

UNIVERSITY OF TECHNOLOGY SYDNEY

**An Argumentation System that Builds Trusted
Trading Partnerships**

A dissertation submitted for the degree of
Doctor of Philosophy in Computing Sciences

by

Khandaker Shahidul Islam

Sydney, Australia

2010

CERTIFICATE OF AUTHORSHIP/ORIGINALITY

I certify that the work in this thesis has not previously been submitted for a degree nor has it been submitted as part of requirements for a degree except as fully acknowledged within the text.

I also certify that the thesis has been written by me. Any help that I have received in my research work and the preparation of the thesis itself has been acknowledged. In addition, I certify that all information sources and literature used are indicated in the thesis.

Signature of Candidate



A handwritten signature in black ink, followed by the date "11-02-2010". The signature is stylized and difficult to decipher, but appears to contain the letters "S" and "M".

Acknowledgement

I would specially like to thank my thesis supervisors Prof. John Debenham and Prof. Simeon Simoff who have worked hard with me in this years, teaching me many important things, among them the most important one is the encouragement throughout the period of my studies. My gratitude goes to the University of Technology Sydney for accepting my scholarship application, funding conference trips, and simply for giving me the opportunity to enjoy being a part of one of the best universities in Australia. Thanks to my colleagues Paul Bogg, Ante Prodan, Anton Bogdanovych, Lei Zhang, and Hooman Homayounfard as well as to other friendly people from e-Market research group, who were always there when I needed to hear a friendly human voice or share one of my new ideas with them. I am thankful to Deborah Turnbull and Sue Felix for proof reading the draft of this dissertation. I would like to thank all the faculty members, and staffs at Faculty of Engineering and Information Technology who have collaborated with me in these years. Last but not least I would like to express my gratitude to my family members who gave me hospitality during this years, and to all friends, relatives, and colleagues who made these years full of love and of happiness.

Submitted by:

Khandaker Shahidul Islam

Contents

1	Introduction	1
1.1	Motivation and Aim	1
1.2	Research Questions	3
1.3	Outline of the Proposed Solution	5
1.3.1	Contributions and Significance	9
1.3.2	Scope	13
1.4	Structure of the Dissertation	13
2	Related Work	15
2.1	How to Reach an Agreement	16
2.1.1	Negotiation	17
2.1.2	Argumentation	20
2.2	What an Agent is Capable of Performing	21
2.2.1	A Negotiation Agent	22
2.2.2	An Argumentation Agent	24
2.3	Approaches to Argumentation	26
2.3.1	Logical Argumentation	26
2.3.2	Persuasive Argumentation	27
2.3.3	Interest Based Argumentation	28

2.3.4	Preference Based Argumentation	28
2.3.5	Information Based Argumentation	29
2.4	How an Agent Conducts Trading Activities	30
2.4.1	How to Specify Needs and Which Enactments (i.e., Products and Services) Satisfy the Specified Needs	31
2.4.2	Who to Interact With	33
2.4.3	How to Interact	34
2.4.4	How to Enact a Signed Commitment and Evaluate the Enactment (i.e., Payment and Delivery)	34
2.5	How an Agent Repeatedly Conducts Trading Activities	35
2.5.1	The Valuation of Dialogues	36
2.5.2	Summary Measures	38
2.5.3	Rationality	40
2.5.4	The Degree of Cooperation	42
2.6	Information Based Agency	45
2.6.1	A Negotiation Agent that Satisfies a Given Need	47
2.6.2	An Argumentation Agent that Builds Business Relationships	49
2.7	Introduction to the Relationship Aware Argumentation System	51
2.7.1	Requirements	52
2.7.2	A Relationship Aware Argumentation Agent	56
2.8	Discussion	58
3	Argumentation System	60
3.1	Conceptual Framework: the five models to support an argumentation system	61

3.2	The Needs Model	64
3.2.1	Need Attributes	64
3.2.2	Negotiation Object	66
3.2.3	Deal Space	67
3.3	The Opponent Agent Selection Model	69
3.3.1	Random Selection	70
3.3.2	Based on Behavioural Parameters	71
3.3.3	Based on Performance Parameters	73
3.4	The Communication Model	75
3.4.1	Language	75
3.4.2	Ontology	79
3.4.3	Protocol	80
3.4.4	Exchanging Information	81
3.5	The Agreement Model	84
3.5.1	Commitment and Agreement	84
3.5.2	Enactment	87
3.5.3	Evaluation	90
3.6	The Relationship Model	91
3.6.1	The Dialogue History	92
3.6.2	The Evaluation Database	94
3.6.3	Analysis of the Exchanged Arguments and Information	98
3.7	Introduction to the Relationship Aware Argumentation Framework	101
3.7.1	Requirements	102
3.8	Validation	103
3.9	Discussion	104

4	Relationship Aware Argumentation Framework	106
4.1	Functional Components of the Relationship Aware Argumentation Framework	107
4.2	How to Prepare for Interaction	110
4.2.1	Constructing the Social Model	110
4.3	How to Analyze the Exchanged Arguments and Information	113
4.3.1	Extracting the Exchanged Arguments and Information	114
4.3.2	Analyzing the Argument Response Vector	116
4.3.3	Analyzing the Exchanged Information Response Vector	118
4.4	How to Predict the Behavioural Parameters	121
4.4.1	Predicting the Need Attributes of an Opponent Agent	122
4.4.2	Predicting the Contract Acceptance Criteria by an Opponent Agent	123
4.4.3	Predicting the Behaviour Category of an Opponent Agent	127
4.5	Agent Architecture	130
4.6	Validation	133
4.6.1	Experiments	133
4.7	Discussion	139
5	Conclusion and Future Work	141
5.1	Future Work	143
A	Miscellaneous	146
A.1	Ontology	146
A.2	Negotiation Object	147
A.2.1	Need Attributes	148
A.3	Flowcharts	148

A.3.1	A Negotiation Protocol	148
A.3.2	An Argumentation Protocol	149
A.4	The Behaviour Classification Matrix	150
A.5	The Simulation Environment	151
A.6	Sample Outputs	152
A.6.1	The Initial Deal Space and Probability of Contract Acceptance .	152
A.6.2	A Sample of the Dialogue history	154
A.6.3	A Sample of the Evaluation Database	155
A.6.4	An Example of the Arrival Rate Estimation	156

List of Figures

1.1	The Agents in a Simple Argumentation System	9
2.1	Research Work on Information Based Agency	47
2.2	A Negotiation Agent that Satisfies a Given Need	48
2.3	An Argumentation Agent that Builds Business Relationships	50
2.4	A Relationship Aware Argumentation Agent	57
3.1	Conceptual Framework of the Relationship Aware Argumentation System	62
3.2	The Opponent Agent Selection Model	70
4.1	The Relationship Aware Argumentation Framework	108
4.2	The Proposed Relationship Aware Argumentation Agent Architecture	131
4.3	The Simulation Methodology	136
4.4	The Trusted Trading Partnership Test	138
A.1	An Item Ontology	147
A.2	A Free Item Ontology	147
A.3	A Negotiation Protocol	149
A.4	An Argumentation Protocol	150
A.5	A Sample Interface Screen of the Prototype Argumentation System	152
A.6	A Portion of the Dialogue History	154
A.7	A Portion of the Evaluation Database	155

List of Tables

3.1	An Example of Exchanging Information	82
4.1	The Arrival Rate Test Results	137
A.1	A Sample Data for the Arrival Rate Estimation	156

List of Definitions

1.1	E-Commerce	1
1.2	Negotiation	4
1.3	Agent	6
1.4	Argumentation	7
1.5	Argumentation System	7
1.6	Business Relationship	8
1.7	Trading Partnership	8
1.8	Trusted Trading Partnership	8
1.9	Multi Agent Systems	8
2.1	Negotiation Agent	22
2.2	Argumentation Agent	22
2.3	Utterance	22
2.4	Dialogue	23
2.5	World Model	41
2.6	Social Model	41
2.7	Degree of Cooperation	42
2.8	Negotiation Strategy	48
2.9	Relationship Strategy	50
2.10	Relationship Aware Argumentation System	52
2.11	Relationship Aware Argumentation Agent	52
3.1	Need Attribute	65
3.2	Negotiation Object	66
3.3	Deal Space	67

3.4	Commitment	84
3.5	Agreement (or Contract)	85
3.6	Enactment	88
3.7	Strength of a Business Relationship	96
3.8	Argument Response Vector	99
3.9	Exchanged Information Response Vector	99
3.10	Relationship Aware Argumentation Framework	101
3.11	Trading Partnership Set	103
3.12	Arrival Rate	103

Abstract

In e-Commerce, a buying process typically begins with browsing the available products or services, and then selecting the ones that satisfy a given need. The next phase is negotiation to reach an agreement. If an agreement is signed between two parties, they enter into the enactment phase including payment and delivery. After that, they evaluate how well the products or services satisfy their needs. One of the reasons for dissatisfaction is that a trading agent does not know its opponent agent's needs, contract acceptance criteria, or behaviour during their interactions. This dissertation is concerned with the problems and challenges of repeatedly conducted trading activities in e-Commerce applications.

Argumentation is a mode of interaction between agents that enables them to exchange information within messages in the form of arguments to explain their current position and future plans with the intention of increasing the chance of success in the negotiation. How an agent conducts all phases of a buying process through argumentation is an important research query. It becomes difficult to solve this query if an agent has to repeatedly conduct trading activities with its opponent agents. This work describes a novel solution to how an agent builds trusted trading partnerships with its opponent agents.

The requirements of all phases of a buying process are specified by five models: the needs model, the opponent agent selection model, the communication model, the agreement model, and the relationship model. The relationship aware argumentation framework is then proposed. It integrates how the trading agents analyze their interaction history, exchanged information, and any promises made. An agent architecture

is then developed that extends the idea of information based agency. It measures the strength of business relationships and predicts behavioural parameters from the history of interactions.

This dissertation establishes the thesis statement, “*Modelling the strength of relationships between agents and predicting the behaviour of trading partner agents in a multi agent argumentation system enables agents to build trusted trading partnerships*”.

A prototype simulation environment has been developed to conduct the experiments and to validate the thesis statement. The simulated arrival rate obtained by the proposed model is lower than that of an existing model, e.g., the Trust and Honour model. The prototype argumentation system demonstrated a proof of concept. The prototype will be further developed before applying the proposed argumentation system in commercial applications.