Self Organizing Networks

Characteristics of Complex Adaptive Systems

1. *Non-linearity*: This construct means that small actions can stimulate large reactions in which highly improbable, unpredictable and unexpected events have huge impacts
2. *Emergence*: The appearance of patterns occurs due to the collective behaviour. What emerges cannot be planned or intended. The whole of the interactions becomes greater than the sum of the separate parts.
3. *Dynamical systems change*: Interactions within, between and among subsystems and parts are volatile, turbulent, and cascade rapidly and unpredictably.
4. *Adaptation*: Interacting elements respond and adapt to each other so that what emerges and evolves is a function of ongoing adaptation, among both interacting elements and the elements and their environment.
5. *Uncertainty*: Processes and outcomes are unpredictable, uncontrollable and unknowable in advance. There is no clear idea what might happen or how likely possible outcomes are.
6. *Co-evolutionary*: As interacting and adaptive agents self organize, ongoing connections emerge that become coevolutionary as the agents evolve together (co-evolve) within and as part of the whole system over time.

Methods for network modelling

1. Cellular Automata (CA)
2. Agent Based Modelling (ABM)

Cellular Automata

Basics:

- Spacial lattice of Cells
- Not necessarily physical space
- Cell state at t+1 depends on cell state at t plus state of some of the neighbours at t
- Updates follow simple rules (Typically uniform for all cells)
- Useful for examining situations with inherent structure

Von Neumann neighbourhood: Cells to the north, south, east, and west

Moore Neighbourhood: all cells around target node

Depending on the way interactions are structures the following possibilities can happen.

1. CA achieves unique state from any starting condition
2. Repeating patterns emerge
3. Aperiodic-chaotic patterns with consistent statistical properties

4. CA dies out

Agent Based Modelling (ABM)

Agents:

- anything that makes choices in a network
- Autonomous (have own goals and behavior)
- Can be adaptive
- Can exist on multiple levels

Assumptions:

- Agents operate in parallel
- No central command

Rules

Agents Internal Rules

- Akin to cognitive engine
- Typically, table with condition and action
- Simple

A combination of rules leads to emergence

- sum of individuals does not explain completely collective action

Agent Cycle

Act: What can be done? Operating Space? Signals generated?

Get Stimulus: What can be observed? From where?

Process Stimulus: Table only? Learning? Combination Needed?

Telecommunications ABM

- Agents as network entities
- Allows integration of non-telecoms elements
- Captures emergence from collection rules
  - How do telecoms systems handle various events

Acronyms

- CA: Cellular Automata
- ABM: Agent Based Modelling