Modeling & Simulation of Agents in Resource Strategy Games

Barry G. Silverman, PhD
Tony Smith Phd
E;ectrical & Systems Engineering Dept.
Inst. For Research in Cognitive Science (IRCS)
Center for Human Modeling & Simulation
University of Pennsylvania, Philadelphia, PA 19104-6315 (215-573-8368)
barryg@seas.upenn.edu
www.seas.upenn,edu/~barryg

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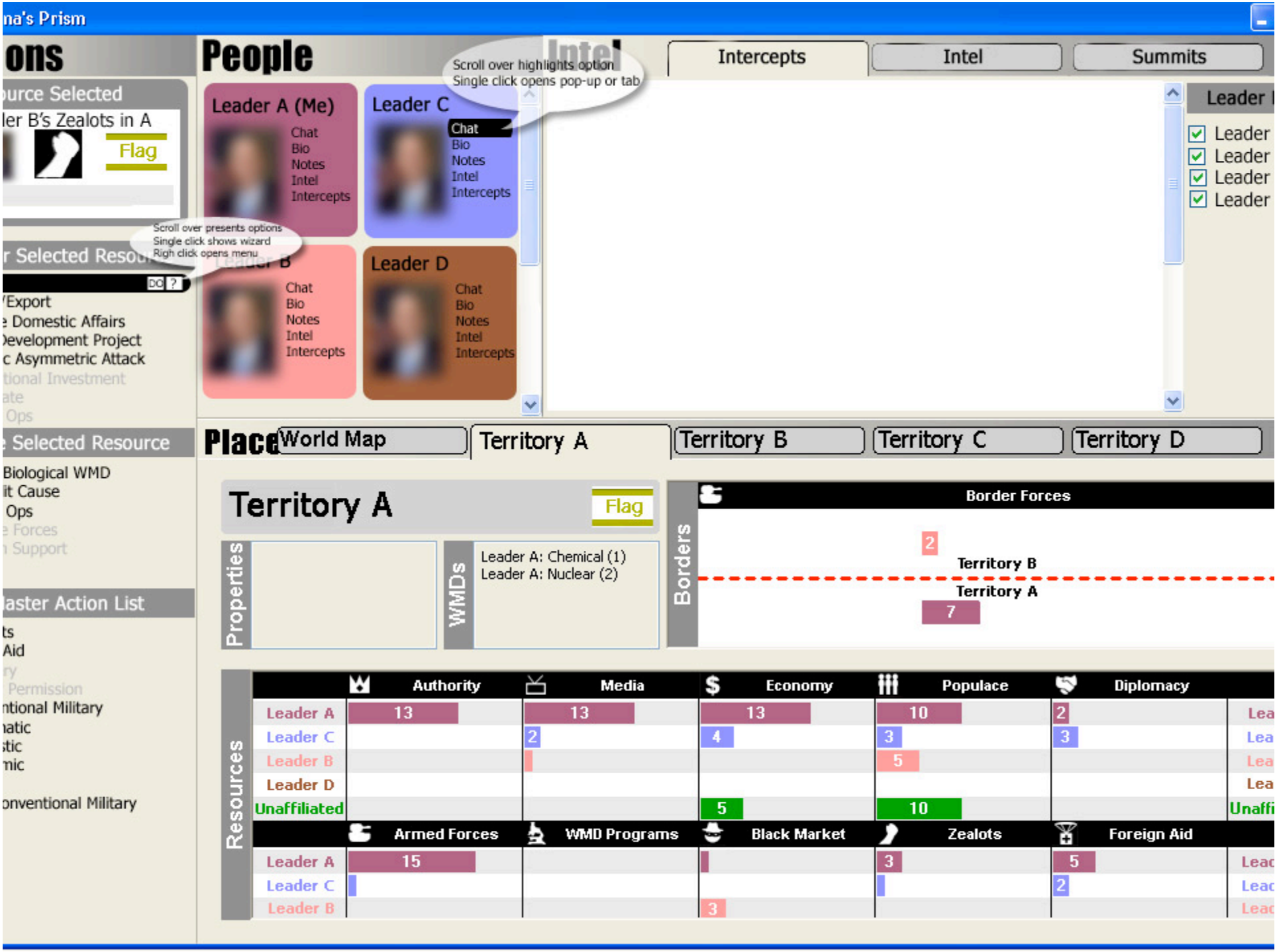
Challenge I: Design a Human Playable Game for Influencing World Leaders & Situations

- Help to Generate Influence Ideas
  - Foster outside box, transformational thinking (ACH)
- Promote Situational Understanding
  - Reduce ‘Mirroring’ Bias
- Trace out Transforming/Influencing Possibilities

Result: LeaderSim Game (Athena’s Prism)

LeaderSim as TableTop Game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Flag
Scroll over highlights option
Single click opens pop-up or tab
Leader A (Me)
Chat
Bio
Notes
Intel
Intercepts
Leader C
Chat
Bio
Notes
Intel
Intercepts
Leader B
Chat
Bio
Notes
Intel
Intercepts
Leader D
Chat
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Intel
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Scroll over presents options
Single click shows wizard
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Place
World Map
Territory A
Territory B
Territory C
Territory D
Territory A
Flag
Properties
WMDs
Leader A: Chemical (1)
Leader A: Nuclear (2)
Borders
Border Forces
2
Territory B
Territory A
7
Resources
Authority
Media
Economy
Populace
Diplomacy
Leader A
13
13
13
10
2
Leader C
2
4
3
3
Leader B
5
Leader D
Unaffiliated
5
10
Armed Forces
WMD Programs
Black Market
Zealots
Foreign Aid
Leader A
15
3
5
Leader C
2
Leader B
3

Best Method of Forecasting Conflict

Table 1 - Accuracy of forecasts doubles with Role Playing*
Percent correct forecasts (number of forecasts)

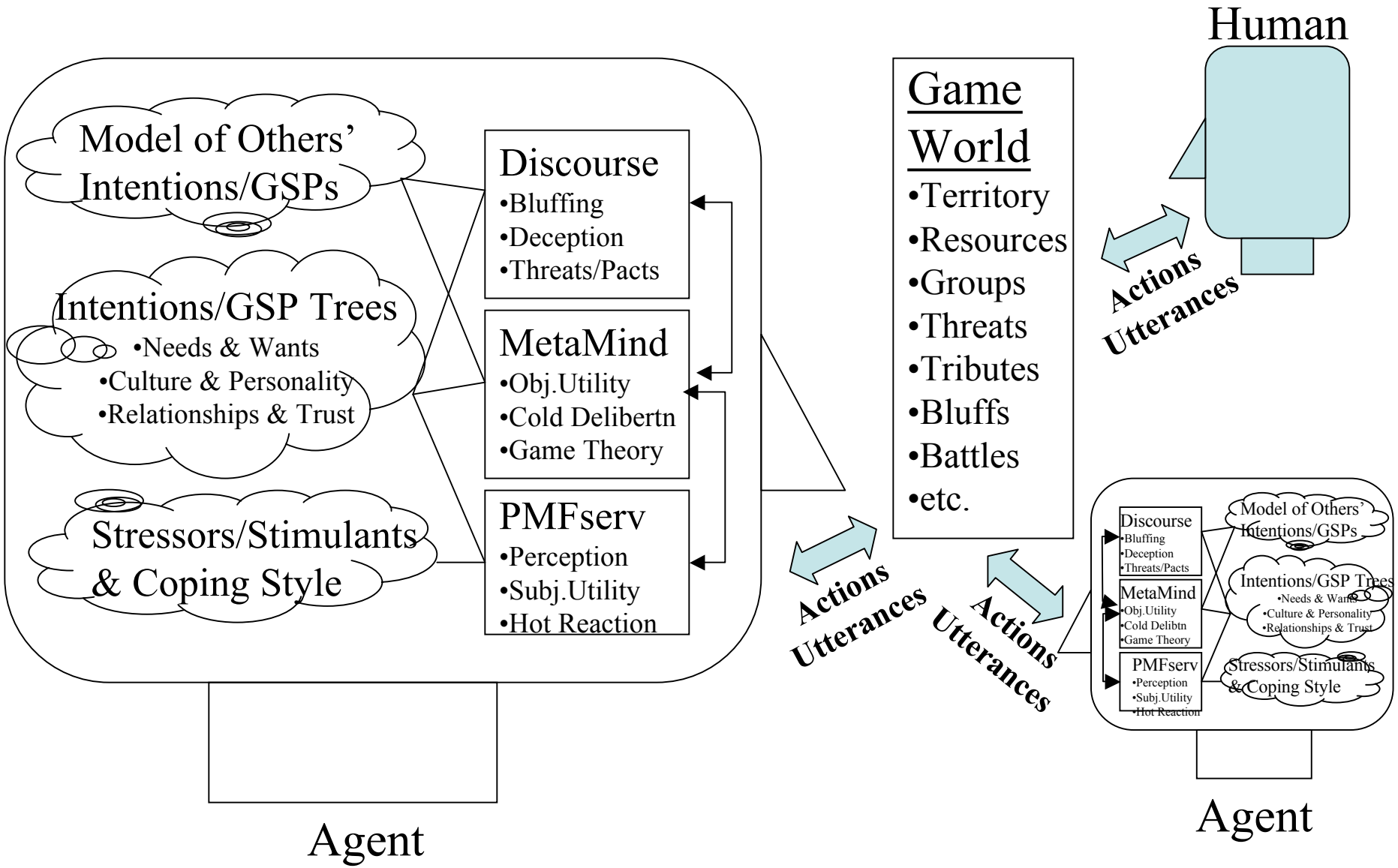
Conflict Case:	**Pure Chance**	**Unaided judgement by novices**		**Game theory experts**		**Simulated interaction with novices**	
Artists Protest	17	5	(60)	6	(17)	**29**	(14)
Distribution Channel	33	15	(68)	23	(13)	**75**	(12)
55% Pay Plan	25	15	(39)	29	(17)	**60**	(10)
Telco Takeover	25	29	(34)	0	(7)	**40**	(10)
Personal Grievance	25	35	(31)	43	(7)	**60**	(10)
Zenith Investment	33	36	(44)	22	(18)	**59**	(17)
Water Dispute	33	51	(35)	75	(8)	**90**	(10)
Nurses Dispute	33	65	(46)	50	(14)	**82**	(22)
Averages (unweighted)	28	**32**	(357)	**31**	(101)	**62**	(105)

*data from Green (2002) and Green & Armstrong (2004), Jnl of Forecasting.

Challenge II: Add PMFserv Agent Opponents to LeaderSim Game

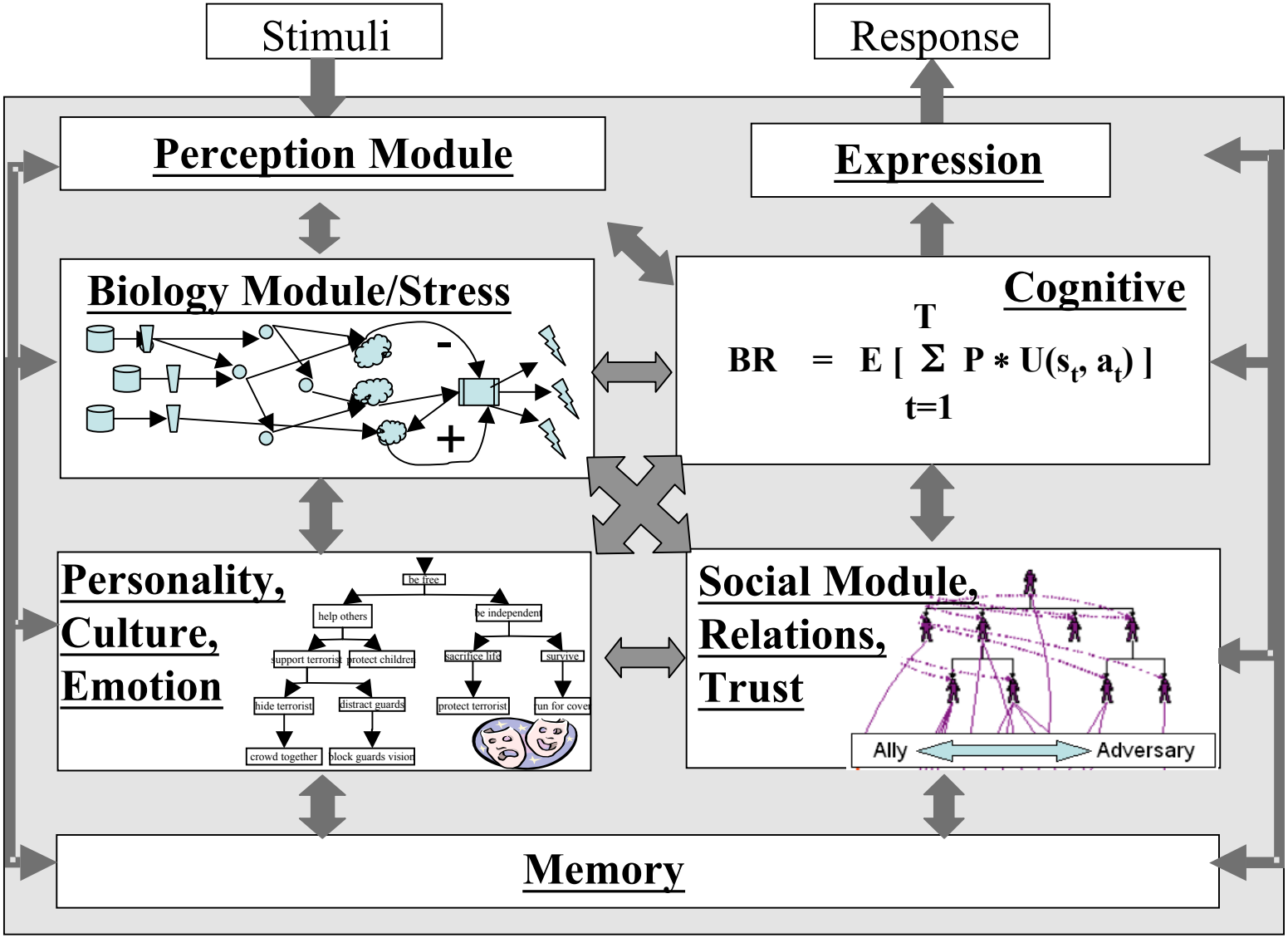
1. Develop a Resource-based Game (~ 12 resources, in ea of 8 lands)
2. Factional Leaders Control Resources by Territory
3. Add Actions Leaders Take (~ 70 actions, 5 speech act types, spying)
4. Observe Human Players, Action Strategies, Speech Acts
5. Develop Agents to Mimic Humans/Real Leaders
    1. Simple game theory
    2. Emotion- and stress-based games (GSP trees: culture/personality)
    3. Static intention models of the other agents (mirror of GSP trees)
    4. Dynamic modeling of others (MOO) – informal proof
    5. Castelfranchi's socio-cognitive model of trust

Agents in Role Playing Game Simulations



PMFserv's Unified Architecture for Cognition

(Breaking Stovepipes Between Sub-Fields)



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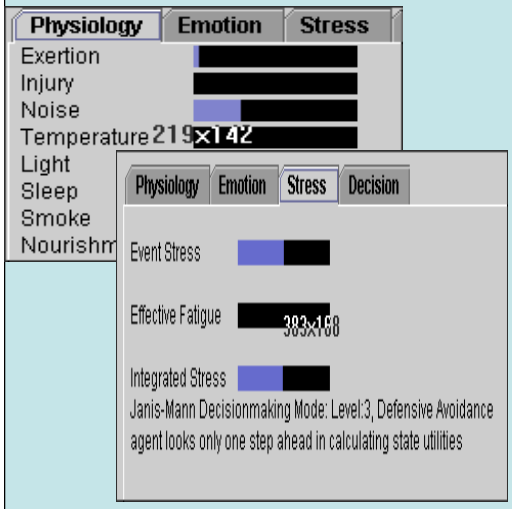
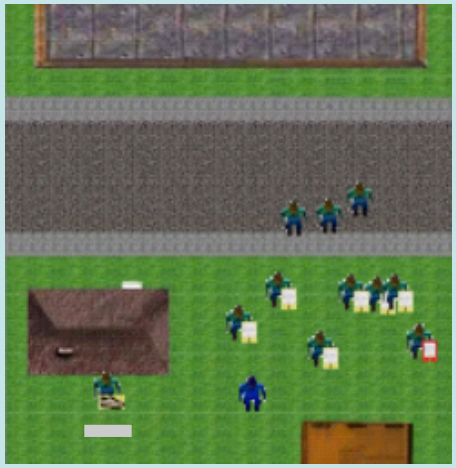
Many Parameters (θ_i) in PMFserv

- Physiology/Biology
  - Nourishment
  - Muscle Energy
  - Injury Levels
  - Sleep Need
  - Adrenaline
  - Others (open to user)
- Stress/Coping Style
  - Time Pressure
  - Event Stress
  - Effective Fatigue
  - Decision Style (5 levels)
    - Adherence
    - Vigilance
    - Panic
- Emotions (11 pairs)
  - Joy/Despair, Fear/Hope, etc.
- GSP Value Trees (10E2 nodes)
  - Long Term Preferences (by Resource and Territory)
  - Standards (Norms, Doctrine)
  - Short Term Goals (Maslow-type)
- Relationship Parameters
  - Alignment Level (Ally-Foe, 5 levels)
  - Group Affiliation (6-10 groups)
  - Valence/CognUnit/Agent-Object
  - Trust (by Resource and Territory)
- Decision Parameters
  - Utility and Cost (continuous)
  - Action Choices (10s to 100s)
  - Discount Factors (risk-prone/averse)
  - World State
- Perception & Modeling of Others
  - N*(GSPs+Relations+Actions)

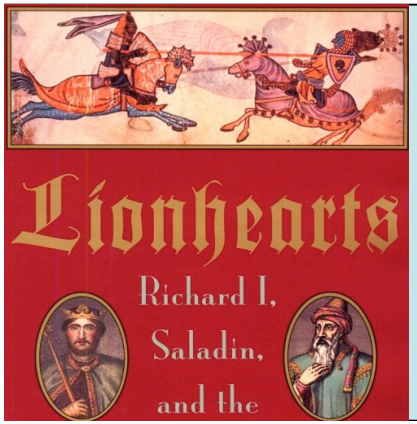
Gallery of Some Past PMFserv Agent Studies





Crowd Behavior Emergence : (Bio-Affect-Values-Panic-Riots)

- **WTO Talks in Seattle -- Protesting/rioting crowds at roadblock: Males (employed/unempl.), females, instigators**
- **Rioting/looting crowds at police station (impact of chanting upon crowd behavior)**
- **Soccer Hooligans (Manchester United Supporters)**
- **Scale up to 2000 agents in Sony OpenSteer**



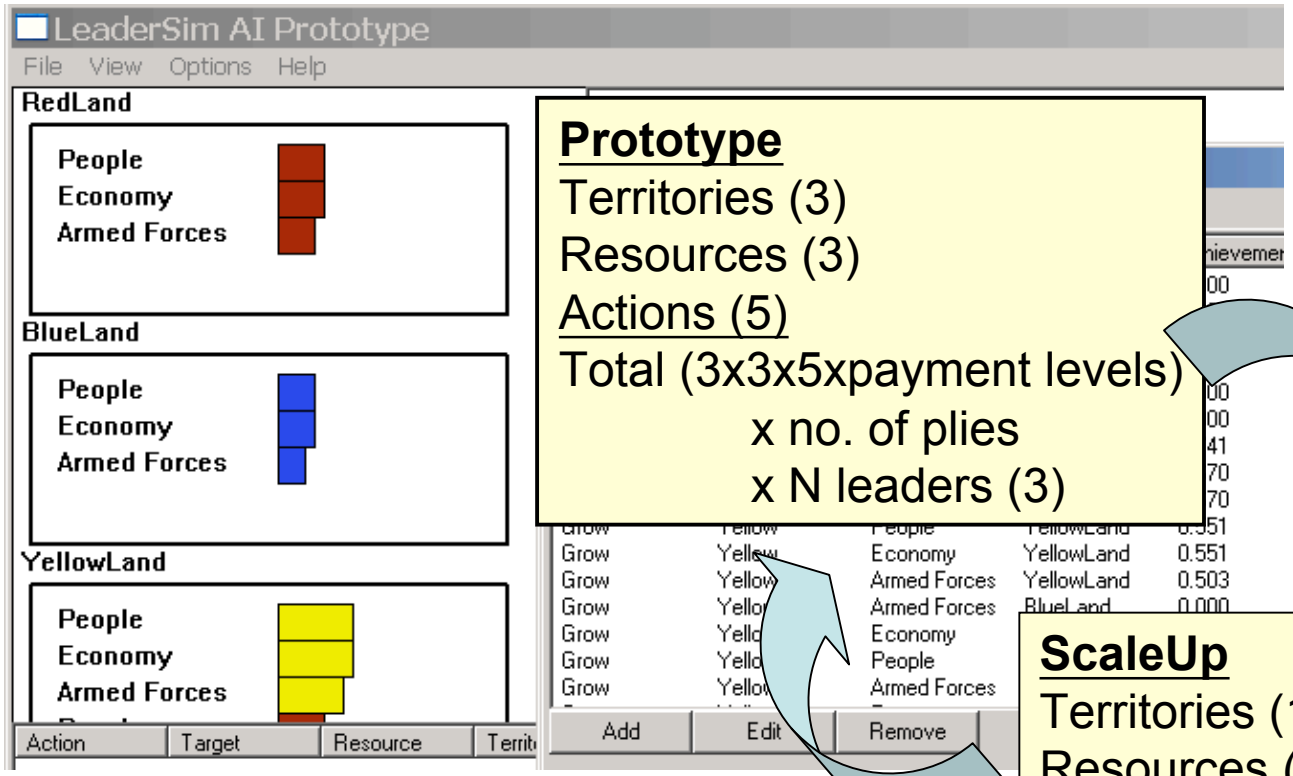
Political Agents for RPGs

- **Nested intention models, speech acts, relationship/reputation management**
- **World leaders in diplomatic strategy role playing game**
- **Third Crusade Leaders (Saladin, Emir, Richard, Philip, etc.)**

Asymmetric Plots (Culture/Emotions)

- **Ambush from terrorists on school bus**
- **Recreate Black Hawk Down: Four types of Somalians**
  - **Women/Kids, Civilian Males, Militia, Clan Leaders**
- **Intifadah dynamics – cell leader, suicide-bomber, Mayor, populace reactions**
- **SE Asia – Prime Minister, Populace, Insurgents**

Scope of LeaderSim



Prototype
Territories (3)
Resources (3)
Actions (5)
Total (3x3x5xpayment levels)
x no. of plies
x N leaders (3)

ScaleUp
Territories (10)
Resources (10)
Actions (70)
Total (10x10x70xpayment levels)
x no. of plies
x N leaders (10)

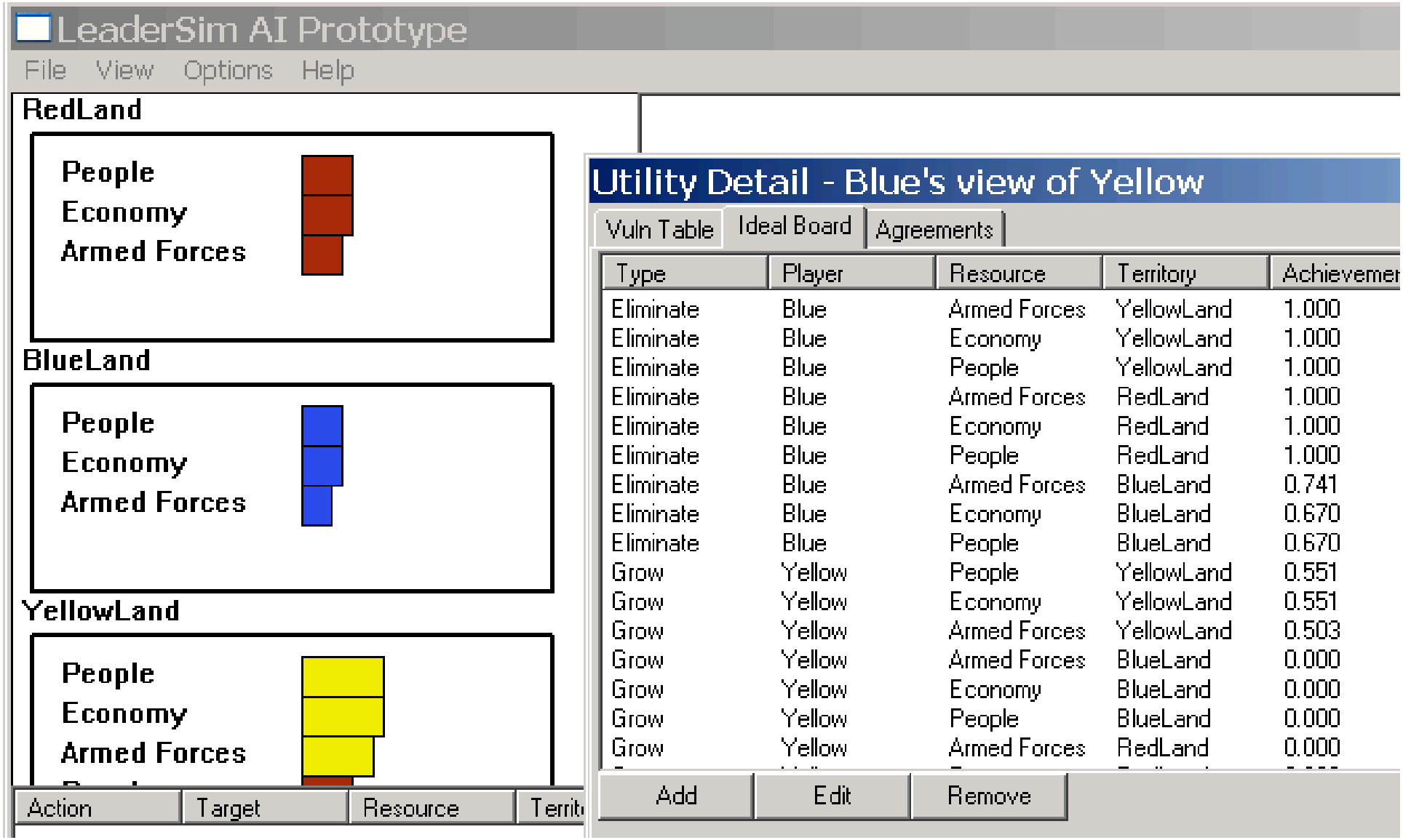
References www.seas.upenn.edu/~barryg/HBMR.html

•.Silverman, BG, Rees, R., Toth, J, et al., (2005, Jan).“Athena’s Prism – A Diplomatic Strategy Role Playing Game for Generating Ideas and Exploring Alternatives”, 1st Internat’l Conf on Intel Anal

•Silverman, B.G., Johns, M., Bharathy, G. (2004, August). “Agent-Based Simulation of Leaders.” ACASA/UPenn, Tech Report.

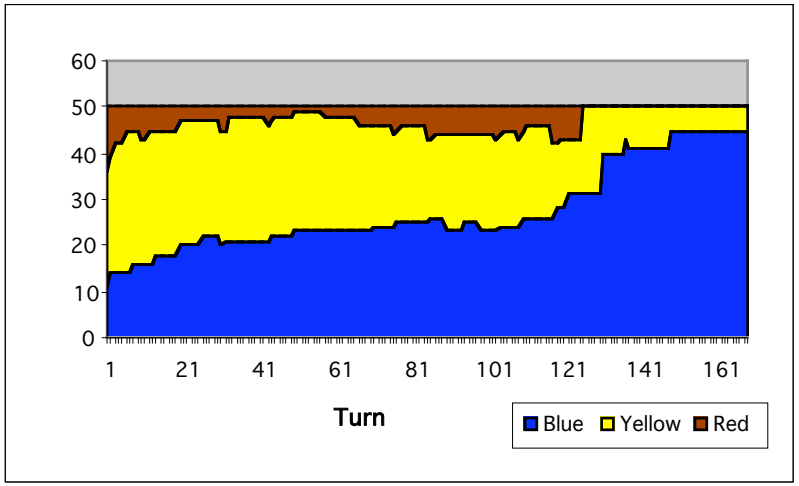
•Silverman, B.G., Johns, M., et al. (2002, May). “Constructing Virtual Asymmetric Opponents from Data and Models in the Literature." 11th BRIMS, SISO.

Agents Form Beliefs about the GSP Trees of other Agents (Static Model: 'Mirroring and Stereotyping)

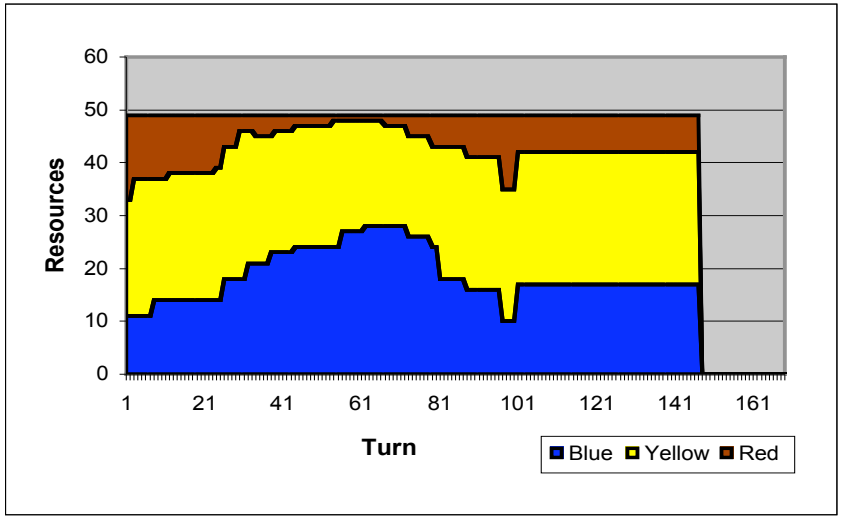


Prototype LeaderSim Results

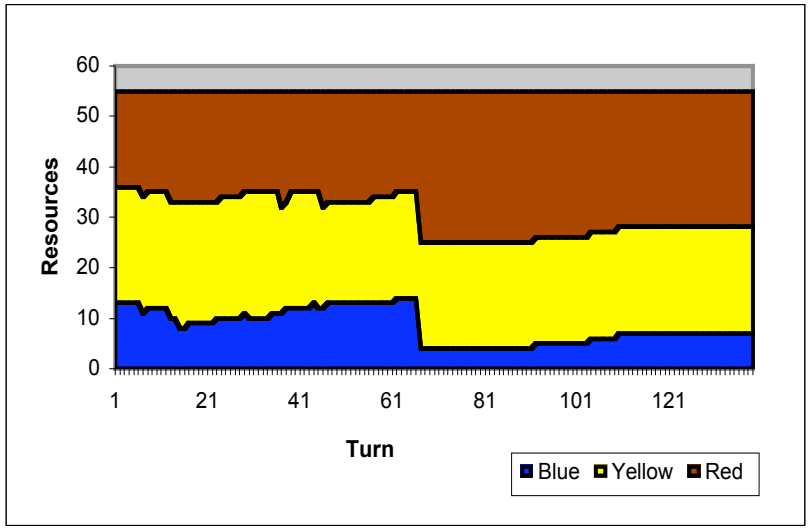
Nash Equilib: 2 winners in conflictual world



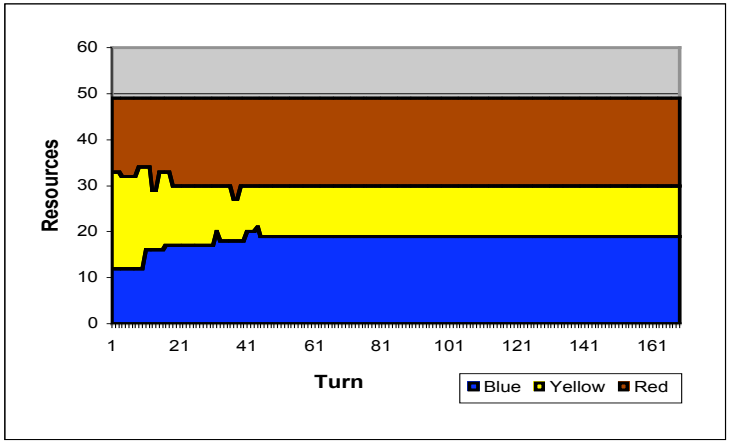
Using threats, Yellow turns Red and Blue against one another



Rare 3 in endgame. Yellow specialized away from Red and Blue.



Y's power is curtailed early. Y then uses treaties to negotiate peace.



Challenge III: Sensitivity Analysis & Wizard for Design of Simulation Experiments

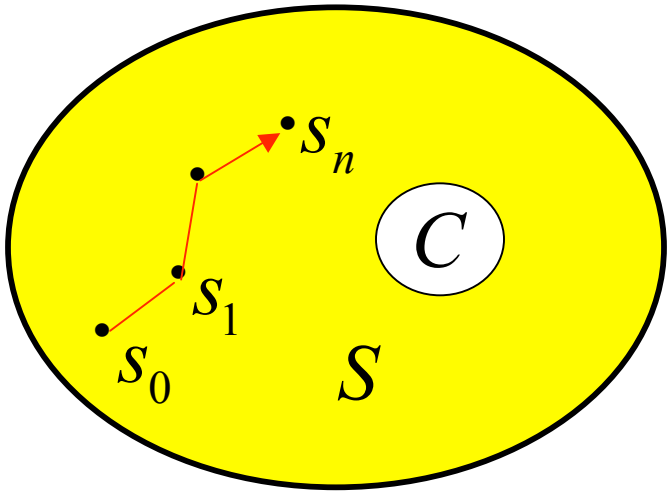
- Find principled way to explore the simulation space
  - Identify possibilities for conflict, non-conflict
- Understand how model parameters (θ_i) influence outcomes
  - Ho: P(Conflict | θ_i) > Threshold OR < Limit
  - Parameter elasticities (e.g., regression estimators)
- Create wizard for Policy Analysts

SENSITIVITY ANALYSIS

S = system states

$C \subset S$ = conflict states

$(s_0, \ldots, s_n)$ = simulation path



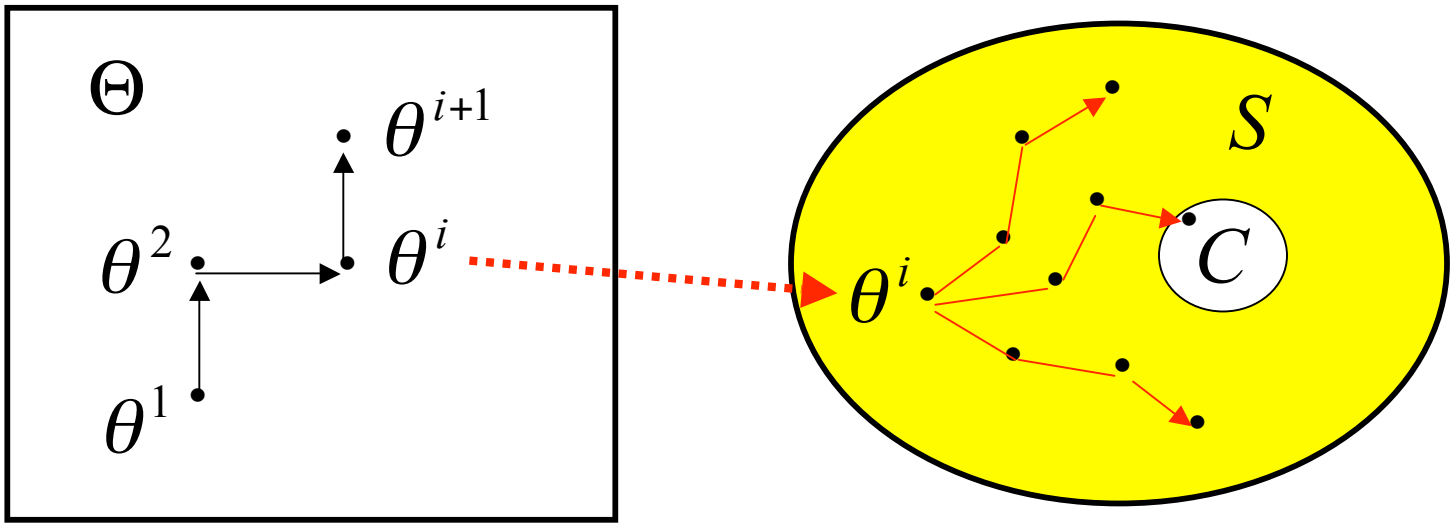
$\theta = (\theta_1, \ldots, \theta_k)$ = simulation parameters

$P(C) = \theta$ = conflict probability

OBJECTIVE: Determine most influential parameters in $P(C) = \theta$

SIMULATION SAMPLING

Θ = parameter space

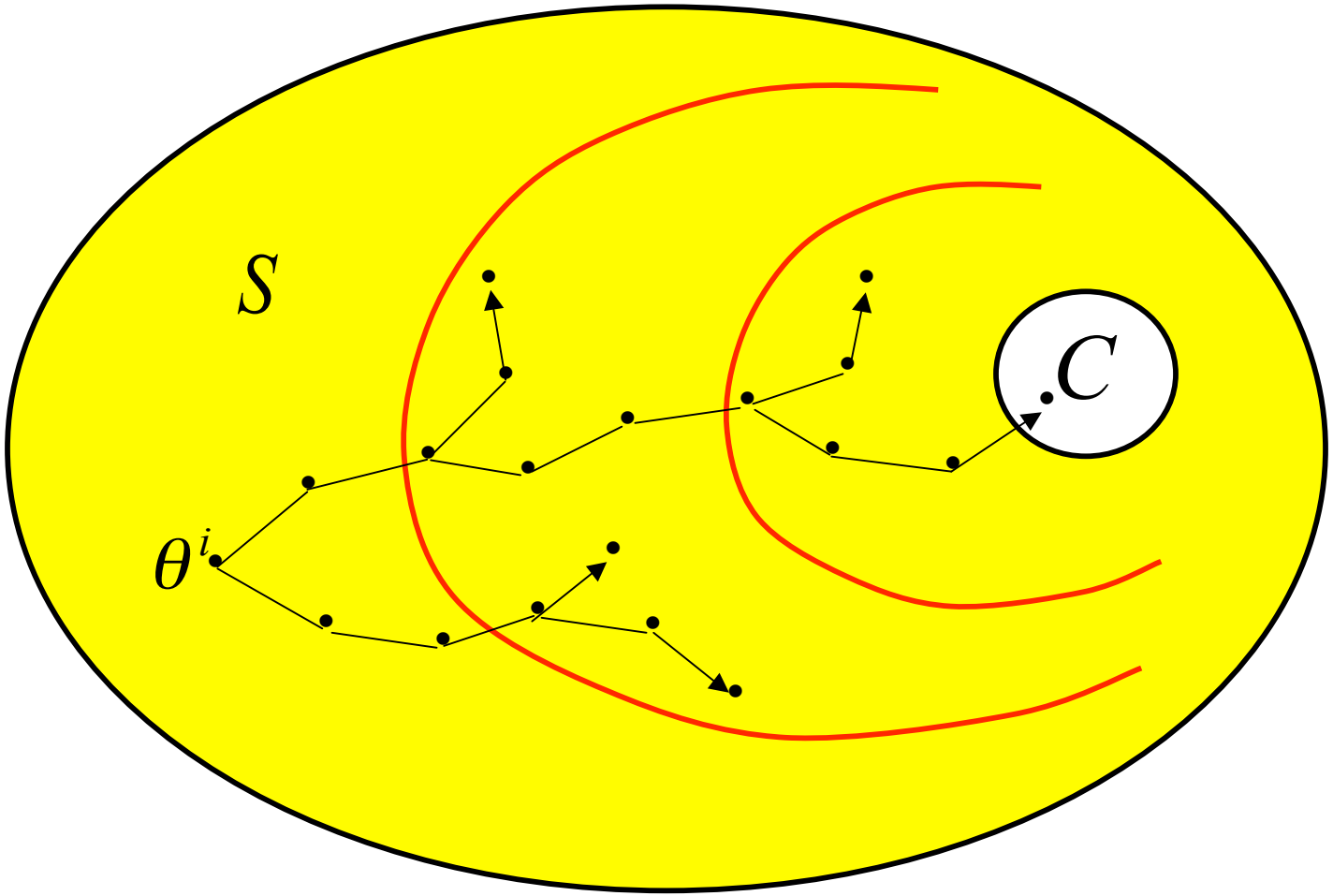


MORRIS RANDOM WALK **SIMULATION SAMPLES**

Morris, M. D. (1991) "Factorial sampling plans for preliminary computational experiments", *Technometrics*, 33: 161-174.

Campolongo, F., S. Tarantola and A. Saltelli (1999) "Tackling quantitatively large dimensionality problems", *Computer Physics Communications*, 117: 75-85.

MULTIPLE - SPLITTING EXTENSION



Glasserman, P., P. Heidelberger, P. Shahabuddin and T. Zajic (1999) “Multilevel splitting for estimating rare event probabilities”, *Operations Research*, 47:585-600.

SENSITIVITY ESTIMATES

SAMPLE DATA: $H_N(\theta)$ = number of C "hits" in N simulation samples using θ

NONPARAMETRIC APPROACHES

$$\hat{P}(C \mid \theta) = \frac{H_N(\theta)}{N}$$

(Simple Relative Frequencies)

PARAMETRIC APPROACHES

$$P(C \mid \theta) = \frac{\exp(\beta_0 + \beta\theta')}{1 + \exp(\beta_0 + \beta\theta')}$$

(Logistic Regression)

→ $\hat{\beta}_i$ = sensitivity estimate for θ_i

SEQUENTIAL OPTIMIZATION APPROACH?

- Given an initial state, s_0, find parameter values, θ, that **achieve "almost minimal" conflict probabilities,** $P(\quad) \quad \theta$.
- Find parameter values, θ, that achieve acceptable risk levels for a wide range of initial conditions, s_0.

→ Are there useful reinforcement learning strategies for accomplishing these objectives?

- Littman's interval estimation for exploring parameter spaces of HMMs
- Schaeffer's hierarchical approach to "near optimal path-finding"
- Carlyle's "D-optimal sequential experiments"

Summary

- **LeaderSim** – Rapidly mockup realworld scenarios and play out how DIME action choices lead to alternative PMESII effects and ways to influence leaders

- **Human Behavior (PMFserv)** – Compose leaders and peoples. Open the agenda to research on parameters across many human behavior disciplines (biology/stress, values/personality/emotion, culture/groups, trust/reputation, decisions/gaming)

- **Sensitivity Studies** – Find principled ways to explore the space of possible outcomes, to avoid conflict states, and to understand the elasticities of behavior parameters as DIME interventions are attempted