国際商取引における書類手続き効率化に関する研究

メタデータ	言語: en 出版者: 公開日: 2019-06-25 キーワード (Ja): キーワード (En): International Trade Transaction Mode, International Logistics Ontology, Supporting System, Optimized information flow, Simulation Modeling 作成者: ポンアナン, カイルン メールアドレス: 所属:
URL	https://doi.org/10.15118/00009907

A Study on Promoting Efficient Paper Procedures in International Trade Transaction

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A dissertation submitted in partial fulfillment of the requirements for the degree of

Doctor of Philosophy of Engineering

of

Muroran Institute of Technology

Course of Advanced Information and Electronic Engineering, Division of Engineering

Mach 2019

DECLARATION

I hereby declare that this thesis is my own work and effort and that it has not been submitted anywhere for any award. Wherever contributions of others are involved, every effort is made to indicate this clearly, with due reference to the literature, and acknowledgement of collaborative research and discussions.

Muroran, March 2019 Klairung PONANAN

ACKNOWLEDGEMENTS

I would never have been able to finish my dissertation without the guidance of my advisor and committee members, help from friends, and support from my family.

Firstly, I would like to express my sincere gratitude to my advisor **Prof. SUTO Hidetsugu** and **Prof. WATANABE Shinya** for the continuous support of my Ph.D. study and related research, for their patience, motivation, immense knowledge and providing me with an excellent atmosphere for doing research. I could not have imagined having a better advisor and mentor for my Ph.D. study. Your advice on both research as well as on my career have been invaluable.

Besides my advisor, I would like to thank the rest of my thesis committee i.e. **Prof. Yoshifumi Okada** for his insightful comments and encouragement, but also for the hard question which encouraged me to widen my research from various perspectives.

I thank my fellow the members of Computational Intelligence Laboratory and System Design Laboratory in for the stimulating discussions, for the helping me about this research, and for all the fun we have had in the last three years. Also, I thank my friends in the following institution. Especially, I would like to say THANK you for my tutor, his name is JUNYA Inafune for amazing help all the time. I thank to SATOSHI Yamashita and JUNYA Tanaka, they were always willing to help me. I also thank to Dr. Woramol Chaowarat WATANABE for academic suggestions.

Moreover, I would like to say THANK YOU for every Thai student that was with me in Muroran. They are not only my friends but also my family here. When I am tired or disappointed, they always stand my side and encourage me to be strong again. I always get spiritual from them. Especially, I would like to thank Tanapun SRICHANTHAMIT, she always stands by me.

Last but not the least, I would like to thank my family for supporting me spiritually throughout writing this thesis and my life in general, especially my mother Mrs. Bangon WICHAI. Words cannot express how grateful I am to them. They were always encouraging me with their best wishes, and always there cheering me up and stood by me through the good and bad times.

Muroran, December 25, 2018 Klairung PONANAN

ABSTRACT

In this thesis, a novel framework for supporting international trade transaction processes in ASEAN countries is proposed. The ASEAN has been established for promoting economic activities in this region. Usually, in international trade transaction, many paperwork processes are required in both import and export countries. The documents required in the processes have been created ad-hoc ways. Such facts make the paperwork processes of the international trade transaction system complex.

Due to the above-mentioned situations, supporting systems for optimizing paperwork processes are required. A framework for such supporting system is proposed in this thesis. This thesis consists of three proposals; (1) an international trade transaction model, (2) an international logistic ontology, and (3) an algorithm for optimizing information flow.

(1) An international trade transaction model: This model is an underlying basis of the framework of supporting system for international trade transaction. The model consists of 3 layers; document layer, information layer and presentation or user interface layer. These layers are based on the results of analyzing the actual international trade transaction processes. Paperwork processes are described on the document layer. Information flow processes are described on the information layer. And the descriptions depending on the users' nationality are described on the presentation layer.

(2) An international logistics ontology: The ontology was created for describing the international trade transaction model. It was created in accordance with the results of surveying documents which are used in international trade transaction processes among the ASEAN countries.

(3) An algorithm for optimizing information flows: This algorithm optimizes information flows on the information layer. Optimized information flows are converted to document flows and they are described on the document flow layer. A case study is shown in order to illustrate processes of the supporting system. In addition, results of multi-agent simulations conducted to investigate effects of the proposed algorithm are shown. The results show that the total time of optimized information flow can be reduced 27.28% when compared with the total time of current information flow.

Keywords: International Trade Transaction Model, International Logistics Ontology, Supporting System, Optimized information flow, Simulation Modeling

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INTRODUCTION

1.1 Background of study

The Associations of Southeast Asian Nations (ASEAN) was formed in 1967 with five nation members: Indonesia, Malaysia, the Philippines, Singapore, and Thailand. Brunei Darussalam (1984), Vietnam (1995), Laos (1997), Myanmar (1997) and Cambodia (1999) joined the association. ASEAN was established to accelerate economic growth and promote regional peace and stability, while enhancing cooperation on economic, social, cultural, technical, and educational matters. ASEAN is a largely organization with an economically and politically diverse membership. Since its founding, ASEAN has followed a slow step-by-step approach in changing regional cooperation in order to make it more legally binding with institutionalized agreements. Figure 1-1 shows the history of ASEAN.

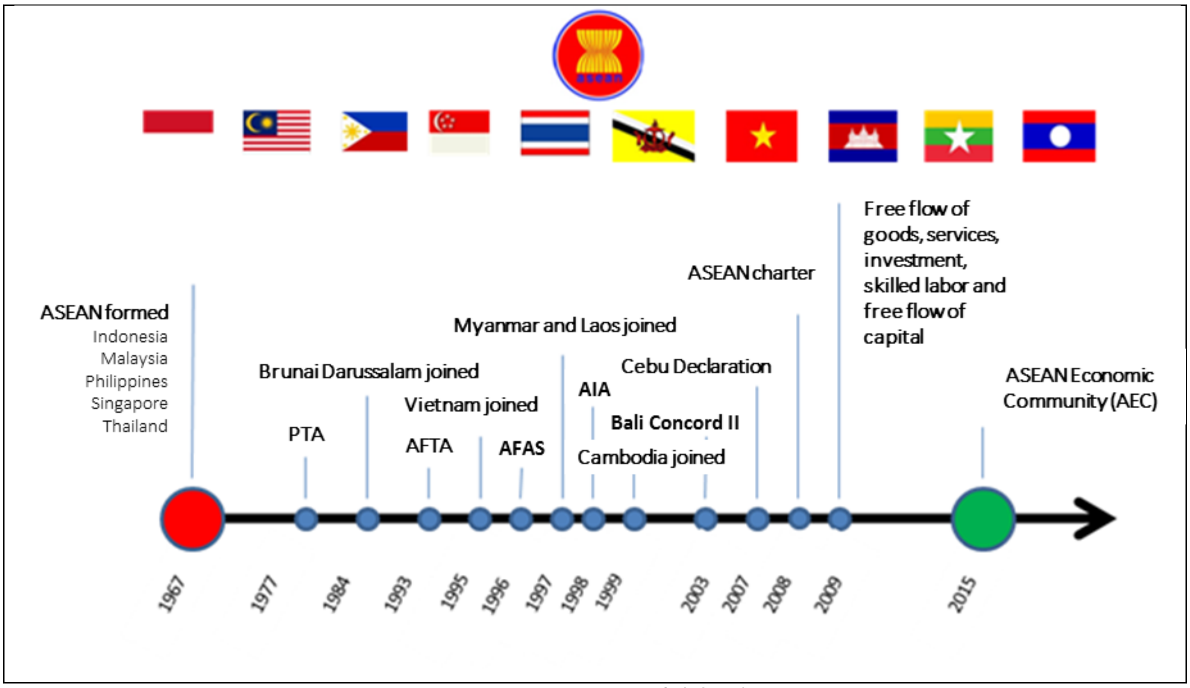


Figure 1-1 History of ASEAN

Source: European ASEAN Business Centre, 2012

ASEAN has agreed to establish a regional economic integration, namely the Asian Economic Community (AEC). The ASEAN was established to promote the ASEAN as a single market and production base [1]. The main objective of the AEC is to transform ASEAN into a region with free movement of goods, services, investment, skilled labor, and free flow of capital. The physical connectivity has been developed by the AEC for enhancing the movement of goods processes [2]. The AEC also is expected to reduce transportation time among the ASEAN countries. In 2015, the ministry of transportation of Thailand has launched a project, the name is "The use of transportation traffic systems as a driving force for the economic strength and the status of transport and traffic hub in the region" in order to enhance transportation abilities of the target region [3]. In the project, some fieldworks have been conducted on Route 12 Economic Corridor (R12), which is an ASEAN highway network. R12 is the shortest international land route connecting Thailand, Lao PDR, Vietnam and Guangxi, China [4]. Although it is the shortest route, the international trade transaction processes on this route still require much time. As a result of the fieldworks, it has become clear that procedure of passing border is one of bottlenecks in the international trade transaction processes. The international trade transactions include complex document flow processes because they have been designing ad-hoc ways. Additionally, multiple languages used in the processes make the problem more complex. Due to the complex document flows, we have to describe similar information in different documents repeatedly.

In the current situation of international trade transaction processes in the ASEAN, logistics service providers are facing with the transportation delay time problem. In order to transport some goods through the ASEAN countries, it takes eight days [5], one day for domestic processes and seven days for preparing information and document which includes waiting time in between each process. Transportation delays occur frequently because of number of documents. These documents are required for declaring the goods in each process of international trade transaction [6]. Each document includes many kinds of information. Similar types of information are filled in different documents repeatedly that effect on paperwork processes. These points make a complex paperwork in each process of international trade transaction. For these reasons, it leads to high transportation cost in an international trade transaction process. Such facts make the process of the international trade transaction process worse. In order to reduce loads of the operators and their human errors, these processes should be optimized. An optimizing information flow algorithm has been proposed for solving the problem of managing information flow among organizations. The algorithm eliminates redundant information flows.

1.2 Goal

The main aim of the research is to propose a method for optimizing information flows among organizations delivering in international trade transaction processes. Research's objectives are:

1. To investigate the information flows among organizations of international trade transaction processes.
2. To review existing methods for modeling in information flows.
3. To propose a method for optimizing information flow in international trade transaction processes.
4. To investigate effect of the proposed method in term of time reductions in the case of international trade transaction processes in ASEAN countries.

1.3 Scope

A scope area of this research is an international trade transaction process in the Associations of Southeast Asian Nations (ASEAN). This study focuses on paperwork processes among organizations who are involved in the trade processes of ASEAN countries both of export side and import side. The ASEAN consists of Indonesia, Vietnam, Laos, Brunei, Thailand, Myanmar, the Philippines, Cambodia, Singapore and Malaysia. The map in Figure 1-2 shows the location of ASEAN country members.

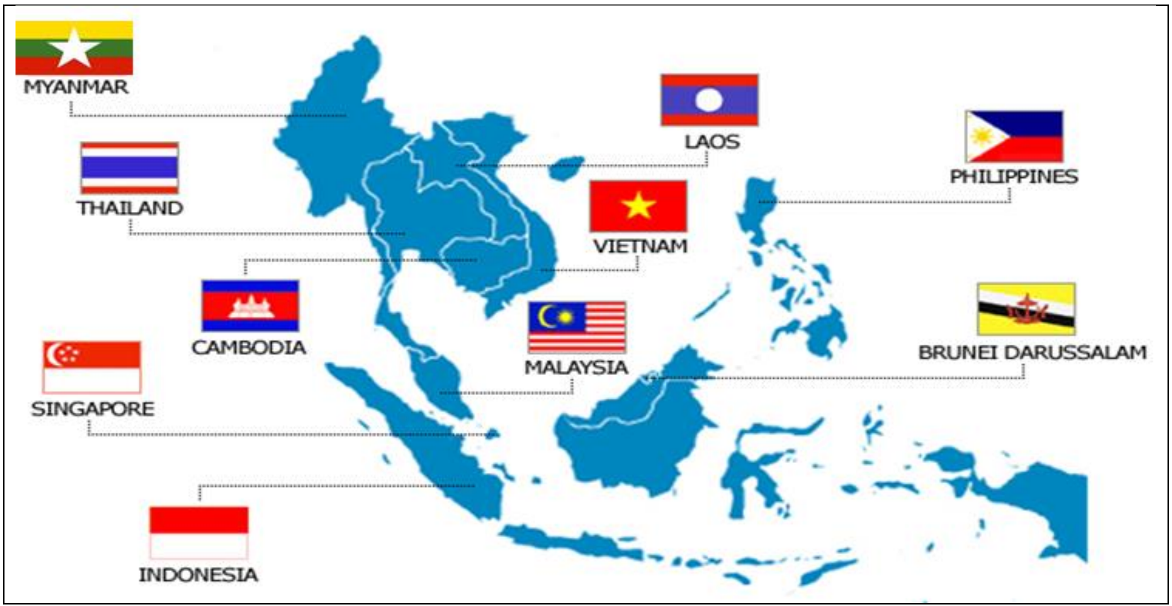


Figure 1-2 ASEAN country members

Source: EU-Indonesia Business Network

1.4 Contributions

The main contribution of this study is a diagrammatic and mathematical modelling technique for optimizing information flow among organizations in the international trade transaction processes. In other to accomplish it, the research with carry out: (1) a surveying the current situation of international trade processes in ASEAN countries, (2) a scientific examination of the state-of-the-art in academic literature for techniques and tools for modelling information flow and (3) a study of international trade transaction practice in the use of tools and techniques for modelling information flow and optimizing information flow. Insights provided by the review and study will then serve as the basis for the modelling and optimizing technique.

1.5 Structure and outline of the thesis

This thesis consists of 6 chapters in which shown in Figure 1-3.

Chapter 1 [Introduction]: A main area of study is addressed in this chapter. I show background and signification of the research problem. After a broad overview of the thesis has been given, objective of research related researches and research methodology have been described.

Chapter 2 [Background]: This chapter presents a comprehensive review of literature on existing techniques for modelling information flow in organizations. The research gap for delivery information flow modelling highlighted in academic literature is also presented. An overview of ontological engineering is described. In addition, an overview of multi-agent simulation also is presented in this chapter.

Chapter 3 [Research Methodology]: In this chapter, specific procedures are shown. The procedures have been used to analyze information flow in the international trade transaction processes. I describe 3 main processes that consist of literature review methodology, proposed technique methodology and simulation methodology.

Chapter 4 [Supporting System International for Trade Transaction]: The backbone of this thesis is described here. This chapter proposes a technique for modelling information flow among organizations in international trade transaction processes that consists of an international trade transaction model, outline of the proposed system, international logistics ontology, and an algorithm for optimizing information flows.

Chapter 5 [Experiments]: Experiments are described in this chapter. This chapter describes case study for optimizing information flow. Simulation models of information flow also are shown in this chapter for evaluate the effectiveness of proposed algorithm.

Chapter 6 [Conclusions and Future Direction]: The study is concluded by summarizing the main outcome of the research and identifying possible directions for future research.

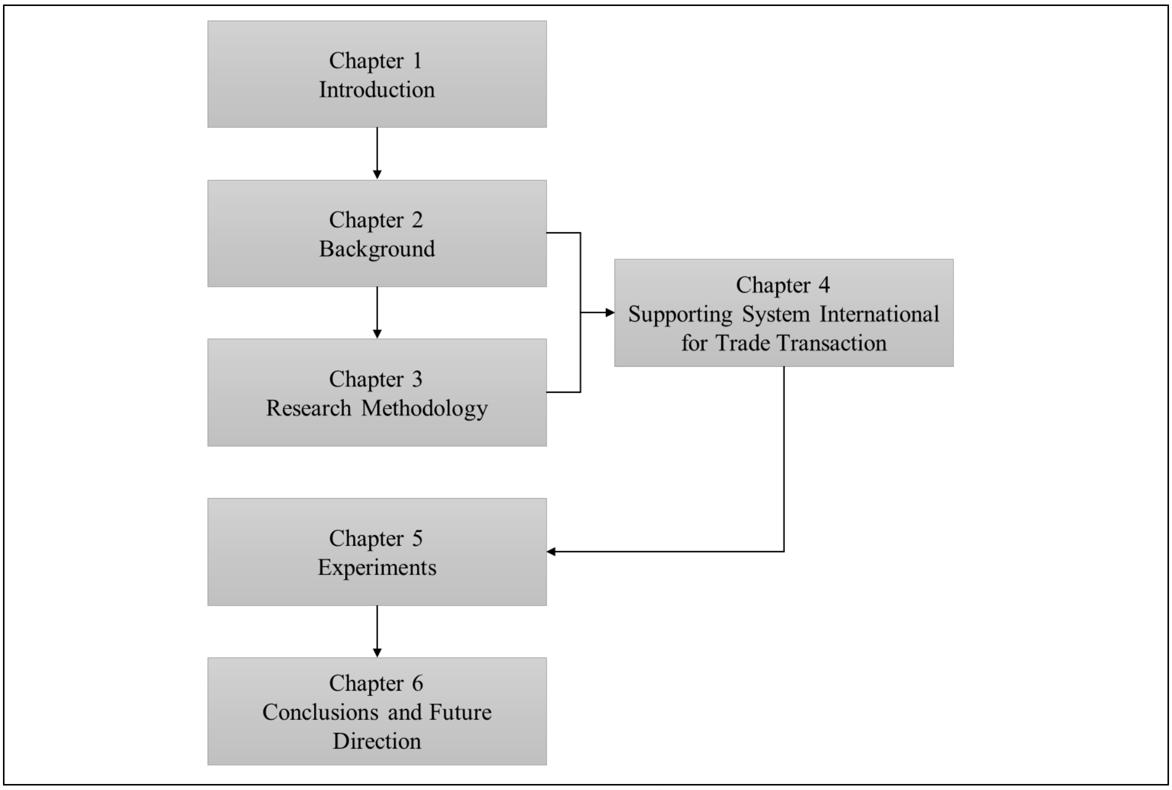


Table 1-1 Structure of the thesis

Chapter 2
BACKGROUND

2.1 Literature review

2.1.1 International trade transaction

International trade transactions evolved a customary and regulatory framework to facilitate the smooth flow of cargo from exporters to importers. In order to carry out international trade, organizations are required to follow a certain set of procedures and deal with a wide range of documents. The exporter needs to comply with rules, regulations, and customs procedures of both the exporting and importing countries. An international trade transaction chain consists of several organizations that form an integral part of the entire system. It includes number of government regulatory agencies in both exporting and importing countries, such as government agencies under the ministry of trade, commerce, inspection agencies, insurance companies, customs and central excise, banking institutions, clearing and forwarding (C&F) agents, shipping companies or airlines, carriers for inland transportation, etc. As exporters and importers are located in two different countries. They are governed by different regulations that effect to complex processes of international trade transactions.

International trade volumes

International trade can be broadly distinguished between trade in goods (merchandise) and services. The bulk of international trade concerns physical goods, while services account for a much lower share. World trade in goods has increased dramatically over the last decade, rising from about $10 trillion in 2005 to more than $18.5 trillion in 2014 to then fall to about $16 trillion in 2016. Trade in services greatly increased between 2005 and 2016 (from about $2.5 trillion to almost $5 trillion). The value of international trade of both goods and services declined substantially in 2015 and 2016 [7]. The graph in Figure 2-1 shows trends of trade of goods and services in 2005-2016.

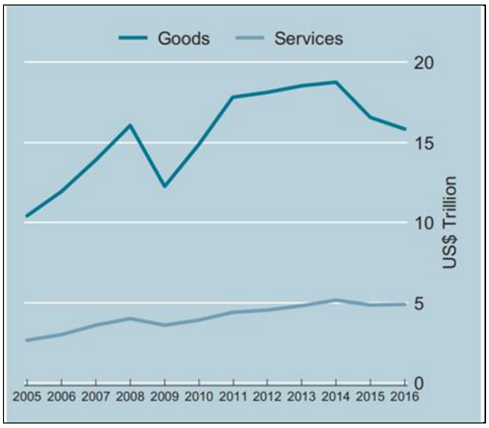


Figure 2-1 Trade of Goods and Services, 2005-2016

Source: UNCTAD secretariat calculations based on COMTRADE data, 2018

Since 2005 the volume of international trade of goods has increased dramatically. However, growth has slowed down significantly in the last few years and virtually stalled in 2015. Volume growth resumed in 2016 but on a subdue rate. During 2015 and 2016, volumes of trade fell for many countries both in terms of imports and exports. The graph in Figure 2-2 shows the volumes of export and import goods in 2005-2015. The volume of international trade in goods has increased dramatically in the last 10 years. In spite of the financial crisis of 2009, developing countries as a group have almost doubled the volumes of trade in goods since 2009. While import volumes have been growing relatively more than export volumes for developing countries, the opposite has happened in regard to developed countries. The relatively larger increase in the volumes of imports can be explained by the increase in consumer demand in developing countries. Growth in trade volumes has slowed down substantially in the last few years, especially in regard to developing countries.

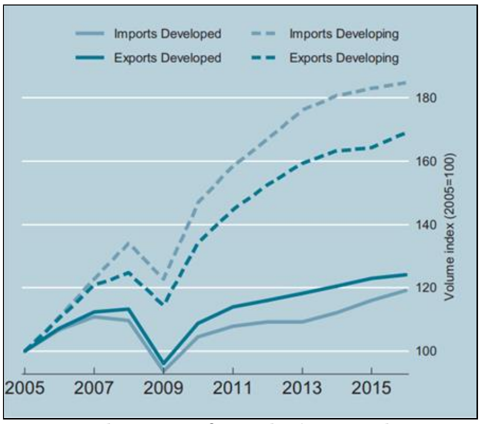


Figure 2-2 Volumes of trade in goods, 2005-2015

Source: UNCTAD secretariat calculations based on COMTRADE data, 2018

Figure 2-3 shows the trade network map. In order to illustrate the importance between and within regions during 2015-2016. The width of the corresponding lines reflects the magnitude of trade in 2016, whereas the size of the nodes reflects total trade for each of the regions. The colors of both the lines and the nodes reflect percentage drops in the value of trade between 2015 and 2016, darker colors indicating greater declines. Increases are in greens. As of 2016, world trade continues to be largely concentrated in three main regions: North America, East Asia and Europe, with a large share of trade being intraregional. In 2016, trade declined in regard to most regions and bilateral trade flows. The value of trade declined substantially more commodity in oil exporting regions as well as in sub-Saharan Africa. The declines in international trade flows were relatively less severe for Europe.

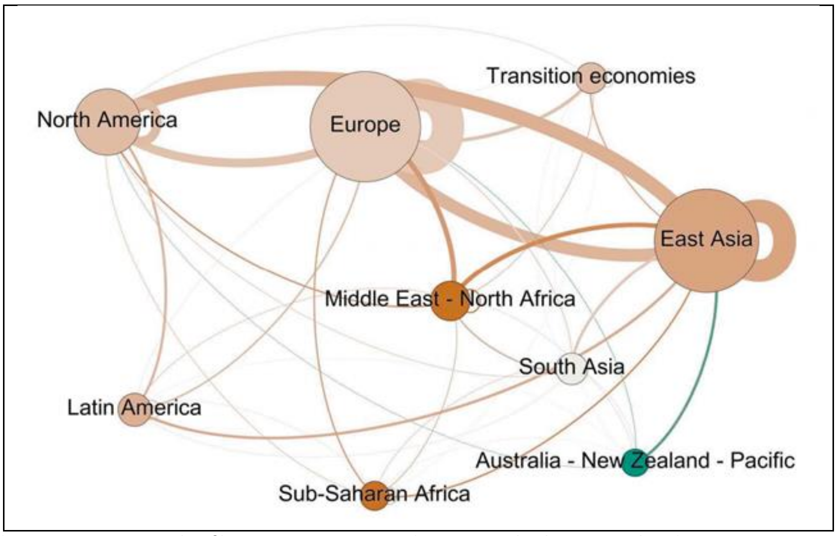


Figure 2-3 Trade flows across regions and change during 2015-2016

Source: UNCTAD secretariat calculations based on COMTRADE data, 2018

International trade documentation

Trade documentation is considered a critical constituent of international sales as export transactions involve much complex documentation work. Trade documentation facilitates international transactions, protecting interests of exporters and importers that are located in two different countries. The successful execution of an export order ensuring physical delivery of goods and remittance of sale proceeds is as important as procurement of an export order and sourcing or production of goods for exports. An export manager should carry out the documentation meticulously to avoid problems related to smooth flow of goods [8]. Certain documents are essential in international trade as a matter of "customs of international trade" and conventions governing international commercial practices. Some documents are required to fulfil the statutory requirements of both exporting and importing countries, such as the export and import declaration, certificate of origin, packing list, pre-shipment inspections, customs requirements, etc.

Doing business [9] collects the data that includes time and cost of international transportation, number of documents needed to trade internationally. The graph in Figure 2-4 shows number of documents of each region. From Figure 2-4, there are 4 types of processes that are divided. In each process, many documents are required such as 22 documents are required for the pre-arrival process that is the average value of ASEAN countries.

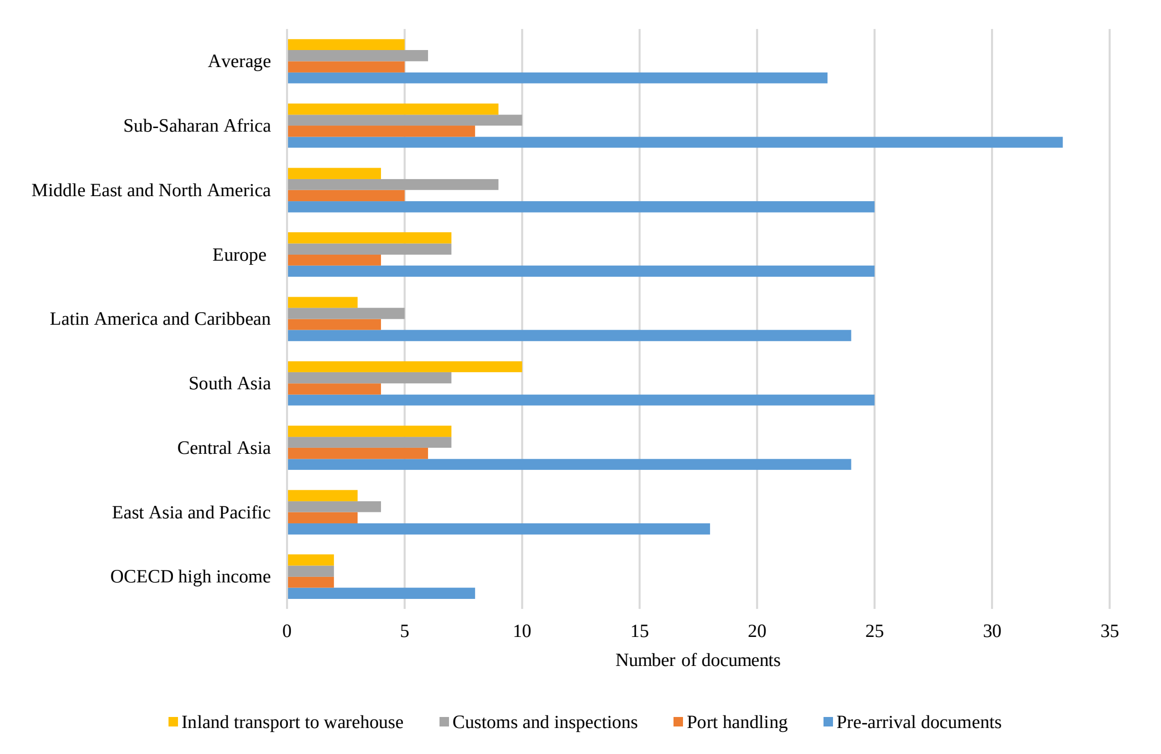


Figure 2-4 Number of international trade documentation in each region, 2016

Source: Doing business, 2016

The graph in Figure 2-5 shows time of export in ASEAN countries. There are 4 processes in the graphs that are explained the time of each process. From the Figure 2-5, the document prepare process takes 9 days that is average value of the ASEAN countries. The graph in Figure 2-6 shows time of import in ASEAN countries. From the Figure 2-6, the document prepare process takes 10 days that is average value of the ASEAN countries.

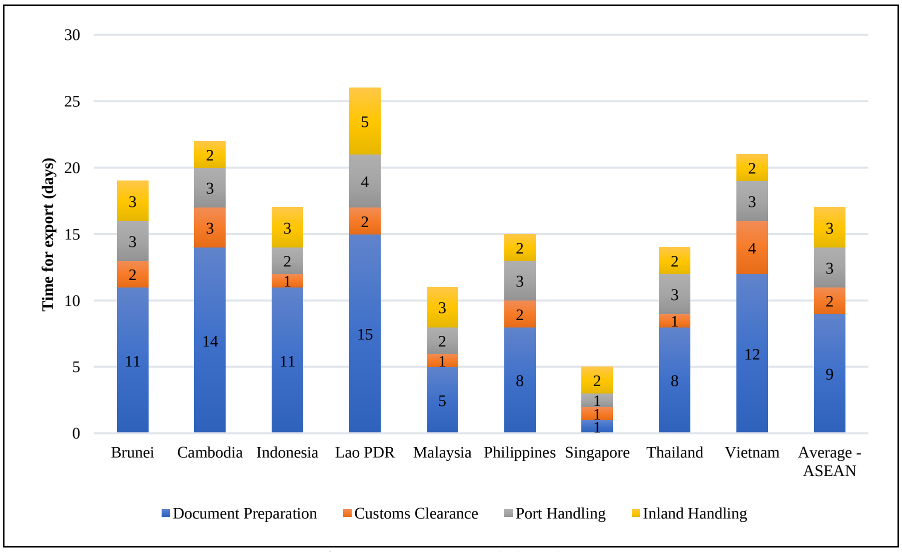


Figure 2-5 Time for export in ASEAN countries, 2013

Source: Trade facilitation consultant for ASW, 2013

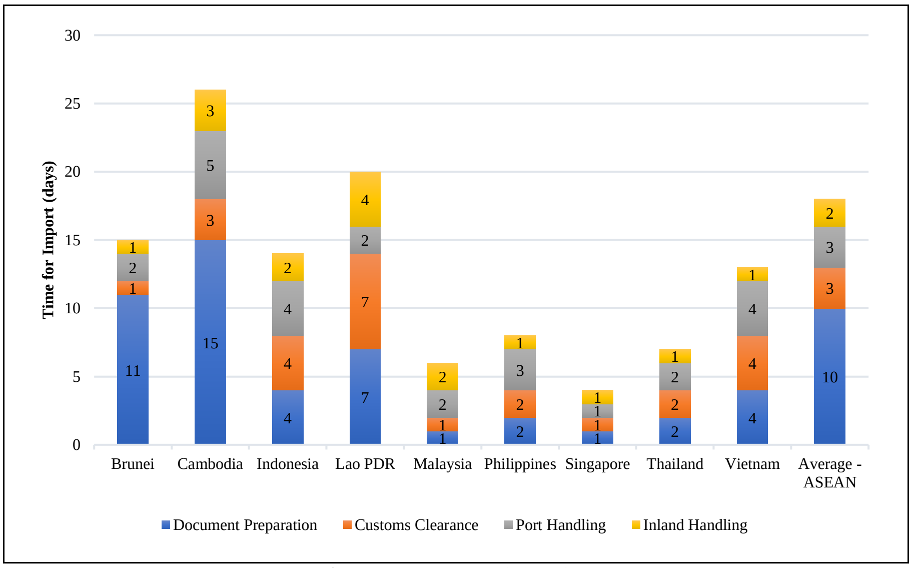


Figure 2-6 Time for import in ASEAN countries, 2013

Source: Trade facilitation consultant for ASW, 2013

2.1.2 Information and information flow for organization

The term "information" is used in four different ways: as a resource, as a commodity, as perception of patterns, and as a constitutive force in society [10]. As a resource, information is interpreted as content from knowledge that is described as data represented or structured for meaning [11] [12]. As a commodity, information is highlighted from the perspective of businesses where the flow of information (usually computerized) is used as trans-organizational communication [13]. As a perception of pattern, information is viewed as the reduction of uncertainty in a system [14]. This reduction of uncertainty is useful as it saves organizational time and cost by minimizing alternate decisions that arise due to uncertainty. As a constitutive force in society, information is viewed as a key element for shaping the structure and behavior of organizations [15]. In this context the flow of information is used to determine the nature of expression and complexity of the transmission structure of information among organizations in the international trade transaction processes.

Information is important to the existence of organizations. In profit driven organizations i.e., businesses, information is a critical factor that determines growth and prosperity [16]. Information flow is defined by the logic of a distributed system that is made up of agents. It is also defined for the relationship in the distributed system [17]. Information flow is viewed as a one way process from a sender to a receiver [18]. There are many kinds of information flow in organizations: person-to-person; person-to-machine and machine-to-machine, from sources such as electronic data interchange and face-to-face conversations, and through channels for communication such as letters, reports, audio files and video recordings [19]. These channels offer the means for a company to communicate internally and externally so as to achieve its business objectives such as the delivery of products and services.

Information flow is an important part of work flows [20] that requires a synergy between humans and computer systems in modern organizations. Information flow is based on information gathering by means of textual, audio, video and graphical media forms. These media forms are used for communication within an organization or among organization [21]. The aim of these media is to describe processes and activities in a system.

There are many studies that focused on information flow. These studies have been undertaken in science and engineering fields such as organizational theory, management science, economics, artificial intelligence and computer science. In organizational theory and management science, the researches have centered on the analysis of information flow. It aims to enhance organizations to manage processes for capturing, storing and retrieving information.

Nicholson [22] investigated the role of production information in the delivery of batch manufactured products by five companies. The purpose of the study was to develop a design (process-flow grid) for information management. Nicholson also emphasized the importance of effectively using computer scheduling systems and of applying trade-offs in capacity, total order intake and lead times.

Iskanius et al. [13] studied the transparency of information flow in the supply chains of steel companies in Northern Finland. They used the findings of their study to identify the elements of a new business design for supply chains. These elements include: customer-alignment, collaboration, systematization, agility, scalability, fast-flow and digitalization. Iskanius et al. also suggested agent-based technologies for managing this new supply chain thinking. They argued that this will improve the flexibility of supply chains and overcome problems of the bullwhip effect i.e. information distortion as it passes through the business network.

Boersma et al. [23] examined information flow for service delivery in the service and call centers of a multi-national electronics company. Following interviews with call agents, the authors made use of the Maturity Index on Reliability (MIR) [24] to propose two new business models for enhancing information flow. The models centered on reducing information losses, encouraging the use of knowledge databases and improving information quality.

Pedroso and Nakano [25] studied the flow of technical information in the supply chain of four pharmaceutical companies. Based on the findings of case studies at the companies, the authors drew a distinction between order information (simple, upstream and timely) and technical information (rich, downstream and early). Pedroso and Nakano also suggested that effective information flow management is dependent on effective logistic processes.

2.1.3 Modeling information flow

Modeling information flow is the process of describing how information is transferred point-to-point along communication channels in an organization and outside of the organizations. Modeling information flow for organizations is motivated by the need to better understand how to: organize and coordinate processes, eliminate redundant information flows and processes, minimize the duplication of information and manage the sharing of intra- and inter-organizational information [26]. It is also required to understand communication barriers among departments that results in sub-optimal and inflexible organizational processes.

Becker et al. [27] have suggested that standard models (as-is models) that should be identified to serve as a starting point for models of planned systems (to-be-models). This sub-section presents, as a first step towards this approach, an analysis of some key diagrammatic information flow models. Diagrammatical tools beyond the scope of information flow, for example models for timeline orientation (UML sequence diagrams), process orientation (flow chart diagrams) or state orientation (state transition diagrams), are omitted.

The GRAI (Graphes à Résultats et Activités Interreliés) Engineering method was developed by GRAI Laboratory at the University of Bordeaux in the 1970s [28]. Figure 2-7 shows the GRAI Modeling Technique which is based on a hierarchical conceptual model (the GRAI model) for supporting decision-making processes during manufacturing and establishing information flow for facilitating these decisions. The GRAI model is divided into two parts: a macrostructure which displays the architecture of the overall system arranged in a hierarchy and a microstructure for system components which are identified in the macrostructure. The macrostructure of the GRAI model as shown in Figure 2-7a decomposes the system to be designed into three sub-systems. The technological system presents the means for delivering products and services such as people, machines and materials. It is also concerned with information flows associated with these tangible/intangible offerings for meeting customer expectations. The decision system can be elaborated in the hierarchy. This hierarchy is arranged according to decision-making levels which contain blocks known as decision centers. The information system links the decision and physical system and the enterprise environment. It also transforms and memorizes information. The microstructure is concerned with decision centers in terms of their intelligence based on recognizing the need for a decision to be made, their modeling capabilities of derived or gathered information, and their choice for selecting appropriate solutions based on criteria, constraints and context. Two main diagrammatical tools are used in the GRAI model: GRAI grids and GRAI nets. Relationships are used in GRAI models to specifically describe information flow and decision flow for co-ordination and synchronization of activities in an organization or system. Relationships are depicted diagrammatically as arrowed lines as shown in Figure 2-7b. Decision flow between two decision centers can be represented as large, emboldened lines, while information flow can be depicted as small dashed lines. GRAI nets are developed after GRAI grids to describe the activities in a decision center [29]. The GRAI nets, as shown in Figure 2-7c, are made up of three constructs: states, activity and supports. States are represented by circles or ovals. Activities are represented as directed arrows, while the supports (information and technological resources) are represented as rectangles.

Petri nets (PNs) or place-transition nets were first proposed by Carl Adam Petri in 1962 for modeling processes in an event-driven system [30]. This system exhibits a wide range of characteristics such as non-determinism, concurrency, synchronicity as well as distributed and/or parallel features. PNs can also be used for representing the information flow in development and simulation of automated manufacturing systems [31]. Diagrammatically, PNs can be used to methodically describe and communicate ideas among designers and implementers. A PN is depicted as a directed, weighted, bipartite graph made up of four main symbols as shown in Figure 2-8. Black dots represent tokens. Tokens may be resources, counters, metrics or attributes. Circles show places and are marked with a non-negative integer *k* of token. Bars depict transitions, while arcs connect places to transitions. In the modeling of PNs, transitions represent events in a system, while places illustrate conditions for occurrence. The tokens provide the premise for the conditions just as input and output places offer pre- and post-conditions for the event respectively.

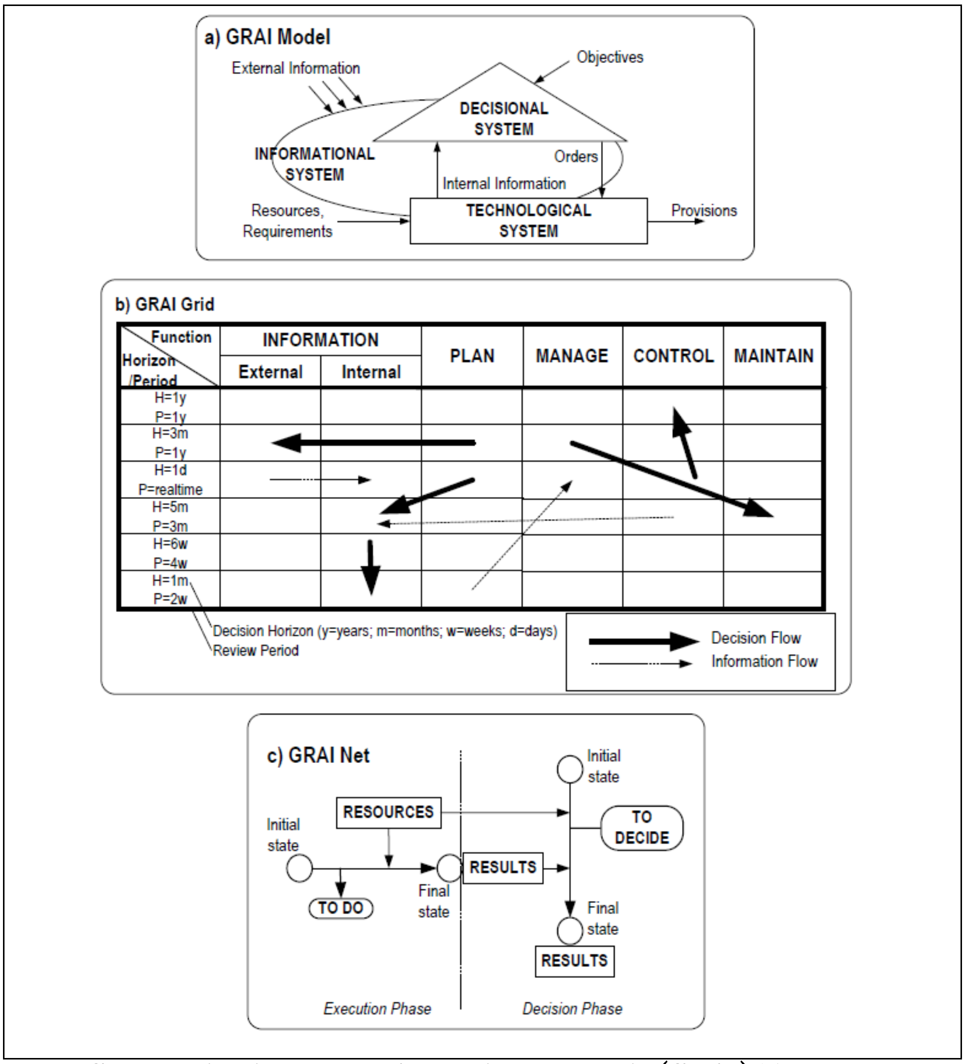


Figure 2-7 Graphes à Résultats et Activités Interreliés (GRAI) Modeling Technique

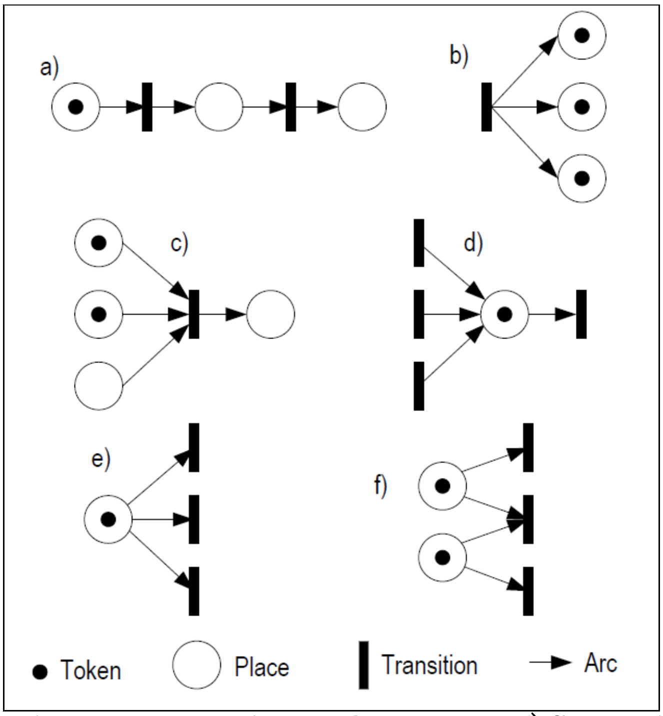


Figure 2-8 Petri net representations and constructs: a) Sequential execution; b) Concurrency; c) Synchronization; d) Merging; e) Conflict; and f) Confusion

Approaches for mathematically modeling information flow in organizations can be classified according to two main categories: flow analysis that propose quantities and information levels for assessing and improving organizational performance and organizational analysis that idealize organizations as different constructs for improving information flow.

Datta and Chaudhuri [32] concentrated on serial and parallel information flow in operation inventory systems for manufacturing organizations. The term "operation inventory system" was used by Datta and Chaudhuri to describe a chain of manufacturing operations separated by inventories under periodic review of base stock systems of ordering. They developed a mathematical model for deciding on the optimum mix for operations that achieve the greatest efficiency.

Four information flow parameters suggested by Krovi et al. [16] offer useful quantities for assessing the level of performance of an organization. Information node density, the first parameter, deals with the complexity of information flow and is computed as the number of intermediate nodes that are present in an information processing channel. Information velocity is the second parameter and deals with the rate at which information is received at a node. Information viscosity, the third information flow parameter, is concerned with the level of conflict at a node i.e. the presence of contradictory information. The fourth parameter, information volatility describes uncertainty in the content, format or timing of information.

Aoyama et al. [33] modelled information (and commodity) flow in organizations with independent but linked sub-networks. They focused on logistics networks that incorporate methodologies for just-in-time manufacturing and inter-period network storage. These logistics networks in modern businesses incorporate web technologies (particularly the internet) in e-logistics for overcoming factors such as language barriers, and time zone and spatial constraints. Aoyama et al. studied the characteristics of logistics in geographic/ virtual spaces and concluded that intermediaries (such as middlemen) can still be important elements in the logistics industry.

Helbing et al. [34] modelled side-links in organizations made up of multiple agents with complex non-linear interactions. The model much like the one proposed by Creti [35] proposed side-links for information flows. But unlike Creti, the model focused on hierarchical, regular area-filling kinds of organizational subdivisions according to triangular, quadratic and hexagonal configurations. Helbing et al. demonstrated how short-cuts and temporary links in hierarchical organizations can contribute to efficient and effective information flow during crisis or disaster response management.

Costa et al. [36] developed a mathematical model of information for complex networks made up of human-made structures. The model analyses trails left by information flow for identifying contamination sources, strategies for immunization and optimal routing paths.

Caldwell [37] developed a feedback control model that analyses the delay between the time information is sent from a source and received at a destination. The model introduces a task time quantity for assessing the use of information and communication technologies (ICTs) for supporting human-human communication and for improving task coordination.

A complex network can be described as a graph $G = (V, E)$ containing a set of vertices V (called nodes or points) that are associated by edges E (called links or lines) [38] as shown in Figure 2-9. The vertices represent entities within a network whereas edges indicate interactions based on relationships in which the entire graph is connected (i.e. for a vertex i in the graph, there is a path made up of edges to another vertex j) or disconnected. A complex network can contain a subgraph $(G') = (V', E')$ – a subset of G where V' and E' are subsets of V and E respectively. In Figure 2-9, subgraphs can be created between sets of vertices *(A, B, C, D), (A, D, G), (B, C, D, F)* and so on. Vertices, edges and topology (that depicts how vertices and edges are arranged) are the main concepts used to characterize information structures for analyzing domains such as the World Wide Web, social networks, brain networks and genetic networks. Within complex network research, social network analysis (SNA) is the main approach adopted by researchers to study and understand relationships, social roles and social structure in organizations [39], [40], [41] and [42].

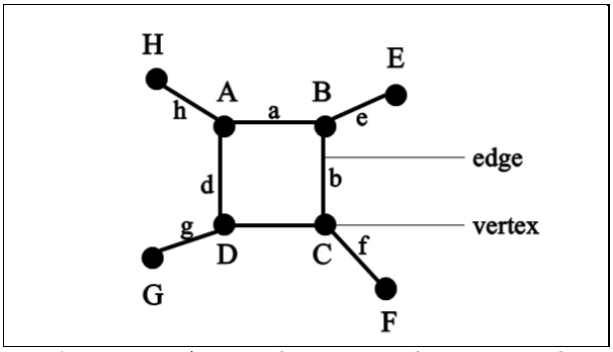


Figure 2-9 A complex network as a graph

2.2 Ontological engineering

Ontological engineering aims to describe knowledges in a domain, provide and share understanding to conceptual knowledge, define common vocabulary and give clear definition to relationships [43]. An ontology is a formal explicit description of concepts in a domain of discourse (**classes** (sometimes called **concepts**)), properties of each concept describing various features and attributes of the concept (**slots** (sometimes called **roles** or **properties**)), and restrictions on slots (**facets** (sometimes called **role restrictions**)). An ontology together with a set of individual instances of classes constitutes a knowledge base. In reality, there is a fine line where the ontology ends and the knowledge base begins [44].

Gruber [45] proposed to model ontologies using frames and first order logic. He identified five kinds of components: classes, relations, functions, formal axioms and instances. In this section we present such components with an example in the traveling domain.

Classes represent concepts, which are taken in a broad sense. For instance, in the traveling domain, concepts are: locations (cities, villages, etc.), lodgings (hotels, camping, etc.) and means of transport (planes, trains, cars, ferries, motorbikes and ships). Classes in the ontology are usually organized in taxonomies through which inheritance mechanisms can be applied. We can represent a taxonomy of entertainment places (theater, cinema, concert, etc.) or travel packages (economy travel, business travel, etc.).

Relations represent a type of association between concepts of the domain. They are formally defined as any subset of a product of n sets, that is: $R \subset C_1 \times C_2 \times \ldots \times C_n$. Ontologies usually contain binary relations. The first argument is known as the domain of the relation, and the second argument is the range. For instance, the binary relation *Subclass-Of* is used for building the class taxonomy. Examples of classifications are: A `Four-Star-Hotel` is a subclass of a `Hotel`, a Hotel is a subclass of a `Lodging`, and a `Flight` is a subclass of `Travel`, which is identified by the `flightNumber`. Binary relations are sometimes used to express concept attributes (aka slots). Attributes are usually distinguished from relations because their range is a datatype, such as string, number, etc., while the range of relations is a concept. The following code defines the attribute `flightNumber`, which is a *string*.

Functions are a special case of relations in which the *n-th* element of the relation is unique for the *n-1* preceding elements. This is usually expressed as: $F: C_1 \times C_2 \times \ldots \times C_{n-1} \rightarrow C_n$. An example of a function is `Pays`, which obtains the price of a room after applying a discount.

Instances are used to represent elements or individuals in an ontology. An example of instance of the concept `AA7462` is the flight AA7462 that arrives at Seattle on February 8, 2002 and costs 300 (US Dollars, Euros, or any other currency).

Introducing Ontological technology into logistic field is just beginning, but some interesting result have reported. One of the main goals of logistics ontologies is supporting optimized information utilization, e.g. time managements, truck location controls, quality controls, etc.

Andreas and Julia [46] have proposed logistics ontologies to annotate logistics services semantically. Their ontologies are modularly organized and covers the overall concepts of the logistics domain. The logistics ontologies include the elements for describing both declarative and procedural aspects. The ontologies model consists of three layers, (1) a logistics semantic layer, (2) a logistics service description layer, and (3) a logistics process description layer. With the ontologies, terms in logistics service are defined clearly.

Ontological technique has been also applied in food industry. MEat Supply Chain Ontology (MESCO), which is an ontology model for traceability in meat supply chains, has been proposed by Pizzuti et al. [47]. Important concepts of meat supply chains are defined in MESCO, such as activity, food product, service product, lot and process. The main features of MESCO are providing definitions of keyword of all activities which is using for tracing from the farmer to the final consumer. The MESCO allows users to illustrate all knowledge and information, which related to the meat traceability domain with unified notification. Moreover, the MESCO enables interoperability among different systems and allows for integrating heterogeneous databases used by each actor involved in the supply chains. The main advantages in using MESCO is providing platform for obtaining essential data, fundamental in case of occurring sudden diseases of foods.

Seedah et al. [48] proposed a standardized knowledge representation method of freight data sources using ontological technology. The method makes knowledge understandable from both of computer systems and humans. The ontology was developed by using the role based classification schema (RBCS) that organizes and classifies data elements. The freight data ontology was developed to resolve users' misunderstanding among different freight databases and support the users to identify a proper data. By using their ontologies, we can use multiple freight data seamless because the semantic gaps are eliminated. Besides, it can identify similar data elements across different data sources, which is same principle with data mining.

Hozo – Ontology Editor [1] has been used to describe the classes of international logistics ontology that will be described in Chapter 4, Section 4.3. Hozo is a tool for building ontologies in a distributed environment. Among many existing ontology building tools, the main characteristics of Hozo are summarized as follows:

- Unlike OWL, its conceptual level is closer to that of humans. OWL is a low-level language which is good for an interlingua for ontology exchange. If one uses it as an ontology representation language directly, it would degrade user's understanding of ontology by restricting their idea to semantic-network/description-logics levels which are inappropriate for understanding ontology.
- Its representation scheme is based on the frame structure
- It helps users build ontologies with Roles in a natural way supported by the advanced theory of Roles.
- It is easy to represent a nested structure of slots. That is, any slot can have its own slots.
- Inheritance information is explicit and is always accessible. Two ways of inheritance: one from super classes through *is-a* link and the other from *class constraint*

[1] http://www.hozo.jp/

- A friendly Graphical User Interface (GUI) is available.
- Version management is available with a useful function for displaying changes.
- Ontology building in a distributed environment over internet is supported.
- Application programming interfaces (APIs) are available for accessing ontologies and instances.

An ontology editor in Hozo provides users with a graphical interface, through which we can browse and modify ontologies by simple mouse operations. Its interface mainly consists of the following 3 panels as shown in Figure 4-6: navigation panel, definition panel and browsing panel. The last two panels are located centrally in this tool. They display the definition of the concept that is selected in the *is-a* hierarchy browser and allows users to edit it. It is composed of a browsing panel and a definition panel.

The browsing panel shows an ontology and users edit it mainly on this panel. It has two display modes. One displays it graphically by using nodes and links. Each node represents a whole-concept or a relation-concept which has slots representing its part-concepts or participant-concepts by such a manner that is shown in Figure 4-7 (a). A diagram of a part-concept is composed of three parts. Each of them represents 1) a *role-concept*, 2) a class constraint, and 3) a *role holder*. A symbol besides a link connecting a whole-concept and a part-concept denotes kinds of relation ("p/o" denotes *part-of relation*, "p/i" denotes *participant-in relation* and "a/o" denotes *attribute-of*) and a numeral represents the number of part-concepts (or attributes). Fig.4-7 (b) shows a person, who is referred in the class constraint, plays "a teacher role", and the wheel becomes a role holder "a teacher". The other mode displays an ontology under editing in RDF(s).

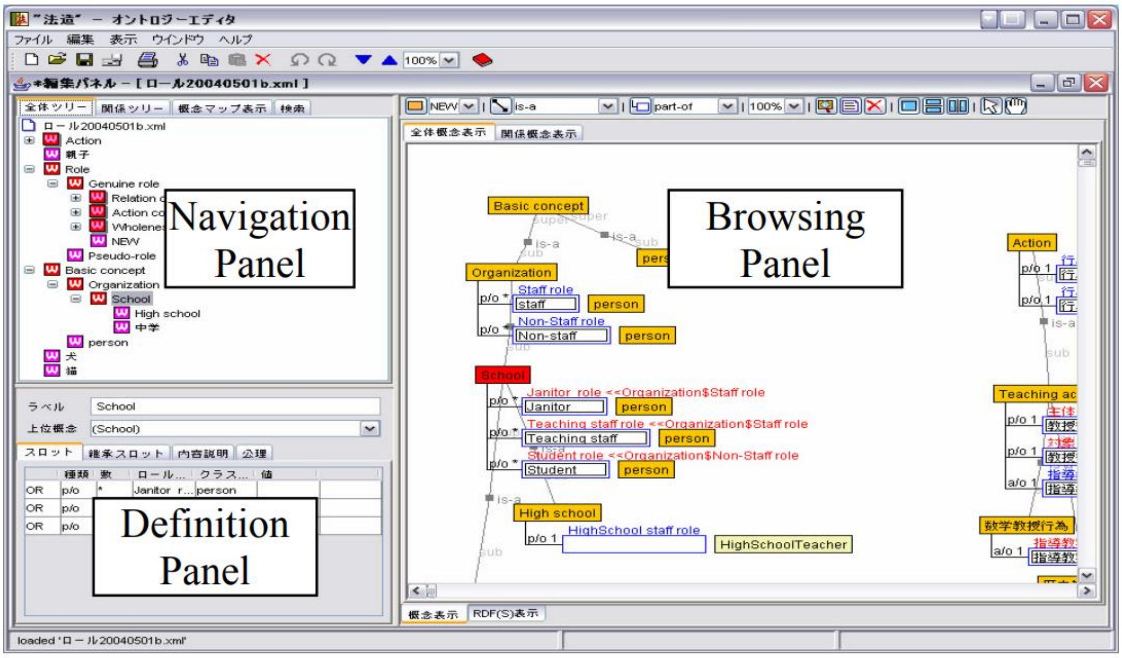


Figure 2-10 A snapshot of Ontology Editor

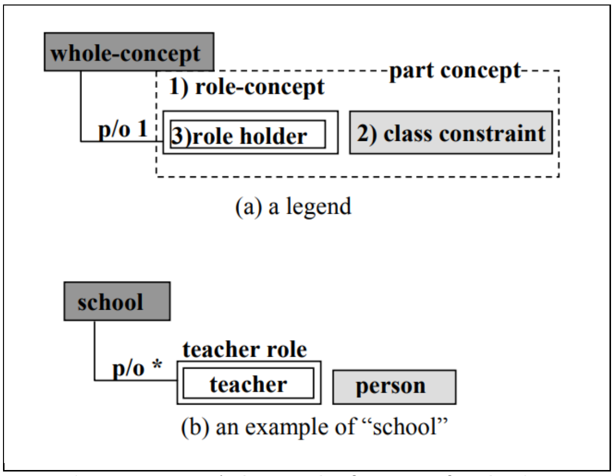


Figure 2-11 A legend of part-of relation

2.3 Multi-agent simulation

Simulation is a powerful tool for modeling, planning and controlling complicated operational systems [49]. The simulation has been used in various purposes: identifying bottlenecks; studying system behaviors; forecasting future events; testing new designs for system. Particularly, many researchers have employed discrete event simulation model for process analysis and improvement.

Vaghefi and Sarhangian [50] have proposed the mathematical model for optimizing inspection costs of the multistage manufacturing system. Simulation experiments were conducted to examine the effects of several parameters. ARENA simulation software was employed for determining the optimal inspection plan.

Hsu et al. [51] explored the customs clearance processes of import goods in Taiwan. Customs clearance network model in the import processes have been constructed for analyzing the delay time of customs clearance processes. Then, the customs clearance processes have been reconstructed by using the application of Radio Frequency Identification (RFID). The simulation models were conducted for comparing the delay time of the reconstructed customs clearance processes with the current customs clearance processes.

Opasanon and Kitthamkesorn [52] have proposed a framework of system for modern customs and cross-border transportation. The proposed framework aims to design infrastructures and facilities of the Sadao customs for serving the freight flows between Thailand and Malaysia. The simulation models have been constructed to justify various operations and designs of border-crossing facilities: immigration control booths; vehicle inspection station; truck clearance area.

Haughton and Michael [53] conducted the simulation model of truck schedules for border-crossing between Canada and the United States. The ARENA simulation software has been employed to analyze the current truck schedules, evaluate alternatives of the truck processing capacity at border crossings. Based on the studies that are mentioned, the simulation model becomes a practical for new system design and operation in various border crossing problem.

In this thesis, simulation models are developed through ARENA simulation software version 15.1[2] to determine the current information flow and the optimized information flow among organizations in international trade processes. The ARENA is a discrete event simulation software, based on the process-oriented simulation scheme, in which travelers are represented by entities flowing through the system.

Discrete-event simulation is an important tool for the modeling of complex system. It is used to represent manufacturing, transportation, and service system in a computer program for the purpose of performing experiments. Representation of the system via computer program enable the testing of engineering design changes without disruption to the system being modeled. Simulation modeling involves elements of system modeling, computer programming, probability and statistics, and engineering design. A key advantage of simulation modeling is its capability of modeling entire systems and complex interrelationships. The representational power of simulation provides the flexible modeling that is required for capturing complex processes. As the result, all important interactions among components of the system can be accounted for within the model. The modeling of these interactions is inherent in simulation modeling because simulation imitates the behavior of the real system. The ARENA is predicted on the modeling the process flow of "entities" through a system. The prediction of future behavior of the system is then archived by monitoring the behavior of various modeling scenarios as a function of simulated time.

The main purpose of simulation model is to allow observations about a particular system to be collected as a function of time. Figure 2-12 illustrates the fact that system is embedded within an environment, and that typically a system requires input and produces output using internal components.

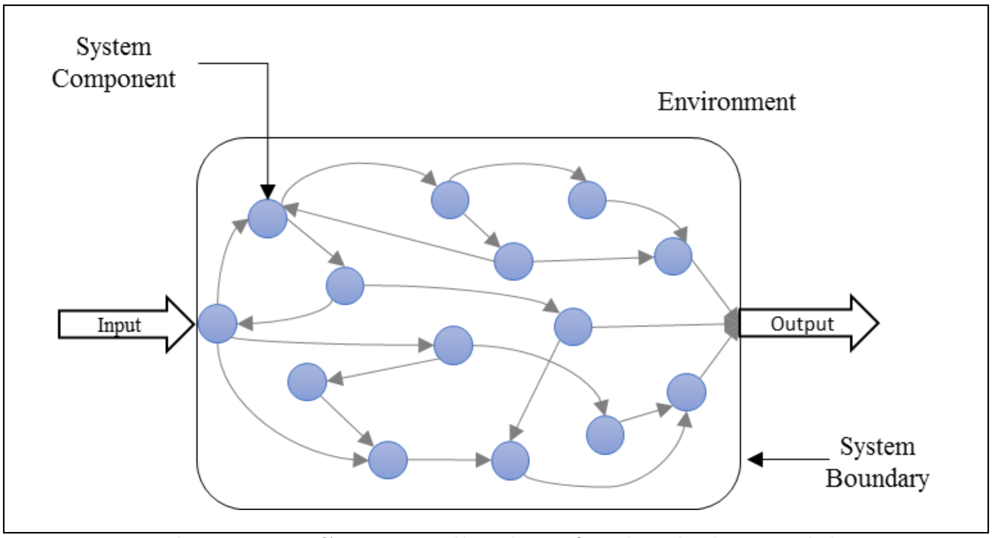


Figure 2-12 Conceptualization of a simulation model

[2] www.arenasimulation.com

Chapter 3
RESEARCH METHODOLOGY

There are 3 phases of the research methodology. These phases are: literature review; proposed method for optimizing information flows and case studies. The research methodology is used in the research phases to fulfil the research objectives as summarized in Table 3-1.

Table 3-1 Relationship between research objectives and research methodology

Objective	Methodology
(1) To investigate the information flows among organizations of international trade transaction processes.	Literature review methodology
(2) To review existing methods for modeling in information flows.	
(3) To propose a method for optimizing information flow in international trade transaction processes.	Proposed method methodology
(4) To evaluate the proposed method by using simulation models in the case of international trade transaction processes in ASEAN countries.	Simulation methodology

3.1 Literature review methodology

To achieve objective (1) and (2), existing method for modeling information flow in an organization and outside of the organizations are reviewed. The information flows among organizations of international trade transaction processes are also investigated. A review of academic literature was carried out through a 3-stage analytical process: plan, source and study.

In the first stage, a plan was drawn up in which the aim, motivation and focus for the literature review were defined. This also included questions which the review would seek to answer as well as the initial or planned structure for the review. For the second stage, academic publications (books, journal articles, conference proceedings, report and other materials) were selected using an online database for literature. The third stage involved studying the publications and re-examining the sources from stage two. The literature review plan drawn up in the first stage was also reconsidered during this stage.

3.2 Proposed technique methodology

To accomplish objective (3), a framework of supporting system for international trade transaction is proposed. The system can generate an optimized process of paperwork from a complex process of international trade transaction. First, an international logistics ontology, which has been developed for describing the international trade transaction model is shown. Then an algorithm for optimizing information flow has been proposed.

3.3 Simulation methodology

To accomplish objective (3), a framework of supporting system for international trade transaction is proposed. The system can generate an optimized process of paperwork from a complex process of international trade transaction. First, an international logistics ontology, which has been developed for describing the international trade transaction model is shown. Then an algorithm for optimizing information flow has been proposed.

1. **D**efine the problem
2. **E**stablish measures of performance for evaluation
3. **G**enerate alternative solutions
4. **R**ank alternative solutions
5. **E**valuate and iterate as necessary
6. **E**xecute and evaluate the solution

The first step in the DEDREE methodology [54] helps to ensure that problem is right. The second step helps to ensure that the problem is solved for the right reason; that is metrics must be coherent with the problem. The next 2 steps ensure that evaluate the multiple solutions to the problem. In other words, these steps help to ensure that the right solution is developed to the problem. In step 5, the process is evaluated by proceeding and allows for iteration. Although an important concept, iteration is new to many modelers. Iteration recognizes that the problem-solving process can be repeated until the desired degree of modeling fidelity has been achieved. Start the modeling at a level that allows it to be initiated and do not try to address the entire situation in each of the steps. Start with small model that work and build them up until we reached our desired goal. It is important to set start and get something established at each step, and then continually repeats the steps until the model is representing reality in the way that we intended. The final step is often overlooked. Simulation is often used to recommend a solution to a problem. This step indicates that if we have the opportunity, we should execute the solution by implementing the decision. Finally, we should always follow up to ensure that the projected benefits of the solution were obtained.

The DEGREE problem-solving methodology should serve us well. However, simulation involves certain unique actions that must be performed during the general overall problem-solving process. When applying DEGREE to a problem that may require simulation, the general DEGREE approach needs to be modified to explicitly consider how simulation will interact with the overall problem-solving process. Figure 3-1 represents a refined general methodology for applying simulation to problem-solving.

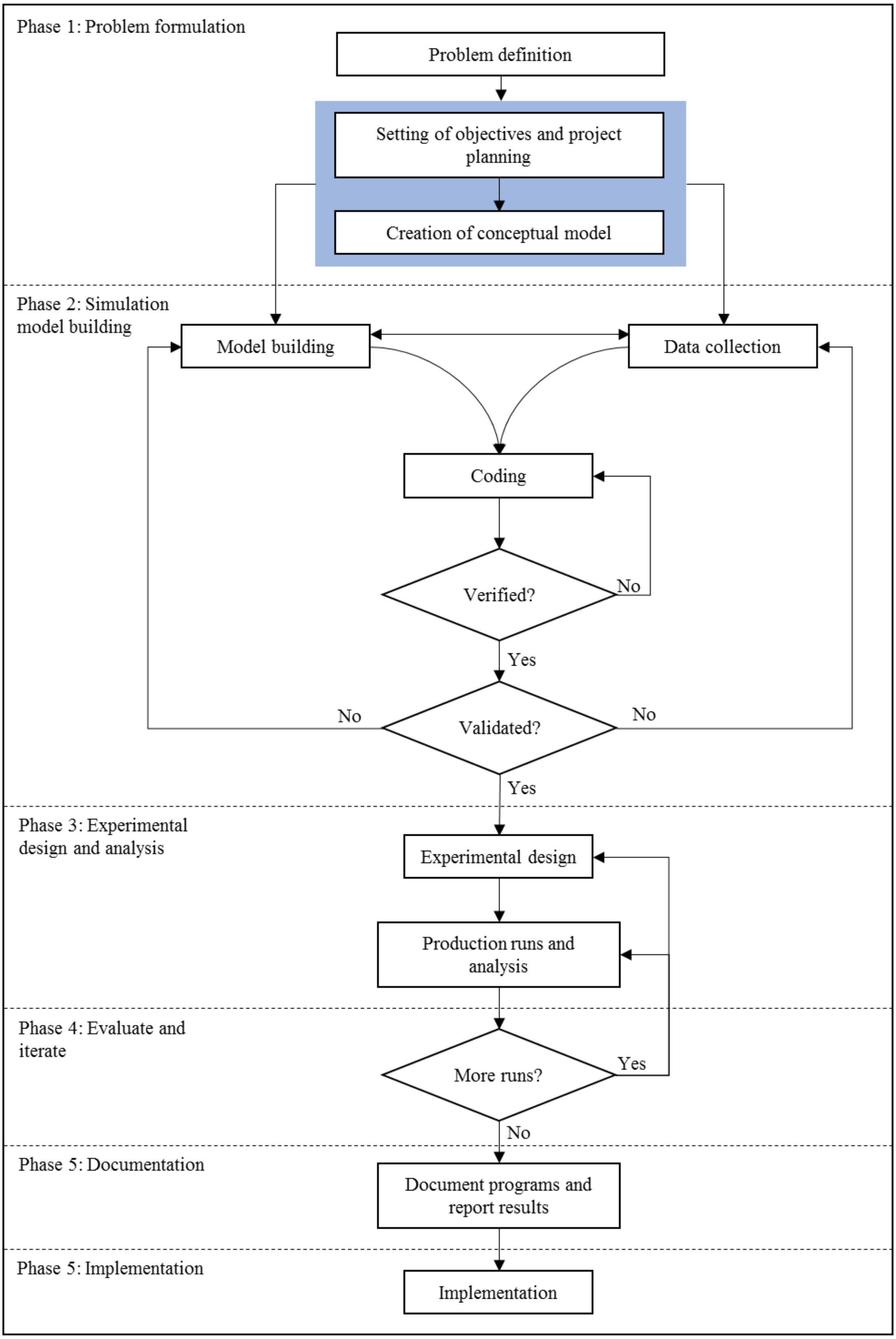


Figure 3-1 General simulation methodology

The first phase, problem formulation, captures the essence of the first two steps in the in the DEGREE process. The second phase, model building, captures the essence of step 3 of the DEGREE process. When building model, we are either explicitly or implicitly developing certain design alternatives. The third phase, experimental design and analysis, encapsulates some of step 3 and 4 of the DEGREE process. In designing experiments, design alternatives are specified, and when analyzing experiments their worth is being evaluated with respect to problem objectives. The fourth phase, evaluate and iterate, captures the notion of iteration. Finally, the fifth and sixth phases, documentation and implementation, complete the simulation process. Documentation is essential to ensure the ongoing and future use of simulation model. Implementation recognizes that simulation projects often fail in the absence of follow-through on recommended solutions.

The problem formulation phase of the study consists of five primary activities.

1. Defining the problem
2. Defining the system
3. Establishing performance metrics
4. Building conceptual models
5. Documenting modeling assumptions

A problem starts with a perceived need. These activities are useful in developing an appreciation for and an understanding of the problem requirements. The basic output of the problem definition activity is a problem definition statement. A problem definition statement is narrative discussion of the problem. A problem definition statement is necessary to accurately and concisely represent the problem stakeholders. The problem definition statement should include all required assumptions so that we can examine their effect on the model during the verification, validation, and experimental analysis steps of the methodology. A well- written problem definition statement ensures that the problem is well understood and that all parties agree on the nature of the problem and the goal of study.

The general goals of simulation study often include:

- Comparison of system alternatives and their performance measures across various factors (decision variables) with respect to some objectives.
- Optimization, a special case of comparison in which are tried to find the system configuration that optimizes performance subject to constraints.
- Prediction of system behavior at some future point in time.
- Investigation to learn about and gain insight into behavior of the system given various inputs.

These general goals will need to be specialized to the problem under study. The problem definition should include a detail description of the objectives of the study, the desired output from the model, and the type of scenarios to be examined or decisions to be made.

The second activity of this phase produce a definition of the system. A system definition statement is necessary to accurately and concisely define the system, particularly its boundaries. The system definition statement is narrative and of ten contains a pictorial representation of the major elements of the system. This ensure that the simulation study is focused on appropriate areas of interest to stakeholders and that the scope of the project is well understood.

When defining the problem and the system, one should naturally begin to develop an understanding of how to measure system performance. The third activity of the problem formulation makes this explicit by encouraging to define the required performance measures for the model. To meaningfully compare alternative scenarios, objective and measurable metrics describing the performance of the system are necessary. The performance metrics should include quantitative statistical measures from any models used in the analysis (e.g., simulation mode), quantitative measures from the systems analysis, (e.g., cost/benefits), and qualitative assessments (e.g., technical feasibility, human operational feasibility). The focus should be placed on the performance measures that are considered to be the most important to system decision makers and tied directly to the objective and unbiased manner to determine which system scenario performs the best according to decision maker preferences.

The simulation models used to evaluate the alternative solutions are then developed, verified, and prepared for analysis. Within the context of a simulation project this process includes:

Input data preparation: Input data is analyzed to determine the nature of data and determine future data collection needs. Necessary data are also classified by area. This classification establishes the different aspects of the model that are used in model development.

Model translation: The act of implementing the model in computer code, including timing and general procedures and the translation of the conceptual models into computer simulation program representations.

Verification: Verification of the computer simulation model is performed to determine whether the program perform as intended. Verification consists of model debugging to locate any errors in the simulation code. Errors of particular importance include improper flow control or entity creation, failure to release resources, and logical/arithmetic errors or incorrectly observed statistics. Model debugging also include scenario repetition using identical random number seeds, “stressing” the model through a sensitively analysis to ensure compliance with anticipated behavior, and testing of individual modules in the simulation code.

Validation: Validation of simulation model is performed to determine whether the simulation model adequately represents the real system. The simulation model is shown to personnel associated with the system in question. Their input concerning model realism is critical in establishing the validity of the simulation. I addition, further observations of system are performed to ensure model validity with respect to actual system performance. A simple technique is to statistically compare the output of simulation model to the output of the real system and to analyze whether there is significant different between two.

Chapter 4
SUPPORTING SYSTEM FOR INTERNATIONAL TRADE TRANSACTION

4.1 International trade transaction model

In international trade transaction processes, many kinds of information are transmitted for carrying out the office procedures. This information is transmitted by using several ways, e.g. paper documents, forms on the internet system, etc. [55]. In addition, each country has its own formats and they are expressed by the local languages. Thus, transmitting processes can be grasped from the three different aspects, i.e. document flows, and information flows, and notifications. Based on the above discussion, the author has proposed a representation model of international trade transaction processes. Figure 4-1 illustrates the proposed model.

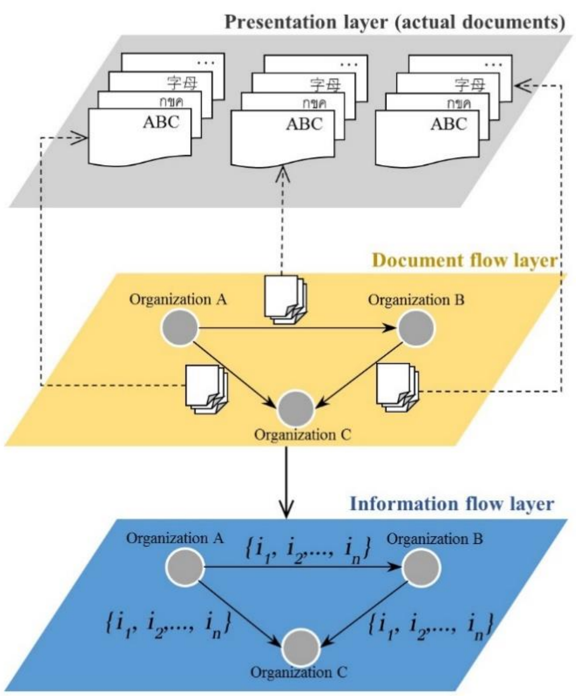


Figure 4-1 International trade transaction Model

This model consists of three layers, Document flow layer, Information flow layer, and Presentation layer. The details of each layer are shown below:

- **Information flow layer**: On this layer, information flows of international trade transactions are represented.
- **Document flows layer**: On this layer, flows of documents in international trade transaction processes are represented. Both of paper and electronic document flows are shown on this layer. Each document on this layer can be considered as a set of information on the Information layer.
- **Presentation layer** or **interface layer**: On this layer, linguistic labels of information are represented. Each information on the information layer is connected with the labels, which are represented by several different languages.

The results of surveying the current documents flow in the international trade transaction processes in ASEAN countries, there are many documents that are required among organizations in both of export and import country side. Figure 4-2 shows a diagram of typical document flow of international trade transaction procedure. These document flows can be abstracted as information flows by using the proposed classes as described in section 4.2. This type of knowledge is described on the information flow layer shown in Figure 4-1 and Figure 4-2. The paths of each document flow have been explored as shown in Figure 4-3.

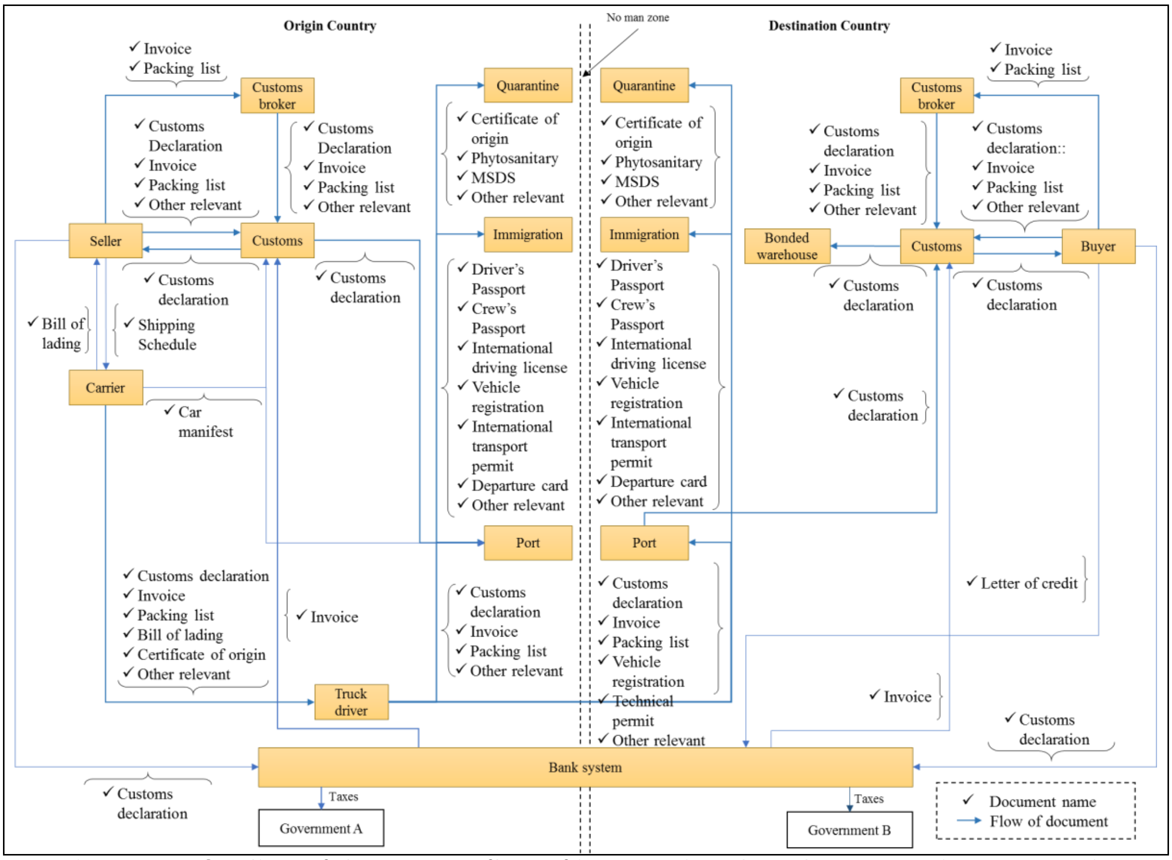


Figure 4-2 Outline of documents flow of international trade transaction process in ASEAN countries

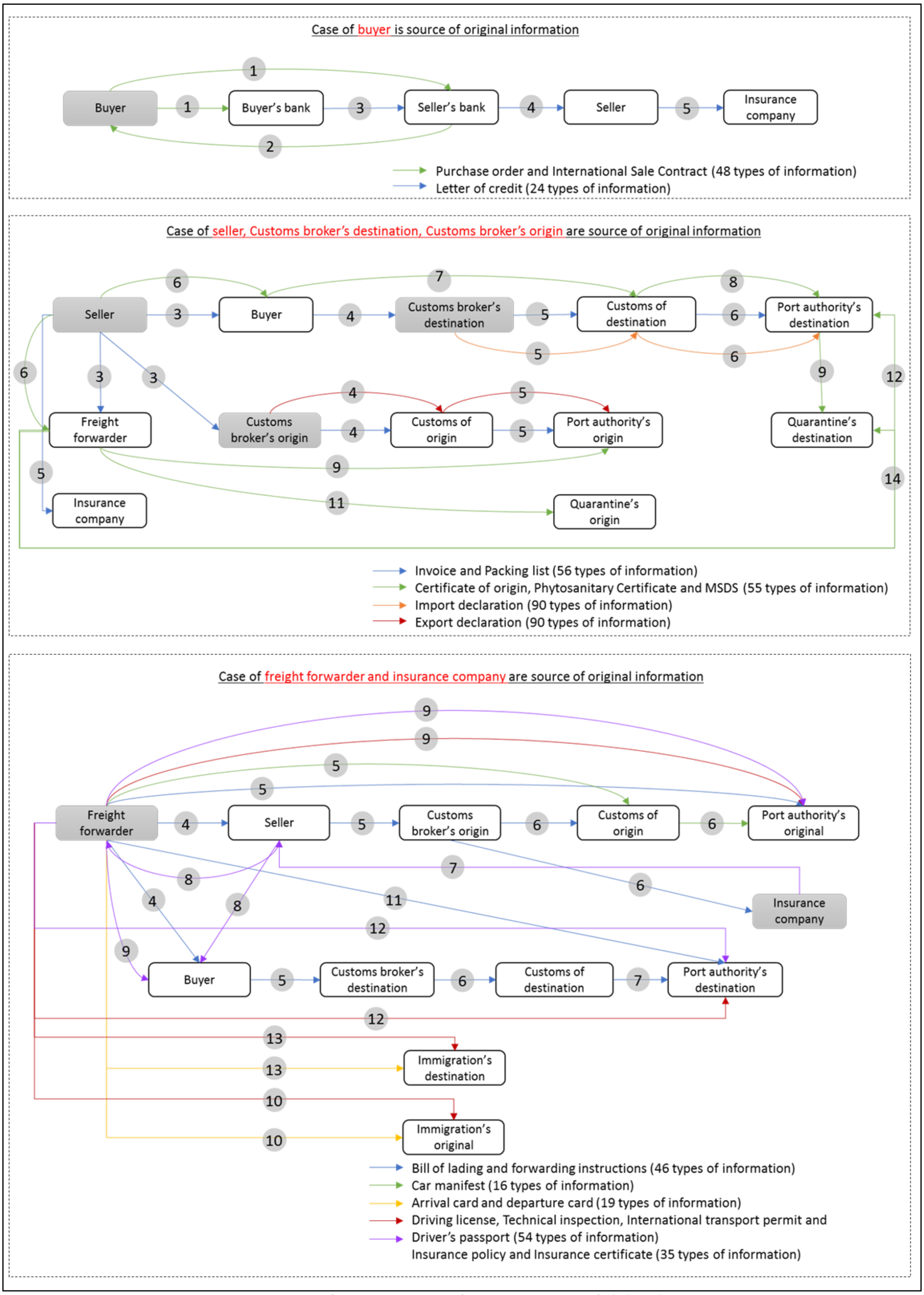


Figure 4-3 Paths of documents flow in case of ASEAN countries

4.2 Outline of supporting system for international trade transaction

Figure 4-4 shows the outline of the supporting system. This system consists of three procedures, (1) Convert (document flows → information flows), (2) Optimize information flows, and (3) Convert (information flows → document flows). The procedures of optimizing document flows are shown below:

1. Current document flows are converted to current information flows.
2. The current information flows are optimized by using the proposed algorithm for optimizing information flows.
3. From the optimized information flows, new document flows are generated.

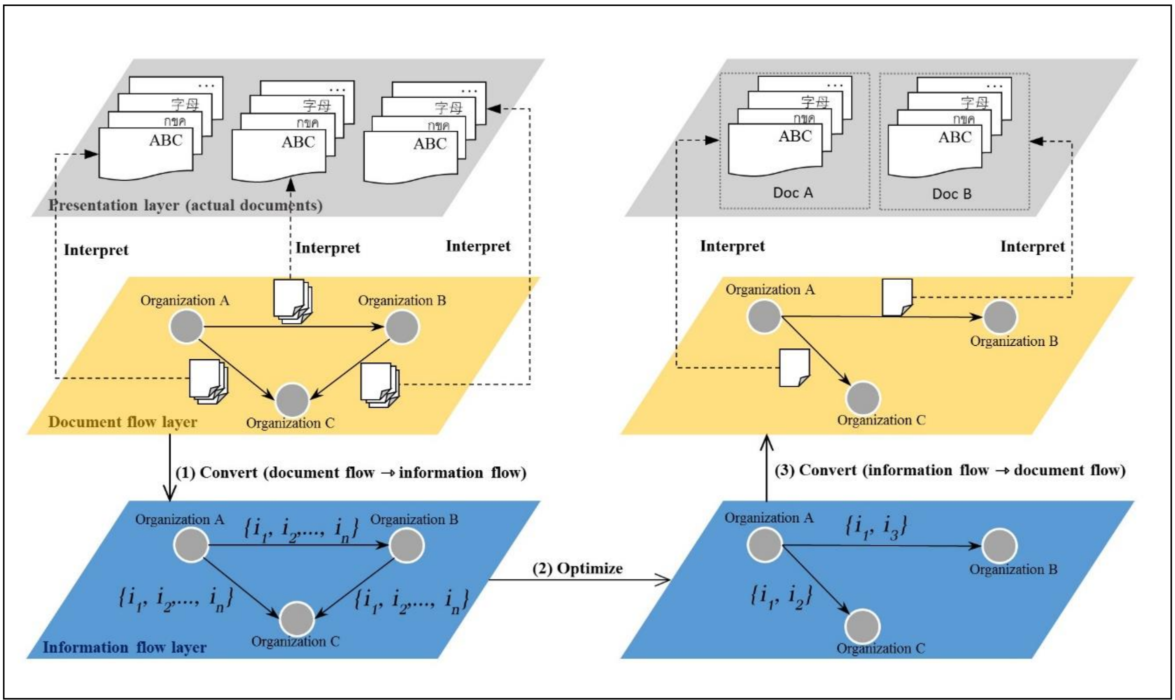


Figure 4-4 Outline of supporting system for international trade transaction

4.3 International logistics ontology

An ontology of international trade transaction domain, which called international logistics ontology, has been developed to represent the proposed model. It has been created in accordance with the results of surveying documents which were used in international trade transaction processes. To design the ontology, two approaches were adopted: top-down and bottom-up [56].

A top-down approach was used to define the most general concepts in common international trade transaction environments. `Organization`, `Item`, `Vehicle`, `Place` and `Price` were defined as sub-concepts of the top concept because they are the essential concepts of the logistics processes. A bottom-up approach was used to define the definition of the most specific classes based on each item on the documents. As a result, classes of `Person_in_Charge`, `Date` and `Reference_Number` have been defined in the ontology.

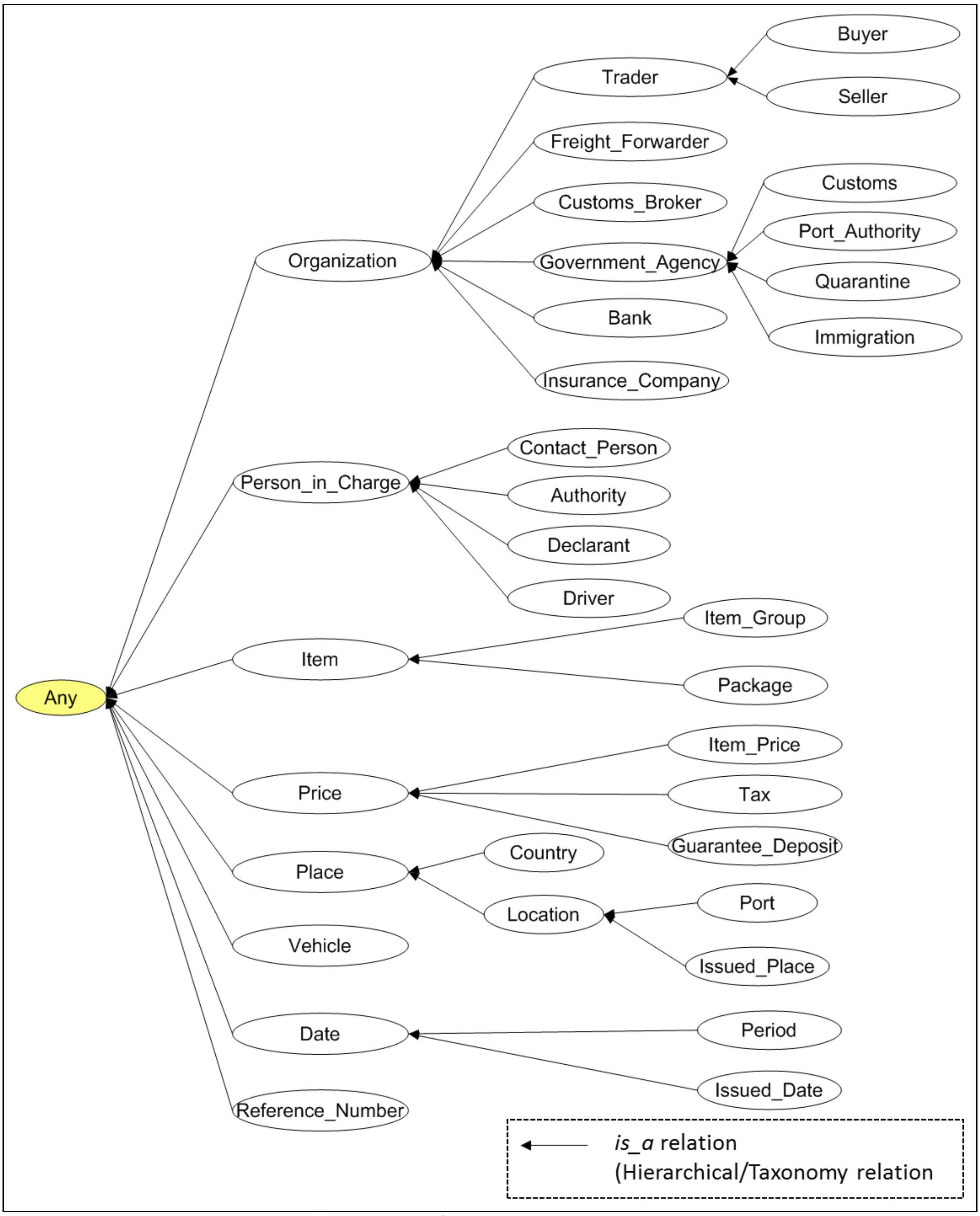


Figure 4-5 Structure of international logistics ontology

Figure 4-5 shows the structure of the ontology. There are eight sub-concepts under the top concept of "any." The details of each sub-concept are shown below:

`Organization`: An instance of the class stands for an actor in the international trade transactions. The class of Organization denotes roles of groups or participants in the processes [57].

`Item`: An instance of the class stands for a product that is transported from an original country to a destination country.

`Vehicle`: An instance of the class stands for a vehicle that is used for carrying products.

`Place`: An instance of the class stands for a location in a country.

`Price`: An instance of the class stands for financial information such as values and currency types.

`Person_in_Charge`: An instance of the class stands for a responsible man. This class is used for determining a person who plays a role in an organization.

`Date`: An instance of the class stands for a date in the documents such as departure date and registration date.

`Reference_Number`: An instance of the class stands for a reference number in the documents, for example, an invoice number, a purchase order number.

From description of the Hozo ontology editor that is mentioned in Chapter 2, Section 2.2, properties of all classes in the international logistics ontology have been identified. Figure 4-8 to 4-15 show detail of each class.

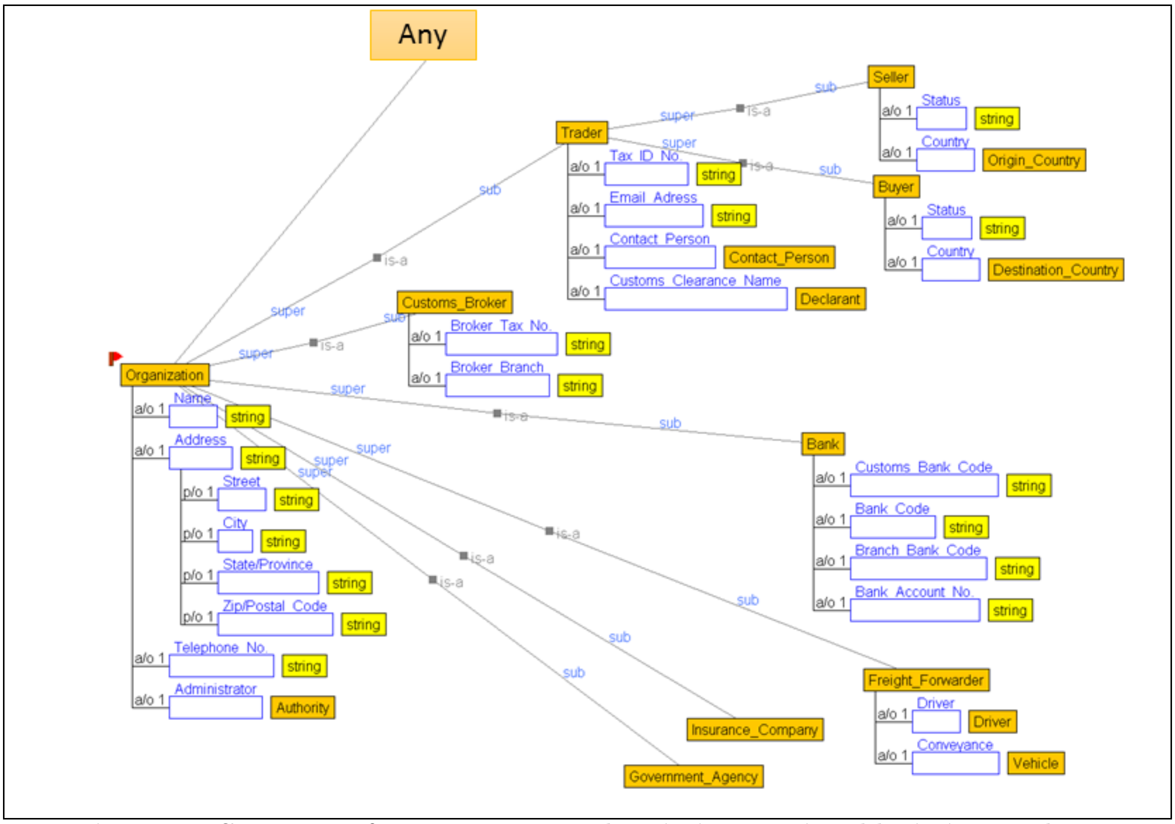


Figure 4-6 Structure of `Organization` class in international logistics ontology

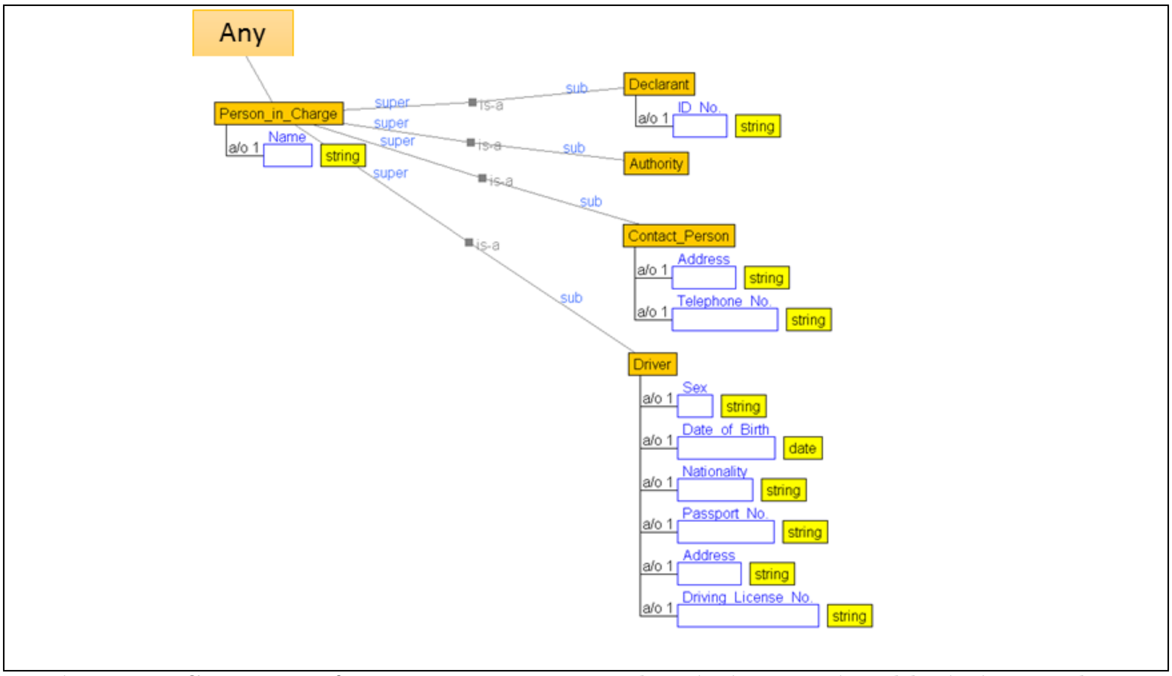


Figure 4-7 Structure of `Person_in_Charge` class in international logistics ontology

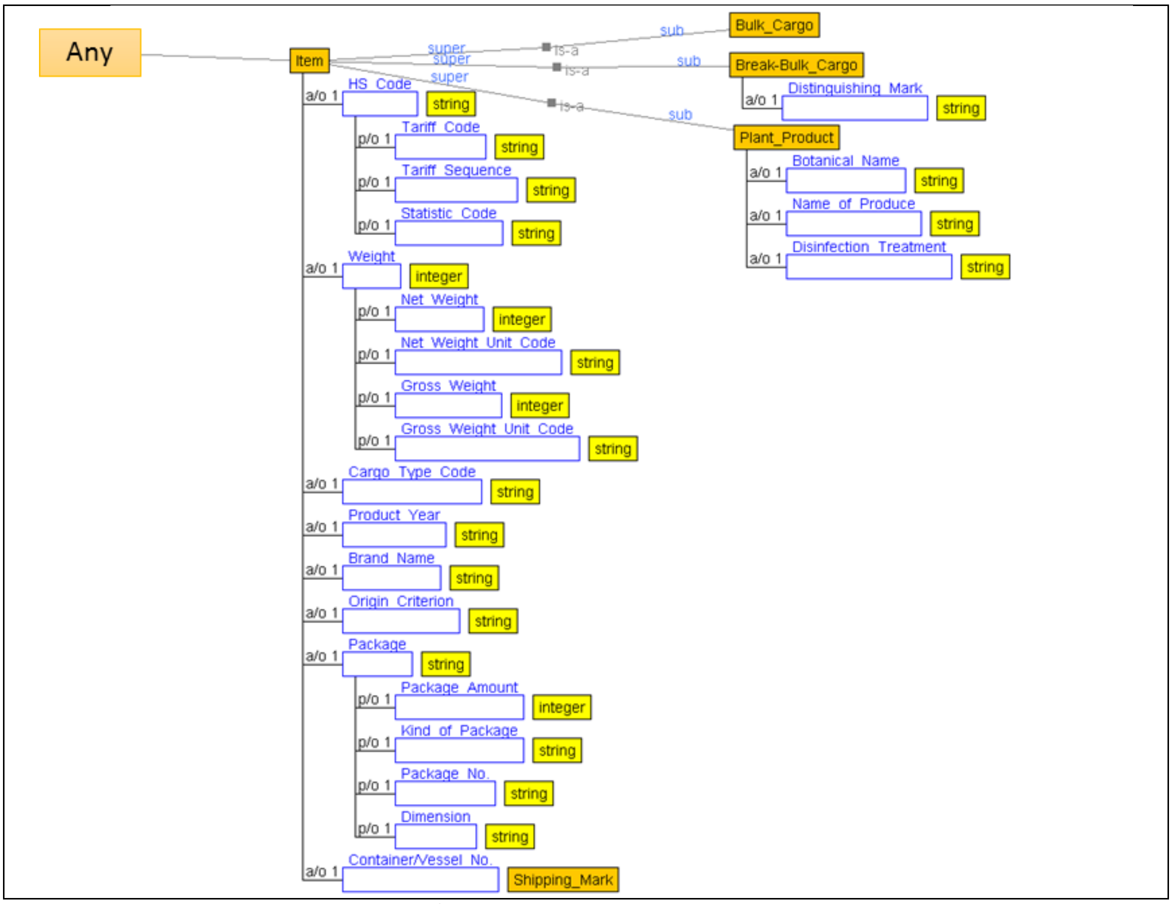


Figure 4-8 Structure of `Item` class in international logistics ontology

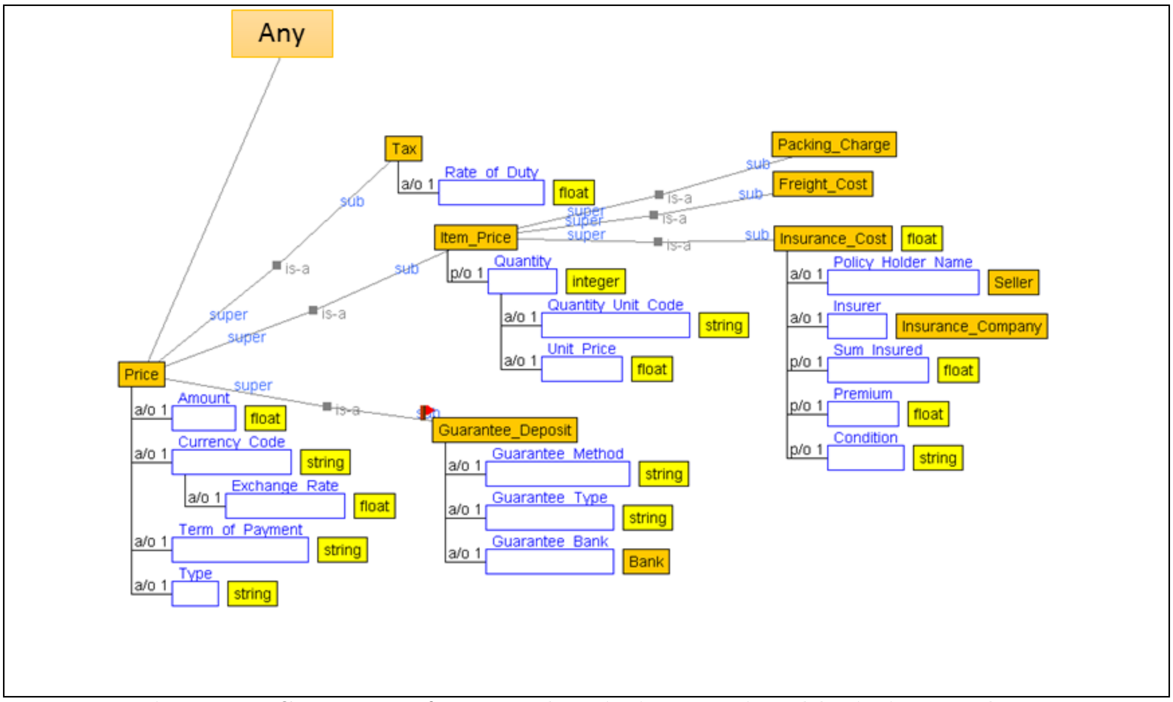


Figure 4-9 Structure of `Price` class in international logistics ontology

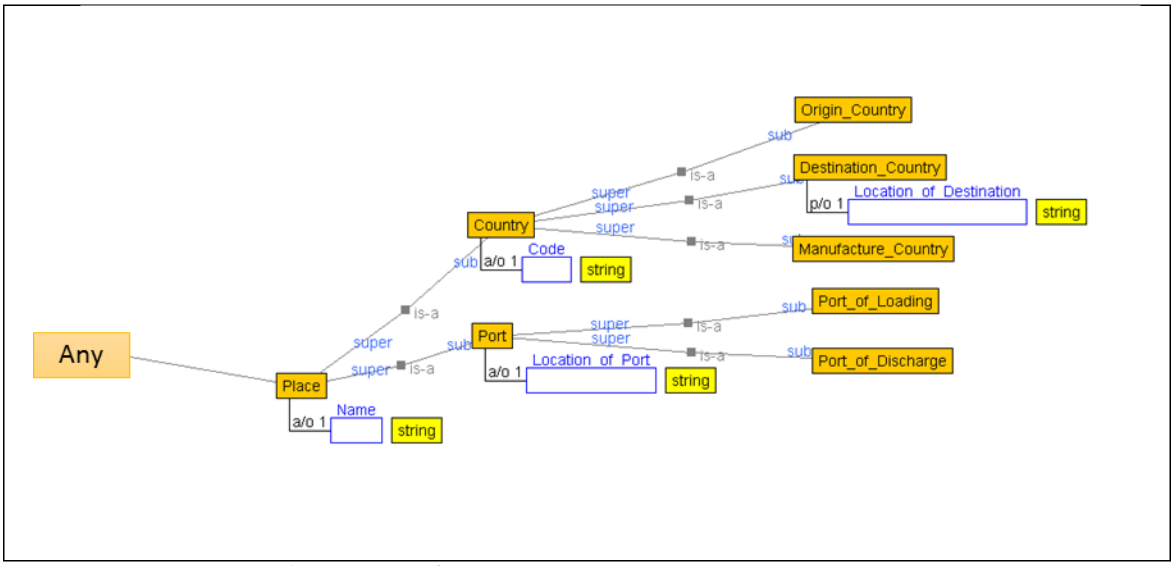


Figure 4-10 Structure of `Place` class in international logistics ontology

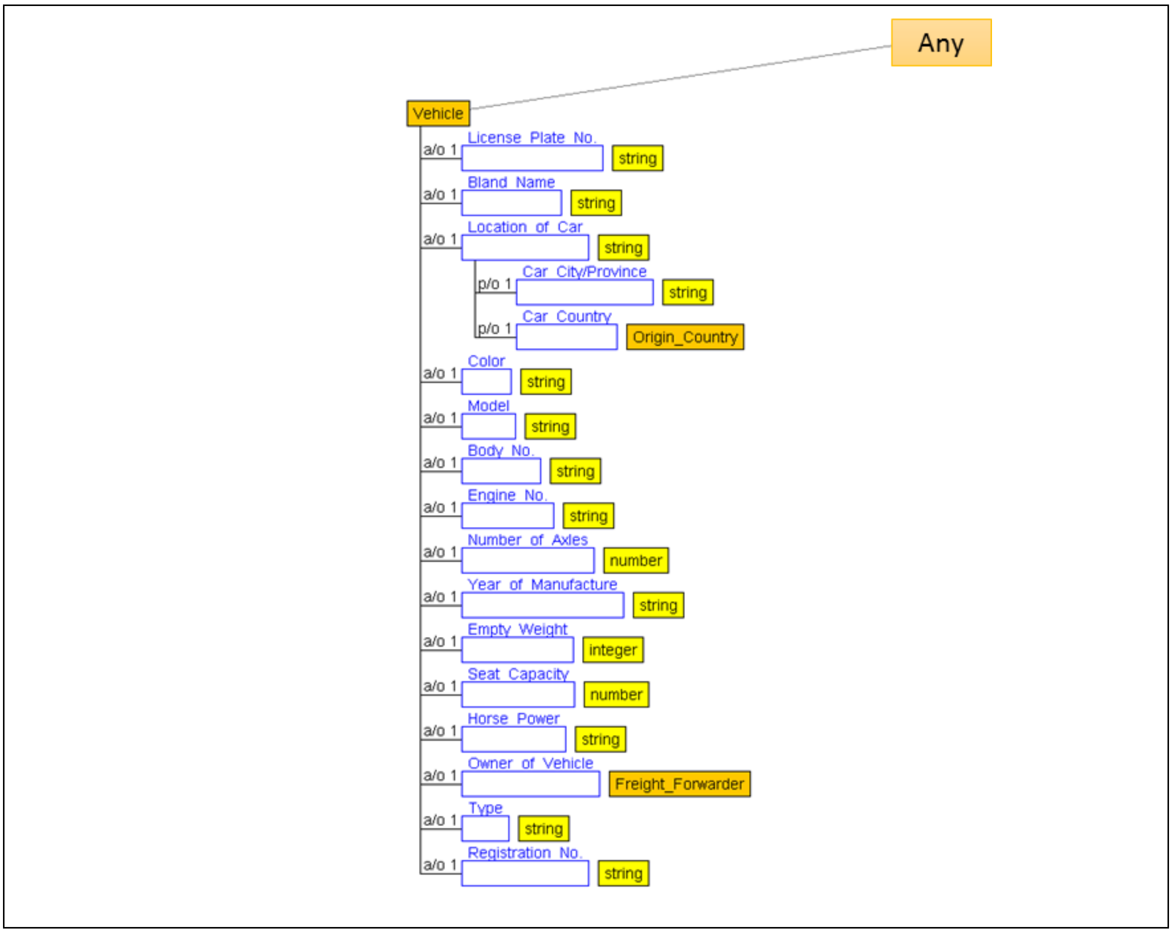


Figure 4-11 Structure of `Vehicle` class in international logistics ontology

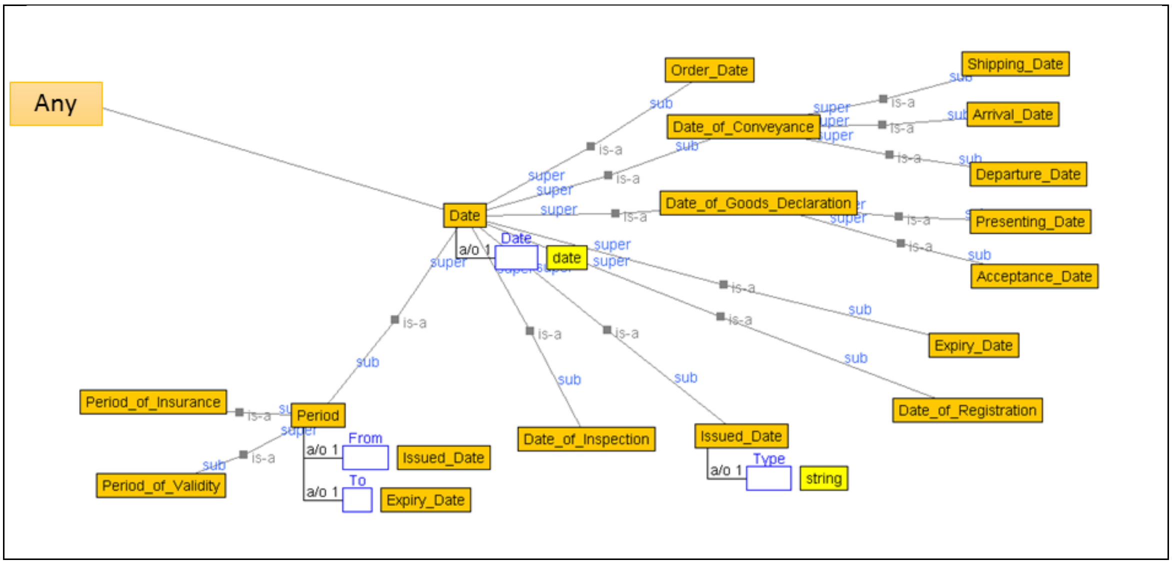


Figure 4-12 Structure of `Date` class in international logistics ontology

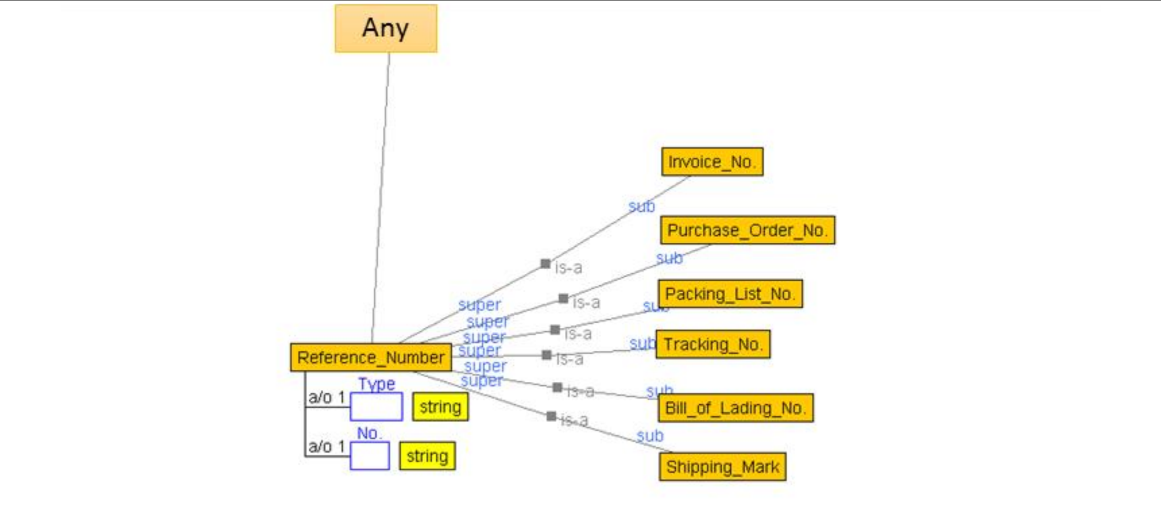


Figure 4-13 Structure of `Referance_Number` class in international logistics ontology

4.4 Algorithm for optimizing information flows

In this section, the proposed algorithm for optimizing information flows is shown. This algorithm is used in the information flow on the information layer that presented in Figure 4-2. The procedures shown in Figure 4-14 represents the proposed algorithm. In this algorithm; $M_{i,j}^{\alpha}$ is a matrix, which stands for flow of information α from source i to destination j, and n stands for number of rows or columns of matrix. Each row of the matrix $M_{i,j}^{\alpha}$ stands for a source node of the information, and each column stands for the destination node of the information. Thus, when an information α is transmitted from source i to destination j, the value of $M_{i,j}^{\alpha}$ is 1, otherwise 0.

Input matrix of information $A = [m^{\alpha}_{i,j}]_{m*n}$, *i*: row, *j*: column

Initial $A' = [m'^{\alpha}_{ij}]_{m*n} \leftarrow \emptyset$

row_max := max $\left(\sum_{i=0}^{n-1} m^{\alpha}_{i,j}\right)$

col_max := max $\left(\sum_{j=0}^{n-1} m^{\alpha}_{i,j}\right)$

do while *col_max*>1

  find *i* where $\sum_{j=0}^{n-1} m^{\alpha}_{i,j} = max$

  find *j* where $\sum_{i=0}^{n-1} m^{\alpha}_{i,j} = max$

  check value of $m'^{\alpha}_{i,j}$ in $A' = [m'^{\alpha}_{ij}]_{m*n}$

    if $m'^{\alpha}_{i,j} = 1$

      find *i* where $\sum_{j=0}^{n-1} m^{\alpha}_{i,j} = second\ value\ of\ max$

      find *j* where $\sum_{i=0}^{n-1} m^{\alpha}_{i,j} = second\ value\ of\ max$

    else

      check disconnection of $m^{\alpha}_{i,j}$

    calculate transitive closure of $A^G = [m^G_{ij}]_{m*n}$

      if $\sum_{i=0}^{n-1} m^G_{i,j} \geq \sum_{i=1}^{n-1} m^{\alpha}_{i,j}$

        $m^{\alpha}_{i,j} = 0$

      else

        put $m'^{\alpha}_{i,j}$=1 in $A' = [m'^{\alpha}_{ij}]_{m*n}$

  row_max := max $\left(\sum_{j=0}^{n-1} m^{\alpha}_{i,j}\right)$

  col_max := max $\left(\sum_{i=0}^{n-1} m^{\alpha}_{i,j}\right)$

end do

Figure 4-14 Procedure of the algorithm for optimizing information flow

Redundancy of information flows among organizations are considered in this algorithm. To reduce the redundancy of information flow, repeated information flows are eliminated. For example, flows of information α shown in Figure 4-15. They can be optimized as shown in Figure 4-16 by using the algorithm.

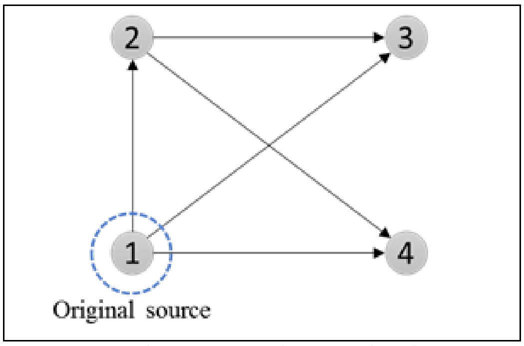


Figure 4-15 Information flows of information α

Table 4-1 A matrix $M_{i,j}^{\alpha}$ which stands for flows of information α

Source	Destination				Sum
	1	2	3	4	
1	X	1	1	1	3
2		X	1	1	2
3			X		0
4				X	0
Sum	0	1	2	2	X

The pseudo-code of the proposed algorithm in Figure 4-14 can be summarized as:

Step 1: Matrix table $A = \left[m_{i,j}^{\alpha}\right]_{m*n}$ is generated from the graph as shown in Table 4-1. In Table 4-1, the last rows and the last columns represent summation of each row and column.
Step 2: Matrix table $A' = \left[m_{i,j}^{\alpha}\right]_{m*n}$ is generated as an empty matrix table for marking visited $m_{i,j}$.
Step 3: Summation of all number in lines is calculated for each row.
Step 4: Summation of all number in rows is calculated for each sum of each column.
Step 5: If for all *col_max* is greater than 1, the following steps are executed. In this case, it is 2 and the following steps are executed.
Step 6: Find a column which has largest number of summation and it is substituted for *i*, i.e. 1 is substituted for *i*.
Step 7: Find a row which has largest number of summation and it is substituted for *j*. In Table 4-1, the largest number is column no. 3 and 4.
Step 8: If numbers of *col_max* are coincided, go to step 9, otherwise select that column for *col_max*.
Step 9: Select a column that has highest index of column number. In this case, column no. 4 is selected for *j*.
Step 10: Value of $m'^{\alpha}_{1,4}$ in $A' = \left[m_{i,j}^{\alpha}\right]_{m*n}$ is checked.
Step 11: If $m'^{\alpha}_{1,4}$=1, go to step 12, otherwise go to step 14.
Step 12: Find a column which has second largest value of summation and it is substituted for *i*.

Step 13: Find a row which has second largest value of summation and it is substituted for j.

Step 14: $m^{\alpha}_{1,4}$ is checked the condition of disconnection by calculating a transitive closure of $A^G = [m^G_{i,j}]_{m*n}$ that is described in Figure 4-17.

Step 15: If summation of all number in columns of $A^G = [m^G_{i,j}]_{m*n}$ is greater than or equal to summation of all number in columns of $A = [m^{\alpha}_{i,j}]_{m*n}$, go to step 16, otherwise go to step 13. In this case $\sum_{i=0}^{n-1} m^G_{i,j}$ greater than $\sum_{i=0}^{n-1} m^{\alpha}_{i,j}$.

Step 16: 0 is substituted for $m^{\alpha}_{1,4}$. Notification of "1" in Table 4-2 stands for the ~~1~~ changed to 0. As the results, the matrix is changed as shown in Table 4-2.

Step 17: $m'^{\alpha}_{i,j} = 1$ is put in $A' = [m'^{\alpha}_{i,j}]_{m*n}$.

Step 18: Summation of all column is calculated again.

Step 19: If for all summation of column is greater than or equal to 1, go to step 4, otherwise stop to find $m^{\alpha}_{i,j}$ to be eliminated.

Table 4-2 Matrix of information flow $m^{\alpha}_{i,j}$ and $m'^{\alpha}_{i,j}$after eliminating edge (1,4) and edge (2,3)

$m^{\alpha}_{i,j}$

Source	Destination 1	2	3	4	Sum
1	X	1	1	~~1~~	2
2		X	~~1~~	1	1
3			X		0
4				X	0
Sum	0	1	1	1	X

$m'^{\alpha}_{i,j}$

Source	Destination 1	2	3	4	Sum
1	X				0
2		X			0
3			X		0
4				X	0
Sum	0	0	0	0	X

Finally, we can get an information flow shown in Figure 4-16 as a graph.

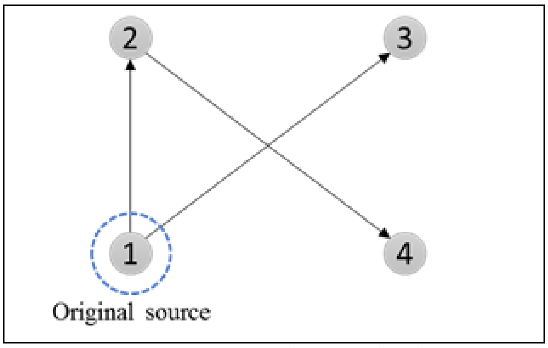


Figure 4-16 Optimized flows of information *a*

Due to a removal of some information flows, reachable information for each node has to confirm. A transitive closure relation is used for investigating reachability of information for each node or disconnection of information flows. The transitive closure can be thought of as establishing a data structure that makes it possible to solve reachability questions (can I get to x from y?) efficiently. After the preprocessing of constructing the transitive closure, all reachability queries can be answered in constant time by simply reporting a matrix entry. Transitive closure is fundamental in propagating the consequences of modified attributes of a graph G [58].

In this thesis, the transitive closure of a directed graph $G= (V, E)$ is a directed graph $G^+ = (V, E^+)$ such that for $\forall < u, v > \in E^+$ if and only if there exists a non-null path from u to v. The *n-step transitive closure* of a directed graph $G = (V, E)$ is a directed graph

$G^n = (V, E^n)$ such that for $\forall < u, v > \in E^n$ if and only if there exists a non-null path from u to v and the length of the path is less than or equals to n. Figure 4-16 shows a graph of optimized flows of information α. A graph of optimized information flow $G = (V, E)$ can be represented by an $m \times n$ adjacency matrix $A = [m_{ij}]_{n\times n}$, where;

$$m_{ij} = \begin{cases} 1, if\ v_i, v_j \in V\ and < v_i, v_j > \in E; \\ 0, \text{otherwise.} \end{cases} \quad (4\text{-}1)$$

The procedures shown below represent the transitive closure:

Transitive closure of $A^G = [m_{i,j}^G]_{m*n}$

1. $n \leftarrow |V[G]|$

   let $A^{(0)} = \left(m_{ij}^{(0)}\right)$ be a new $m \times n$ matrix
2. **for** $i \leftarrow 1$ to n
3.   **do** for $j \leftarrow 1$ to n
4.   **do if** $i = j$ or $(i, j) \in E[G]$
5.   **then** $m_{ij}^{(0)} \leftarrow 1$
6.   **else** $m_{ij}^{0} \leftarrow 0$
7. **for** $k \leftarrow 1$ to n
8.   **for** $i \leftarrow 1$ to n

           for $j \leftarrow 1$ to n

               $m = m_{ij}^{(k-1)} \vee \left(m_{ik}^{(k-1)} \wedge m_{kj}^{(k-1)}\right)$
9. Return A^n

Figure 4-17 Procedure of the transitive closure

The graph of optimized information flow, its adjacency matrix is shown in Figure 4-18. The adjacent matrix representations for its transitive closure and its transitive closure are displayed in Figure 4-19.

$$A = \begin{pmatrix} 0 & 1 & 1 & 0 \\ 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \end{pmatrix}$$

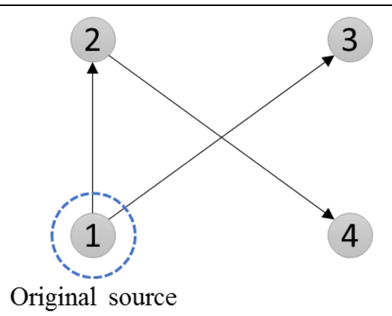


Figure 4-18 Adjacency matrix of optimized information flow

$$A = \begin{pmatrix} 0 & 1 & 1 & 1 \\ 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \end{pmatrix}$$

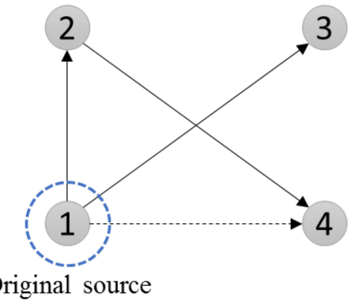


Figure 4-19 Transitive closure of optimized information flow

From the results of transitive closure, information *a* can be reached from original source to all of nodes.

Chapter 5
EXPERIMENTS

5.1 Case study for optimizing information flow

In this section, a case study is shown in order to explain the details of the proposed framework. Examples of document flows, in which four types of documents are transmitted among seven organizations are used. The organizations consist of (1) a seller, (2) a customs broker of origin, (3) a customs of origin, (4) a freight forwarder, (5) a customs of destination, (6) a customs broker of destination and (7) a buyer. They are described by using the `Organization` class shown in section 4.2. Four types of documents: (1) commercial invoice, (2) packing list, (3) bill of lading and (4) Forwarding instructions are used in the case study. The details of the documents are explained below:

Commercial invoice: Commercial invoices are used by customs to calculate taxes. They are also used in billing processes to request payment for products and services. Commercial invoices are issued by sellers and suppliers. Usually, these documents include information of an import company and ID numbers of transported items. Figure 5-1 shows a format of commercial invoices and information included in it. The left side of the figure shows the format and the right side of the figure shows the information by using the international logistics ontology shown in section 4.2. In this section, each class is described by using a two-line table: The first line stands for "instance name: class name" and the second line stands for properties. For example, in the upper box of right side in Figure 5-1 means that `import_company` is an instance of Trader class, and it has properties of `Name` and `Address`.

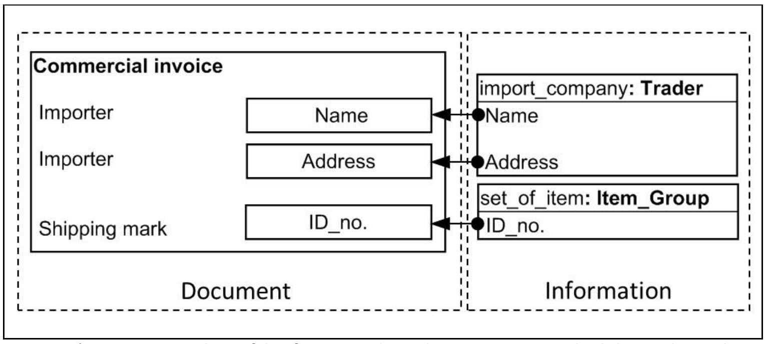


Figure 5-1 An example of information in commercial invoice document

Packing List: A packing list is issued by sellers and exporters. The purpose of this type of documents is to provide information of items for transport agencies, government authorities, and customers. In a packing list, details of package are described along with number of packages, and details of import company, i.e. name and address. Figure 5-2 shows a format of packing lists and information included in it.

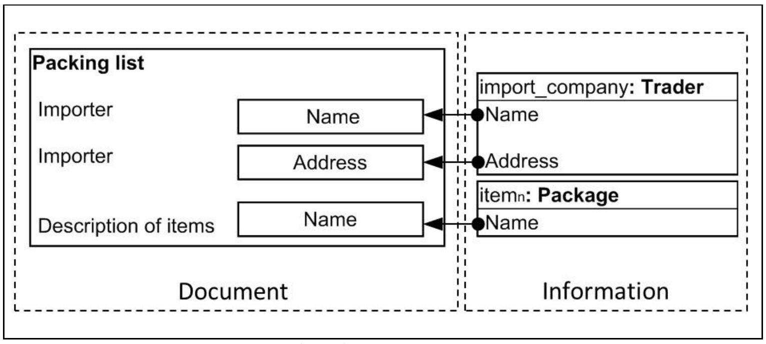


Figure 5-2 An example of information in packing list document

Bill of Lading: A bill of lading is issued by a party who provides the physical transportation services, i.e. freight forwarders. Usually, this type of documents is sent to sellers, exporters, shippers, and consignor. Bill of lading is used as a receipt for cargoes. This document also contains the details of vehicle such as license plate number of a vehicle. Figure 5-3 shows a format of bill of ladings and information included in it.

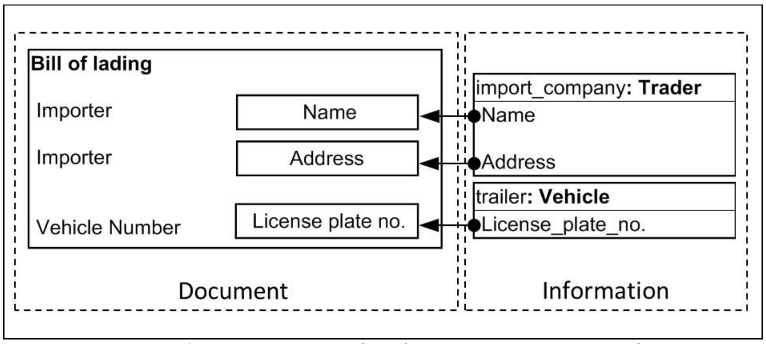


Figure 5-3 An example of information in bill of lading

Forwarding Instructions: In this document, conditions of shipment and details of packages are described such as size of each package. A forwarding instruction is prepared by a freight forwarder. Figure 5-4 shows a format of forwarding instructions and information included in it.

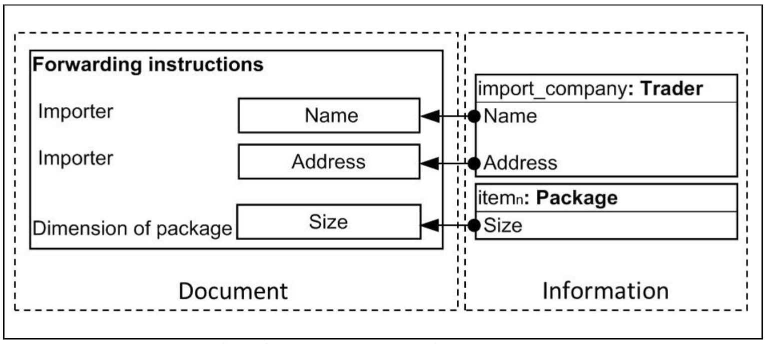


Figure 5-4 An example of information in forwarding instructions document

Figure 5-5 shows the flows of documents which shown above. In these flows, six types of information are exchanged among seven nodes.

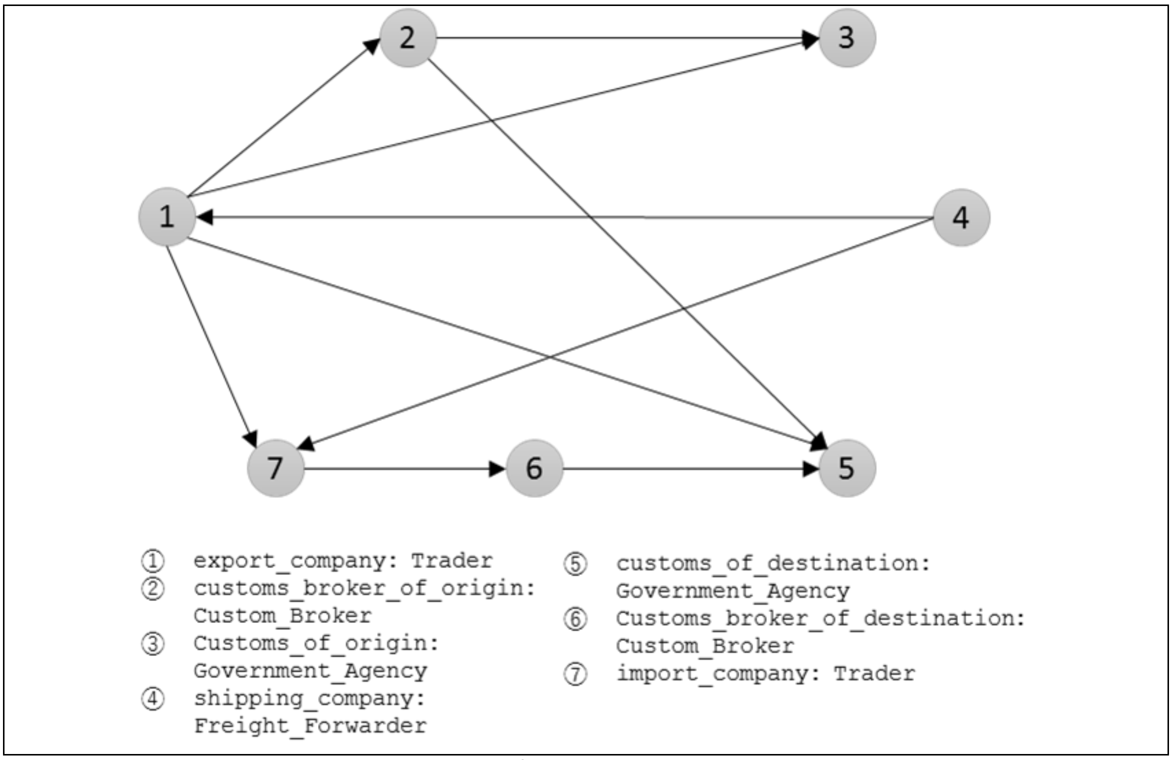


Figure 5-5 Flows of documents in the case study

5.1.1 Example of optimizing document flow

In order to evaluate effectiveness of the proposed system that was described in section 4.2 outline of the supporting system., this case study is employed for representation the whole processes of optimizing document flows as shown below:

Step (1) Create current information flows matrix

A matrix which represents the document flows is generated. Table 5-1 shows the generated matrix. In this step, the matrix of current document flows is converted to matrices of information flows $(M_{i,j}^{\alpha})$, where α stands for an index of information included in the documents, i stands for the source of information, and j stands for the destination of the information respectively.

Table 5-1 A matrix which represents the current documents flows

Source \ Destination	Seller	Customs Broker of Origin	Customs of Origin	Freight Forwarder	Customs of Destination	Customs Broker of Destination	Buyer
Seller	X	• Commercial Invoice • Packing List	• Commercial Invoice • Packing List		• Commercial Invoice • Packing List		• Commercial Invoice • Packing List
Customs Broker of Origin		X	• Commercial Invoice • Packing List		• Commercial Invoice • Packing List		
Customs of Origin			X				
Freight Forwarder	• Bill of Lading • Forwarding Instructions			X			• Bill of Lading • Forwarding Instructions
Customs of Destination					X		
Customs Broker of Destination					• Commercial Invoice • Packing List	X	
Buyer						• Commercial Invoice • Packing List	X

Step (2) Optimize information flows

The information flows are optimized by using the algorithm described in the Section 4.4. Six informations are used in the case study. Here, an information of `Organization. Trader. [import_company. Name]` is focused on for explanations. It is contained in all of 4 documents that are described above. The flows of this information are described as the matrix $M_{i,j}^{import\_company}$ shown in Table 5-2. There are 10 edges in the matrix. $m_{1,5}^{import\_company}$, $m_{1,3}^{import\_company}$, $m_{2,5}^{import\_company}$ and $m_{4,1}^{import\_company}$ are eliminated with the algorithm. The optimized information flow $(M'_{i,j}{}^{import\_company})$ is shown on the right side in Table 5-2. As same ways, all information flows are optimized as shown in Table 5-3 to 5-7. The results are shown in Table 5-8 as a matrix $M'_{i,j}{}^{\alpha}$.

Table 5-2 Current information matrix ($M_{i,j}^{import\_company}$) and optimized information matrix ($M'^{import\_company}_{i,j}$)

Current information flow ($M_{i,j}^{import\_company}$)

Source \ Destination	Seller	Customs Broker of Origin	Customs of Origin	Freight Forwarder	Customs of Destination	Customs Broker of Destination	Buyer	Sum
Seller	X	1	1		1		1	4
Customs Broker of Origin		X	1		1			2
Customs of Origin			X					0
Freight Forwarder	1			X			1	2
Customs of Destination					X			0
Customs Broker of Destination					1	X		1
Buyer						1	X	1
Sum	1	1	2	0	3	1	2	X

Optimized information flow ($M'^{import\_company}_{i,j}$)

Source \ Destination	Seller	Customs Broker of Origin	Customs of Origin	Freight Forwarder	Customs of Destination	Customs Broker of Destination	Buyer	Sum
Seller	X	1	~~1~~		~~1~~		1	2
Customs Broker of Origin		X	1		~~1~~			1
Customs of Origin			X					0
Freight Forwarder	1			X			~~1~~	1
Customs of Destination					X			0
Customs Broker of Destination					1	X		1
Buyer						1	X	1
Sum	1	1	1	0	1	1	1	X

Table 5-3 Current information matrix ($M_{i,j}^{import\_address}$) and optimized information matrix ($M'^{import\_address}_{i,j}$)

Current information flow ($M_{i,j}^{import\_address}$)

Source \ Destination	Seller	Customs Broker of Origin	Customs of Origin	Freight Forwarder	Customs of Destination	Customs Broker of Destination	Buyer	Sum
Seller	X	1	1		1		1	4
Customs Broker of Origin		X	1		1			2
Customs of Origin			X					0
Freight Forwarder	1			X			1	2
Customs of Destination					X			0
Customs Broker of Destination					1	X		1
Buyer						1	X	1
Sum	1	1	2	0	3	1	2	X

Optimized information flow ($M'^{import\_address}_{i,j}$)

Source \ Destination	Seller	Customs Broker of Origin	Customs of Origin	Freight Forwarder	Customs of Destination	Customs Broker of Destination	Buyer	Sum
Seller	X	1	~~1~~		~~1~~		1	2
Customs Broker of Origin		X	1		~~1~~			1
Customs of Origin			X					0
Freight Forwarder	1			X			~~1~~	1
Customs of Destination					X			0
Customs Broker of Destination					1	X		1
Buyer						1	X	1
Sum	1	1	1	0	1	1	1	X

Table 5-4 Current information matrix ($M_{i,j}^{item\_amount}$) and optimized information matrix ($M'^{item\_amount}_{i,j}$)

Current information flow ($M_{i,j}^{item\_amount}$)

Source \ Destination	Seller	Customs Broker of Origin	Customs of Origin	Freight Forwarder	Customs of Destination	Customs Broker of Destination	Buyer	Sum
Seller	X	1	1		1		1	4
Customs Broker of Origin		X	1		1			2
Customs of Origin			X					0
Freight Forwarder	1			X			1	2
Customs of Destination					X			0
Customs Broker of Destination					1	X		1
Buyer						1	X	1
Sum	1	1	2	0	3	1	2	X

Optimized information flow ($M'^{item\_amount}_{i,j}$)

Source \ Destination	Seller	Customs Broker of Origin	Customs of Origin	Freight Forwarder	Customs of Destination	Customs Broker of Destination	Buyer	Sum
Seller	X	1	~~1~~		~~1~~		1	2
Customs Broker of Origin		X	1		~~1~~			1
Customs of Origin			X					0
Freight Forwarder	1			X			~~1~~	1
Customs of Destination					X			0
Customs Broker of Destination					1	X		1
Buyer						1	X	1
Sum	1	1	1	0	1	1	1	X

Table 5-5 Current information matrix ($M_{i,j}^{item\_ID\ no.}$) and optimized information matrix ($M'^{item\_ID\ no.}_{i,j}$)

Current information flow ($M_{i,j}^{item\_ID\ no.}$)

Source \ Destination	Seller	Customs Broker of Origin	Customs of Origin	Freight Forwarder	Customs of Destination	Customs Broker of Destination	Buyer	Sum
Seller	X	1	1		1		1	4
Customs Broker of Origin		X	1		1			2
Customs of Origin			X					0
Freight Forwarder	1			X			1	2
Customs of Destination					X			0
Customs Broker of Destination					1	X		1
Buyer						1	X	1
Sum	1	1	2	0	3	1	2	X

Optimized information flow ($M'^{item\_ID\ no.}_{i,j}$)

Source \ Destination	Seller	Customs Broker of Origin	Customs of Origin	Freight Forwarder	Customs of Destination	Customs Broker of Destination	Buyer	Sum
Seller	X	1	~~1~~		~~1~~		1	2
Customs Broker of Origin		X	1		~~1~~			1
Customs of Origin			X					0
Freight Forwarder	1			X			~~1~~	1
Customs of Destination					X			0
Customs Broker of Destination					1	X		1
Buyer						1	X	1
Sum	1	1	1	0	1	1	1	X

Table 5-6 Current information matrix ($M_{i,j}^{item\_size}$) and optimized information matrix ($M'^{\,item\_size}_{i,j}$)

Current information flow ($M_{i,j}^{item\_size}$)

Source \ Destination	Seller	Customs Broker of Origin	Customs of Origin	Freight Forwarder	Customs of Destination	Customs Broker of Destination	Buyer	Sum
Seller	X	1	1		1		1	4
Customs Broker of Origin		X	1		1			2
Customs of Origin			X					0
Freight Forwarder				X				0
Customs of Destination					X			0
Customs Broker of Destination					1	X		1
Buyer						1	X	1
Sum	0	1	2	0	3	1	1	X

Optimized information flow ($M'^{\,item\_size}_{i,j}$)

Source \ Destination	Seller	Customs Broker of Origin	Customs of Origin	Freight Forwarder	Customs of Destination	Customs Broker of Destination	Buyer	Sum
Seller	X	1	~~1~~		~~1~~		1	2
Customs Broker of Origin		X	1		~~1~~			1
Customs of Origin			X					0
Freight Forwarder				X				0
Customs of Destination					X			0
Customs Broker of Destination					1	X		1
Buyer						1	X	1
Sum	0	1	1	0	1	1	1	X

Table 5-7 Current information matrix ($M_{i,j}^{trailer\_license\ plate\ no.}$) and optimized information matrix ($M'^{\,trailer\_license\ plate\ no.}_{i,j}$)

Current information flow ($M_{i,j}^{trailer\_license\ plate\ no.}$)

Source \ Destination	Seller	Customs Broker of Origin	Customs of Origin	Freight Forwarder	Customs of Destination	Customs Broker of Destination	Buyer	Sum
Seller	X							0
Customs Broker of Origin		X						0
Customs of Origin			X					0
Freight Forwarder	1			X			1	2
Customs of Destination					X			0
Customs Broker of Destination						X		0
Buyer							X	0
Sum	1	0	0	0	0	0	1	X

Optimized information flow ($M'^{\,trailer\_license\ plate\ no.}_{i,j}$)

Source \ Destination	Seller	Customs Broker of Origin	Customs of Origin	Freight Forwarder	Customs of Destination	Customs Broker of Destination	Buyer	Sum
Seller	X							0
Customs Broker of Origin		X						0
Customs of Origin			X					0
Freight Forwarder	1			X			1	2
Customs of Destination					X			0
Customs Broker of Destination						X		0
Buyer							X	0
Sum	1	0	0	0	0	0	1	X

Table 5-8 A matrix which represents the optimized information flows ($M'^{\alpha}_{i,j}$)

Destination / Source	(1) Seller	(2) Customs Broker of Origin	(3) Customs of Origin	(4) Freight Forwarder	(5) Customs of Destination	(6) Customs Broker of Destination	(7) Buyer
(1) Seller	X	• *import_company*: **Trader** [Name] • *import_company*: **Trader** [Address] • *item*$_n$: **Package** [Amount] • *set_of_item*: **Item_Group** [ID_no.]					• *import_company*: **Trader** [Name] • *import_company*: **Trader** [Address] • *item*$_n$: **Package** [Amount] • *set_of_item*: **Item_Group** [ID_no.]
(2) Customs Broker of Origin		X	• *import_company*: **Trader** [Name] • *import_company*: **Trader** [Address] • *item*$_n$: **Package** [Amount] • *set_of_item*: **Item_Group** [ID_no.]				
(3) Customs of Origin			X				
(4) Freight Forwarder	• *item*$_n$: **Package** [Size] • *trailer*: **Vehicle** [License_plate_no.]			X			• *item*$_n$: **Package** [Size] • *trailer*: **Vehicle** [License_plate_no.]
(5) Customs of Destination					X		
(6) Customs Broker of Destination					• *import_company*: **Trader** [Name] • *import_company*: **Trader** [Address] • *item*$_n$: **Package** [Amount] • *set_of_item*: **Item_Group** [ID_no.]	X	
(7) Buyer						• *import_company*: **Trader** [Name] • *import_company*: **Trader** [Address] • *item*$_n$: **Package** [Amount] • *set_of_item*: **Item_Group** [ID_no.]	X

Table 5-9 A matrix which represents the optimized document flows

Source \ Destination	(1) Seller	(2) Customs Broker of Origin	(3) Customs of Origin	(4) Freight Forwarder	(5) Customs of Destination	(6) Customs Broker of Destination	(7) Buyer
(1) Seller	X	Document A					Document A
(2) Customs Broker of Origin		X	Document A				
(3) Customs of Origin			X				
(4) Freight Forwarder	Document B			X			Document B
(5) Customs of Destination					X		
(6) Customs Broker of Destination					Document A	X	
(7) Buyer						Document A	X

Step (3) Convert information flows to document flows

Then, the information flows are converted to document flows. First, group of cells which has same information is found in Table 5-8. We can find that $m_{1,2}^{Import\_company}$, $m_{1,7}^{Import\_company}$, $m_{2,3}^{Import\_company}$, $m_{6,5}^{Import\_company}$, and $m_{7,6}^{Import\_company}$ have the same information. Thus, they are made as a group. In this way, two groups of information are made:

Group A; `import_company:` **`Trader`** `[Name], import_company:` **`Trader`** `[Address], item`$_n$`:` **`Package`** `[Amount] and set_of_item:` **`Item_Group`** `[ID_no.]`

Group B; `item`$_n$`:` **`Package`** `[Size] and trailer:` **`Vehicle`** `[License_plate_no.]`

Information included in a group are arranged into a document. In this case, informations in Group A are put into **Document A**, and information in Group B are put into **Document B** respectively as shown in Table 5-9. The flow of **Document A** has five edges i.e. (1) → (2), (2) → (3), (1) → (7), (6) → (5), and (7) → (6). The flow of **Document B** has two edges which are (4) → (1) and (4) → (7). Finally, the optimized document flow is obtained as shown in Figure 5-6.

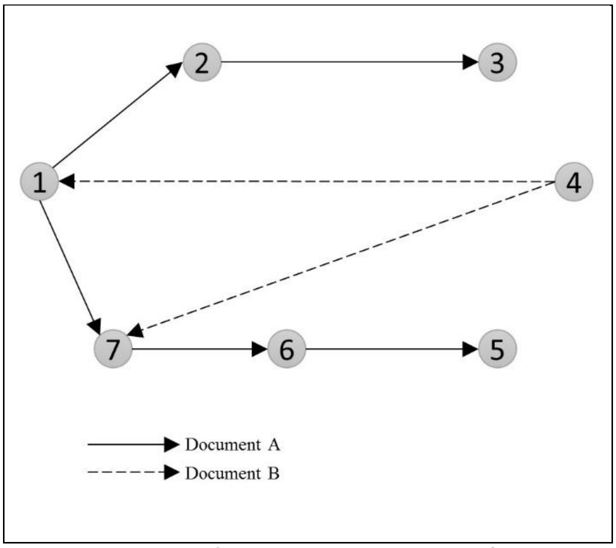


Figure 5-6 Optimized document flows

5.1.2 Discussion

After optimizing information flows, the number of information transmissions is decreased. Some distance between original node and destination node is increased. To discuss the distance between original node and destination node, an example is shown. Figure 5-6 shows information flows of the example. In this figure, **Graph A** represents an original information flows and **Graph B** represents the optimized information flows.

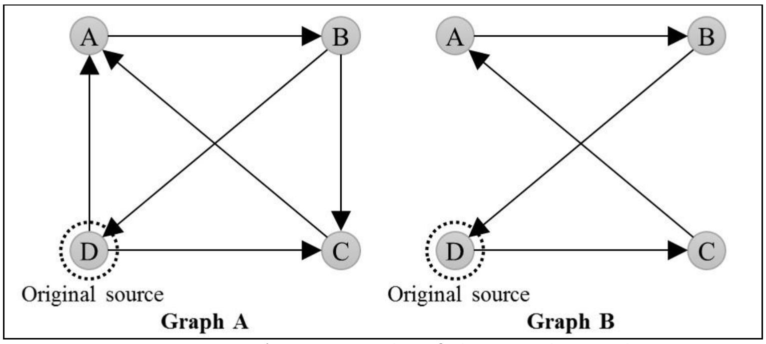


Figure 5-7 An example of directed graphs

The **Graph A** consists of six edges and four nodes. For each node, some indegree edges are eliminated until the number of indegrees become one. In this case, edges of DA and BC are eliminated as represented by **Graph B** in Figure 5-6. Although these edges are eliminated, all of the nodes can receive the information. However, the distance between node D and A increased from 1 ($D \rightarrow A$) to 2 ($D \rightarrow C \rightarrow A$) because the edge BC is eliminated.
In some cases, the distance may induce additional financial and time costs of transmissions.

Timings of retrieving information also have to be considered. Some information must be synchronized together but the algorithm does not consider the situations. Tackling these three problems is the direction of the future works.

5.2 Simulation models

5.2.1 Experimental design

In the processes of exporting some product from Thailand to another ASEAN countries, twenty-two types of documents are used in 16 organizations. In these types of documents 555 types of information are included. To make simple state of simulations, 12 types of documents with 4 types of information and 14 organizations are used in this experiment. The graph in Figure 5-8 shows average number of packages that will be transported by a logistics service provider. The number of packages were calculated by using the data collection of the ABC co., Ltd [3]. These sets of data were collected for twenty days (weekday) in November 2014. In the simulation, the frequency of appearing packages are determined in accordance with the graph. When a package appeared, a document is sent from a seller (`export_company`) to a logistics service provider (`freight_forwarder`).

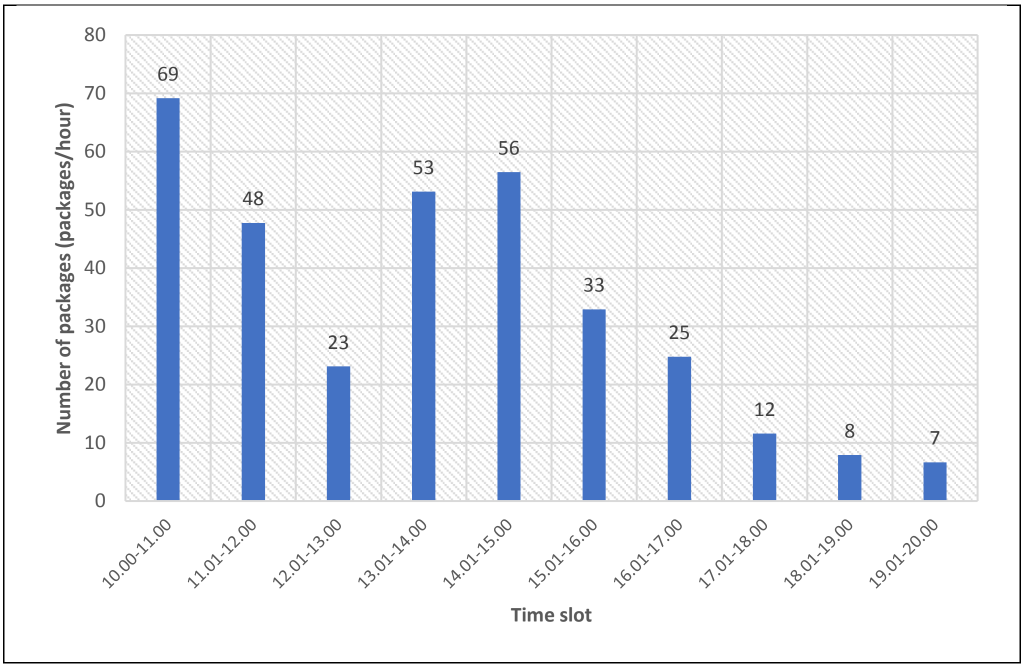


Figure 5-8 Average number of packages a day

Each organization in the transaction process conducts a task for each document. The task consists of "writing" and "recording." The required time for each task was calculated by using data collection from ABC co., Ltd. As shown in Appendix C. The required time for the task depends on the document. Thus, the time are determined as following:

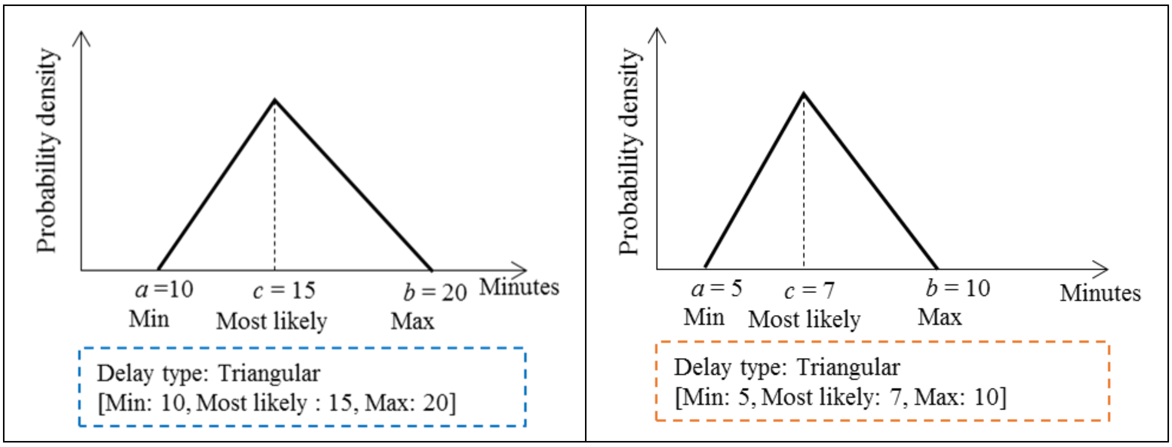
Writing: a minimum time is 10 minutes, a maximum time is 20 minutes, and a most likely time is 15 minutes.

Recording: a minimum time is 5 minutes, a maximum time is 10 minutes, and a most likely time is 7 minutes.

In each task, staffs are needed: 3 staffs for writing and 1 staff for recording. These staffs are used for treating the documents.

[3] ABC co., Ltd., Annual Report, 2014

In this experiment, the required times are defined by using a probability density function of a triangular distribution which depend on the case of documents. The required time of writing task is assumed as a function which shown as graph in Figure 5-9 (a). The service time of recording process is assumed as a function which shown as graph in Figure 5-9 (b).



(a) Writing task (b) Recording task

Figure 5-9 Triangle distribution function of writing and recording task

A triangular distribution is a continuous probability distribution with a probability density function shaped like a triangle. It is defined by three values: the minimum value (*Min*), the maximum value (*Max*), and the peak value (*Most likely*). The probability density function of a triangular distribution

The formula for the probability density function is:

$$f(x) = \begin{cases} 0, & x < a \\ \frac{2(x-a)}{(b-a)(c-a)}, & a \le x \le c \\ \frac{2(b-x)}{(b-a)(c-a)}, & c \le x \le b \\ 0, & x > b \end{cases} \quad (5\text{-}1)$$

The aim of this experiment is to investigate the effect of the algorithm shown in Chapter 4, Section 4.4. In this experiment, information flow simulations are con generated. Figure 5-10 shows a conceptual of information flow simulation.

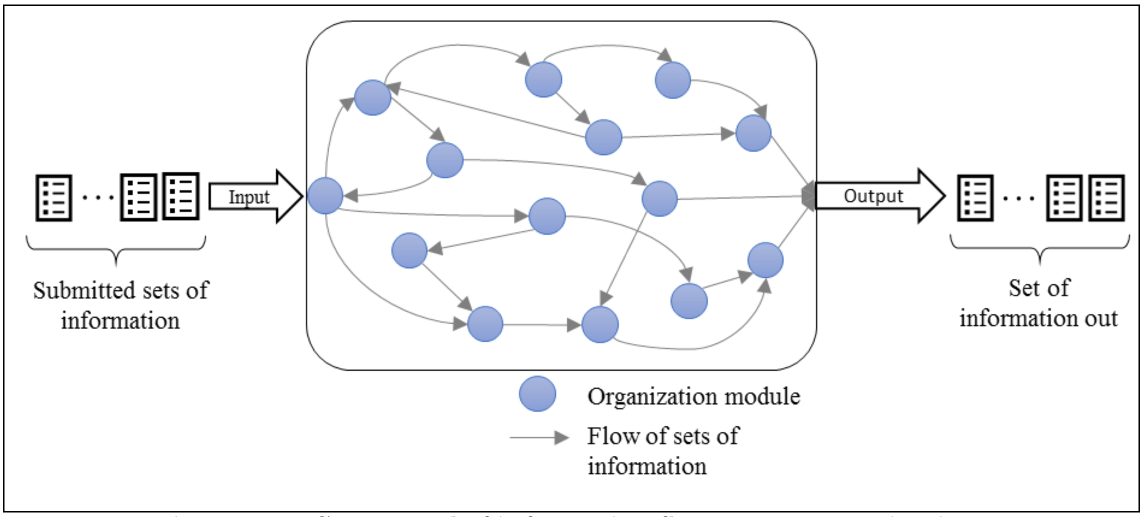


Figure 5-10 Conceptual of information flow among organizations

Number of submitted documents are defined as the type of schedule which are submitted at first organization in the ASEAN transaction process during a day. The submitted rates of documents can be assumed by using the number of transported packages as shown in Figure 5-8. In this simulation, initial number of iterations is 10 trials at 95% confidence interval. In order to reduce error value (half-width) from the simulation, number of iterations should be increased. The number of iterations is determined as equation (5-2) or (5-3).

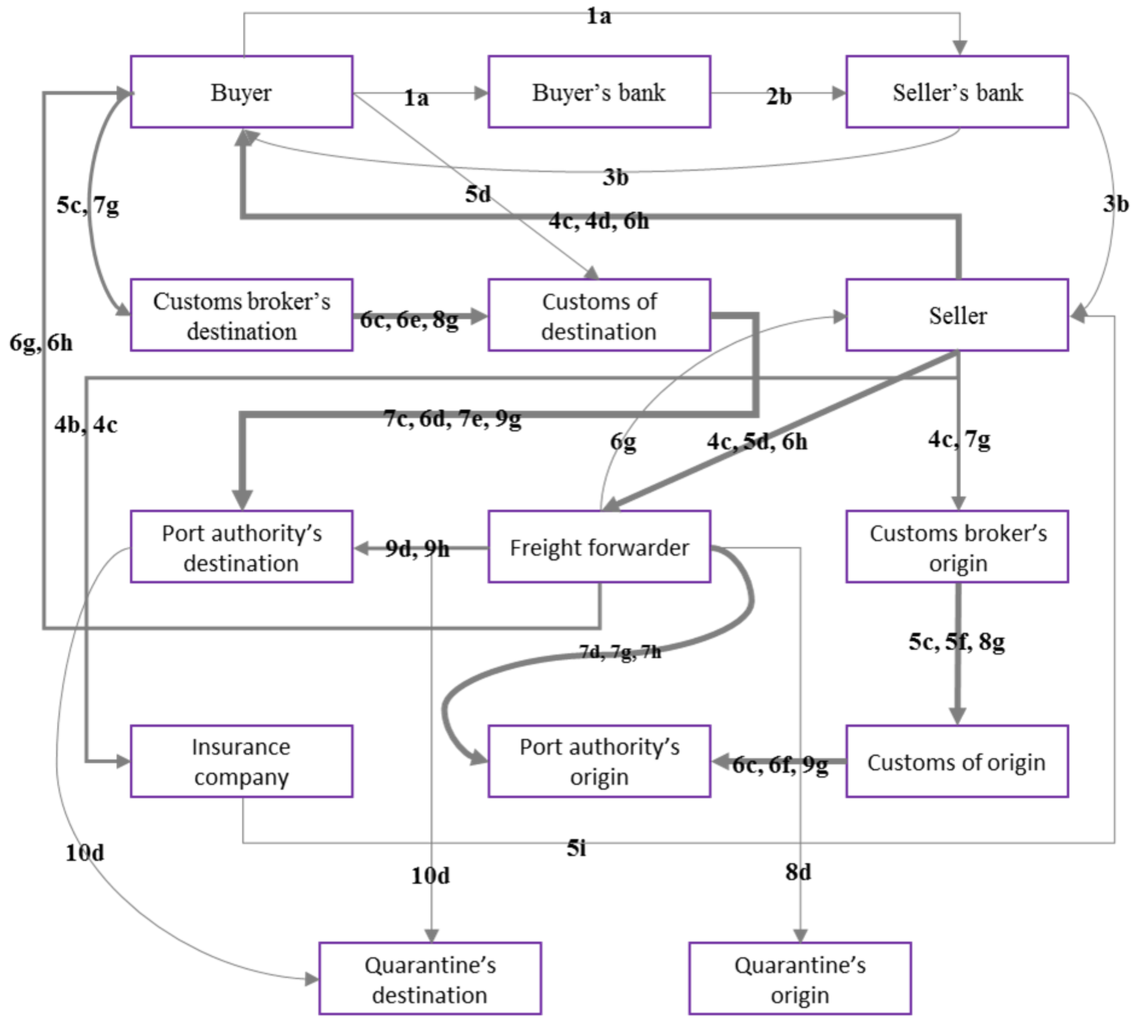
$$n \cong t^2_{\alpha/2,n-1} \frac{s^2}{h^2} \qquad (5\text{-}2)$$

$$n \cong n_0 \frac{h_0^2}{h^2} \qquad (5\text{-}3)$$

Where n denotes the number of replications, n_0 denotes initial number of replications, s denotes standard deviation value, h_0 denotes initial half-width of number of submitted documents, and h denotes desired half-width. After calculating number of replications, 10, 40, and 100 iterations are used in this simulation. In each iteration, an iteration length is 10 hours. The outline of the current and optimized information flow will be described in section 5.2.2 and 5.2.3.

5.2.2 Information flows before applying the proposed algorithm

In order to make the simulation real, the actual ASEAN trade transaction processes were investigated. Figure 5-11 shows the transaction model that is created based on the results. In this figure, nodes represent organizations, arrows represent flows of sets of information (document). Line width of the arrows stand for number of sending same type of information. First Document i.e. purchase order is generated by Buyer (`import_company`). Then the document with sets of information is moved through other organizations based on organized orders that are shown on arrows in Figure 5-11. From Figure 5-11, we can see that many organizations send or receive same type of information repeatedly. For example, a customs of destination sends a port authority's destination same type information four times.



List of documents

a: Purchase order and international sale contract
b: Letter of credit
c: Invoice and packing list
d: Certificate of origin and phytosanitary Certificate
e: Import declaration
f: Export declaration
g: Bill of lading and forwarding instructions
h: Insurance policy and insurance certificate

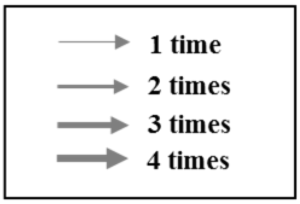


Figure 5-11 Outline of actual information flow model

5.2.3 Information flows after applying the proposed algorithm

The flows of sets of information are optimized by using the proposed algorithm described in Chapter 4, Section 4.4. Figure 5-12 shows the transaction model after using the proposed algorithm. In this model, nodes represent organizations, line arrows represent flows of sets of information. From Figure 5-11 and 5-12, we can compare that number of sending and receiving the sets of information are reduced obviously after applying the proposed algorithm. In Figure 5-12, organizations receive a set information one time that is affected on number of recording information.

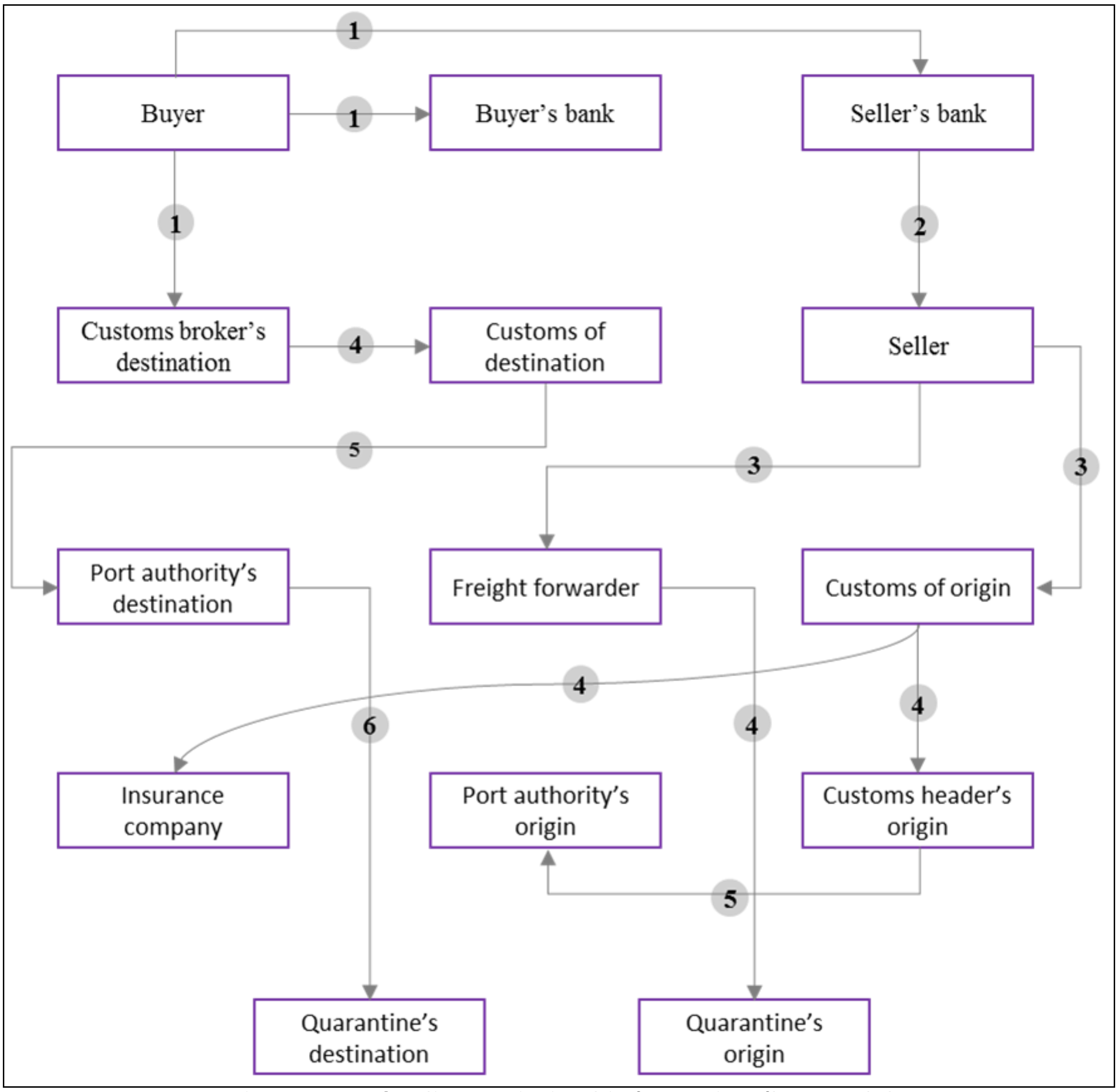


Figure 5-12 Outline optimized information flow model

5.2.4 Results

In this section, the results of multi-agent simulations which were conducted to investigate the effects of the proposed algorithm are shown. The results show that number of the treated sets of information after optimizing information flows can be increased 25.32% when compared with the treated sets of information before optimizing information flow. Table 5-10 shows average number of sets of information between before and after optimizing information flow. From Table 5-10, we can see that before optimizing information flows, 14 sets of information can be completed from all tasks of organizations at 95% confidence level. After optimizing information flows, 56 sets of information can be completed from all tasks at 95% confidence level.

Table 5-10 Comparing average number of sets of information between before and after optimizing information flow

Number of iterations	Before optimizing information flow			
	Submitted sets of information	Half width	Treated sets of information	Half width
10	315.60	±8.4700	14.00	±0.3800
40	323.50	±3.4200	14.00	±0.1600
100	331.36	±1.9200	14.16	±0.1000
Number of iterations	After optimizing information flow			
	Submitted sets of information	Half width	Treated sets of information	Half width
10	324.40	±8.0200	55.60	±0.2300
40	328.90	±2.9800	55.90	±0.1400
100	330.00	±1.7700	55.92	±0.0900

The graph in Figure 5-13 shows times of before and after optimizing information flow. There are three types of bar in the graph: blue bars represent value-added time (VA time), orange bars represent waiting time, and grey bars represent transfer time. From the graphs, total time of information flow can be reduced from 8.21 hours to 5.97 hours at 95% confidence level after optimizing information flow. The waiting time is 1.48 hours for writing tasks and 0.18 hours for recording tasks before optimizing information flows at 95% confidence level. The graphs in Figure 5-14 and 5-15 show the waiting time and queues of writing and recording tasks.

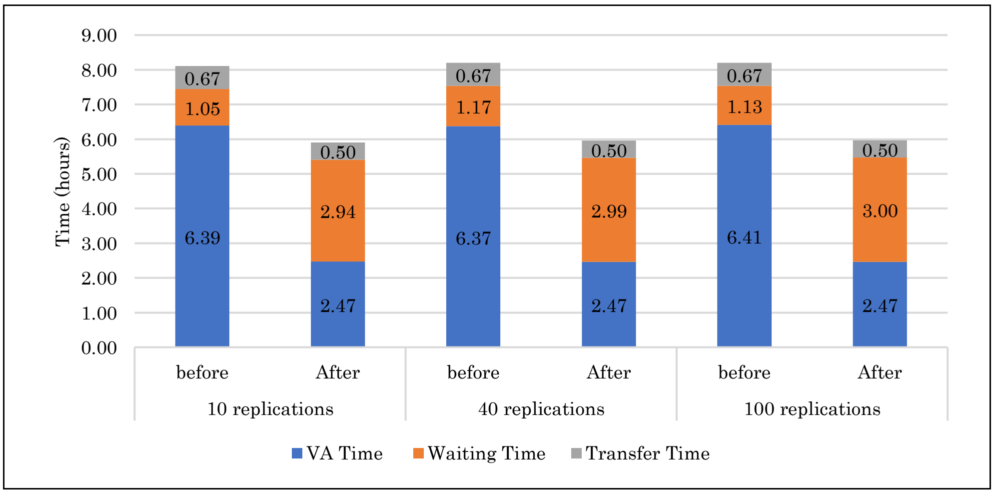


Figure 5-13 Time of before and after optimizing information flow

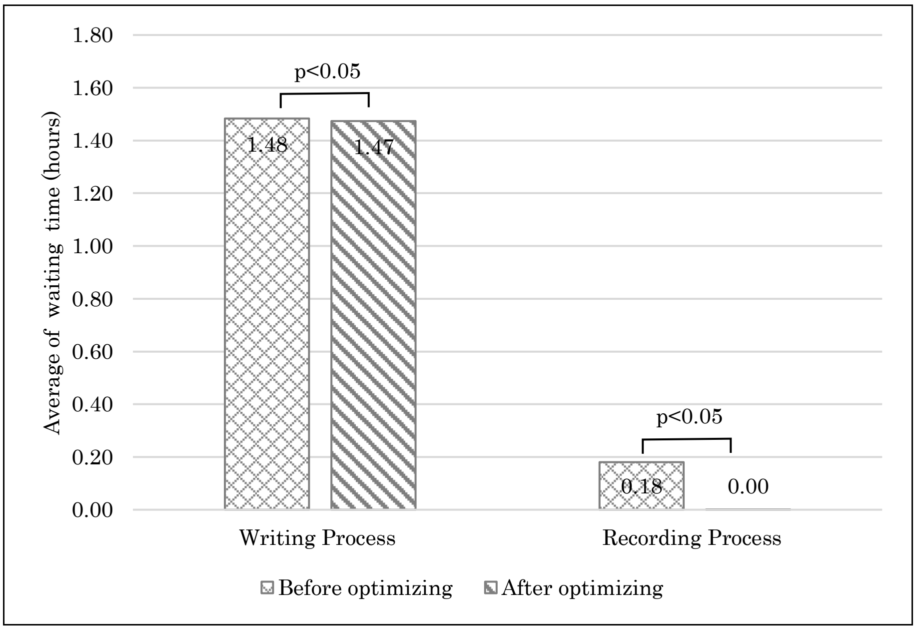


Figure 5-14 Average waiting times of writing and recording task

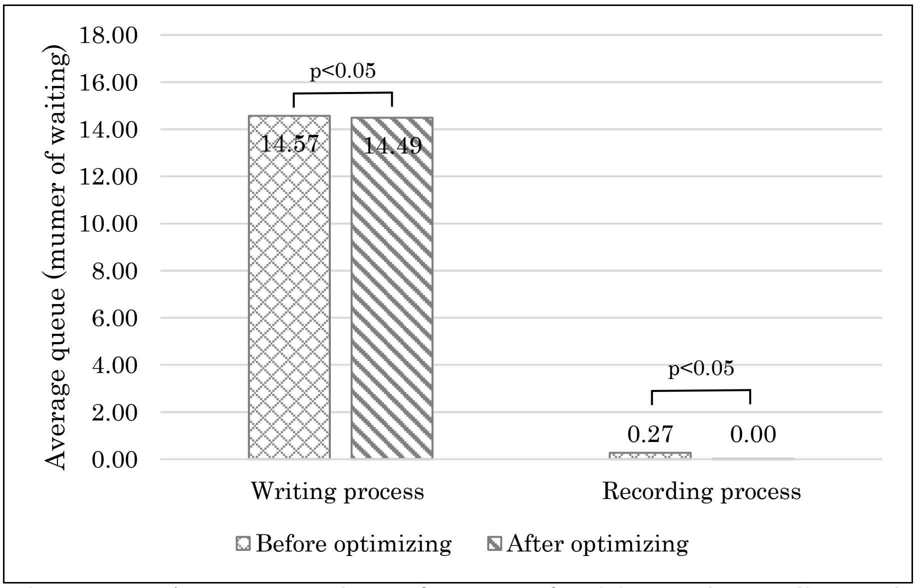


Figure 5-15 Average numbers of queues of writing and recording task

5.2.5 Discussion

After optimizing information flows, the number of sending and receiving sets of information have been decreased. From the results of multi-agent simulations, the reduction in number of sending and receiving the sets of information are able to reduce total time of information flows. The graph in Figure 5-13, total time of information flows is reduced 27.28% after applying the proposed algorithm. Although the total time could be reduced, waiting times are remained in each task of the paperwork processes. From the graph in Figure 5 - 13, we can see the waiting times after optimizing information flows is 50.25% of total time at 95% confidence level. The value-added time (VA time) after optimizing information flow is 61.41% less than before applying the proposed algorithm at 95% confidence level. Due to reductions of VA time, the speed of sets of information are faster than before applying the proposed algorithm. It makes increased queues of the sets of information at each organization. When sets of information are submitted at each organization, some sets of information must wait until the other sets of information are finished for treating by a staff. Workloads of staffs in before and after applying the proposed algorithm are different because number of documents' arrival is increased in each organization. With the same number of staffs, it is difficult to deal with the queue of sets of information after optimizing the flow. Therefore, number of staffs in each task should be considered for reducing waiting times. In order to design number of staffs, modified information flows are constructed to design number of staffs for realizing optimal waiting times of information flows. In the modified information flow simulations, the document with sets of information is moved through other organizations based on organized orders shown in Figure 5-12. In each case, different number of staffs are defined by increasing number of staffs. There are 6 cases of modified information flow that are shown in Table 5-11.

Table 5-11 Number of staffs in each case of modified information flows

Simulation	Number of staffs		
	Writing task	Recording task	Total
Before optimizing	3	1	23
After optimizing	3	1	23
Modified (1)	5	1	24
Modified (2)	2	2	32
Modified (3)	4	2	36
Modified (4)	5	2	38
Modified (5)	4	3	50
Modified (6)	5	3	52

The graphs in Figure 5-16 to 5-21 show times of before, after and modified information flows. In this graph: blue bars represent value-added time (VA time), orange bars represent waiting time, and grey bars represent transfer time.

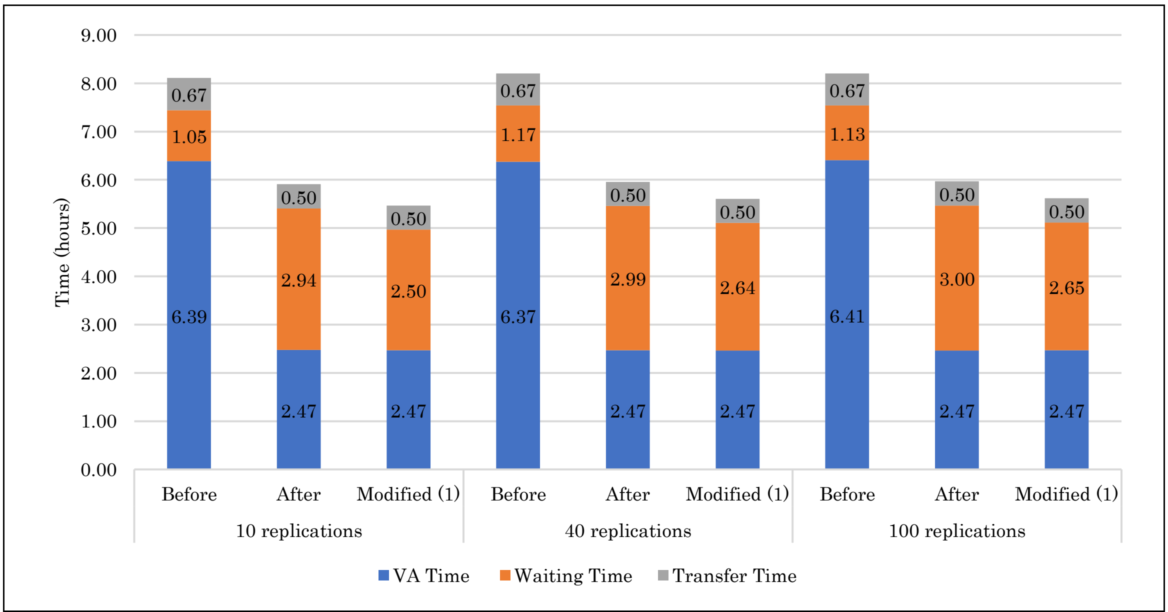


Figure 5-16 Time of before, after optimizing and modified information flow (1)

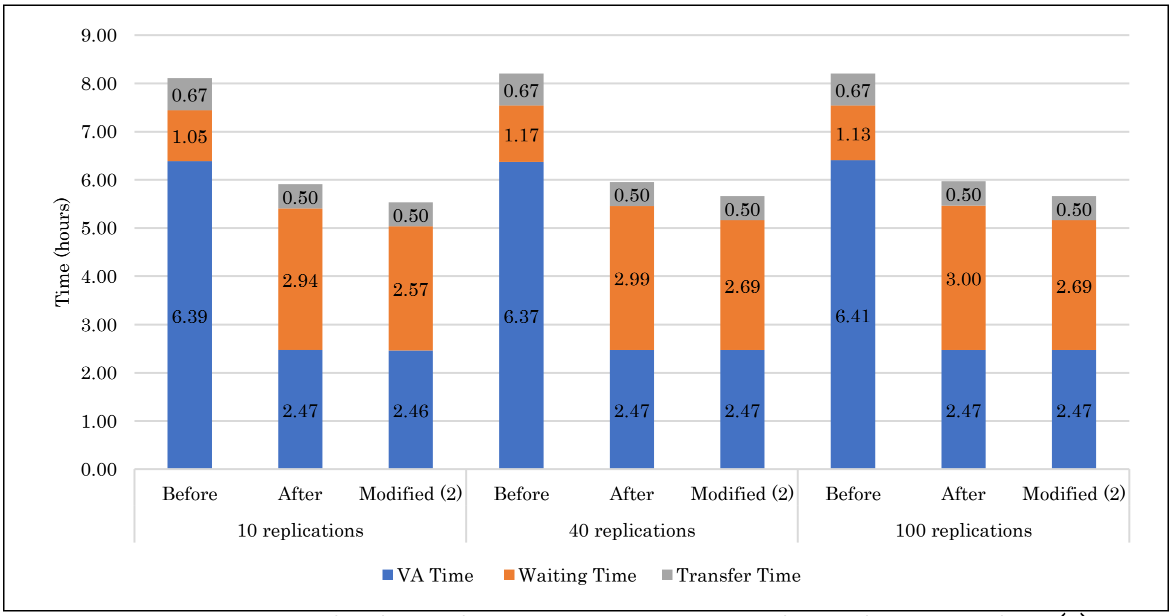


Figure 5-17 Time of before, after optimizing and modified information flow (2)

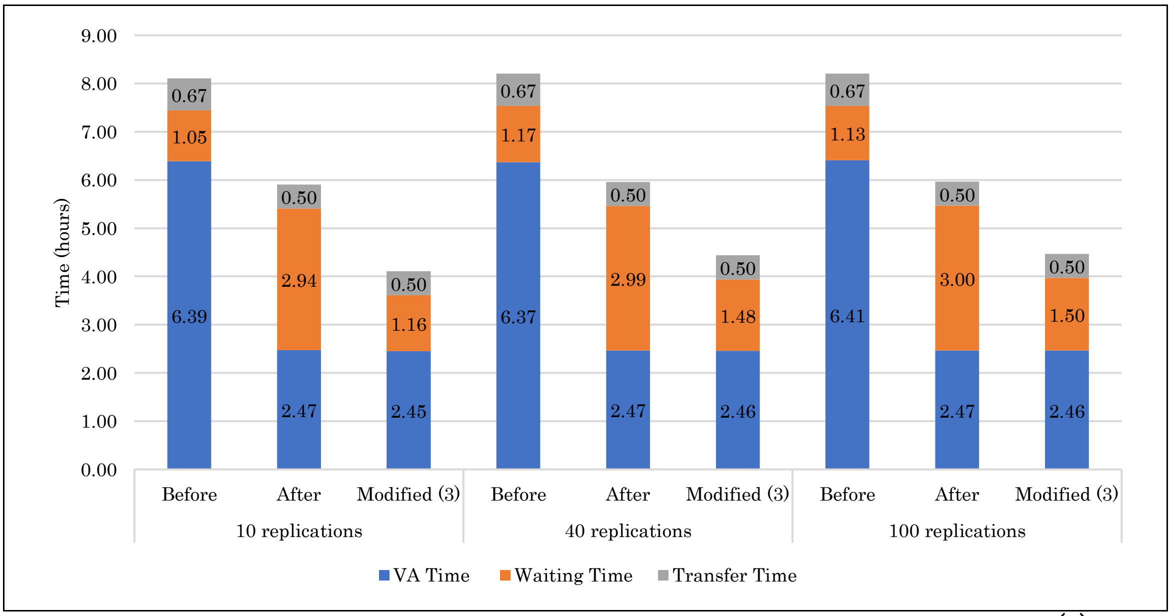


Figure 5-18 Time of before, after optimizing and modified information flow (3)

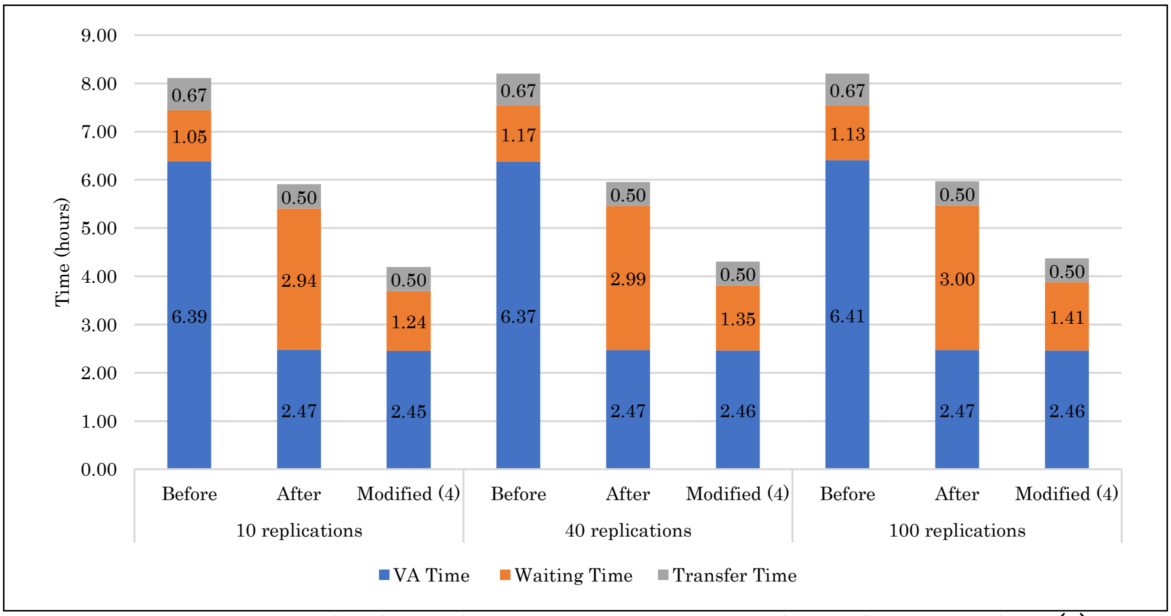


Figure 5-19 Time of before, after optimizing and modified information flow (4)

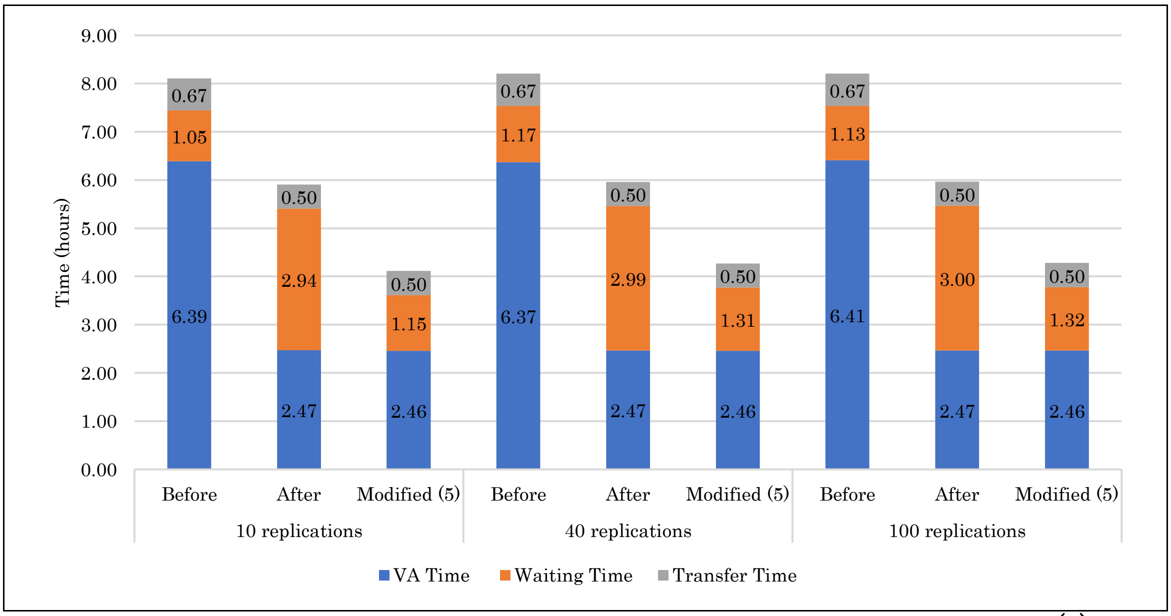


Figure 5-20 Time of before, after optimizing and modified information flow (5)

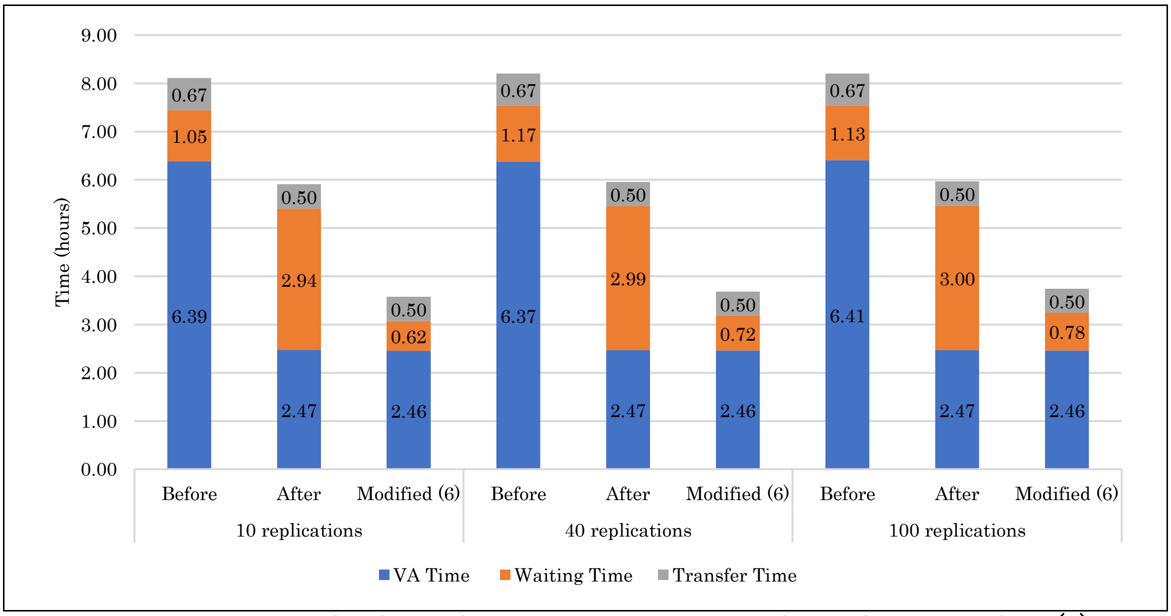


Figure 5-21 Time of before, after optimizing and modified information flow (6)

From graphs in Figure 5-16 to 5-21, we can see that the average numbers of waiting time have been reduced after adjusting number of staffs in each case. The waiting time of the modified information flow (1) is less 12% than the optimized information flow. The waiting time of the modified information flow (2) is less 10% than the optimized information flow. The waiting time of the modified information flow (3) is less 50% than the optimized information flow. The waiting time of the modified information flow (4) is less 53% than the optimized information flow. The waiting time of the modified information flow (5) is less 56% than the optimized information flow. The waiting time of the modified information flow (6) is less 74% than the optimized information flow.

As describe above, modified information flow (6) is the best in the simulations from the aspect of time. However, it needs most number of staffs. Although adding number of staffs in each process can help to reduce waiting time, number of staffs are affected on costs of each organization. The cost effect will be considered in the future direction.

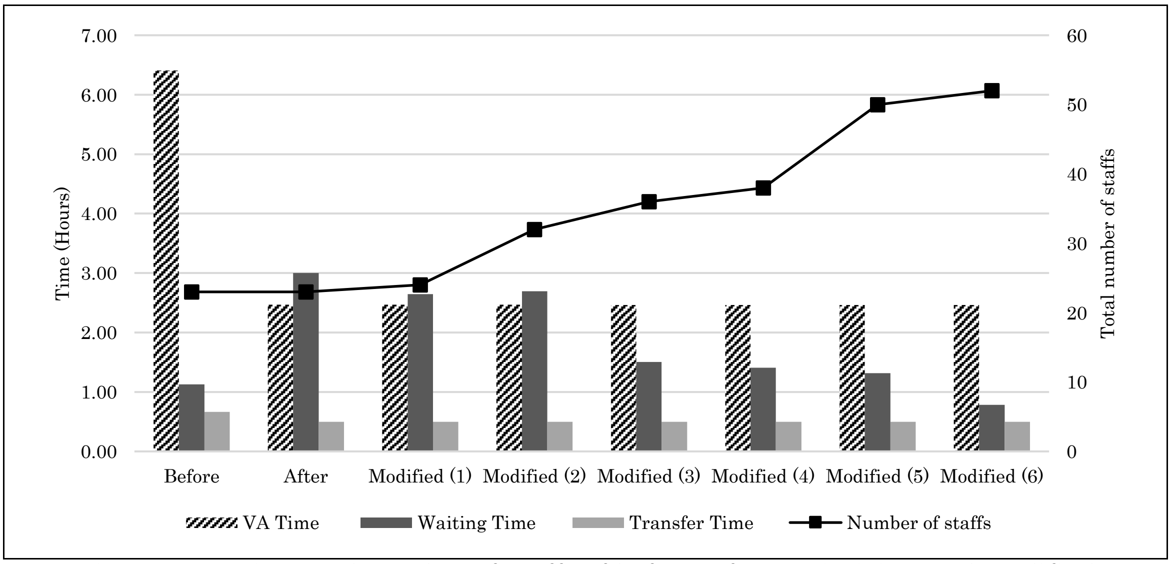


Figure 5-22 Time and number of staffs of before, after optimizing and modified information flows (1) – (6)

Chapter 6
CONCLUSIONS AND FUTURE DIRECTIONS

6.1 Conclusions

Based on surveying actual processes of international trade transaction in ASEAN countries. 3 aspects in the international trade transaction trade processes are found that consist of document layer, information layer and presentation layer. These 3 aspects have been considered to determine an international trade transaction model. Then the international trade transaction model is shown for describing international trade transaction processes. There are 3 layers in the model that consist of information flow layer, document flow layer and presentation or interface layer.

In this thesis, a framework of supporting system for international trade transaction system has been proposed. This system consists of three procedures, (1) Convert (document flows → information flows), (2) Optimize information flows, and (3) Convert (information flows → document flows). Due to many types of information that are contained in each document, an ontology has been required for interpreting information in each document. Therefore, an international logistics ontology has been developed for describing the model and interpreting information. The results of surveying, complex of information flows also have discovered. In order to solve the complex of information flows, an algorithm for optimizing information flow has been proposed. With the proposed algorithm, we can optimize document flows in international trade transaction processes.

Due to the proposed algorithm, information flow simulations are conducted for evaluating the proposed algorithm. These simulations are also employed for representation the information flow before and after optimizing of the paperwork processes. The results of simulation, total time of information flows can be reduced 27.28% after applying the optimizing information flow algorithm. Furthermore, in order to reduce waiting time, number of staffs in each organization are designed in the modified information flow simulations. The average of waiting time can be reduced at least 10% that is compared with the average of waiting time of optimized information flows. Developing user friendly system is expected with the proposed framework due to different languages of each country. The presentation layer of the international trade transaction model is also expected to contribute to develop user-friendly systems, because they can provide suitable language environment for the users by using the layer. To implement practical system, we also have to develop whole of classes of the ontology.

6.2 Directions for future works

An algorithm for optimizing information flow is proposed based on reducing redundancies of information flow. From the results of optimizing information flow, redundancies information flows are eliminated. Although we can reduce some redundant information flows, the distance between source and destination of information is not considered yet. The distance of some information flow is still far from original source. In some cases, the distance may induce additional financial and time costs of transmissions. Timings of retrieving information also have to be considered. Some information must be synchronized together but the algorithm does not consider the situations. Therefore, further studies should be made to develop the proposed model for proving the reliability of intermediate node. Tackling these problems is the direction of the further studies. Moreover, number of staffs in each organization should be considered as a factor that is affected on costs of each organization.

APPENDIX A

Table A-1 The data collection of information arrivals by the ABC co., Ltd in November 2014

Time	Date																				Average
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
10.00-11.00	67	56	65	71	62	65	100	69	64	69	71	73	92	68	72	64	69	54	63	69	**69.15**
11.01-12.00	77	38	44	51	44	65	53	46	44	38	44	48	55	40	36	48	38	48	46	52	**47.75**
12.01-13.00	63	19	17	15	21	27	40	15	15	18	19	23	25	15	21	15	23	19	35	17	**23.10**
13.01-14.00	27	56	50	55	40	62	44	59	51	78	48	68	26	58	66	51	65	56	52	50	**53.10**
14.01-15.00	21	55	56	73	62	76	31	56	54	70	61	68	45	52	72	52	66	54	56	49	**56.45**
15.01-16.00	2	41	43	47	36	40	15	35	43	37	29	45	25	33	25	43	37	28	35	19	**32.90**
16.01-17.00	7	27	25	31	12	52	2	23	25	20	30	28	22	24	21	25	33	27	36	25	**24.75**
17.01-18.00	5	7	10	16	11	10	8	6	20	10	10	29	7	10	14	20	10	13	6	10	**11.60**
18.01-19.00	8	14	11	2	2	6	2	14	6	6	2	16	10	2	10	9	6	7	14	11	**7.90**
19.01-20.00	3	3	6	8	7	2	7	4	3	6	12	6	7	14	6	5	10	12	4	8	**6.65**
Total	**280**	**316**	**327**	**369**	**297**	**405**	**302**	**327**	**325**	**352**	**326**	**404**	**314**	**316**	**343**	**332**	**357**	**318**	**347**	**310**	**333.35**

Source: ABC co., Ltd

APPENDIX B

Table B-1 Set of information in commercial invoice document

Class	Property
Reference_Number	Invoice. No.
Date. Issued_Date	Invoice. Date
Reference_Number	Purchase order. No.
Payment	Item price. Term_of_Payment
Organization. Trader. Seller	Export_company. Status
Organization. Trader. Seller	Export_company. Name
Organization. Trader. Seller	Export_company. Tax_ID_No.
Organization. Trader. Seller	Export_company. Address
Place. Country	Origin_country. Code
Organization. Trader. Seller	Export_company. E-mail
Organization. Trader. Buyer	Import_company. Status
Organization. Trader. Buyer	Import_company. Name
Organization. Trader. Buyer	Import_company. Tax_ID_No.
Organization. Trader. Buyer	Import_company. Address
Place. Country	Destination_country. Code
Organization. Trader. Buyer	Import_company. E-mail
Payment	Item_price. Currency_Code
Item_Group	$Item_1$, $Item_2$, …, $Item_n$. Manufacture_Country_Name
Item_Group	$Item_1$, $Item_2$, …, $Item_n$. Weight
Item_Group	$Item_1$, $Item_2$, …, $Item_n$. HS_Code
Payment	Item_price. Number_of_Item
Payment	Item_price. Unit_of_Measure
Payment	Item_price. Unit_of_Price
Payment	Item_price. Total_Amount
Payment	Freight_cost. Total_Amount
Payment	Insurance_cost. Total_Amount
Payment	Invoice. Total_Amount
Payment	Freight_cost. Currency_code
Payment	Insurance_cost. Currency_code
Payment	Packing_charge. Currency_code
Person_in_Charge. Authority	Export_company. Name

Table B-2 Set of information in packing list document

Class	Property
Reference_Number	Packing_list. No.
Date. Issued_Date	Packing_list. Date
Date	Shipping_date. Date
Date. Isssued_Date	Purchase_order. Date
Reference_Number	Purchase_order. No.
Reference_Number	Invoice. No.
Person_in_Charge. Contact_Person	Export_company. Name
Organization. Trader. Seller	Export_company. Name
Organization. Trader. Seller	Export_company. Address
Organization. Trader. Seller	Export_company. Telephone_No.
Organization. Trader. Buyer	Import_company. Name
Organization. Trader. Buyer	Import_company. Address
Person_in_Charge. Contact_Person	Import_company. Name
Organization. Trader. Buyer	Import_company. Telephone_No.
Item_Group. Package	$Item_1$, $Item_2$, …, $Item_n$. Amount
Item_Group. Package	$Item_1$, $Item_2$, …, $Item_n$. No.
Item_Group. Package	$Item_1$, $Item_2$, …, $Item_n$. Type
Item_Group. Package	$Item_1$, $Item_2$, …, $Item_n$. Dimension
Item_Group	$Item_1$, $Item_2$, …, $Item_n$. Weight
Item_Group	Set_of_item. Container_No.
Person_in_Charge. Authority	Export_company. Name

Table B-3 Set of information in bill of lading document

Class	Property
Date. Issued_Date	Bill_of_lading. Date
Reference_Number	Bill_of_lading. No.
Organization. Freight_Forwarder	Transportation_provider. Name
Organization. Freight_Forwarder	Transportation_provider. Address
Organization. Trader. Buyer	Import_company. Name
Organization. Trader. Buyer	Import_company. Address
Person_in_Charge. Contact_Person	Import_company. Name
Person_in_Charge. Driver	Transportation_provider. Name
Vehicle	Trailer. License_Plate_No.
Item_Group	Set_of_item. Container_No.
Reference_Number	Tracking. No.
Place. Location. Port	Loading_port. Name
Place. Location	Place_of_reciept. Address
Place. Location. Port	Discharge_port. Name
Place. Location	Place of delivery. Address
Vehicle	Vessel. License_Plate_No.
Item_Group. Package	$Item_1$, $Item_2$, …, $Item_n$. Amount
Item_Group. Package	$Item_1$, $Item_2$, …, $Item_n$. Type
Item_Group	$Item_1$, $Item_2$, …, $Item_n$. Weight
Payment	Freight_cost. Total_Amount
Payment	Freight_cost. Term_of_Payment
Place. Location. Issued_Place	Transportation_provider. Address
Date. Issued_Date	Bill_of_lading. Date
Date	Departure_date. Date

Table B-4 Set of information in forwarding instructions document

Class	Property
Reference_Number	Bill_of_lading. No.
Organization. Freight_Forwarder	Transportation_provider. Name
Organization. Freight_Forwarder	Transportation_provider. Address
Organization. Trader. Buyer	Import_company. Name
Organization. Trader. Buyer	Import_company. Address
Organization. Trader. Buyer	Import_company. E-mail
Organization. Trader. Buyer	Import_company. Telephone_No.
Person_in_Charge. Contact_Person	Import_company. Name
Person_in_Charge. Driver	Transportation_provider. Name
Vehicle	Vessel. License_Plate_No.
Item_Group. Package	$Item_1$, $Item_2$, …, $Item_n$. Amount
Vehicle	Trailer. License_Plate_No.
Item_Group	$Item_1$, $Item_2$, …, $Item_n$. Weight
Item_Group. Package	$Item_1$, $Item_2$, …, $Item_n$. Type
Item_Group. Package	$Item_1$, $Item_2$, …, $Item_n$. Dimension
Place. Location. Port	Loading_port. Name
Place. Location. Port	Discharge_port. Name
Place. Location	Place_of_reciept. Address
Place. Location	Place_of_delivery. Address
Item_group	Set_of_item. Temperature_Required
Item_Group	Set_of_item. Type
Person_in_Charge. Authority	Transportation_provider. Name
Date. Issued_Date	Forwarding_instructions. Date

APPENDIX C

Table C-1 Data collection of time for writing process

No.	Time of writing process (minutes)	No.	Time of writing process (minutes)
1	10	41	25
2	22	42	10
3	35	43	17
4	27	44	26
5	11	45	35
6	12	46	27
7	22	47	11
8	9	48	12
9	12	49	25
10	17	50	12
11	13	51	10
12	13	52	17
13	12	53	26
14	9	54	23
15	25	55	23
16	20	56	14
17	15	57	12
18	12	58	12
19	23	59	10
20	11	60	17
21	17	61	26
22	12	62	23
23	13	63	23
24	33	64	14
25	23	65	12
26	31	66	10
27	22	67	17
28	13	68	26
29	12	69	23
30	10	70	23
31	17	71	14
32	23	72	12
33	23	73	23
34	23	74	12
35	14	75	10
36	12	76	17
37	23	77	26
38	11	78	23
39	17	79	23
40	12	80	14

No.	Time of writing process (minutes)	No.	Time of writing process (minutes)
81	12	91	10
82	23	92	17
83	12	93	15
84	10	94	12
85	17	95	23
86	26	96	11
87	23	97	17
88	23	98	12
89	14	99	13
90	12	100	10

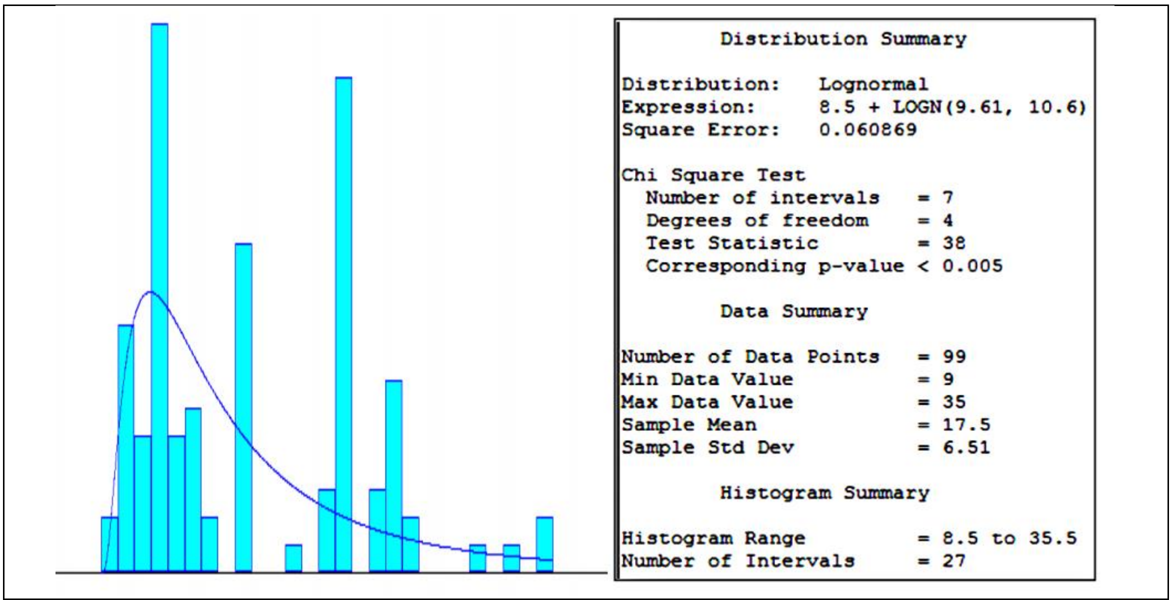


Figure C-1 Distribution summary for Lognormal fit to service times of writing process

Table C-2 Data collection of time for recording process

No.	Time of recording process (minutes)	No.	Time of recording process (minutes)
1	4	51	8
2	7	52	4
3	3	53	5
4	5	54	8
5	6	55	8
6	4	56	6
7	10	57	10
8	7	58	8
9	3	59	4
10	5	60	5
11	4	61	8
12	5	62	7
13	7	63	7
14	12	64	5
15	5	65	8
16	6	66	8
17	9	67	8
18	5	68	7
19	8	69	7
20	11	70	5
21	10	71	7
22	6	72	6
23	9	73	8
24	4	74	6
25	9	75	7
26	10	76	6
27	8	77	6
28	4	78	6
29	5	79	6
30	8	80	6
31	10	81	5
32	7	82	11
33	5	83	5
34	4	84	7
35	6	85	5
36	8	86	8
37	6	87	5
38	7	88	8
39	6	89	5
40	6	90	5
41	9	91	8
42	9	92	5
43	10	93	5
44	8	94	7
45	7	95	5
46	7	96	6
47	8	97	6
48	8	98	12
49	6	99	8
50	10	100	7

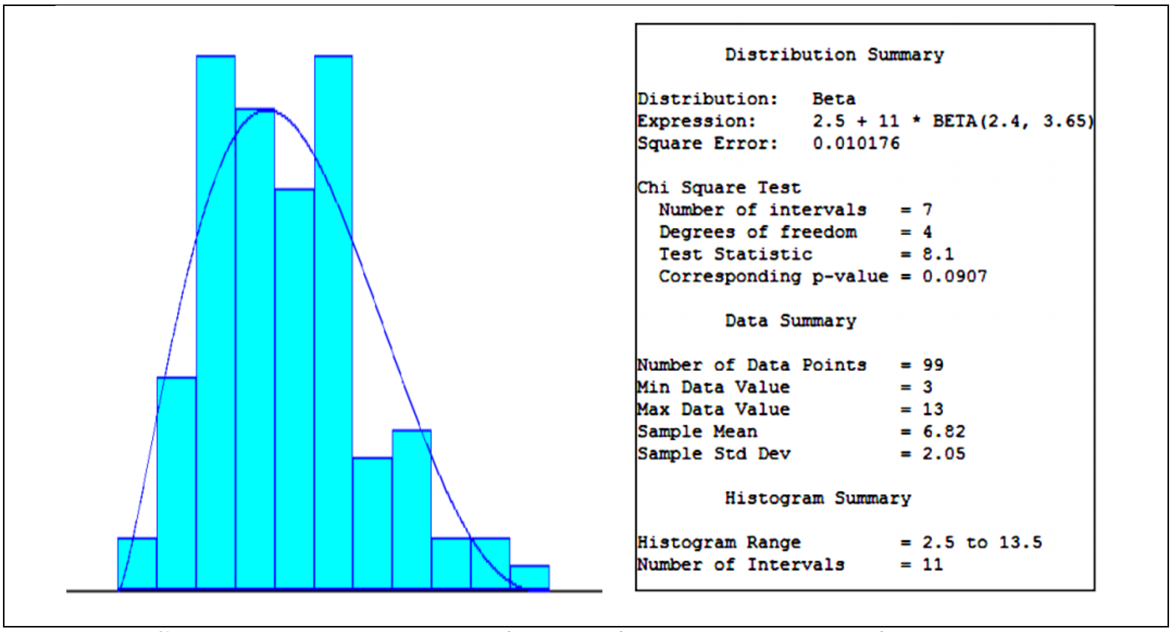


Figure C-2 Distribution summary for Beta fit to service times of recording process

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- Klairung PONANAN, Tanapun SRICHANTHAMIT, Woramol Chaowarat WATANABE, Shinya WATANABE and Hidetsugu SUTO, “A Framework of Supporting System for Optimizing Information Flow in International Trade Transaction”, International Journal of Affective Engineering, Vol. 18, No. 1, 2019, DOI: 10.5057/jjske.TJSKE-D-18-00040.

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- Klairung Ponanan, Hidetsugu Suto and Shinya Watanabe. “An approach for supporting system of international logistics based on ontological engineering”, 2017 International Conference on Biometrics and Kansei Engineering (ICBAKE2017), Tokyo, Japan, pp.49-54, September 2017.

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- Klairung Ponanan, Hidetsugu Suto and Shinya Watanabe, “Ontological approach for international transportation problems”, Joint Seminar on Environmental Science and Disaster Mitigation Research 2017 (JSED2017), 室蘭工業大学 教育・研究 7 号館, pp.137-138, March 2017.
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