Preface

Agent-based systems serve as a foundation for a new breed of computer modeling and simulation technologies that act as virtual laboratories for scientists in many disciplines such as health sciences, social sciences, and ecosystem. One of the fundamental questions of agent-based systems has traditionally been how should agents make decisions given they inhabit an environment where their actions may have unforeseen or unpredictable effects on others? This question often raises interesting points about the extent to which the individual autonomy of agents should be sacrificed for global needs and desires of society. Volume 3 (2011) of the *International Journal of Agent Technologies and Systems* presents a contribution to solving this question. By employing realistic models based off of recent advances in decision-making and social interaction, we are able to reproduce realistic behavior based on rational agents.

**AGENT AND MULTI-AGENT SYSTEMS**

An *agent* is defined as a mapping from perceptions to actions (Russell, 1995). It can be achieved via hardware (e.g. robotics) or software systems. The agent resides in the environment, behaves autonomously, purposively, and flexibly; it may have sensing, adaptive, social, and emotional capabilities (Wooldridge, 1995). The capabilities of a single agent are limited by its knowledge, its computing resources, and its perspective. Particularly, when interdependent problems arise, agents in the system must coordinate with one another to ensure that interdependent problems are properly managed. Thus, they form *multi-agent systems*. In a multi-agent system, multiple agents that cooperate towards the achievement of a joint goal are viewed as a *team*. *Teamwork* is a cooperative effort by a team of agents to achieve a joint goal (Tambe, 1997; Cannon-Bowers, 1997).

**AGENT-BASED SYSTEMS**

Agent-Based Systems integrate the technologies of modeling and simulation and agent systems; and consists of three distinct, yet related, areas that can be grouped under two categories, as follows (Yilmaz & Ören, 2006):

- **Simulation for Agents (agent simulation):** simulation of agent systems in engineering, human and social dynamics, military applications, etc.
Agents for Simulation (which has two aspects): agent-supported simulation that deals with the use of agents as a support facility to enable computer assistance in problem solving or enhancing cognitive capabilities; and agent-based simulation that focuses on the use of agents for the generation of model behavior in a simulation study.

On one hand, agent-based systems allow us to use agents to develop domain-specific simulation; on the other hand, it supports the use of agent technology to develop simulation techniques and toolkits that are subsequently applied either with or without agents. The real world problems are complex and there is no single agent-based abstraction that can solve every problem. The integration of simulation and agent technology can help us better understand complex real world problems and improve our capability in developing autonomic simulation systems with robust decision making in real-time for these problems.

ADVANCES IN AGENT TECHNOLOGIES AND SYSTEMS SERIES

The Advances in Agent Technologies and Systems Series is an annual journal summation volume published by IGI Global. As one of the premier platforms to the synergy of agent modeling and simulation technologies, the International Journal of Agent Technologies and Systems attracts enthusiastic responses every year, and has an impressive Editorial Board (http://www.igi-global.com/journal/international-journal-agent-technologies-systems/1109).

The Volume 3 in 2011 published 18 papers from 8 countries. Every paper was assigned to an associate editor and was reviewed by three referees. Every paper was revised at least one round based on referees’ comments and resubmitted for final acceptance.

It is worth noting that part of the published papers in this volume were selected and extended from the Agent-Directed Simulation Symposium at the SpringSim Multiconference in Boston, April 4-5, 2011. The Agent-Directed Simulation Symposium is an annual conference as part of the Spring Simulation Multiconference (SpringSim) sponsored by the Society for Modeling and Simulation International. A further round of call for papers was sent to all accepted papers. Authors were asked to significantly expand and improve their ADS paper in order to make a submission to the International Journal of Agent Technologies and Systems. All submissions were reviewed by three referees. Finally, we accepted six to published in the journal.

This volume investigates six different research domains in agent-based systems: Agent System Design, Agent Collaboration, Social Simulation, Simulation in E-Business, Simulation in Health Sciences, Simulation in Ecosystem. The volume also includes a Book Review. We believe that this volume provides the most recent developments in these selected topics and will be an important source of information for researchers in the area of agent-based systems.

The following sections present all papers in this volume in the six research domains and the book review.

AGENT SYSTEM DESIGN

The design of agent systems deals with building interaction and collaboration in distributed and dynamic domains, where each autonomous agent works cooperatively to solve a part of a problem in parallel.
However, a team of agents is more flexible and efficient than a group of single agents only when a flexible and efficient means of coordinating the agents exists. In many ways, the agent system design problem is similar to that of parallel computing: doubling the number of processors used in a computation usually will not double the speed with which the solution is found. The extra processing power does not become an advantage until a sophisticated means of cooperative processing is found. This challenge inspires many design patterns and rule definitions.

In agent literature, Jennings first emphasizes that coordination is a key property that guarantees better multi-agent team performance (Jennings, 1993). Without coordination, a multi-agent system can become a collection of incohesive individuals. He developed a model of coordination, whose two central concepts are (joint) commitment and (social) convention. Jennings views a commitment as a promise to take a certain action, and conventions as rules for monitoring these commitments. He argues that “all coordination mechanisms can ultimately be reduced to joint commitments and their associated social conventions”.

In this volume, the chapter titled “Design of Multi Agent System for Resource Allocation and Monitoring” by Manish Arora and M. Syamala Devi proposes to use the Agent Unified Modeling Language to design a multi-agent system for resource allocation and monitoring. The objective of Resource Allocation and Monitoring System is to make the procedures involved in allocating fund resources to competing clients transparent so that deserving candidates get funds. Proactive and goal directed behaviour of agents make the system transparent and intelligent. This chapter presents design of Multi Agent Systems for Resource Allocation and Monitoring using Agent Unified Modelling Language (AUML) and implementation in agent based development tool. At a conceptual level, three agents are identified with their roles and responsibilities. The identified agents, functionalities, and interactions are also included, and results show that multi agent technology can be used for effective decision making for resource allocation and monitoring problem.

Next paper is titled “The Effects of Different Interaction Protocols in Agent-Based Simulation of Social Activities” by Nicole Ronald, Theo Arentze, and Harry Timmermans. Decision-making in models of activity and travel behaviour is usually individual-based and focuses on outcomes rather than the decision process. Using agent-based modelling techniques and incorporating interaction protocols into the model can assist in modelling decision-making in more detail. This chapter describes an agent-based model of social activity generation and scheduling in which utility-based agents interact with each other to schedule activities. Six different protocols are tested. The authors show that the model outcomes reflect minor changes in the protocol, while changing the order of the protocol leads to significantly different outcomes, hence the protocol plays a large role in the simulation results and should be studied in more detail.

AGENT COLLABORATION

Back in 1992, a group of Australian researchers propose planned team activity in the logical and practical design of rational agents cooperating in a team (Kinny, 1992). This is a pioneer work in agent collaboration. In present time, the practices presented in this work, such as common knowledge, still guides the research in agent collaboration. Kinny et al. suggest that joint plans (common to all agents) that specify the means of satisfying joint goals are supplied in advance, rather than being generated by the agents. Their argument is that the agents embedded in a dynamic environment can respond rapidly
to important events by adopting applicable plans. The joint plans are represented by concepts of skills and team members’ roles. These plans usually will be qualified by preconditions that specify under what circumstances they are applicable. The plan execution for each agent consists of the selection and hierarchical expansion of these plans.

To achieve the planned team activity, common knowledge necessary for coordination and synchronization of agents’ activities is imposed on the agents. The common knowledge that includes mutual beliefs about the world and about each other’s actions places strong requirements upon agents’ observation. Kinny et al. propose that the common knowledge can be achieved alternatively by communication between agents. This approach implies the need of effective communication. The assumption that the plans of individual agents are known at compile time might enhance the team’s proactivity by the possibility of reasoning in advance about which team members potentially can achieve certain goals.

In this volume, “A Collaborative Framework for Multiagent Systems” by Moamin Ahmed, Mohd Sharifuddin Ahmad, and Mohd Zaliman M. Yusoff demonstrates the use of software agents to extend the role of humans in a collaborative work process. The extended roles to agents provide a convenient means for humans to delegate mundane tasks to software agents. The framework employs the FIPA ACL communication protocol, which implements communication between agents. An interface for each agent implements the communication between humans and agents. Such interface and the subsequent communication performed by agents and between agents contribute to the achievement of shared goals.

The next chapter is titled “Initial Formulation of an Optimization Method Based on Stigmergic Construction” by Aditya C. Velivelli and Kenneth M. Bryden. Sign-based stigmergic methods such as the ant colony optimization algorithm have been used to solve network optimization, scheduling problems, and other optimization problems that can be visualized as directed graphs. However, there has been little research focused on the use of optimization methods based on sematectonic stigmergy, such as coordination through collective construction. This chapter develops a novel approach where the process of agent-directed stigmergic construction is introduced as a general optimization tool. The development of this new approach involves adopting previous work on stigmergic construction to a virtual space and applying statistical mechanics-based techniques to data produced during the stigmergic construction process. From this, a unique procedure for solving optimization problems using a computational procedure that simulates sematectonic stigmergic processes such as stigmergic construction is proposed.

SOCIAL SIMULATION

In multi-agent simulations, when agents communicate with each other or work together on a common goal, agents are often organized into networks. While the value of simulation as a tool in the natural sciences has been realized for quite some time, its potential in the social sciences is only beginning to be explored. A class of simulation used to study social behavior and phenomena is known as social simulations. One particular type of social simulation is known as agent based social simulation. Here agents are used to model social entities such as people, groups, and towns. One purpose of these models is to reproduce realistic behavior in the simulation, which is then used to draw conclusions about the corresponding real world entities. If realistic behavior can be reproduced then researchers in the social sciences can be given virtual laboratories from which they can experience the same benefits received by the natural sciences. Such a framework for modeling realistic behavior needs to reproduce both in-
ternal decision-making as well as social interactions. This is certainly not an easy task as entire fields are founded in researching both of these questions.

The applications of human behavioral simulations could be applied to investigate social phenomena. They could be used to make predictions about how people will act in complex situations. For example, these simulations could be used to investigate emergency evacuation plans, or for military purposes where they can test various strategies in a safe environment (Brooks, et al., 2004; Christensen & Sasaki, 2008). They could even be used for entertainment purposes, as in various simulation-based video games (Aylett, Louchart, & Pickering, 2004).

In this volume, the chapter titled “Meta-Monitoring Using an Adaptive Agent-Based System to Support Dependent People in Place” by Nicolas Singer, Sylvie Trouilhet, and Ali Rammal proposes software architecture to monitor elderly or dependent people in their own house. Many studies have been done on hardware aspects resulting in operational products, but there is a lack of adaptive algorithms to handle all the data generated by these products due to data being distributed and heterogeneous in a large scale environment. The authors propose a multi-agent classification method to collect and to aggregate data about activity, movements, and physiological information of the monitored people. Data generated at this local level is communicated and adjusted between agents to obtain a set of patterns. This data is dynamic; the system has to store the built patterns and has to create new patterns when new data is available. Therefore, the system is adaptive and can be spread on a large scale. Generated data is used at a local level, for example to raise an alert, but also to evaluate global risks. This chapter presents specification choices and the massively multi-agent architecture that was developed; an example with a sample of ten dependant people gives an illustration.

Next chapter is titled “Simulating Tolerance in Dynamic Social Networks” by Kristen Lund and Yu Zhang. This chapter studies the concept of tolerance in dynamic social networks where agents are able to make and break connections with neighbors to improve their payoffs. This problem was initially introduced to the authors by observing resistance (or tolerance) in experiments run in dynamic networks under the two rules that they have developed: the Highest Rewarding Neighborhood rule and the Highest Weighted Reward rule. These rules help agents evaluate their neighbors and decide whether to break a connection or not. They introduce the idea of tolerance in dynamic networks by allowing an agent to maintain a relationship with a bad neighbor for some time. In this research, the authors investigate and define the phenomenon of tolerance in dynamic social networks, particularly with the two rules. The chapter defines a mathematical model to predict an agent’s tolerance of a bad neighbor and determine the factors that affect it. After defining a general version of tolerance, the idea of optimal tolerance is explored, providing situations in which tolerance can be used as a tool to affect network efficiency and network structure.

Researchers Rajiv Kadaba, Suratna Budalakoti, David DeAngelis, and K. Suzanne Barber study agent virtual reality. Their paper is titled “Modeling Virtual Footprints,” which presents a persona mapping algorithm to compare an individual’s view to their virtual signatures vs. the view of it in their social network. Entities interacting on the web establish their identity by creating virtual personas. These entities, or agents, can be human users or software-based. This research models identity using the Entity-Persona Model, a semantically annotated social network inferred from the persistent traces of interaction between personas on the web. A Persona Mapping Algorithm is proposed which compares the local views of personas in their social network referred to as their Virtual Signatures, for structural and semantic similarity. The semantics of the Entity-Persona Model are modeled by a vector space model of the text associated with the personas in the network, which allows comparison of their Virtual
Signatures. This enables all the publicly accessible personas of an entity to be identified on the scale of the web. This research enables an agent to identify a single entity using multiple personas on different networks, provided that multiple personas exhibit characteristic behavior. The agent is able to increase the trustworthiness of on-line interactions by establishing the identity of entities operating under multiple personas. Consequently, reputation measures based on on-line interactions with multiple personas can be aggregated and resolved to the true singular identity.

The paper titled “History Sensitive Cascade Model” by Yu Zhang, Maksim Tsikhanovich, and Georgi Smilyanov introduces a history dependent diffusion algorithm for social network. Diffusion is a process by which information, viruses, ideas, or new behavior spread over social networks. Traditional diffusion models are history insensitive, i.e. only giving activated nodes a one-time chance to activate each of its neighboring nodes with some probability, but history dependent interactions between people are often observed in the real world. This chapter proposes the History Sensitive Cascade Model (HSCM), a model of information cascade through a network over time. The authors consider the “activation” problem of finding the probability of that a particular node receives information given that some nodes are initially informed. In this chapter, it is also proven that selecting a set of $k$ nodes with greatest expected influence is NP-hard, and results from submodular functions are used to provide a greedy approximation algorithm with a $1 - 1/e - e$ lower bound, where $e$ depends polynomially on the precision of the solution to the “activation” problem. Finally, experiments are performed comparing the greedy algorithm to three other approximation algorithms.

The last chapter in this section is titled “Norms of Behaviour and Their Identification and Verification in Open Multi-Agent Societies” by Wagdi Alrawagfeh, Edward Brown, and Manrique Mata-Montero. Norms have an obvious role in the coordinating and predicting behaviours in societies of software agents. Most researchers assume that agents already know the norms of their societies beforehand at design time. Others assume that norms are assigned by a leader or a legislator. Some researchers take into account the acquisition of societies’ norms through inference. Their works apply to closed multi-agent societies in which the agents have identical (or similar) internal architecture for representing norms. This chapter addresses three things: 1) the idea of a Verification Component that was previously used to verify candidate norms in multi-agent societies, 2) a known modification of the Verification Component that makes it applicable in open multi-agent societies, and 3) a modification of the Verification Component, so that agents can dynamically infer the new emerged and abrogated norms in open multi-agent societies. Using the JADE software framework, we build a restaurant interaction scenario as an example (where restaurants usually host heterogeneous agents), and demonstrate how permission and prohibition of behavior can be identified by agents using dynamic norms.

**E-BUSINESS SIMULATION**

The first chapter in this category studies an important topic in E-Business—trust. The chapter is titled “Enhanced Reputation Model with Forgiveness for E-Business Agents” by Radu Burete, Amelia Badica, Costin Badica, and Florin Moraru (University of Craiova, Romania). Trust is a very important quality attribute of an e-service. In particular, the increasing complexity of the e-business environment requires the development of new computational models of trust and reputation for e-business agents. In this chapter, the authors introduce a new reputation model for agents engaged in e-business transactions. The model enhances classic reputation models by the addition of forgiveness factor and the use of new sources of
reputation information based on agents groups. The chapter proposes an improvement of this model by employing the recent con-resistance concept. Finally, the authors show how the model can be used in an agent-based market environment where trusted buyer and seller agents meet, negotiate, and transact multi-issue e-business contracts. The system was implemented using JADE multi-agent platform and initially evaluated on a sample set of scenarios. The chapter introduces the design and implementation of the agent-based system together with the experimental scenarios and results.

The chapter titled “Multi-Agent Negotiation Paradigm for Agent Selection in B2C E-Commerce” proposes a negotiation rule for B2C business. It is by Bireshwar Dass Mazumdar, Swati Basak, and Neelam Modanwal. Multi Agent System (MAS) model has been extensively used in the different tasks of E-Commerce such as Customer Relation Management (CRM), negotiation, and brokering. The objective of this chapter is to evaluate a seller agent’s various cognitive parameters like capability, trust, and desire. After selecting a best seller agent from ordering queue, it applies negotiation strategies to find the most profitable proposal for both buyer and seller. This mechanism belongs to a semi cooperative negotiation type, and selecting a seller and buyer agent pair using mental and cognitive parameters. This work provides a logical cognitive model, logical negotiation model between buyer agent and selected seller agent.

The next chapter is titled “The Performance of Grey System Agent and ANN Agent in Predicting Closing Prices for Online Auctions” by Deborah Lim, Patricia Anthony, and Chong Mun Ho. The introduction of online auction has resulted in a rich collection of problems and issues especially in the bidding process. During the bidding process, bidders have to monitor multiple auction houses, pick from the many auctions to participate in and make the right bid. If bidders are able to predict the closing price for each auction, then they are able to make a better decision making on the time, place, and the amount they can bid for an item. However, predicting closing price for an auction is not easy since it is dependent on many factors such as the behavior of each bidder, the number of the bidders participating in that auction as well as each bidder’s reservation price. This chapter reports on the development of a predictor agent that utilizes Grey System Theory GM (1, 1) to predict the online auction closing price in order to maximize the bidder’s profit. The performance of this agent is compared with an Artificial Neural Network Predictor Agent (using Feed-Forward Back-Propagation Prediction Model). The effectiveness of these two agents is evaluated in a simulated auction environment as well as using real eBay auction’s data.

The last chapter in this category focuses on price-making in game theory. The chapter is titled “Price Rigidity and Strategic Uncertainty: An Agent-Based Approach” by Robert Somogyi and János Vincze. The phenomenon of infrequent price changes has troubled economists for decades. Intuitively one feels that for most price-setters there exists a range of inaction, i.e., a substantial measure of the states of the world, within which they do not wish to modify prevailing prices. Economists wishing to maintain rationality of price-setters resorted to fixed price adjustment costs as an explanation for price rigidity. This chapter proposes an alternative explanation, without recourse to any sort of physical adjustment cost, by putting strategic interaction into the center-stage of the analysis. Price-making is treated as a repeated oligopoly game. The traditional analysis of these games cannot pinpoint any equilibrium as a reasonable “solution” of the strategic situation. Thus, decision-makers have a genuine strategic uncertainty about the strategies of other decision-makers. Hesitation may lead to inaction. To model this situation, the authors follow the style of agent-based models, by modeling firms that change their pricing strategies following an evolutionary algorithm. In addition to reproducing the known negative relationship between price rigidity and the level of general inflation, the model exhibits several features
observed in real data. Moreover, most prices fall into the theoretical “range” without explicitly building this property into strategies.

SIMULATION IN HEALTH SCIENCES

This category presents three chapters from the University of Notre Dame in the area of health sciences. The first chapter is titled “A Spatial Agent-Based Model of Malaria: Model Verification and Effects of Spatial Heterogeneity” by S. M. Niaz Arifin, Gregory J. Davis, and Ying Zhou. In Agent-Based Modeling (ABM), an explicit spatial representation may be required for certain aspects of the system to be modeled realistically. A spatial ABM includes landscapes in which agents seek resources necessary for their survival. The spatial heterogeneity of the underlying landscape plays a crucial role in the resource-seeking process. This study describes a previous agent-based model of malaria, and the modeling of its spatial extension. In both models, all mosquito agents are represented individually. In the new spatial model, the agents also possess explicit spatial information. Within a landscape, adult female mosquito agents search for two types of resources: Aquatic Habitats (AHs) and Bloodmeal Locations (BMLs). These resources are specified within different spatial patterns, or landscapes. Model verification between the non-spatial and spatial models by means of docking is examined. Using different landscapes, the authors show that mosquito abundance remains unchanged. With the same overall system capacity, varying the density of resources in a landscape does not affect abundance. When the density of resources is constant, the overall capacity drives the system. For the spatial model, using landscapes with different resource densities of both resource-types, the authors show that spatial heterogeneity influences the mosquito population.

The second chapter is titled “Assessing the Impact of Temperature Change on the Effectiveness of Insecticide-Treated Nets” by Gregory J. Davis. Malaria is a vector-borne illness affecting millions of lives annually and imposes a heavy financial burden felt worldwide. Moreover, there is growing concern that global climate change, in particular, rising temperature, will increase this burden. As such, policy makers are in need of tools capable of informing them about the potential strengths and weaknesses of intervention and control strategies. A previously developed agent-based model of the Anopheles gambiae mosquito is extended, one of the primary vectors of malaria, to investigate how changes in temperature influence the dynamics of malaria transmission and the effectiveness of a common malaria intervention: Insecticide-Treated Nets (ITNs). Results from the simulations suggest two important findings. Consistent with previous studies, an increase in mosquito abundance as temperature increases is observed. However, the increase in mosquito abundance reduces the effectiveness of ITNs at a given coverage level. The implications and limitations of these findings are discussed.

The third chapter is titled “A Framework for Modeling Genetically-Aware Mosquito Vectors for Sterile Insect Technique” by James E. Gentile and Samuel S. C. Rund. Vector-borne diseases account for 16% of the global infectious disease burden (WHO, 2004). Many of these debilitating and sometimes fatal diseases are transmitted between human hosts by mosquitoes. Mosquito-targeted intervention methods have controlled or eliminated mosquito-borne diseases from many regions of the world but regions of constant transmission (holoendemic areas) still exist (Molineaux, et al., 1980). To eliminate these illnesses, researchers need to understand how interventions impact a mosquito population so as to identify potential avenues for new intervention techniques. This paper presents a software architecture that allows researchers to simulate transgenic interventions on a mosquito population. The authors present specifications for a model that captures these transgenic aspects and present a software architecture
that meets those needs. The authors also provide a proof of concept and some observations about sterile insect technique strategies as simulated by this architecture.

SIMULATION IN ECOSYSTEM

We present one chapter in simulating ecosystem. The title is “Quasi-PSO Algorithm for Modeling Foraging Dynamics in Social Mammals” by Marco Campenni and Federico Cecconi. In this chapter, the authors present a computational model of a fundamental social phenomenon in the study of animal behavior: the foraging. The purpose of this work is, first, to test the validity of the proposed model compared to another existing model, the flocking model; then, to try to understand whether the model may provide useful suggestions in studying the size of the group in some species of social mammals.

CONCLUSION

Agent-based systems have long eluded the collaboration system, health sciences, business and management sciences, social sciences, and many more disciplines as viable tools. This is in part due to the fact that objects’ in the world actions and interactions do not adhere to well defined rules. However, recent advances in studying both decision theory and organization theory have provided insight into the mechanics behind behavior either by human or other creatures. In order to provide these disciplines with a viable tool, agent-based systems must provide a proper computational model of both decision-making and social interaction then these structures and institutions and the cognitive capabilities of the agents that comprise them must be modeled to a level where computational complexity is not sacrificed on the behalf of realism. This volume presents a contribution to this goal. By employing realistic models based off of recent advances in decision making and social interaction, we are able to reproduce realistic behavior based on rational agents.

Yu Zhang
Trinity University, USA

REFERENCES


