Chapter 9
Society of Agents:
A Framework for Multi-Agent Collaborative Problem Solving

Steven Walczak
University of South Florida, USA

ABSTRACT

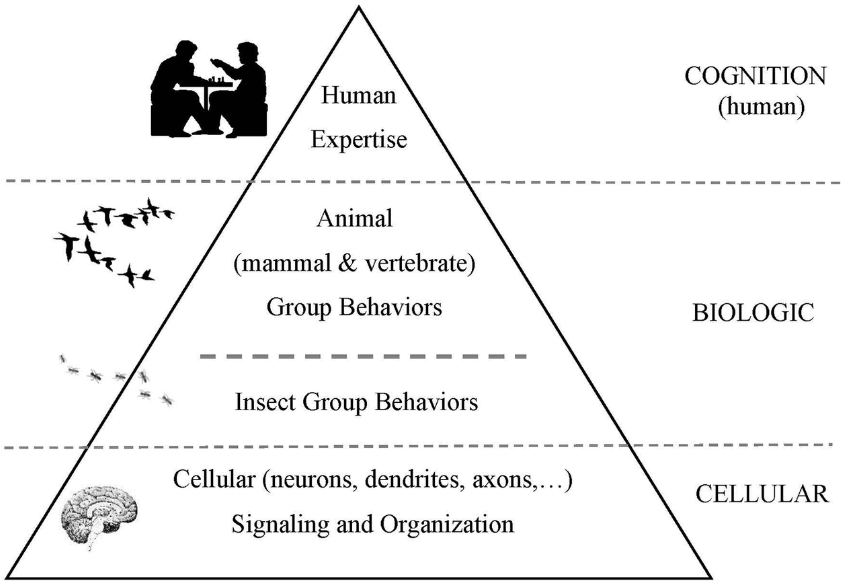
The development of multiple agent systems faces many challenges, including agent coordination and collaboration on tasks. Minsky's The Society of Mind provides a conceptual view for addressing these multi-agent system problems. A new classification ontology is introduced for comparing multi-agent systems. Next, a new framework called the Society of Agents is developed from Minsky's conceptual foundation. A Society of Agents framework-based problem-solving and a Game Society is developed and applied to the domain of single player logic puzzles and two player games. The Game Society solved 100% of presented Sudoku and Kakuro problems and never lost a tic-tac-toe game. The advantage of the Society of Agents approach is the efficient re-utilization of agents across multiple independent game domain problems and a centralized problem-solving architecture with efficient cross-agent information sharing.

INTRODUCTION

Distributed semi-autonomous intelligent problem solving is the function of multi-agent systems. Ontologisms or formalisms (frameworks) for development of multi-agent systems are recognized as a critical element for further development of multi-agent research (Chen & Chen, 2008). A natural classification of intelligent multi-agent problem solving strategies is implicit in nature. The highest level of self-contained intelligence is reflected in agents that model human intelligent problem solving by embedding evaluation heuristics based on human expertise within the agents, with examples coming from Othello (Samothrakis et al., 2013), a.k.a. Reversi, and checkers (Neto et al., 2014), a.k.a. draughts. The next step down are systems that mimic other biologic systems and include ant colony and beehive optimization agents (Madureira, 2014) among a vast number of other biologically inspired collaboration mechanisms for problem solving. The final classification layer is based on how intelligence develops at the cellular

DOI: 10.4018/978-1-7998-0951-7.ch009

Figure 1. Intelligence and collaboration tradeoff in multi-agent classification



level and includes artificial neural networks (ANNs) embedded in agents, such as the ANN based agents for playing a specific type of poker (Nicolai & Hilderman, 2009). This agent and multi-agent ontology is shown in Figure 1. The ontology facilitates classification and comparison between agent systems.

As agent systems progress upward in the classification triangle shown in Figure 1, the autonomous intelligence of the system increases, which causes a corresponding decrease in the number of agents required to solve a general problem in the agent's domain. The agent classification triangle in Figure 1 classifies agents based on their relative position within the triangle with increasing knowledge-based problem-solving capability corresponding to the height in the triangle and the width of the triangle indicating the necessary quantity of collaborating agents required for solving problems within their domain. This may be understood in plain language by looking at the number of living agents or corresponding units involved in problem solving for the different communities. A single human can solve a chess endgame problem, whereas animal communities solve survival challenges in groups of several animal agents to several dozen and insect colonies typically manage survival problems using hundreds to thousands of individuals. The human brain contains millions to billions of neurons (West & Gundersen, 1990), which are the building blocks of consciousness and intelligence. Thus, as the foundational model of agents within a multi-agent system moves down the pyramid from cognitive to biologic models and then from biologic to cellular, a greater number of agents are required to collaborate to produce intelligent behaviors.

Although this classification provides a straightforward ontology for evaluating required knowledge and collaboration levels within multi-agent systems, it still lacks a formal framework to define how collaboration between agents functions. The research presented in this paper defines a framework for agent interactions and collaborations in cellular level multi-agent systems. The framework is founded upon Minsky's (1986) *Society of Mind* paradigm, which was never formally instantiated, and is therefore called the Society of Agents (SoA). The idea of utilizing a social perspective to facilitate agent interactions is not new and has been used in developing agent communications for almost two decades (Ferber, 1999;