Introduction to Complex Problems

Robert Brown

Miles McNall

Innovations in Collaborative Modeling
East Lansing, Michigan
June 4, 2015

Track Two Overview

Thursday, June 4

9:30 – 10:50 AM	Introduction to Complex Problems
11:00 AM – 12:00 PM	Panel Discussion: Building Sustainable Community-University Participatory Modeling Partnerships
1:20 – 2:30 PM	Social Network Analysis Demonstration
2:50 – 4:10 PM	Agent-based Modeling Demonstration
4:20 PM – 5:20	Topical Networking Session

Friday, June 5

9:30 – 12:10 AM	Participatory System Dynamics Modeling
1:40 – 3:00 PM	Demonstration: Modeling the Detroit Food System

Introduction to Complex Problems

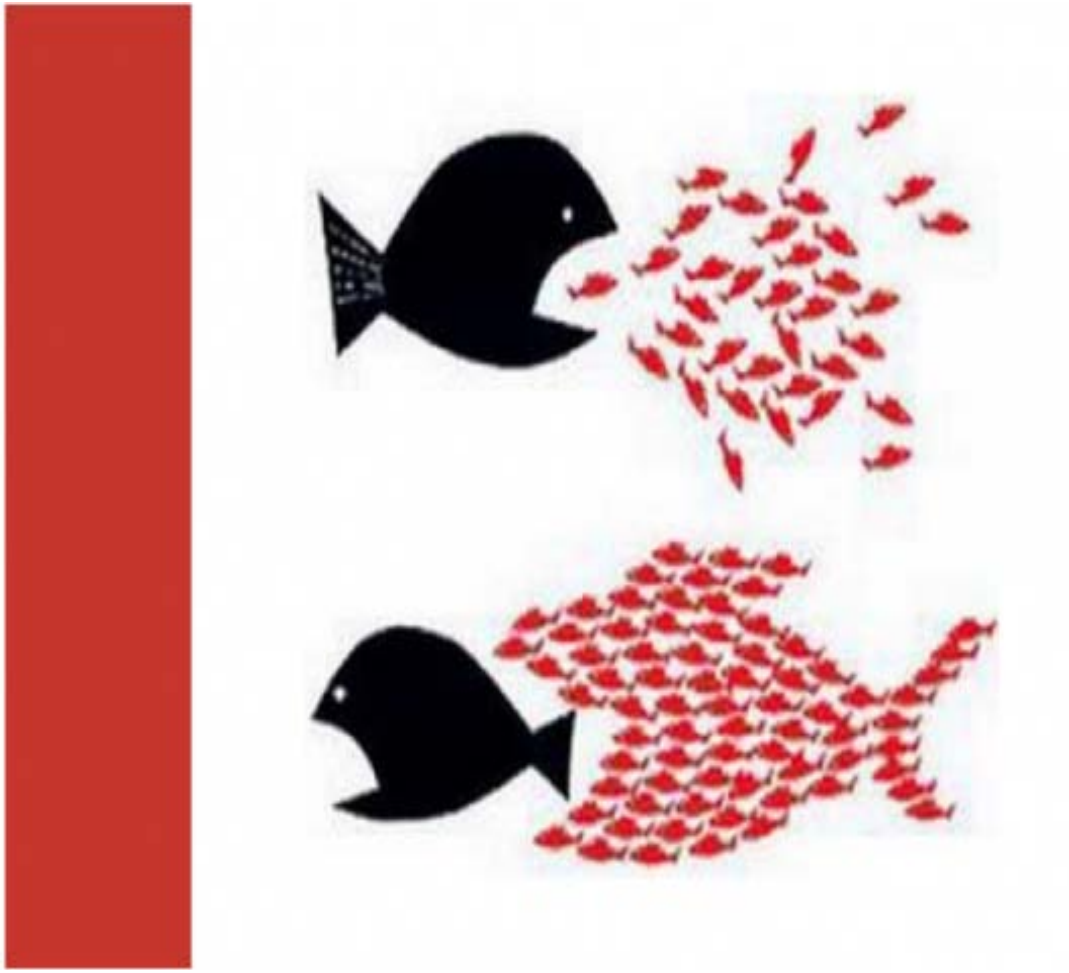
I. Characteristics of Complex Issues/Problems

II. Systems Thinking and Modeling

III. System Mapping

I. Understanding Characteristics of Complex Issues/Problems

Situation Matters



Simple Situations

Following a Recipe

- Right recipe essential
- "Best practices" can be defined
- Gives same results (almost) every time
- What needs to be done is *known*

Glouberman & Zimmerman, 2004

Complicated Situations

Sending a Rocket to the Moon

- Coordination and integration of many areas of technical knowledge and expertise
- Formula are required
- The faithful execution of precisely defined protocols increases the chances of success
- What needs to be done is *knowable*

Glouberman & Zimmerman, 2004

Complex Situations

Raising a Child

•No “right” recipes or protocols

•Experience helps, but it doesn’t guarantee success

•What needs to be done is *unknowable* in advance

Glouberman & Zimmerman, 2004

Cynefin *(kun-ev'in)* Framework

KNOWN – SIMPLE	KNOWABLE – COMPLICATED
• Cause and effect relationships are repeatable, perceivable, and predictable • **Best practices and standard operating procedures are possible** • **Process reengineering**	• Cause and effect are separated over time and space • **System analysis** • **Scenario planning**
UNKNOWABLE IN ADVANCE – COMPLEX	**UNKNOWABLE EVER – CHAOS**
• Cause and effect are only coherent in retrospect and do not repeat • Complex adaptive systems • **Pattern management**	•No cause and effect relationships are perceivable •**Stability the focus of interventions** •**Crisis management**

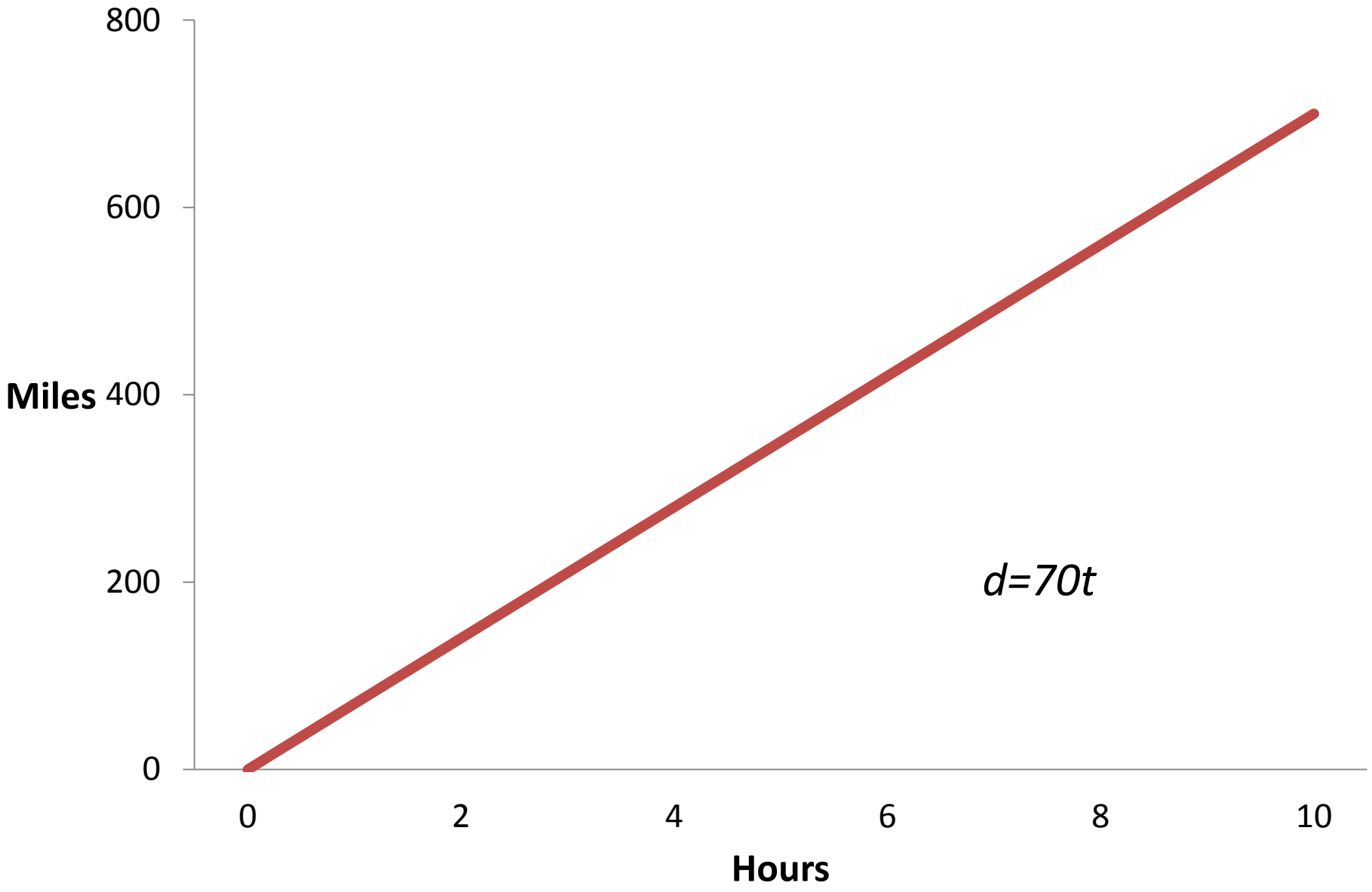
Snowden and Boone, 2007

Characteristics of Complex Systems

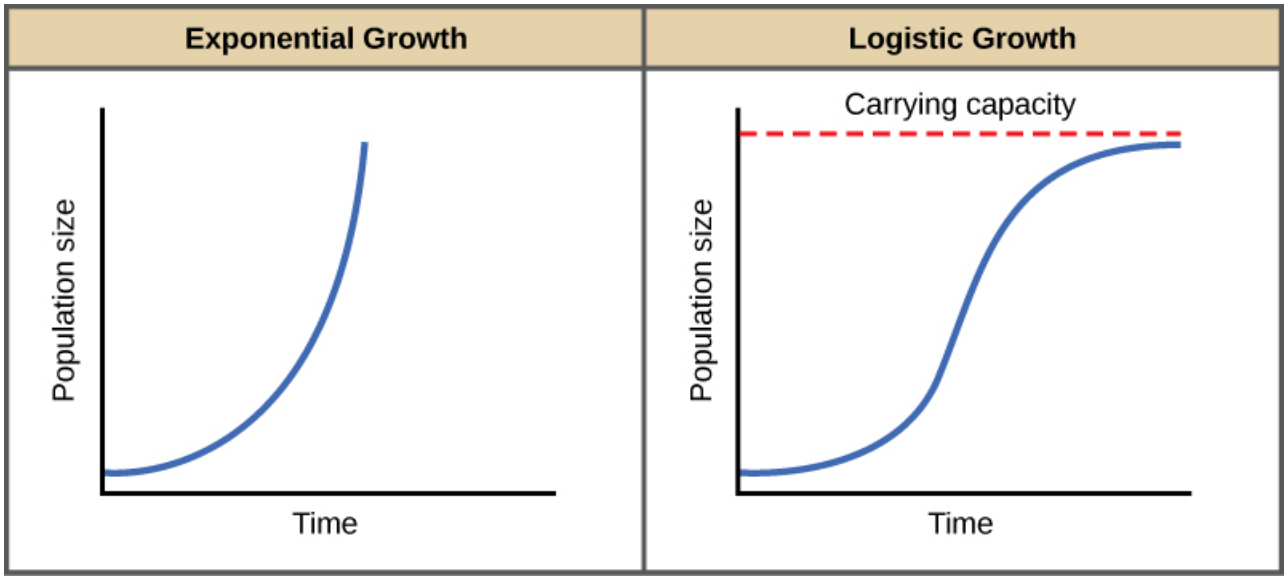
- Nonlinear
- Emergent
- Dynamical
- Adaptive
- Uncertain

Patton, 2011

Linear



Non-linear



Source: https://www.boundless.com/biology/textbooks/boundless-biology-textbook/population-and-community-ecology-45/environmental-limits-to-population-growth-251/exponential-population-growth-929-12185/

Emergence

http://www.trojanmice.com/articles/complexadaptivesystems.htm

Dynamic

https://c1.staticflickr.com/5/4077/4874375445_860972092a_b.jpg

Adaptive

http://en.wikipedia.org/wiki/Anti-predator_adaptation#/media/File:Phrynosoma_mcallii.jpg

Uncertainty

II. Systems Thinking and Modeling

A very brief introduction

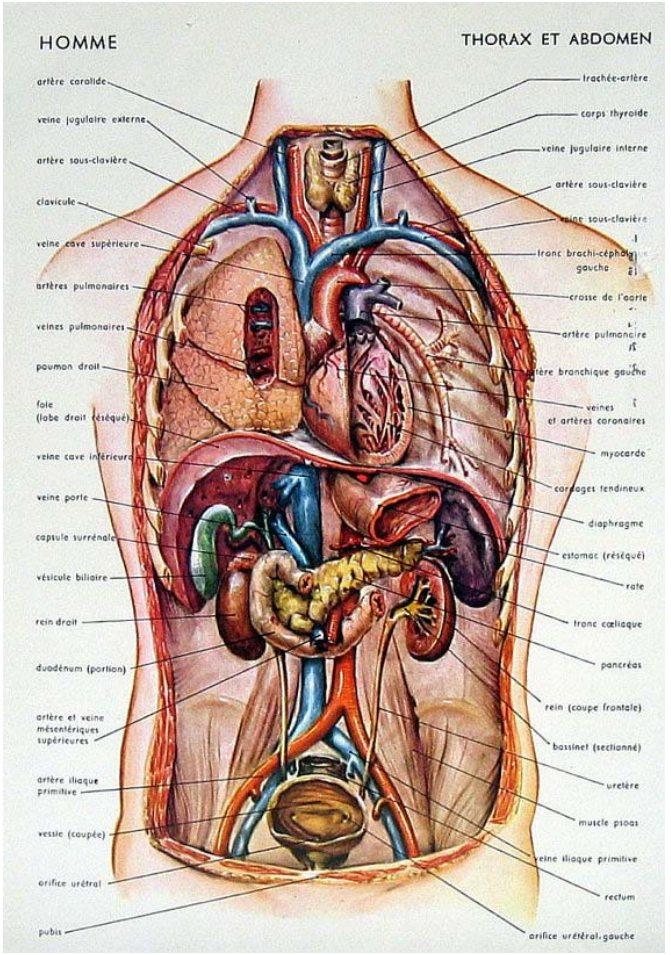
Why Systems Thinking and Modeling?

Complexity

What is a System?

"A system is a group of **interacting**, interrelated, or interdependent **components** that form a complex and unified **whole**"

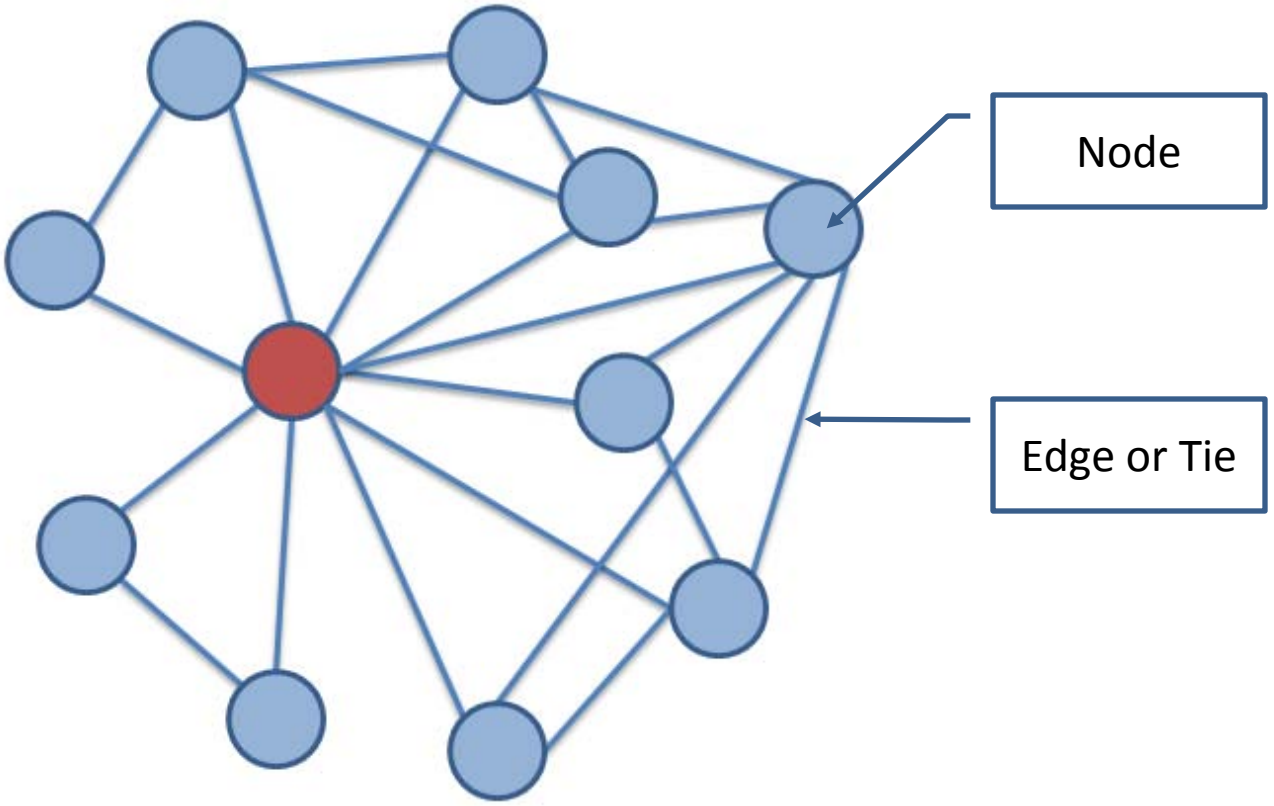
(Anderson & Johnson, 1997, p. 2)



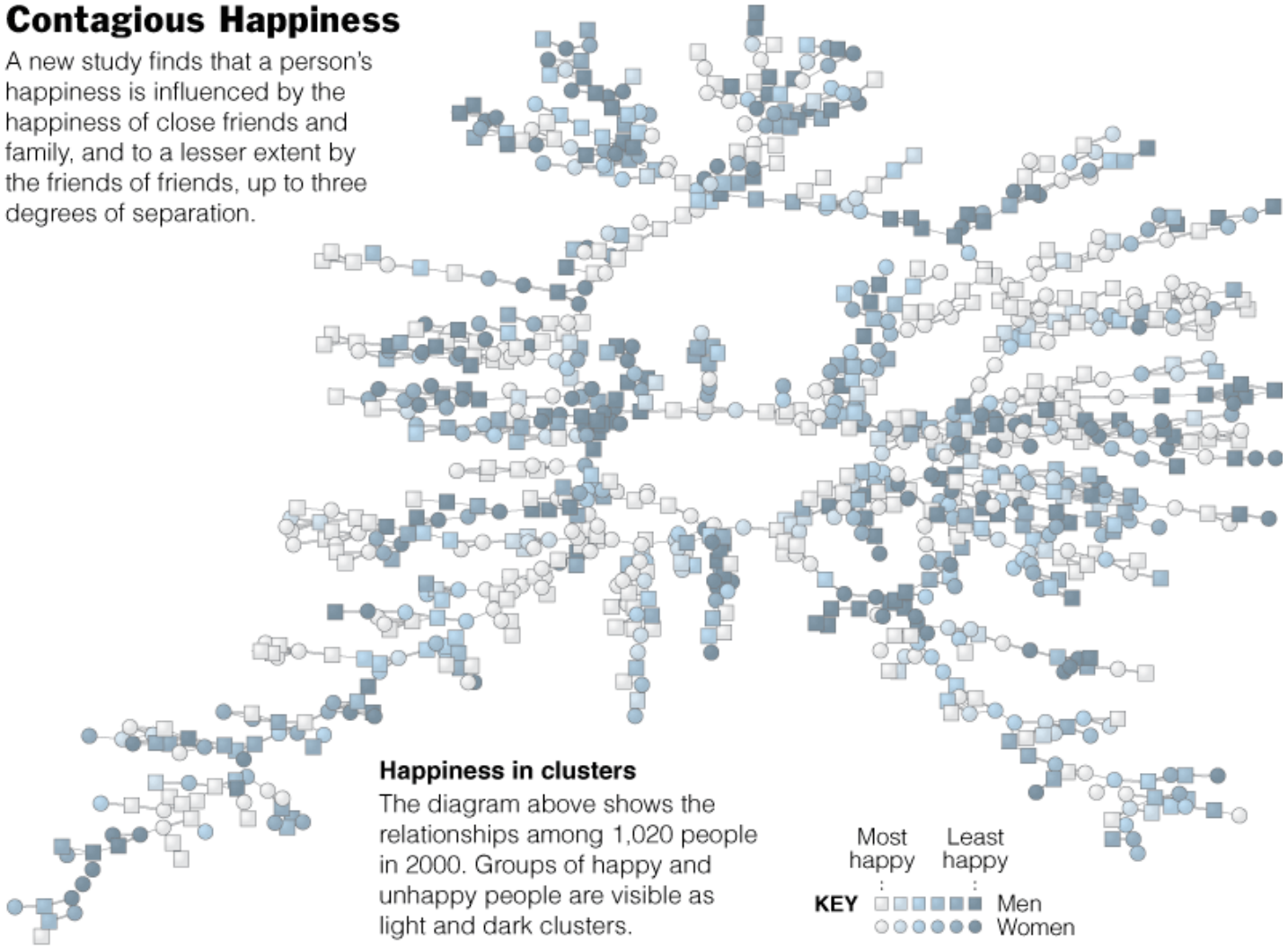
Systems Sciences

- System Dynamics Modeling
- Agent-based Modeling
- Social Network Analysis

Social Network Analysis

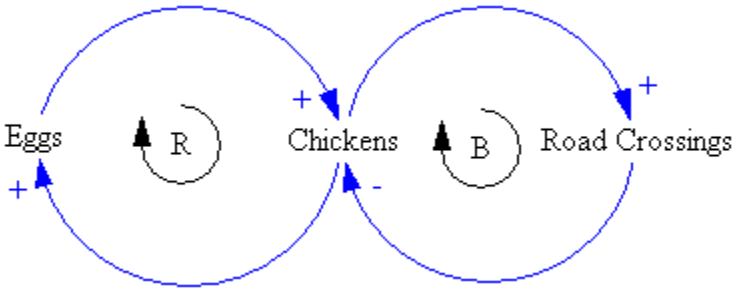


Social Network Analysis

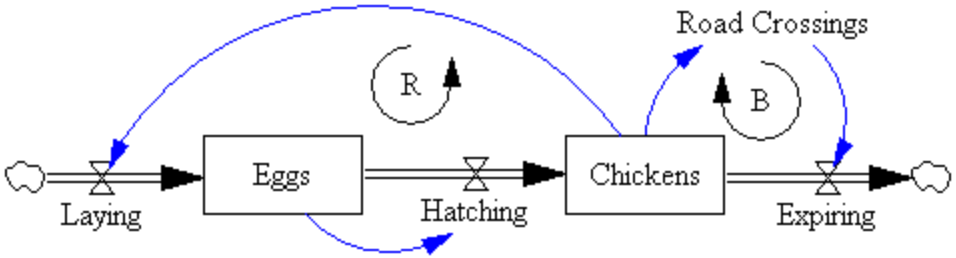


System Dynamics Modeling

Casual Loop Diagram

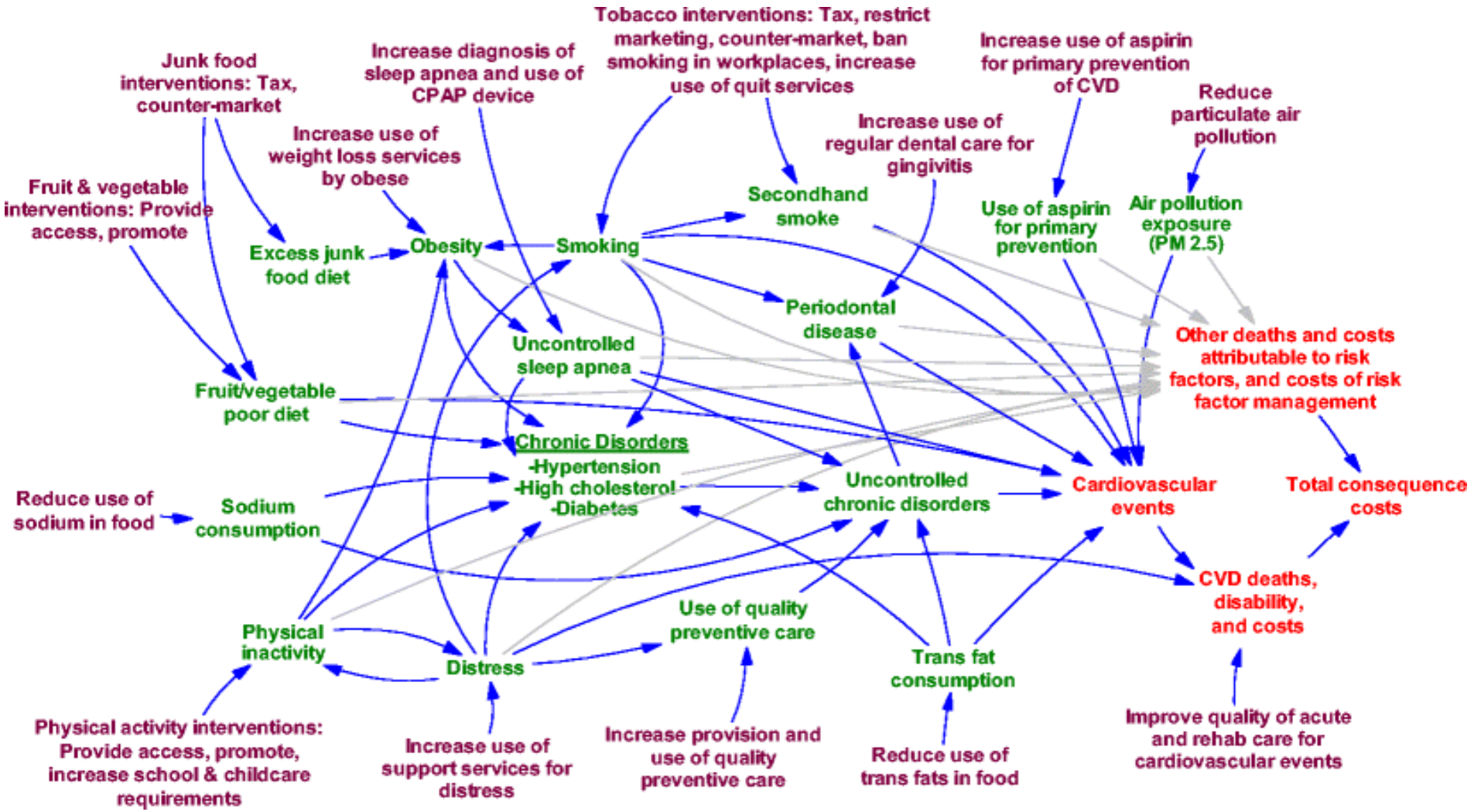


Stock and Flow Diagram



Source: http://blog.metasd.com/2010/04/are-causal-loop-diagrams-useful/

System Dynamics Example



Burke, J. G., Lich, K. H., Neal, J. W., Meissner, H. I., Yonas, M., Mabry, P. L., (2014, May). Enhancing Dissemination and Implementation Research Using Systems Science Methods. *International Journal of Behavioral Medicine.*

Agent-based Modeling

- **Agent-based models** simulate the actions and interactions of **autonomous agents** to assess their effects on the system as a whole
- Complex patterns of behavior **emerge** from the interactions of autonomous agents obeying a few **simple rules**.

Flocking Simulation

- **Boids** (Craig Reynolds, 1986)

- Three simple rules:
  - **separation**: steer to avoid crowding local flockmates
  - **alignment**: steer towards the average heading of local flockmates
  - **cohesion**: steer to move toward the average position (center of mass) of local flockmates

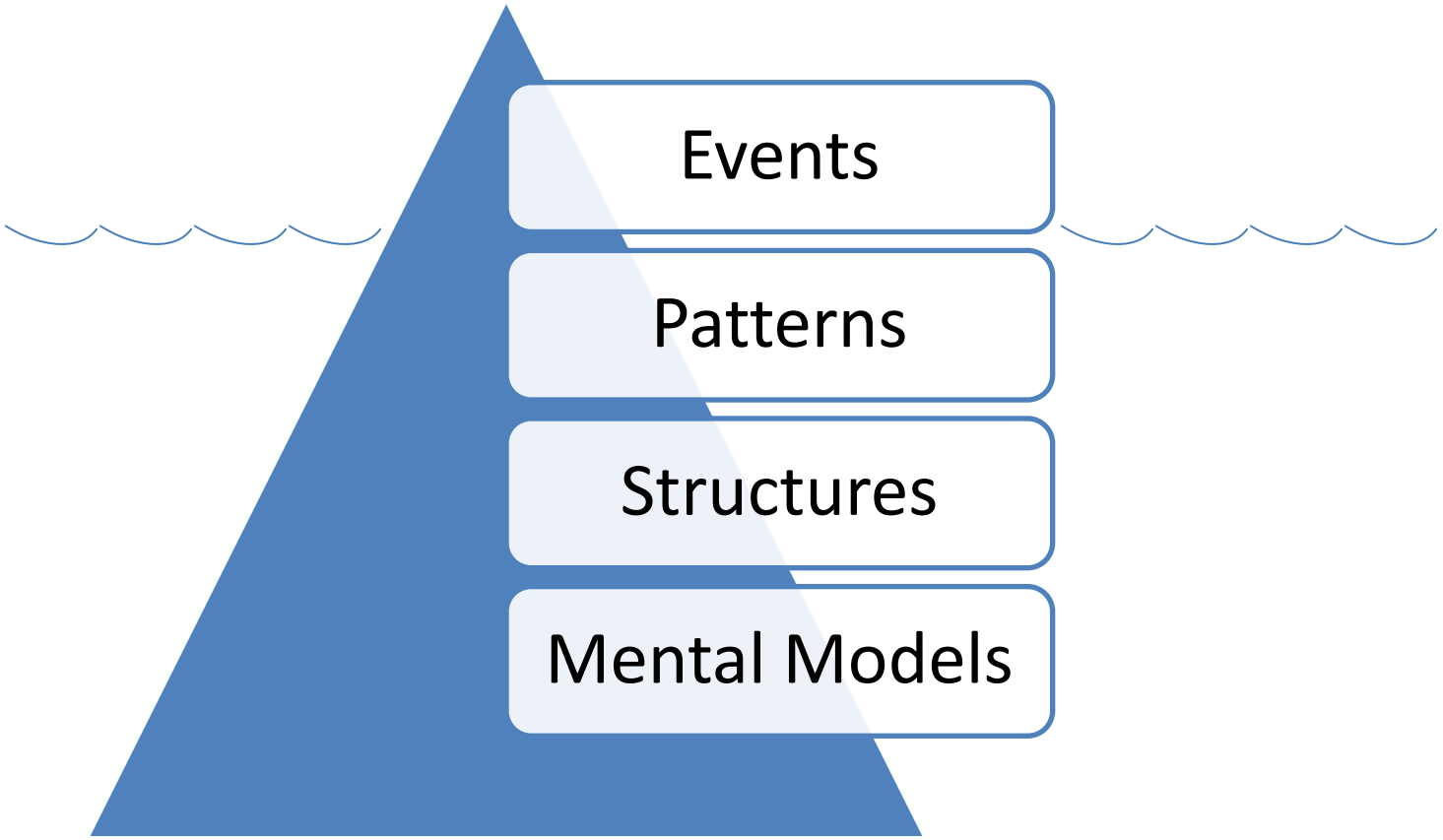
Run Simulation

System Structure → System Behavior

- The behavior of a system is determined by its structure – the way in which its components are interrelated

- To change the behavior of a system, change its structure

4 Levels of Systems Thinking



May 21, 2005. **HOUSTON** – Houston schools have been implicated in a cheating scandal after test scores in some Texas school districts made suspicious leaps.

October 5, 2012. **EL PASO** – Lorenzo García, the former superintendent of the El Paso Independent School District, was sentenced to three and a half years in prison for a cheating scandal.

April 12, 2013. **WASHINGTON** – District of Columbia schools officials say they've found cheating at 11 schools during the last school year.

April 14, 2013**. COLUMBUS** – School officials changed grades from failing to passing.

April 17, 2014. **LAS VEGAS** — Three Clark County School District employees are on leave after a state investigation concluded adults altered the answer sheets on standardized tests at a Las Vegas elementary school.

May 08, 2014. **PHILADELPHIA** – Five Educators Charged in Philadelphia Test Cheating Scandal.

April 14, 2015. **ATLANTA** – Eight of the Atlanta 10 educators convicted of racketeering in one of the nation’s largest public school cheating scandals were sentenced to prison terms of up to seven years.

What's missing from this explanation?

- March 2015 - ATLANTA, GA –During the investigation, Michael Bowers, a former Georgia attorney general who investigated the cheating scandal, heard that **educators cheated out of pride, to earn bonuses, to enhance their careers or to keep their jobs**, he said.

Structures & Mental Models

DISCUSS:

- What was the underlying **structure** that generated the patterns?
  - What factors were associated with the events
  - How were those factors interrelated?

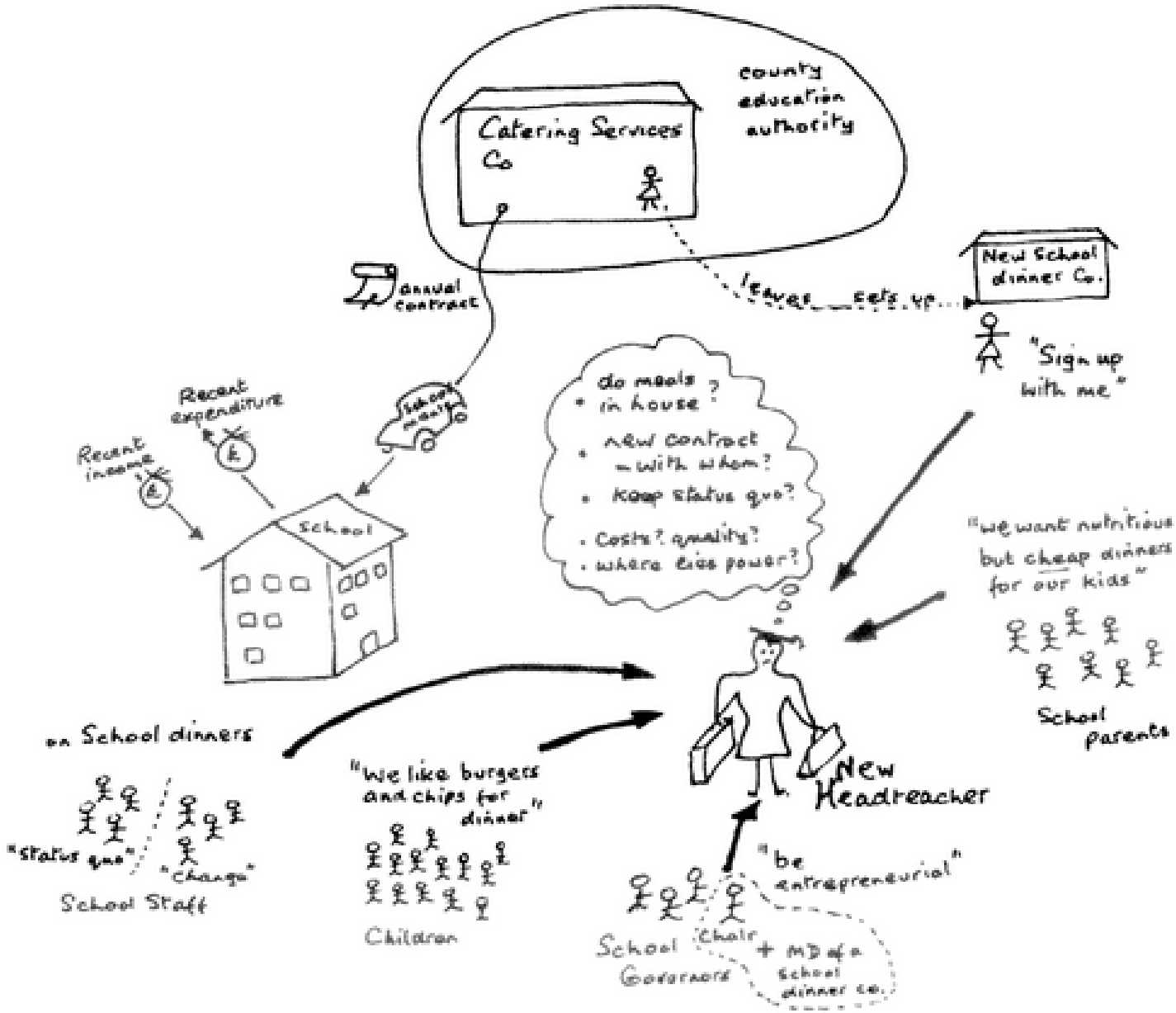
- What **mental models** might have generated the structures, patterns, and events?
  - What ideas about how to measure and promote academic achievement were involved?

III. System Mapping

Rich Pictures

- In making a Rich Picture the aim is to capture, informally, the main **entities**, **structures**, and **viewpoints** in the situation, the **processes** going on, the current recognized **issues** and any potential ones.

Source: Checkland & Poulter, 2006



Source: Checkland & Poulter, 2006

Instructions

1. **Structures.** Draw all of the physical entities involved in the issue/problem (people, organizations, institutions, and relevant aspects of the physical landscape).
2. **Processes.** Draw all of the ongoing activities or changes occurring within the system.
3. **Issues, concerns, or conflicts**. Represent the main issues or concerns for each individual or group as thought bubbles. Indicate any conflict between groups.
4. **Report out** in 30 minutes.

Summary

- Characteristics of complex problems/systems
- Systems/thinking and modeling
- Structures and mental models
- Systems mapping

What's Next

Thursday, June 4

11:00 AM – 12:00 PM	Panel Discussion: Building Sustainable Community-University Participatory Modeling Partnerships
1:20 – 2:30 PM	Social Network Analysis Demonstration
2:50 – 4:10 PM	Agent-based Modeling Demonstration
4:20 PM – 5:20	Topical Networking Session

Friday, June 5

9:30 – 12:10 AM	Participatory System Dynamics Modeling
1:40 – 3:00 PM	Demonstration: Modeling the Detroit Food System

References & Resources

- Anderson, V., & Johnson, L. (1997). *Systems thinking basics*. Cambridge: Pegasus Communications.
- Checkland, P., & Poulter, J. (2006). *Learning for action: a short definitive account of soft systems methodology and its use for practitioner, teachers, and students (Vol. 26).* Chichester: Wiley.
- Glouberman, S., & Zimmerman, B. (2004). Complicated and complex systems: What would successful reform of Medicare look like? In P.G. Forest, T. McIntosh, & G. Marchildon (Eds.), *Health care services and the process of change* (pp. 21-53). Toronto: University of Toronto Press.
- Hovmand, P. S. (2014). *Community Based System Dynamics.* NY, USA: Springer.

References & Resources

- Meadows, D. H. (2008). *Thinking in systems: A primer.* Chelsea Green Publishing.
- Neal, Z. P. (2012). *The connected city: How networks are shaping the modern metropolis.* Routledge.
- Patton, M. Q. (2011). *Developmental evaluation: Applying complexity concepts to enhance innovation and use.* Guilford Press.
- Snowden, D. J., & Boone, M. E. (2007). A leader's framework for decision making. *Harvard Business Review, 85*(11), 68.
- Williams, B., & Hummelbrunner, R. (2010). *Systems concepts in action: a practitioner's toolkit.* Stanford University Press.

Contact Information

Miles McNall, Ph.D.
Director, Community Evaluation and Research Collaborative
University Outreach and Engagement
Michigan State University
Kellogg Center
219 S. Harrison Road Rm. 93
East Lansing, MI 48824
(517) 353-8977
mcnall@msu.edu
http://outreach.msu.edu/cerc/

Robert E. Brown
Associate Director, Center for Community and Economic Development
University Outreach and Engagement
Michigan State University
Kellogg Center
219 S. Harrison Road Rm. 93
East Lansing, MI 48824
(517) 353-8977
brownr23@msu.edu