

# International Electronic Settlement Processing Model of Pre-paid Transit Card

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## ABSTRACT

Diffusion of electronic money that use smart card in all over the world spreads rapidly. But, utilization of electronic money in traffic field has non-relation. This document removes these non-relation and proposes electron settlement processing model that extension is possible between the countries. First, for this model, We set up traffic card exchange processing and fare exact calculation processing condition. And we present use model for electron purse for traffic card exchange processing. We present concept and requirements for non-exchange processing model about exchange for own country money use model. We present direction exact calculation processing model for extension between international, relay engine exact calculation processing model, non-exchange exact calculation processing model, and propose becoming model for exact calculation processing model.

**Key Words** : Exchange, Exact Calculation, Traffic Card, Electron Settlement, Electron Purse

## I. Introduction

The supply of e-money using a smart card in United States, Europe and Asian countries in addition to our country is being rapidly spread in the various fields such as traffic, stores and payment of public utility charges, etc. For the last 15 years, the maturity of e-money technology on traffic industry has grown rapidly<sup>[1,3]</sup>. The closedness of a fee payment architecture among different operation institutes is the biggest problem since the use of e-money is subject to the sole initiatives of transportation authorities.

Many countries are pursuing the e-payment compatibility of their transportation card by using a smart card. But it is necessary to provide with a different viewpoint for the compatibility of a transportation card for international compatibility of a transportation card.

Besides, since the basic techniques of trans-

portation facilities on the methods of operation and fee calculation between countries are different from each other, the globally compatible use of e-money is difficult to implement. For example, the use of different currency at different countries is not easy due to the difficulty of the exact calculation of money exchange rate<sup>[4,5]</sup>.

The international compatibility of a transportation card means that money of one country is transferred to other country, and that currency of one country is converted into currency of other country. This is achieved by means called the exchange rate. After all, the international compatibility of a transportation card means that it receives significant influence by the function of the international financial market.

As a result, the in-depth research on the international electronic payment processing for compatibility of a transportation card should be preceded in a technical viewpoint for compatibility of mutual operation such as the existing smart card,

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point of access(terminal) and system, etc. as well as in an economical and legal aspects called international finance such as money exchange and settlement of accounts, etc.<sup>[1,2,5]</sup>.

Under these circumstances, the present paper brings many implications in a point that it provides with a research model toward a basis of inter-governmental discussions in the future and can influence on standardizing the compatibility of a transportation card within each country.

Accordingly, the scope of the paper limits to the relations between the operating agency of transportation facilities, users, and Issuers respectively, since they are the major contact points in which the settlement is generated.

This research aims to examine the relations between users and transportation facilities in an exchange aspect, and to limit to a method for settlement of accounts in an operating agency of transportation facilities and card Issuer. Additionally, this research sets various models of international electronic settlement processing for compatibility of a Pan-Asia transportation card through various money exchange and settlement methods, and proposes its realization possibility.

## II. Money Exchange and Settlement Processing Model

### 2.1 Setting of Conditions for Money Exchange and Fee Settlement Processing of Transportation Card

For the international compatibility of a transportation card, the card should guarantee that the currency of one country is used under specific conditions in other countries. For this, the conversion into the currency of other country should be preceded, when the unified currency like EU is not used. Another method is to define the currency of a specific country or the third currency as a representative currency.

The introduction of a unified representative currency removes many constraints to compatibility of transportation card by improving its usage conditions or conversion procedure of currency.

However, its implementation is very difficult in that the economic scale and the degree of freedom in each country are different from each other. The introduction of a unified currency is not a concern of discussion under the circumstances that the regulation on foreign exchange, such as an exchange rate and inflow & outflow of foreign currency, etc. and the economic freedom level are different. For the same reason, the introduction of a unified currency in the Asian region is still an experimental level, which motivates the present research. This paper, thus, does not deal with the introduction of a representative currency, but concerns of using the currency of a specific country facilitated with money exchange.

In this circumstance, the important elements are exchange rate and the trade mechanism of foreign currency. Various Asian countries are operating various systems. The governmental regulation appears differently in trade of foreign currency in each country. Some countries requires the legal approval or report mandatory in foreign currency's trade with a certain scale, whereas other countries allowing it freely.

In order to process money exchange in the Asian region under these circumstances, the following conditions should be met<sup>[6-8]</sup>.

- 1) The means of which financial authorities can manage the flow of foreign currency and by which the movement between countries is carried out should be provided.
- 2) It shouldn't affect the currency independence of each country.
- 3) It should be able to predict an exchange rate and should be affected by the exchange rate.
- 4) It shouldn't give inconvenience more than foreign currency trade being currently carried out.

### 2.2 Conditions of Settlement Processing

The settlement processing is an issue regarding how the movement of goods carried out through compatibility of a transportation card between countries will be handled. The settlement of accounts occur between an operator of transportation

facilities and an issuer of e-money issuing a transportation card and storing its value. The problem of this settlement doesn't occur in the existing closed-type system where an operator both issues and operates a card. The various types of general settlement inside specific countries or a region corresponds to one of the following categories<sup>[6,7,9]</sup>.

- When there is one e-money issuer in one operator of transportation facilities
- When there are many e-money issuers in one operator of transportation facilities
- When there are one e-money issuer in many operators of transportation facilities
- When there are many e-money issuers in many operators of transportation facilities

Under these circumstances, the relations of 1 : N, M : 1 and M : N are formed in the settlement between an operator and an issuer. Here, when there are many e-money issuers in many operators of transportation facilities, the number of relations for settlement becomes  $M * N$ , and its complexity increases to the magnitude of order. If an agency C in charge of settlement between relations of M : N is inserted as a method of solving the complexity, the number of relations for settlement in (Fig. 1(4)) is reduced to  $M + N$ , and thus more effective and efficient operation is possible.

If the international compatibility issue is added to a general settlement environment being carried out inside specific countries or a region like this, the

following additional consideration factors should be considered.

First, the foreign exchange processing in settlement is the most important part in settlement between countries. Therefore, there is an issue on how the composition asking settlement to an issuer of other countries will be handled. A method that needs settlement processing of the shortest path and minimizes costs for settlement processing should be suggested. Additionally, the issue on how it secures reliability on counterparts of settlement is also a consideration factor.

The reliability on counterparts of settlement becomes more important consideration factor in the international trade rather than domestic trade.

If the settlement is not carried out because of any reason, the operator of transportation facilities loses the transaction. The necessary consideration factors for international settlement processing can be defined as follows.

- 1) The costs and efficiency should be enhanced by suggesting a processing method of the shortest path.
- 2) The method for securing reliability of an issuer should be suggested.

### III. Money Exchange Processing Model of Transportation Card

Two questions like 'will I exchange money at any point of time?' and 'where will I exchange money?' should be considered in exchanging money to currency of other countries. Also, the means on charging e-money of a transportation card (increasing a value of e-money) and refund (reducing a value of e-money and encashing) should be considered. In addition to these, there are various advantages and disadvantages exist according to the number of e-wallet for currency use and processing of each country and its usage (Refer to Table 1).

Also, whether or not the money exchange processing will be carried out in a stage being used between other countries is an important variable in the model (Refer to Table 2).

The settlement processing model includes 3

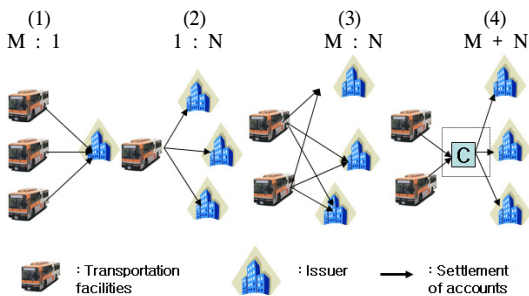


Fig. 1. Relationship Diagram of Settlement of Accounts between Transportation Facilities and Issuer

Table 1. No. of e-wallet and Advantages & Disadvantages according to Usage

No. of e-wallet	Advantages	Disadvantages
1 piece	- Easy to use - Easy treatment	- Need frequency exchange - Difficult to cope with various systems
2 pieces (exclusive wallet)	- Easy to use - Easy treatment	- Disadvantageous in multiple currency treatment
2 pieces	- Convenient to travelers in 2 nations	- Need memory of stored currency
More than 2 pieces	- Simultaneous currency treatment of various nations is possible.	- Technical obstacles - Weak practicality

Table 2. Comparison Table of Processing Model

Division	Money Exchange Processing Model	No Money Exchange Processing Model
Processing Model	- Inconvenient to users	- Convenient to users
No. of e-wallet	- Need more than 2 pieces	- Need only one piece
Money exchange and money exchange fee	- Frequent money exchange - Charge in money exchange fee	- No money exchange - Charge of money exchange fee is less than a money exchange processing model
Risk Factor	- Security of money exchange processing point of access	- Renewal of exchange rate information

different models; 1) direct settlement processing model that an operator of transportation facilities directly demands the e-money value to an e-money issuer, 2) intermediate agency model that places an intermediate agency intermediating between an issuer and an operator of transportation facilities and processes settlement, and 3) centralized model that processes settlement processing between agencies of all countries related to an intermediate agency in a bundle.

Besides, there are various forms of a decentralized intermediate agency's settlement processing model that places an intermediate agency according to a settlement processing unit of a certain scale and

Table 3. Characteristics by Settlement Processing Model

Division		Characteristics
Direct Processing Model		- Complex processing model, Big trade scale - Suitable for a small scale
Intermediate Agency Model	Centralized type	- Simple processing model, Big trade scale - Suitable for a relatively big scale
	Decentralized type	- Comparatively complex processing model, Small trade scale - Suitable for small scaled nation's participation model
	Hierarchical type	- Complex processing model, Very small trade scale - Suitable for a participation model of a nation over a small scale

processes settlement. Unlike a model with one intermediate agency, there exists an hierarchical intermediate agency's settlement processing model placing a central intermediate agency in charge of intermediation between intermediate agencies<sup>[6-8]</sup>.

The settlement processing model has structure and function similar to the form from no money exchange processing. The value of e-money deducted from a point of process with exchange rate information exists in a form of securities for demanding an issuer. The direct settlement processing model and intermediate agency model are placed here.

The above-mentioned models are again divided into a money exchange processing model and no money exchange processing model according to the existence of money exchange processing.

#### IV. International Electronic Settlement Processing Model

##### 4.1 Definition of Model

The international electronic settlement processing model induces an electronic settlement processing candidate model by combining money exchange and settlement methods, and sets a necessary model through review of this. The No-Money Exchange-Hierarchical Settlement Processing Model should be applied as the international electronic settlement processing model, when the actual application of

operation is considered.

The no-money-exchange-hierarchical settlement processing model is a model that a specific user(Au) of a specific country(A) directly uses the value and unit(Am) of e-money stored in the transportation card at an operator(Bt) of transportation facilities of other country without a money exchange procedure, and that the an operator(Bt) of transportation facilities of other country demands settlement of the using amount to an intermediating agency in a currency unit of its own country and processes by utilizing e-money of a user's nation like securities.

The no-money-exchange-hierarchical settlement processing model doesn't go through a separate money exchange procedure unlike a money exchange-hierarchical settlement processing model because it can directly use the currency unit of other country even in any country. The major subject and role participating in this model are as follows. The difference from the money exchange-hierarchical settlement processing model is that the exchange rate has a role of a separate subject in the no-money-exchange-hierarchical settlement processing model.

- Users(U) : Entity using a transportation card
- Issuer of e-Money(I) : Agency that issues e-money and takes charge of its charging and refund
- Financial Institution(X) : Institution that stores a value of e-money issued by an issuer
- Operator of Transportation Facilities(T) : Performs a role of demanding e-money used by users to an actual value as facilities providing a transportation service to users and collecting fee.
- Central Settlement Processing Intermediation Agency(CO) : Agency that intermediates and performs intergovernmental settlement between settlement processing intermediation agencies decentralized in various countries, and solely performs money exchange trade for settlement by country.
- Decentralized Settlement Processing Intermediation Agency(C) : Agency that intermediates and

performs settlement between an e-money issuer and an operator of transportation facilities belonging to each country and settlement with other country.

- Transportation Card(S) : Physical entity storing e-money
- Access Contacts (Terminal Device, P) : Terminal device collecting fee by transferring from a transportation card to a value of e-money as physical contacts that users use the transportation card.
- Settlement processing System(G) : Computer system that treats processing of an issuer, an operator of transportation facilities and a settlement processing intermediation agency.
- Network : Communication system connecting a settlement processing system and a terminal device, etc.
- Currency : Commodity money being used in each country.
- Money Exchange Information : Performs a role as an important subject at the No Money Exchange-Hierarchical Settlement Processing Model as exchange rate information being processed at a terminal device, and receives exchange rate information from a decentralized settlement processing intermediation agency that an operator of transportation facilities performs settlement transaction.
- Legal System : Various systems being applied to a specific country or internationally

The above-mentioned respective subjects are necessary elements in composing the No Money Exchange-Hierarchical Settlement Processing Model, and its processing model gets to act through these organic relations.

(Figure 2) shows a linkage model between each factors in a model that more than minimum 2 countries participate. The structure for information processing of an intermediate agency of ①, between an intermediate agency and transportation facilities of ②, between an intermediate agency and an issuer of ③, and between a terminal device and transportation facilities become major information

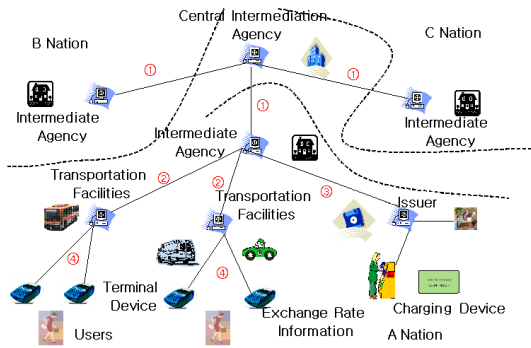


Fig. 2. Linkage between each Objects in no Money Exchange-Hierarchical Settlement Processing Model

structure for international settlement processing in the model of (Figure 2).

The central settlement processing intermediation agency gets to perform only settlement between countries with decentralized settlement processing intermediation agency being decentralized. The key information structure for settlement processing((① of Figure 2) from the decentralized intermediation agency to the central intermediation agency is simply defined as follows.

Dispersion → Central Intermediate Agency	Settlement target country	Settlement target agency	Transfer amount	Settlement amount
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The transfer amount becomes the total amount indicated as a currency unit of a settlement target country, which has the same value as the settlement amount indicated as its own currency.

This structure is written according to a settlement target agency(issuer) of a settlement target country. Unlike the No Money Exchange-Hierarchical Settlement Processing Model, as this transaction doesn't generate money exchange between users and an issuer, the transaction of the central settlement processing intermediation agency was carried out with only the currency unit of a country, where the decentralized settlement processing intermediation agency belongs to, in the transaction with the decentralized settlement processing intermediation agency. Also, the central settlement processing

intermediation agency exchanges money and provides the currency necessary between each countries.

The key information structure for settlement from the central intermediation agency to the decentralized intermediation agency is defined as follows.

Center → Decentralized Intermediate Agency	Settlement Country	Settlement target agency	Settlement amount
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As viewed in the settlement processing model, the transaction, which the transfer of an actual currency value is carried out, becomes a form that the difference part between the total amount being required from the central intermediation agency and the amount billed by the decentralized intermediation agency is transferred.

The information structure of the transportation facilities and the decentralized intermediation agency((③ of (Figure 2)) becomes basic material for settlement transportation fee demanded from transportation facilities inside one country to an issuer of other country.

Transportation facilities → Intermediate agency	Settlement target country	Settlement target agency	Transfer amount	Settlement amount
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The above information structure is written for settlement by settlement target country and target agency, but in this case, the reverse information structure doesn't exist. Here, the settlement amount is the amount of a currency unit of its own country, and the transfer amount is the amount of a currency unit of a settlement target country corresponding to this, which is a value of e-money collected from a terminal device.

The information structure of between the issuer and the decentralized intermediation agency becomes basic information for paying transportation fee billed from other country to the corresponding issuer to other country. The settlement information is

generated from the intermediation agency to the issuer, so the information structure for this is defined as follows. Here, the currency unit of billed amount coincides with the currency unit of an issuer, so a separate money exchange procedure is not necessary.

Decentralized Intermediate Agency → Issuer	Settlement Country	Settlement amount
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The information structure of between a terminal device and an operator of transportation facilities(④ of (Figure 2)) becomes basic material for settlement transportation fee to an issuer of other country. The information collected here is added to the information billed by other transportation facilities at the intermediation agency and becomes information being delivered to the central intermediation agency.

The information structure being processed at an intermediate agency of ①, between an intermediate agency and transportation facilities of ②, between an intermediate agency and an issuer of ③, and between a terminal device and transportation facilities, etc. become added or removed while going through each class. The efficiency of processing can be enhanced by delivering only necessary information to a target agency, and the simplicity of operation can be sought in the settlement processing model.

Terminal device → Transportation facilities	Settlement target country	Settlement target agency	Transfer amount	Settlement amount
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#### 4.2 Verification of Model

Until now, while giving several conditions, supposition and actual cases, the Money Exchange-Hierarchical Settlement Processing Model and no Money Exchange-Hierarchical Settlement Processing Model were set. But the verification on whether the electronic settlement processing is carried out according to the defined state under the given conditions and supposition, which these

models are given, is necessary. However, as there are already results of similar verification on the deferred net settlement clearing system and credit card system, etc. verified for a long time from the existing international electronic settlement system, the present thesis aims to suggest only the method and frame for verification.

##### 4.2.1 Verification Method

Two models get to act differently from each other in settlement of the central intermediation agency and decentralized intermediation agency. Before the users use the transportation facilities, it was carried out in the Money Exchange-Hierarchical Settlement Processing Model.

The verification of a model is composed in the order of forming an imaginary settlement model that subjects are participating, setting imaginary users respectively, and using the transportation facilities and settling this by using e-money.

For this, the conditions are set as follows, and after the processing scenario was executed, the effectiveness and practicality of the model are verified by comparing and reviewing the result.

##### 4.2.2 Setting of Settlement Model

In order to verify the model, its processing result was analyzed after supposing the circumstances as follows.

- One central settlement processing agency is established.
- The N countries and N decentralized settlement processing agency are established.
- The value of N is set as 20, and then it sequentially tests on 2, 5, 8 and 13 countries.
- The first country is set as a base country, and the country code from 01 to 20 is used for division of the countries.
- The M transportation facilities and L issuers are established in each country.
- The value of M and L is decided in the range from 1 to 10 by using the random number of a country.
- For division of transportation facilities, it is added to the country code by using the two

- digit number code from 01 to 10.
- For division of issuers, it is added to the country code by using the two digit number code from 01 to 10.
- In the transportation fee of each country, the transportation fee of a base country is set as a 500 currency unit, and the fee is set as a value added after issuing the random number with the range from -400 to +400(cut-off in case of less than 10 units).
- The number of users received a transportation card from each issuer of each country is set as the number of 10 units between from 100 to 1000.
- The users are divided by using a user division code from 0001 to 1000 in an issuer code.
- The size of currency provided to users is assigned to 20 times of the corresponding country's transportation fee.
- When the currency unit of a base country is set as 100, the intergovernmental exchange rate is decided by utilizing the equivalent value in Table 4.
- The money exchange fee is treated as 2% in case of purchase, and 2% in case of sale. (The number of Issuer, transport facilities, transport fee and the number of users is utilized to a test after being decided according to given conditions by using the number of columns.)
- Use of Transportation Facilities of Users
- The random number is issued according to the code order of users, and the transportation facilities to be used are decided according to this, so the fee is paid. After the random number with the size of 3-fold number of the total number of transportation facilities is issued, it is treated like the transportation facilities are not used, when the larger number than the total number of transportation facilities comes out. (this is carried out three times.)
- In the Money Exchange-Hierarchical Settlement Processing Model, the total money is exchanged directly before using of transportation

Table 4. Basic Data for verifying Settlement of Accounts

Nation	No. of Issuer	No. of Transportation Facilities	Base Monetary Value	Transportation Fee	Currency Unit	No. of Users
01	-	-	100	500	Am	-
02	-	-	120	-	Bm	-
03	-	-	140	-	Cm	-
04	-	-	160	-	Dm	-
05	-	-	180	-	Em	-
06	-	-	200	-	Fm	-
07	-	-	220	-	Gm	-
08	-	-	240	-	Hm	-
09	-	-	260	-	Im	-
10	-	-	280	-	Jm	-
11	-	-	300	-	Km	-
12	-	-	320	-	Lm	-
13	-	-	340	-	Mm	-
14	-	-	380	-	Om	-
15	-	-	400	-	Pm	-
16	-	-	420	-	Qm	-
17	-	-	440	-	Rm	-
18	-	-	460	-	Sm	-
19	-	-	480	-	Tm	-
20	-	-	500	-	Um	-

facilities, and the money exchange of an issuer is also carried out at the same time.(The money exchange fee is subtracted in case of money exchange.)

#### 4.2.3 Test Procedure of Money Exchange-Hierarchical Settlement Processing Model

The random number is issued according to the code order of users, and the transportation facilities to be used are decided according to this, so the fee is paid. After the random number with the size of 3-fold number of the total number of transportation facilities is issued, it is treated like the transportation facilities are not used, when the larger number than the total number of transportation facilities comes out. The total amount of e-money is exchanged to the currency of the corresponding country at the time of using transportation facilities. The settlement is processed after repeating the process 3 times. The countries of 2, 5, 8, 13 and 20 pieces are supposed to respectively participate, and the respective



country was tested. The following items are analyzed according to the result, and the realization possibility of the model is assessed.

- The total amount of settlement of decentralized intermediation agency by country
- The total amount of money exchange and money exchange fee by country and issuer
- Settlement details of between facilities belonging to decentralized intermediation agency
- Ratio of the total amount of settlement versus the using amount according to increase of the number of countries
- Ratio of the total amount of exchanged money and money exchange fee versus the using amount according to increase of the number of countries
- Ratio of the settlement amount of between a decentralized intermediation agency and an affiliated institution versus the using amount according to increase of the number of countries

#### 4.2.4 Test Procedure of no Money Exchange-Hierarchical Settlement Processing Model

- The random number is issued according to the code order of users, and the transportation facilities to be used are decided according to this, so the fee is paid. After the random number with the size of 3-fold number of the total number of transportation facilities is issued, it is treated like the transportation facilities are not used, when the larger number than the total number of transportation facilities comes out. The settlement is processed after repeating the process 3 times. The countries of 2, 5, 8, 13 and 20 pieces are supposed to respectively participate, and the respective country was tested. The following items are analyzed according to the result, and the realization possibility of the model is assessed.
- The total amount of settlement of decentralized intermediation agency by country

- The total amount by money exchanged by central intermediation agency and money exchange fee
- Settlement details of between facilities belonging to decentralized intermediation agency
- Ratio of the total amount of settlement versus using amount according to increase of the number of participation countries
- Ratio of the total amount of exchanged money and money exchange fee versus the using amount of a central intermediation agency according to increase of the number of countries
- Ratio of the settlement amount of between a decentralized intermediation agency and an affiliated institution versus the using amount according to increase of the number of countries

## V. Conclusions

The present thesis set an international electronic settlement processing model for compatibility of a transportation card. The possibility that can pay fee of transportation facilities of other country was discovered through the present research, while the money exchange of e-money is not executed, and the simplicity of settlement was sought in a model accompanied with money exchange by designing hierarchical settlement processing structure.

This model facilitates participation of a specific country and has characteristics capable of effectively coping with increase and decrease of issuers or transportation facilities. Additionally, what the transportation card accompanied with money exchange needs more than 2 e-wallets was verified through an example. As it was verified that the compatibility of a transportation card with one e-wallet can be achieved in the no money exchange model, this research suggested a new viewpoint to compatibility discussion of e-money including international transportation card in the future.

The test for comparison and assessment between models should be preceded to objectively verify the

suggested model in the future. Also, the clearly required standard on a necessary part should be suggested by standardizing the suggested model. And the review on network technology, security technology and distributed processing technology for defining a settlement model should be carried out side by side.

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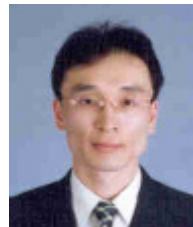


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