

Agent-Based Modeling: A Bridge Between Games & Social Sciences

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Outline

- ◇ What is **Agent-Based Modeling (ABM)** in a nutshell?
- ◇ Simple **Hands-On Illustration:**
The Schelling Tipping Game
- ◇ **Demonstration Software** for the Schelling Tipping Game
- ◇ From Game Demos to Practical Use:
Commercial Applications of ABM

What is ABM?

- ◆ Computational study of processes modeled as dynamic systems of interacting agents
- ◆ A 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

- Schelling was a co-recipient of the 2005 Nobel Prize in Economics. He is considered a “father” of ABM.

The Schelling Tipping Game

Micro-level rules of the game



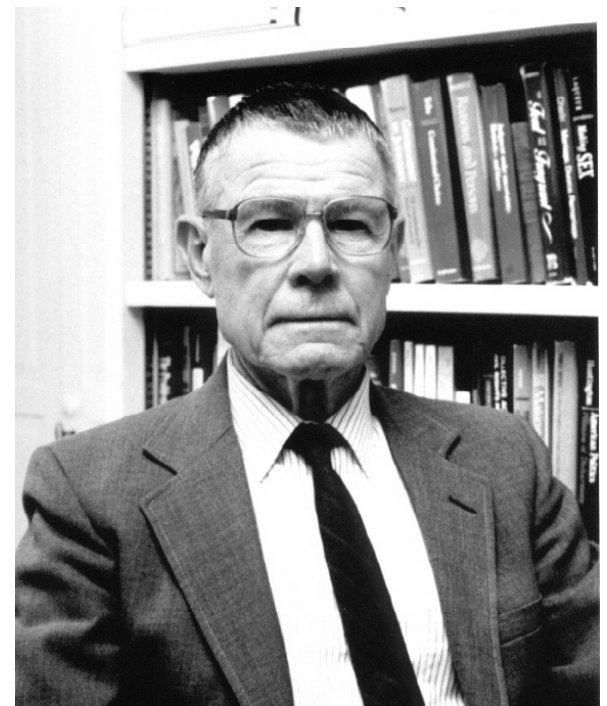
Stay if **more than one third** of your neighbors are "kin"

$> 1/3$



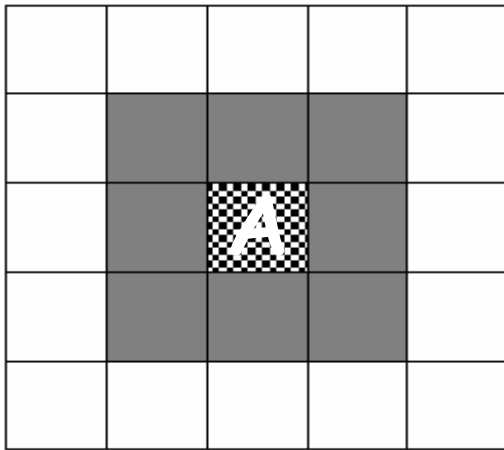
$\leq 1/3$

Move to random "tolerable" vacant location otherwise, if possible.

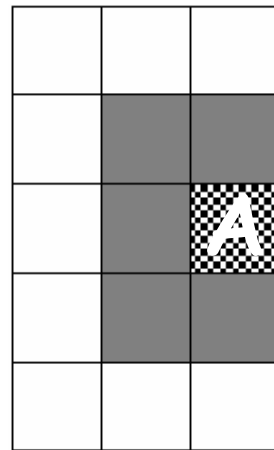


Thomas C. Schelling
*Micromotives and
Macrobavior*, 1978

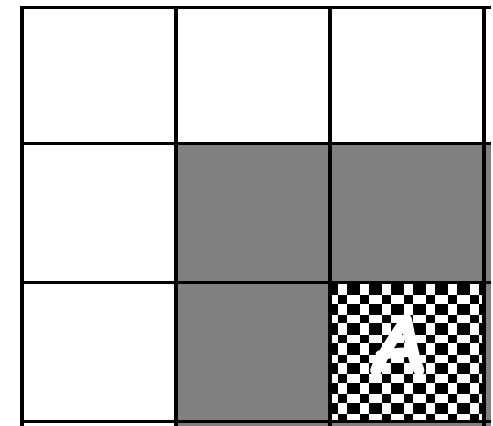
Counting "Neighbors" for the Schelling Tipping Game



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

- ◆ Each agent is "happy" (no need to move) if **more than 1/3** of its neighbors are of same type.
- ◆ Boxes below give number of neighbors that must be "same type" for happiness given the total neighbors an agent has, from 0 to 8.

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

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	

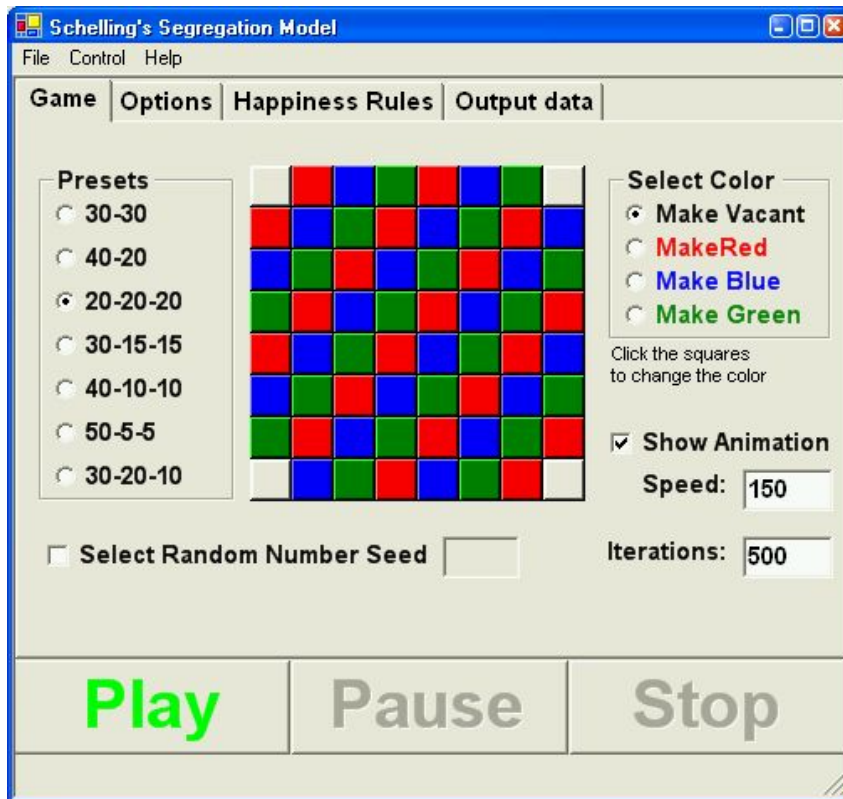
Now "Play the Game" !!

- ◆ Given the pattern on previous slide, everyone is happy and no one moves. Now **remove 10** randomly selected agents from the board.
- ◆ Starting from the top row, moving from left to right, row by row, **check for unhappy agents**.
- ◆ Every time you encounter an unhappy agent, **if possible move him** 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 does the **resulting pattern** display?

Extended Schelling Tippling Game Demo

Basic Model by T. Schelling; Demo developed by C. Cook

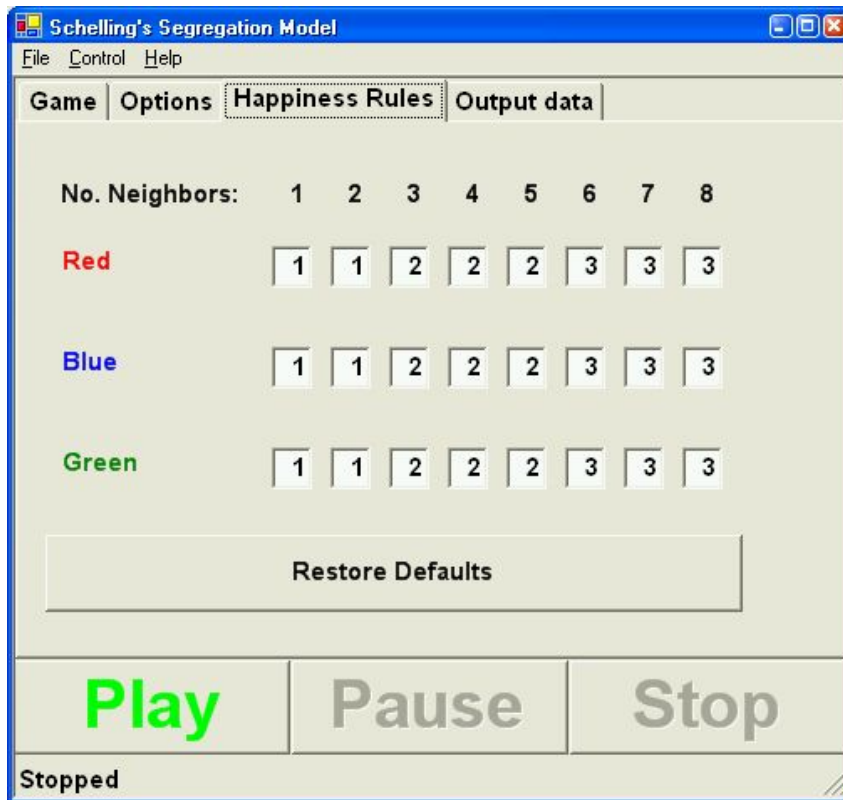
<http://www.econ.iastate.edu/tesfatsi/acedemos.htm>



- ❑ Checkerboard city model
- ❑ 3 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
- Given n neighbors, how many have to be like me in order for me to be happy at my current location?
- Unhappy agents attempt to move to vacant spots at which they would be happy.
- Does this cause city to "tip" into a segregated pattern?

A More Advanced Version of the Schelling Tipping Game (Mark Fossett, Texas A&M, sociweb.tamu.edu/vlabresi/sslite3.htm)

SimSeg Lite

Progress
30 Cycles

Dissimilarity Scores
White-Black 70
White-Hispan ... 75
Hispan-Black ... 79

Isolation, Clustering, & Centralization
W 79 75 26
B 58 43 34
H 61 51 34

Moves in Cycle
Attempted 1143
Completed ... 311

Households
White 2706
Black 937
Hispan 930
Vacant 180

©VLAB-RESI
Texas A&M Univ.

User Defined Scenario | 30 Cycles | Displaying Ethnicity & SES

M2-Means Testing -ON | I5-Inequality V.High | A5-Area Strat V.High | S4-Seek SES & HQ

D1-No Discrimination | P5-Survey Preferences (per Bobo et al.) | N2-Nearby Areas -ON

Help | Reset | Continue | Show Settings | Legend

Numerous Commercial ABM Applications

www.econ.iastate.edu/tesfatsi/AgentLink.50CommercialApplic.MLuck.pdf

The success of the Internet has changed the way we think about computing. No longer is computing just about numerical calculation, or information processing, it is now about interaction and co-ordination between distinct entities.

Agent systems provide us with the means to design and implement interactive computing, whether between machines, or people, or both.

Professor Michael Luck
AgentLink Roadmap Co-ordinator
School of Electronics and Computer Science
University of Southampton

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, shop/price bots, scheduling,...

In Summary: Why ABM?

- a technique for theorizing
 - that is 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
 - that encourages "out of control" programming that can surprise and inform

On-Line ABM Resources

- ◆ **On-Line Guide for Newcomers to ABM**
www.econ.iastate.edu/tesfatsi/abmread.htm
- ◆ **Chris Cook's Schelling Demo (plus many more)**
www.econ.iastate.edu/tesfatsi/acedemos.htm
- ◆ **Self-Study Guide/eBook for ABM (econ stressed)**
www.econ.iastate.edu/classes/econ308/tesfatsion/