Agent-Based Modeling:

A Bridge Between Games & Social Sciences

Presenter:

Leigh Tesfatsion

Professor of Economics
Courtesy Professor of Mathematics
Iowa State University, Ames, IA
https://www2.econ.iastate.edu/tesfatsi/
tesfatsi@iastate.edu

Workshop
Office of Pre-collegiate Programs
for the Talented and Gifted (OPPTAG)
April 5, 2008

Presentation Outline

- What is **Agent-Based Modeling (ABM)**?
- Simple Hands-On Illustration: **Schelling Tipping Game**
- Schelling Tipping Game: **Demonstration Software**
- From Games to Practice: **ABM Commercial Applications**

What is ABM?

- Computational study of processes modeled as **dynamic systems of interacting agents**

- **Culture-dish approach**

ABM Culture-Dish Analogy

- Modeler constructs a “virtual world” on a computer populated by various **agent types**
- Modeler sets **initial world conditions**
- Modeler then steps back to observe how the **world develops over time**
- World events are **driven by agent interactions**

ABM Agent Types

Agents = Encapsulated software programs representing individual, social, biological and/or physical entities

✱ **Cognitive agents** are capable (in various degrees) of

- **Behavioral adaptation**
- **Social communication**
- **Goal-directed learning**
- **Endogenous evolution of interaction networks**
- **"Autonomy"** (self-activation and self-determinism based on private internal processes)

So who has seen ABM in action?

Conjecture = Everyone Has!!

From http://www.massivesoftware.com/showcase/film/

Eragon

Charlotte's Web

X-Men: Last Stand

Harry Potter:
Order of the Phoenix

Fellowship of the Ring (1st Trilogy)

Flags of Our Fathers

I,Robot

King Kong

Two Towers
(2nd in Trilogy)

Pirates of the Caribbean: World's End

Ratatouille

Night at the Museum

Movies, Movies, …

Happy Feet

Blades of Glory

Ant Bully

Elektra

Return of the King

World Trade Tower

Lion, Witch, & the Wardrobe

Live Free Or Die Hard

One Night with the King

Resident Evil: Extinction

Renaissance

300

And More Movies!!

ABM Hands-On Illustration: Schelling Tipping Game

Basic Motivation

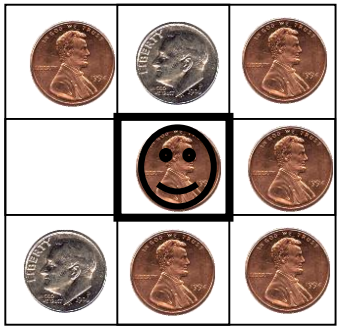
- **An interesting and important puzzle:**
  - after 1964, housing discrimination was illegal
  - since 1950, racial prejudice has declined
  - yet, neighborhoods remain highly segregated

- **T. C. Schelling (1978) hypothesized that segregation:**
  - does not need to be imposed (top-down)
  - does not reflect preferences (bottom-up)
  - self-organizes through dynamic interaction

Note: Schelling, a co-recipient of the 2005 Nobel Prize in Economics, is considered a "father" of ABM.

The Schelling Tipping Game

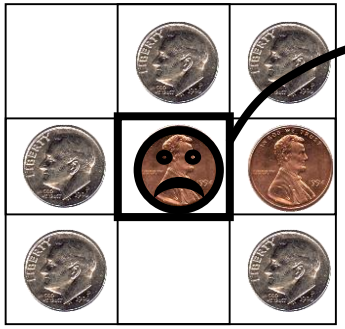
Micro-level rules of the game



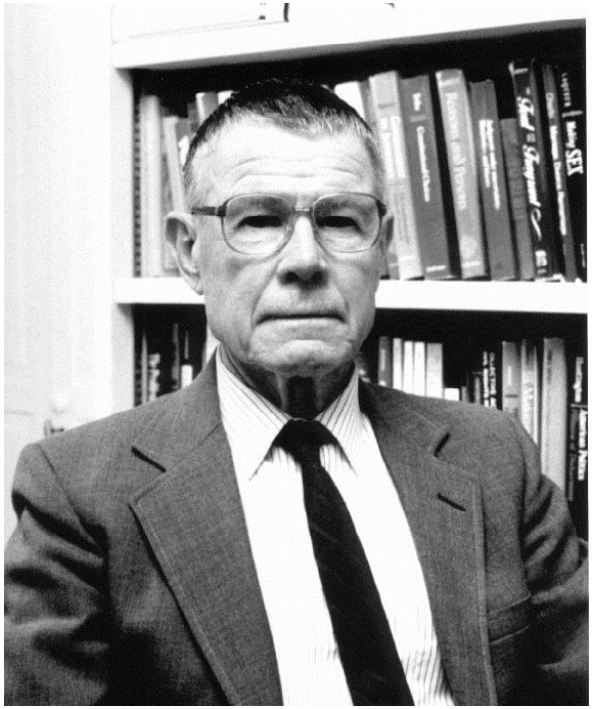
<u>Stay</u> if more than one third of your neighbors are "kin"

$> 1/3$

$\leq 1/3$



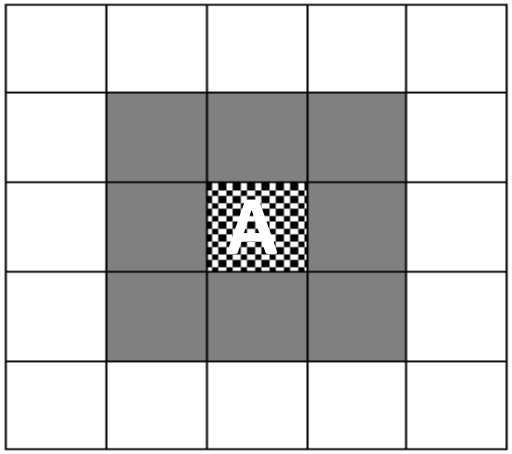
<u>Otherwise, move</u> to a random "tolerable" vacant location, if possible.



Thomas C. Schelling

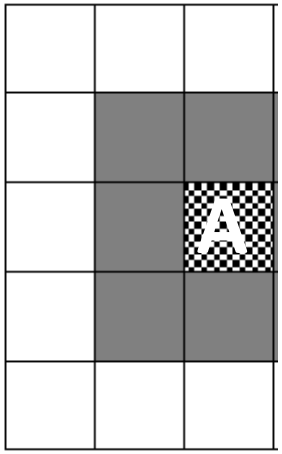
***Micromotives and Macrobehavior,* 1978**

Counting “Neighbors“ for an Agent A In the Schelling Tipping Game



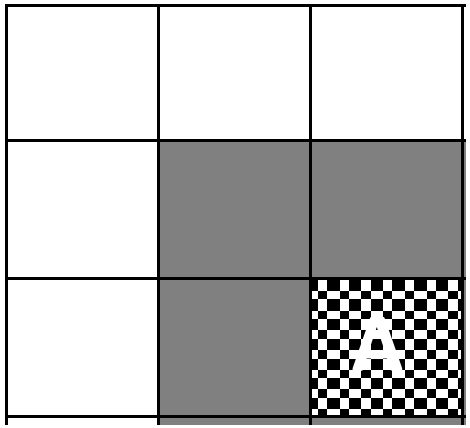
Interior agent A

up to 8 neighbors



Border agent A

up to 5 neighbors



Corner agent A

up to 3 neighbors

"Happiness Rule" for the Schelling Tipping Game

- An agent A is "happy" (no need to move) if **more than 1/3** of A's neighbors are of same type as A.
- **Top row of boxes**, below, gives the current total number of A's neighbors, from 0 to 8.
- **Bottom row of boxes**, below, gives how many of these neighbors must be the "same type" as A in order for A to be happy.

0	1	2	3	4	5	6	7	8
0	1	1	2	2	2	3	3	3

A's Total Neighbors

Starting Pattern for the Schelling Tipping Game

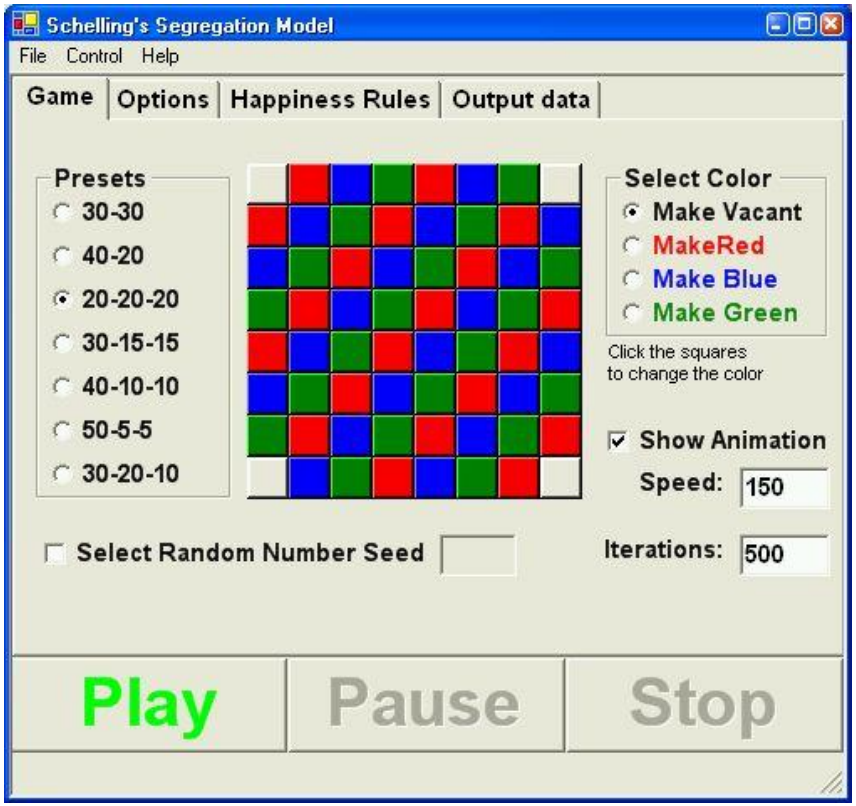
	o	x	o	x	o	x	
o	x	o	x	o	x	o	x
x	o	x	o	x	o	x	o
o	x	o	x	o	x	o	x
x	o	x	o	x	o	x	o
o	x	o	x	o	x	o	x
x	o	x	o	x	o	x	o
	x	o	x	o	x	o	

Now “Play the Game” !!

- Given the pattern on previous slide, everyone is happy and no one moves. Now **remove 10 agents randomly selected from the board.**
- Next, starting from the top row and moving from left to right, row by row, **check for an unhappy agent**.
- Every time you encounter an unhappy agent, **if possible move this unhappy agent** to a “tolerable” vacant square where he is happy; **otherwise remove him**.
- Keep going until there are no unhappy agents left on the board. What degree of segregation is displayed in the **resulting agent location pattern**?

Extended Schelling Tippling Game Demo

Basic Model by T. Schelling; Demo developed by C. Cook
https://www2.econ.iastate.edu/tesfatsi/acedemos.htm

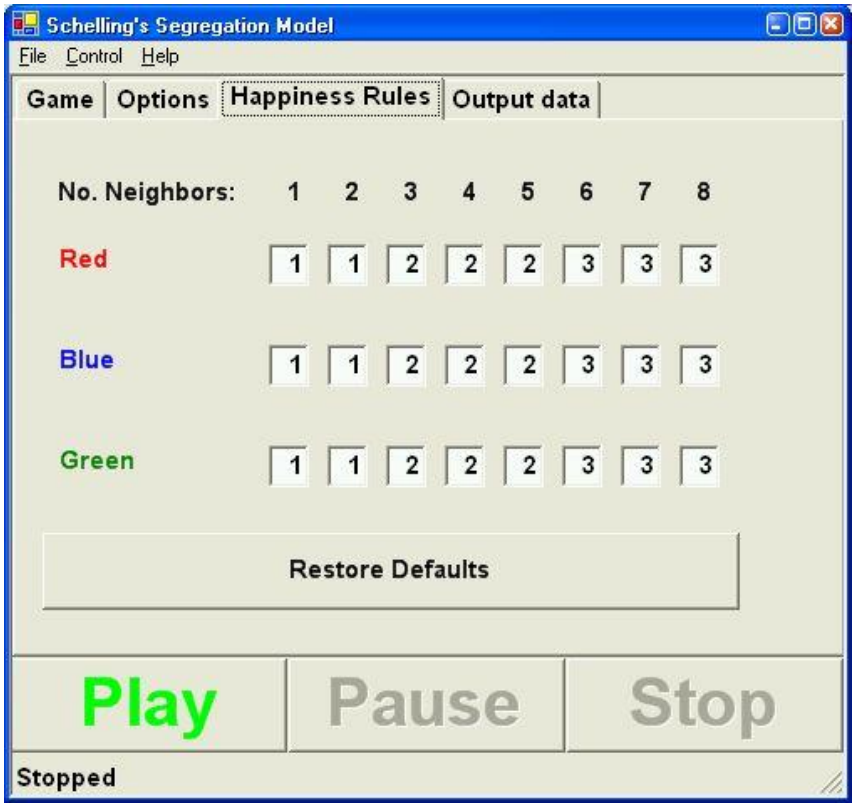


- Checkerboard city model
- **Three** agent types (**red**, **blue**, **green**), plus vacant locations
- Agents satisfied with their location if "enough" of their neighbors are of their own type; otherwise, they move.

➢ **KEY FINDING:** City can "tip" into high segregation even if agents have only mild preferences for living with agents of their own type!

Schelling Tipping Game Demo … Continued

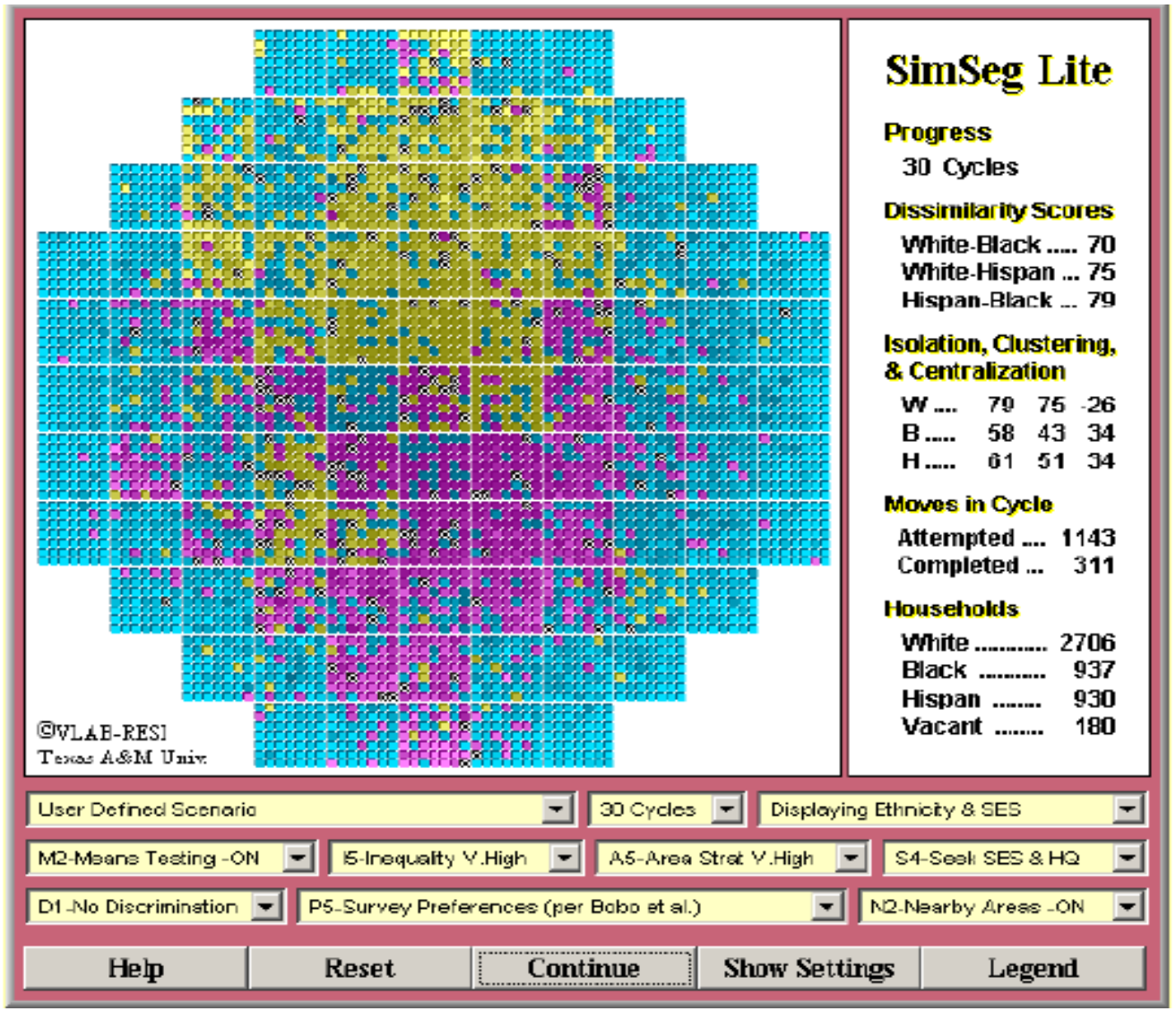
(Agent Happiness Rules)



- User specifies a happiness rule for each **agent type** (**red**, **blue**, or **green**)
- User specifies a **happiness rule** for each agent type: *Given an agent A with n neighbors (between 1 and 8), how many have to be the same type (color) as A in order for A to be happy at its current location?*
- Unhappy agents attempt to move to vacant spots at which they would be happy.
- Does this cause the city to "tip" into a segregated pattern?

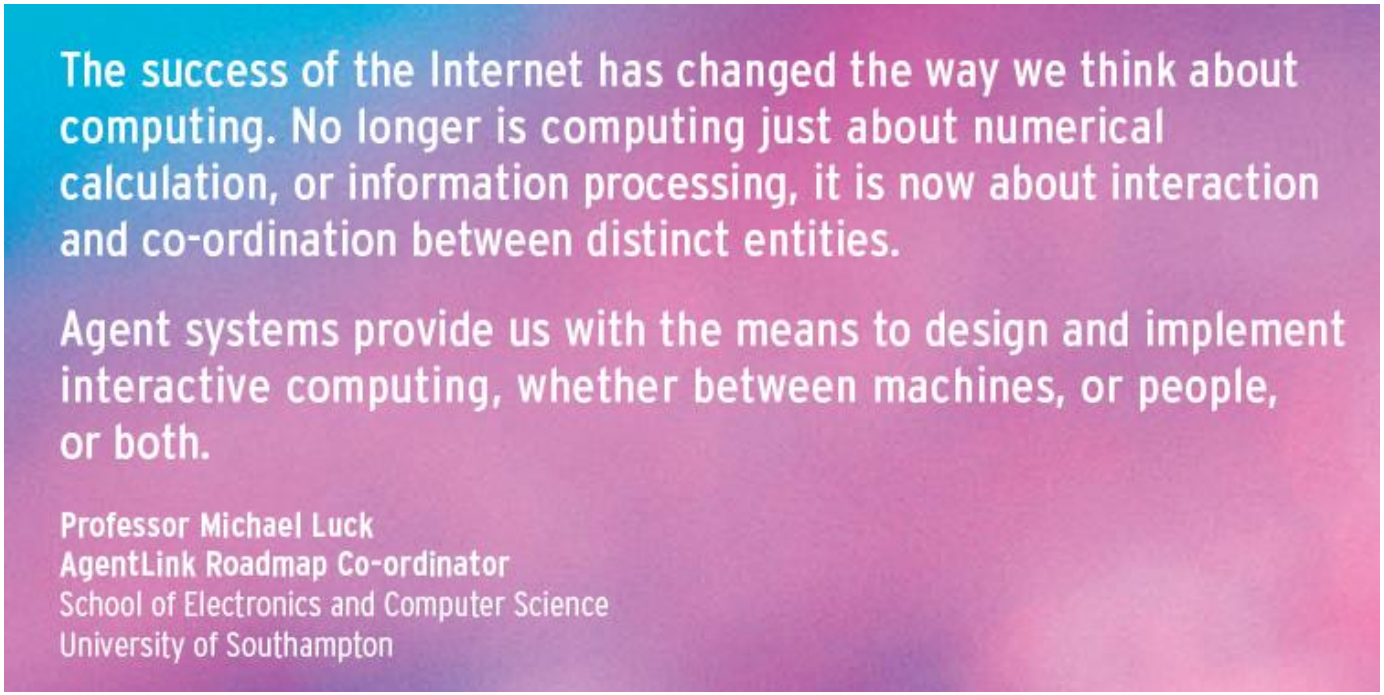
A More Advanced Version of the Schelling Tipping Game

(Mark Fossett, Texas A&M University, sociweb.tamu.edu/vlabresi/sslite3.htm)



Numerous Commercial ABM Applications

https://www2.econ.iastate.edu/tesfatsi/AgentLink.50CommercialApplic.MLuck.pdf



Examples:

Satellites, primary health care, business management, Internet auctions (eBay), insurance claims processing, large-scale transport, movies, manufacturing, telecommunications, deep-space exploration, product distribution routing, military gaming, autonomic computing, flexible manufacturing, Roomba vacuums, shopbots, pricebots, scheduling, …

In Summary: Why ABM?

- **a technique for theorizing**
  - designed to address complex real-world issues
- **a practical approach to real-world issues**
  - that permits modeling tools to be adapted to the problem instead of having to adapt the problem to the tools
- **and a fun way to explore real-world issues**
  - that permits creative experimentation with new ideas and
  - encourages “out of control” programming that can surprise and inform

On-Line ABM Resources

- **On-Line Guide for Newcomers to ABM**
  https://www2.econ.iastate.edu/tesfatsi/abmread.htm

- **Chris Cook's Schelling Demo (plus many more)**
  https://www2.econ.iastate.edu/tesfatsi/acedemos.htm

- **Self-Study Guide/eBook for ABM (econ stressed)**
  https://www2.econ.iastate.edu/classes/econ308/tesfatsion/