A Framework of Supporting System for Optimizing Information Flow in International Trade Transaction

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Abstract: The current international trade transaction processes among ASEAN countries are facing high-costs structure because of the redundant paperworks. Furthermore, multiple languages used in these processes make the problems more difficult. In this paper, a framework of system, which helps to resolve the problems is proposed. The system can generate an optimized process of paperworks from a complex process. First, an international trade transaction model, which is an underlying basis of the framework is defined. Second, an international logistics ontology, which has been developed for describing the model is shown. Then, an algorithm for optimizing information flows is proposed. Furthermore, a case study is shown in order to explain the proposed framework. This framework contributes to reduce the paperwork costs of international trade transaction processes.

Keywords: International trade transaction model, International logistics ontology, Supporting system, Optimized information flow

1. INTRODUCTION

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 [1]. 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 [2].

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 informations in different documents repeatedly. Such facts make the process of the international trade transaction system worse. In order to reduce loads of the operators and their human errors, these processes should be optimized.

In this paper, a basic framework of supporting system for optimizing the document flows in international trade transaction is proposed to solve the problems. First, an international trade transaction model is defined for describing the basic framework of international trade transaction system. The model is designed from three aspects, information flow, document flow and presentation. Second, an international logistics ontology is developed to describe the international trade transaction model. Third, an algorithm for optimizing information flow is proposed for removing redundancies of information flows in the international trade transaction system. Finally, a case study is shown in order to explain the details of the proposed algorithm.

2. BACKGROUND

2.1 Related works

In logistics systems, information flow is one of the important elements because it provides necessary informations to realize the international delivery system. Some information flow models already have been proposed. Mainly, these models are used for the following purposes: (1) analyzing information flows; (2) developing information management systems; (3) supporting communication with outside of the organizations.

Boersma et al. [3] have proposed two new information flow models by using the Maturity Index on Reliability (MIR) [4] in order to improve information flows between customer services and call centers. The aims of these two models are reducing information losses, encouraging to use knowledge databases and improving information qualities.
Helbing, et al. [5] have proposed a hierarchical model by investigating the current information flows in order to control information flows among several organizations. The aim of this model is to reduce risks of information losses and time losses.

Petkova, et al. [6] also have designed an information flow model by using MIR in order to enhance quality and reliability of information flows from customers to manufacturers. This information flow model has been designed for realizing deliveries of user feedbacks to the appropriate sections.

Caldwell [7] has developed a feedback control model for analysing information flows in an organization. The purpose of this model is to solve the problems of information delay.

Petrauskas [8] has proposed an information flow model by using Petri nets for improving effectiveness of material flows of organizations. This model is used for supporting decision makers in material procurement processes.

As the above mentioned, there are many studies that have been conducted. However, investigating redundancies of information flows is outside of the boundaries of these studies.

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 [9, 10].

It allows designers to share concepts which included in the domain of the target [11]. Ontological engineering has been used in many areas that related to information integration such as information systems, applications and web services, document management systems, and enterprise management systems.

Ontological engineering consists of three main components [12]:

- **A class** represents a concept of a thing or an event. Classes have hierarchical structures, e.g. a vehicle class has car class and track calls as the child.
- **A relation** represents a type of association between concepts or concept’s properties in a domain.
  - A is-a relation is an inheritance relationship that is derived child classes that inherit attributes from their parent class.
  - A part-of relation represents a composition relation, for example, an engine is a part of a car.
  - A has-a relation is the inverse version of the part-of relation, for example, a car has an engine.
  - An individual represents an instance of a class.

They can have some roles which determine their behaviors.

In this paper, ontological engineering is introduced to describe an international trade transaction model.

3. BASIC IDEA OF SUPPORTING SYSTEM OF INTERNATIONAL TRADE TRANSACTION

3.1 Supporting system for international trade transaction

3.1.1 International trade transaction model

In international trade transaction processes, many informations are transmitted for carrying out the office procedures. These informations are transmitted by using several ways, e.g. paper documents, forms on the internet system, etc. [13]. 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 authors have proposed a representation model of international trade transaction processes. Figure 1 illustrates the proposed 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.

![Figure 1: International trade transaction model](image-url)
• **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 informations on the Information layer.

• **Presentation layer or interface layer**: On this layer, linguistic labels of informations are represented. Each information on the information layer is connected with the labels, which are represented by several different languages.

3.1.2 **Outline of the proposed system**

Figure 2 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.

3.2 **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 [14].

A top-down approach was used to define the most general concepts in common international trade transaction environments. **Organization**, **Item**, **Vehicle**, **Place** and **Payment** 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 3 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 [15].
- **Item**: An instance of the class stands for a product that is transported from an origin 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 informations such as values and currency types.

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**Figure 2**: Outline of supporting system for international trade transaction
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.

3.3 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 2. The procedures shown below represents the proposed algorithm.

In this algorithm; $M_{ij}^\alpha$ is a matrix, which stands for flow of information $\alpha$-th from source $i$ to destination $j$, and $n$ stands for number of nodes of matrix. Each row of the matrix $M_{ij}^\alpha$ stands for a source node of the information, and each column stands for the destination node of the information. Thus, when an information $\alpha$ is transmitted from source $i$ to destination $j$, the value of $M_{ij}^\alpha$ is 1, otherwise 0.

1. Generate matrix of information $(M_{ij}^\alpha)$, $i$ row, $j$ column

2. row_max := max $\sum_{i=0}^{n-1} M_{ij}^\alpha$

3. col_max := max $\sum_{j=0}^{n-1} M_{ij}^\alpha$

4. do while col_max>1

5. find $i$ where $\sum_{i=0}^{n-1} M_{ij}^\alpha = row_max$

6. find $j$ where $\sum_{j=0}^{n-1} M_{ij}^\alpha = col_max$

7. $M_{ij}^\alpha = 0$

8. row_max := max $\sum_{i=0}^{n-1} M_{ij}^\alpha$

9. col_max := max $\sum_{j=0}^{n-1} M_{ij}^\alpha$

10. end do

For example, flows of information $a$ shown in Figure 4. They can be optimized as shown below by using the algorithm.

- **Step 1**: Matrix $M_{ij}^a$ is generated from the graph as shown in Table 1. In Table 1, the last rows and the last columns represent summation of each row and column.

- **Step 2**: Summation of all lines is calculated for each row. Then the largest number of summation, i.e. 3 is substituted for row_max.

- **Step 3**: Find a row which has the largest number of summation and the row number is substituted for col_max. In this case, 2 is substituted for col_max.

![Figure 3: Structure of international logistics ontology](image)

![Figure 4: Information flows of information $a$](image)
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4. CASE STUDY

In this section, a case study is shown in order to explain the details of the proposed method.

4.1 Outline of case study

An example of document flows, in which four types of documents are transmitted among seven organizations are considered. The organizations consist of (1) a seller, (2) a customs broker of origin, (3) a customs header of origin, (4) a freight forwarder, (5) a customs header of destination, (6) a customs broker of destination and (7) a buyer. They are described by using the Organization class of the ontology shown in Figure 3. 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 in the next section.

4.2 Documents

(1) **Commercial invoice**: Commercial invoices are used by customs headers 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 informations of an import company and ID numbers of items [15]. Figure 6 shows a format of commercial invoices and informations included in it. The left side of the figure shows the format and the right side of the figure shows the informations by using the international logistics ontology shown in Section 3.2. 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 6 means that import_company is an instance of Trader class, and it has properties of Name and Address.

(2) **Packing List**: A packing list is issued by sellers and exporters. The purpose of this type of documents is to provide informations of items for transport agencies,

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Table 1: A matrix $M_{a,i,j}$ which stands for flows of information $a$

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

Table 2: Matrix of information flow ($M_{a,i,j}$) after eliminating edge (1,4)

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

- **Step 4**: If $col_{max}$ is greater than 1, the following steps are executed. In this case, it is 2 and the following steps are executed.
- **Step 5**: Find a row which has largest and it is substituted for $i$, i.e. 1 is substituted for $i$.
- **Step 6**: Find a column which has largest and it is substituted for $j$, i.e. 4 is substituted for $j$.
- **Step 7**: 0 is substituted for $M_{a,i,j}$. Notification of “4” in Table 2 stands for the 1 changed to 0. As the results, the matrix is changed as shown in Table 2.
- **Step 8**: Summation of all lines is calculated again for each row. Then the largest number of summation is substituted for row_max.
- **Step 9**: Find a row which has the largest number of summation and the row number is substituted for col_max.
- **Step 10**: The step 4 to 9 are repeated until $col_{max}$ is less than or equal to 1.

Finally, we can get an information flow shown in Figure 5 as a graph.

Figure 5: Optimized flows of information $a$

![Optimized flows of information $a$](image)

Figure 6: An example of informations in commercial invoice document
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 7 shows a format of packing lists and informations included in it.

(3) **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 vehicle [15]. Figure 8 shows a format of bill of ladings and informations included in it.

(4) **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 9 shows a format of forwarding instructions and informations included in it.

4.3 Optimizing document flow

Figure 10 shows the flows of documents which shown above. In these flows, six types of information are exchanged among seven nodes.

(1) **Create current information flows matrix**

A matrix which represents the document flows is generated. Table 3 shows the generated matrix.

Table 3: A matrix which represents the current documents flows

| Destination | Source | Seller | Customs Broker of Origin | Customs Header of Origin | Freight Forwarder | Customs Header 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 | • Commercial Invoice • Packing List | • Commercial Invoice • Packing List |
| Customs Broker of Origin | X | • Commercial Invoice • Packing List | • Commercial Invoice • Packing List | • Commercial Invoice • Packing List | • Commercial Invoice • Packing List | • Commercial Invoice • Packing List | • Commercial Invoice • Packing List |
| Freight Forwarder | • Bill of Lading • Forwarding Instructions | X | • Commercial Invoice • Packing List | • Commercial Invoice • Packing List | • Commercial Invoice • Packing List | • Commercial Invoice • Packing List | • Commercial Invoice • Packing List |
| Customs Header of Origin | X | | | X | | | |
| Customs Broker of Destination | X | | | | | | |
| Customs Broker of Destination | | • Commercial Invoice • Packing List | X | | | | |
| Buyer | | | | | | • Commercial Invoice • Packing List | X |
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In this step, the matrix of current document flows is converted to matrices of information flows \((M_{ij})\), where \(i\) stands for an index of information included in the documents, \(j\) stands for the source of information, and \(j\) stands for the destination of the information respectively.

(2) Optimize information flows

The information flows are optimized by using the algorithm described in the Section 3.3. Six informations are used in the case study.

Here, an information of Organization. Trader.

Table 4: Current information matrix \((M_{ij}^{\text{import\_company}})\) and optimized information matrix \((M'_{ij}^{\text{import\_company}})\)

| Destination | Seller | Customs Broker of Origin | Customs Header of Destination | Freight Forwarder | Customs Header of Destination | Buyer | Sum |
|-------------|--------|--------------------------|-------------------------------|------------------|-------------------------------|-------|-----|
| Seller      | X      | 1                        | 1                             | 1                | 4                             |       |     |
| Customs Broker of Origin | X      | 1                        | 1                             | 2                |                               |       |     |
| Customs Header of Origin |        |                          |                               |                  |                               |       |     |
| Freight Forwarder |        |                          |                               |                  |                               |       |     |
| Customs Header of Destination |        |                          |                               |                  |                               |       |     |
| Buyer       |        |                          |                               |                  |                               |       |     |

Sum

Table 5: A matrix which represents the optimized information flows \((M'_{ij}^{\text{import\_company}})\)

| Source | Seller | Customs Broker of Origin | Customs Header of Destination | Freight Forwarder | Customs Header of Destination | Customs Broker of Destination | Buyer |
|--------|--------|--------------------------|-------------------------------|------------------|-------------------------------|-------------------------------|-------|
| Seller |        |                          |                               |                  |                               |                               |       |
| Freight Forwarder |        |                          |                               |                  |                               |                               |       |
| Customs Header of Origin |        |                          |                               |                  |                               |                               |       |
| Customs Broker of Destination |        |                          |                               |                  |                               |                               |       |
| Buyer |        |                          |                               |                  |                               |                               |       |

[Import_company. Name] is focused on for explanations. It is contained in all of 4 documents that are described in Section 4.2. The flows of this information are described as the matrix \(M_{ij}^{\text{import\_company}}\) shown in Table 4. There are 10 edges in the matrix, \(M_{1,3}^{\text{import\_company}}, M_{1,5}^{\text{import\_company}}, M_{2,5}^{\text{import\_company}}\) and \(M_{4,1}^{\text{import\_company}}\) are eliminated with the algorithm. The optimized information flow \((M'_{ij}^{\text{import\_company}})\) is shown on the right side in Table 4. As same ways, all information flows are optimized. The results are shown in Table 5 as a matrix \((M'_{ij})\).
Table 6: A matrix which represents the optimized document flows

| Source                  | Seller | Customs Broker of Origin | Customs Header of Origin | Freight Forwarder | Customs Header of Destination | Customs Broker of Destination | Buyer |
|-------------------------|--------|--------------------------|--------------------------|------------------|-------------------------------|-------------------------------|-------|
| Seller                  | X      | Document A               |                          |                  |                               |                               |       |
| Customs Broker of Origin|        |                          | X                        |                  |                               |                               |       |
| Freight Forwarder       | Document B |                          |                          |                  |                               |                               |       |
| Customs Header of Origin|        |                          |                          |                  |                               |                               |       |
| Customs Broker of Destination|        |                          |                          |                  |                               |                               |       |
| Buyer                   |        |                          |                          |                  |                               | Document A                   |       |

(3) Convert information flows to document flows

Then, the information flows are converted back to document flows.

First, group of cells which has same informations is found in Table 5. 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 informations. Thus, they are made as a group. In this way, two groups of informations are made:

Group A: \( \text{import\_company:} \text{Trader [Name], import\_company:} \text{Trader [Address], item\_n:} \text{Package [Amount]} \) and \( \text{set\_of\_item:} \text{Item\_Group [ID\_no.]} \)

Group B: \( \text{item\_n:} \text{Package [Size] and trailer:} \text{Vehicle [License\_plate\_no.]} \)

Informations included in a group are arranged into a document. In this case, informations in Group A are put into Document A, and informations in Group B are put into Document B respectively as shown in Table 6.

The flow of Document A has five edges i.e. \( 1 \rightarrow 2 \), \( 2 \rightarrow 3 \), \( 1 \rightarrow 7 \), \( 6 \rightarrow 5 \), and \( 7 \rightarrow 6 \). The flow of Document B has two edges which are \( 4 \rightarrow 1 \) and \( 4 \rightarrow 7 \). Finally, the optimized document flow is obtained as shown in Figure 11.

4.4 Discussion

After optimizing information flows, the number of information transmissions is decreased from fifty times to thirty-one times without any losses of informations. However, information conservation of the algorithm has not been proved yet. The reliability must be confirmed in the future.

Distance between original node and destination node also must be considered. To discuss the issue, an example is shown. Figure 12 shows information flows of the example. In this figure, Graph A represents original informations flows and Graph B represents an optimized information flows.

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 12. 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.
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In some cases, the distance may induce additional financial and time costs of transmissions. Timings of retrieving informations also have to be considered. Some informations must be synchronized together but the algorithm does not consider the situations. Tackling these three problems is the direction of the future works.

5. CONCLUSIONS AND FUTURE WORK

In this paper, a framework of supporting system for international trade transaction system has been proposed. First, an international trade transaction model is shown for describing international trade transaction processes. An international logistics ontology has been developed for describing the model. An algorithm for optimizing information flow has been proposed. With the proposed algorithm, we can optimize document flows in international trade transaction processes. Developing user friendly system is expected with the proposed framework. 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.

The authors are planning to conduct simulations to evaluate the proposed framework and develop the pilot system after solving some problems mentioned in the previous section. To implement practical system, we also have to develop whole classes of the ontology.

ACKNOWLEDGMENTS

This works was supported by Grants-in-Aid for Scientific Research from Japan Society for the Promotion of Science (no. 26330269 and 15K00486)

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