AGENT-BASED DESIGN PATTERNS APPROACH AND ITS APPLICATIONS FOR BUSINESS-TO-CONSUMER E-COMMERCE

By

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To

My Parents, my Wife, and my Children

Whose encouragement and support made this thesis possible

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS

		Page
1.1	θ_1	170
1.2	θ_2	170
1.3	V	171
1.4	$\dot{\beta}$	171
1.5	Φ_V	171
1.6	(ψ, β)	171
1.7	ψ	171
1.8	β	171
1.9	χ^2	171
1.10	H_0	172
1.11	H_1	172
1.12	$\dot{\gamma}$	172
1.13	$\dot{\alpha}$	172
1.14	$P(\Delta, \alpha)$	172
1.15	(ω, ζ)	172
1.16	η	172
1.17	λ	173
1.18	α	173

LIST OF ABBREVIATIONS

ABRM	Agent-Based Role Modeling
ACF	Automated Collaborative Filtering
ADP	Agent Design Patterns
AIAD	Agent Interface Applet Design
AMC	Agent-Manager-Controller
AOBE	Agent-Oriented Business Engineering
AOSE	Agent-Oriented Software Engineering
APDBE	Agent Pattern Driven Business Engineering
API	Application Programming Interface
ASDK	Agent Software Development Kit
ATP	Agent Transfer Protocol
AUML	Agent Unified Modeling Language
B2B	Business-to-Business
B2C	Business-to-Consumer
BAP	Business Agent Patterns
BBL	Business-to-Business Lifecycle
BOM	Business Object Model
C2C	Consumer-to-Consumer
CBBM	Consumer Buying Behavior Model
CBECD	Component-Based Electronic Commerce Development
CBSD	Component-Based Software Development
CEC	Customized Electronic Commerce
CIAgent	Constructing Intelligent Agent
CIDBP	Customer Information Delivery Business Pattern

CORBA	Common Object Request Broker Architecture
CPF	Commerce Process Framework
DBMS	DataBase Management Systems
DecDP	De-coupler Design Pattern
DPM	Deliberative Purchasing Model
DSECSM	Decision-Support Electronic Commerce Scope Model
DSS	Decision-Support Systems
DynDP	Dynamic Design Pattern
EAA	Electronic Auction Agent
ECCM	Electronic Commerce Component Model
ECDTF	E-Commerce Development Task Force
ECLF	Electronic Commerce Layering Framework
ECMS	Electronic Commerce Management Systems
EDI	Electronic Data Interchange
EECSM	Extended E-Commerce Scope Model
EJB	Enterprise JavaBeans
EPA	Electronic Property Agent
ETA	Electronic Tour Agent
FIPA	Foundation Intelligent Physical Agents
GUI	Graphical User Interface
HTML	Hyper Text Markup Language
ICT	Information Communication Technology
IPS	Institute of Post graduate Studies, USM
JDBC	Java DataBase Connectivity
JSP	Java Server Page

JVM	Java Virtual Machine
KB	Knowledge Base
KQML	Knowledge Query Manipulation Language
LAN	Local Area Network
LRT	Likelihood Ratio Test
MBBP	Multi-Bidding Business Pattern
MedDP	agent Mediator Design Pattern
MVC	Model-View-Controller
OMG	Object Management Group
ODP	Object Design Patterns
PAM	Personal-Agent-Manager
PECS	Proprietary E-Commerce Systems
RPC	Remote Procedure Calling
SBBP	Selling/Buying Business Pattern
SCICAD	Shrink-Wrapped-Customizable-Info-Commerce Deployment
SOM	Software Object Model
SQL	Structured Query Language
UML	Unified Modeling Language
USM	Universiti Sains Malaysia
WAN	Wireless Area Network
WAP	Wireless Application Protocol
WWW	World Wide Web
XML	eXtensible Markup Language

LIST OF APPENDICES

PENDEKATAN REKABENTUK PATERN BERASASKAN AGEN DAN APLIKASINYA DALAM E-NIAGA BISNES-PELANGGAN

ABSTRAK

Dengan meningkatnya penggunaan agen-agen perisian dalam persekitaran e-dagang, analisis dan reka bentuk agen sering dilakukan menggunakan satu pendekatan, dinamakan pendekatan Permodelan Peranan Berasaskan Agen. Pendekatan ini mempunyai beberapa kelemahan seperti kurangnya penggunaan semula komponen-komponen agen dan kurangnya kefleksibelan dari segi penambahan dinamik agen dalam sistem e-dagang terbuka.

Untuk mengatasi kelemahan-kelemahan ini, satu pendekatan yang lebih efisien dalam kejuruteraan perisian bisnes, dinamakan Kejuruteraan Bisnes Pacuan Corak Agen telah dibangunkan dalam tesis ini untuk menghasilkan Corak Agen Bisnes, yang akan digunakan untuk mendokumenkan corak perdagangan berasaskan agen untuk sistem-sistem berasaskan bisnes. Corak Agen Bisnes yang dimaksudkan ialah: Corak Reka Bentuk Dinamik, Corak Reka Bentuk Pengganding Semula, dan Corak Reka Bentuk Pengantara Agen.

Berpandukan objektif utama, kami mencadangkan Rangka Lapisan Perdagangan Elektronik yang akan mengatasi kelemahan-kelemahan rangka e-dagang yang lain serta mewujudkan satu asas bagi pembangunan Model Skop E-Dagang Lanjutan dan Pengawal Agen-Pengurus. Daripada Rangka Lapisan Perdagangan Elektronik, Model Skop E-Dagang Lanjutan, dan Pengawal Agen-

Pengurus maka terhasillah pembangunan Kejuruteraan Bisnes Pacuan Corak Agen secara semula jadi.

Kajian penyelidikan masa depan memerlukan Corak Agen Bisnes tambahan untuk menyediakan suatu asas yang kukuh untuk mendokumenkan corak-corak perdagangan agen bagi e-dagang Bisnes-Pelanggan.

AGENT-BASED DESIGN PATTERNS APPROACH AND ITS APPLICATIONS FOR BUSINESS-TO-CONSUMER E-COMMERCE

ABSTRACT

As the use of software agents continues to grow in e-commerce environments, the analysis and design of agents are often done using an approach, called the Agent-Based Role Modeling (ABRM) approach. This approach has some drawbacks such as lack of reusability of agent components and lack of flexibility in dynamic addition of agents in open e-commerce systems.

To overcome shortcomings, a more efficient approach in business software engineering, called the Agent Pattern Driven Business Engineering (APDBE) is developed in this thesis to create Business Agent Patterns (BAP), which will be used to document agent-based commerce patterns for business-based systems. Such BAP are: the Dynamic Design Pattern (DynDP), the De-coupler Design Pattern (DecDP), and the Agent Mediator Design Pattern (MedDP).

Towards the main objective, we propose the Electronic Commerce Layering Framework (ECLF) that would overcome shortcomings of other e-commerce frameworks and establishes the basis for the development of the Extended E-Commerce Scope Model (EECSM) and the Agent-Manager-Controller (AMC). The ECLF, EECSM, and AMC lead to APDBE development in a natural manner.

Future research work requires additional BAP to provide a sound foundation to document agent commerce patterns for Business-to-Consumer e-commerce.

CHAPTER 1

INTRODUCTION

1.1 Areas of Research and Objectives

The Internet is a vast repository of information consisting of millions of Web pages and users. Since the advent of the Internet, Electronic Commerce (e-commerce) has been one of the most attractive applications, earning large revenues and forging a rapid growth in related technologies. Features of e-commerce, such as reduction in search cost, multi-attribute based comparison, and access to a large number of consumers have made e-commerce attractive to both on-line buyers and sellers. However, the Internet platform has redefined certain principles within traditional commerce, and if e-commerce practitioners fail to appreciate and react to this, it will lead to their failure in the marketplace.

One of the most pervasive technologies used in e-commerce are software agents. Software agents, also called "Agent-Mediated e-commerce" (Guttman, Moukas and Maes, 1998; He, Jennings and Leung, 2003), are now one of the core features of the e-commerce domain. Software agents are now used everywhere to support virtual business processes and to facilitate businesses to enhance e-marketplaces.

The use of software agents has increased rapidly in importance over the last decade, with more and more being done on intelligent agents supporting e-commerce and other Internet-based transactions. Agents[1] are developed and deployed to perform tasks such as matchmaking, monitoring, negotiation,

[1] Agents and Software Agents are used interchangeably in this thesis.

bidding, auctioning, transfer of goods, and follow-up support. The main role of agent-based commerce is to collect information from multiple commercial sites, filter it and then to respond to the appropriate requests by both sellers and buyers.

Agent design patterns form a new methodology used to improve the development of software agents by capturing solutions to common problems in agent design (Lange and Oshima, 1998; Aridor and Lange, 1998). They are applied in different systems such as knowledge management systems, real-time systems, network management systems, and data mining systems. Agent design patterns in e-commerce are used to support the different e-commerce paradigms: business-to-business (B2B), business-to-consumer (B2C), and consumer-to-consumer (C2C).

This thesis has as its main objectives to extract agent-based design patterns for business-based systems and to document them in a pattern language. This involves identifying the agent design patterns and business patterns to develop Business Agent Patterns (BAP) for business-based systems, and then to execute and document the extracted patterns and their relationships to each other. The thesis also uses design patterns for mobile and stationary agents and for Multi-Agent Systems in distributed large-scale environments such as e-commerce. In order to demonstrate how these patterns should be used, the thesis includes a reference implementation and case studies for typical e-commerce scenarios using a technique for the aggregation of agents into groups in a centralized fashion.

To implement this technique, an approach called Agent Pattern Driven Business Engineering (APDBE) for business-based systems is developed. The approach is considered as a development approach for the Agent-Oriented Business Engineering (AOBE) methodology. The developed approach uses patterns for agent technology and object-oriented technology for Business Process Re-engineering to create BAP. The approach developed in the thesis is straightforward and achieves better designs for business-based systems in the e-commerce domain.

In working towards the main objectives, this thesis looks at various e-commerce frameworks that have been proposed by different researchers and then proposes a generalized framework that overcomes shortcomings in other frameworks, called the Electronic Commerce Layering Framework (ECLF). ECLF includes Information Communication Technology (ICT) layers, which comprises five layers, namely Delivery, Business Processes (Services), Processors, Knowledge Base Components, and Infrastructure. The proposed framework forms the basis for the development of the Extended E-Commerce Scope Model (EECSM) (Faiz and Aman, 2003) and Decision-Support E-Commerce Scope Model (DSECSM), these latter two in turn forming the basis for arriving at the main objective, the APDBE approach mentioned earlier. Figure 1.1 illustrates the overall schema for the work in this thesis.

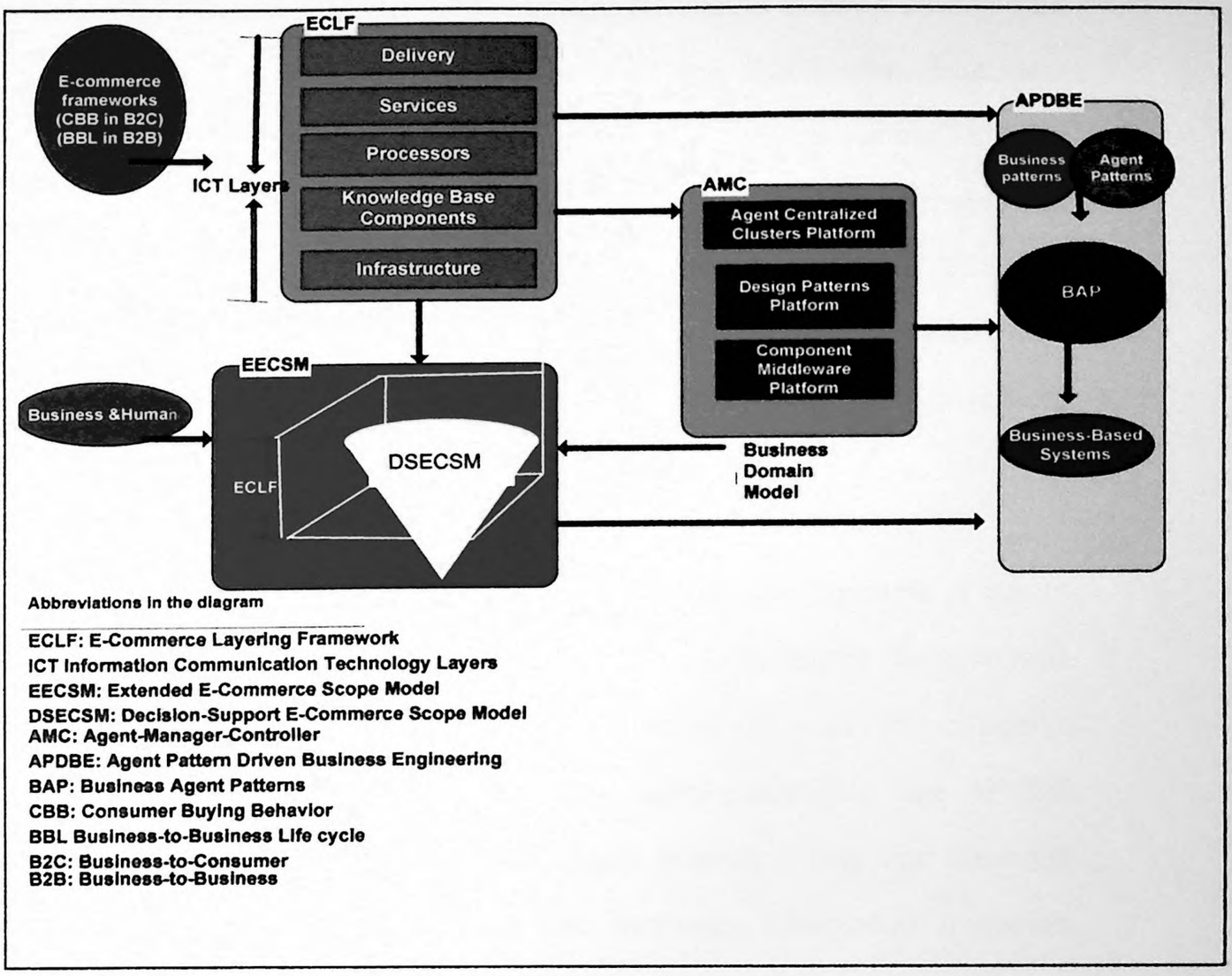

Figure 1.1: Research Activities Schema Development

EECSM is the core of the thesis and is described as the 4th generation development methodology for the e-commerce based domain. This model has three scopes viewed in a three-dimensional vector space, namely Human, Business, and Infrastructure that interact to establish business patterns (on the Human-Business interaction plane) to be mapped with components of ICT layers of the ECLF (on the Infrastructure-Business interaction plane) riding on infrastructure components (of the Human-Infrastructure interaction plane) to form Business Domain Models for the APDBE approach. An example of a Business Domain Model is the DSECSM, which integrates Decision-Support

Systems into e-commerce. DSECSM combines Decision-Support Systems as an ICT component of the Processors layer of the ECLF (from Business-Infrastructure plane) with the multi-bidding business pattern of the multi-bidding business model (from Human-Business plane) and an infrastructure component (from Human-Infrastructure plane) of the EECSM. Furthermore, DSECSM comprises at least four basic Decision-Support Systems modules: data collection module, process module, testing module, and decision-making module.

One of the major problems that arise in Multi-Agent Systems is due to the decentralization of business agents in a distributed e-commerce environment. The decentralization mechanism limits the autonomy of agents and increase problems in coordination and communication. The APDBE approach proposes to cluster business agents in such a way that improves agent collaboration and coordination and facilitates information exchange amongst agents.

Business agents are clustered and centralized to address business patterns as suggested by EECSM and DSECSM. In order to control business agent clusters for the APDBE, the Agent-Manager-Controller (AMC) is developed, which comprises three platforms: Agent Centralized Clusters Platform, Design Patterns Platform, and Component Middleware Platform.

The main objectives of this research are summarized as follows:

1- Derive agent-based design patterns BAP based on the development approach, called APDBE.

2- Use BAP to document agent commerce patterns for business-based systems in terms of pattern components, technical implementation tools and analytical implementation tools.

In working towards the main objectives, the following gives research sub-objectives:

1- Explore the ECLF as a generalized framework that overcomes shortcomings of other e-commerce frameworks.

2- Use ECLF to establish the EECSM as 4^{th} generation model in e-commerce environments.

3- Establish the DSECSM of the EECSM, which integrates Decision-Support Systems into e-commerce.

4- Use ECLF, EECSM, and DSECSM as basis for the development of the APDBE approach.

5- Explore business patterns scenarios of the EECSM and DSECSM for the APDBE approach.

6- Explore AMC platforms in which APDBE rides on.

7- Use AMC platforms to create BAP, implement and document agent-based commerce patterns for business-based systems.

1.2 Scope of the Thesis and Main Contributions

The following list out the main contributions of this thesis and indirectly lays down the scope of the work:

- We design the ECLF in this thesis in an attempt to generalize and overcome some of the shortcomings in other e-commerce frameworks. ECLF comprises several ICT layers of e-commerce components and facilitates the flow of information among them.

- Based on the ECLF, we propose the EECSM as a 4th generation development model to the three generations of e-commerce systems. See (Zwass, 1996, 1998; Bichler, Segev and Zhao, 1998; Zhao, Hongjun and Vojislav, 1998). EECSM has three main scopes viewed in a three-dimensional vector space: Human, Business, and Infrastructure. EECSM categorizes business patterns called Selling Buying Business Pattern (SBBP) of the procurement business model and Customer Information Delivery Business Pattern (CIDBP) of the Infomediary business model for the APDBE approach.

- We propose the DSECSM as a major component of the EECSM. DSECSM is a Business Domain Model that integrates Decision-Support Systems into e-commerce and is used to support multi-bidding business processes in Multi-Bidding Business Pattern (MBBP) of the bidding business model for the APDBE.

- We develop the APDBE approach which comprises three stages: analysis, design and implementation. The analysis stage establishes business patterns of Business Domain Model from the EECSM and DSECSM. Business patterns of the Business Domain Model are compared with the corresponding ADP or ODP to create BAP in the design stage. BAP is then implemented and used to document agent commerce patterns for business-based systems in the

implementation stage. The APDBE has an advantage over the traditional Agent-Based Role Modeling (ABRM) approach and the case-to-case design approach in that it makes use of agent and object patterns to improve designs for e-commerce and also to promote reuse.

- We establish an agent-centric controller to support the APDBE, namely the AMC. AMC is proposed to manage and control business agents and constitutes three platforms: Agent Centralized Clusters Platform, Design Patterns Platform, and Component Middleware Platform. We propose three agent centralized clusters of the AMC to be compared with ADP and ODP for SBBP, CIDBP, and MBBP called commerce agents cluster, information agents cluster, and bidding agents cluster respectively.

- We establish and implement three BAP, which are used to document agent commerce design patterns for business-based systems. Such BAP are: the Dynamic Design Pattern (DynDP), the De-coupler Design Pattern (DecDP), and the Agent Mediator Design Pattern (MedDP). BAP can then document agent commerce patterns: the Facilitator-Shopping pattern, the Controller-Shopping pattern, the Info-Servicing pattern, and the Customer Decision-Making pattern. Implementation of BAP follows Pattern Description Scheme.

1.3 Outline of the Thesis

The contents of this thesis derive from three main fields: computer science, information systems, and business. The related components in each field are developed independently until they combine within the domain of e-commerce modeling and then within Business Software Engineering. The

division into chapters of this thesis follows this flow of development as illustrated in Figure 1.2.

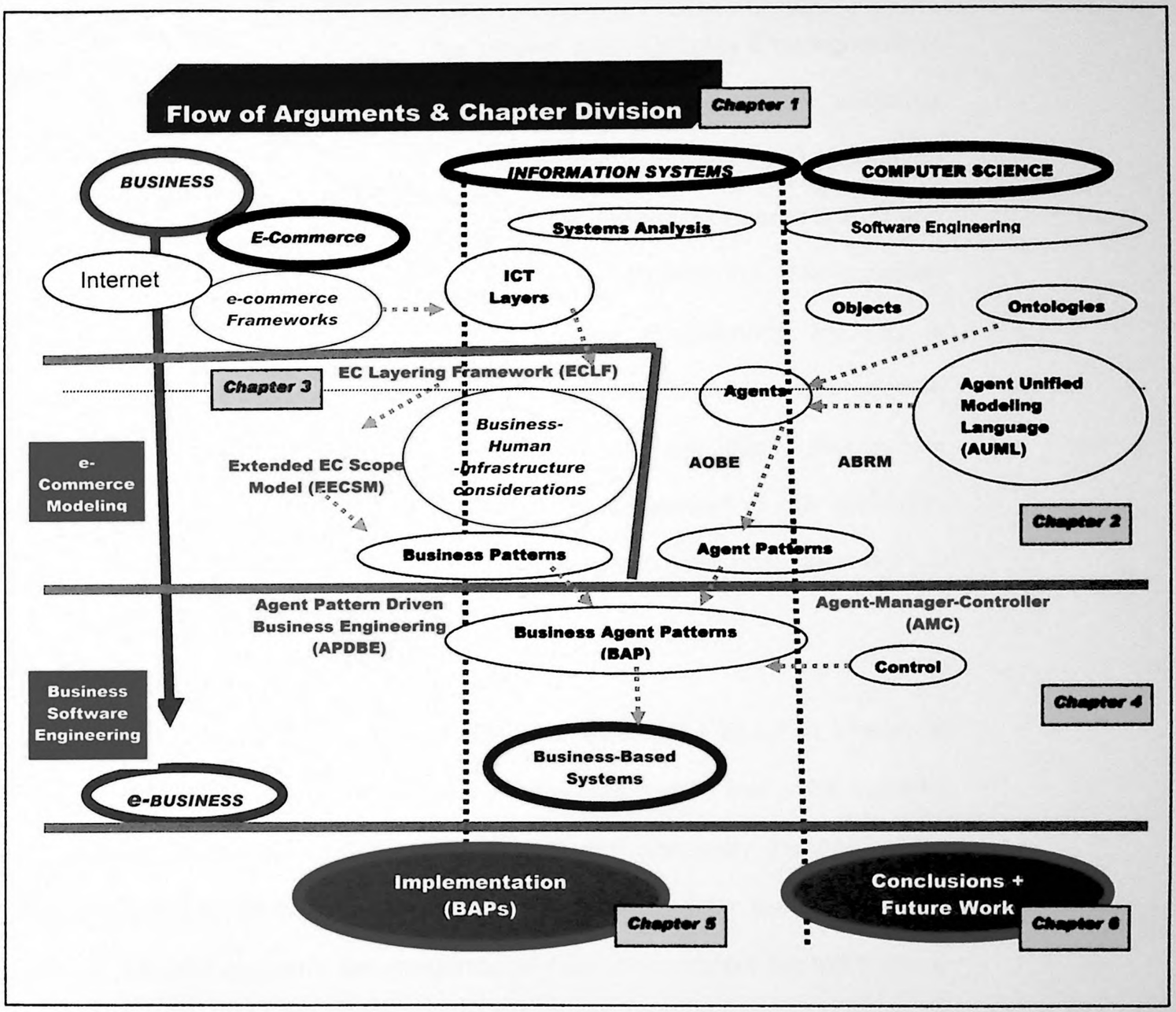

Figure 1.2: Roadmap for Chapters Division

Chapter 1 presents a brief summary of the domain and the main objectives of the thesis. A general schema for the work to be carried out is presented, followed by a list of the main contributions of the thesis.

Chapter 2 presents a literature survey of the basic concepts in e-commerce modeling and discusses problems encountered with current e-commerce frameworks, towards forming the basis for establishing our generalized framework, the ECLF. This chapter also highlights a background of software agents, their characteristics, and design component tools, in particular the Agent Interface Applet Design (AIAD) components and the PAM application for agent development. At the end of this chapter, the role of agents in B2B and B2C e-commerce, Decision-Support Systems, Knowledge Management Systems, and ADP in Agent-Oriented Software Engineering (AOSE) is discussed. The chapter concludes with the traditional ABRM approach in AOSE and introduces the AOBE methodology, which is specifically designed for Business Process Re-engineering towards the development of our approach, the APDBE for business-based systems, as a means to overcome drawbacks in the traditional ABRM approach.

Chapter 3 highlights our generalized framework, the ELCF in attempt to overcome shortcomings of e-commerce frameworks, which forms the basis for the development of the EECSM, the APDBE, and ultimately the AMC. The chapter highlights EECSM scopes and their interactions for e-commerce. In addition, EECSM supports the integration of Decision-Support Systems into e-commerce, which is done via the DSECSM that we also present.

Chapter 4 is devoted to propose the APDBE as a development approach in software engineering in an attempt to overcome shortcomings of the ABRM approach. The APDBE aims to use agent design patterns or object design patterns with well defined business patterns in a Business Domain Model to

establish Business Agent Patterns (BAP). At the end of this chapter, we propose the AMC to support business agent clusters that addresses business patterns of the EECSM and DSECSM.

Chapter 5 is devoted to implement BAP for business-based systems based on the APDBE approach. We establish three BAP to facilitate selling/buying business processes, customer information searching processes, and multi-bidding processes: the Dynamic Design Pattern (DynDP), the De-coupler Design Pattern (DecDP), and the agent Mediator Commerce Design Pattern (MedDP). BAP are implemented and analyzed by the methodology given in (Gramma *et al.,* 1995; Schelfthout, Coninx and Hellboogh, 2002) as a means to document commerce design patterns for business-based systems: the Facilitator-Shopping pattern, the Controller-Shopping pattern, the Info-Servicing pattern, and the Customer Decision-Making pattern. The implementation of BAP is done via various tools in the component middleware platform of the AMC. This chapter includes prototypes and screenshots based on a Java-based oriented application, namely the PAM framework, which is used to create and run agent clusters. We highlight findings on the evaluation of the design and overall applicability.

Chapter 6 summarizes the main points of the thesis and lists the main conclusions. Some suggestions for future work are also given.

CHAPTER 2

LITERATURE SURVEY

2.1 Introduction

This chapter presents several concepts in e-commerce modeling and Agent-Oriented Software Engineering (AOSE) that are required in this thesis, beginning with the evolution of e-commerce in section 2.2, followed by section 2.3 and section 2.4 which discuss the e-commerce development environment and the basic requirements for e-commerce systems respectively. Section 2.5 discusses an overview of problems with current e-commerce frameworks. In an attempt to overcome some of these limitations, we analyze the frameworks in view of the development of our generalized framework called the Electronic Commerce Layering Framework (ECLF) to be proposed in chapter 3. From the computational angle and towards forming the basis for the development of business-based systems, section 2.6 gives an overview of software agents, their characteristics, and their types. Furthermore, this section highlights the Java-based environment and its characteristics for coding Agent-Interface Applet Design (AIAD). Section 2.7 discusses business agents in e-commerce and the decentralization problem. Section 2.8 and section 2.9 present the role of software agents in e-commerce, Decision-Support Systems, and Knowledge Management Systems respectively. Section 2.10 presents Agent Design Patterns (ADP), while section 2.11 discusses the traditional Agent-Based Role Modeling (ABRM) approach in AOSE. Section 2.12 presents a more business-based approach, the Agent-Oriented Business Engineering (AOBE) methodology, which will be extended to our development approach, the Agent Pattern Driven Business Engineering (APDBE). The APDBE will be proposed

in chapter 4 as a means to overcome shortcomings within the ABRM approach, and is primarily used to derive agent-based commerce design patterns for e-commerce systems. Finally, section 2.13 summarizes the main points and highlights conclusions derived from this chapter.

2.2 Evolution of Electronic Commerce (e-commerce)

Several definitions can be found for e-commerce. The Electronic Commerce Association gives a general definition: "electronic commerce covers any form of the business or administrative transaction or information exchange that is executed using any information and communication technology." (Till, 1998). Another definition is given by (Turban *et al.,* 2000): "e-commerce describes the process of buying and selling or exchanging of products, services, and information via networks including the Internet". However, e-commerce is not just about doing business or buying and selling over the Internet, it is also about the way companies do business and about servicing customers and collaborating with business partners.

E-commerce uses many web site design models, including the brand awareness and image building model, cost saving model, promotion model, info-mediary model, brokerage model, retail model, mall model, advertising model, subscription model, community model, manufacturer model, procurement model, bidding model, pricing model, negotiation model, auction model, and customization model (Wen, Chen and Hwang, 2001). Furthermore, e-commerce involves different paradigms (Chan *et al.,* 2001). Business-to Business (B2B) is an automated way in which companies collaborate across a supply chain management with their customers, where both buyers and sellers

are business organizations. General Electric's Trading Process Network (www.tpn.geis.com) is an example of B2B e-commerce. The most commonly used and most widespread paradigm is Business-to-Consumer (B2C). Here, businesses directly reach out to consumers by means of their on-line websites. Buyers navigate through websites by filling their shopping cart, much as they do in a real store. When buyers finish, they make an electronic payment and the product is shipped to them. Amazon is a booming example of B2C (www.amazon.com). An extended paradigm of e-commerce is Consumer-to-Consumer (C2C). In C2C, the consumer puts in place an item for bidding. Other interested consumers can then bid for it before a given deadline. The highest bid then wins. An excellent example of C2C is eBay (www.eBay.com).

Electronic commerce encompasses a wide range of issues (Blake, 2001) including security, trust, reputation, payment mechanisms, advertising, electronic product catalogs, intermediaries, multimedia, shopping experience, back office management, workflow management, supply chain management, service discovery, knowledge management, automated negotiation and pricing, plus auctioning and transactional reasoning.

2.3 Development Environment for E-Commerce Systems

E-commerce systems are based on the development of technologies. The development of e-commerce systems in software engineering may be categorized into three generations: (a) Proprietary E-Commerce Systems (PECS), (b) Component-Based E-Commerce Development (CBECD), and (c) E-Commerce Management Systems (ECMS). Categorization of e-commerce

systems leads to explore EECSM as a 4th generation development model for e-commerce environments.

2.3.1 Proprietary E-Commerce Systems (PECS).

In the 1st generation of e-commerce systems (Zwass, 1996), developers write e-commerce systems using HTML and Java Script. Databases for the system use standard database management system (DBMS) and the Internet browser serves as the development platform. This simple method has greatly promoted the use of e-commerce applications, but it did not cater for interoperability between applications and did not encourage reusability of its components.

2.3.2 Component-Based Electronic Commerce Development (CBECD)

The 2nd generation of e-commerce system development is commonly based on object frameworks for e-commerce applications (Zwass, 1998). An object framework is treated as a collection of cooperating objects providing an integrated solution, leading to what is known as Component-Based E-Commerce Development (CBECD). This methodology provides several advantages, including higher quality products, reduced market complexity, better utilization of human resources, the ability to respond to changes, and high reusability for future projects. Arguably, CBECD is a 'necessity' for the business-to-business (B2B) environment. For instance, it allows complex e-commerce systems to be built from several loosely coupled sub-systems, (Zhao and Misic, 1998; Zwass, 1998). Bichler, Segev and Zhao, (1998) demonstrated this possibility using several low-level electronic commerce services (such as

payment, profile, and selection services), commerce facilities support such as (contract, service management, and related desktop facilities), and market infrastructure (such as catalog, brokerage, and agency facilities).

At the core of the component-based approach lies a system kernel containing basic functions needed by most e-commerce applications. Various other components can be requested from the class library and plugged into the system as required by system developers. According to the *reuse* phenomenon in Component-Based Software Development (CBSD) (Stazinger, Orvik and Tore, 2001), this approach may allow developers to begin at a higher level and eliminate a lot of unnecessary lower level programming.

Generally, CBECD is a great step toward better productivity, reusability, interoperability, and efficiency compared to the first generation that relies on proprietary programming (Rahman and Bignall, 2001). This new approach is expected to become increasingly popular as standard class libraries and e-commerce architectures become more widely available. Nevertheless, the approach still entails some level of integration (albeit loose) between the e-commerce system kernel and its various components. This then leads to the third generation of e-commerce system development, which emphasizes the complete separation of e-commerce applications from development facilities.

2.3.3 E-Commerce Management Systems (ECMS)

ECMS is considered as the 3rd generation in the trend of e-commerce system development (Zhao, Hongjun and Vojislav, 1998), in particular in terms of system interoperability, as indicated in Figure 2.1.

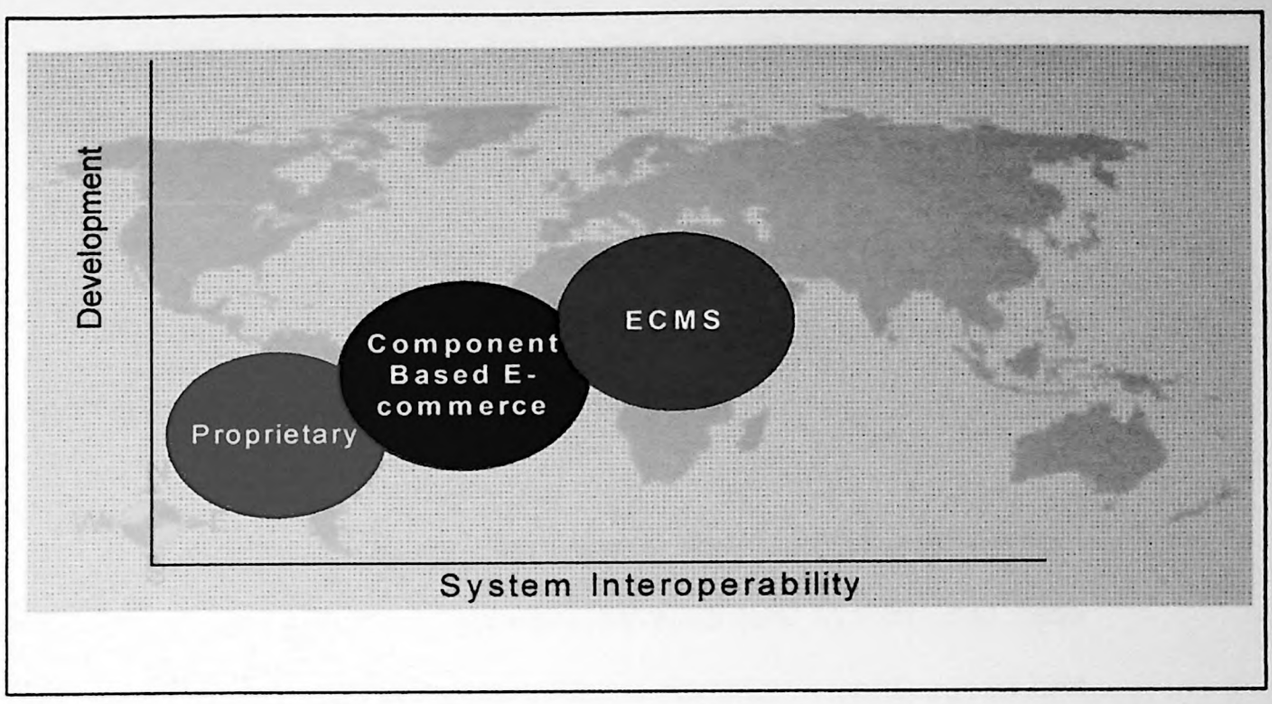

Figure 2.1: Trend in the Development Environment for E-Commerce

The approach uses various generic e-commerce functions to serve the needs of customers as well as sellers. The main difference between CBECD and ECMS is in the ability of ECMS to integrate e-commerce facilities tightly and yet provide further development facilities on top of the integrated facilities, as indicated in the ECDTF model[1]. Such development facilities include, among other things, a policy manager, a process modeler, and an application designer.

ECMS is defined as a software system that provides generic facilities to support the efficient development of e-commerce applications. The role of such an integrated application software development environment will make the development of e-commerce applications easier and faster, furthermore, it can help to consolidate the e-commerce technologies by integrating object-oriented

[1] The Object Management Group (OMG) defined a reference model that includes ten facilities referred to as the Electronic Commerce Domain Task Force (ECDTF). See (Bichler, 1997).

technologies, Web information systems, database systems, and workflow systems. The integration enables end users to develop e-commerce applications without coding.

ECMS is based on four perspectives, namely electronic market model, workflow paradigm, intelligent agents, and blackboard architecture, which are used to support e-commerce activities in e-commerce.

ECMS is not considered as an agent-based development environment for e-commerce systems, but it is a software development system that uses software agents to assist users for implementing e-commerce applications and to facilitate operations of customers. The design of software agents within ECMS can be done by application developers and end users. Different types of software agents may vary in different ECMS, and as such there are no specific design techniques for agents development used in ECMS.

2.4 Basic Requirements for E-Commerce Systems

Most e-commerce systems support a pattern of stages that include: (a) Need identification, (b) Information exchange for products and companies, (c) Negotiation for price discovery, (d) Contract establishment, (e) Contract fulfillment, and finally (f) Guarantee and feedback.

Such a pattern has three basic requirements: (1) Information about markets, participants and business models. This includes information on the available products or services, their respective specifications, sellers, buyers, intermediaries, delivery terms, and market policies; (2) The negotiation process,

where decision-making takes place. Here, the parties involved in business transactions reach common decisions or solutions according to business models and market policies; and (3) The completion of exchange process, where the transactional process is completed, goals are achieved and services are exchanged for payments.

As the size of e-commerce systems and the number of buyers, sellers, and transactions are growing rapidly, there is a clear need for the automation of the processes involved. New models for this automation will inevitably involve software agents, e-commerce, and Decision-Support Systems.

It has to be noted that e-commerce systems need to take into account the general criteria that are needed to ensure viability. It is based on these criteria that most e-commerce implementations are judged:

1- Interoperability: This is predominantly a technical issue that refers to the ability of distinct pre-existing systems to work together to accomplish a given goal. Interoperability has major implications to businesses, people, and enterprises, in that it facilitates the coupling of business services in different organizations.

2- Functionality: Most e-commerce frameworks support e-marketplaces for added business value. Electronic Marketplaces with their economic, social, and technological emphases are creating a competitive environment, where companies need to redefine how they conduct business, what business strategies to adopt, and what operational and organizational areas to change.

3- Trust: In an electronic environment, the need for trust is crucial. Classical trust in traditional e-marketplaces needs to be transformed into electronic trust. The degree of trust is based on the level of security that is supported by the technology. Electronic trust based-technologies now support business processes and business partnerships.

2.5 Problems with Current E-Commerce Frameworks

In the following sub-sections, a survey is conducted to highlight problems with current e-commerce frameworks. These problems will lead to the development of the ECLF to be proposed in chapter 3, which is considered as a generalized framework and addresses most shortcomings of other frameworks. Furthermore, the ECLF establishes the basis for the development of the EECSM to be proposed also in chapter 3. The ECLF constitutes a cornerstone of this thesis.

2.5.1 Zwass's Hierarchical Framework

Zwass (1996, 1998) presented a comprehensive hierarchical framework for e-commerce consisting of four meta-levels: infrastructure, services, products, and structures. This model provides seven functional levels ranging from wide-area telecommunications infrastructure to electronic marketplaces and electronic hierarchies. An e-commerce system is structured in a hierarchy of several levels in which each of the lower levels provides a well-defined functional support for the higher ones. Zwass also introduced a "layering" approach in which a number of layers are used to define areas of functionality or tasks. The separation of tasks enables changes to be made in any one layer

without affecting other layers. Furthermore, development of solutions can be made without impact on other e-commerce activities.

The separation of layers in the model does indeed mean that a change at one layer does not normally affect the other layers. However, each layer is rather rigidly defined such that no additional components can be added nor further layers be incorporated.

2.5.2 Kalakota and Whinston Framework

Kalakota and Whinston (1996) developed a generic framework for e-commerce system development. They used a different approach compared to Zwass in which four infrastructures are supported, i.e., network, multimedia content, messaging and concern. The authors also suggested that the elements of a framework should include the convergence of technical, policy and business projects. Their model is quite useful to beginners but lacks theoretical depth and as such makes it difficult to incorporate the model into empirical research with e-commerce applications placed on top. The framework also cannot be used as a foundation for a more detailed analytical study.

2.5.3 Riggins and Rhee's Domain Matrix

Riggins and Rhee (1998) developed a domain matrix to view e-commerce systems. This is based on the type of relationships, and their internal or external focus. The framework takes as its axes the "location of the application user" and the "type of relationship". It is useful to companies whose wish is to classify their trading collaborators into internal and external (and within these, into new and ongoing) relationships. Figure 2.2 shows Riggins

and Rhee's domain matrix. However, the model is limited in its identification of technical types as it is primarily focused on trading relationships.

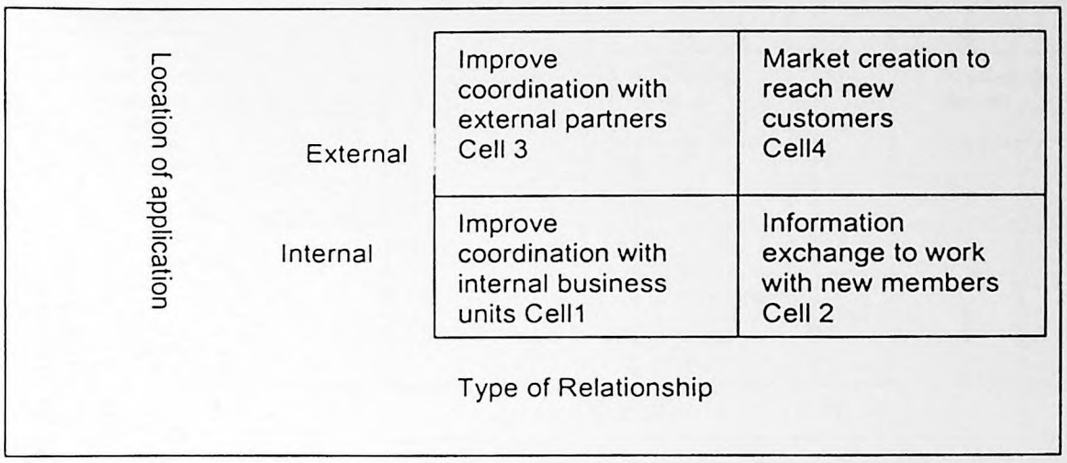

Figure 2.2: E-commerce Matrix Model

2.5.4 Clarke's Framework / the Deliberative Purchasing Model (DPM)

Clarke (1993, 2000) suggested a Deliberative Purchasing Model (DPM). The model, as shown in Figure 2.3 below, is based on a six-phase process model, which in turn is designed to support different phases of business transactions. The model can be considered as an extension of the earlier Electronic Data Interchange (EDI) model. The focus of this model is on procurement (buying and selling) rather than on the other components of e-commerce, which limits its general applicability.

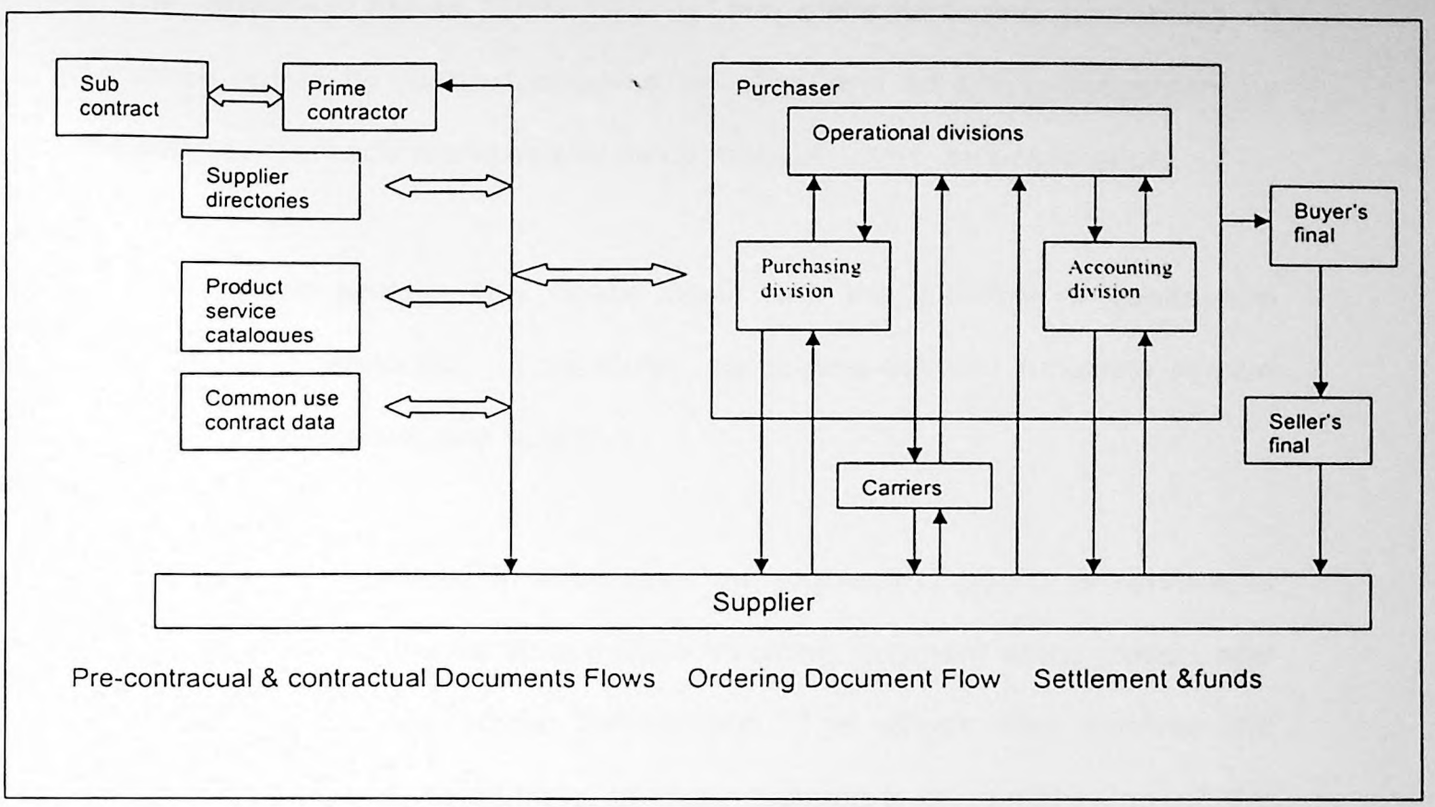

Figure 2.3: Clarke's Six- Phase Framework

The six phases in Clarke's model are as follows:

- ***The pre-contractual phase.*** The buyer seeks information about suppliers of goods, services, plus the prices, terms and conditions applicable to a purchase. The sellers seek information about prospective purchasers of their goods and services (i.e., marketing with advertising).

- ***The contractual phase.*** During this phase, a formal relationship is established between the buyer and the seller with the agreed terms and conditions being applied to transactions under the contract.

- ***The ordering phase.*** This involves the placement and processing of purchase orders (in contractual terms, an offer) and an acknowledgement by the seller of his readiness to deliver (in contractual terms, an acceptance).

- ***The logistic phase.*** This phase deals with the delivery of goods and performance of services. In particular, some post-delivery functions involve inspection, acceptance, and rejection.

- ***The settlement phase.*** In this phase, the payment of goods or services is performed. Relevant transactions include invoicing, payment authorization, and the payment/remittance advice transmission. This phase also involves the provision by financial institutions to their customers of confirmation of the transactions affecting their accounts, and providing statements of the transactions as well as their balances.

- ***The post-processing phase.*** After the basic transactions have been completed, a number of additional activities may be performed, for example, management information is gathered and reported. In addition, the sale may have resulted in a relationship between the buyer and the seller relating to the servicing, maintenance, and upgrading, as well as to the eventual replacement of the goods or an asset (such as for a photocopying or fax machine).

2.5.5 Selz and Schubert Framework

Selz and Schubert (1998) classified an e-commerce model to four phases to form an electronic marketing model. The four phases, within which

some of the phases of Clarke's model have been incorporated, are: *information*, *agreement*, *settlement*, and *communication*:

- ***Information phase.*** Where customers search for potential sellers, look for the right products and decide on alternative options.

- ***Agreement phase.*** Where interactions take place between buyers and sellers on the terms of purchase, which may also involve negotiations. In the case of auctions, interactions can also occur among buyers. Software agents play an important role in this phase.

- ***Settlement phase.*** Where monetary transactions occur between buyers and sellers.

- ***Communication phase.*** Which is a support phase that emphasizes the concept of community building taking place between customers and firms, and amongst each other.

Unfortunately, the model is limited to specific processes of electronic purchasing between buyers and sellers, and this makes it less general. Another limitation is that the model does not include a general architectural model for software agents. It limits the use of software agents to particular phases, in particular to the information phase.