

# Labor Institutions and Market Performance

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## An Agent-Based Computational Economics Approach

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# Outline

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- ★ What is Agent-Based Computational Economics (ACE)?
- ★ Labor Institutions and Market Performance: What does ACE have to offer?
- ★ Illustration: (M. Pingle/L. Tesfatsion, 2003)  
“Evolution of Worker-Employer Networks and Behaviors Under Alternative Non-Employment Benefits”
- ★ Trade Network Game (TNG) Lab Implementation  
[www.econ.iastate.edu/tesfatsi/TNGHome.htm](http://www.econ.iastate.edu/tesfatsi/TNGHome.htm)

# What is Agent-Based Computational Economics (ACE)?

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- ◆ **Culture-dish approach** to the study of decentralized market processes
- ◆ **Computational study** of economic processes modeled as dynamic systems of interacting agents

**ACE Resource Site:**

[www.econ.iastate.edu/tesfatsi/ace.htm](http://www.econ.iastate.edu/tesfatsi/ace.htm)

★ **ACE Labor Market Research Site:**

[www.econ.iastate.edu/tesfatsi/alabor.htm](http://www.econ.iastate.edu/tesfatsi/alabor.htm)

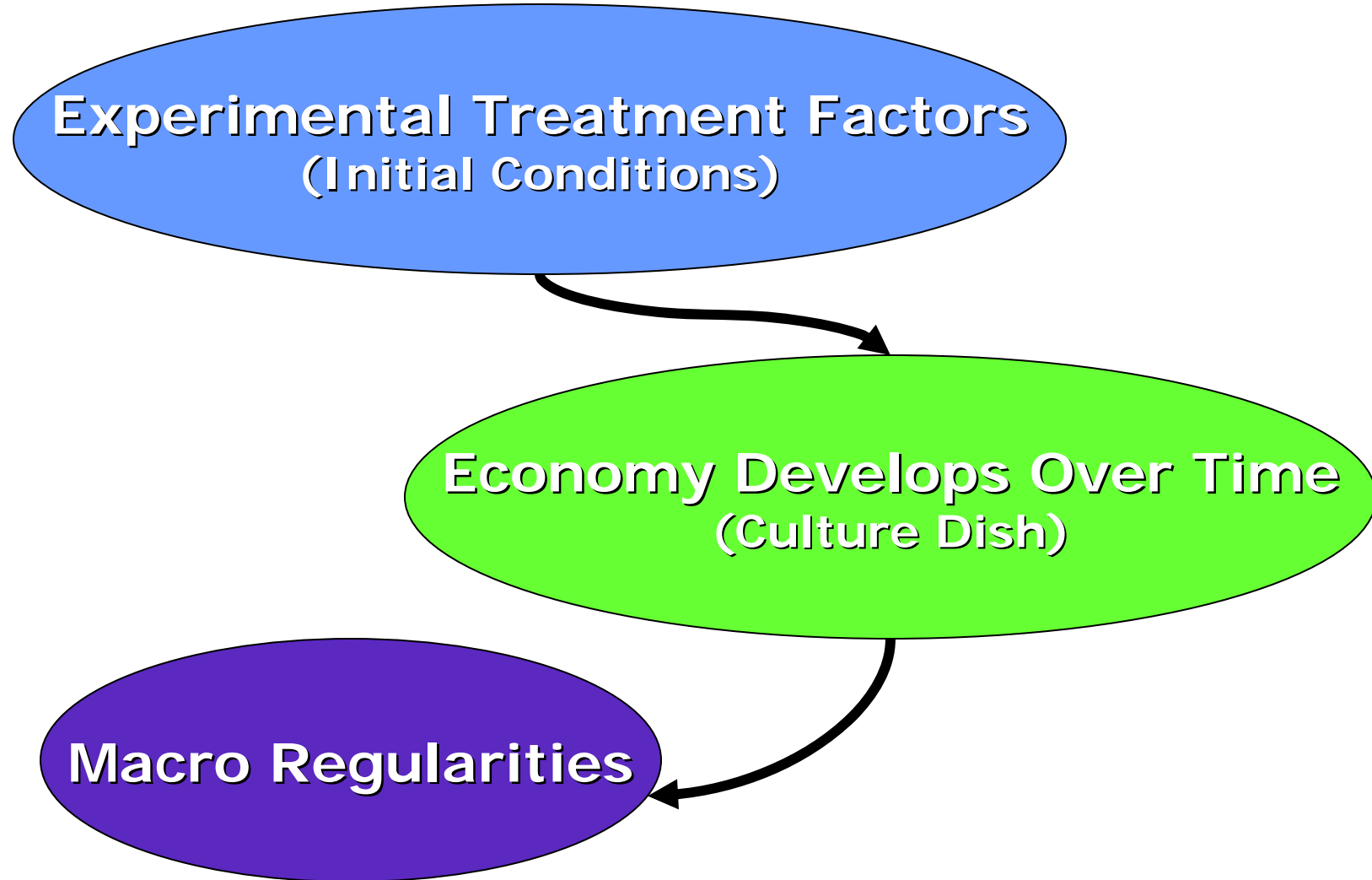
# ACE Modeling: Culture Dish Analogy

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- ◆ Modeler constructs a **computational economic world** populated by various types of agents (economic, social, biological, & physical)
- ◆ Modeler sets **initial conditions**
- ◆ The world then **develops over time** without further outside intervention
- ◆ World driven solely by **agent interactions**

# ACE Modeling: Culture Dish Analogy

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# Key Characteristics of ACE Models

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- ◆ **Agents** are encapsulated software programs capable of
  - *Adaptation* to environmental conditions
  - *Social communication* with other agents
  - *Goal-directed learning*
  - *Autonomy* (self-activation and self-determinism based on private internal processes)
- ◆ Agents can be situated in realistically rendered problem environments
- ◆ Behaviour/interaction patterns can develop endogenously over time

# Current ACE Research Areas

(<http://www.econ.iastate.edu/tesfatsi/aapplic.htm> )

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- \* Embodied cognition
- \* Network formation
- \* Financial Economics
- \* Labor Markets
- \* Industrial organization
- \* Macroeconomics
- \* Technological change and economic growth
- \* Market design
- \* Automated markets and software agents
- \* Parallel experiments (real & computational agents)
- \* Empirical validation and verification of ACE models
- \* **Many others...**

# Labor Institutions and Market Performance

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## Some Key Issues:

- ◆ Labor contracts typically **incomplete**
- ◆ Supplemented by government programs with **numerous eligibility restrictions**
- ◆ **Difficult to test program effects** by means of conventional analytical and/or statistical tools

## Example: U.S. Programs Providing Unemployment Benefits (UB)

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- ◆ UB only paid to “no fault of their own” unemployed
- ◆ UB recipients must continue to seek employment
- ◆ UB levels based on past earnings
- ◆ UB of limited duration
- ◆ UB financed by taxes imposed on employers
- ◆ Additional UB often granted when unemployment rate is abnormally high for prolonged periods
- ◆ **Example:** IA Unemployment Insurance Guide (29pp)  
<http://www.iowaworkforce.org/ui/guide.htm>

# Empirical UB Findings

*(Handbook of Labor Economics, Vols. 1-3, Elsevier, 1999)*

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- ◆ Higher benefit **level** increases duration of unemployment spells.
- ◆ Increased benefit **duration** increases unemployment rate (unemployed as percentage of labor force).
- ◆ **Evidence of other impacts of UB is considerably more mixed** (endogeneity, small sample bias problems,...)

# Common Approach to UB Theoretical Modeling

*(Handbook of Labor Economics, Vols. 1-3, Elsevier, 1999)*

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- ◆ Dynamic Programming (DP)
- ◆ Jobs arise and end randomly
- ◆ Unemployed receive UB
- ◆ Workers compare DP value of new job vs. current job or unemployment
- ◆ Each worker maximizes lifetime expected utility
- ◆ **Precise predictions possible, but empirical support unclear.**

# Potential Contributions of an ACE Approach to Labor Research

[www.econ.iastate.edu/tesfatsi/alabor.htm](http://www.econ.iastate.edu/tesfatsi/alabor.htm)

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- ◆ Employers/workers can be modeled as **autonomous interacting agents**
- ◆ Matching process can be preferential (**endogenous hires, quits, and firings**)
- ◆ **Learning** can be calibrated to data (empirical, human-subject experimental)
- ◆ **Evolution** of behaviors/interaction networks
- ◆ Relatively easy to incorporate **realistically detailed structural features** (market protocols, policy rules, program eligibility requirements,...)

# Illustration: An ACE Study of “Non-Employment Payments” (NEP)

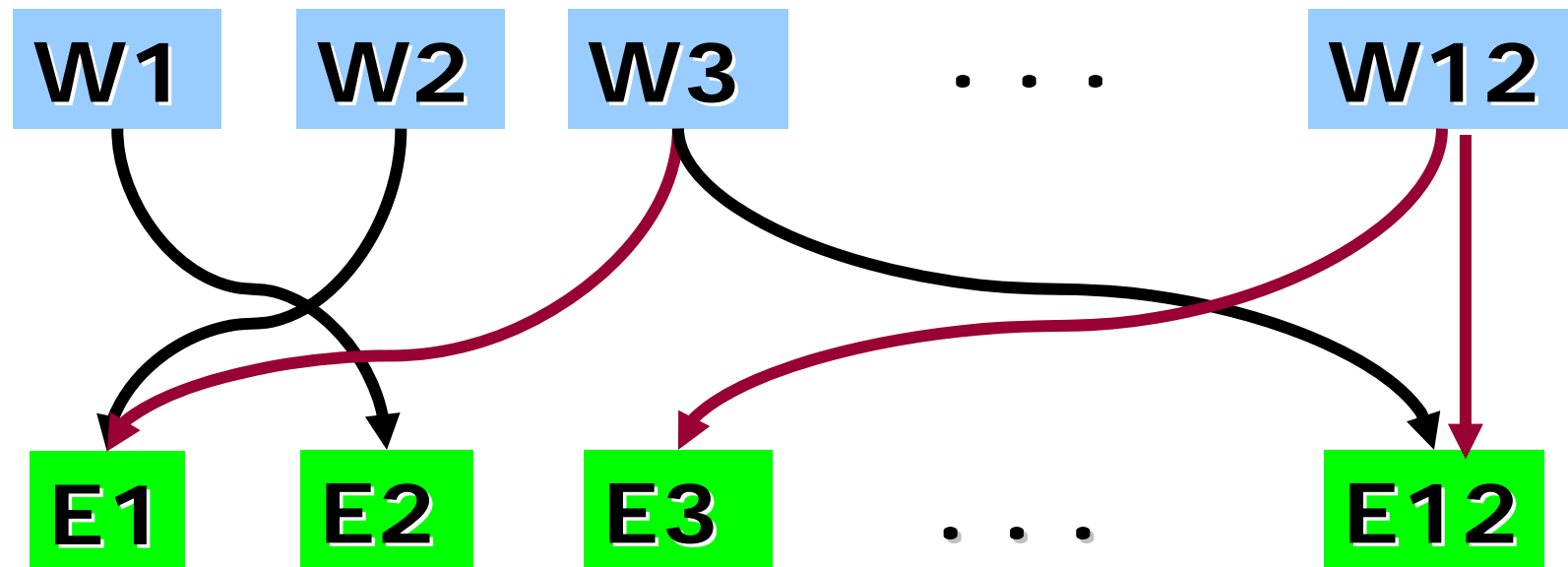
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- ◆ **Joint work with M. Pingle (U of Nevada-Reno)**
- ◆ Published in *New Directions in Networks*, 2003, Edward-Elgar volume, edited by A. Nagurney  

M. Pingle and L. Tesfatsion, “Evolution of Worker-Employer Networks and Behaviors under Alternative Non-Employment Benefits: An Agent-Based Computational Economics Study”
- ◆ Pre-print available at  
[www.econ.iastate.edu/tesfatsi/alabmplt.pdf](http://www.econ.iastate.edu/tesfatsi/alabmplt.pdf)
- ◆ Parallel human-subject experiments conducted

# ACE Labor Market Framework

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Preferential job search with choice/refusal of partners:  
**Red directed arrow** indicates **refused work offer**.

## Focus on Interaction Effects → Endogenous Heterogeneity of Agents

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- ❁ 12 workers with **same observable attributes** in initial period  $T=0$
- ❁ 12 employers with **same observable attributes** in initial period  $T=0$
- ❁ Each worker can work for at most one employer in each period  $T$
- ❁ Each employer can provide at most one job opening in each period  $T$
- ❁ **Worksite strategies** in initial period  $T=0$  are **random and private info**

# Each worker and employer has...

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- ❁ ***Public methods for requesting/receiving info*** about various market and NEP policy protocols
- ❁ ***Public communication methods***—workers and employers can talk with each other.
- ❁ ***Privately stored data*** that can change over time through experiences/communications
- ❁ ***Private behavioral methods*** that include expectation formation & learning about preferred worksite partners and worksite strategy choices

# A Worker Agent

## Public Access:

### // **Public Methods**

Protocols governing job search;  
Protocols governing negotiations with potential employers;  
Protocols governing non-employment payments program;  
Methods for communicating with other agents;  
Methods for retrieving stored Worker data;

## Private Access Only:

### // **Private Methods**

Method for calculating own expected utility assessments;  
Method for choosing/refusing employers [**learning**];  
Method for updating own worksite strategy [**learning**];

### // **Private Data**

Data about own self (history, utility fct., current wealth...);  
Data recorded about external world (employer behaviors,...);  
Addresses for other agents [**permits agent communication**]

# An Employer Agent

## Public Access:

### // **Public Methods**

Protocols governing search for workers;  
Protocols governing negotiations with potential workers;  
Protocols governing non-employment payments program;  
Methods for communicating with other agents;  
Methods for retrieving stored Employer data;

## Private Access Only:

### // **Private Methods**

Method for calculating own expected profit assessments;  
Method for choosing/refusing workers [**learning**];  
Method for updating own worksite strategy [**learning**];

### // **Private Data**

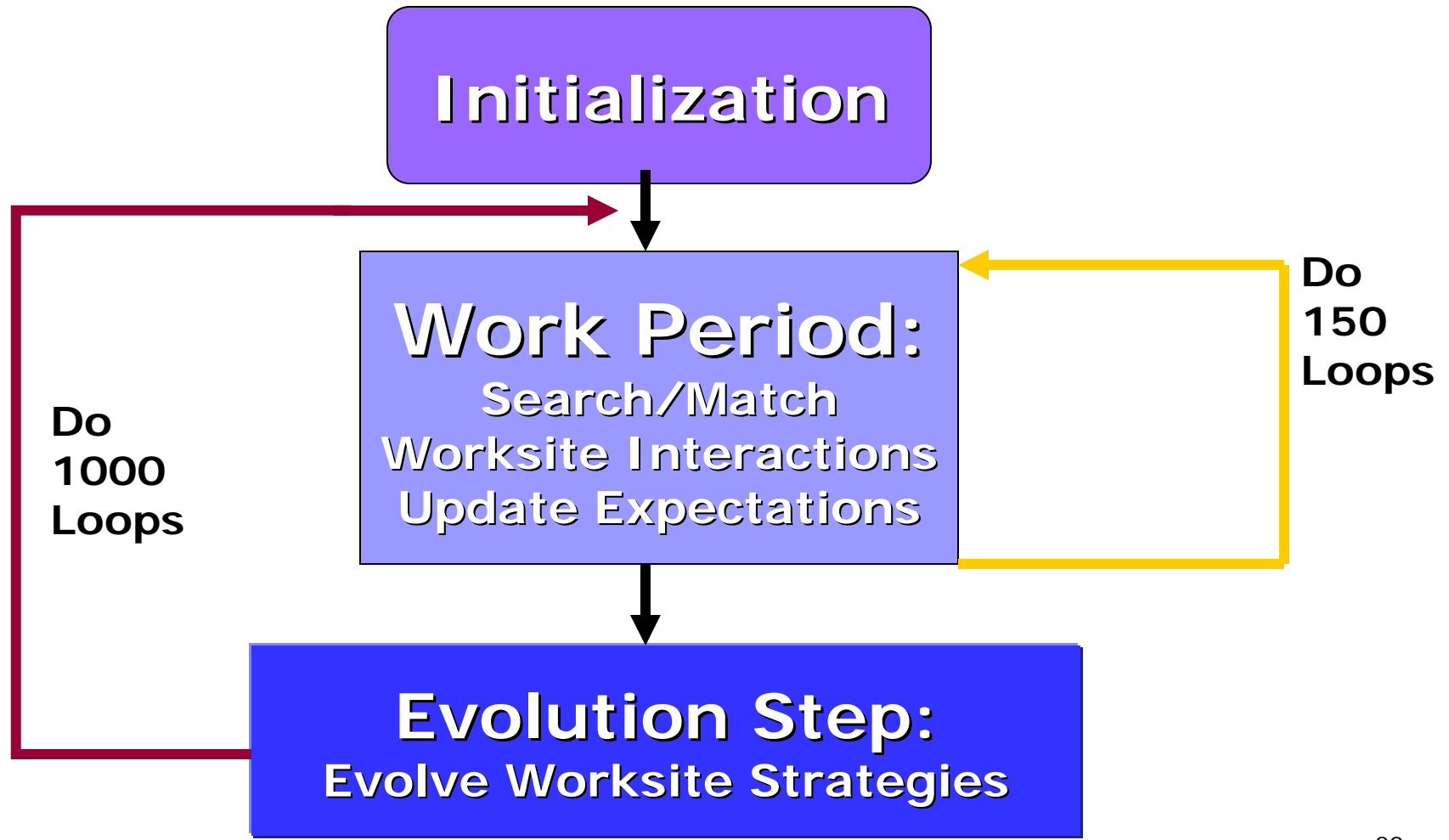
Data about own self (history, profit pct., current wealth...);  
Data recorded about external world (worker behaviors,...);  
Addresses for other agents [**permits agent communication**]

# Flow of Activities in the ACE Labor Market

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- ❁ Workers make offers to preferred employers at a small cost per offer (**quits allowed**)
- ❁ After batching work offers, employers accept or refuse these offers (**firings allowed**)
- ❁ Each matched pair engages in one worksite interaction (**PD - cooperate or defect**)
- ❁ After 150 work periods, each worker (employer) updates its iterated prisoner's dilemma strategy for interactions with each potential employer (worker).

# Flow of Activities in the ACE Labor Market



# Worksite Interactions as Prisoner's Dilemma (PD) Games

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		Employer	
		C	D
Worker	C	(40,40)	(10,60)
	D	(60,10)	(20,20)

D = Defect (Shirk); C = Cooperate (Fulfill Obligations)<sub>1</sub>

# Key Issues Addressed

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How do **changes** in the level of the non-employment payment (NEP) affect...

- ✦ **Worker-Employer Interaction Networks**
- ✦ **Worksite Behaviors:** Degree to which workers/employers shirk (defect) or fulfill obligations (cooperate) on the worksite
- ✦ **Market Efficiency** (total surplus net of NEP program costs, unemployment/vacancy rates,...)
- ✦ **Market Power** (distribution of total net surplus)

# Experimental Design

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- ❁ **Treatment Factor: NEP**

  - Non-Employment Payment (NEP) paid to each unemployed worker and each employee having no workers

- ❁ **Three Tested Treatment Levels:**

  - NEP=0, NEP=15, NEP=30

- ❁ **Runs per Treatment: 20**

  - 1 Run = 1000 Generations;

  - 1 Generation = 150 Work Periods Plus Evolutionary Step

- ❁ **Data Collected Per Run:** Network patterns, behaviors, and market performance (reported in detail for generations 12, 50, 1000)

# Three NEP Treatments in Relation to PD Payoffs

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①  $\text{NEP}=0 < L=10$

②  $L=10 < \text{NEP}=15 < D=20$

③  $D=20 < \text{NEP}=30 < C=40$

**NOTE:** Work-site PD payoffs given by:

$$\begin{aligned} L \text{ (Sucker)} &= 10 < D \text{ (MutualDef)} &= 20 \\ &< C \text{ (MutualCoop)} &= 40 \\ &< H \text{ (Temptation)} &= 60 \end{aligned}$$

# Market Efficiency Findings

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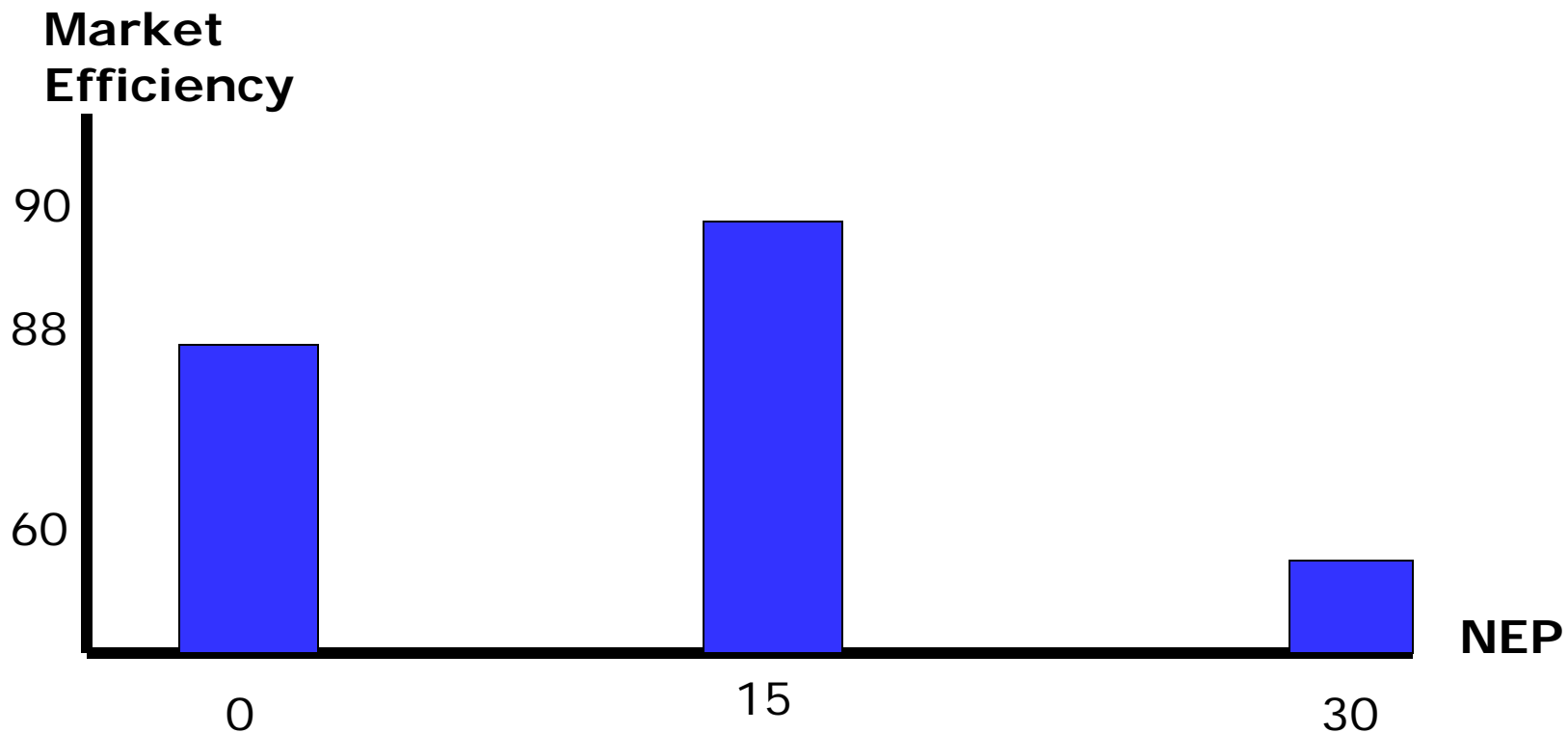
As NEP level **increases** from 0 to 30...

- ❁ **higher** average unemployment and vacancy rates are observed; ← **KNOWN EFFECT**
- ❁ **more** work-site cooperation observed on average among workers & employers who match. ← **NEW EX POST EFFECT**

**Note:** These outcomes have **potentially offsetting** effects on market efficiency.

# Efficiency Findings...

*Market Efficiency (utility less NEP program costs) averaged across generations 12, 50, and 1000 for three different NEP treatments*



# Efficiency Findings...

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- ⊗ NEP=15 yields *highest efficiency*
- ⊗ NEP=0 yields *lower* efficiency  
(too much shirking)
- ⊗ NEP=30 yields *lowest efficiency*  
(program costs too high – everyone too picky!)

# Multiple Attractors

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- \* Two distinct “behavioral attractors” observed for each NEP treatment...
  - **NEP=0 and NEP=15:**
    - ◆ First Attractor = Latched network supporting *mutual cooperation*;
    - ◆ Second Attractor = Latched network supporting *intermittent defection*
  - **NEP=30:**
    - ◆ First Attractor = Latched network supporting *mutual cooperation*
    - ◆ Second Attractor = Disconnected network reflecting *total coordination failure*

# The Following Diagrams Report...

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## ① Two-sided (W-E) network distributions

**0**=Stochastic fully connected network;

**12**=Latched in pairs



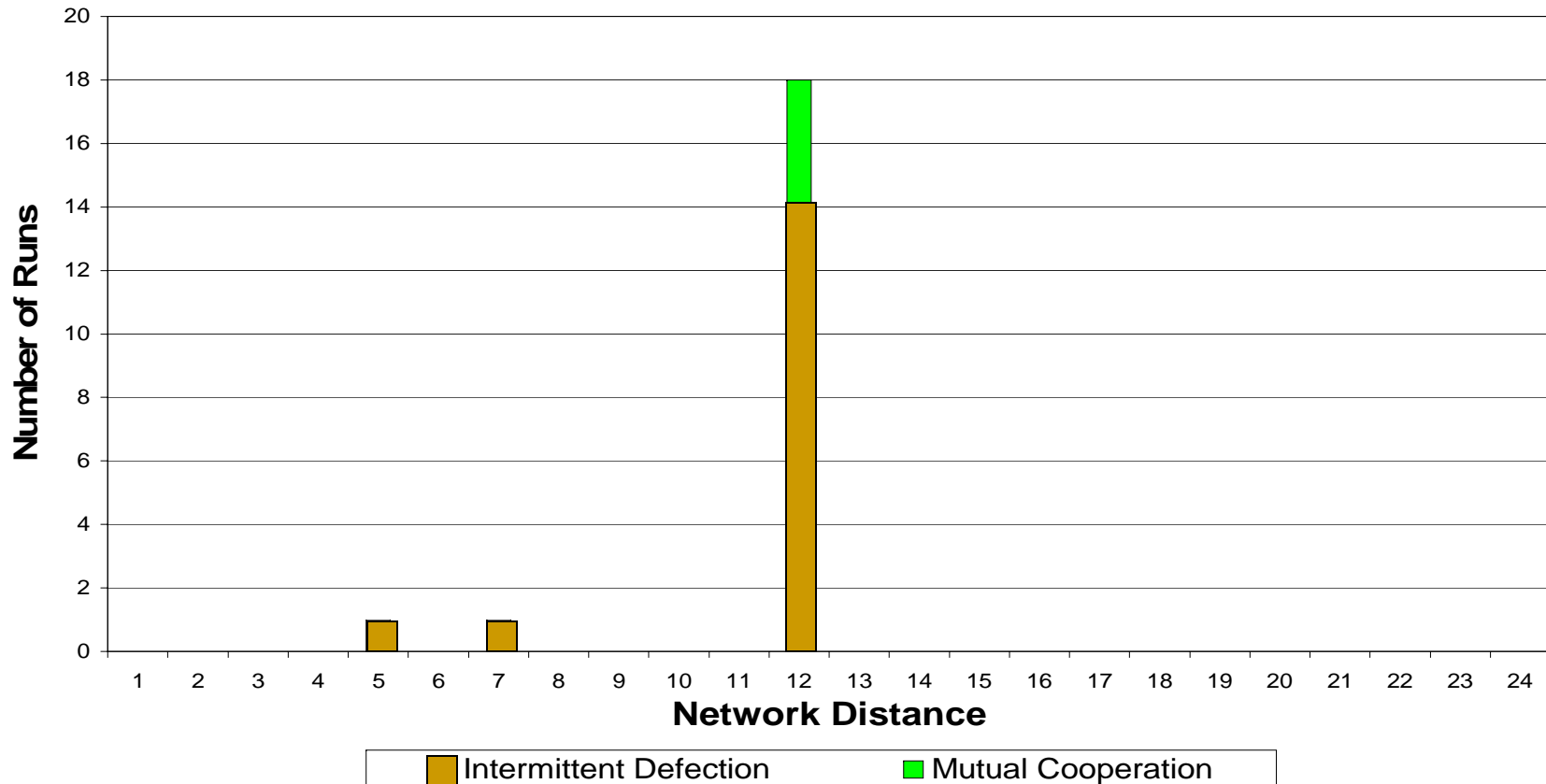
The diagram illustrates a latched pair of nodes. It consists of two blue rectangular boxes, each containing the letter 'W', arranged horizontally. Below each 'W' box is a black arrow pointing downwards to a green rectangular box containing the letter 'E'. To the right of the second 'E' box is an ellipsis (...).

**24**=Completely disconnected

## ② Worksite behaviors that are supported by these network outcomes

# Network Distribution for **NEP=0** Sampled at End of **Generation 12**

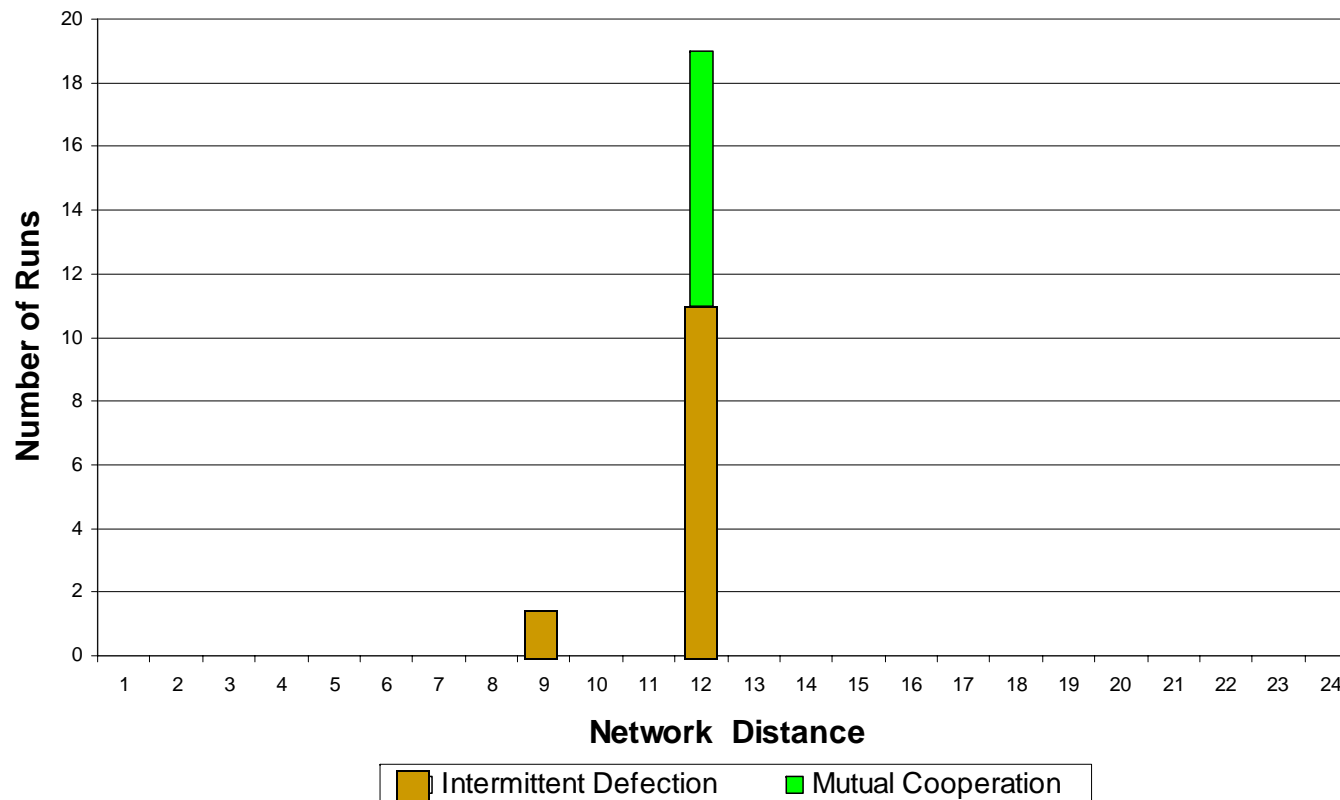
Network Distribution for ZeroT:12



# Network Distribution for **NEP=0** Sampled at End of **Generation 50**

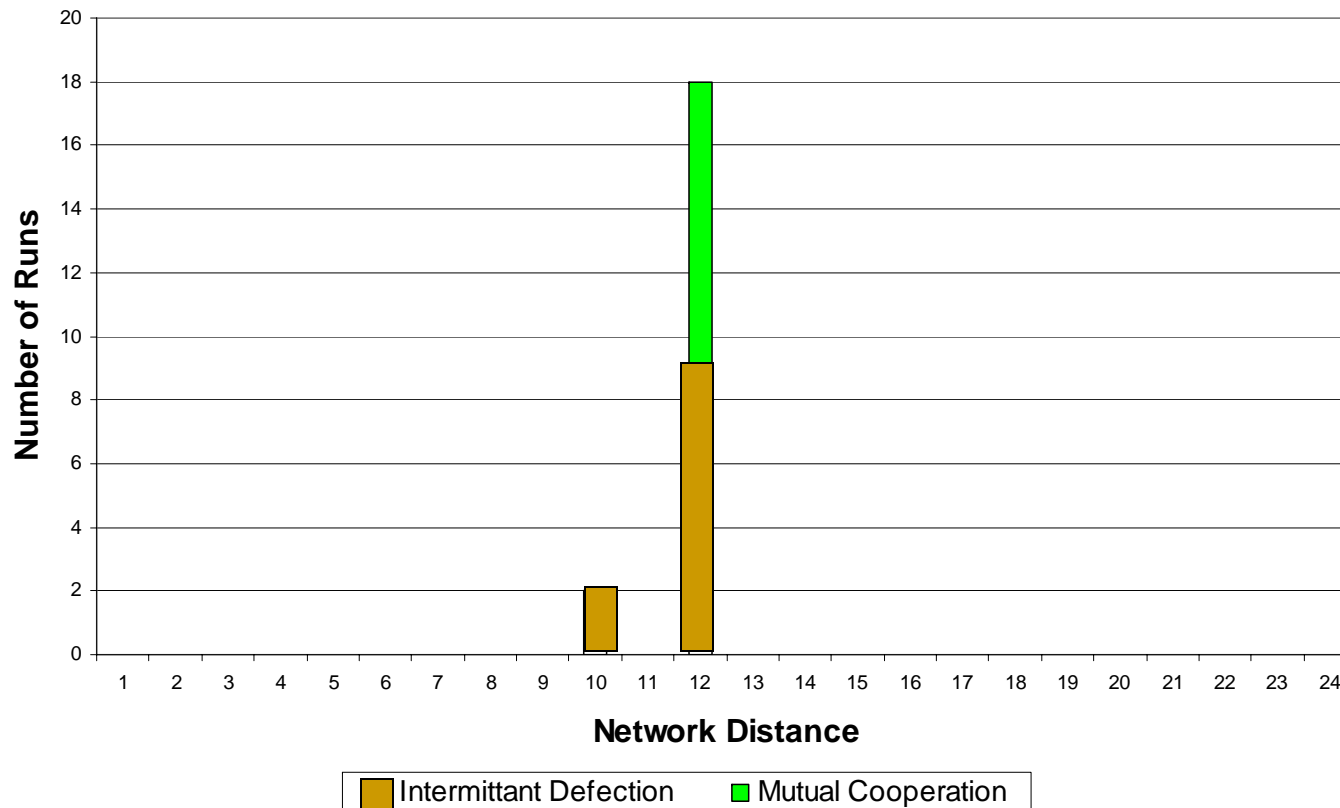
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Network Distribution for ZeroT:50



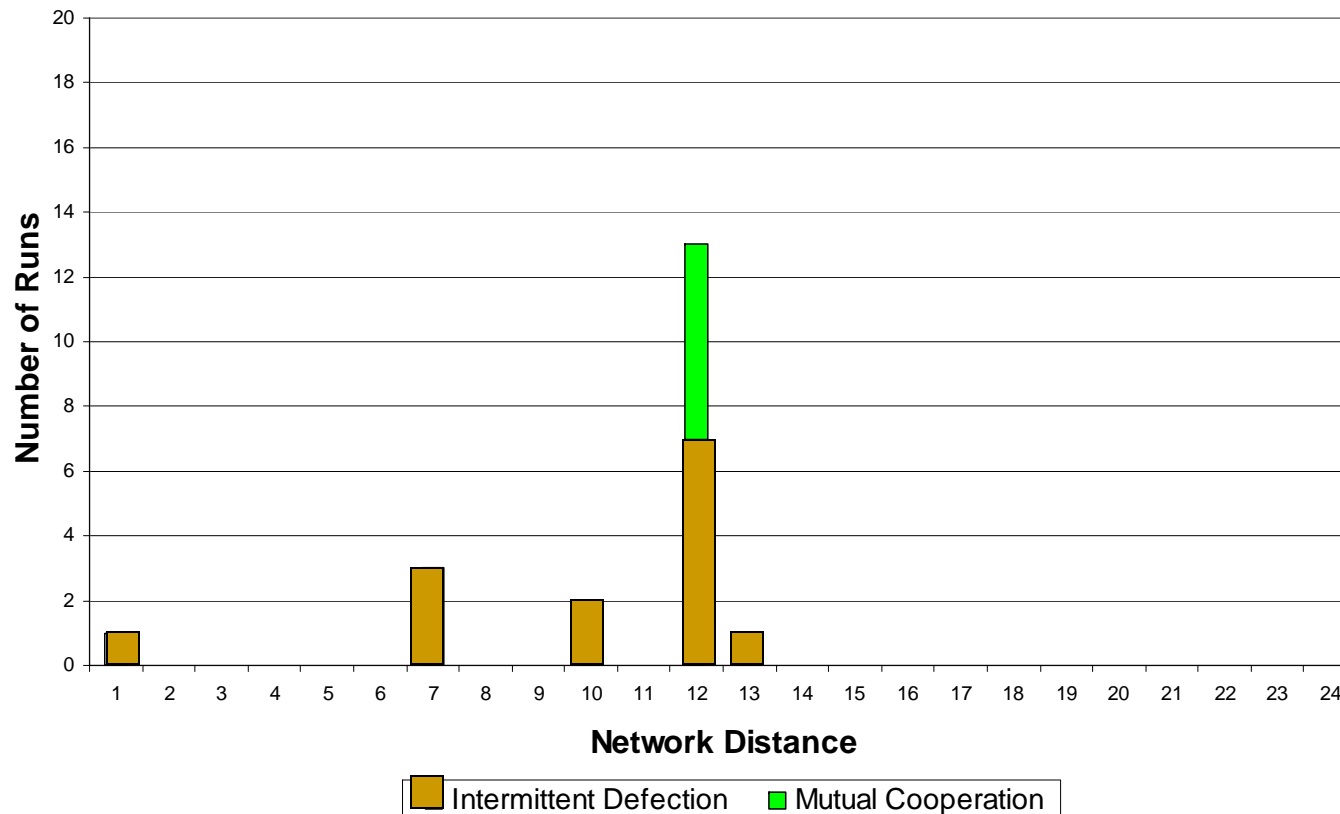
# Network Distribution for **NEP=0** Sampled at End of **Generation 1000**

Network Distribution for ZeroT:1000



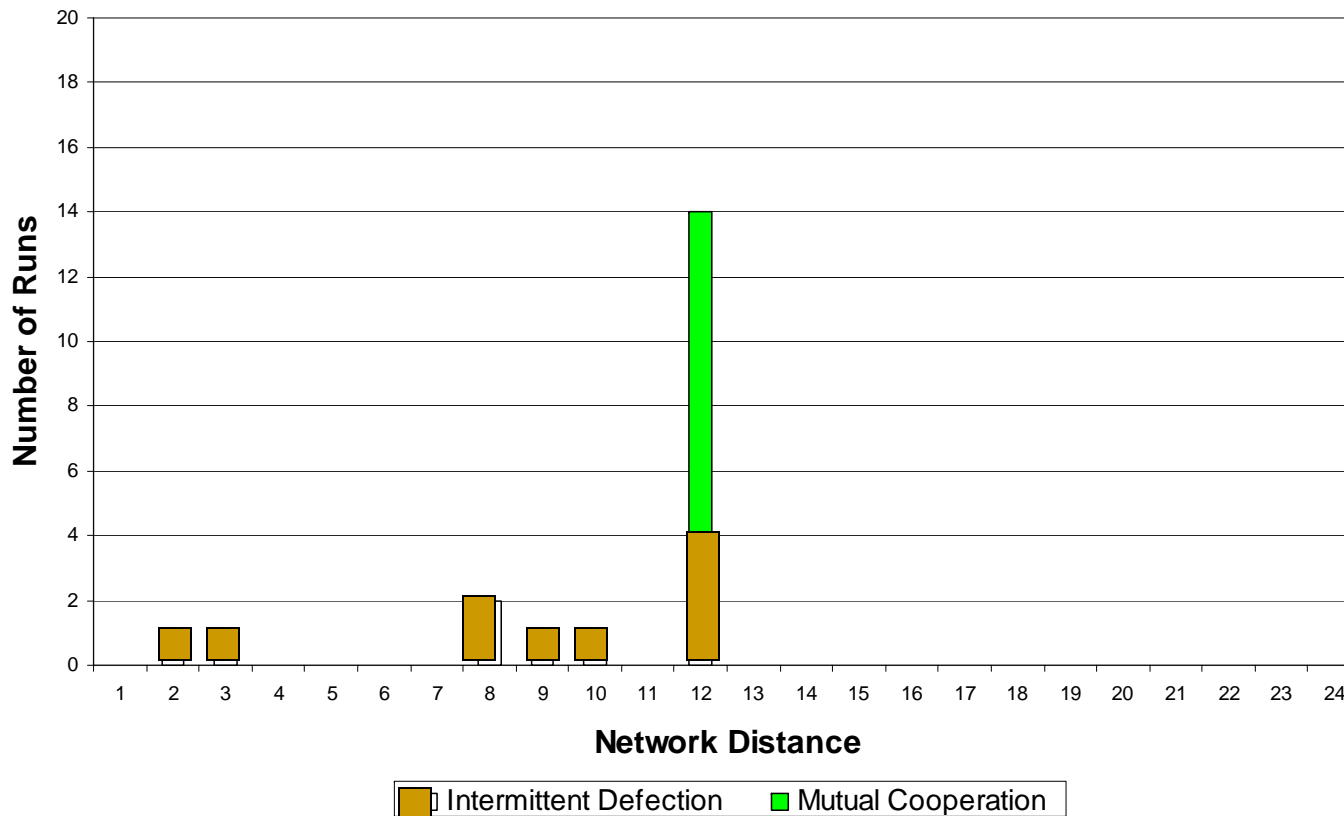
# Network Distribution for **NEP=15** Sampled at End of **Generation 12**

Network Distribution for LowT:12



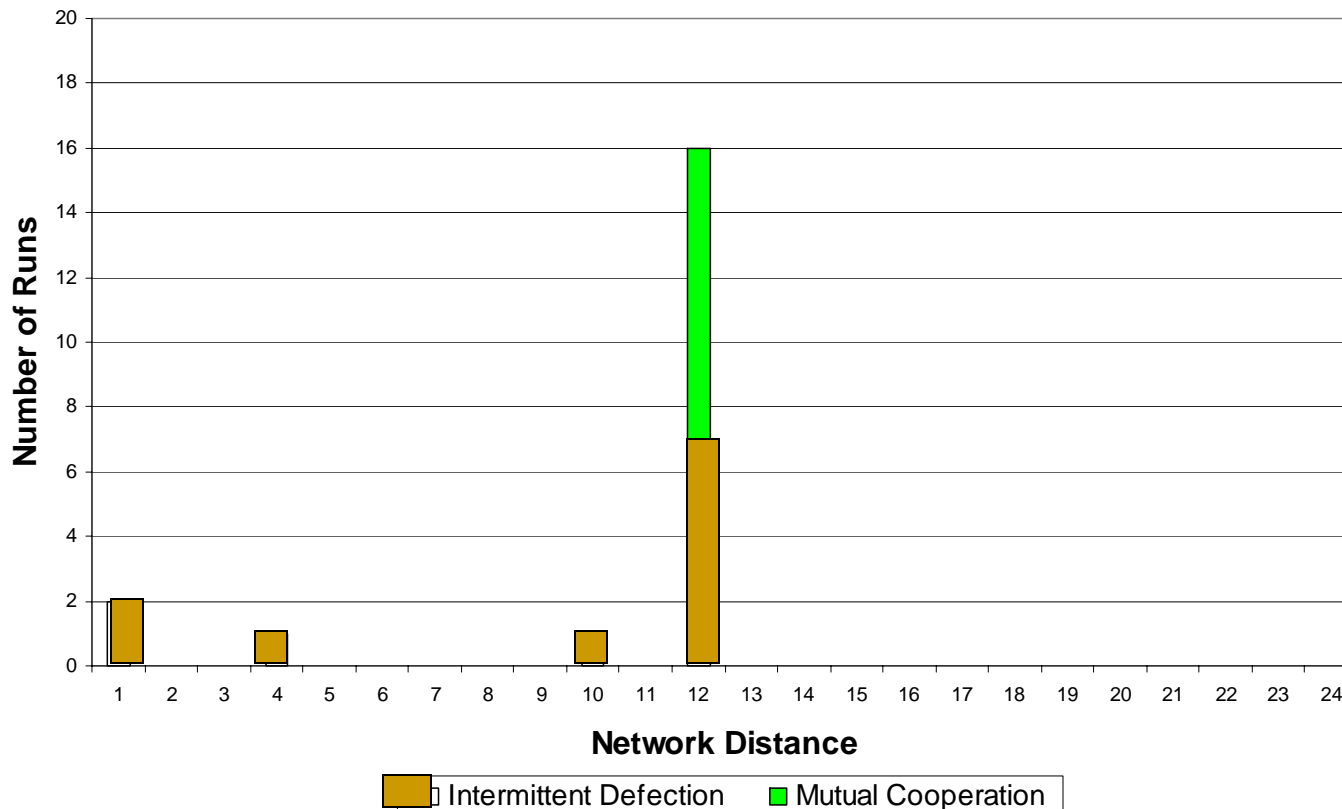
# Network Distribution for **NEP=15** Sampled at End of **Generation 50**

Network Distribution for LowT:50



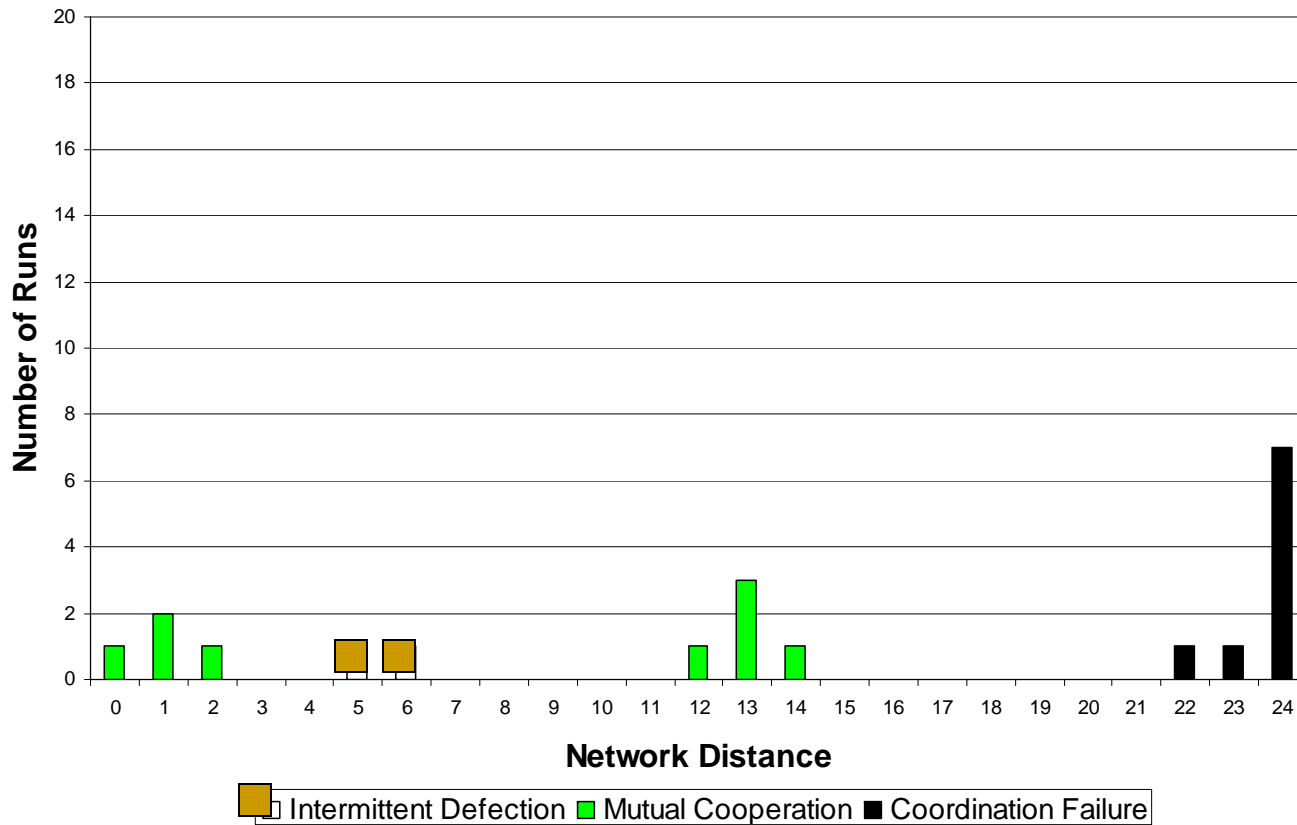
# Network Distribution for **NEP=15** Sampled at End of **Generation 1000**

Network Distribution for LowT:1000



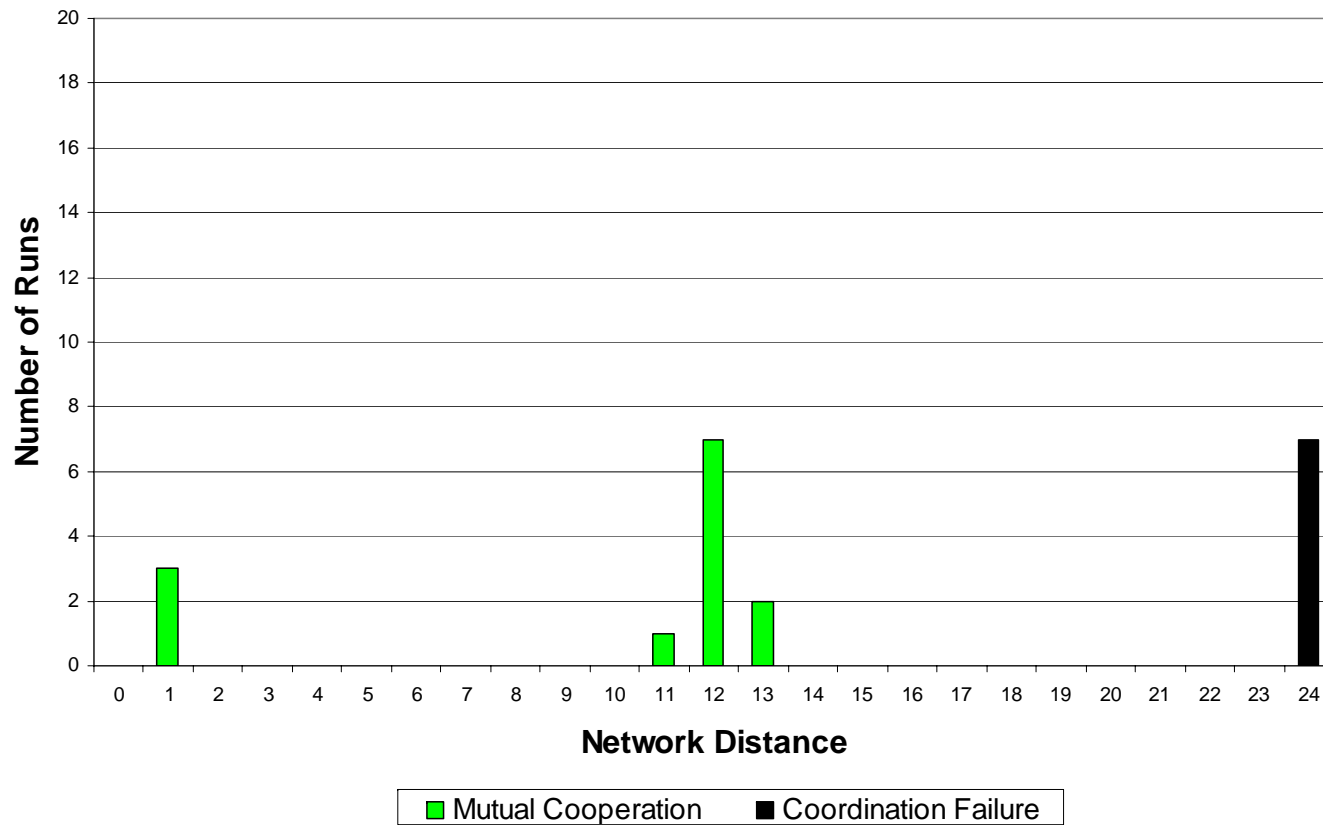
# Network Distribution for **NEP=30** Sampled at End of **Generation 12**

Network Distribution for HighT:12



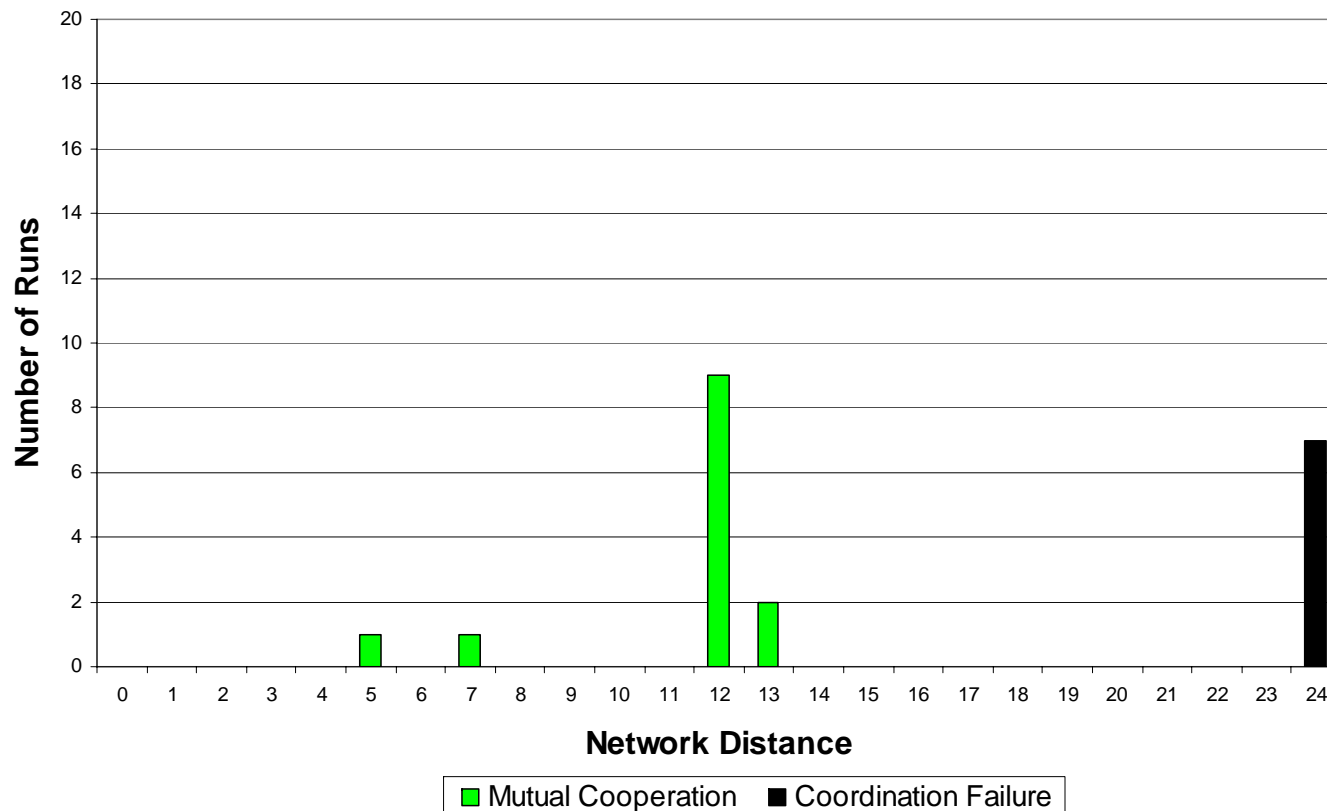
# Network Distribution for **NEP=30** Sampled at End of **Generation 50**

Network Distribution for HighT:50



# Network Distribution for **NEP=30** Sampled at End of **Generation 1000**

Network Distribution for HighT:1000



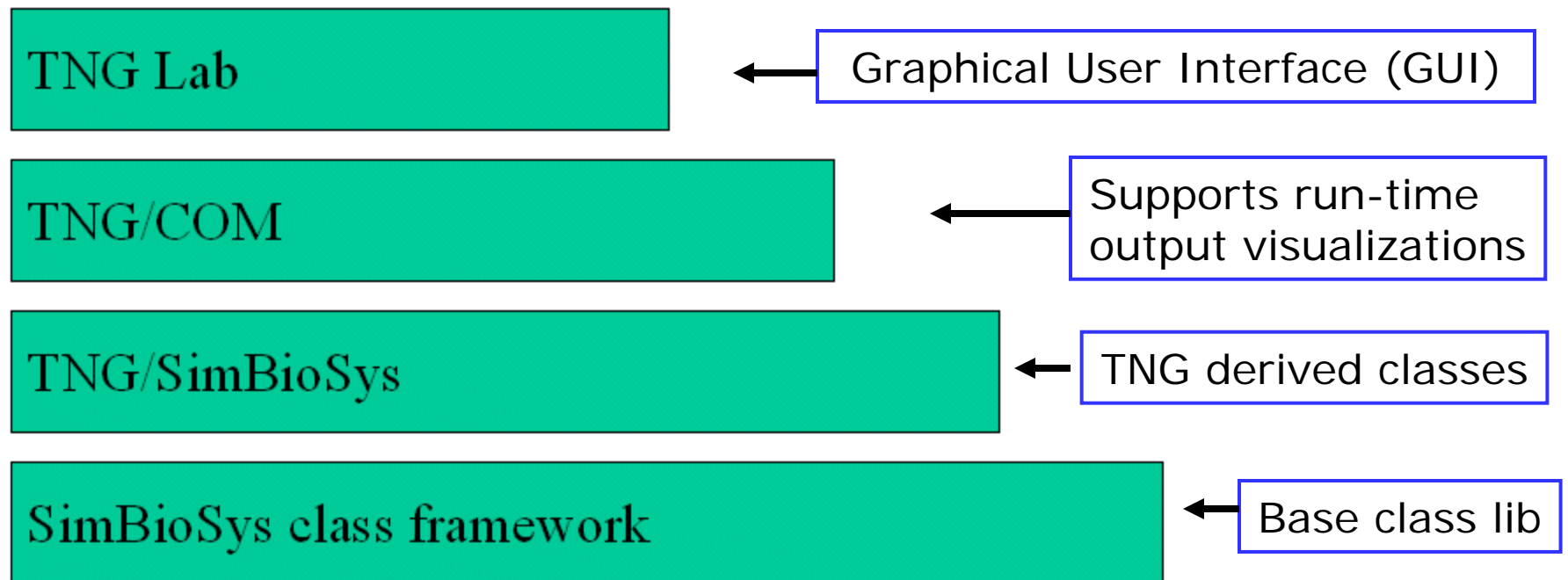
# Summary of Findings

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- ⊗ Changes in NEP *systematically* affect unemployment, vacancy, worksite behaviors, and welfare outcomes
- ⊗ Worker-employer networks tend to be either *fully latched in pairs* or *completely disconnected*
- ⊗ But... even fully latched networks support *spectral (multiple-peaked)* behavioral distributions (potential pooling problems)

# Implementation via Trade Network Game (TNG) Lab: Architecture of the TNG Lab

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**TNG Homepage:**

<http://www.econ.iastate.edu/tesfatsi/tnghome.htm> <sup>40</sup>

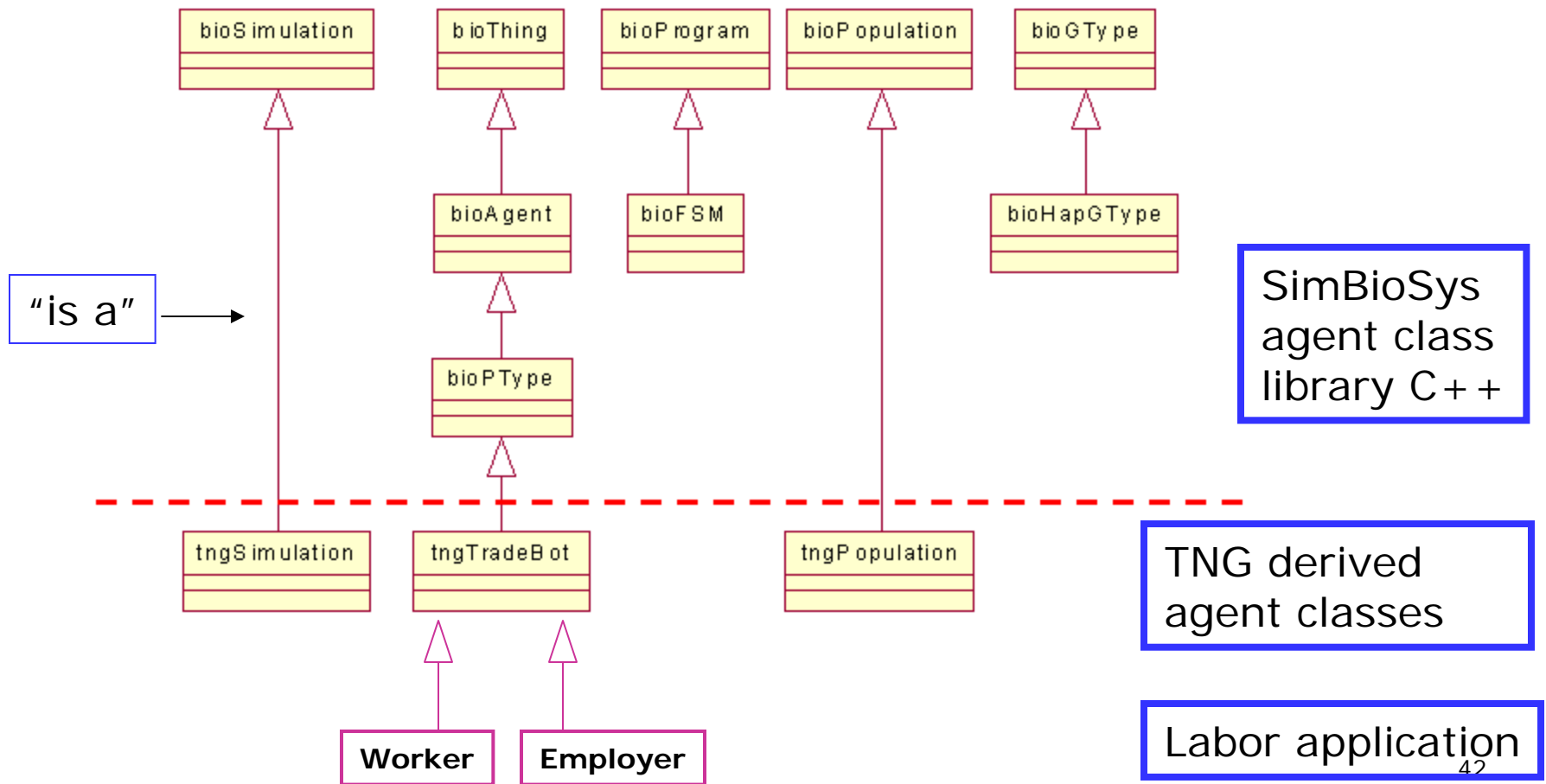
# SimBioSys Class Framework

(David McFadzean, M.S. Thesis, 1995)

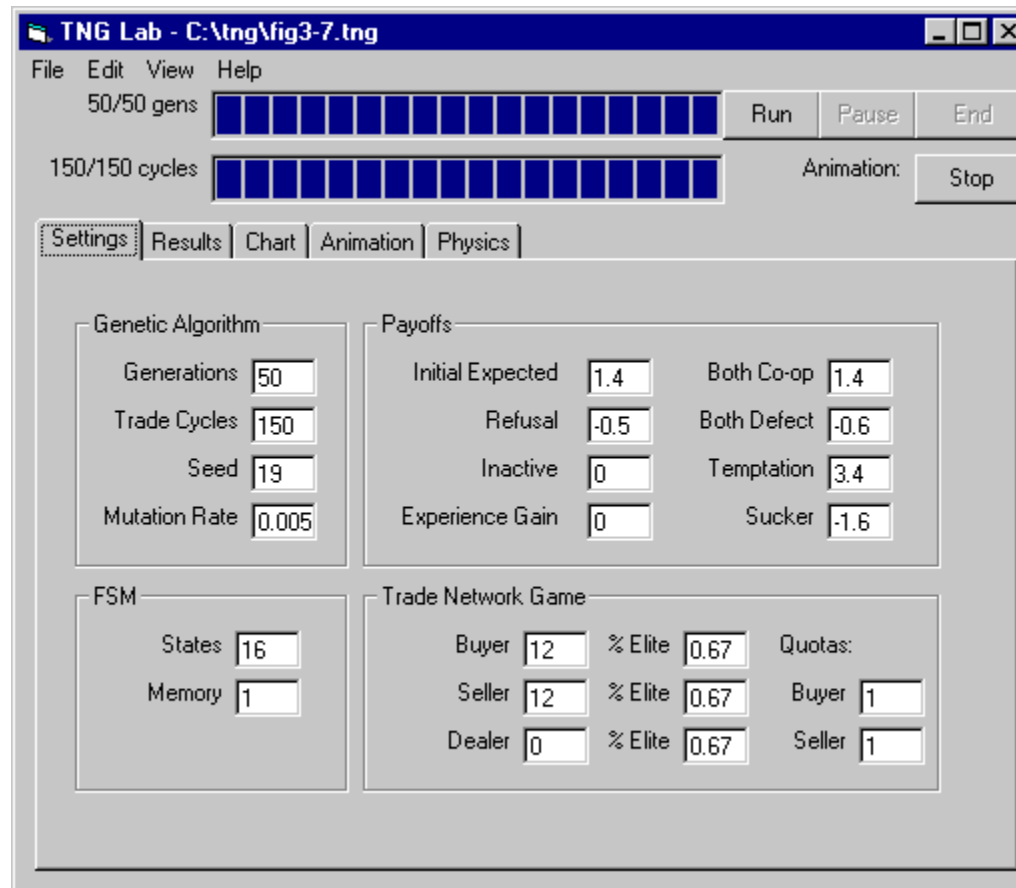
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- Simulation toolkit
- C++ class library
- Designed for artificial life simulations  
(populations of autonomous interacting agents evolving in a virtual spatial world)

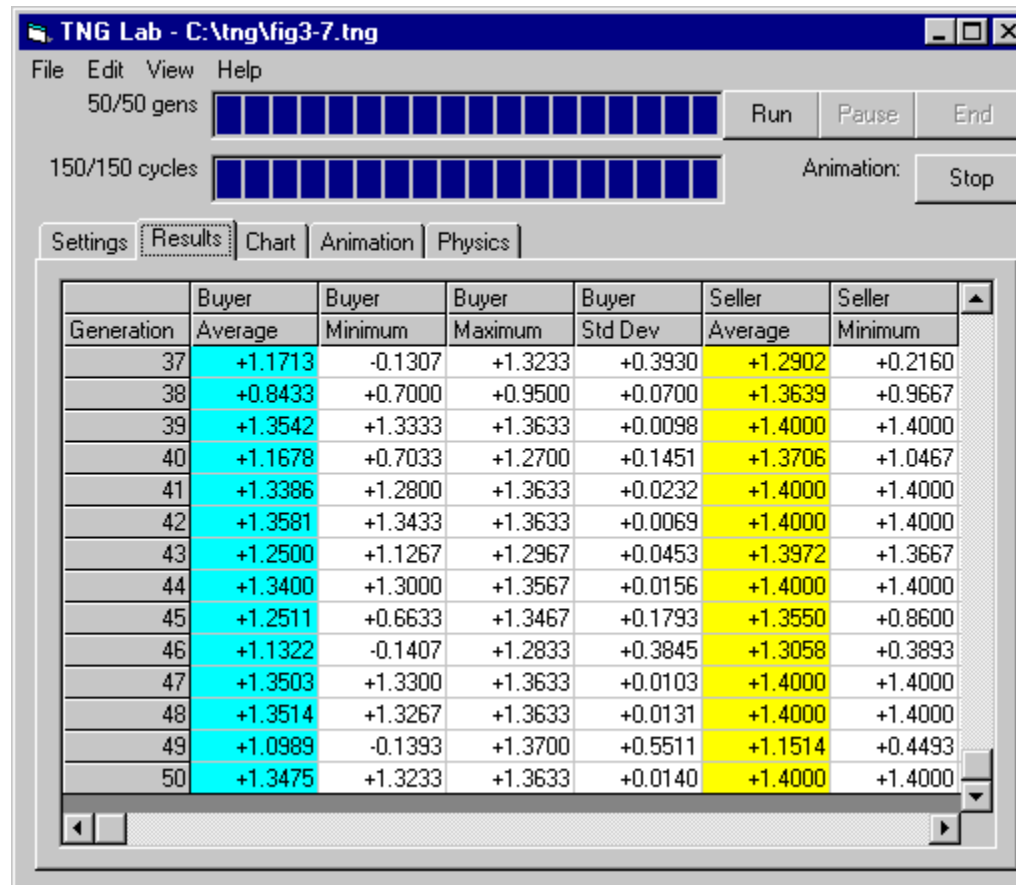
# TNG Lab: Agent Hierarchy in Unified Modeling Language (UML)



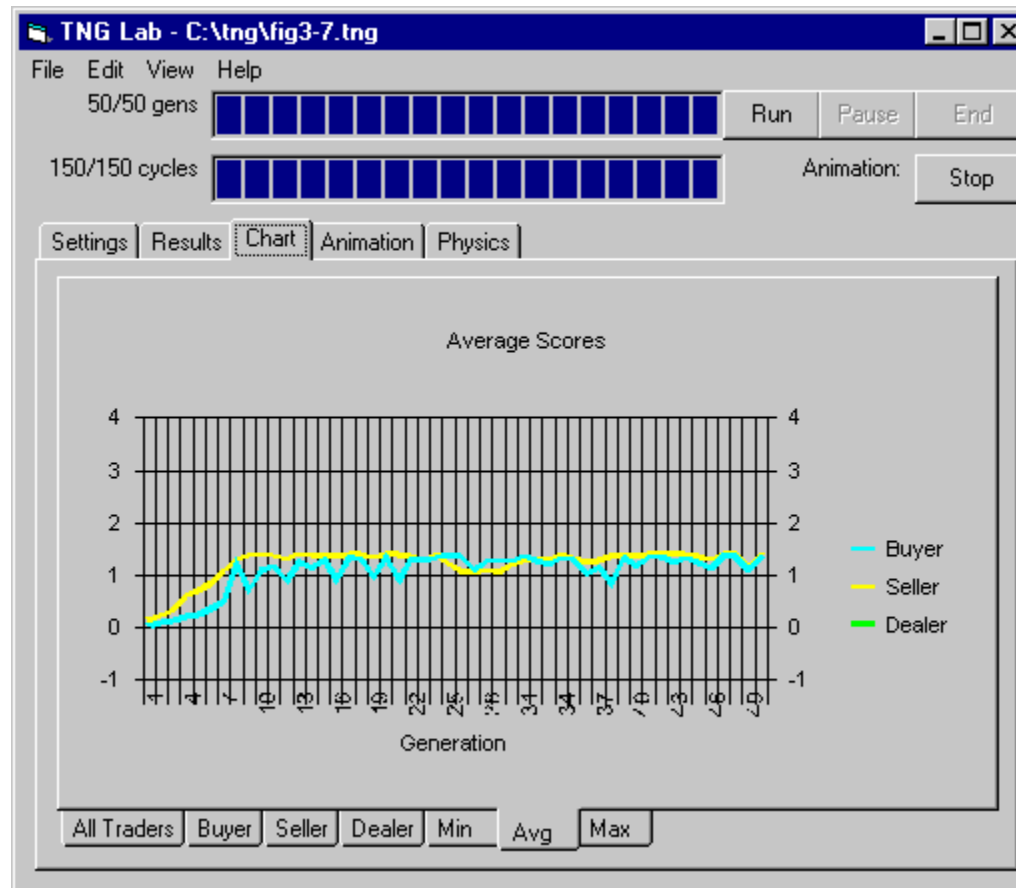
# TNG Lab Graphical User Interface (GUI) Settings Screen



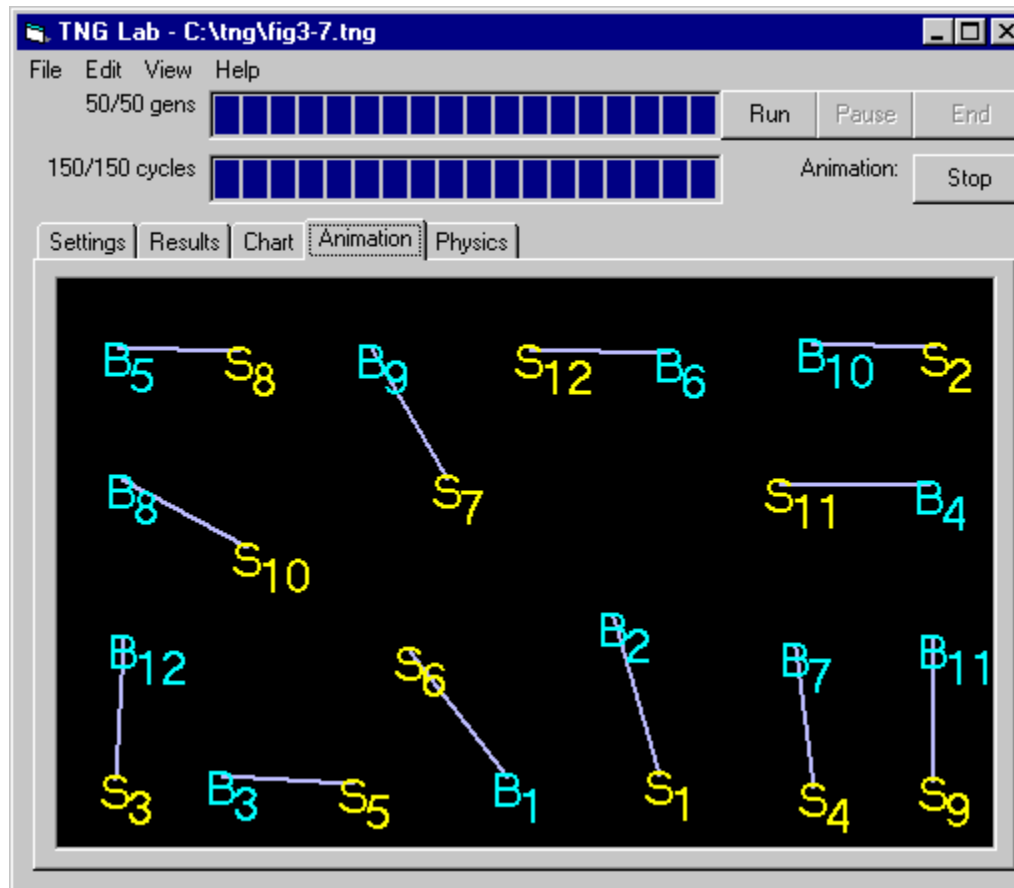
# TNG Lab GUI: Results Screen



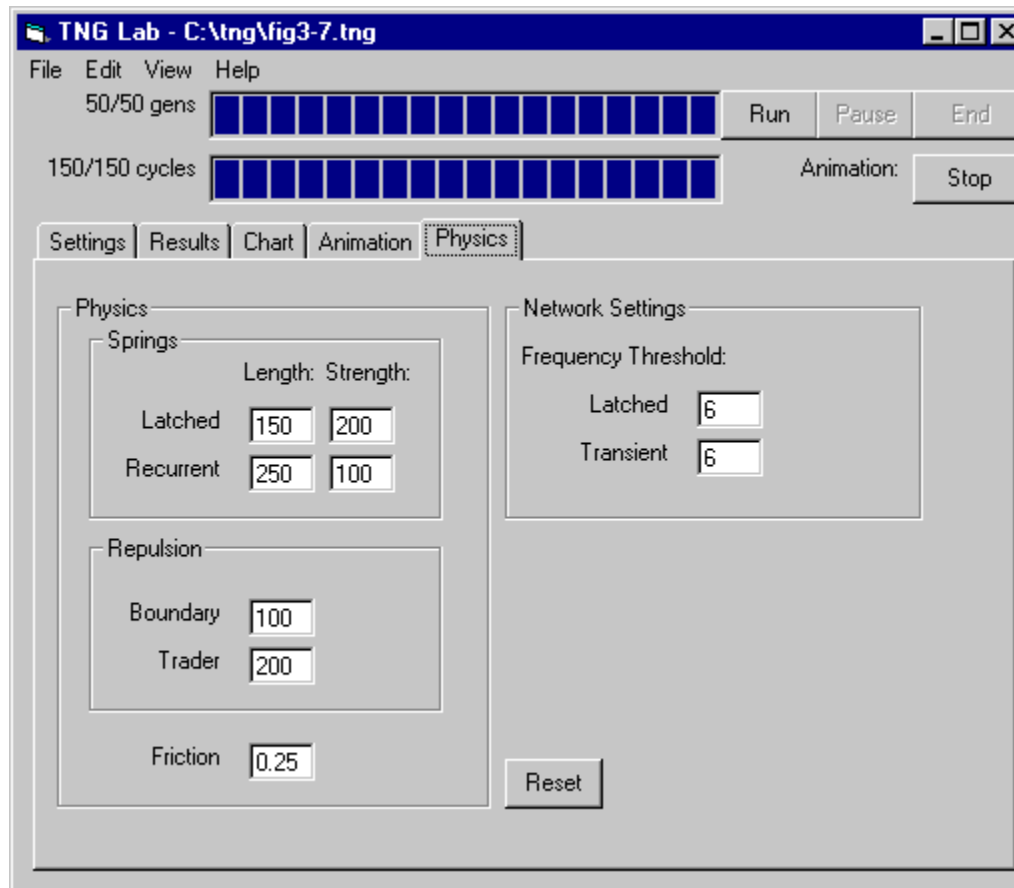
# TNG Lab GUI: Chart Screen



# TNG Lab GUI: Network Animation Screen



# TNG Lab GUI: Physics Screen



# Online Software Resources

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- **ACE General Software and Toolkits**

[www.econ.iastate.edu/tesfatsi/acecode.htm](http://www.econ.iastate.edu/tesfatsi/acecode.htm)

- **ACE Computational Laboratories**

[www.econ.iastate.edu/tesfatsi/acedemos.htm](http://www.econ.iastate.edu/tesfatsi/acedemos.htm)

- **Research Area: Development and Use of Computational Laboratories**

[www.econ.iastate.edu/tesfatsi/acomplab.htm](http://www.econ.iastate.edu/tesfatsi/acomplab.htm)

- **TNG Lab Homepage**

[www.econ.iastate.edu/tesfatsi/tnghome.htm](http://www.econ.iastate.edu/tesfatsi/tnghome.htm)