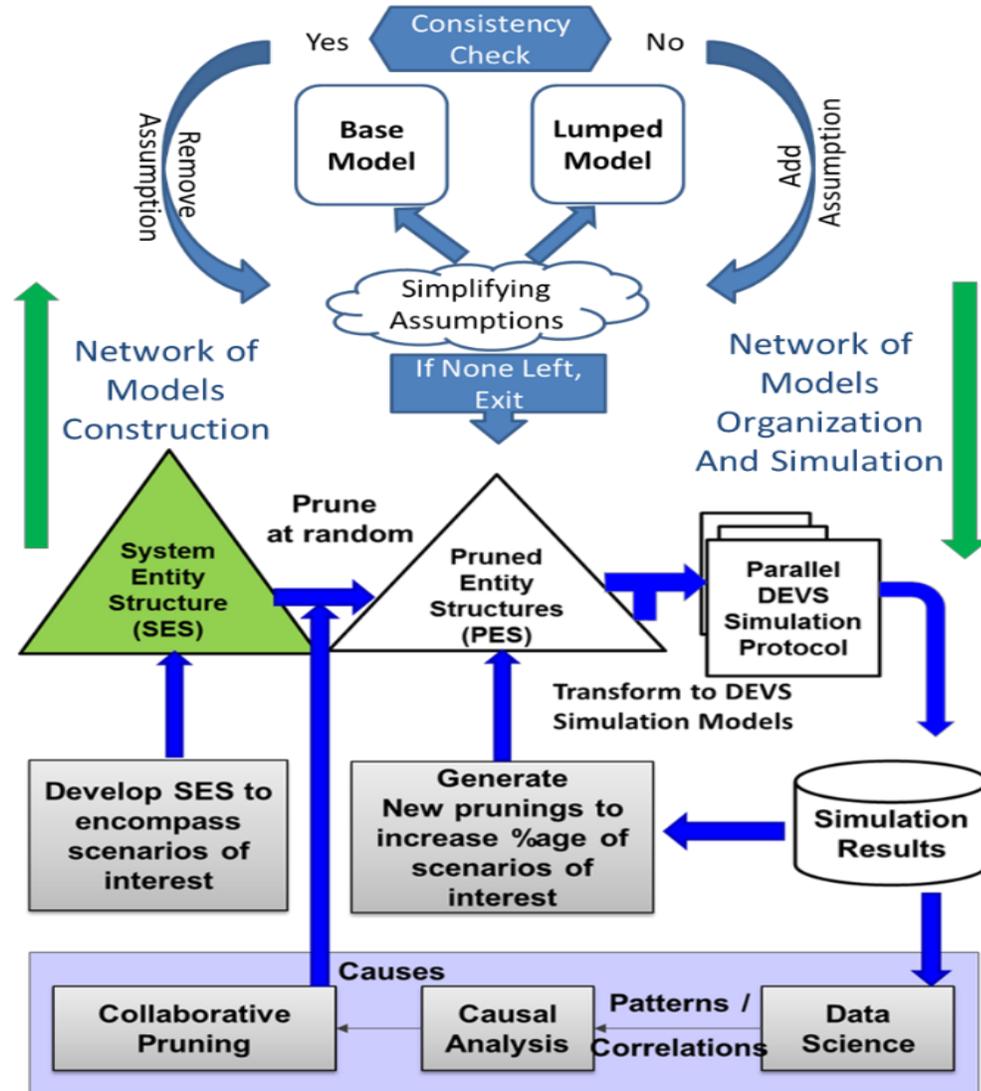


Phase 3 : Transform models to real application

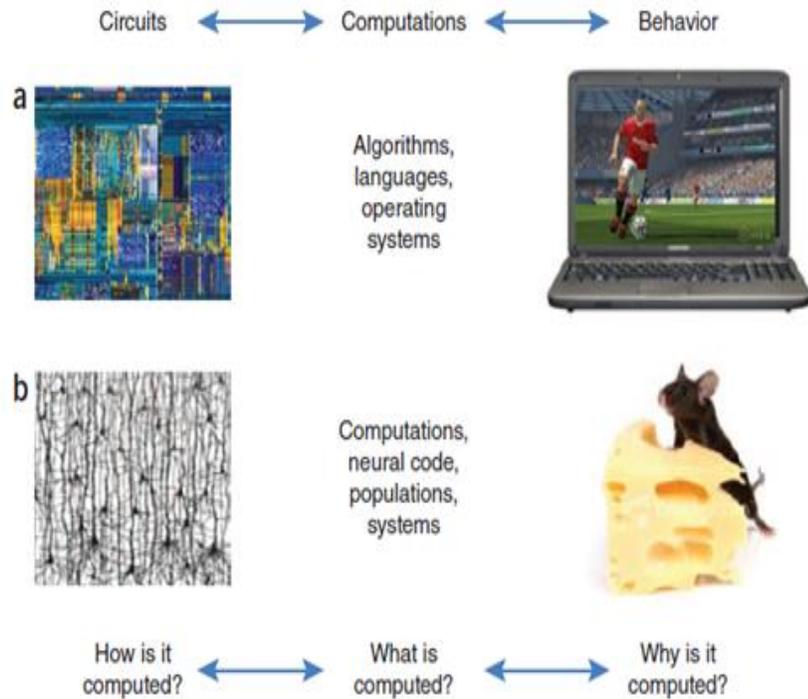
- Continue to use same models of phase 2
- Directly interface to real world application



DEVS-Based Multi-Resolution Model Development



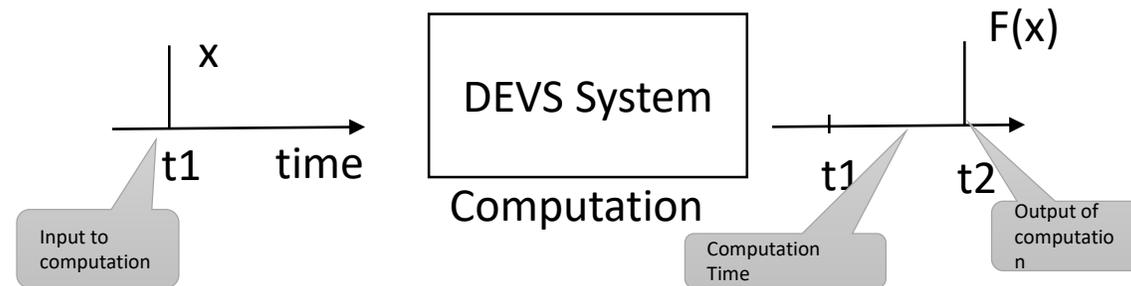
Course in Neurocognition with A. Muzy at U. Nice



Article

Temporal Modeling of Neural Net Input/Output Behaviors: The Case of XOR

Bernard P. Zeigler^{1,*} and Alexandre Muzy²



Some Considerations in temporal computation

Some implications:

- DNN may overemphasize recognition
- May be impractical in real-time applications

- Time dispersion of input events
- Coincidence of events
- End-to-end computation time
- Waiting time before a new input can be submitted
- Accuracy/Speed Tradeoff