



Rapid Synthesis of Multi-Model Simulations for Computation Experiments in C2

Himanshu Neema, Harmon Nine, Graham Hemingway, Janos Sztipanovits, Gabor Karsai
ISIS, Vanderbilt University
{himanshu,hnine,hemmings,sztipaj,gabor} @isis.vanderbilt.edu



*GMU-AFCEA SYMPOSIUM on
Critical Issues in C4I
Lansdowne, VA
May 19, 2009*



Outline



- Program Background
- A typical C2 Architecture, Issues to study
- Multi-modeling integration challenges
- Our approach: The C2 Wind Tunnel (C2WT)
- C2WT capabilities
- Recent C2 scenario demonstrated with C2WT
- C2WT current status



Program Background



AFOSR: Partnership for Research Excellence and Transition (PRET) in Human System Interaction Program

Project: Human Centric Design Environments for Command and Control Systems: The C2 Wind Tunnel

Program manager:

Dr. John Tangney and Dr. David Luginbuhl

PRET Team:



Vanderbilt University: Institute for Software Integrated Systems(ISIS)



George Mason University: System Architectures Laboratory (SAL)

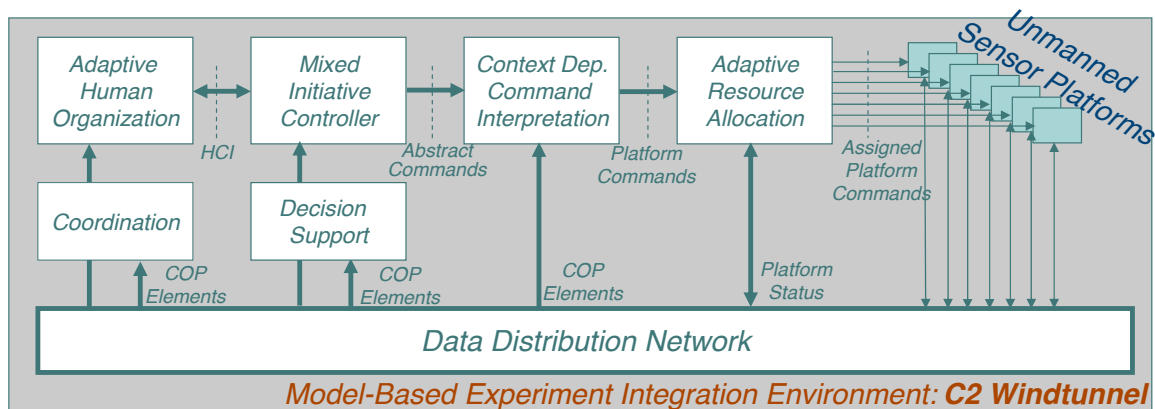


UC Berkeley

3



Typical C2 Architecture



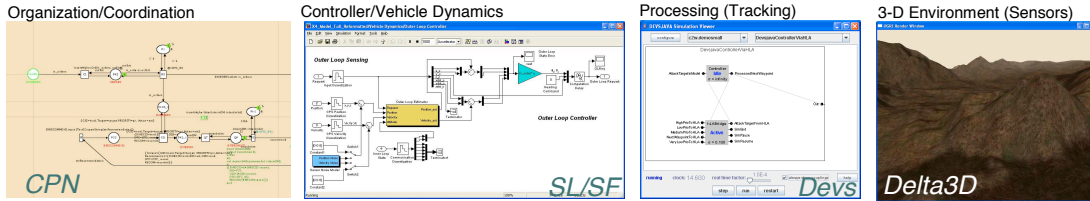
C2 issues to be studied experimentally:

- **Distributed Mission Operation**
 - Synchronization and coordination
 - Distributed dynamic decision making
 - Network effects
- **Increased Information Sharing**
 - Shared situation awareness
 - Common Operation Picture (COP)
 - Network effects
- **Seamless Integration of Manned/Unmanned Assets**
 - Mixed-Initiative Teams
- **System Level Impact Analysis**
 - Cyber attacks
 - Resilience solution
 - Strategy/gaming

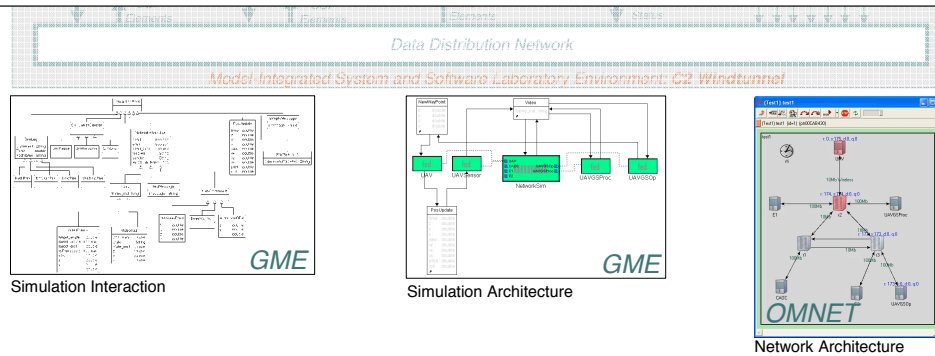
4



Multi-Model Simulation Integration



How can we integrate the simulated heterogeneous system components?
How can we integrate the simulation engines?
How can we rapidly synthesize and deploy integrated simulations?



5



Multi-Model Integration Challenges



Integrating *models*

- Heterogeneous models for different domains: human organizations, communication networks, C2 software systems, vehicle simulations, etc. These models need to talk to each-other somehow.
- Needed: an overarching *integration model* that **connects** and **relates** these heterogeneous domain models in a logically coherent framework.

Integrating the *system*

- Heterogeneous simulators and emulators for different domains: Colored Petri Nets, OMNET++, DEVS, Simulink/Stateflow, Delta3D, etc.
- Needed: an underlying *software infrastructure* that **connects** and **relates** the heterogeneous simulators in a logically and temporally coherent framework.

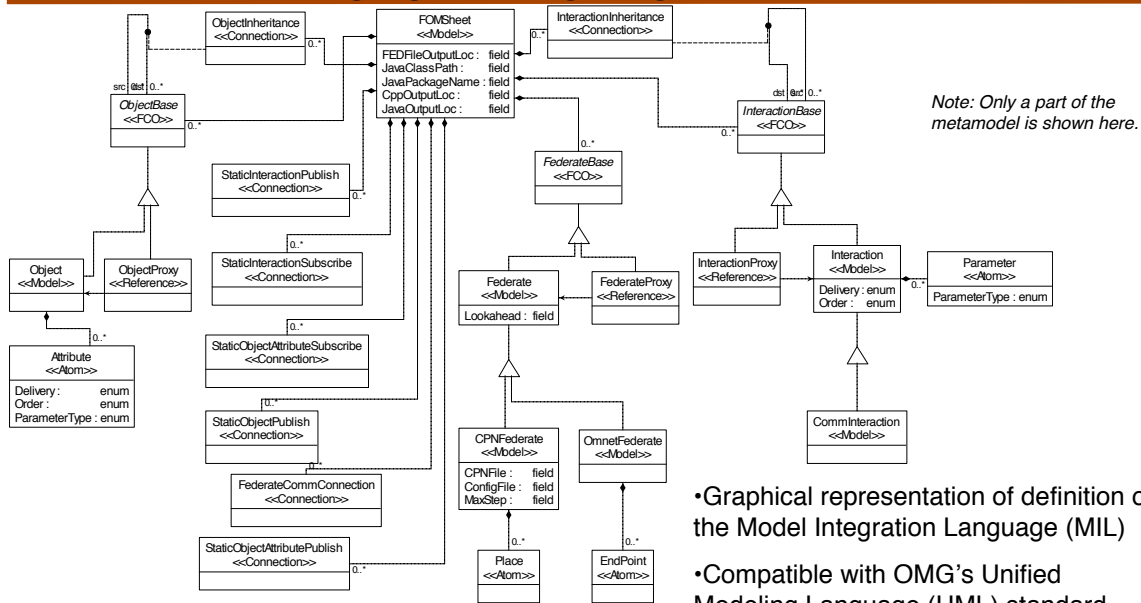
Key idea: Integration is about messages and shared data across system components. Why don't we model these messages and shared data elements and use these models to facilitate model and system integration?

6



C2WT Metamodel

Defines language for integrating models in scenarios

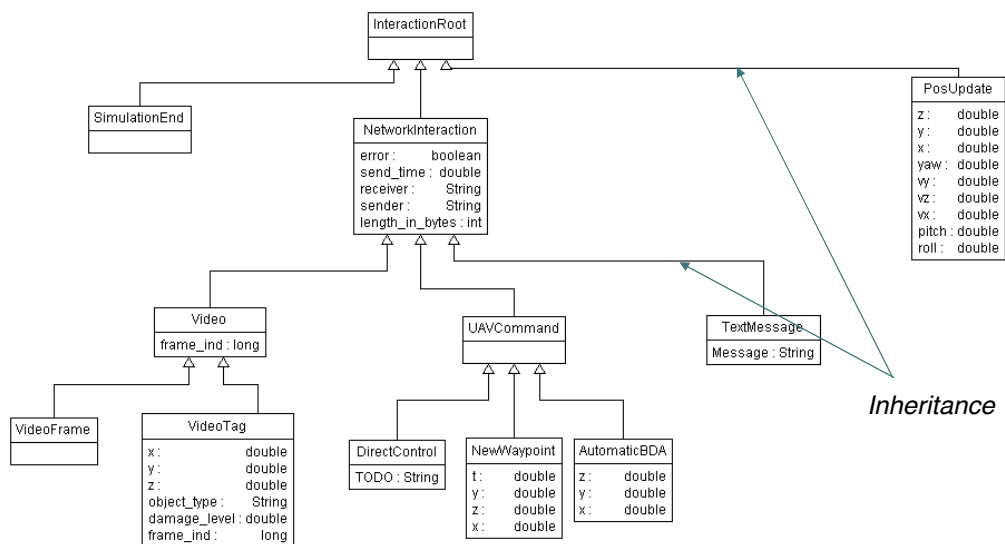


- Graphical representation of definition of the Model Integration Language (MIL)
- Compatible with OMG's Unified Modeling Language (UML) standard
- Defines the syntactic, semantic, and presentation information of a domain

7



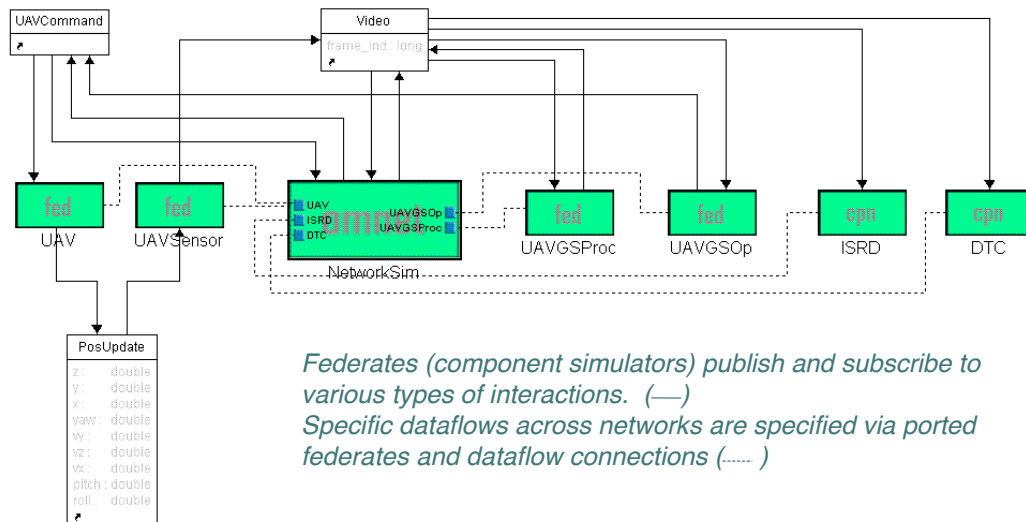
Example: A specific data-model used in a complex C2 scenario



8



Example: Integration model of a specific C2 scenario



9



C2WT Integration Platform Modeling and Run-time Environment



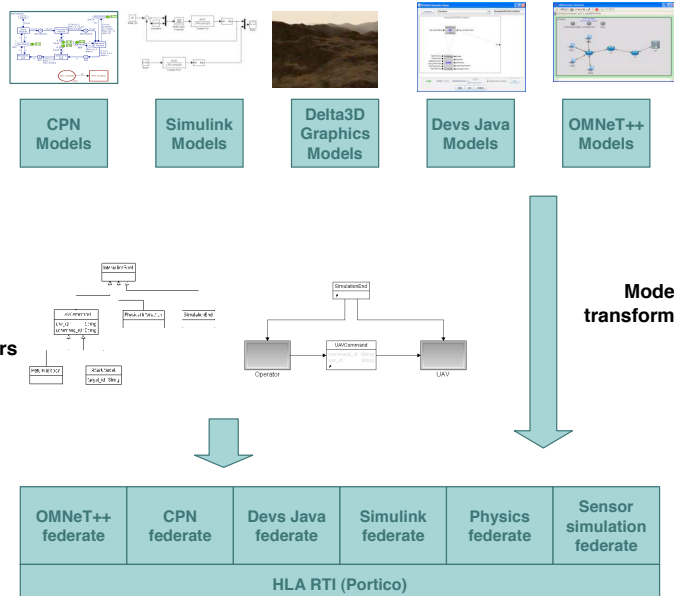
Simulation models

Domain specific models -- abstract simulation models

- Data models
 - interaction & data models
- Integration models
 - data-flow, timing, & parameters

Configuration

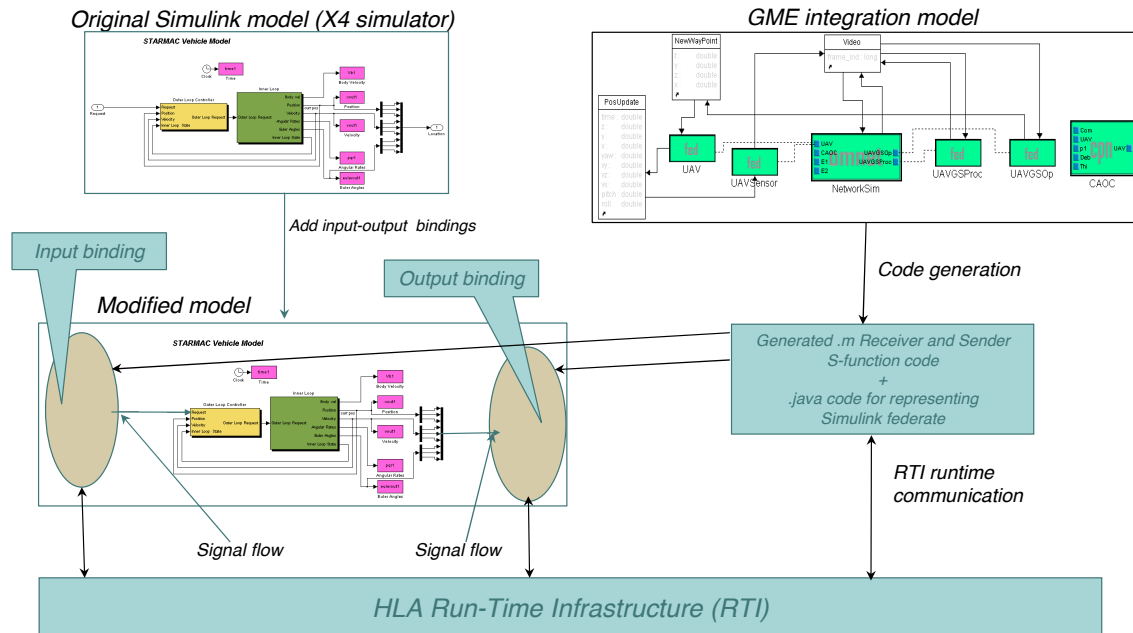
Domain specific federates



10



Example: Simulink Model Integration (Vehicle dynamics)



11



Multi-modeling with C2WT



Three levels of modeling & customization:

- Modeling the modeling tools - Infrastructure**
 - Performed “one-time” when a new simulation platform (model type) is integrated [usually by developers]
- Modeling the integration of the models – Scenarios**
 - Performed when a new scenario has to be experimented [usually by subject matter experts who can describe scenarios]
 - Requires:
 - Models of model tools used (‘federates’)
 - Data models
 - Integration models: Interactions among the models
- Modeling the situations – Experiments**
 - Execution platform, experiment setup, deployment [usually by experimenters who can parameterize experiments and analyse experimental results]

Level	Example	Expertise	Function	Frequency	Currently Supported
Infrastructure		Meta-modeling. Model-transformation.	Adding new model types, integrating new tools.	Incorporating a new discipline or model type in the infrastructure.	<ul style="list-style-type: none"> Matlab / Simulink CPN Tools C++/Java DevJava OMNeT++ Google Earth 3D Delta3D Ogre3D Open interface to integrate newer simulation tools
Mission		Interaction modeling. Component modeling	End-to-end modeling of mission scenarios.	Startup activities for new studies.	<ul style="list-style-type: none"> Interaction modeling with HLA interactions and objects Component modeling to design scenario elements
Experiment		Component modeling. Experiment design. Data analysis.	Configure and parameterize component models for individual experiments and measure selected performance data	Performing studies and evaluations by running experiments	<ul style="list-style-type: none"> Experiment design Component parameterization Automatic Expt. deployment Expt. data collection in MySQL database Data analysis scripts

12



- **Provides a rapid system integration technology**
 - For empirical studies in human system interaction paradigms in dynamic C2 architectures.
- **Supports Scenario driven experimentation**
 - Extensible infrastructure supported by metamodeling.
 - Rich suite of modeling languages already covering C2 team/organizational modeling aspects.
 - Model-based simulation integration exploring metamodeling and model transformation.
- **Provides infrastructure for detailed instrumentation & analysis**
 - Foundation for driving operational tools and cognitive performance monitoring tools.
 - Detailed simulation logging at various levels (status, scenario, debugging).
 - WebTAS (Web-enabled Temporal Analysis System) integration.
- **Parameterizable models and scalable distributed infrastructure**
 - Parameterized scenario specifications.
 - Experiment control and human in the loop simulation.
 - Automated federation deployment, batch execution of scenarios, experimentation, and analysis.
- **High quality, open source tools and components**
 - Most of the tools used are in use worldwide by the research community and industry (MIC Tools, Omnet++, Portico, Devs, Delta3D, CPN, OGRE).
- **Very low cost, open-source infrastructure**
 - Distributable to the research community and government industry users

13



- The OpenC2WT community website is:
 - <http://wiki.isis.vanderbilt.edu/OpenC2WT>
- A website for C2WT community, for end users, contributors, and developers.
- Provides access to the C2WT installation release
- Provides all “relevant” documentation and example cyber scenarios demonstrated with C2WT
- Provides re-usable simulation “component libraries”
- Serves as a primary means for C2WT dissemination and collaboration

14

15

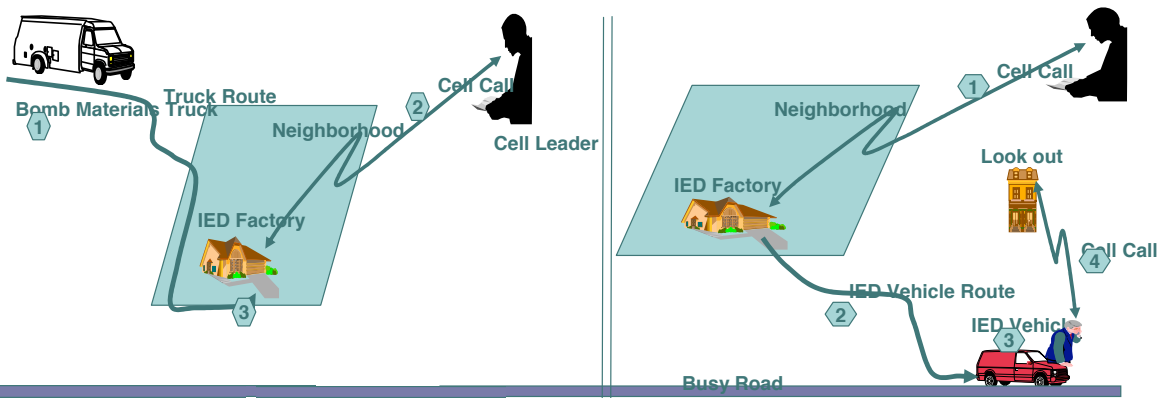
16



The Storyline



- Intel learns that a delivery of bomb making materials is to be made to the bomb making facility. The exact location of the loading point of the delivery truck is not known, but the expected route and key identifying features (e.g. type and color) of the delivery truck is provided
- Two UAVs (UAV 1 and 2) are in the vicinity of the expected truck route and the neighborhood where the bomb making facility may be located. A third UAV (3) is within range if needed



- Red truck with bomb materials travels from supply location to the IED factory
- Red Cell Leader calls IED factory to report pending delivery of bomb making materials
- Bomb materials truck arrives at IED factory

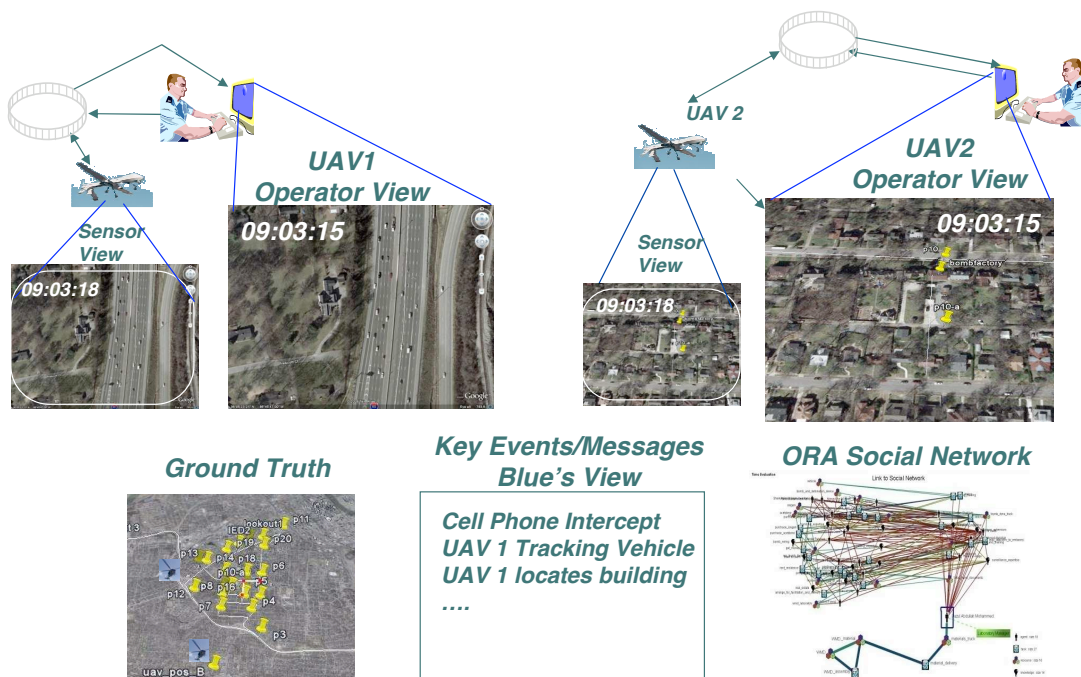
- Vehicle with IED leaves factory and travels to pre arranged bombing location
- Vehicle driver arms IED
- Vehicle driver leaves vehicle and calls lookout facility saying the IED is armed

17



Experimentation:

Providing answers to Command and Control questions



18



C2WT Current Status



- The C2WT is a prototype of an operational system
- The C2WT has been installed at AFRL/RI – Rome Research site and is operational
- The C2WT is being prepared by AFRL/RI for transition to AFIOC
- The C2WT has been implemented and is operational at Vanderbilt, George Mason and Carnegie Mellon Universities with the models shown in the demonstration
- The C2WT is being used by research communities like at Sandia and BAE systems

19



Thank you!



- Questions?
- Contact:
 - Himanshu Neema
 - Email: himanshu@isis.vanderbilt.edu
- The OpenC2WT community website
 - <http://wiki.isis.vanderbilt.edu/OpenC2WT>

20