**FRAME: Complex Adaptive Systems**

*Harnessing Complexity*

by Robert Axelrod and Michael D. Cohen

## Components of the Model

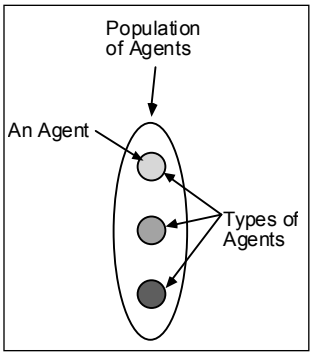
Following is a list and brief description of the components of the model

*An Agent*

An agent is an individual "actor" in a complex environment. Normally we think of people as agents, but families, businesses and governments can also be considered agents. Trees, birds and insects are some of the agents in the complex system we call "a forest". An agent has the ability to interact with its environment, and with other agents in the environment. An agent can respond to what happens around it and can do things more or less purposefully. (A rock, then, would not qualify as an agent in the forest ecosystem because it cannot respond to what happens around it.)

*A Type of Agent*

We can differentiate between "types" of agents using a variety of criteria. We might want to differentiate schoolchildren into "shy" and "aggressive" types. Or we may prefer to categorize them by hair color, or reading skill, or athletic ability. An agent is part of the same population if it can use the same strategy that is being employed by another agent.

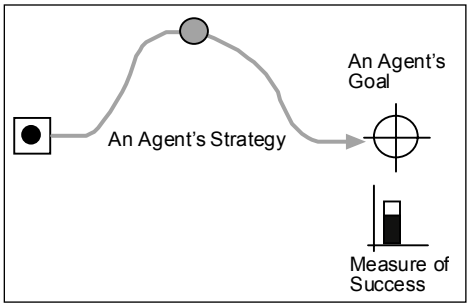



*A Population of Agents*

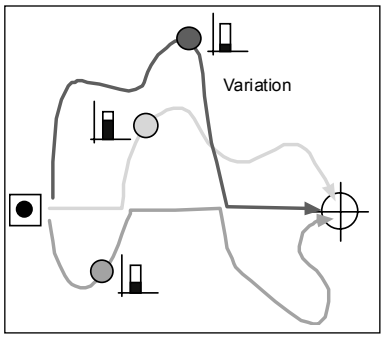
The concept of a population or collection of agents is important for three reasons. First, by being part of a population, an individual (agent) increases the number of possibilities for learning new and successful strategies. Second, a population can serve as the recipient for a newfound improvement. Third, the population serves as part of the environment in which an agent lives. For example, as a business manager, you can learn from the population of managers who face similar problems, you can spread what you have learned to a population of co-workers, and you can see your company as one part of a population of businesses and consumers that you adapt to even while they adapt to you.

*A Strategy*

Every agent has goals and employs strategies to pursue them. An employee might help a co-worker in the hope that the co-worker will do the same in return. Someone in need of money might ask friends for a small loan. These are strategies.

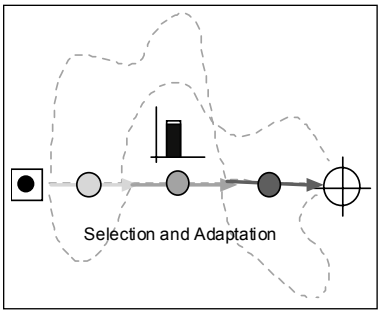



The strategies that an agent uses will change over time. One source of change is the agent's understanding about how well a particular strategy is working. If a child learns that whining never gets him what he wants, he will (eventually) search for other strategies to attain his goals. Agents also learn new strategies by copying the successful strategies that they observe in others.




*Variation*
As strategies are copied and shared through a population, some variation will occur. Variation serves to increase the diversity of the population of strategies. Variation can occur through mutation (where part of the strategy is changed because of error), migration (where new agents with new strategies move into the population), or through combination (where two or more successful strategies are blended to create a new strategy).

*Selection*
With all of the diversity created by variation, agents will be forced to choose strategies that appear to be successful. This will mean that less successful strategies will "die out" as fewer and fewer agents choose them. This is a form of "selection" by which successful strategies are copied and employed while less successful strategies are left to die out. Selection takes place through either trial-and-error or imitation of the successful strategies employed by other agents. This tends to reduce variation.




*Adaptation*
When the selection process leads to an improvement according to some measure of success (goal), we call this adaptation. Adaptation increases the performance of the individual agent according to its own success criteria. Because the success criteria might be different for different agents, a particular selection or change might be an adaptation for some agents but not for others.

*Complex Adaptive System*
A "system" includes one or more populations of agents and all of the strategies that those agents employ. A "complex" system is one in which the actions of agents are tied very closely to the actions of other agents in the system. When the agents in a system are actively trying to improve themselves ("adapt"), then the system is a Complex Adaptive System.

*An Overview of the Complex Adaptive Systems Framework* "**Agents**, of a **variety** of **types**, use their **strategies**, in patterned **interaction**, with each other and with artifacts. **Performance measures** on the resulting events drive the **selection** of agents and/or strategies through processes of error-prone **copying** and **re-combination**, thus changing the frequencies of the types within the **system**."

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