SECURE: Stochastic Enhanced Control of Unstable Regional Environments

Georgiy Levchuk, PhD (Aptima)
Bruce Skarin (Aptima)
Daniel Serfaty (Aptima)
Krishna Pattipati, PhD (UCONN)

Presented at 2008 CCRTS

APTIMA®
HUMAN-CENTERED ENGINEERING
www.aptima.com
Woburn, MA ▪ Washington, DC

© 2008, Aptima, Inc.

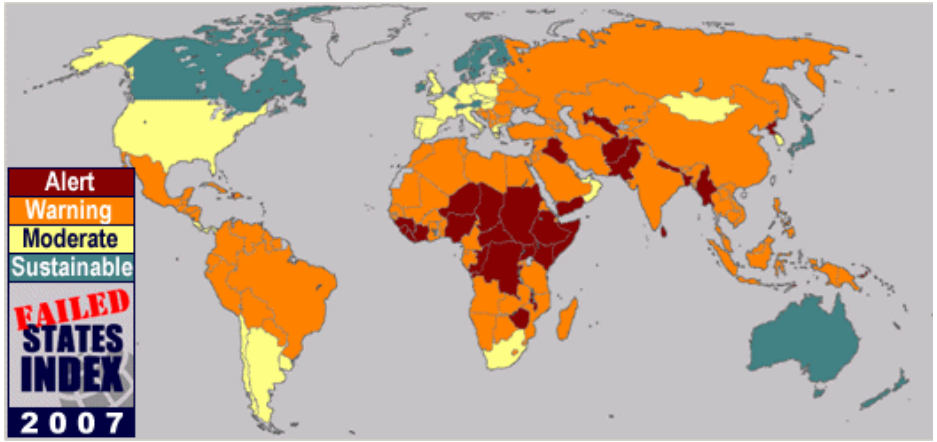
Overview

- The problem & needs
- Solution concept
- Model descriptions
- Future validation plans

© 2008, Aptima, Inc.

The Problem

- International crises pose challenges to U.S. national security
  - Failed states fuel regional conflicts, harbor terrorists hostile to the U.S. or are unable to protect themselves against the spread of terrorism
  - Regional conflicts cause humanitarian disasters requiring ever-increasing resources from the international community & create political, economic, and social instability in the neighboring countries
- Actions reactive to conflicts are too costly and barely effective
  - Need to **anticipate** and **prevent** disasters



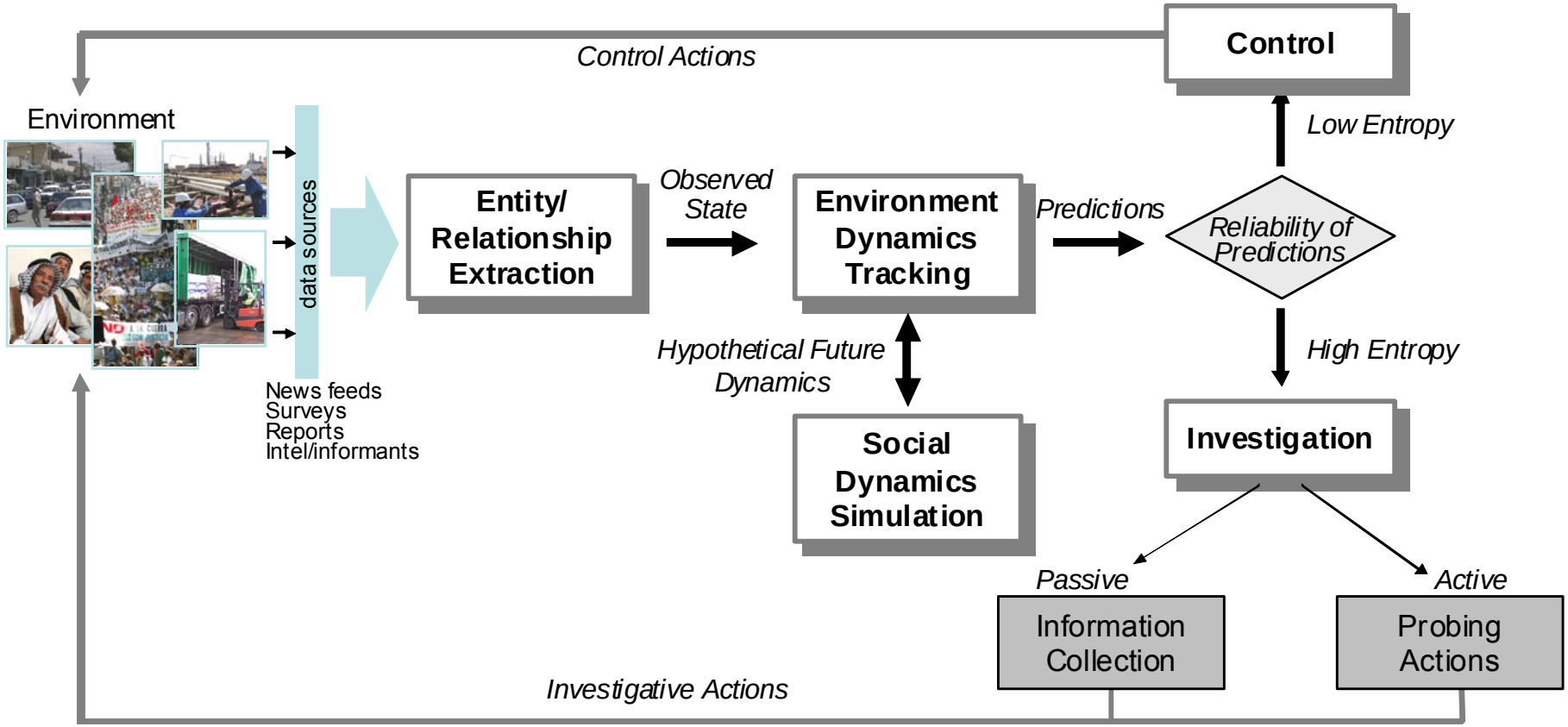
© 2008, Aptima, Inc.

The Needs

- Prediction of True Environment Dynamics
  - Large uncertainty in available data
  - Cannot act based on current observations alone
  - Need to understand the trends
  - Need to understand “who is doing/will do what to whom” to act effectively
- Control in the Presence of Uncertainty
  - Must act when multiple dynamics are likely
  - Preventive actions: change the environment towards a desired state while being robust to the uncertainty in current forecasts
  - Investigative actions: improve our knowledge of the environment
    - to enable better control of the environment in the future
    - passive information collection & active probing actions

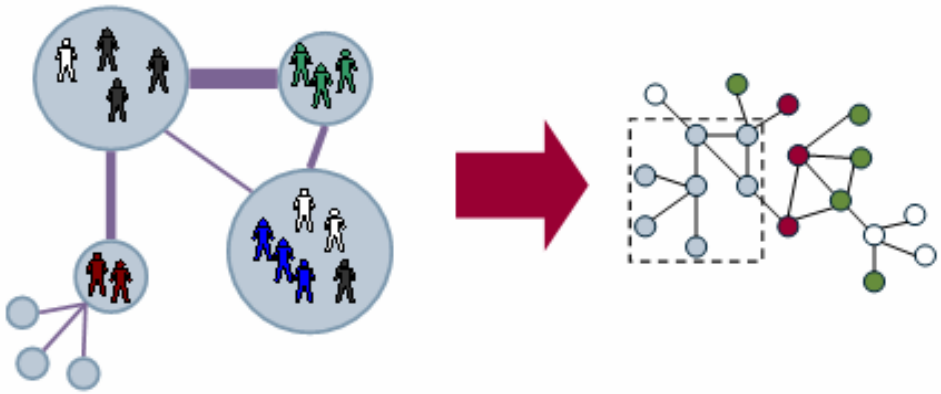
© 2008, Aptima, Inc.

Solution Workflow



© 2008, Aptima, Inc.

Notion of the "State": Indicator of Instability as *Power Balance Network*



- Indicator of regional/state instability = *power balance network* (PBN) in the area of interest

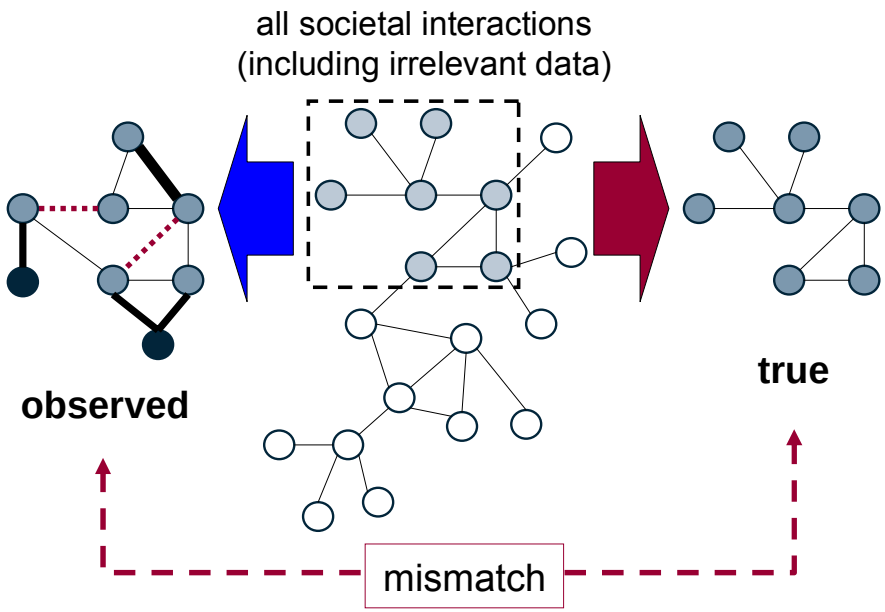
- Network is a labeled graph with nodes and links and labeled with multiple attributes

- PBN indicator is based on the *interaction network* that defines the state and relationships among groups, organizations, institutions, and individual members of society

- Nodes: groups, organizations, government, states, and individuals
- Node attributes: size/membership of the groups, beliefs of people, economic power of organizations, social identities of individuals and groups, and other economic and social features
- Links: *who does what to whom* in the area of interest – social interactions and influences, economic transactions, behavioral interactions, political events and activities, etc.,
- Link attributes: the frequency and types of interactions among the nodes

© 2008, Aptima, Inc.

The Data Problem



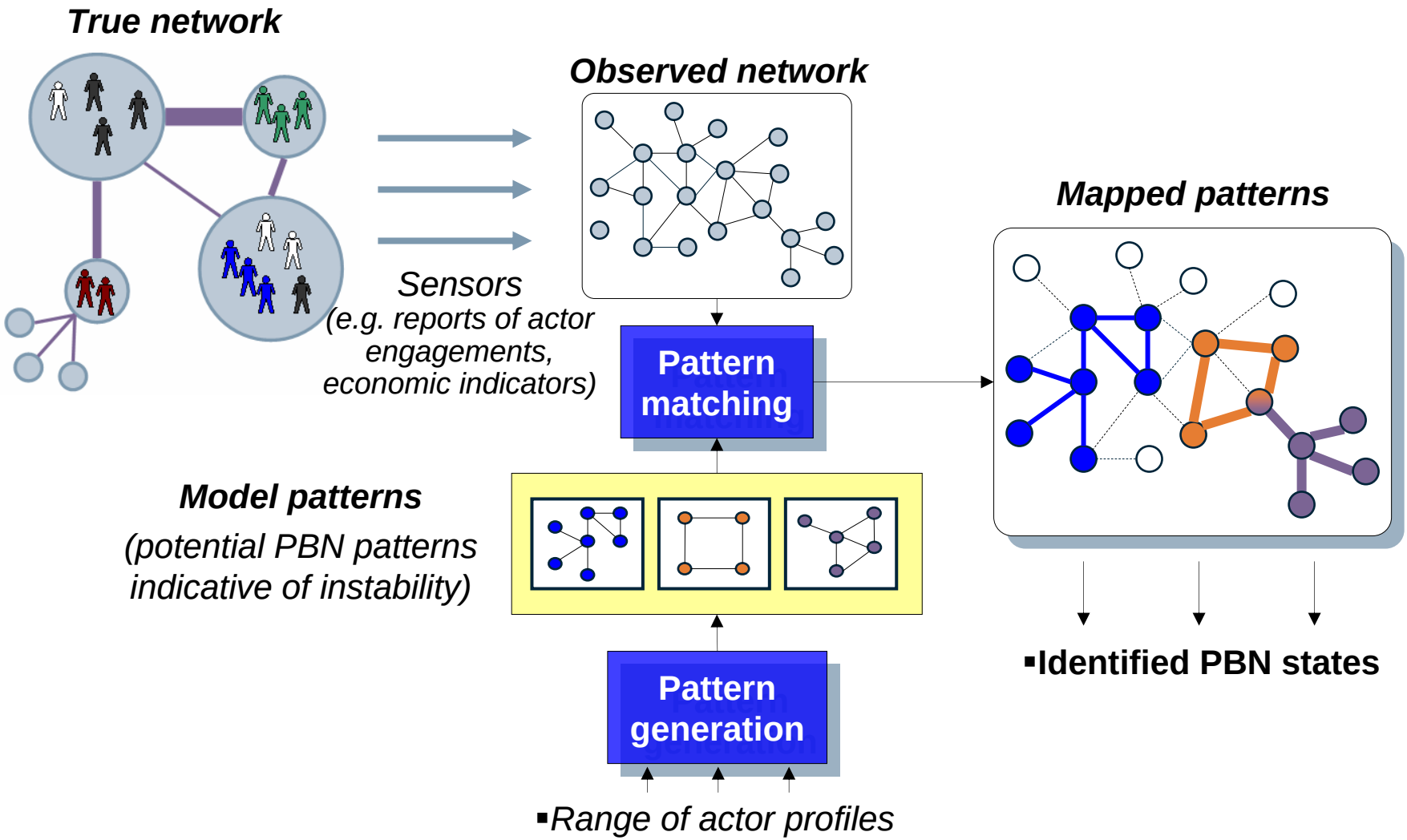
Errors in Data:

- Large numbers of actors/interactions/attributes that are irrelevant
- Large numbers of actors/interactions/attributes that are missing
- Large numbers of actors/interactions/attributes that are uncertain
- Large numbers of actors/interactions/attributes that are deceptive/erroneous

- True state of the power balance is not known
- We obtain observed state of PBN, which does not have a perfect match with the true state of PBN due to the data gaps and classification issues.
- Need to recognize the true state of the PBN and find the mapping between the observed and true PBN nodes that produces the best match

© 2008, Aptima, Inc.

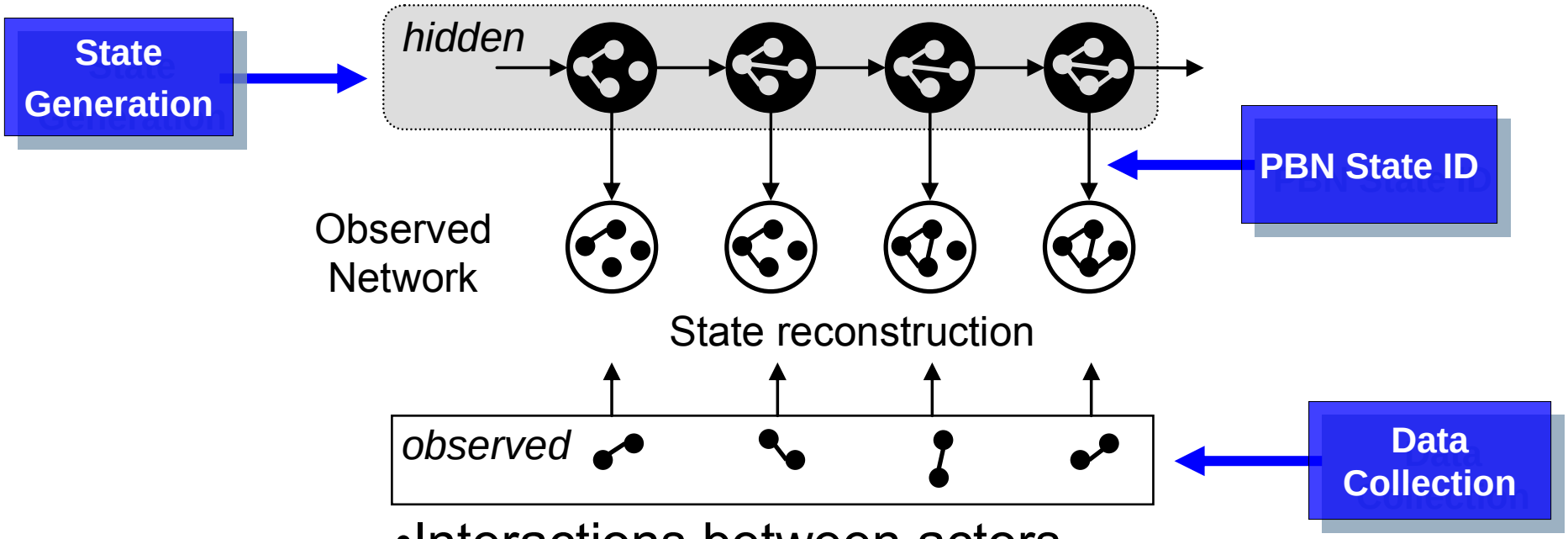
PBN State Identification



PBN State Tracking

Network State Dynamic

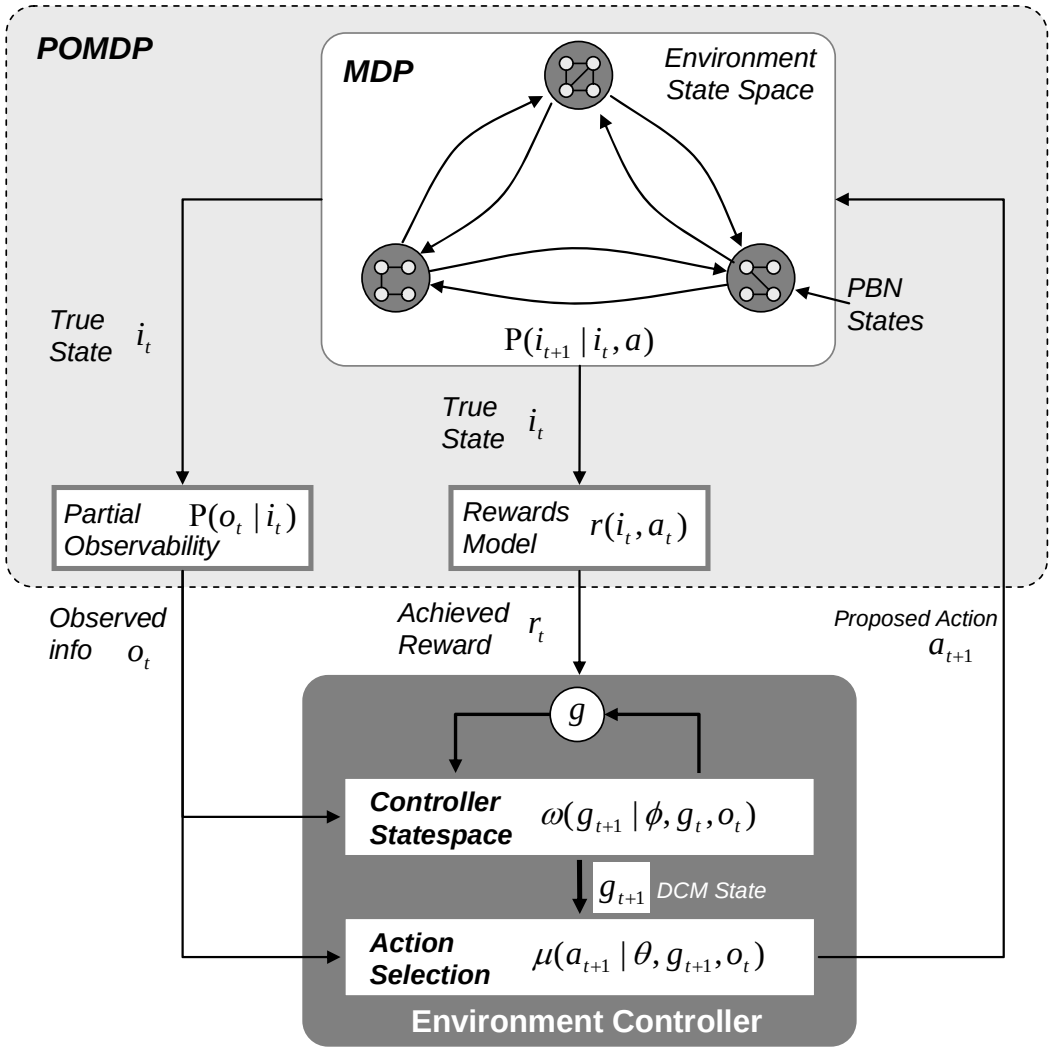
True Network State Evolution



- Interactions between actors
- Actions and attributes of actors

© 2008, Aptima, Inc.

PBN Control Model



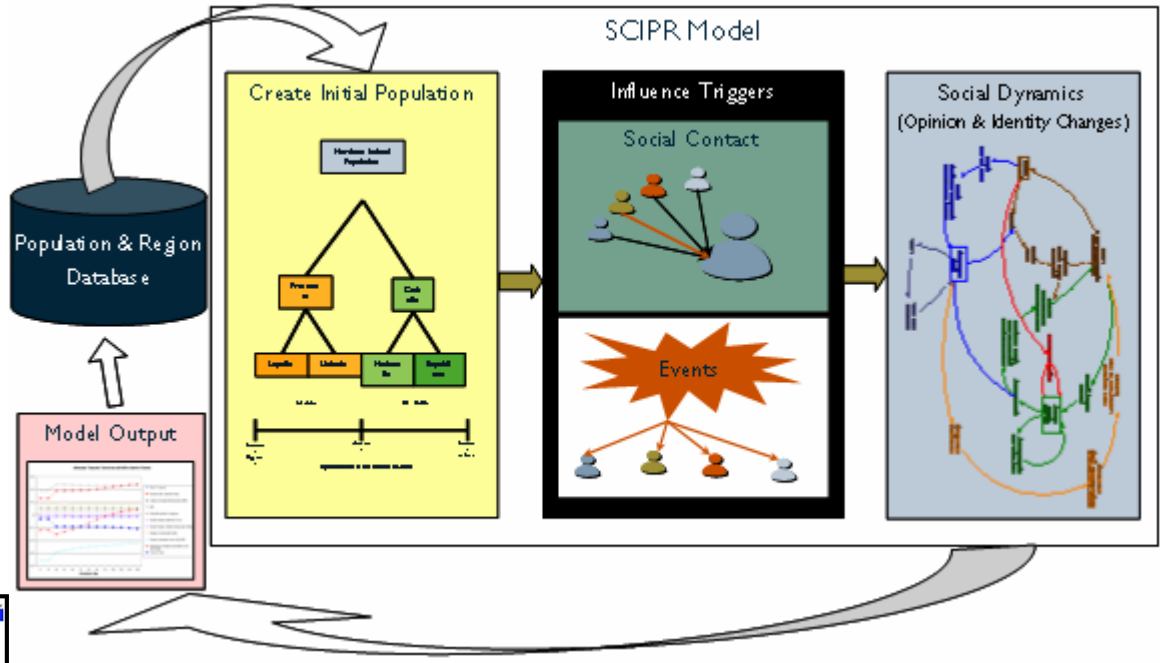
- Partially observable states of PBN
- Rewards based on specific (un)desired states
- Costs of actions

- Represent control in the presence of prediction and effect uncertainty
- Use stochastic control methodology
  - Learn from historic data and adapt over time
  - Reduce complexity

© 2008, Aptima, Inc.

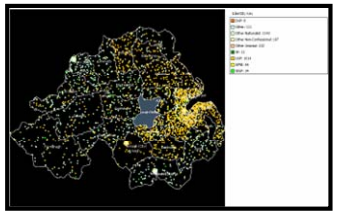
Potential Network Dynamics Generation based on Models of Social Interactions

- **Network interaction** is modeled as agent-to-agent and event-agent influences
  - Profiles of actors include identities and opinions
  - Identity = membership, role
  - Opinion = attitudes, knowledge, beliefs, etc.

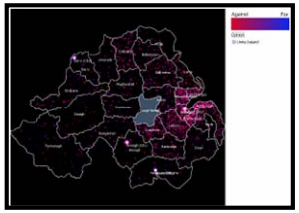


Initial Relationships

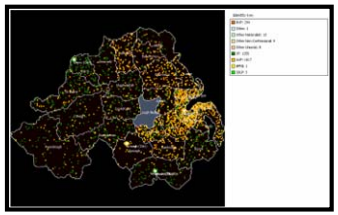
Identities/Affiliations

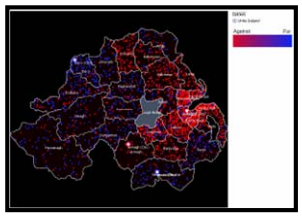


Opinions/Attitudes



Emergent Relationships



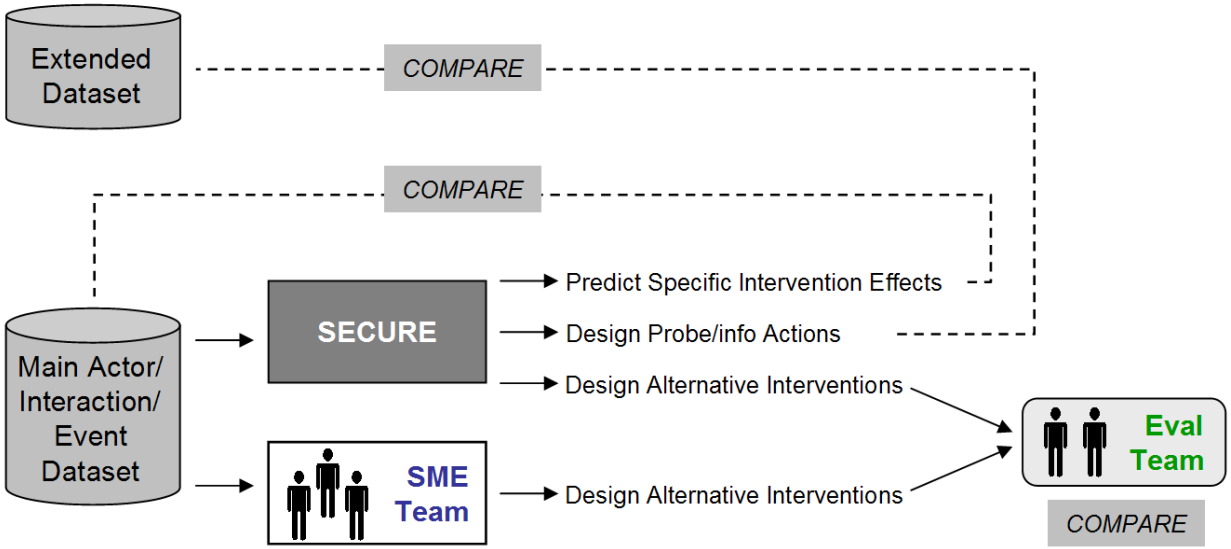


Objectives:
predict reactions & emergent relationships

Interactions occur, the responses to information exchanges and events comes from
- Social identity theory
- Theories of social influence

© 2008, Aptima, Inc.

SECURE Validation Process



- **Learning/Causality:** *Discover Power Balance Patterns Indicating Conflict Tendencies*. SECURE finds which power balance/interaction networks correspond to what incidents using historic data, and infers the causes of the conflicts by looking at the socio-economic power imbalance among specific groups in PBN.
- **Inference:** *Discover the power balance that most explains observed data*. Given uncertain observations, the SECURE finds the true state of the power balance /interaction patterns.
- **Forecasting:** *Track balance dynamics and predict its evolution*. SECURE forecasts the most likely evolution of the power balance dynamics over time.
- **Prevention:** *Act to influence and prevent conflicts*. SECURE finds the cost-effective action strategies to prevent the conflicts and state failures by (i) driving the power balance to desired state; (ii) preventing undesired power balance states; and (iii) collecting the data for increased awareness.

© 2008, Aptima, Inc.

APTIMA®

HUMAN-CENTERED
ENGINEERING