GENERIC NODAL ABSTRACTION FOR ENHANCING HUMAN-AGENT COLLABORATIVE MODEL WITH AN INTEGRATED SECURITY AND TRUST ASPECTS

KHUDHAIR ABBAS MOHAMMED

Doctor of Philosophy

UNIVERSITI MALAYSIA PAHANG

SUPERVISOR'S DECLARATION

I hereby declare that I have checked this thesis and in my opinion, this thesis is adequate in terms of scope and quality for the award of the degree of Doctor of Philosophy.

____

(Supervisor's Signature)

Full Name : DR. MAZLINA ABDUL MAJID

Position : ASSOCIATE PROFESSOR

Date :

STUDENT'S DECLARATION

I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Malaysia Pahang or any other institutions.

____

(Student's Signature)

Full Name : KHUDHAIR ABBAS MOHAMMED

ID Number : PCC15001

Date :

GENERIC NODAL ABSTRACTION FOR ENHANCING HUMAN-AGENT COLLABORATIVE MODEL WITH AN INTEGRATED SECURITY AND TRUST ASPECTS

KHUDHAIR ABBAS MOHAMMED

Thesis submitted in fulfillment of the requirements
for the award of the degree of
Doctor of Philosophy

Faculty of Computer Systems and Software Engineering

UNIVERSITI MALAYSIA PAHANG

APRIL 2019

ACKNOWLEDGEMENTS

Firstly, all praise and thanks to Allah (Azza wa jalla) for His Divine Guidance and help in completing this research project.

My Salaam and Gratitude to the Beloved Prophet Mohammed (Peace and Blessings of Allah Be Upon Him) who was sent by Allah to be a great teacher for the human kind.

I would like to thank my supervisor, Assoc. Prof. Dr. Mazlina Abdul Majid and co-supervisor Prof. Dr. Mohd Sharifuddin bin Ahmad, for their encouragement, ideas, and support throughout the research project. I appreciate and cherish the moments I have spent with them since the start of this research. We have had productive discussions and constructive arguments over the theories and concepts proposed in this thesis.

I am deeply grateful to my parents, for teaching me to value excellence and for encouraging me to achieve my potential degree. I certainly would not be where I am today without their nurture, guidance, love and care throughout my life. Whatever I do, I will not be able to return the love, bestowal and support. I pray Allah for perfect health and prolong age and may Allah reward you richly.

I am greatly appreciating very much my brothers and sisters for their unconditional love and support. I realize how lucky I am to have them. May Allah bless them all.

My special thanks and love go to my wife. She has patiently stood by me to achieve this goal without much complaining. Thank You. I also would like to thank my children Jannah, Ayah, Ahmed, and Abdulazeez for bringing the joy to my heart in the difficult times of this long journey.

I would like to thank my friends, colleagues, fellow students for their support and the faculty staff and members for their hard work as well.

ABSTRAK

Sistem Kolaborasi merupakan platform berdaya maju yang memainkan peranan yang besar dalam prestasi tugas. Ini sangat ketara apabila Sistem Kolaborasi yang dimodelkan berdasarkan manusia dan agen perisian yang memerlukan tugasan dan tanggungjawab di dalam proses-proses sistem, merangkumi penyelesaian-penyelesaian terbaik, dan menambah baik kemahiran menyelesaikan masalah yang dihadapi pengguna-pengguna (manusia). Walau bagaimanapun, hasil dari permodelan perisian agen di dalam sistem-sistem kolaborasi mencatatkan beberapa masalah. Ini disebabkan oleh kepelbagaian tugas dan prosedur. Akibat dari isu-isu yang dinyatakan, implementasi kepada tugas yang dijadualkan dan proses aliran kerja menjadi sukar dan mencabar. Di dalam tesis ini, kami mencadangkan pendekatan inovatif untuk memodelkan sistem kolaborasi manusia-agen yang memberi kemudahan kepada kolaborasi dan proses-proses aliran kerja yang efektif. Pendekatan ini menggunakan manusia bersama agen yang pelbagai (MAS) dibawah tingkah-laku kolaborasi. Tingkah laku kolaboratif dibina berdasarkan konsep abstraksi nodal pintar, di mana setiap nod pintar terdiri daripada manusia, ejen pengantara, agen normal dan fungsi-fungsi yang dikongsikan. Fungsi-fungsi tersebut diberikan kepada nod yang sepadan dengan fungsi-fungsi yang dimiliki manusia, agen-agen normal dan agen pengantara mereka. Abstraksi nodal adalah generik, yang boleh digunakan dalam banyak aplikasi domain. Pendekatan Abstraksi Nodal Generik (Generic Nodal Abstraction - GNA) disusun dengan nod utama dan sub-nod untuk membentuk seni bina hierarki yang bermanfaat. Konsep ini memberi tanggapan bahawa agen boleh digunakan bagi membantu rakan-rakan manusia dalam pelbagai proses aliran kerja dan dalam pengendalian tugas biasa. Untuk mengenal pasti tugas umum bagi manusia dan pengantaranya yang rapat dan agen normal di dalam nod, kami menjalankan tinjauan soal selidik mengenai jabatan sumber manusia (HR) dari organisasi yang berlainan (majlis perbandaran dan kerja awam dan pentadbiran penjagaan kesihatan). Soal selidik yang dijalankan bertujuan mendapatkan maklumat yang berkaitan dengan fungsi yang dilakukan oleh pekerja-pekerja mereka. Bagi memastikan keselamatan dan ketepatan maklumat yang dikongsi dilaksanakan melalui pendekatan GNA, kami mengintegrasikan pendekatan tersebut dengan keselematan dan sub model yang amanah. Sub model yang digunakan membolehkan maklumat yang dikongsi antara nod tersebut selamat, efisien, tepat dan meningkatkan tahap keyakinan, boleh diharap dan boleh dipercayai pada nod GNA. Kami telah menguji GNA dan keputusannya mengesahkan (i) pendekatan GNA memudahkan kolaborasi antara manusia dan/atau ejen untuk melaksanakan tindakan-tindakan bersama di dalam tahap kerjasama yang mudah, (ii) ia mengurangkan beban kerja manusia dan mengurangkan edaran penyelesaian masalah, dan (iii) hasilnya, ia membuktikan yang GNA dengan keselamatan dan aspek amanah telah meningkatkan daya maju sistem kolaborasi manusia agen apabila beroperasi dalam pelbagaian persekitaran.

ABSTRACT

Collaborative systems are viable platforms for humans that play substantial roles in task performance. Notably, collaborative systems that are modelled based on humans and software agents entail tasks and responsibilities within system processes, covers the most suitable solutions, and improve problem-solving skills of the human users. However, the issues of modelling software agents in collaborative systems present some problems caused by the diversity of tasks and the procedures. Consequently, such issues pose critical challenges to implement scheduled tasks and workflow processes. Models, which compose of humans and systems manifest various complexities. A significant challenge is how to construct purpose-built approaches for multi-agent models that collaborate with humans based on humans' demands and positions to reduce his/her workload daily processes. In this thesis, we propose an innovative approach for modelling a human-agent collaborative system that facilitates effective collaboration and alleviate human workflow process. This approach employs humans with multi-agent systems (MAS) under applicable collaborative behavior. The applicable collaborative behavior is built based on the concept of an intelligent nodal abstraction, in which each intelligent node comprises of a human, mediator agent, normal agents, and their shared functions. The functions are assigned to the node which corresponds to those that belong to a human, normal agents and their mediator agent. The nodal abstraction is generic, which could be deployed in many domain applications. The Generic Nodal Abstraction (GNA) approach is conceived with a main node and sub-nodes to shape a hierarchical architecture which benefits. This concept espouses the notion that agents could be deployed to assist their human counterparts in various workflow processes and handle mundane tasks. To identify generalized tasks for the human and his/her tightly-coupled mediator and normal agents in a node, we conduct a questionnaire survey on human resource departments (HR) of different organizations (municipalities and public work and healthcare administration) soliciting information pertaining to the functions performed by their employees. To ensure the safety and accuracy of the shared information performed in the GNA approach, we integrate the approach with security and trust aspects. These aspects enable safe, efficient and precise information sharing between the nodes and increase the GNA nodes confidentiality, reliability, and trustworthy. We test and simulate the GNA approach which confirm that, (i) the GNA approach facilitates the collaboration between the humans and/or agents to perform their shared actions in a convenient cooperative levels, (ii) it reduces humans' workload and mitigate the distributed problem-solving, and (iii) consequently, its proves that the GNA with security and trust aspect enhances the viability of human agent collaborative systems when operating in various environments.

TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

ACL	Agent Communication Language
AI	Artificial Intelligence
AIMA	Artificial Intelligence Modern Approach
BDI	Beliefs, Desires, and Intentions
CSRP 1986	Civil Service Rules and Policies issued in 1986
CST	Collaboration, Security, and Trust
DAI	Distributed Artificial Intelligence
EE	Eligible Employee
FIPA	The Foundation for Intelligent Physical Agents
FU	Financial Unit
GNA	Generic Node Abstraction
HAC	Human-Agent Collaboration
HMDA	Human-Mediator Agent with one agent Node
HMDAs	Human-Mediator agent with multiple Agents' node
HoD	Head of Department
HR	Human Resource
IoT	Internet of Things
JADE	The Java Agent DEvelopment
JDK	Java Development Kit
KAoS	Knowledgeable Agent-oriented System
KQML	Knowledge Query and Manipulation Language
KSE	Knowledge Sharing Effort
MACVILLE	Multi-Agent Collaborative VIrtuaL Learning Environment
MAS	Multi-Agent Systems
MDA	Mediator agent with one agent node
NH	human-only node
OAA	Open Agent Architecture
O-MaSE	Organization based Multi-agents System Engineering
PIC	Person In Charge
PVM	Performance Visualization Module
SDLC	Software Development Life Cycle

SMAs	Server Manager Agents
SMMall	Shared Mental Models for all
SNA	Social Network Analysis
UAVs	Unmanned Aerial Vehicles
UM	Unit Manager
VMs	Virtual Machines
VU	Vacancy Unit
XML	Extensible Mark-up Language

REFRENCES

Abdul Majid, M., (2011). Human behaviour modelling: An investigation using traditional discrete event and combined discrete event and agent-based simulation. *Ph.D. Thesis. University of Nottingham, UK.*

Abedinzadeh, S. and Sadaoui, S., (2013). ScubAA: A human plausible reasoning approach to agent trust management. *In International Conference on Software Engineering and Knowledge Engineering,* A-2.

Adam, C., Danet, G., Thangarajah, J. and Dugdale, J., (2016). BDI modelling and simulation of human behaviours in bushfires. *In International Conference on Information Systems for Crisis Response and Management in Mediterranean Countries,* 47-61.

Adameit, S., Betz, T., Cabac, L., Hars, F., Hewelt, M., Köhler-Bußmeier, M., Moldt, D., Popov, D., Quenum, J., Theilmann, A. and Wagner, T., (2010). Modelling distributed network security in a petri net-and agent-based approach. *In German Conference on Multiagent System Technologies*, 209-220.

Ahlbrecht, T., Dix, J., Fiekas, N., Köster, M., Kraus, P. and Müller, J.P., (2016). An architecture for scalable simulation of systems of cognitive agents. *International Journal of Agent-Oriented Software Engineering*, 5(2-3), 232-265.

Ahmed, M., Ahmad, and Yusoff, M., (2010). Modeling agent-based collaborative process. *In International Conference on Computational Collective Intelligence*, 296-305.

Andreadis, G., Klazoglou, P., Niotaki, K. and Bouzakis, K.D., (2014). Classification and review of multi-agents systems in the manufacturing section. *Procedia Engineering*, 69, 282-290.

Baker, M. and Bielaczyc, K., (1995). Missed opportunities for learning in collaborative problem-solving interactions. *In World Conference on Artificial Intelligence in Education*, 210-217.

Base64. (2016). "What is Base 64 encoding?", from https://howtodoinjava.com/java8/base64-encoding-and-decoding-example-in-java-8/, last accessed on (February, 2015).

Becker-Asano, C. and Wachsmuth, I., (2010). Affective computing with primary and secondary emotions in a virtual human. *Autonomous Agents and Multi-Agent Systems,* 20(1), 32.

Bellifemine, F., Bergenti, F., Caire, G. and Poggi, A., (2005). *Jade—a Java agent development framework. In Multi-Agent Programming*. Springer, Boston, MA.

Bellifemine, F.L., Caire, G. and Greenwood, D., (2007). *Developing multi-agent systems with Jade.* John Wiley & Sons.

Bergenti, F., Iotti, E. and Poggi, A., (2016). Core features of an agent-oriented domainspecific language for Jade agents. *In International Conference on Trends in Practical Applications of Scalable Multi-Agent Systems*, 213-224.

Bertuccelli, L., Beckers, W. and Cummings, M., (2010). Developing operator models for UAV search scheduling. *In International Conference on Guidance, Navigation, and Control,* 78-63.

Bhamra, G.S., Verma, A.K. and Patel, R.B., (2014). Intelligent software agent technology: an overview. *International Journal of Computer Applications*, 89(2), 19-31.

Bradshaw, J.M., (1996). KAoS: An open agent architecture supporting reuse, interoperability, and extensibility. *In 10th International Workshop Knowledge Acquisition for Knowledge-Based Systems*, 1-19.

Bresciani, P., Perini, A., Giorgini, P., Giunchiglia, F. and Mylopoulos, J., (2004). Tropos: An agent-oriented software development methodology. *Autonomous Agents and Multi-Agent Systems,* 8(3), 203-236.

Briggs, G.M. and Scheutz, M., (2013). A hybrid architectural approach to understanding and appropriately generating indirect speech acts. *In 27th AAAI Conference on Artificial Intelligence,* 1213-1219.

Butner, J.E., Wiltshire, T.J. and Munion, A.K., (2017). Modeling multi-agent self-organization through the lens of higher order attractor dynamics. *Frontiers in Psychology,* 8, 380.

Byrski, A., Dreżewski, R., Siwik, L. and Kisiel-Dorohinicki, M., (2015). *Evolutionary multi-agent systems. The Knowledge Engineering Review*, 30(2), 171-186.

Caillou, P., Gaudou, B., Grignard, A., Truong, C.Q. and Taillandier, P., (2017). A Simple-to-use BDI architecture for Agent-based modeling and simulation. *In International Conference on Advances in Social Simulation*, 15-28.

Cao, M., Luo, X., Luo, X.R. and Dai, X., (2015). Automated negotiation for e-commerce decision making: A goal deliberated agent architecture for multi-strategy selection. *Decision Support Systems,* 73, 1-14.

Chen, H., Finin, T., Joshi, A., Kagal, L., Perich, F. and Chakraborty, D., (2004). Intelligent agents meet the semantic web in smart spaces. *IEEE Internet Computing,* 8(6), 69-79.

Chen, W., Durfee, E. and Dumas, M., (2009). Human agent collaboration in a simulated combat medical scenario. *In International Symposium on Collaborative Technologies and Systems*, 367-375.

Chen, W., Manikonda, V. and Durfee, E., (2007). A flexible human agent collaboration (hac) framework for human-human activity coordination (h2ac). *In International Symposium Regarding the" Intelligence" in Distributed Intelligent Systems*, 38-41.

Chira, O., Chira, C., Tormey, D., Brennan, A. and Roche, T., (2003). A multi-agent architecture for distributed design. *In International Conference on Industrial Applications of Holonic and Multi-Agent Systems*, 213-224.

Chitre, M., Bhatnagar, R. and Soh, W.S., (2014). UnetStack: An agent-based software stack and simulator for underwater networks. *In International Conference on Oceans-St. John's,* 1-10.

Chouhan, S.S. and Niyogi, R., (2016). Multi-agent planning with collaborative actions. *In Australasian Joint Conference on Artificial Intelligence*, 609-620.

Ciortea, E.M., Tulbure, A. and Huţanu, C.T., (2016). Multi-agent for manufacturing systems optimization. *In International Conference on Series: Materials Science and Engineering*, 1-6.

Cobb-Clark, D.A., (2001). Getting ahead: The determinants of and payoffs to internal promotion for young US men and women. *In Worker Wellbeing in a Changing Labor Market*, 339-372.

Coppolino, L., Srl, E., Jäger, M., Kuntze, N. and Rieke, R., (2014). A trusted information agent for security information and event management. *Security Analysis of System Behaviour*, 265, 253-265.

Cordasco, G., De Chiara, R., Mancuso, A., Mazzeo, D., Scarano, V. and Spagnuolo, C., (2011). A framework for distributing agent-based simulations. *In European Conference on Parallel Processing*, 460-470.

Cummings, M.L., Brzezinski, A.S. and Lee, J.D., (2007). The impact of intelligent aiding for multiple unmanned aerial vehicle schedule management. *IEEE Intelligent Systems: Special Issue on Interacting with Autonomy*, 22(2), 52–59.

Das, A. and Islam, M.M., (2012). SecuredTrust: A dynamic trust computation model for secured communication in multiagent systems. *IEEE Transactions on Dependable and Secure Computing*, 9(2), 261-274.

Day, M.Y., Shih, S.P. and Chang, W., (2011). Social network analysis of research collaboration in information reuse and integration. *In Information Conference on Reuse and Integration*, 551-556.

De Pauw, G., Wagacha, P.W. and de Schryver, G.M., (2009). The SAWA corpus: A parallel corpus English-Swahili. *In 1st International Workshop on Language Technologies for African Languages*, 9-16.

De Tjerk, E.G., Henryk, F.A. and Neerincx, M.A., (2010). Adaptive automation based on an object-oriented task model: Implementation and evaluation in a realistic c2 environment. *Journal of Cognitive Engineering and Decision Making*, 4(2), 152-182.

Debar, H., Dacier, M. and Wespi, A., (2000). A revised taxonomy for intrusion-detection systems. *In International Conference on Annales des télécommunications*, 361-378.

Delle Fave, F.M., Rogers, A., Xu, Z., Sukkarieh, S. and Jennings, N.R., (2012).

Deploying the max-sum algorithm for decentralised coordination and task allocation of unmanned aerial vehicles for live aerial imagery collection. *In International Conference on Robotics and Automation*, 469-476.

Dunin-Keplicz, B. and Verbrugge, R., (2011). *Teamwork in multi-agent systems: A formal approach.* John Wiley & Sons.

Ehlert, P.A. and Rothkrantz, L.J., (2001). Microscopic traffic simulation with reactive driving agents. *In International Conference on Intelligent Transportation Systems*, 861-866.

El Ajjouri, M., Benhadou, S. and Medromi, H., (2015). New collaborative intrusion detection architecture based on multi agent systems. *In International Conference on Wireless Networks and Mobile Communications*, 1-6.

Fan, X. and Yen, J., (2011). Modeling cognitive loads for evolving shared mental models in human–agent collaboration. *IEEE Transactions on Systems, Man, and Cybernetics*, 41(2), 354-367.

Farnham, D. and Pimlott, J., (1995). *Understanding industrial relations*. Burns & Oates.

Finin, T., Fritzson, R., McKay, D. and McEntire, R., (1994). KQML as an agent communication language. *In 3rd International Conference on Information and Knowledge Management*, 456-463.

Firesmith, D.G. and Henderson-Sellers, B., (2002). *The open process framework: An introduction.* Pearson Education.

Florea, A.M., (1998). *Introduction to multi-agent systems. International Summer School on Multi-Agent Systems*. Bucharest, 6.

Franklin, S., A. Graesser, (1996). Is it an Agent or just a Program? A Taxonomy for Autonomous Agents. *In 3rd International Workshop on Agents Theories, Architectures, and Languages*, 1-10.

Furmankiewicz, M., Sołtysik-Piorunkiewicz, A. and Ziuziański, P., (2014). Artificial intelligence and multi-agent software for e-health knowledge management system. *Informatyka Ekonomiczna*, 2(32), 51-63.

Galland, S., Knapen, L., Gaud, N., Janssens, D., Lamotte, O., Koukam, A. and Wets, G., (2014). Multi-agent simulation of individual mobility behaviour in carpooling. *Transportation Research Part C: Emerging Technologies*, 45, 83-98.

Genesereth, M.R., (1994). *Software agents michael R.* Genesereth Logic Group Computer Science Department Stanford University. USA

Golpayegani, F., Dusparic, I., Taylor, A. and Clarke, S., (2016). Multi-agent collaboration for conflict management in residential demand response. *Computer Communications*, 96, 63-72.

Gonçalves, E.J.T., Cortés, M.I., Campos, G.A.L., Lopes, Y.S., Freire, E.S., da Silva, V.T., de Oliveira, K.S.F. and de Oliveira, M.A., (2015). MAS-ML 2.0: Supporting the modelling of multi-agent systems with different agent architectures. *Journal of Systems and Software,* 108, 77-109.

Gutierrez-Garcia, J.O. and Ramirez-Nafarrate, A., (2015). Collaborative agents for distributed load management in cloud data centres using live migration of virtual machines. *IEEE Transactions on Services Computing,* 8(6), 916-929.

Hamid, N.H.A., Ahmad, M.S., Ahmad, A., Mustapha, A., Mahmoud, M.A. and Yusoff, M.Z.M., (2015). Trusting norms: A conceptual norms' trust framework for norms adoption in open normative multi-agent systems. *In 12th International Conference on Distributed Computing and Artificial Intelligence,*149-157.

Hancock, P.A., Billings, D.R., Schaefer, K.E., Chen, J.Y., De Visser, E.J. and Parasuraman, R., (2011). A meta-analysis of factors affecting trust in human-robot interaction. *Human Factors*, 53(5), 517-527.

Hanna, N. and Richards, D., (2012). A collaborative agent architecture with human-agent communication model. *In International Workshop on Cognitive Agents for Virtual Environments,* 70-88.

Hayzelden, A.L. and Bigham, J., (1999). *Software agents for future communication systems.* Springer Science and Business Media.

Hedin, Y. and Moradian, E., (2015). Security in multi-agent systems. *Procedia Computer Science,* 60, 1604-1612.

Huynh, T.D., Jennings, N.R. and Shadbolt, N.R., (2006). An integrated trust and reputation model for open multi-agent systems. *Autonomous Agents and Multi-Agent Systems,* 13(2), 119-154.

Itika, J., (2011). *Fundamentals of human resource management: Emerging experiences from Africa.* African Public Administration and Management Series. African Studies Centre, Leiden.

Ivan, I., Ciurea, C. and Pavel, S., (2010). Very large data volumes analysis of collaborative systems with finite number of states. *Journal of Applied Quantitative Methods,* 5(1), 14-28.

Izumi, T., Santoro, N. and Viglietta, G., (2017). Population protocols with faulty interactions: the impact of a leader. *In 10th International Conference on Algorithms and Complexity,* 454.

Jadbabaie, A., Lin, J. and Morse, A.S., (2003). Coordination of groups of mobile autonomous agents using nearest neighbour rules. *IEEE Transactions on Automatic Control,* 48(6), 988-1001.

Jain, U.K., Bhatia, R.K., Rao, A.R., Singh, R., Saxena, A.K. and Sehar, I., (2014). Design and development of halogenated chalcone derivatives as potential anticancer agents. *Tropical Journal of Pharmaceutical Research,* 13(1), 73-80.

Jennings, N.R., Sycara, K. and Wooldridge, M., (1998). A roadmap of agent research and development. *Autonomous Agents and Multi-Agent Systems,* 1(1), 7-38.

Jing, Q., Vasilakos, A.V., Wan, J., Lu, J. and Qiu, D., (2014). Security of the internet of things: perspectives and challenges. *Wireless Networks,* 20(8), 2481-2501.

Jöst, M., Merdes, M. and Malaka, R., (2004). Listening to agents–transparent representation and presentation of agent communication in mobile systems. *In International Conference on Object-Oriented and Internet-Based Technologies,* 55-68.

Kazemi, A., Zarandi, M.H.F. and Azizmohammadi, M., (2017). A hybrid search approach in production-distribution planning problem in supply chain using multi-agent systems. *International Journal of Operational Research,* 28(4), 506-527.

Khosravifar, B., Bentahar, J., Gomrokchi, M. and Alam, R., (2012). CRM: An efficient trust and reputation model for agent computing. *Knowledge-Based Systems,* 30, 1-16.

Labrou, Y., Finin, T. and Peng, Y., (1999). Agent communication languages: The current landscape. *IEEE Intelligent Systems,* (2),.45-52.

Li, S. and Kokar, M.M., (2013). Agent communication language. *In Flexible Adaptation in Cognitive Radios,* 37-44.

Lipponen, L., (2002). Exploring foundations for computer-supported collaborative learning. *In International Conference on Computer Support for Collaborative Learning*, 72-81.

Liu, C.L. and Liu, F., (2011). Stationary consensus of heterogeneous multi-agent systems with bounded communication delays. *Automatica,* 47(9), 2130-2133.

Louis, V. and Martinez, T., (2005). The Jade semantic agent: Towards agent communication oriented middleware. *AgentLink News,* 18, 16-18.

Lu, G., Lu, J., Yao, S. and Yip, Y.J., (2009). A review on computational trust models for multi-agent systems. *The Open Information Science Journal,* 2, 18-25.

Ma, C.Q. and Zhang, J.F., (2010). Necessary and sufficient conditions for consensusability of linear multi-agent systems. *IEEE Transactions on Automatic Control,* 55(5), 1263-1268.

Macal, C. and North, M., (2014). Introductory tutorial: Agent-based modeling and simulation. *In International Conference on Winter Simulation*, 6-20.

Majid, M.A., Aickelin, U. and Siebers, P.O., (2009). Comparing simulation output accuracy of discrete event and agent based models: A quantitative approach. *In International Conference on Computer Simulation Society for Modeling and Simulation*, 177-184.

Majid, M.A., Fakhreldin, M. and Zamli, K.Z., (2016). An enhanced simulation model for complex human pedestrian movement system using hybrid discrete event and agent based simulation. *International Information Institute (Tokyo). Information,* 19(9B), 4213.

Maliah, S., Shani, G. and Stern, R., (2017). Collaborative privacy preserving multi-agent planning. *Autonomous Agents and Multi-Agent Systems*, 31(3), 493-530.

McBurney, P. and Luck, M., (2007). The agents are all busy doing stuff. *IEEE Intelligent Systems*, 22(4), 6-7.

Meads, G., Ashcroft, J., Barr, H., Scott, R. and Wild, A., (2008). *The case for interprofessional collaboration: In Health and Social Care.* John Wiley & Sons.

Mekdeci, B. and Cummings, M.L., (2009). Modeling multiple human operators in the supervisory control of heterogeneous unmanned vehicles. *In 9th International Workshop on Performance Metrics for Intelligent Systems*, 1-8.

Mekid, S., (2006). Further structural intelligence for sensors cluster technology in manufacturing. *Sensors*, 6(6), 557-577.

Merabet, G.H., Essaaidi, M., Talei, H., Abid, M.R., Khalil, N., Madkour, M. and Benhaddou, D., (2014). Applications of multi-agent systems in smart grids: A survey. *In International Conference on Multimedia Computing and Systems*, 1088-1094.

Mohammed, K.A., Ahmad, M.S., Mostafa, S.A. and Sharifuddin, F.M.A.M., (2012). A nodal approach to modeling human-agents collaboration. *International Journal of Computer Applications, Foundation of Computer Science,* 43(12), 33-40.

Mohammed, K.A., Mostafa, S.A., Ahmad, M.S. and Mahmoud, M.A., (2014). A qualitative analysis of human-agent functions for collaborative multi-agent system. *In International Conference on Information Technology and Multimedia*, 244-249.

Moradian, E., (2013). Security of e-commerce software systems. *In Agent and Multi-Agent Systems in Distributed Systems-Digital Economy and E-Commerce,* 95-103.

Mouratidis, H. and Giorgini, P., (2007). Secure tropos: A security-oriented extension of the tropos methodology. *International Journal of Software Engineering and Knowledge Engineering,* 17(02), 285-309.

Mouratidis, H., Giorgini, P. and Manson, G., (2003). An ontology for modelling security: The tropos approach. *In International Conference on Knowledge-Based and Intelligent Information and Engineering Systems,* 1387-1394.

Müller, F., (2016). *What is a speech act? A brief introduction to Searle's theory on speech acts.* GRIN, Verlag.

Mustapha, K., Mcheick, H. and Mellouli, S., (2016). Smart cities and resilience plans: A multi-agent based simulation for extreme event rescuing. *In Smarter as the*

New Urban Agenda, 149-170.

Mwinyi, A.K., Al-Haddad, S.A.R., Hashim, S.B. and Abdullah, R.B.H., (2014). Review on multi-agent system collaboration in learning management system domain by deploying wireless sensor networks for student location detection. *Journal of Computer Science*, 10(6), 995.

Norling, E., (2004). Folk psychology for human modelling: Extending the BDI paradigm. *In 3rd International Conference on Autonomous Agents and Multiagent Systems*, 202-209.

Nwana, H., (1996). Software Agents: An overview. Intelligent Systems Research. *The Knowledge Engineering Review*, 11(3), 205-244. .

Nwana, H.S. and Wooldridge, M., (1996). Software agent technologies. *BT Technology Journal*, 14(4).

Nyame-Asiamah, F. and Patel, N.V., (2009). Research methods and methodologies for studying organisational learning. *In European and Mediterranean Conference on Information Systems*, 1-12

Olfati-Saber, R., Fax, J.A. and Murray, R.M., (2007). Consensus and cooperation in networked multi-agent systems. *In Proceeding of IEEE*, 215-233.

Park, J.S. and Jang, G.J., (2015). Implementation of voice emotion recognition for interaction with mobile agent. *In 3rd International Conference on Human-Agent Interaction*, 307-308.

Perrault, C.R. and Kohen, P.R., (1977). Overview of planning speech acts. *In International Joint Conference on Artificial Intelligence*, 119.

Pinyol, I. and Sabater-Mir, J., (2013). Computational trust and reputation models for open multi-agent systems: A review. *Artificial Intelligence Review*, 40(1), 1-25.

Poslad, S., Charlton, P. and Calisti, M., (2002). Specifying standard security mechanisms in multi-agent systems. *In International Workshop on Deception, Fraud and Trust in Agent Societies*, 163-176.

Poveda, G. and Schumann, R., (2016). An ontology-driven approach for modeling a multi-agent-based electricity market. *In German Conference on Multiagent System Technologies*, 27-40.

Pujari, S. and Mukhopadhyay, S., (2012). Agent oriented e-learning system for visually impaired students using Jade agent technology. *International Journal of Advanced Research in Computer Science*, 3(3), 48-56.

Ramchurn, S.D., Farinelli, A., Macarthur, K.S. and Jennings, N.R., (2010). Decentralized coordination in robocup rescue. *The Computer Journal*, 53(9), 1447-1461.

Ramchurn, S.D., Fischer, J.E., Ikuno, Y., Wu, F., Flann, J. and Waldock, A., (2015). A study of human-agent collaboration for multi-UAV task allocation in dynamic environments. *In International Joint Conferences on Artificial Intelligence*, 1184-1192.

Ramchurn, S.D., Wu, F., Jiang, W., Fischer, J.E., Reece, S., Roberts, S., Rodden, T., Greenhalgh, C. and Jennings, N.R., (2016). Human–agent collaboration for disaster response. *Autonomous Agents and Multi-Agent Systems*, 30(1), 82-111.

Rao, A.S. and Georgeff, M.P., (1995). BDI agents: From theory to practice. *In 1st International Conference on Multi-Agent Systems*, 312-319.

Rao, A.S. and Georgeff, M.P., (1995). The semantics of intention maintenance for rational agents. *In 14th International Joint Conference on Artificial Intelligence*, 704-710.

Rao, A.S., (1996). AgentSpeak (L): BDI agents speak out in a logical computable language. *In European Workshop on Modelling Autonomous Agents in a Multi-Agent World*, 42-55.

Rashvand, H.F., Salah, K., Calero, J.M.A. and Harn, L., (2010). Distributed security for multi-agent systems-review and applications. *IET Information Security*, 4(4), 188-201.

Ren, W. and Cao, Y., (2010). *Distributed coordination of multi-agent networks: Emergent problems, models, and issues.* Springer Science & Business Media.

Ren, W. and Sorensen, N., (2008). Distributed coordination architecture for multi-robot formation control. *Robotics and Autonomous Systems,* 56(4), 324-333.

Rogers, A., Farinelli, A., Stranders, R. and Jennings, N.R., (2011). Bounded approximate decentralised coordination via the max-sum algorithm. *Artificial Intelligence*, 175(2), 730-759.

Rosaci, D. and Sarné, G.M., (2013). Cloning mechanisms to improve agent performances. *Journal of Network and Computer Applications*, 36(1), 402-408.

Rosaci, D., (2012). Trust measures for competitive agents. *Knowledge-Based Systems,* 28, 38-46.

Russell, S., Norvig, P. and Intelligence, A., (1995). A modern approach. *Artificial Intelligence,* 25(27), 79-80.

Sanders, T., Oleson, K.E., Billings, D.R., Chen, J.Y. and Hancock, P.A., (2011). A model of human-robot trust: Theoretical model development. *In International Conference on Human Factors and Ergonomics Society Annual Meeting*, 1432-1436.

Santra, S. and Acharjya, P.P., (2013). A Study and analysis on computer network topology for data communication. *International Journal of Emerging Technology and Advanced Engineering,* 3(1), 522-525

Sato, G.Y., Azevedo, H.J. and Barthès, J.P.A., (2012). Agent and multi-agent applications to support distributed communities of practice: A short review.

Autonomous Agents and Multi-Agent Systems, 25(1), 87-129.

Sawa, Y., Bhakta, R., Harris, I.G. and Hadnagy, C., (2016). Detection of social engineering attacks through natural language processing of conversations. *In 10th International Conference on Semantic Computing*, 262-265.

Schut, M., Wooldridge, M. and Parsons, S., (2004). The theory and practice of intention reconsideration. *Journal of Experimental & Theoretical Artificial Intelligence,* 16(4), 261-293.

Searle, J.R., (1980). *The background of meaning. In Speech act theory and pragmatics*. Springer, Dordrecht.

Shajari, M. and Ghorbani, A.A., (2004). Application of belief-desire-intention agents in intrusion detection & response. *In PST*, 181-191.

Shih, D.H., Chiang, H.S., Yen, D.C. and Huang, S.C., (2013). An intelligent embedded system for malicious email filtering. *Computer Standards and Interfaces,* 35(5), 557-565.

Singh, B., Tran, D., Mkandawire, S. and Rodriguez, A., (2017). *Self-adjusting mobile platform policy enforcement agent for controlling network access, mobility and efficient use of local and network resources*, U.S. Patent 9,781,645.

Stranders, R., (2006). Argumentation based decision making for trust in multi-agent systems. *IEEE Transactions on Knowledge and Data Engineering,* 6(1), 64-71.

Suguri, H., (1999). A standardization effort for agent technologies: The foundation for intelligent physical agents and its activities. *In Annual Hawaii International Conference on System Sciences*, 80-61.

Taddeo, M., (2010). Modelling trust in artificial agents, a first step toward the analysis of e-trust. *Minds and Machines*, 20(2), 243-257.

Thirumalai, C.S. and Senthilkumar, M., (2016). Secured E-mail system using base 128 encoding scheme. *International Journal of Pharmacy And Technology*, 8(4), 21797-806.

Tramullas, J. ed., (2012). *Library Automation and OPAC 2.0: Information Access and Services in the 2.0 Landscape: Information Access and Services in the 2.0* Landscape. IGI Global.

Tsai, W.T., Fan, C., Chen, Y. and Paul, R., (2006). Ddsos: A dynamic distributed service-oriented simulation framework. *In 39th International Conference on Annual Symposium on Simulation*, 160-167.

Tweedale, J.W., (2014). A review of cognitive decision-making within future mission systems. *Procedia Computer Science,* 35, 1043-1052.

Van Hoof, B. and Thiell, M., (2014). Collaboration capacity for sustainable supply chain management: small and medium-sized enterprises in Mexico. *Journal of*

Cleaner Production, 67, 239-248.

Van Wissen, A., Gal, Y.A., Kamphorst, B.A. and Dignum, M.V., (2012). Human–agent teamwork in dynamic environments. *Computers in Human Behavior*, 28(1), 23-33.

Vidoni, R., (2011). A multi agent robotic system for simulation and control of a manufacturing process. *Acta Technica Corviniensis-Bulletin of Engineering,* 4(1), 93.

Walton, D., Toniolo, A. and Norman, T.J., (2016). Speech acts and burden of proof in computational models of deliberation dialogue. *In 1st European Conference on Argumentation*, 1-20.

Wang, X., Shi, Z., Zhang, F. and Wang, Y., (2015). Dynamic real-time scheduling for human-agent collaboration systems based on mutual trust. *Cyber-Physical Systems,* (2-4), 76-90.

Wardell, D.C., Mills, R.F., Peterson, G.L. and Oxley, M.E., (2016). A method for revealing and addressing security vulnerabilities in cyber-physical systems by modeling malicious agent interactions with formal verification. *Procedia Computer Science*, 95, 24-31.

Wijngaards, N.J., Overeinder, B.J., van Steen, M. and Brazier, F.M., (2002). Supporting internet-scale multi-agent systems. *Data & Knowledge Engineering,* 41(2-3), 229-245.

Willmott, S., Calisti, M., Faltings, B., Macho-Gonzalez, S., Belakhdar, O. and Torrens, M., (2000). CCL: Expressions of choice in agent communication. *In 4th International Conference on Multi-Agent Systems*, 325-332.

Wooldridge, M. and Jennings, N.R., (1995). Intelligent agents: Theory and practice. *The Knowledge Engineering Review,* 10(2), 115-152.

Wooldridge, M., Jennings, N.R. and Kinny, D., (2000). The Gaia methodology for agent-oriented analysis and design. *Autonomous Agents and Multi-Agent systems,* 3(3), 285-312.

Yu, B. and Singh, M.P., (2003). Detecting deception in reputation management. *In 2nd International Joint Conference on Autonomous Agents And Multi-Agent Systems*, 73-80.

Yu, W., Chen, G. and Cao, M., (2010). Some necessary and sufficient conditions for second-order consensus in multi-agent dynamical systems. *Automatica,* 46(6), 1089-1095.

Yuan, J., Zhang, Q.M., Gao, J., Zhang, L., Wan, X.S., Yu, X.J. and Zhou, T., (2016). Promotion and resignation in employee networks. *Physica A: Statistical Mechanics and its Applications,* 444, 442-447.

Yue, X., Qiu, X., Ji, Y. and Zhang, C., (2009). P2P attack taxonomy and relationship analysis. *In 11th International Conference on Advanced Communication*

Technology, 1207-1210.

Zambonelli, F., Jennings, N.R. and Wooldridge, M., (2003). Developing multi-agent systems: The Gaia methodology. *ACM Transactions on Software Engineering and Methodology,* 12(3), 317-370.

Zambonelli, F., Omicini, A., Anzengruber, B., Castelli, G., De Angelis, F.L., Serugendo, G.D.M., Dobson, S., Fernandez-Marquez, J.L., Ferscha, A., Mamei, M. and Mariani, S., (2015). Developing pervasive multi-agent systems with nature-inspired coordination. *Pervasive and Mobile Computing*, 17, 236-252.

Zhang, A., (2014). *Collaboration in the australian and chinese mobile telecommunication markets.* Springer. Berlin and Heidelberg.

Zhao, R., Papangelis, A. and Cassell, J., (2014). Towards a dyadic computational model of rapport management for human-virtual agent interaction. *In International Conference on Intelligent Virtual Agents*, 514-527.

Zhou, H. and Benton Jr, W.C., (2007). Supply chain practice and information sharing. *Journal of Operations management,* 25(6), 1348-1365.