AGENT-ORIENTED CONCEPTUAL MODELS AND ARCHITECTURE DEVELOPMENT FOR INTELLIGENT FINANCIAL DECISION SUPPORT SYSTEMS

YINGFENG WANG

MASTER OF PHILOSOPHY
CITY UNIVERSITY OF HONG KONG
October 2006
Agent-oriented conceptual models and architecture development for intelligent financial decision support systems

Submitted to
Department of Information Systems
for the Degree of Master of Philosophy

By

Yingfeng Wang

October 2006
ABSTRACT

Modern financial world has become heavily dependent on technology. People are facing all kinds of complicated, dynamic and distributed problems all the time. The demand for computer-based financial decision support services is rising dramatically. Under this circumstance, numerous different kinds of decision support systems (DSSs) have been researched, designed and implemented in almost every financial aspect, including portfolio risk management, automated securities trading, family financial planning, anti-money laundering, and etc. However, there are certain drawbacks among existing financial DSSs (FDSSs). Some are suffering from their lack of popularity, flexibility, adaptability and collaboration. In order to solve these problems, intelligent agent technology is applied in this research to deal with the complex, uncertain, and inevitable real world financial problems. Even those intelligent financial decision support systems (IFDSSs), which are claimed to be intelligent enough to overcome these common problems, are constructed without solid theoretical support. In order to solve these problems, agent-oriented conceptual models are proposed for providing a unified framework for analysis, design and implementation of IFDSSs. Furthermore, a multi-agent system architecture is also designed by applying the model.

Modeling is an essential aspect of information systems development. Indeed, an information system can be viewed as a representation, or a model, of another system (usually termed the real system). Modeling is especially important in the analysis stage of systems development when abstract models of the represented system and its organizational environment are created. Such models are termed conceptual models. A conceptual model should reflect knowledge about the application domain rather than about the implementation of the information system. Conceptual modeling has been
defined as a formal description of “some aspects of the physical or social reality for the purpose of understanding and communicating” (Mylopoulos, 1992). This study depicts the conceptual models for IFDSSs, including the more general and high-level decision making process model, and the derived conceptual model for IFDSSs in semantic schema containing the overall knowledge representations.

To demonstrate the usability and effectiveness of the model and the system architecture proposed, and possible development mechanism is discussed. Moreover applications in two applicable financial domains are presented in the study, including family financial planning system (Gao, Wang, and et al., 2004; Gao, Wang, and et al., 2005; Gao, Wang, and et al., 2006a; Gao, Wang, and et al., 2006c;) and anti-money laundering system (Gao, Wang, and et al., 2006b; Wang et al., 2006). In each application domain, mapping model and architecture are provided and discussed in detail, and prototype system is designed and implemented, and evaluated.

The major contributions of this research are the theoretical investigations of the decision making process in different financial domains and the general framework for design and implementation of intelligent financial decision support systems. This study starts from the high-level conceptual modeling of the domain knowledge, on basis of the knowledge representation and in-depth understanding of the general financial problems, and then develops the system architecture. Afterward, applications in different applicable domains are discussed so that the conceptual models and system architecture are validated and evaluated.
TABLE OF CONTENTS

ABSTRACT.................................................................................................................. i

ACKNOWLEDGEMENTS ..................................................................................... iii

TABLE OF CONTENTS......................................................................................... v

LIST OF FIGURES ............................................................................................ viii

LIST OF TABLES.................................................................................................. x

CHAPTER 1. INTRODUCTION.................................................................................1

1.1 Research Question ..........................................................................................1

1.2 Research Objectives.......................................................................................3

1.2.1 General Objectives.....................................................................................3

1.2.2 Demonstration in Specific Domains ............................................................4

1.3 Research Methodologies................................................................................7

1.3.1 Design Science Methodology..................................................................9

1.3.2 Agent-oriented Analysis and Design..........................................................11

1.4 Organization of Thesis..................................................................................13

CHAPTER 2. LITERATURE REVIEW..................................................................15

2.1 Intelligent Agent Technology.........................................................................15

2.1.1 Intelligent Agents......................................................................................15

2.1.2 Multi-Agent Systems...............................................................................19

2.1.3 Agent-oriented modeling........................................................................21

2.2 Intelligent Financial Decision Support Systems (IFDSSs).........................26

2.2.1 Financial Planning Systems....................................................................27

2.2.2 Anti-Money Laundering Systems..............................................................28
### 2.2.3 Research Opportunities

2.3 SUMMARY

### CHAPTER 3. AGENT-ORIENTED CONCEPTUAL MODELS AND ARCHITECTURE DEVELOPMENT FOR IFDSS

3.1 OVERVIEW

3.2 DECISION MAKING PROCESS MODEL FOR IFDSS

3.3 AGENT-ORIENTED CONCEPTUAL SEMANTIC MODEL FOR IFDSS

3.4 MULTI-AGENT SYSTEM ARCHITECTURE FOR IFDSS

3.5 GENERAL SYSTEM IMPLEMENTATION AND DEPLOYMENT

   3.5.1 Web-Services Incorporating Agents

   3.5.2 System Implementation Architecture

   3.5.3 General System Development

3.6 SUMMARY

### CHAPTER 4. INTELLIGENT FAMILY FINANCIAL PLANNING SYSTEM (IFFPS)

4.1 BACKGROUND

4.2 DECISION MAKING PROCESS MODEL OF FFP

4.3 AGENT-ORIENTED CONCEPTUAL SEMANTIC MODEL FOR FFP

4.4 MULTI-AGENT SYSTEM ARCHITECTURE FOR IFFPS

4.5 SYSTEM IMPLEMENTATION AND DEPLOYMENT

4.6 SYSTEM OPERATION

4.7 RESULT OF EMPIRICAL INVESTIGATION

   4.7.1 Variables and Hypotheses

   4.7.2 Results

   4.7.3 Discussion
### Table of Contents

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.8 SUMMARY</td>
<td>88</td>
</tr>
<tr>
<td><strong>CHAPTER 5. INTELLIGENT MONEY LAUNDERING MONITORING AND DETECTION SYSTEM (MLMDS)</strong></td>
<td>90</td>
</tr>
<tr>
<td>5.1 BACKGROUND</td>
<td>92</td>
</tr>
<tr>
<td>5.2 DECISION MAKING PROCESS MODEL OF MLMDP</td>
<td>97</td>
</tr>
<tr>
<td>5.3 AGENT-ORIENTED CONCEPTUAL SEMANTIC MODEL FOR MLMDP</td>
<td>102</td>
</tr>
<tr>
<td>5.4 MULTI-AGENT SYSTEM ARCHITECTURE FOR IMLMDS</td>
<td>110</td>
</tr>
<tr>
<td>5.5 SYSTEM IMPLEMENTATION AND DEPLOYMENT</td>
<td>115</td>
</tr>
<tr>
<td>5.6 SYSTEM OPERATION</td>
<td>119</td>
</tr>
<tr>
<td>5.7 SUMMARY</td>
<td>121</td>
</tr>
<tr>
<td><strong>CHAPTER 6. CONCLUSIONS</strong></td>
<td>123</td>
</tr>
<tr>
<td>6.1 THESIS SUMMARY</td>
<td>123</td>
</tr>
<tr>
<td>6.2 FUTURE RESEARCH</td>
<td>129</td>
</tr>
<tr>
<td>REFERENCES</td>
<td>131</td>
</tr>
</tbody>
</table>