Modeling Individuals: Agent-based Approaches

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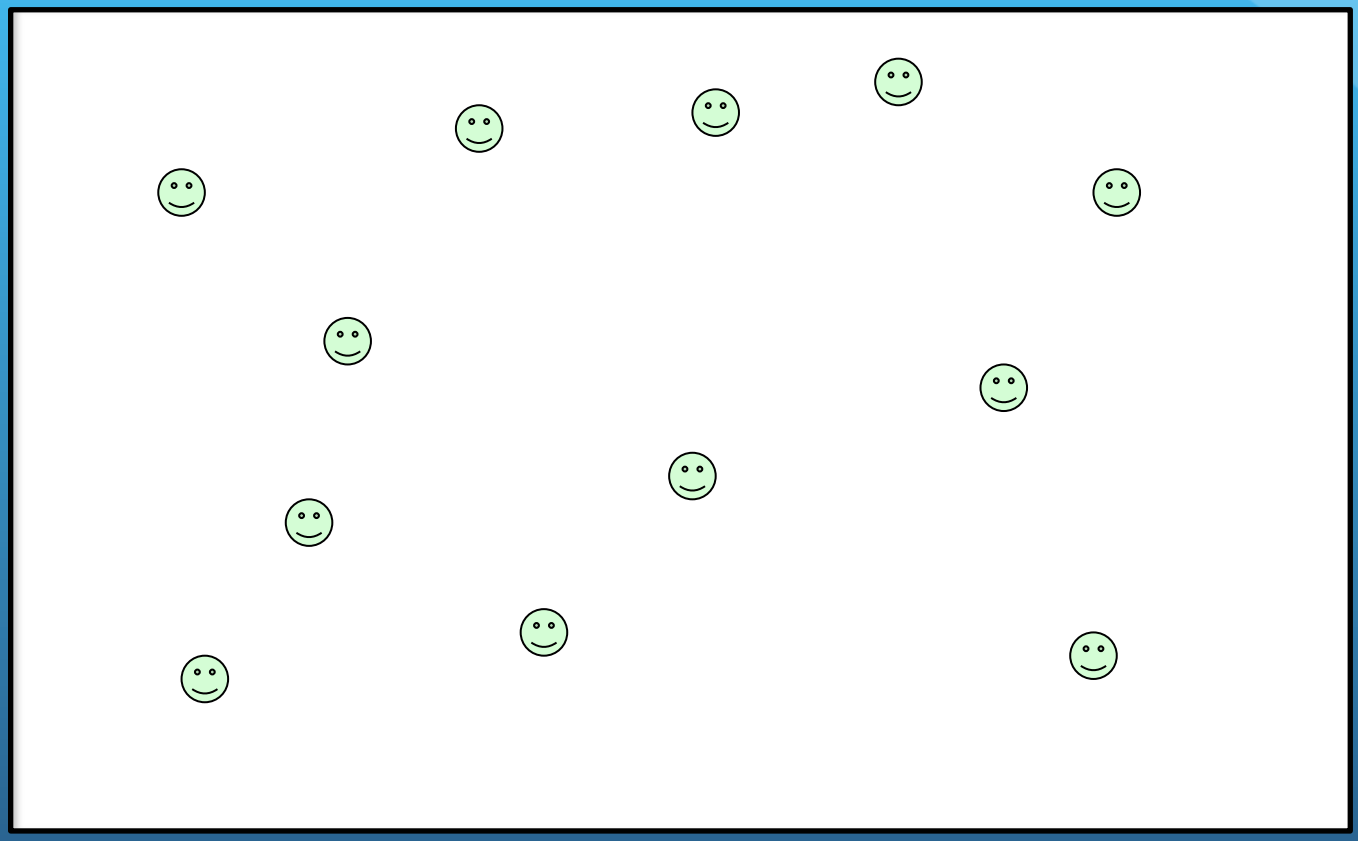
The Concept

- Use computer simulation to model lots of individuals in the same environment
- Each can move around the environment
- Each has a susceptibility to disease and a current disease state (S, I, R, etc.)
- Rules for movement, interaction and behavior

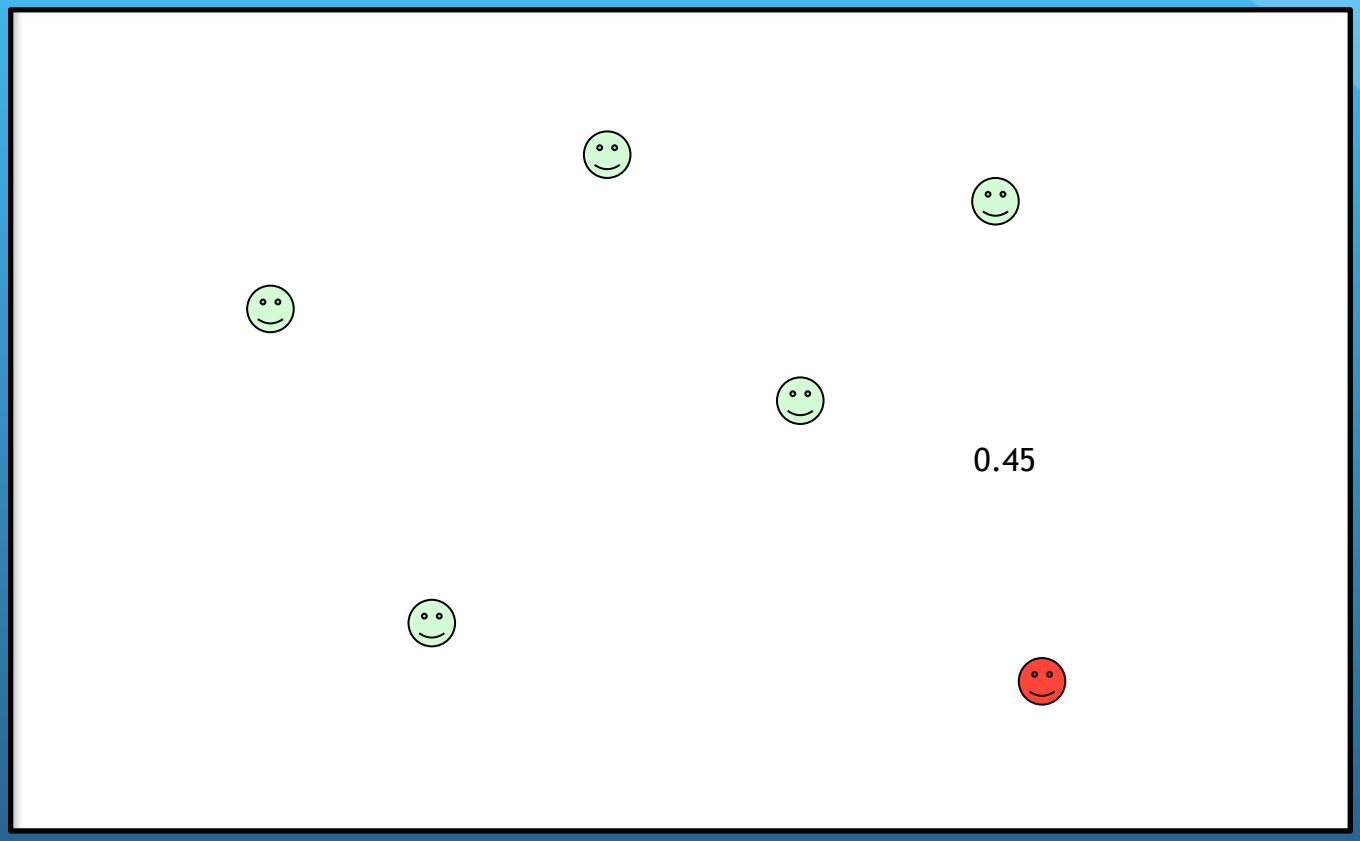
Why Is This Interesting?

- Very flexible approach
- New kinds of randomness
- Complex results arise from simple, low level interactions
  - Quilts
  - Can help discover patterns other models later describe

Basic Example



With Infection

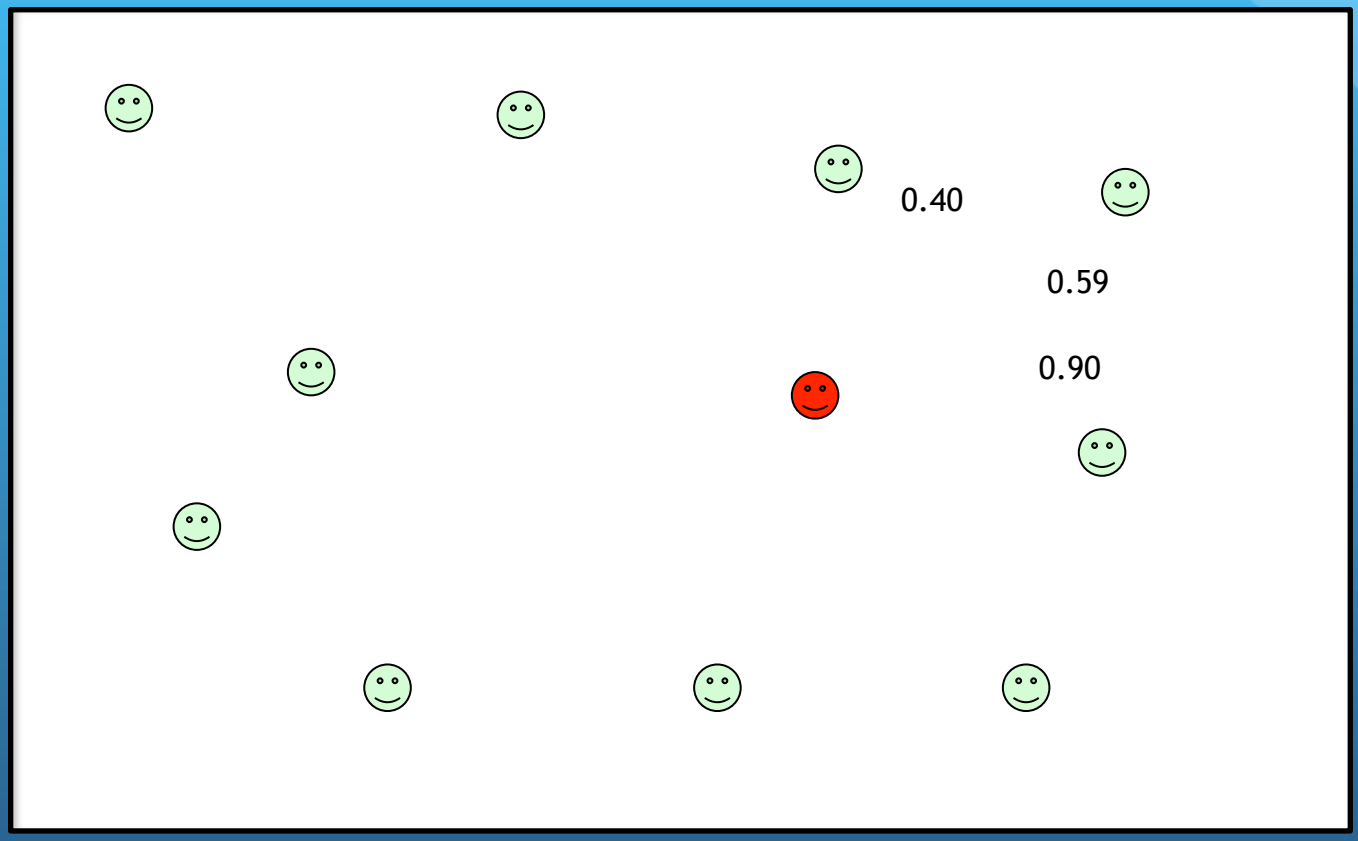


Again, transmission with some probability *p*
p = 0.65

Analogies to Other Models

- Entirely random mixing (as with the previous example):
  - Should have results identical to a compartmental model
  - Added randomness
- Model where agents group and associate with each other:
  - Should have results similar to a network model with those same associations

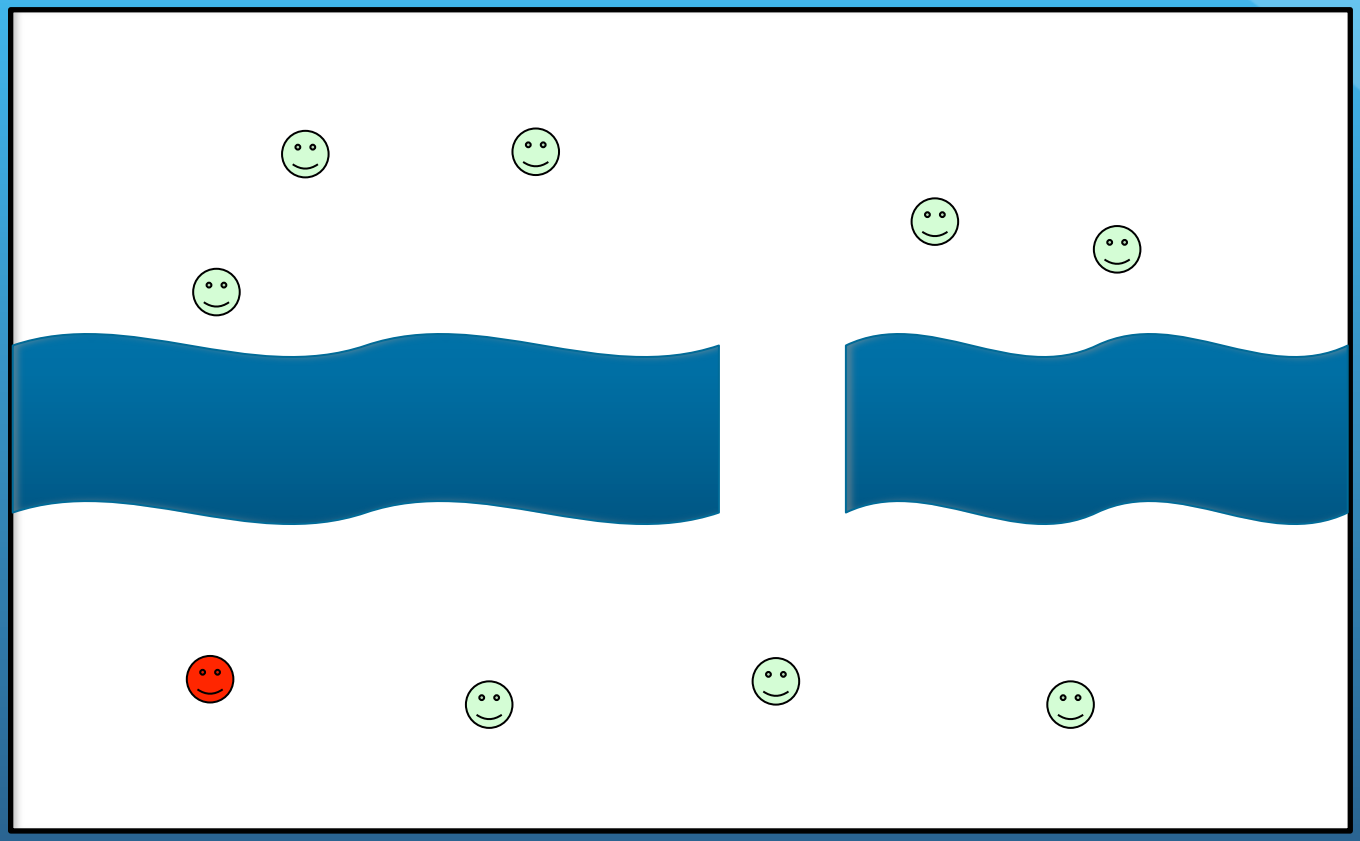
Network-analog



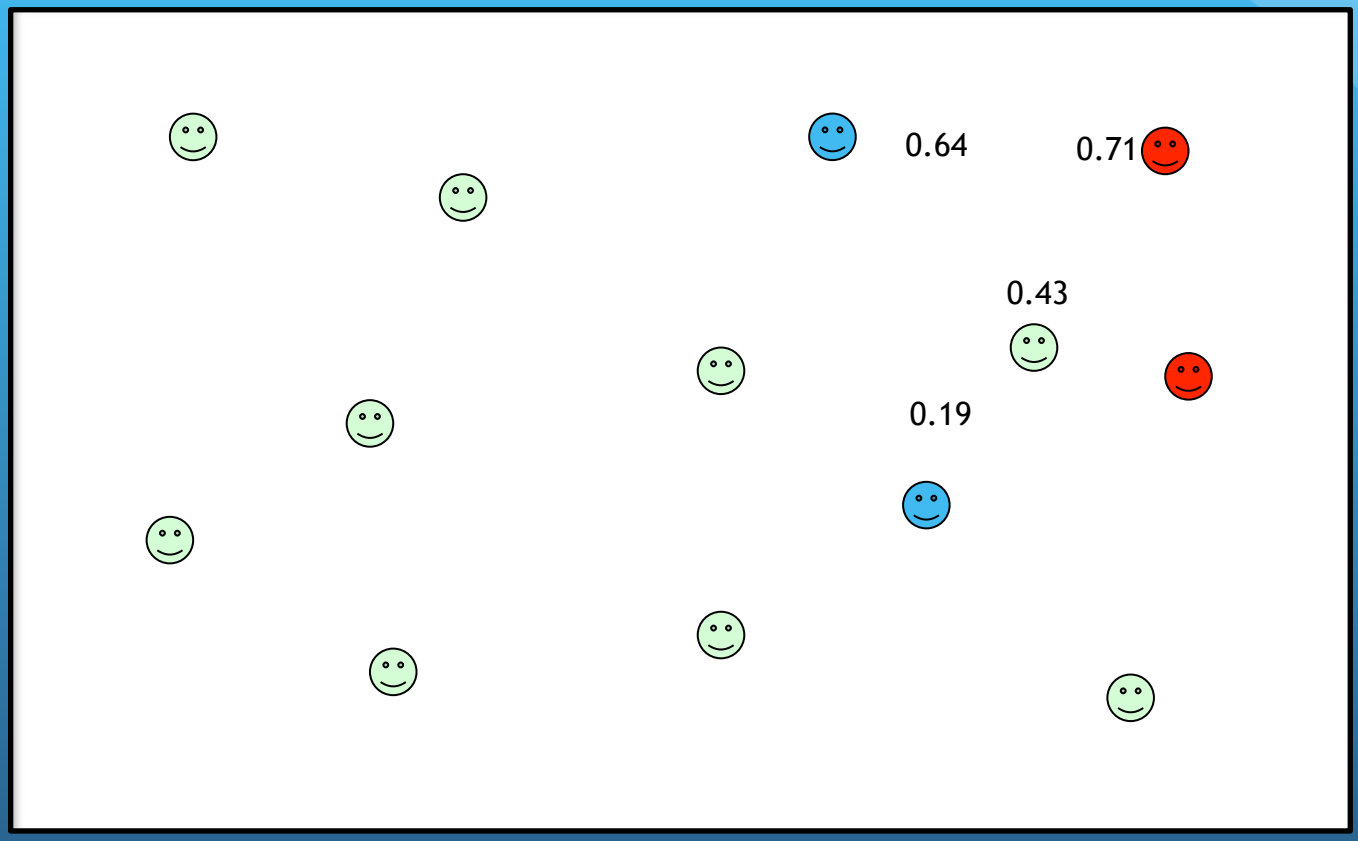
Where ABMs Are Unique

- Add a type of stochasticity not present in other models
  - Random *but* rule-based mixing
  - Can be influenced by environmental conditions
  - Positions and states of other individuals
- Model different classes of individual more easily
  - Can do this in other models, but it's less intuitive

Environmental and Other Agent States



Different Classes of Individuals



$p_{Civilian} = 0.65$
$p_{Law} = 0.40$
$g = 0.75$

More Complexity

- As with other models, ABMs can be more complex
  - Grouping and behavior processes
  - Individually generated traits for each agent
  - Direct interaction with the environment – spatially discrete models
  - Huge numbers of agents – a human body, an entire hospital, an entire healthcare *system*, an entire city…
- ABMs are a *massively* powerful tool

A Note of Caution

- Ease of adding complexity
  - Parameter choices are difficult
    - Individual level data, distributions for random variables
  - Easy to get carried away
    - Focus shifts to modeling the system, not the question
- Randomness means simulating the system repeatedly
  - Computing power

Other Tradeoffs

- Few analytic solutions – those that exist are *hard*
- Difficult to describe and publish
  - Consider the figures in this presentation
  - Can use flow-charts like the SIR model diagrams for individuals, but harder to represent the whole population
    - No equations
  - Results can be hard to visualize
- Randomness means simulating the system many times
  - Computational power
  - Programming expertise