76th MORSS
10-11-12 JUNE 2008

MORS Military Operations Research Society

GOVERNMENT DISCLOSURE FORM 712B

MORS P#: (if known)

DEADLINE: 2 MAY 08
Fax to: 703-933-9066

PART I **Author Request** – The following author(s) request authority to disclose the following presentation at the next MORS Symposium with subsequent publication in the MORSS Final Report, for inclusion on the MORSS CD and/or posting on the MORS web site.

Principal Author: MIHAELA D. QUIRK

Other Author(s):

Principal Author's Organization: DEFENSE THREAT REDUCTION AGENCY

Complete mailing address: DR. MIHAELA QUIRK
DTRA-RD-NTE
DEFENSE THREAT REDUCTION AGENCY
8725 JOHN KINGMAN RD. STOP 6201
FORT BELVOIR VA 22060-6201

X Mihaela Quirk.

Principal Author's Signature: ↑ Date: April 25/08

Phone: 703-767-6388

FAX: 703-767-8603

Email: mihaela.quirk@dtra.mil

Title of Presentation: COMPUTATIONAL MODELS OF GROUP DYNAMICS

This presentation is believed to be: ☐ SECRET ☐ CONFIDENTIAL ☒ UNCLASSIFIED and will be presented in:

☐ Special Session ☐ Tutorial ☐ Demo ☐ CG: A–B–C–D–E–F (Circle one) ☐ List all WG(s) #:

PART II **Government Releasing Official Endorsement and DoD Directive 5230.24** – Required Applicable Distribution Statement

The Releasing Official, with the understanding that MORS Symposia are supervised by the OCNO N81, that all attendees have current security clearances of at least SECRET and that no foreign nationals will be present confirms that the overall classification of the presentation is:

☐ SECRET ☐ CONFIDENTIAL ☒ UNCLASSIFIED ☐ OTHER: _____ and authorizes disclosure at the meeting.

Classified by: Declassified by:

Downgrade to: On:

The applicable distribution statement below must be checked and stated to complete this form.

☒ **Distribution statement A:**
This presentation/paper is unclassified, approved for public release, distribution unlimited, and is exempt from U.S. export licensing and other export approvals under the International Traffic in Arms Regulations (22 CFR 120 et seq.)

☐ **Other distribution statement:** (List here or attach separate sheet)

Releasing Official's title: Dep. Chief of PA

Printed name: Cameron M. Hardy

Organization: DTRA-PA

Complete mailing address:

X Cameron Hardy

Releasing Official's Signature: ↑

Date: 5/9/08

Phone:

FAX:

DEFENSE THREAT REDUCTION AGENCY • UNITED STATES OF AMERICA •

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
01 JUN 2008	**N/A**	**-**

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
Computational Models of Group Dynamics for National and International Security Applications	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Defense Threat Reduction Agency Nuclear Technologies Directorate**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release, distribution unlimited

13. SUPPLEMENTARY NOTES
See also ADM202527. Military Operations Research Society Symposium (76th) Held in New London, Connecticut on June 10-12, 2008, The original document contains color images.

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**UU**	**19**	

Computational Models of Group Dynamics for National and International Security Applications

Mihaela D. Quirk, Ph.D.

Defense Threat Reduction Agency
Nuclear Technologies Directorate

The views expressed herein are those of the author and do not necessarily reflect the official policy or position of the Defense Threat Reduction Agency, the Department of Defense, or the United States Government.

Overview

Classes of problems

Algorithmic representation of social dynamics

Identify and evaluate “soft metrics”

Directions:

- Mathematical models of strategic interactions
- Models for soft metrics
- Formalism for scenario specification
- Validation and technological challenges
- Knowledge bases and model refinement

Concluding remarks

Introduction: classes of problems

Aim: a methodology to build a computational framework to capture individual and group behavior.

Dimensions and attributes:

CBRNE threats: veracity

Context: geopolitical, economic

Adversary: organization

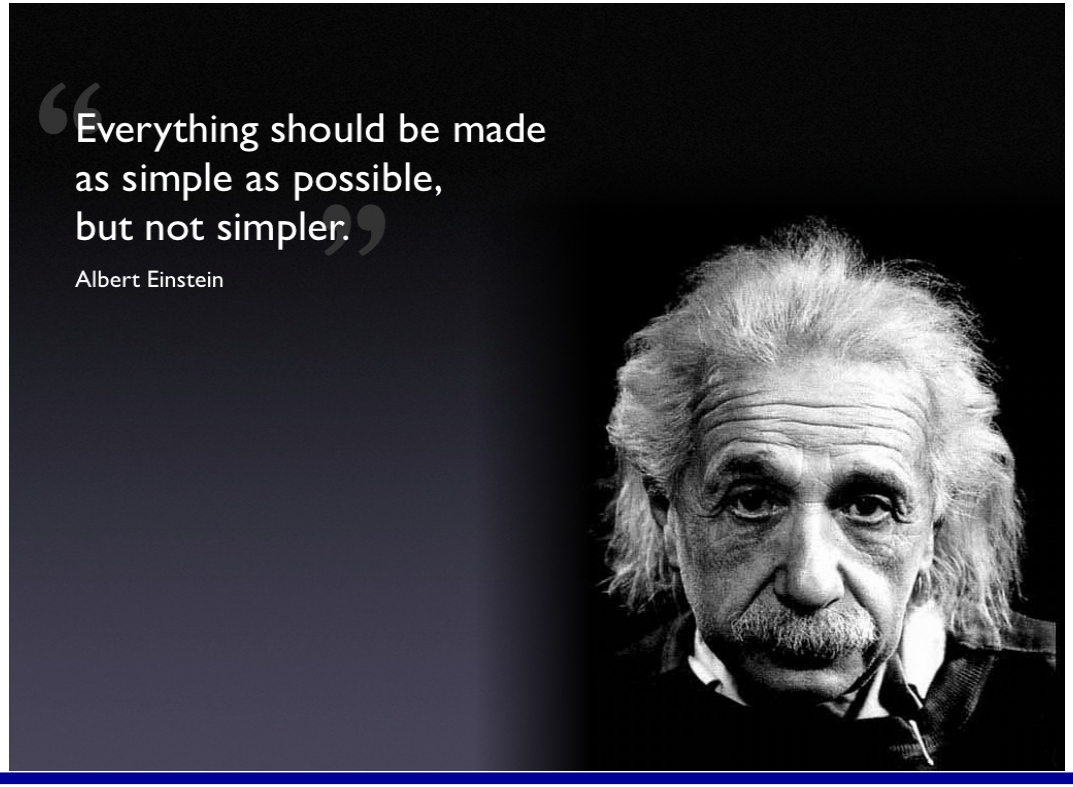
Organization: social, cultural, religious, economic

Strategic interactions/group dynamics

- Classical models:
  - Agent-based models
  - Game theory
- Social sciences, anthropology: models and computational approaches
- Policy
- Political analyses
- Goal: develop a suite of formally specified and implementable computational models of strategic interactions
- Emphasis on the formal certifiability and scalability

Mathematicians must justify their existence

"So far as the law of mathematics refer to reality they are not certain; and so far as they are certain, they don't refer to reality." Albert Einstein, 1951



Mathematical models of strategic interactions

- Priorities: the emergence of social hierarchies, the dynamics of opinions, and the emergence of leadership in social structures.
- The models will be developed in a quantitative theory of social dynamics.
- Theoretical analysis relies on techniques such as scaling, asymptotic analysis, boundary layer analysis, and extreme value statistics.
- Improved frequent patterns algorithm used to detect abnormal behaviors
- Large complex networks (CN) which have computationally intractable properties of interest

Mathematical models of strategic interactions

- Graph representation of the topology of agents' states and an update schedule capturing causal dependencies among agents.
- Measures and techniques for dynamic graph algorithms

- AGENT-BASED MODELS
- GAME THEORY
- STATISTICS
- POSSIBLITY/EVIDENCE/BELIEF/PLAUSIBILITY

Mathematical models of soft metrics

- Motivation and intent
- In a game-theoretical context: reflection of disparities among utilities
- Economic studies of long term effects
- Setting: multi-valued logic, possibility and probability measures

Implementation and validation

- Social sciences, anthropology,
- Situation theory, the theory of moves,
- In-group/out-group theory, decision theory, game theory, etc.
- Example: honor-based societies.
- Implement a prototype of formal specifications for scenarios and courses of actions
- “Universal scenario generator” that captures the most salient features of a multi-agent simulation.

Implementation and validation

- Focus on efficient representation and management of contexts
- Build a knowledge base and enhance existing models of group behavior, terrorism, infrastructures,
- Design predictive methodologies – yes, it is possible!

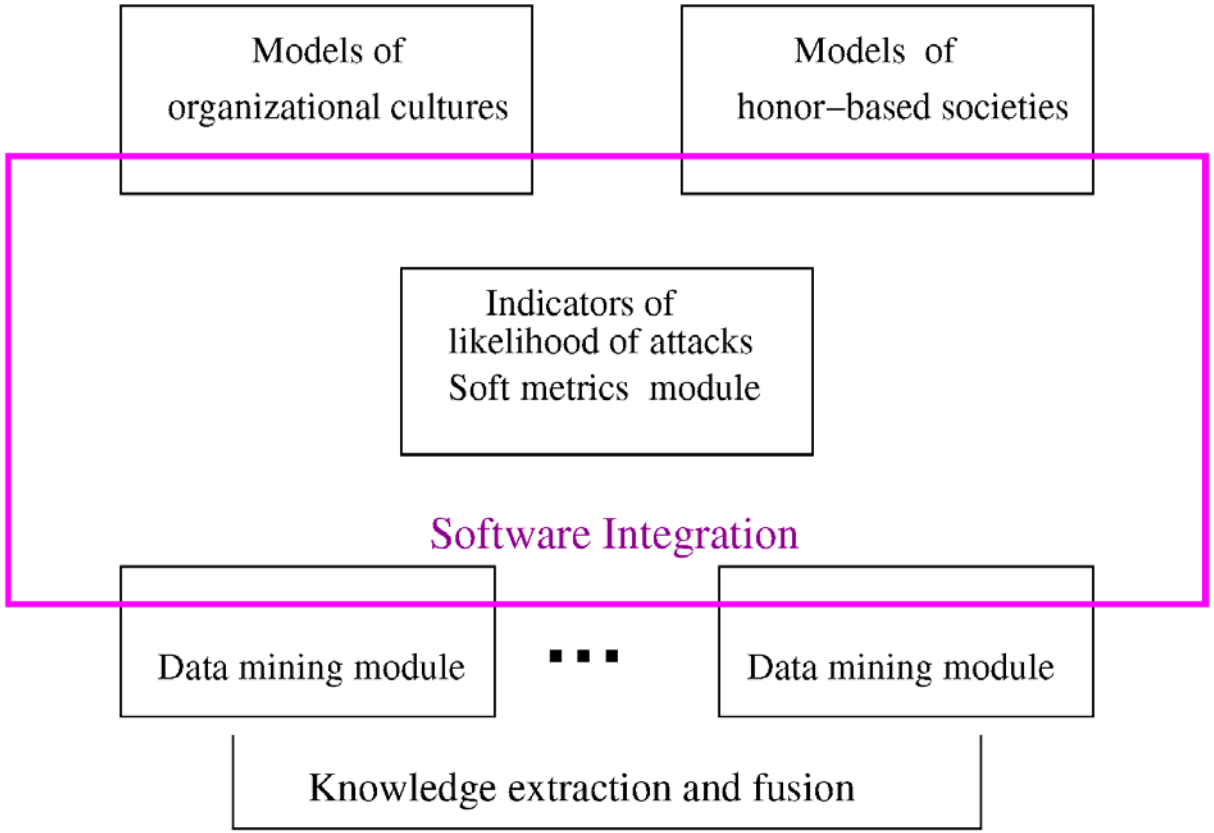
Validation and technological challenges

- Validation permeates the work
- Soft metrics devised for both defenders and adversaries.
- Select a *relevant* set of soft metrics
- Classes of decision agents: SME, decision makers, people.
- Technological challenges: heterogeneous database management systems, so as to resolve both syntactic and semantic conflicts.
- Research performance and functionality improvements to ensure scalability of large agent-based simulations of CN

Formalism for scenario specification

- A test for the success of the method: the extent to which it can represent theoretical frameworks such as: game theory, theory of moves to model international relations, models of bounded rationality (for computational efficiency), and models of collective action.
- A formalism for specification and representation of scenarios of use for multi-agent simulations with natural language semantics (situation theory) and
- Formal verification

High level overview



Agent-based models

Simon's Bounded Rationality:

Agent-based models, following Simon (1982), also assume Bounded Rationality. " Indeed, in the absence of Turing machine (universal calculator), it is difficult not to."

Epstein (2006) reflects:

"One wonders how the core concerns and history of economics would have developed if, instead of being inspired by continuum physics ... blissfully unconcerned as it is with effective computability — it had been founded on Turing. Finitistic issues of computability, learnability, attainment of equilibrium (rather than mere existence), problem complexity, and undecidability, would then have been central from the start. Their foundational importance is only now being recognized."

Agent-based models

Epstein notes on the virtues of boundedly rational agents ...

“As Duncan Foley summarizes:

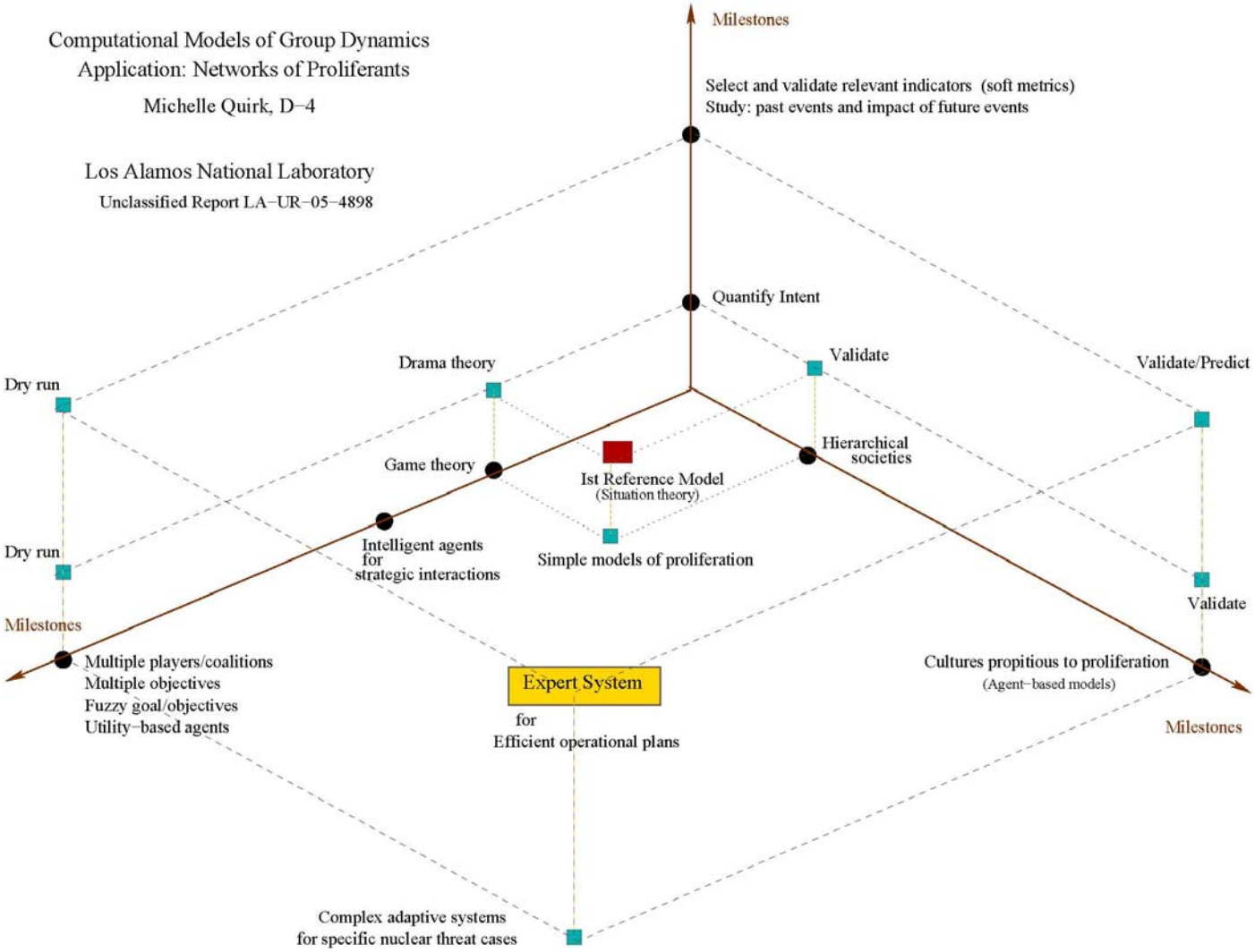
`The theory of computability and computational complexity suggest that there are two inherent limitations to the rational choice paradigm.

- One limitation stems from the possibility that the agent’s problem is in fact undecidable, so that no computational procedure exists which for all inputs will give her the needed answer in finite time.
- A second limitation is posed by computational complexity in that even if her problem is decidable, the computational cost of solving it may in many situations be so large as to overwhelm any possible gains from the optimal choice of action’ (Albin 1998)”

Game theory, Bayesian statistics

- Game theory: an analysis tool, not always a prediction tool
- Probabilities: too restrictive, hence misused
- Learning-based models: promising yet there is no training data

An integrated framework



Concluding remarks

- The problem dictates the method!
- Failures are unthinkable.