Group Robotics

We discussed related topics

- Terminology
- Why group behavior is useful
- How group behavior can be controlled
- Why group behavior is very hard
- Approaches to group behavior
- Examples

From Natural to Artificial Systems

Models of Competition and Cooperation

Table of Contents

Introduction

What is an agent?

- An agent is anything that can be viewed as perceiving its environment through sensors and acting upon that environment through effectors.

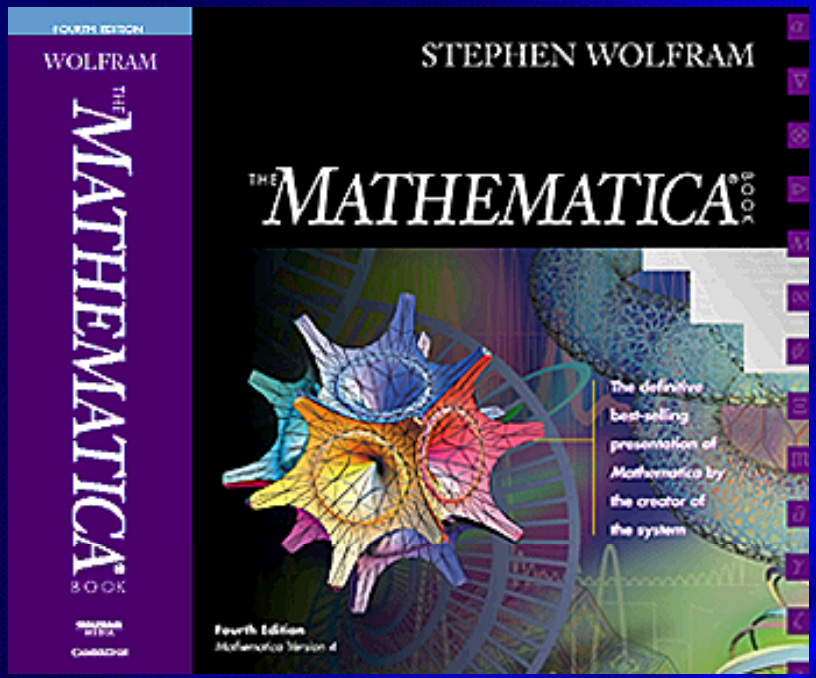
(from Intelligent Agents by Dr. Jacob)

Introduction (cont.)

Competition – event in which persons compete

Cooperation – association of persons for common benefit

Mathematica

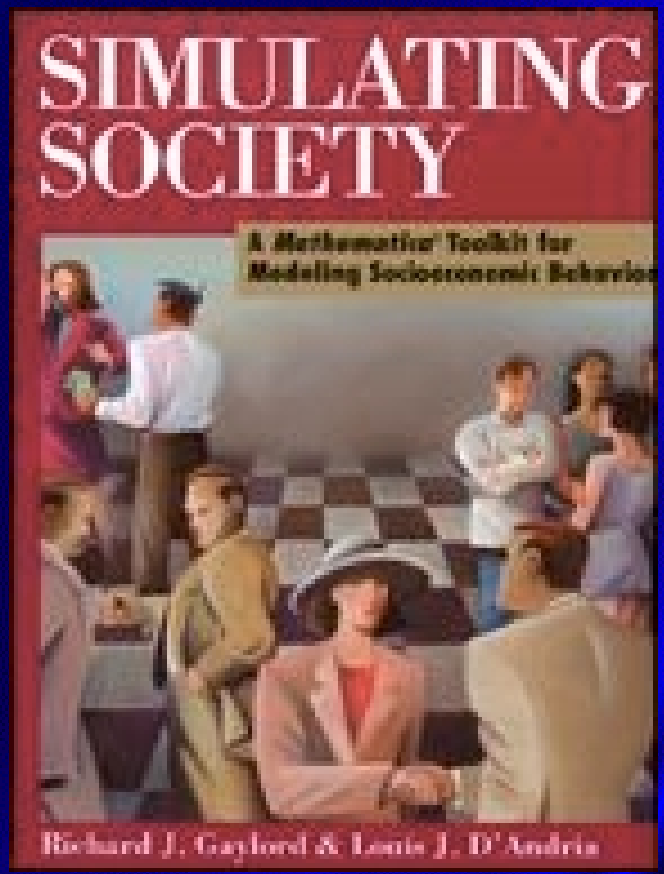


- Powerful Multi-Use Tool.
- Thousands of built in functions.
- Easy to use programming tool.
- Used for all simulations in this presentation.

Mathematica As A Programming Language

- Rule based language – good for simulations
- Very strong pattern matching
- Rules for our simulations rely on this.
  - The pattern matching is used to determine which rule is carried out on the agent

Mathematica Toolkit Simulating Society



- "Simulating Society" by Gaylord & D'Andria
- Simulations involving groups of agents
- Builds on others work and uses Mathematica as the tool for the simulations
- All simulations in our presentation are from this book

Modeling a Society of Mobile Heterogeneous Individuals

Overview of the system

- Decentralized
- Discrete
- Dynamic

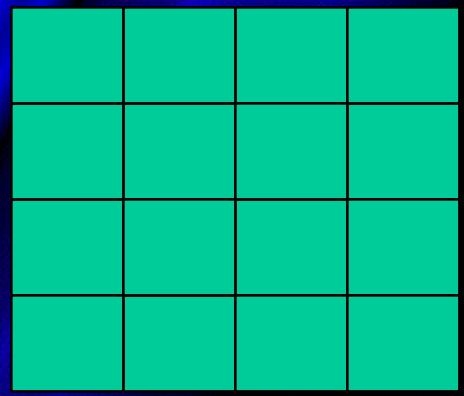
Modeling a Society of Mobile Heterogeneous Individuals

Discrete dynamical system properties

- Space is represented in 2-D
- Each cell is defined as a state
- The system evolves over time
- Cells updated using rules

Modeling a Society of Mobile Heterogeneous Individuals

Simulation



- Square n x n lattice
- Population of density - p
- The system evolves time steps - t

Modeling a Society of Mobile Heterogeneous Individuals

Populating Society

- An empty site has a value of 0
- A site occupied by an individual has a value which is a list

Note: it is useful to focus on the lattice sites rather than on the individuals.

Modeling a Society of Mobile Heterogeneous Individuals

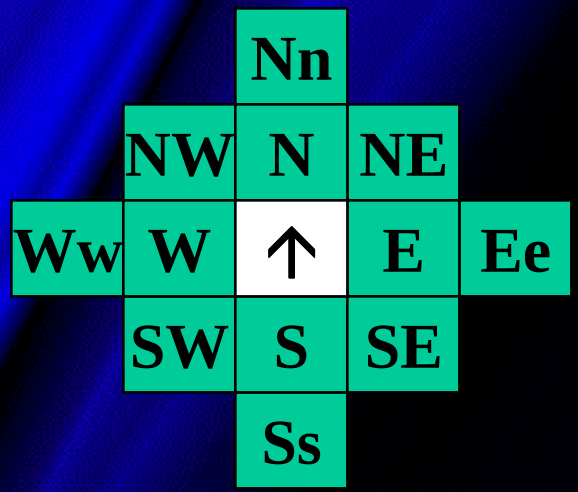
Executing a Time Step

- Time step is executed in two or more consecutive *partial-steps*
- In each partial-step, a set of rules is applied to each site in the lattice

Modeling a Society of Mobile Heterogeneous Individuals

Movement

- One agent per cell
- Neighborhood
- Direction
- Walk rules for **updating a lattice site** have the form:

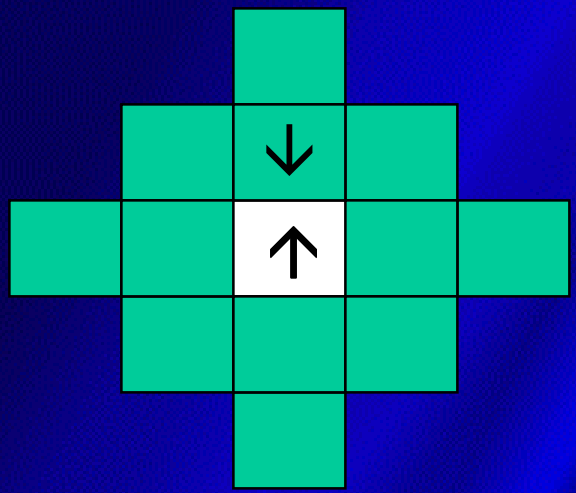


walk[site, N, E, S, W, NE, SE, SW, NW, Nn, Ee, Ss, Ww]

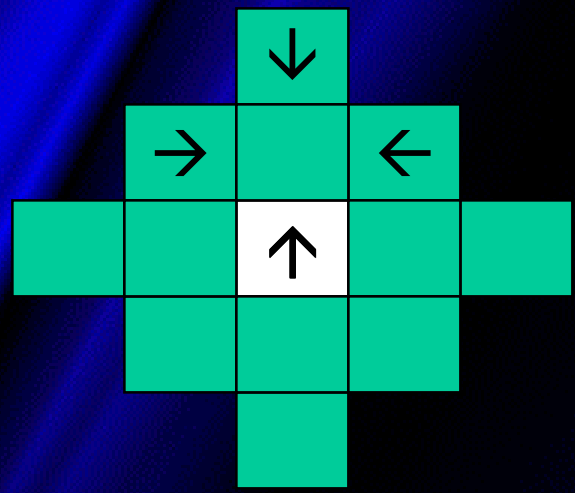
Modeling a Society of Mobile Heterogeneous Individuals

Each lattice occupied by an agent becomes empty unless:

Scenario #1



Scenario #2



Cell remains occupied by the agent, who chooses a random direction to face

Modeling a Society of Mobile Heterogeneous Individuals

Interaction

- Person to Person
- Person to Group

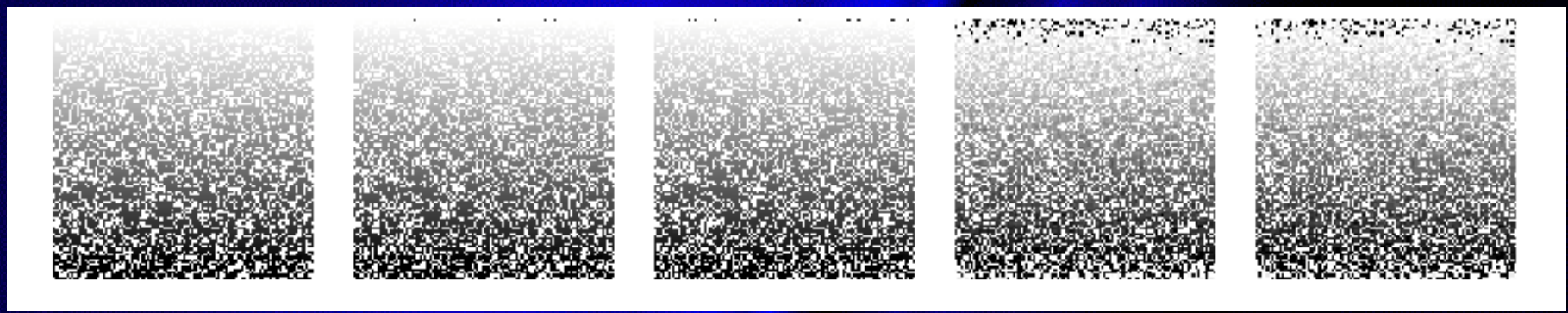
Evolving the System

- The system evolves over *t* time steps, starting with the initial lattice configuration and society

Modeling a Society of Mobile Heterogeneous Individuals

Running the Simulation:

Random Walkers



Step 1 Step 2 Step 3 Step 498 Step 499

Transmitting Culture

Transmitting Culture

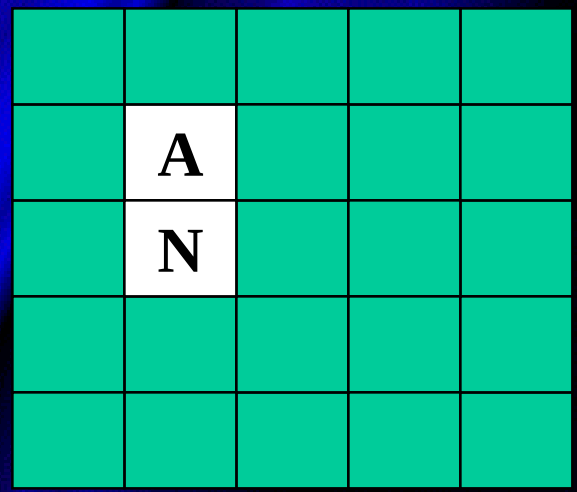
What is Cultural Transmission?

Axelrod's *Model of* Transmission of Culture

Transmitting Culture

Axelrod's Model

- Consists of a *Meme* list of *Features* and *Traits*
- A = {3, 2, 1, 7, 5}
- N = {4, 8, 1, 2, 5}



Transmitting Culture

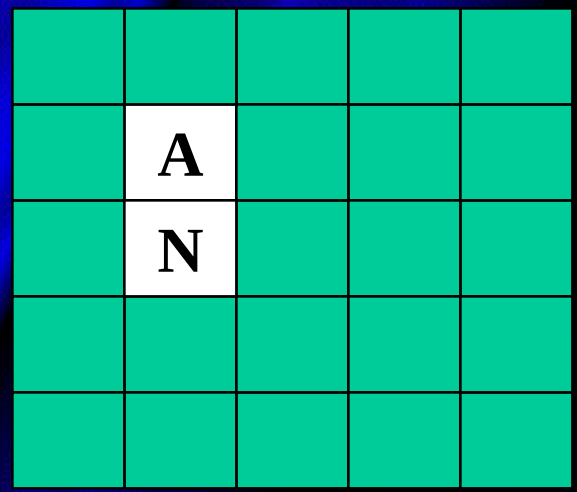
The System

- A = {3, 2, 1, 7, 5}
- N = {4, 8, 1, 2, 5}

Cultural Exchange

- A = {3, ***x***, 1, 7, 5}
- N = {4, **8**, 1, 2, 5}

Where ***x*** is a randomly chosen integer between 2 and 8.



Transmitting Culture

Modification to Axelrod's Model

- Incorporating mobility
- Incorporating bilateral cultural exchange

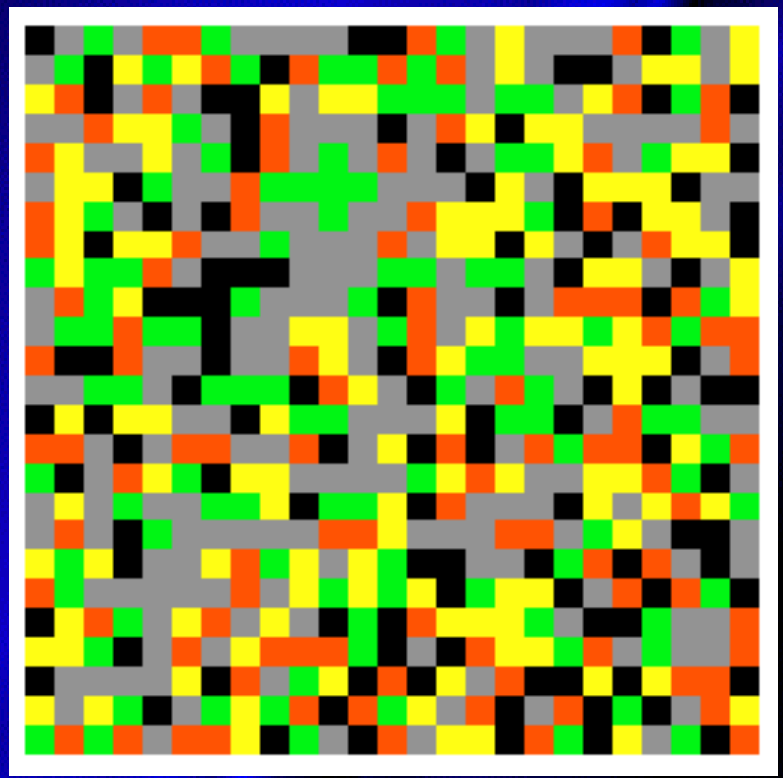
Other Models

- Social Status and Role Models

Bill Gates

Transmitting Culture

Running the Simulation



Deciding Whether to Interact

Deciding Whether to Interact

To Interact or Not to Interact

- Good behavior versus bad behavior

The Prisoner's Dilemma [Revisited]

- Payoffs resulted from interaction
- Benefit if positive payoff
- Cost if negative payoff

Deciding Whether to Interact

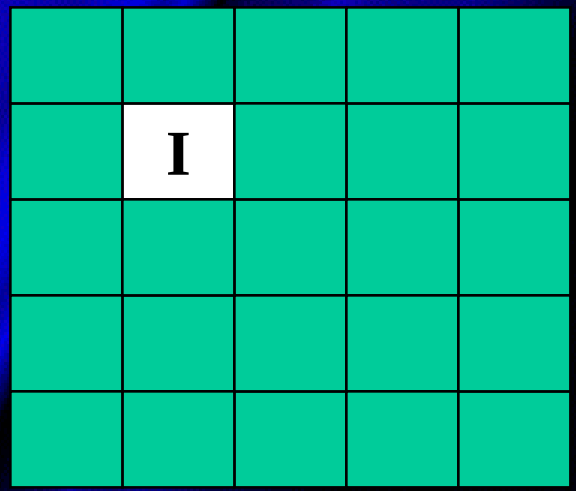
The System

- Square n by n lattice

Populating Society

- Empty site has 0
- Good & Bad guys
- Site occupied by an individual has a list

  I = {a, b, c, d, e}



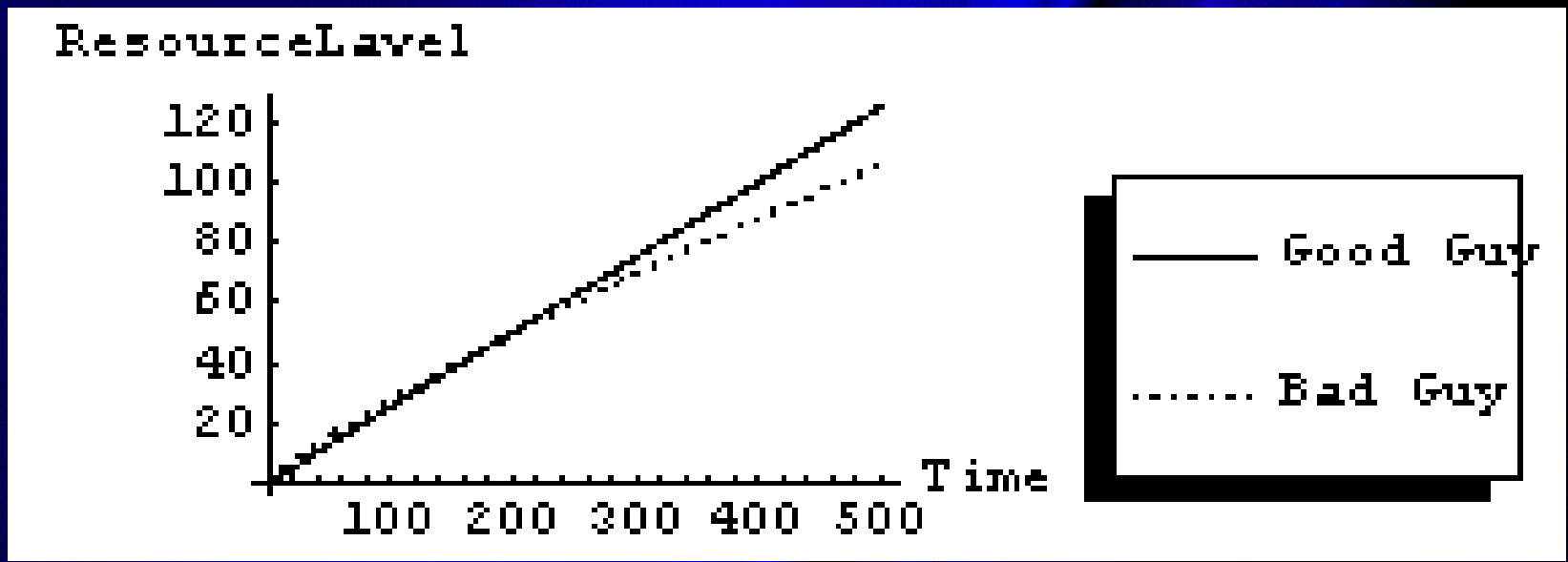
Deciding Whether to Interact

Executing the Interaction Partial-Step

- Memory Checking
- Refuse or Accept Interaction
- Update List

Deciding Whether to Interact

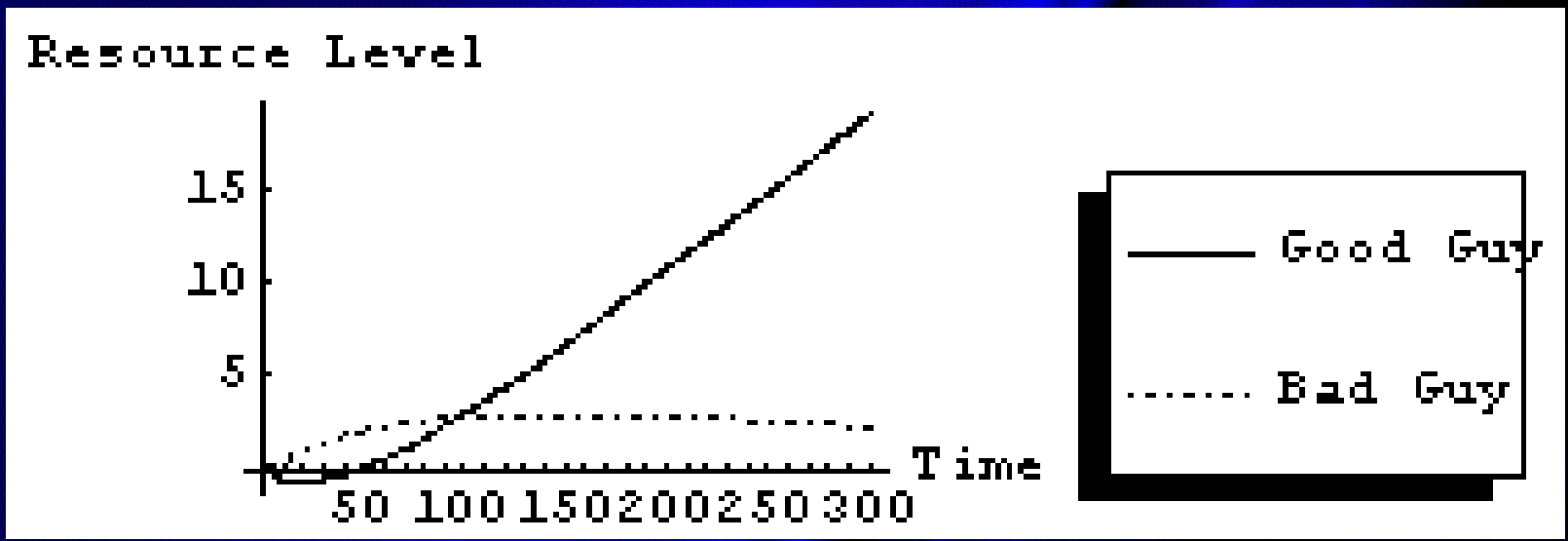
Running the Simulation



Graph of Good Guy vs. Bad Guy

Deciding Whether to Interact

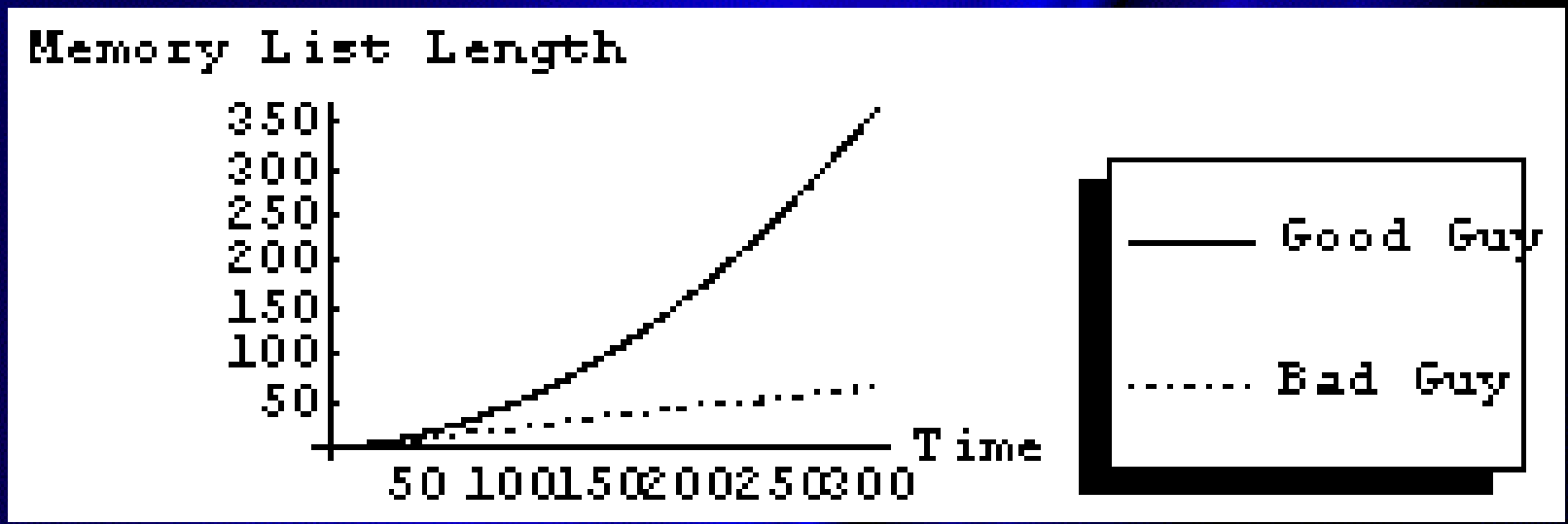
Public Knowledge



Graph of Good Guy vs. Bad Guy

Deciding Whether to Interact

Public Knowledge



Graph of Good Guy vs. Bad Guy

Deciding Whether to Interact

Signals

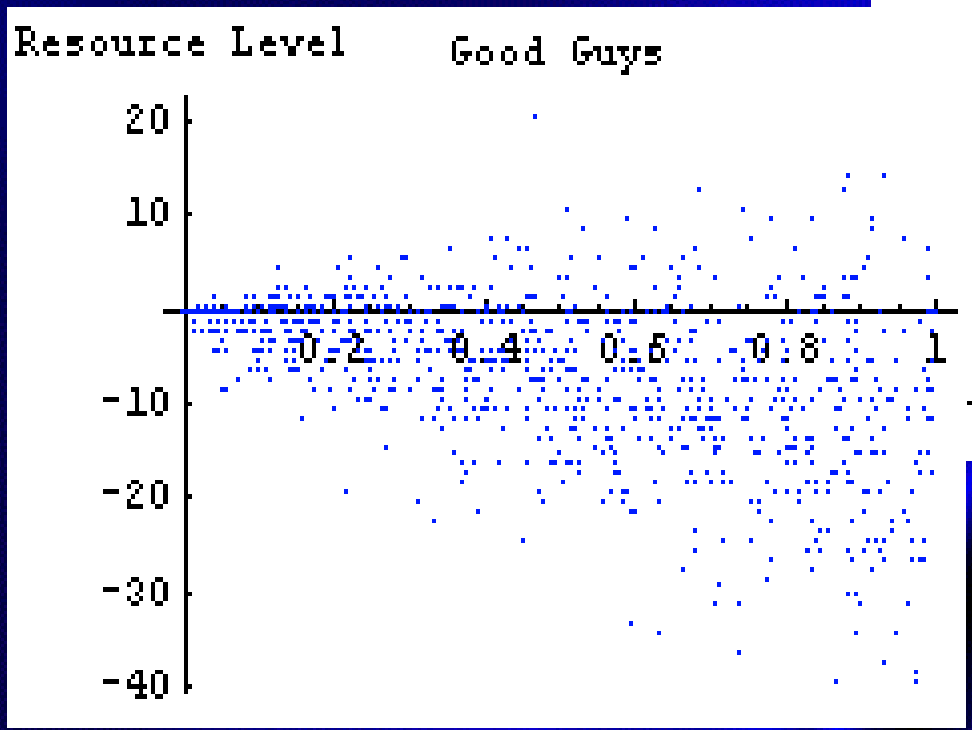
"I suggest you deactivate your emotion chip for now."

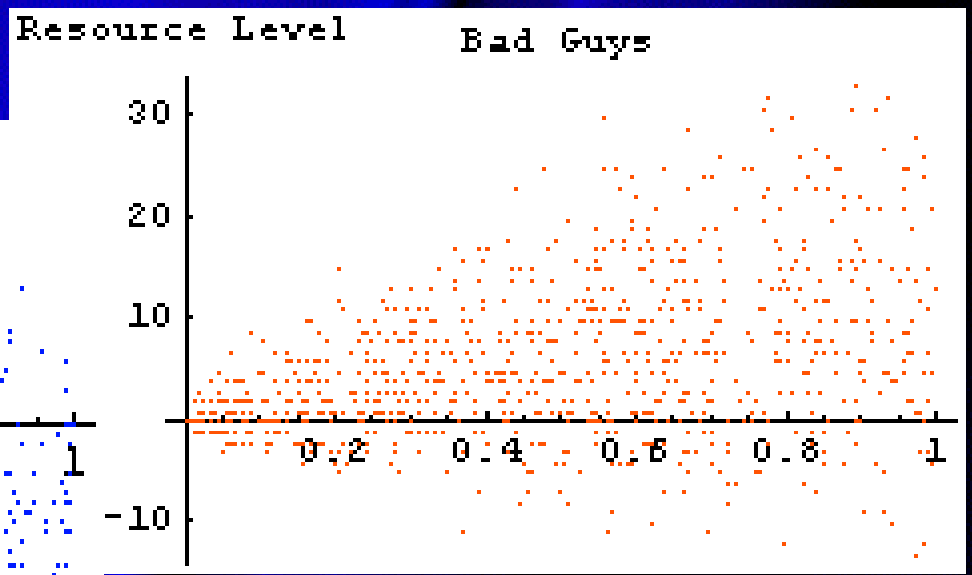
Patrick Stewart in *Star Trek: First Contact* (1996)

http://www.geocities.com/Area51/Vault/126/

Deciding Whether to Interact

Use of Vibes





Graphs of Good Guys and Bad Guys

Deciding Whether to Interact

Study - The UNIX Case:

- Introduction
  - Too many variations of UNIX
  - Setting a Standard
  - UNIX International Inc. (UII)
  - Open Software Foundation (OSF)
  - Two types of Companies

Deciding Whether to Interact

Study - The UNIX Case:

- Uses Landscape Theory
  - size: s_i
  - propensity: p_{ij}
  - configuration: X
  - distance: d_{ij}
  - frustration: $F_i(X)$
  - energy: E(X)

Deciding Whether to Interact

Study - The UNIX Case:

- Assumptions
  - Cooperation
  - Competition
- Additional parameters α and β used to indicate close rivals
- Nash Equilibrium

Deciding Whether to Interact

Study - The UNIX Case:

- Results: Only two configurations that were also Nash Equilibriums

Specialist
Generalist

Configuration A	
Alliance 1	Alliance 2
Sun	DEC
AT&T	HP
Prime	***Apollo***
IBM	***Intergraph***
	SGI

Configuration B	
Alliance 1	Alliance 2
Sun	AT&T
DEC	Prime
HP	IBM
	Apollo
	Intergraph
	SGI