

# Introduction to Complex Systems

BBAS 413 Complexity Management & BBAS 423 Leading Social Change with Systems Thinking

## Definition of a System:

A system is a collection of *elements* and *connections* between them that produce a whole with *collective properties*.

- Elements: the parts that interconnect to form the system.
- Connections: exchanges of energy, material, and/or information
- Collective properties:
  - A pattern of relationships that persists through time
  - A joint function or purpose
  - Emergent properties—macro-level behaviours that are qualitatively different from the behaviours of the parts
  - A new aggregate entity, such as an organism

Systems also feature:

- Boundaries that demarcate the system from its outside environment, which are often fuzzy, subjective, and permeable.
- Energy flows that sustain the constant motion (dynamism) of the system.

## Types of Systems:

System:	Examples:	Elements:	Connections:	Collective Properties:
<b>Complicated</b>	<ul style="list-style-type: none"> <li>• Dominos</li> <li>• Rube Goldberg machines</li> </ul>	<ul style="list-style-type: none"> <li>• Uniform or diverse</li> <li>• Fixed properties</li> </ul>	<ul style="list-style-type: none"> <li>• Constrained</li> <li>• Linear and sequential</li> </ul>	<ul style="list-style-type: none"> <li>• An outcome or function</li> </ul>
<b>Complex non-adaptive</b>	<ul style="list-style-type: none"> <li>• Vortex in a bathtub</li> <li>• Climate</li> </ul>	<ul style="list-style-type: none"> <li>• Uniform or diverse</li> <li>• Fixed properties</li> </ul>	<ul style="list-style-type: none"> <li>• Dense</li> <li>• Recursive and simultaneous</li> </ul>	<ul style="list-style-type: none"> <li>• Emergent properties</li> </ul>
<b>Complex adaptive</b>	<ul style="list-style-type: none"> <li>• Agent based models</li> <li>• Ecosystems</li> </ul>	<ul style="list-style-type: none"> <li>• Diverse</li> <li>• Fixed properties</li> <li>• Diverse agents act according to schemas that are (largely) fixed in their genotypes.</li> </ul>	<ul style="list-style-type: none"> <li>• Dense</li> <li>• Competitive, producing selection pressures</li> </ul>	<ul style="list-style-type: none"> <li>• Evolution</li> <li>• Dynamic equilibria</li> </ul>
<b>Reflexive-Representational complex adaptive</b>	<ul style="list-style-type: none"> <li>• Human society</li> </ul>	<ul style="list-style-type: none"> <li>• Diverse agents and schematic rules</li> <li>• Changing properties</li> <li>• Diverse agents can self-consciously modify the rules of their schemas</li> </ul>	<ul style="list-style-type: none"> <li>• Dense</li> <li>• Strategic and empathetic</li> <li>• Self-reflective</li> </ul>	<ul style="list-style-type: none"> <li>• Adaptation by learning</li> </ul>