Assessing Business Processes by Checking Transaction Documents for Inconsistency Risks

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Abstract: Business processes can be assessed by checking transaction documents for inconsistency risks and can be classified into two categories. Inconsistency refers to a mismatch between items (product name, quantity, unit price, amount price, etc.) among transaction documents. For any process in the first category, the consistency of any pair of transaction documents in the process is checked, and there is no risk of inconsistency. For any process in the second category, the consistency of some pairs of transaction documents in the process cannot be checked, and there is a risk of inconsistency. This paper proposes a method for the assessment of risk inconsistencies. The assessment can be used to design and evaluate business processes for a company's internal control over financial reporting. A business process diagram and inconsistency risk detection algorithm for classifying business processes is provided.

1 INTRODUCTION

From the viewpoint of internal control, management has a responsibility to establish business processes that do not cause deficiencies over financial reporting. When deficiencies over financial reporting are pointed out by auditors, companies lose the reliability of their investors. (Shimizu, Nakamura, 2007); (Maruyama et al., 2008); (Sasano, 2006).

Certified Public Accountants (CPAs) examine the consistency among accounting transaction documents (slips, vouchers, etc.) related to transactions when performing an accounting audit. They check whether there is a mismatch between them and confirm the reliability of transactions. (Yamaura, 2002)

If such checks and confirmations performed by CPAs to posted transactions are incorporated into the business process, more reliable transactions may be realized. Company workers check between received slips and archived slips on the same transaction for consistencies in product name, quantity, unit price, and amount price in business processes. In other words, checking and confirming the consistency of transactions are already performed on-site.

However, these checks are independently performed at each department of a company during the business process. Therefore, any inconsistencies among whole documents in transactions cannot be detected solely by checks performed in one department when such transactions pass through multiple departments.

For example, there are transaction documents "a", "b", and "c" in a transaction. When division "A" checks transaction documents "a" and "b", and division "B" checks transaction documents "b" and "c", inconsistencies in whole documents for the transaction are detected considering a transitive relation between "a" and "c" through "b". Conversely, when division "A" checks documents "a" and "b", and "B" only has document "c" any inconsistencies between them cannot be detected because there is no relation between "a", "b", and "c".

The detection of inconsistencies between transaction documents depends on what divisions check in transaction documents, i.e., the business process.

This paper proposes a method for assessment of risk inconsistencies. The assessment can be used to design and evaluate business processes for a company's internal control over financial reporting. A business process diagram and an inconsistency risk detection algorithm for classifying business

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processes are provided.

The paper is organized as follows. The next section describes business process modeling using our business process diagram while Section 3 introduces an inconsistency risk detection algorithm for classifying business processes. Section 4 presents a case study. Section 5 discusses related work. Section 6 concludes this paper.

2 BUSINESS PROCESS DIAGRAM

A business process diagram is a diagram used to describe business processes of a company by listing business events and archived transaction documents and checked documents set. At first we will explain the elements and notations of the "business process diagram" using a simple example.

2.1 An Order-to-Delivery Process Diagram

This simple diagram (Figure 1) describes an "order-to-delivery process" in which a company orders goods from a vendor, and the vendor delivers the goods to the company. In this process, the company orders goods from the vendor with a purchase order document. When the vendor receives the purchase order document, it prepares the goods for shipping and delivers them with an invoice. The company receives the goods with the invoice and checks between the purchase order and the goods to ensure consistency with the invoice. The diagram in Figure 1 describes the "order-to-delivery process."

In this diagram, 【vendor】 and 【company】 show entities. An "order" and a "deliver" are events in the transaction process. The events are indicated by arrows pointing from a sending entity toward a receiving entity of a transaction document. The events are run sequentially from top to bottom along a timeline of the entities.

The sides of an arrow are visualized by the following symbols to distinguish between a transmission and a reception.

"●": start of the process, "▽": end of an event
"△": start of an event, "▼": end of the process

On a side of the timeline between "▽" (end of an event) and "△" (start of a following event), work at the acceptance event can be described. (The work can be omitted.)

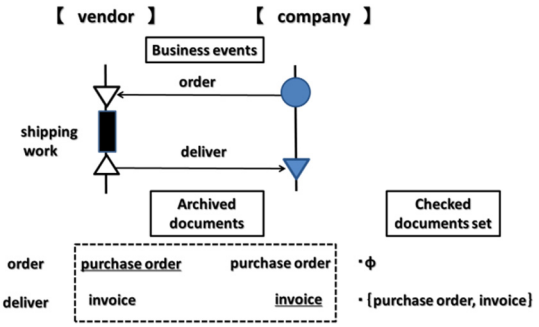

Figure 1: Order-to-Delivery Process Diagram.

In general, each transaction document is issued in accordance with a business event in the transaction. A "purchase order" and an "invoice" issued in this business process are described sequentially in the dashed frame indicating the archived transaction documents under the timeline of each entity. A line is drawn under a received document to distinguish it from a sent document. Business events, an "order" and a "deliver," can be described in the side of the dashed frame to link to the transaction documents, a "purchase order" and an "invoice."

In general, workers of a company also check between a received transaction document and archived transaction documents on the same transaction for consistencies in product name, quantity, unit price, and amount price in business processes. In the "order-to-delivery process diagram," the state of transaction documents, whether checked or not by a division receiving a transaction document, is described.

At first, when 【vendor】 receives a purchase order, it does not keep any documents. Therefore, a checked documents set ϕ (empty set) is described. Next, when 【company】 receives an invoice, it keeps the purchase order. As 【company】 checks between the invoice and the purchase order, a checked documents set {purchase order, invoice} is described.

2.2 Elements and Notation of Business Process Diagram

As shown using the simple example, the business process diagram consists of the following elements.

- "Division": entity that performs the work in the process.
- "Timeline": time flowing from top to bottom.
- "Event": things needed to send and receive a transaction document from one division to

another division in a predetermined order.

- "Transaction document": documented work instructions and/or operating report in the business process.
- "Archived documents": transaction documents that the divisions sent and received.
- "Checked documents set": set of documents that the department is keeping (including a received document).

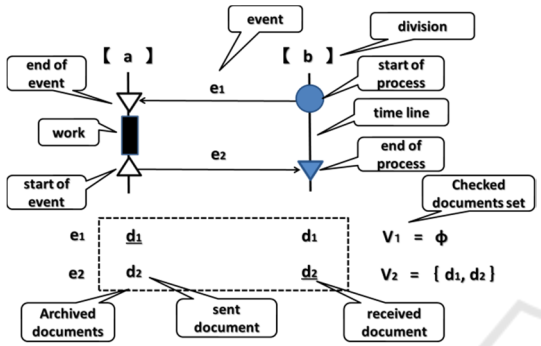

Figure 2: Business Process Diagram.

"Division", "Events", "Transaction document", "Archived documents", and "Checked documents set" are symbolized and defined as follows.

- Division a, b ∈ Div (Div: the entire division)
- Event e_n (a, b) ∈ E (E: the entire event): the n-th event to send and receive a document from division "a" to division "b".
- Event order n ∈ N (N: natural number)
- Transaction document d_n ∈ Doc (Doc: all documents): the document to send and receive in the event e_n (a, b)
- Archived documents S_n (a): documents that division "a" sent and received until the event en
- Checked documents set V_n: set of the documents S_n (a) that division "a" received the document d_n in the event e_n

The elements and notation of the business process diagram notation are shown in Figure 2.

2.3 Preconditions for Business Process Diagram

There are some preconditions for the business process diagram to represent practical standard business processes.

In a business process, when a person in charge in the division receives a transaction document, he/she works in accordance with business rules and issues a transaction document for reporting his/her task or indicating a task of the next division. When he/she receives a transaction document from another division, and archive documents of the transaction are kept in this division, he/she can prevent an operational error by comparing the common items (product name, quantity, unit price, amount price, etc.) between the received document and archived documents.

Business process diagrams are used to detect inconsistency risks by examining mistakes or frauds. Accordingly, in the business process diagram it is assumed that transaction documents are not changed during storage and delivery. In other words, a sent document and a received document concerning the same event are regarded as the same.

It is also assumed that the event order of the business process is fixed. In general, business events in the company, in accordance with the principle of the separation of duty, are performed without being indicated by a transaction document. Therefore, in the business process diagram, the division not receiving a transaction document cannot send a transaction document except at the start of the event.

For example, in the purchase order process, the accounting division cannot pay for goods without receiving disbursement approval by the procurement division. In other words, each business event is carried out in the usual fixed order.

2.4 Example of Business Process Diagram at Risk for Inconsistency

Figure 3, which has a slightly modified business process diagram compared with Figure 1, 【company】 division of Figure 1 is divided into 【purchase】 division and 【warehouse】 division. The business event of receiving a report from 【warehouse】 division to 【purchase】 division is added.

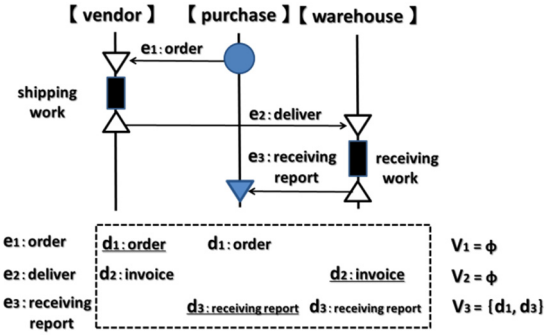

Figure 3: Business Process Diagram at Risk for Inconsistency.

Looking at the checked documents set V_i, received report d_3 and order d_1 is compared. However, invoice d_2 is not compared. Therefore, inconsistencies cannot be detected even if there is an error in the invoice. The business process diagram in Figure 3 is at risk for inconsistency of transaction documents.

3 INCONSISTENCY RISK DETECTION ALGORITHM

When a business process diagram is given, we provide an inconsistency risk detection algorithm that determines whether the business process has inconsistency risks among transaction documents.

The inconsistency risk detection algorithm is based on the equivalence relation of transaction documents. Transitive closure for the checked document matrix of the business process diagram is calculated using the Floyd-Warshall algorithm. (Cormen et al., 2009).

When the elements of the transitive closure matrix are all 1, no risk of inconsistency is decided. When the elements of the transitive closure matrix are 0, a risk of inconsistency is decided.

3.1 Documents Check and Equivalence Relation

"Documents check" compares common items of a received document to archived documents in the receiving division. Common items of transaction documents in the business process are product name and quantity, unit price, amount price, etc.

We determined that "documents check" serves as an equivalence relation as the result of the following analysis of "documents check."

Document d_1 is naturally compared with itself (reflexivity law). When document d_1 is compared with document d_2, document d_2 is compared with document d_1 (symmetric law). In addition, if document d_1 and document d_2 are compared, and document d_2 and document d_3 are compared, then document d_1 and d_3 have also been compared (transitive law).

Comparing reflexivity law and symmetry law is a convincing operation. For transitivity law, it has also been determined that a convincing operation can be assumed.

It should be noted that our discussion is based on the assumption of the sameness between the sent document and the received document, and the transitive law of "documents check".

3.2 Inconsistency Risk Detection Algorithm

The state of the comparison with the entire set of transaction documents of business process diagram Doc = $\{d_1, \cdots, d_n\}$ is represented by a matrix (Checked Documents Matrix).

Checked documents matrix T(i, j) is set as 1 if document d_i and document d_j are compared. T(i, j) is set as 0 if they are not compared.

Since the checked documents have an equivalence relation, the diagonal elements (i, i) are consistently 1 by reflexivity law, and (i, j) component and (j, i) component are equal by symmetric law.

We will explain the Checked Documents Matrix T using the following example. The entire set of documents of the matrix are Doc = $\{d_1, d_2, d_3\}$.

Checked Documents Matrix T^0

	d_1	d_2	d_3
d_1	1	1	1
d_2	1	1	0
d_3	1	0	1

Checked Documents Matrix T^0 describes how document d_1 is compared with d_2 and d_3, but document d_2 is not compared with d_3.

However, document d_2 and d_1 are compared, and document d_1 and d_3 are compared in T^0, so document d_2 and d_3 are also compared by transitive law.

At first glance, document d_2 and d_3 seemed not to be compared in T^0. But matrix T^1 applying the transitivity law represents the true state of checked documents.

Checked Documents Matrix T^1 of applying transitive law

	d_1	d_2	d_3
d_1	1	1	1
d_2	1	1	1
d_3	1	1	1

As described above, continuing to apply the transitivity law for initial checked documents matrix T^0, by calculating T^1, $T^2 \cdots$, transitive closure T subsequently cannot be applied by the transitivity law any more. Transitive closure T represents the true state of checked documents.

Then, starting from the initial checked documents matrix T^0, by applying the transitivity law, if the elements (i, j) of checked documents matrix T (transitive closure) are all 1, all the documents have been checked. Therefore, there is no risk of inconsistency in the business process. Conversely, if the elements (i, j) of transitive closure T include zero, no documents are checked with each other. Therefore, there is a risk of inconsistency in

the business process.

The inconsistency risk detection algorithm of the business process diagram is as follows.

<Inconsistency Risk Detection Algorithm>

1) Set the initial checked documents matrix T0.
   - All elements of T^0 are set to 0, and for Checked Documents Set Vi of the business process diagram, when V_i contains document d_i and d_j, (i, j) of T_0 is set to 1 for all i.
   - Diagonal elements of T^0 are set to 1. When the element (i, j) is 1, the symmetry element (j, i) is set to 1.
2) Calculate the transitive closure of checked documents matrix T^0.
   - Calculate the T^n by applying the Floyd-Warshall algorithm (Cormen et al., 2009).

【Floyd-Warshall Algorithm (Cormen et al., 2009) 】

The (i, j) element of the matrix T^k is t^k_{ij}.

for k = 1 to n

T^k = a (t^k_{ij}) is a new matrix

for i = 1 to n

for j = 1 to n

$t^k_{ij} = t^{k-1}_{ij} \vee (t^{k-1}_{ik} \wedge t^{k-1}_{kj})$

return T^n.

3) When the elements of the transitive closure T^n are all 1, there is no risk of inconsistency in the business process. When the elements of T^n are not all 1, there is some risk of inconsistency in the business process.

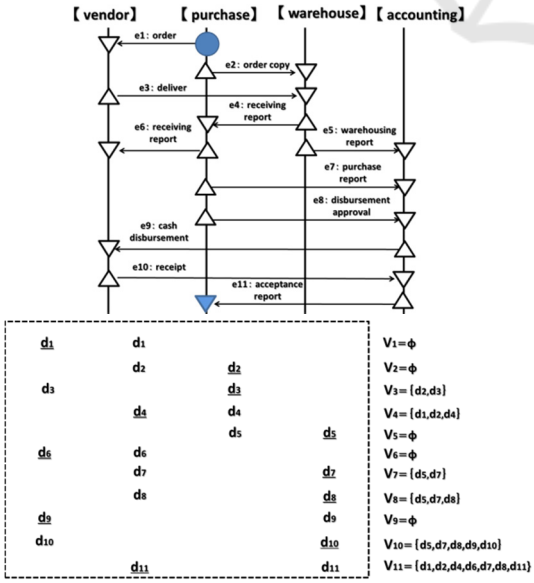

Figure 4: Standard Purchase Order Process Diagram.

4 CASE STUDY BY STANDARD PURCHASE ORDER PROCESS

The assessment of the standard purchase order process is performed in this case study. First, we make the business process diagram of the standard purchase order process (Figure 4) and extract the checked documents matrix from the checked documents sets V_i (for all i). Next, the inconsistency risk detection algorithm is applied for checked documents matrix T^0, and the inconsistency risk of the process is judged.

4.1 Purchase Order Process Diagram and Inconsistency Risk Judgment

In the standard purchase order process, the purchase division orders goods from the vendor and notifies the warehouse division of the order. The vendor delivers the goods to the warehouse, and the warehouse receives them and sends the receiving report to the purchase division. The purchase division requests the accounting division for the payment in accordance with the invoice. The accounting division completes the disbursement and informs the purchase division about it to prevent duplicate payments. (Sasano, 2006); (Kaneko 2001)

This standard purchase order process diagram is shown in Figure 4.

The inconsistency risk detection algorithm is applied to the checked documents matrix T^0, as shown in Figure 5. Since the elements of transitive closure matrix T^{11} are all 1, no risk of inconsistency in the standard purchase order process is determined.

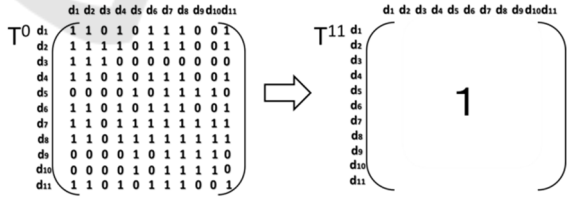

Figure 5: Transitive Disclosure Matrix T^{11} of Checked Documents Matrix T^0.

5 RELATED WORK

We are currently unaware of any studies that model the business process by focusing on the documents generated in the business process and that assess the business process for inconsistency risks.

From the perspective of specific practical analysis of business rules and business processes,

the study described in this paper is considered to be unique.

Business process studies from the perspective of law compliance and standards are part of the field of business process compliance. These studies provide a framework for internal control in accordance with the Committee of Sponsoring Organizations of the Treadway Commission (COSO) and in accordance with health care privacy as established by the U.S. Health Insurance Portability and Accountability Act of 1996 (HIPPA) by analyzing the entire laws and standards. (Breaux et al., 2006); (Siena et al., 2009) However, this paper does not provide a specific method that conforms to the standards established by COSO and HIPPA.

We are aware of a Resources, Events, and Agents (REA) study that analyzes and models financial accounting systems. In that study, all aspects of financial accounting are analyzed, but specific proposals for accounting audits are not provided. (McCarthy, 1982)

6 CONCLUSION

Comparison of received transaction documents with archived transaction documents by a person in charge of each division in a company is naturally performed to prevent any errors in the operation of each division. However, we cannot conclude that such a simple check in each division is enough to ensure consistency for the entire set of transaction documents in the business process, despite consistency in transaction documents belonging to individual divisions.

As indicated above, if the business process is properly designed, the consistency for the entire set of transaction documents is ensured. This operation approximately corresponds to auditing done by CPAs to confirm the existence of transactions.

This paper proposes a method of assessing business processes by checking transaction documents for inconsistency risks. This method consists of a “Business Process Diagram” and an “Inconsistency Risk Detection Algorithm.”

Using the "Business Process Diagram" and the "Inconsistency Risk Detection Algorithm,” business processes can be classified in two categories. For any process in the first category, the consistency of any pair of transaction documents in the process is checked, and there is no risk of inconsistency. For any process in the second category, the consistency of some pairs of transaction documents in the process cannot be checked, and there is a risk of inconsistency.

When a business process is properly designed to meet the needs of the business process in the first category, inconsistency risks can be reduced.

We confirmed in the case study that the standard purchase order process established in the practices, due to the accumulation of experience over many years, is a business process in the first category.

This study aims to establish a high-quality method for inconsistency risk evaluation that can be incorporated into business rules and business processes by analyzing documents that are created on the basis of business rules and business processes. In this study, we modeled the business processes of transactions and assessed them for consistency risks. We will pursue logical verification by using CafeOBJ to refine our "Inconsistency Risk Detection Algorithm."

We will research a method to investigate mistakes and fraud in business processes in the future.

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