Transaction Breaks: A Litany of Errors

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Abstract

Transaction processing systems, whether traditional or Web-based, are prone to error. A “transaction break” occurs when the normal execution process for a transaction has to be suspended because of an unresolved issue. In almost all cases, costly human intervention and negotiation between trading partners is required to solve the problem. There are all sorts of reasons why transaction breaks occur, including faulty software systems, human error, and physical mishaps. Such breaks are estimated to occur in about 11% of all transactions and to cost e-commerce participants billions of dollars per year (Gartner, 2000). This paper analyzes the sources of transaction breaks and describes a software support system called a Transaction Processing Resolution Net (TPRN) that assists in their resolution.

Keywords: electronic commerce, B2B transaction processing, error resolution

1. Introduction

Information technology advances over the last forty years have increased our ability to process large volumes of transactions by orders of magnitude. However, according to a recent study by the Gartner Group (Gartner, 2000) the information revolution has a long way to go in terms of efficiency. According to this study, problems associated with document mismanagement account for 40-60% of white collar employee time, and increase employee costs by 20-25%. These mishandling
costs occur both in the internal organizational systems and in systems that deal with interorganizational transactions. The problems persist despite advances in the automation of work through workflow management systems (Georgakopoulos and Hornick, 1995) and the introduction of electronic data interchange (EDI) and electronic market places (Riggins and Mukhopadhyay, 1999).

In this paper, we focus on the errors that disrupt the flow of interorganizational transactions for supply chain management and distribution – regardless of whether these errors occur in the context of traditional paper-based systems or in more advanced electronic systems. While paper-based systems are obviously more prone to some kinds of human error, we show that transaction errors are unavoidable even in electronic systems, at least, as they are currently designed. Approximately 11% of e-business transactions experience errors and require human intervention for their resolution (Gartner, 2000). According to this study, such “problem transactions” cost 300% more than transactions that do not require intervention. This translates into an increase in the average cost of a transaction of more than 20%.

One approach to the problem of transaction errors is first to identify the possible sources of transaction error and then to design appropriate tests and the response to each type of error. In effect, this means that a second layer of logic/software is added to the underlying processes so that the responses to most errors can be handled on a routine basis. A second approach is to allow errors to happen, but to provide automated assistance to help resolve them when they occur. We advocate a mixture of these two approaches.

In the next section of the paper, we identify and classify various sources of transaction error. Section 3 is devoted to an in-depth analysis of possible errors in a typical supply chain purchasing/accounts payable system. Section 4 presents our design approach together with an outline of the technology required to support our approach. Section 5 presents conclusions and outlines possibilities for further research.

2. Sources of Transaction Error

Usually, application systems are designed first for correct behavior under normal or “correct” conditions. System developers then modify their systems to guard against erroneous data and to anticipate exception conditions. Data verification checks and steps to recover from errors and abnormal conditions are added to the computer code. The objective is to achieve stable applications that assure that the firm’s data is maintained in a correct state at all times. Transactions are either completed correctly or not at all. Adherence to the ACID paradigm1 ensures that automated transactions are executed safely. Systems that can handle business transactions of long duration, where satisfaction of the ACID conditions would be impractical for

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1 ACID is an acronym for the desirable transaction properties of atomicity, consistency, isolation, and durability properties of transactions (Stonebraker and Hellerstein, 1999)
efficiency reasons, have also been developed, particularly in the workflow field (Leymann and Roller, 2000).

Handling exception and error conditions as described in the previous paragraph adds to the difficulty and expense of developing code. However, it seems that no amount of programming and testing effort can guard against all errors. Application systems consisting of hundreds of thousands of lines of code that often have to interact with other systems of similar size will usually fail at fairly frequent intervals (Yourdon, 1998).

Thus, our inability to develop truly error-free code is an inescapable source of errors in transaction processing. In any case, even a completely error-free system can not guard against human errors and abnormal physical incidents that can occur in the process of executing a transaction. The most common errors in transaction processing occur for three reasons, all of which are difficult to detect using current technology. The first reason is human error. For example, a receiving clerk might mistakenly record the wrong number of units received. As a result, the Accounts Payable (AP) clerk is unable to enter a payment voucher and the invoice is set aside pending further research. To guard against human errors, systems can be designed to include reminders and checks and balances such as multiple approvals. However, these measures only partly alleviate the problem.

A second source of transaction error that is even more difficult to detect and guard against, is a misunderstanding between two parties to a transaction. The elements of a typical trading partner agreement are shown in Table 1 (WfMC, 2001). (This chart was designed to reflect the elements that have to be agreed upon in order to coordinate the workflow management systems (WFMS) of two trading partners. It therefore subsumes the elements in a more traditional trading agreement.) A misunderstanding might occur about any one of these contractual items. For example, one of the trading partners might ignore, be unaware of, or misinterpret a clause in their service contract pertaining to costs associated with the transportation of goods. As a result, shipping costs might be inadvertently charged to the buyer. The Accounts Payable clerk will be unable to match the purchase order (PO), receiving document, and invoice and will therefore not generate a payment voucher in the ERP system. Again, the transaction will be set aside pending further research.

The final reason for transaction errors arises in the case of physical goods. For example, goods might be damaged en route or sent to the wrong address. Once again, the AP representative must spend time researching the particulars of the transaction before he/she is able to key a payment voucher into the ERP system.

We call an error in a transaction for any of the above reasons, a “Transaction Break.” When such an error occurs, the normal processing of the transaction associated with the error is interrupted. An exception flag is raised, and, in many cases, the issue is resolved manually by initiating a dialogue between representatives from multiple, often geographically dispersed, groups (e.g. buyer, supplier, contracting, receiving, records management, etc.) Since transaction errors often prevent processing clerks from recording the transaction in the line of business (LOB) system, clerical staff must rely on paper-based logs to track
transactions through the manual resolution process. In some cases, the erroneous transaction may simply be ignored. This might occur, for example, when the discrepancies are not of great consequence to either party and it is cheaper and easier simply to absorb the errors. However, ignoring discrepancies can lead to inaccurate data, hidden costs, and poor decision making with regard to the management of supply and distribution processes. The bottom line is that transaction breaks can account for more than 40% of operating costs (Gartner, 2000) and cost large firms millions of dollars each year (Optika, 2001b).

<table>
<thead>
<tr>
<th>Element of Agreement</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall Properties</td>
<td>Contract duration</td>
</tr>
<tr>
<td>Identification</td>
<td>Business partner information</td>
</tr>
<tr>
<td>Communication Properties</td>
<td>HTTP, SMTP, etc.</td>
</tr>
<tr>
<td>Security Properties</td>
<td>Authentication, non-repudiation</td>
</tr>
<tr>
<td>Roles</td>
<td>Actors</td>
</tr>
<tr>
<td>Actions</td>
<td>Reserve, modify, etc.</td>
</tr>
<tr>
<td>Responsiveness</td>
<td>Timeout</td>
</tr>
<tr>
<td>Sequencing Rules</td>
<td>Modify after reserve</td>
</tr>
<tr>
<td>Constraints</td>
<td>Modify before 6 p.m.</td>
</tr>
<tr>
<td>Recourse Actions</td>
<td>Refund, etc.</td>
</tr>
<tr>
<td>Error Handling</td>
<td>Retries, actions invoked</td>
</tr>
<tr>
<td>Legal Text</td>
<td>Penalty if unreachable</td>
</tr>
</tbody>
</table>

**Table 1: Components of a Trading Partner Agreement**

### 3. Detailed Analysis of Error Possibilities

In the previous section, we identified the major sources of transaction error and concluded that many transaction errors were unavoidable given current approaches to interorganizational systems design. In the remainder of the paper, we use an example to illustrate our approach to the analysis of errors and the design of a system for resolving errors efficiently when they do occur.

Our example is a typical supply chain scenario adapted from (Optika, 2001a). This is illustrated in Figures 1 and 2. The order entry, inventory, picking, logistics and invoicing systems on the supplier side interact with the buyer’s purchasing, receiving and accounts payable systems. Figure 1 shows the order and delivery cycle and Figure 2 the billing cycle. (The payment cycle, which would complete the transaction, is not shown to conserve space.) As indicated in the figures, these transaction cycles are independent of the technology used by each organization, which may be paper-based, use traditional EDI, or employ more advanced transport
mechanisms such as XML-EDI. The given scenario assumes that the supplier company performs the transportation of goods. Otherwise, a third company, the transporter, would be involved in the resolution process for some of the errors. The processes in Figures 1 and 2 are typical of traditional ways of doing business but may differ from firm to firm.

![Figure 1: Typical Order and Deliver Transaction Cycle](image)

As mentioned above, the first step in our approach is to partially design the recovery mechanism for each common type of transaction break. To start the design process, we list the particular errors and the general nature of the resolution process as in Table 2. The identifiers for each transaction break are taken from Figures 1 and 2. All of these errors require human intervention of some sort. The table lists the key personnel in the supplier and buyer organizations that need to communicate with each other to resolve each of the errors. As illustrated below, many other individuals may be involved in the resolution process. This information is an essential input to the system described in the next section because communication has to be established between the responsible parties in order to negotiate or resolve each transaction break occurrence.
To illustrate the current process for resolving transaction errors, consider the following real life study of a single transaction break at a south-western US manufacturer.

Transaction Type: Manufacturing Inventory Replenishment

1) Initiation: An outsourcing manufacturing company orders five pallets of electronic components. The components are required to meet manufacturing quotas for the month. The components arrive at the receiving dock and a receiving document is keyed for the various items. The content of the pallets are placed in inventory. Almost simultaneously, an invoice for the components is received by the centralized accounts payable (AP) group.

2) Discovery: The AP clerk receives a batch of 100 invoices to process at a time. When the AP clerk attempts to key the invoice for the electronic components, a flag is raised by the ERP system alerting the clerk that there is no record that the part number (NSC22451xt) was ordered. The organization will not partial pay invoices. Instead, the invoice is set aside, and the AP clerk proceeds to process subsequent invoices. At the end of the day, the AP supervisor picks up the completed batches for filing and routes all unprocessed invoices to the research group.
### Table 2: Transaction Break Analysis

3) Research: The researcher assigned to the case orders supporting documentation from records management. Records management will usually take two days to retrieve a PO from the procurement system, but receipt documents can take much longer to retrieve from the warehouse’s file system. The transaction remains on hold until all documentation arrives. With documentation in hand, the researcher discovers that the part number on the purchasing document differs from the part...
number on the receiving and invoice document in the last two characters (NSC22451bx). This is probably a mistyped entry in the purchasing system or a part substitution by the supplier. The researcher copies all of the documentation, highlights the problem, and sends the packet to purchasing for further research by the buyer. The buyer receives the packet by inter-office mail and begins to research the problem. First, voice mails are traded with the floor manager to determine if the parts have made it to the floor, and to confirm the part number. Next the buyer contacts a representative of the supplier to notify him/her of the problem shipment. Meanwhile, the supplier’s receivables department makes daily inquiries of the AP department to determine status of payment. Because there is no entry in the ERP system for the referenced invoice, the AP department is unable to report the status of the invoice in question. The supplier’s receivables department resends the invoice as a matter of practice.

4) Resolution: After several days of messages between the buyer and the supplier, it is determined that the part is, indeed, a newer, functionally equivalent, version of the requested part. The floor manager is again contacted to determine if the substitution should be accepted. The line department will also have to approve the substitution after reviewing the master supplier agreement. After several more days, the decision is made to accept the shipment. AP is notified and provided with the necessary details. The AP clerk must now retrieve the invoice from file, and complete the transaction processing. The terms with this supplier allow for a 5% 15-day payment discount. Since the discount terms are calculated by the ERP system automatically, no discount is realized.

The same study estimated the costs for this errant transaction as shown in Table 3. The number of human contact points (shown in bold in the above narrative) is 9. While the lost discount is the largest component of the cost of this transaction, note that the processing cost increased by a factor of 46!

<table>
<thead>
<tr>
<th>Metric</th>
<th>Typical Transaction</th>
<th>This Transaction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time to Process (Person-hours)</td>
<td>.25</td>
<td>11.5</td>
</tr>
<tr>
<td>Touches</td>
<td>2</td>
<td>9</td>
</tr>
<tr>
<td>Processing Cost - Labor (Fully loaded)</td>
<td>$6.18</td>
<td>$284.40</td>
</tr>
<tr>
<td>Lost Discount</td>
<td>$3,400</td>
<td></td>
</tr>
<tr>
<td>Total Cost of Discrepancy</td>
<td>$3684.40</td>
<td></td>
</tr>
</tbody>
</table>

Table 3: Example Transaction Break Statistics

Transaction breaks are disruptive and costly. To reduce their impact, our approach is to provide automated support for both parties to the transaction so that the errors can be resolved quickly. In essence, we describe an online negotiation support
system (Beam et al, 1999). Following (Optika, 2001b) we call this a “Trading Partner Resolution Net” (TPRN) system.

The TPRN provides automated support for the resolution process as follows. First, each transaction error must be detected either by human operators, or by the workflow, ERP or legacy systems involved in the transaction process. Referring to Table 2, the TPRN has knowledge of the roles (or actual people) responsible for resolving each of the “standard” exception types. Using this information, the TPRN can establish the appropriate communication links. It then, supports the four steps in the manual resolution process illustrated above, namely, Initiation, Discovery, Research, and Resolution. It is the last stage in the resolution process that leads us to consider the TPRN as an example of a negotiation support system (Balasubramanian and Mohan 2001).

4. The Design of a TPRN System

This section describes an architecture designed to resolve problems arising from transaction breaks in a cost effective manner. After describing the system, we return to the example manufacturing transaction break described in section 2 and show how the TPRN can reduce the cost of resolving the transaction break by an order of magnitude.

The requirements for a TPRN follow from a consideration of the case study discussed in the preceding section. These are:

- Easy detection and flagging of transaction discrepancies.
- Support for identifying and contacting the persons in each trading partner organization that need to be notified.
- Automatic retrieval of all documents that are obviously relevant to the transaction break, including ancillary documents such as the trading partner agreement.
- More general search capabilities so that the status and contents of any possibly related transaction documents can be located on demand.
- Facilities providing easy access to all related documents by the identified personnel.
- Facilities to support communication and negotiation between the interested parties. These include multiple synchronous and asynchronous communication channels and the ability to remotely share, annotate, and modify documents.
- After resolution, the ability to complete the errant transaction and return it to the normal processing stream.
- Logs of all resolution activities and performance reporting capabilities.

A possible Web-based architecture is shown in Figure 3. The example is based on Siebel AG’s use of Optika’s Resolve package and Accorde workflow management system. The figure depicts a typical “purchasing” supply chain scenario. The
regular transaction flow between the supplier and buyer might take many forms, including paper, fax, EDI, or direct computer-to-computer transfers.

Figure 3: Architecture for Transaction Break Resolution

In Figure 3, a number of technologies are leveraged to support transaction processing. The WFMS and the TPRN are integrated with the LOB systems on both the buy- and sell-side. The integration occurs on several levels. First, for simple document management (reports, invoices, etc.,) the integration is achieved using data obtained by scanning and indexing paper-based documents, fax-in, direct feed of XML or EDI data, or by intercepting the print stream output of the LOB systems. The documents are then inserted into the workflow or added to a “Resolution Package” (ResPack) in the virtual office space for the appropriate supplier. Second, the WFMS has built in interfaces to most ERP and CRM systems that support direct integration for commonly required functions (e.g., search for all documents related to the transaction displayed on the ERP system’s screen and add the documents to a ResPack.) This integration is realized as a client-side integration thereby limiting the impact and cost associated with direct database or back office server integration. Lastly, for more complex functions, and for integration between buy-side and sell-side systems, an XML gateway, such as WebMethods’ Business-to-Business integration (B2Bi) server (Webmethods, 2001), provides business rules and interfaces for moving transaction data between the TPRN and multiple LOB, workflow, or ERP systems. This allows the buyer and supplier to interact
effectively regardless of the type of ERP or eCommerce systems involved. The WebMethods B2Bi server is packaged with adapters to support most ERP, CRM, eCommerce, and mainframe systems thereby limiting the complexity and amount of custom development required to link the various systems. The functions in the XML adapter are typically called through business rule activated scripts (VB Script or Java Script) in the WFMS or directly in the TPRN system. At times compiled code may be used to interact with methods in the XML Gateway's adapters.

We now trace the flow of events through the four phases of the transaction resolution cycle that were introduced above.

Initiation. Transactions are processed as normal. The interesting innovations occur when the normal flow of transactions is interrupted for any of the reasons discussed in the preceding sections.

Discovery. Potential errors may be detected either by the system or by processing personnel. In Figure 3, it is assumed that the processing personnel work through a WFMS and that the background processing is performed through an ERP system such as SAP or J. D. Edwards. (Other configurations including manual processing and legacy mainframe systems are possible.) The key to the transaction resolution process is that errors are flagged and reported to the Resolve System shown in the figure. At this point, Resolve must have the knowledge and ability to automatically retrieve documents that might be relevant to the case. These are published to the relevant trading partner’s “virtual space” (see below) on a Web site that can be accessed by all partners. At the same time, the personnel in both organizations are notified that a problem has occurred.

Research. As shown in the figure, a Web site provides trading partner personnel access to the information they need to resolve transaction breaks. Each trading partner of the host firm is given its own private “virtual space” on the Web site. The virtual space contains fixed data such as the trading agreement documents that describe the business relationship peculiar to that trading partner. As transaction breaks occur, the virtual space is populated by ResPacks consisting of the documents (purchase order, shipping document, receiving document, etc.) that are directly related to each problem transaction. The virtual space also contains records of all written communications that occur during the problem resolution process. These communications include fax, e-mail, instant messages, asynchronous chat, annotations attached to the transaction documents, etc. Another communication feature provided through the Web site is the ability to co-browse documents (using the telephone as an additional communication channel.) This array of information and communication features allows trading partner personnel to explore the problem either individually or cooperatively.

Resolution. Problem resolution occurs when both parties agree to a solution through any of the communications mechanisms mentioned in the previous step. At this point, the Resolve system is able to return the problem transaction to the normal processing stream.

It can be seen that the TPRN Web site is at the heart of the solution. The Web site provides cheap, user-friendly, and universal access to information plus a broad
range of synchronous and non-synchronous communication channels that can be used to resolve the problem. Media types that can be used range from “thin” (e-mail) to “rich” (co-browsing). Personnel are spared time-consuming searches for documents, tedious paper shuffling, the need to record a paper trail, and problems associated with “telephone tag.”

The TPRN provides information to all parties involved in the resolution of a transaction break. For an invoice mismatch problem in an Accounts Payable application, the system retrieves an image of the problem invoice and displays it in a window on the screen. Another window lists other documents relevant to the problem transaction. In the lower left of the screen the functions that are available to assist in the resolution of the problem are displayed. The bottom part of the screen shows messages that have been exchanged as part of the negotiation process (see Optika, 2001 for an example screen.)

We now return to the Manufacturing Inventory transaction problem described in Section 2. Using the TPRN, the steps involved in the resolution process are as follows:

Initiation. The outsourcing manufacturing company orders five pallets of electronic components. The pallets arrive, a receiving document is keyed and the components are placed in inventory. The centralized accounts payable department receives the paper-based invoice.

Discovery. The invoice is immediately scanned, indexed and injected in to the AP WFMS, which evaluates the index criteria and routes the invoice to the appropriate AP queue. The invoices (now individual work packages) are prioritized in real time by a number of criteria including vendor terms, monetary amount, and date received. The AP clerk selects the next work package from the queue, is presented with an electronic copy of the invoice, and begins to key the payment voucher. Again the AP clerk cannot key the voucher because an item number on the invoice does not match any of the item numbers on the referenced purchase order. Instead of handing off the invoice at the end of the day to the AP supervisor, the AP clerk simply closes the work package and processes the next transaction on the list. The WFMS evaluates the attributes of the closed package, determines that the package was not completed normally, and immediately routes the package to a discrepancy queue. The AP clerk experienced no disruption in processing due to the exception. The AP Supervisor is removed as an intermediary. The WFMS allows the AP department to track the transaction even though it could not be keyed into the business system.

Research. The discrepant transaction is received nearly instantaneously in the Research Queue. The WFMS prioritizes the work based on defined criteria and queries the procurement, receiving system, and document management systems to retrieve all information relevant to the transaction. It combines this content with the attributes of the work package to create a Resolution Package in the TPRN. Additionally, the WFMS sends an e-mail notification to the buyer, the purchasing agent, and the supplier. The e-mail message contains general information about the discrepant transaction and a hypertext link to the TPRN. The supplier is the first to
respond to the e-mail alert and enters the TPRN to evaluate the problem. Reviewing
the PO and invoice, the supplier quickly discovers that the cause of the discrepancy
is a mismatched part number. Aware of changes in the product line, the supplier
realizes that the problem was caused by a substitution of a newer model of the same
component. The supplier adds a note in the ResPack detailing the cause of the
discrepancy and the reason for the substitution and offers to honor the price of the
originally ordered parts. Additionally, the supplier adds an updated parts sheet, and
detail spec sheets for both the ordered and substituted parts. Later the same day,
the buyer enters the TPRN in response to the e-mail notification. The buyer reads the
explanation provided by the supplier, compares the specification sheets for the
parts, and concludes that the parts are acceptable. The buyer adds a comment to the
discussion accepting the substitution citing time constraints as a reason to accept the
substitution despite clauses in the vendor agreement explicitly prohibiting them.

Resolution. Later the same day the discrepant work package filters to the top of an
AP researcher’s work list. The AP researcher enters the TPRN and finds the cause
and resolution of the discrepancy already determined. The AP researcher changes
the status of the ResPack to “closed” and issues the required debit/credit memo
using a tool provided by the TRPN. The researcher key’s the voucher using the
originally order part number and completes the work package. The documentation
of the discrepancy and agreed upon resolution are automatically archived. Using the
TPRN, the transaction was resolved in a single day with each of the parties touching
the transaction only once. The transaction was processed and payment remitted
before the supplier’s account’s receivable department had reason to inquire about it.
But if an inquiry was received for whatever reason, the vendor support
representative could use the WFMS to determine the status of the transaction in
real-time. Table 4 shows the estimated cost of the transaction break using the
TPRN.

<table>
<thead>
<tr>
<th>Metric</th>
<th>Typical Transaction</th>
<th>This Transaction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time to Process (Person-hours)</td>
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<td>.625</td>
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<td>Touches</td>
<td>2</td>
<td>5</td>
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<tr>
<td>Processing Cost - Labor (Fully loaded)</td>
<td>$6.18</td>
<td>$15.45</td>
</tr>
<tr>
<td>Total Cost of Discrepancy</td>
<td>$9.27</td>
<td>$9.27</td>
</tr>
</tbody>
</table>

*Table 4: Hypothetical Transaction Break Statistics*

Finally, we should point out that, in addition to providing cost savings to both
parties, the enhanced communications provided by the TPRN can help cement
relationships and turn a potentially aggravating situation into a positive experience.
5. Conclusions

Errors in transaction processing due to human error and physical mishaps are an inescapable accompaniment of both traditional and electronic commerce. Currently, only ad hoc, largely manual processes are used to resolve these errors. The economic consequences of this approach to handling errors are enormous. The main message of this paper is that new, partially-automated processes designed to handle transaction breaks in a far more efficient manner are both possible and desirable.

In this paper, we sketched a simple approach to the analysis of transaction errors and described a commercial system that implements these ideas and that has been deployed at a number of major companies in the United States. While initial data from these applications is promising, it is too early to make a definitive statement about the costs and benefits of using a TPRN. Future research will involve further case studies and surveys to gather information on the costs and benefits of the TPRN approach. TPRNs also present a rich laboratory for the study of real life negotiation processes. In particular, we plan to investigate the steps that humans take to resolve differences and the relative effectiveness of the various communication tools (e-mail, instant chat, co-browsing, telephone, etc.) that are provided by the TPRN system.

References


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