Proposal of knowledge representation method for integrated local tax practice based on Bills of Materials (BOM)

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Abstract This article presents a new knowledge representation to integrate the tax practices of local governments. Currently, each local government develops its own taxation processing systems. From the efficiency point of view, these systems should be unified into one integrated system with easy maintenance ability for frequent tax system revision. Therefore, this paper proposes a knowledge representation method using SPBOM (Series Product Bill of Manufacturing) to implement the integrated system with considering the local rule which every local government has. As a result of a sample coding of taxation knowledge using proposed knowledge representation method, the authors have got an insight of compact knowledge representation. Furthermore, more efficient business support will be available, when the concept of event-driven processing is employed.

Keyword Information Systems Development, BOM, Event-driven Programming, Tax, SaaS

1. Introduction
Current local tax practice is performed individually. Information system which supports tax practice is developed and used by each local governments (prefectural and municipality government) independently. However, since the ratio of local taxes rises by shifting of tax revenues from the nationwide to the regional level, the local government should strengthen the tax collection ability and make the tax practice activities more efficiency. For example, as a one solution, the municipality and the prefecture perform the cooperation of the tax practice in Kyoto Prefecture. By this cooperation, they try to reduce the taxation cost and improve the efficiency.

Current systems which support local tax practice is an “order-made” system for each local government. These systems often include rules which are only available to each municipality – some tax rates, a number of due date, and the difference of the calculation of the levy are determined by local ordinances. Also these systems are often implemented as a set of modules which are specific to each tax item. Though the tax practices have rules peculiar to tax item and local government, tax practices have a lot of common practices. It is not preferable to operate the bespoke system from the viewpoint of information systems development and maintenance. In other words, we should realize the integrated tax practice system - it respects rules specific to each municipality and tax item, and in addition, it should be a general-purpose system which treats municipalities and tax items.

This paper proposes and considers a common model for local tax practice based on SPBOM (Series Product Bill of Manufacturing) so as to realize above-mentioned system. This model can express the processing of each tax item of each municipality as data, and in addition, common processing can be expressed as common data. It may be able to adapt to integrated local tax practices by SaaS (Software as a Service) which corresponds to municipalities with a server and set to each customer.

2. Background and purpose
When local governments introduce the system which supports tax practice, development method of the system is an entrusted development on nationwide. The contractors develop the system specification based on the workflow that they asked a person who takes charge of the tax practice, and usually they develop the system as a bespoke system. However, the tax practice system which was developed by the current method includes some problems.

First, these systems are implemented as modules which are specific to each tax item despite the tax practices have a lot of common practices: car tax, light motor vehicle tax and fixed property tax. It is not preferable to develop each module for similar processing from the viewpoint of information systems development and maintenance.

Second, the system is developed by an entrusted...
development. Outline of the local tax is established by Local Tax Act which is the laws of Japan. The tax practice workflow has many special rules which are ordinances of each local government etc., for example, rate of tax, and calculation method of arrears. However, such systems should be made originally a common package, and these systems which were customized are delivered to the client of each place (local government). In reality, however, these systems are remodeled into existing similar system, and delivered so often.

For such a development status, people insisted always “establish a standard”. This insistence is to unify rules of tax practice of local governments (number of due date when pay taxes in installments, calculation method of arrears, rate overdue interest, etc.) into a specific local government by force. “establish a standard” is that a new local government is established, and local governments are unified to new one. However, this is not good, because the scale and the tradition are different in each local government. Originally, the tax practice should change depending on the scale of the local governments (population, area, and industrial type, etc.). Moreover, standardization of this force limits the taxation rights of the local governments partially.

Considering the above mentioned situation, at first it is necessary for various kinds of tax practice to be able to be realized by a single system. Furthermore, this system should support the local rule of each local government easily.

In addition, a past tax practice systems have a big problem by another one. It is that the systems do not do anything, if a user does not operate the systems. For example, the person in charge of tax practice of the local governments must access from oneself a screen of the system, order investigation and decision for tax, and extract a delinquent list. Otherwise, the processing of tax practice does not advance to next. Therefore, the processing of tax practice does not advance to next. Therefore, the person in charge tax practice processes the extraction of the delinquent etc. at the constant date (the date of grounds of the taxation is different according to the tax item.). However, the change of the tax delinquency state should not be born by the operation of the person in charge, because the change should be born by non-payment when the constant date which send demand letter passes.

To solve these problems, “close but not the same business processing” needs construction method of tax practice system to implement in compact and easy to maintain form. So in tax practice case, the system construction which can support flexibly with a small difference by each local government (number of due date when pay taxes in installments, calculation method of arrears, rate overdue interest etc.) is necessary.

Therefore, we pay attention to SPBOM (Series Product Bill of Manufacturing). BOM (Bill of Materials) is a part list used by manufacturing industry, and, SPBOM is integration of BOM and the manufacturing process. SPBOM thinks about the set of a similar “thing” called “family”. The standard of the similarity of a “thing” is an attribute and a manufacturing process of the “thing”. For example, a ballpoint pen has various colors and width, but a manufacturing process of the ballpoint pen is similar. SPBOM can express manufacturing process compactly, because not all kinds of items have a part list in a process of corresponding but “close but not the same items” are expressed as a difference of “attribute”. In addition, SPBOM can reduce the amount of data volume, because SPBOM has the knowledge to produce, so the repetition of data is removed.

3. Proposal technique

We propose a system consisting of “Knowledge representation of the tax practice processing” based on SPBOM, “Knowledge representation of the tax itself”, “Event driven engine” (Fig.1). At first, this system generates the “Tax instance” from input etc. As time progresses, “Event driven engine” maps “Tax instance” onto “Processing and State”. As a result, the processing changes autonomously. The attribute value of Tax instance is updated by processing advancing. Below, we will explain the method of forming the system in detail.

![Fig.1 Block Diagram of the Proposed System](image)

3.1. Knowledge representation of the tax practice processing

We use the SPBOM for “Knowledge representation of the tax practice processing”. In SPBOM, materials, parts, and manufacture are expressed by essentially same “item
group” and small feature “attribute”. Similarly, the tax practice is expressed by looking on the similar practice as a family and specific rules to each tax item and local government as attributes. Therefore, we think that a tax of a taxpayer is processed, and we express item group in SPBOM as input and output documents etc., a work as a processing, and a work method as a processing method (Fig.2).

![Fig.2 Outline of the Proposed Knowledge Representation using SPBOM](image)

**3.2. Knowledge representation of the tax**

SPBOM expresses the manufacturing process. Similarly, the knowledge representation of the tax practice also can be expressed by processing of a tax of a taxpayer. Therefore, we think about a tax object which has attributes values as a processed thing (Fig.3).

![Fig.3 An example of Tax Object](image)

As an abstract concept of this tax object, specific rule of the tax items and the local government is expressed as hierarchy of the tax class. So, to express the hierarchy of each tax item, a similar tax class is brought together and generalized as tax group classes. And, to represent specific rules of each local government, the information determined by the tax laws is succeeded to, the tax class specializes in the tax class of each local government (Fig.4).

![Fig.4 An Example of Layered Tax Structure](image)

In addition, the tax class which represents knowledge generates tax instance for every tax payer. When the tax item has tax due dates, tax instances of each tax due date (lower instance) is generated by a low rank of tax instance (higher instance) (Fig.5).

![Fig.5 An Example of Layered Tax Instance](image)

**3.3. Event driven engine**

We think that the tax practice should be realized by event driven simulation. Event driven simulation is used for a long time various fields in the LSI - CAD etc. The main purpose is the reduction of the computational complexity. The logical calculus can be efficiently executed by not calculating every time from the input gate logic value of the logical circuit but dispersing only the part which the difference existed.

**3.3.1. Autonomous processing by event driven simulation**

As for the tax practice, practice is carried out in sequence by a date. When the taxation information is given, the amount of tax is calculated on a certain set day (imposition day). And though a tax notice was sent, when the tax was not paid after a certain date, the reminder is sent to tay payer. In addition, when the tax is unpaid even if fixed time passes, the letter of demand is sent. When the tax is unpaid, the disposal is carried out (compulsory execution). The above-mentioned flow can be realized by event driven processing.

The aim of event driven simulation in this system is not the reduction in the computational complexity. The extraction for the nonpayment is performed by the instructions of the user. For example, the delinquent of personal municipal inhabitants' tax is extracted by “Scan” tax data. If event driven simulation is performed, only a delinquent can move to the next stage, that is a collection letter sending, automatically. The computational complexity of the extraction processing is $O(N)$ when the number of taxpayers is $N$. Computational complexity may be reduced by event driven simulation, but this is not a big effect.

Rather, the event driven simulation has the aim in the achievement of autonomous processing. Even if the person in charge does not order the demand processing, if extraction for the nonpayment is performed autonomously,
mail is automatically sent to the person in charge, so a demand of the processing is enabled. In addition, the office counter work may have a system glitch, for example, processing to pick up an item which satisfies a specific condition from hundreds of thousands in table is performed by the tax practice system. If event driven simulation which carries out for difference little by little, this problem is hard to happen.

### 3.3.2. Event driven engine

In the proposed method, tax instance in 3.2 is sent in knowledge representation of tax practice described in 3.1 as event. The event basically changes to the next processing by the time passage, so the attribute value of the tax instance is changed by processing (Fig.6). Here, a wait state to advance to the next processing is expressed as “State”. In addition, the higher instance cannot advance if all lower instances do not advance to the next processing (Fig.7). As a result, the tax item which has tax due dates can be expressed.

![Fig.6 An Example of Tax Event Flow](image)

![Fig.7 An Example of Parents Event Flow](image)

### 3.3.3. High function by the concurrent simulation

Moreover, in case of a business processing system, we often understand that the input data is a mistake, and revise the data. For example, the error in writing of the payment day of already payed notice in writing is discovered after the original date of payment passed. Therefore, the event has already spread by the mistake data. For those reason, this function which an event moves back is necessary for this proposal system.

In this case, all events generated from mistake data were canceled, and the event is spread again based on the correction data (Fig.8). In spreading again, when the input data of upstream timewise value is changed, the data of downstream which was functionally dependent to upstream data do not use an old value. However not functional dependency, the data should use an old value again.

![Fig.8 Original State before Data Modification](image)

![Fig.9 Propagation for the Modified Data](image)

### 3.3.4. Event spreading to the future

Besides above-mentioned correction that goes back to the past, the event spreading toward the future can be realized easily by knowledge representation of BOM type and event driven mechanism, too. The user must reply problem saying that “When the grandmother and I are other home, how much is the amount of a tax?.” In this case, the event is spreading toward the future as shown in Fig.10. Besides an original timing wheel, this system has the timing wheel that advances time, assumed to backtrack and cancel. About the data item needed in event spreading, we think that event driven function needs a function that promotes data entry about data item.

![Fig.10 Event Propagation for Taxpayer A and B](image)
4. Application result

In this chapter, we describe the application result of proposed method described in Chapter 3 to tax practice. This time, for tax practice of the annual processing about the local tax of prefectures and cities, we developed the mock-up by hearing, Local Tax Act, and the local taxes ordinance, etc.

The target of tax items are light motor vehicle tax, motor vehicle tax, fixed asset tax, corporate municipal inhabitant’s tax, corporate prefectural tax, corporate enterprise tax, individual municipal inhabitant’s tax, individual prefectural tax, individual enterprise tax, real estate acquisition tax, automobile acquisition tax, hot-spring tax, and hunting tax. Some of results are following Fig.11–16.

For example, light motor vehicle tax is a local tax classified in municipal, normal, and direct tax, and collected by ordinary collection. Fig.11 shows knowledge representation of the tax practice processing and transition of the tax instance in this proposal technique. The tax practice is expressed as a flow of investigation, taxation, receipt, and delinquency.

5. Discussion

In this chapter, from the application experience in Chapter 4, we consider the realization of the cooperation by a system of local governments and tax items.

At first, about cooperation in each local government, by the generalization hierarchy of the tax class like Fig.4 mentioned in 3.2, rules specific to each local government can be expressed as difference of attribute value. For example, in the case of light motor vehicle tax, light motor vehicle tax class in Fig.17 is considered. In this case, 1.5 times the excessive tax rate is provided in the city.

In addition, when the numbers of due date of the tax are different by local government, cooperation can be express with referring a number of lower instance by due date.

Furthermore, the tax practice might be omitted by local government. For example, to the taxpayer who does not pay the tax even if the reminder was sent, generally, the letter of demand is sent. However, the letter of demand is not determined in Local Tax Act. It is an original act by each local government. Therefore, for the local government that does not do the notification processing, the notification processing is omitted as Fig.18, and the processing should be blown off from reconcile of notification to compulsory execution.


Second, about the tax integration among tax items, the images such as Fig.11~13 (light motor vehicle tax, motor vehicle tax, fixed asset tax) and Fig.14~16 (corporate municipal inhabitant's tax, corporate prefectural tax, corporate enterprise tax) are expressed as about the same knowledge representation, respectively. However, a lot of similarities between Fig.11~13 and Fig.14~16 are seen in after “extracting of the delinquency” part, and few parallels in before part. This is guessed by difference between processes of tax collection. In this case, the difference is in between ordinary collection and self-assessment and payment. Therefore we consider similar classes of tax which is mentioned in 3.2, as classes based on process of tax collection. In Fig.19, Classes for Ordinary Collection is represented as a generalization class of light motor vehicle tax, motor vehicle tax and fixed asset tax. The distinctions such as tax object, tax rate, date for assessment based on tax items is expressed as attributes. Therefore tax class in identical group of tax class can be indicated with same process of tax operation.

And there are four kinds of processes of tax collection, which are include such as ordinary tax collection, self-assessment and payment, special tax collection, and stamp payment. We think that all tax classes are distinguished at most four types.

From above, if we use this approach, a number of local governments and tax items will be simply expressed by common knowledge representations of tax process while specific rules are kept.

6. Conclusion

Each local government has own tax practice system which is in one’s way likes rules specific. However, there are many tax practice through no fault of these own rule, therefore it is expected to make these operations more efficient and available at low cost with collaboration tax practice system.

With that, in this paper, we have proposed Knowledge representation of the tax practice using SPBOM, Knowledge representation of the tax, Event driven engine, and discussed about these.

We have developed the mock-up of the system. As a result of examining it, we have gained an insight that local tax practice integration between each local government can be achieved by methods such as generalization hierarchy of tax class, -high-low tax instance depend on due date, and shift of path on tax processes. And local tax practice integration between each tax item will be realized by difference between processes of tax collection.

The mock-up assumes only 13 kinds of local taxes, therefore as an issue in the future, we should build model which adapts all of tax items and think of fulfillment about integrating every tax item.

References

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