Panel on Model Interoperability

Workshop on Current Issues in Predictive Approaches to Intelligence and Security Analytics

IEEE International Conference on Intelligence and Security Informatics
Vancouver, BC, May 23-26, 2010

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Panelists

- **Antonio Sanfilippo -** Chief Scientist in the Computational and Statistical Analytics Division at Pacific Northwest National Laboratory (*Panel Chair*)
  - Lead a multi-lab team that established the ***Motivation & Intent*** thrust at the DHS S&T Directorate. Currently leading a multi-year Laboratory Initiative on Technosocial Predictive Analytics at PNNL
- **Alexander Levis -** Professor of Electrical, Computer and Systems Engineering, and director of the System Architectures Laboratory, George Mason University
  - Chief Scientist of the US Air Force (2001-04). Recipient of the Exceptional Civilian Service medal from the Air Force (1994, 2001, 2004), the Air Force Chief's Medallion and the IEEE Third Millennium
- **Ed Waltz -** Chief Scientist, Intelligence of BAE Systems Advanced Information Technologies
  - Leads modeling and simulation research at BAE Systems and has led numerous hard target and counter Denial & Deception projects for the IC. Co-author of *Counter-deception Principles and Applications for National Security*, Artech 2001
- **William Reynolds -** Founder, President and Chief Science Officer of Least Squares Software
  - A leader in the field of complexity for more than twenty years. Has focused on complex systems for intelligence analysis in the last 8 years, conducting numerous case studies
- **Luke Overbey -** Researcher at the Space and Naval Warfare Systems Center Atlantic, Information Operations Division
  - Has led several research projects on complex systems for intelligence support to information operations. Currently leading the Virtual Integrated Support to Information Operations program

PAISA-10 Workshop at ISI 2010

- Workshop topic
  - Current Issues in Predictive Approaches to Intelligence and Security Analysis
- 11 papers on three themes
  - Model Interoperability and Meta-Modeling
  - Model Diagnostics and Evaluation
  - Collection, Analysis and Coalescence of Evidence
- Panel on Model Interoperability – main conference event
- Invited talk by Ed Waltz, BAE Systems
  - *Anticipatory Intelligence Analysis: Integrating Multiple Models for Joint Intelligence Preparation*
  - ***Starting at 12:45pm today, in the Princess Louisa Suite***

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Why are we doing this?

- Factors such as globalization and the increased speed of knowledge sharing keep escalating the asymmetric nature of threats to the security, health and sustainable growth of our society
  - Strategic surprises emerging from non-linear relationships between trigger and target events
- Anticipatory analysis has to become an everyday activity in decision-making to counter adversities and maximize opportunities

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Current Issues in Predictive Analytics

- Currently, the use of anticipatory reasoning is hindered by the lack of systematic methods for model integration and model evaluation
  - Failure to achieve interoperability across models from diverse domains and disciplines curtails our ability to address complex problems
  - Failure to verify and validate models hinders user acceptance and realistic understanding of a model's analytic reach

Panel questions

- Why is model interoperability needed?
- What are the major challenges in pursuing model interoperability?
- What capabilities are needed to achieve model interoperability?
- What infrastructure is needed to promote model interoperability?
- How can interoperable models be verified and validated?
- How can funding agencies help?

Alexander Levis

- Why is model interoperability needed?
  - ***Because no model alone can capture the complexities of the human terrain.***
- What are the major challenges in pursuing model interoperability?
  - ***Different modeling languages used to build models contain different embedded assumptions (axioms) and deal in different ways with time, uncertainty and ambiguity.***
  - ***These considerations impose explicit and implicit constraints on the interoperation of models even when they address the same question using the same data.***

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Alexander Levis

- What capabilities and infrastructure are needed to achieve model interoperability?
  - ***Understand the ontology of the modeling languages, find ways to deal with different descriptions of time,…***
  - ***One needs to address interoperability at the physical layer, the syntactic layer, the semantic layer and the workflow layer.***
- How can interoperable models be verified and validated?
  - ***Individual models can be subjected to V&V***
  - ***We are only beginning to explore the V&V of sets of interoperating models expressed in different modeling languages***
- How can funding agencies help?
  - ***Is this line of inquiry mature enough to warrant research programs?***

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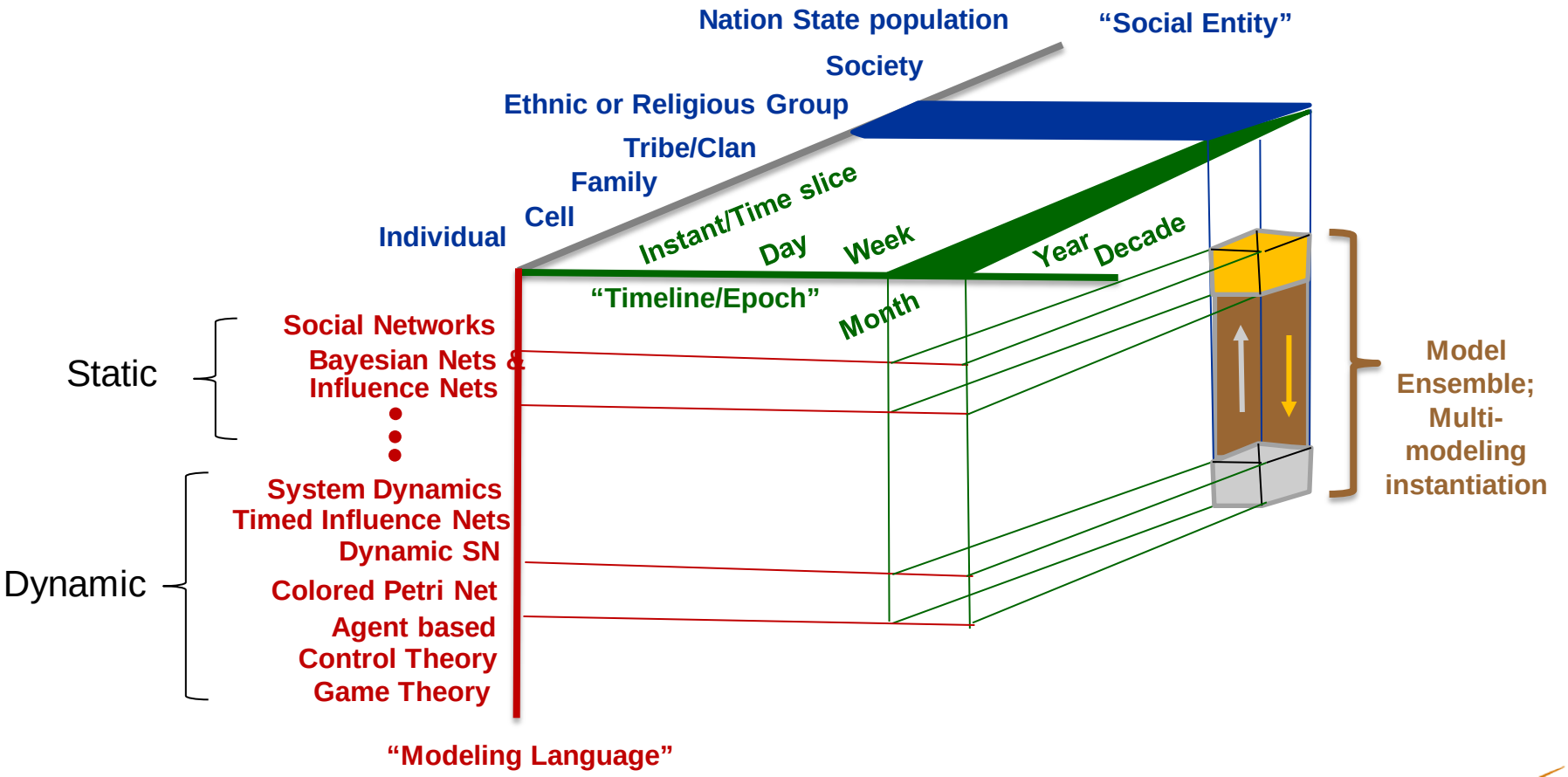
Model Interoperation for Multi-Modeling Construct



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Ed Waltz

- Why is model interoperability needed?
  - ***To address "broad" issues, such as PMESII systems, a range of models paradigms (e.g. Agent-based, system dynamics, etc.) are often required to represent the interacting systems that are producing phenomena (effects) being studied***
- What are the major challenges in pursuing model interoperability?
  - ***Analytic approach selection – Why model? What to model? How much model?***
    - ***Model integration approach selection (Multiple are available)***
    - ***Model interoperability standard (s) selection***
    - ***Model environment and variable ontologies***
    - ***Modeling frameworks***

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Ed Waltz

- What capabilities are needed to achieve model interoperability?
  - ***Robust standards and frameworks that readily integrate models from existing modeling tools***
- What infrastructure is needed to promote model interoperability?
  - ***Modeling frameworks that are flexible and allow rapid model development, composition, and testing-validation, and allow comparison and tracking with the real-world***
- How can interoperable models be verified and validated?
  - ***"Validate for purpose"***
  - ***Independent validation, followed by integrated validation procedures for physical system models***
  - ***Continuous validation for many social system models (Trust-but-verify , every day)***

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Ed Waltz

- How can funding agencies help?
  - ***Follow the guidance of the excellent study by the 2008 NRC Study " Behavioral Modeling and Simulation: From Individuals to Societies" (6 Thrusts below)***
    - ***Theory Development***
    - ***Uncertainty, Dynamic Adaptability, Rational Behavior***
    - ***Data Collection Methods***
    - ***Federated models***
    - ***Validation and Usefulness***
    - ***Tools and Infrastructure for Model Building***
  - ***Begin transition and field evaluation of limited proven prototypes; perform open evaluation of utility. (Find a way to measure utility of new analytic methodologies)***

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William Reynolds

- Why is model interoperability needed and what are the major challenges?
  - ***We use multiple models for efficiency reasons - we identify different segments of reality and different groups develop expertise in those segments and identify appropriate conceptualizations, approximations and laws.***
  - ***The decision on how problems should be segmented are often based on historical expertise or availability of data.***
  - ***This leads to problems, as each segment tends to regard the other as exogenous - which is not always the case, sometimes facts from one segment "bleed in" to another, potentially violating assumptions and understandings constructed in the isolated segment***

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William Reynolds

- What capabilities and infrastructure are needed to achieve model interoperability?
  - ***Understanding overlapping models, providing alternative descriptions of the same phenomena, either across levels of granularity or at the boundaries of federated models (eg a macroeconomic model vs. an agent-based model).***
  - ***Mechanisms to provide software contracts that could ensure that the model simulations are presenting consistent versions of reality could be valuable (see also question 5).***
- How can interoperable models be verified and validated?
  - ***Ultimately all validations are based on comparison (the scientific method being the premier example), so techniques like triangulation and model docking need to be formalized and further developed.***
  - ***This is often complicated by "apples to oranges" problems which make interpretation of comparison result difficult.***

William Reynolds

- How can funding agencies help?
  - ***Development of conceptual approaches that support "bridge" from one area to another and help support understanding of issues arising from isolating conceptual subsystems from larger integrated complex systems.***
  - ***Develop systematic techniques for determining the cost-benefits for selecting a level of modeling resolution given and application space and policy and data constraints.***
  - ***Develop formalized "back of the envelope" reasoning methodologies and tools to help address problems of segmentation, granularity and validation transparently, efficiently and at a strategic level, to aid investigators and PMs developing federated simulation programs.***

Luke Overbey

- Why is model interoperability needed?
  - ***Models are created by people with expertise in a segmented domain of the real world.***
  - ***We need to forecast the complex human terrain that often spans multiples of these segmented domains and take advantage of legacy models.***
- What are the major challenges in pursuing model interoperability?
  - ***Models need to interoperate in terms input/output flows***
  - ***Incompatibilities due to differences in data types, model resolution and time scales, and software data structures.***
  - ***Inconsistencies across vocabulary and ontologies used by the various disciplines needed for technosocial modeling.***
  - ***Multidisciplinary expertise that can help to interrelate models***

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Luke Overbey

- What capabilities and infrastructure are needed to achieve model interoperability?
  - ***Capabilities for bridging across interfaces to models and diverse modeling formalisms.***
  - ***Infrastructure for federating models within a common framework, and models that allow for integration into these federated structures.***
- How can interoperable models be verified and validated?
  - ***Model integration adds complexity to the model validation task***
  - ***Technosocial models need to be validated for the specific capacity in which they will be used, and must be continually re-validated following changes to the environment***
  - ***Error and uncertainty needs to be understood with regard to how it gets translated across the interfaces of models and between models and data.***

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Luke Overbey

- How can funding agencies help?
  - ***Development of software infrastructures to support integrated modeling frameworks.***
  - ***Development of a refined formalisms for verification and validation of technosocial models and the integration of technosocial models.***
  - ***User-centric research and development of integrated models and mixed initiative efforts that include model developers and users from different domains working together to create models***.