Proposal and Verification of a Workflow Coordination Model for Core Business

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ABSTRACT

As corporations continue to introduce workflow systems, there come to be multiple different such systems--for processing of core-business tasks, for information processing, for clerical work--coexisting in the workplace. A number of different models for coordination of different workflow systems have been proposed; but workflows for core-business tasks constitute the central business processes of the company, and certain aspects of coordination of such workflows differ from other kinds of coordination. This paper clarifies these differences, and proposes a model for coordination, which takes these differences into consideration. In addition, the application of this models an actual system and confirmation of its effectiveness are also reported.

1. Introduction

The widespread adoption of groupware in corporations has been accompanied by electronic processing of more and more office tasks and numerous attempts to boost productivity of clerical work through workflow systems. Studies of a variety of such schemes have appeared in the literature [1-5].

Workflow systems may be broadly divided into those targeting standardized tasks, in which the flow of processing is fixed from the start, and those addressed to nonstandardized tasks involving numerous participants and referenced information, the flow of which is set dynamically. Examples of the former include core-business1 tasks, information-centered processing, and office tasks; instances of the latter include discussions on a given theme, collection of opinions, and cursory reviews of draft reports by involved parties.

As corporations adopt such workflow systems, a number of such systems come to coexist, and there arises a need for users to employ such systems selectively according to the purpose and to effect close communication between different systems. In particular, core-business tasks govern an entire series of corporate activities from the receipt of orders through to product shipment and including sales, design, material procurement and manufacturing. The problem of how to shorten turnaround of this series of operations is crucial to corporate competitiveness. Core-business workflow systems must support such operations, and close coordination of a number of workflow systems holds the key to reducing overall turnaround. In addition, core-business workflows of a corporation are not limited to the company itself; rather, tasks are completed only on inclusion of customers, suppliers and other third parties. Liaison between workflow systems among companies connected by a network is vital. Various studies on methods for branching and combination of processes in workflow systems have been reported [7,8]. In addition, the WfMC (Workflow Management Coalition) has made a number of proposals for standardization of interfaces to coordinate different workflow systems [12-19]. However, there has been no mention in the literature of methods for coordination, which focus on the special nature of core-business workflow systems.

In contrast with coordination of other types of workflow, coordination and communication of core-business workflow must be based on the entirety of corporate information. The range of business processes that are covered by such coordination is another criterion for judging its effectiveness. In this paper, we propose a model of coordination, which incorporates such elements. We also construct an actual system according to this coordination model, and demonstrate its effectiveness.

Below, section 2 analyzes workflows in companies, section 3 proposes a model for coordination of core-business workflows, section 4 describes construction of an actual system based on this model and discusses verification results, and section 5 evaluates and further discusses the proposed model.

2. Analysis of Workflows in Companies

2.1 Standardized and non standardized workflows

Workflow tasks in the typical company may be categorized as follows.

(1) Standardized tasks

(a) Core-business workflow tasks

This is a workflow of tasks incidental to the productive activities of accompany--sales, design, materials, production, accounting, and physical distribution. Corporate core-business information systems which target both reduction of the cycle time from orders through to shipments and a real-time grasp of management data, employing a single integrated database, to drive the operation of different subsystems, have come into widespread use. Workflow systems must likewise be constructed from a single integrated database.

(b) Information-task workflow

In these tasks various informations is retrieved from the core-business database and processed to create different types of data, or to generate totals.

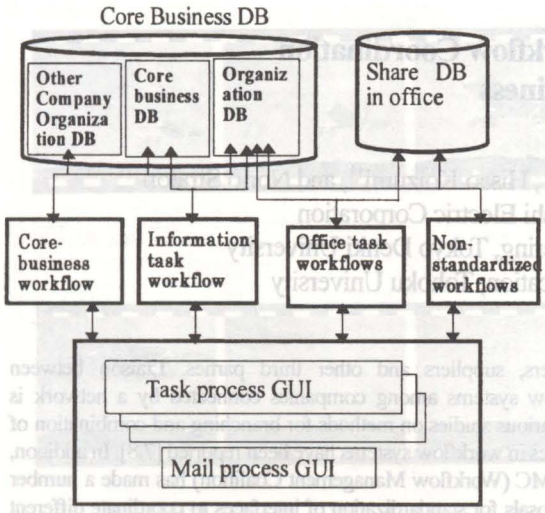

Fig.1 4 kinds of workflow in work place

(c) Office task workflows

These workflows address various tasks performed in offices, including such diverse duties as confirming the minutes of a meeting, inquiring about approval for consumable orders, and confirming of business trip reports.

(2) Nonstandardized workflow

In these tasks, a specific theme is set and related discussions are held, opinions are summarized and collected via questionnaires, an initial draft of some report is prepared, the draft is reviewed by participants, and so on.

2.2 Approaches to workflow systems in the corporation

Figure 1 shows four types of corporate workflow systems. In the figure, the core-business workflow system is based on the core-business database, the office task workflow system is based on a shared database in offices, and the information workflow system is based on both the core-business database and the shared database. And all these workflow reference the corporate organizational information for deciding real person in the path.

Nonstandardized workflow reference the shared database in offices, but workflow routes are set dynamically in each case while referencing corporate organizational information.

Startup of all workflows relies on electronic mail (e-mail); on opening the startup e-mail, a processing screen appears automatically.

2.3 Business processes and workflows in corporations

On the other hand, numerous business processes are executed within a company, from order receipt through to shipment, but there is considerable variation depending on the features of the product groups being handled. For instance, even when dealing with the same type of industrial equipment, the production processes, sales agents, and customer characteristics will all be different for motors and for numerical-control equipment. Hence organizations handling such products will also differ according to the product group characteristics. In order to shorten the cycle time from order receipt to shipment and enhance corporate competitiveness, it is essential that the different units of these business processes be assigned to a single organizational entity as business process units. An information system to support this entity must not simply be a system integrated through the use of Integrated Package Software; rather, it must be constructed as a separate system for the business process unit. By this means, it is possible to construct an information system, which is maximally tailored to the unit, without any need to consider other business process units.

2.4 Functions necessary for coordination of core-business workflow systems

There exist various workflow systems within a company, but the nucleus consists of the workflow systems attached to core-business business processes. Such a workflow system must ultimately be continuous from order receipt through to shipment; other workflow systems must either occur independently, or must be linked to the former. When constructing core-business information systems operating under an integrated database for each business process unit, it is relatively easy to obtain a consolidated workflow system extending from order receipt to delivery by constructing core-business workflow system under the core-business database.

However, business and manufacturing use information systems, which are specific to business process units, whereas accounting, materials procurement and other common tasks may be referred to as single systems for the entire business group. In such cases, coordination of core-business workflow systems becomes necessary. Figure 2 shows an example of construction of individual workflow systems in each company. In the figure, the business process units A and B and the materials division each operate under separate integrated databases.

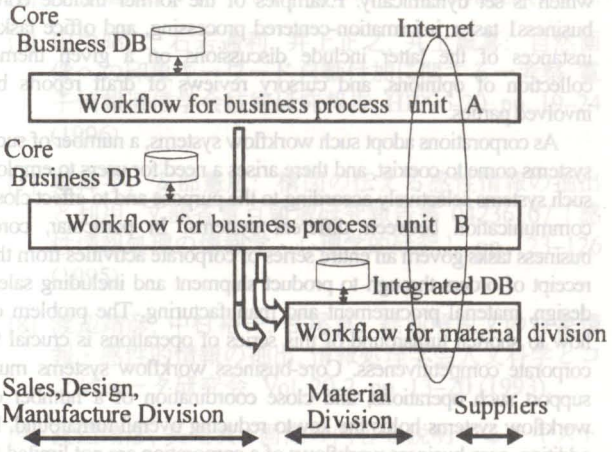

Fig.2 Sample of business workflow connection

The workflow system operating under business process unit A performs processing including the materials division and suppliers, but the ordinary ordering tasks performed in the materials division are executed in a workflow operating from the materials database. All of these workflow systems are coordinated with the workflow systems of suppliers via the Internet.

Broadly, there are four types of functions needed for coordination of core-business workflow systems. The first are functions enabling a single user to utilize different workflow systems without any sense of incompatibility or conflict. The second are functions for the smooth exchange of triggers and data between two workflow systems. The third group of functions ensures that the necessary parts of the integrated database can be readily accessed by different workflow systems. Finally, the fourth set is for connections with other companies via the Internet. These function groups are indicated in Table 1.

Table 1. Functions needed for coordination

Item	Function	Detail
User interface for multi-workflow system user	Function of Invent notifications	Mail systems must send mail as triggers for same user interface (Same reception box)
Triggers for each other systems	Ability to call another workflow processing object	Each object can call other processing object
	Ability in distributed environment	Each object can call other object by CORBA interface
Database access	Each tasks can access other core business database	Requirement for parts of other core business databases mapping into a virtual local database
Connection with other companies	Coordination function by networks	Coordination by mail or CORBA

3. Proposal of a Model for coordination of Core-Business Workflow Systems

3.1 Characteristics of the Model

We next propose a coordination model, which satisfies these conditions. In this model, coordination is achieved between the workflow systems of multiple business process units of a given company, and there is also coordination with the workflow systems of other companies

This model has 4 characteristics. First it has the unique organizational database. In this database all information for deciding workflow path is include. Second in integrated database for each core business unit it has a mapping data for other core business database partially. Third it has workflow coordination objects and these objects absorb difference of the interface for different workflow engines. Last it has a function of connection by e-mail for other companies.

3.2 Architecture of the Model

The architecture of the model appears in Fig. 3. In this figure, the coordination model comprises the following.

(a) Workflow engines: These govern the entire workflow system, and exist separately for each workflow type. In the figure, there are three workflow engines, 2 engine exist within the system of company A, whereas another engine exist in suppliers and other companies B.

(b) Organizational information: This is information pertaining to the organization; it is used to identify the actual individuals in a specified organization (for instance, superiors). Even when there are multiple integrated databases, the information for the overall organization is collected in a single place, and all workflows reference this information. This organizational information includes organizational information for related companies in part.

(c) Processing objects: These are processing units for individual tasks. There exist object groups corresponding to business processes for each core-business task, and links are created between these objects through workflow processing.

(d) Workflow coordination object: This is a specialized object used to trigger startup between workflow processes. The coordination object for workflow A starts the coordination object for workflow B, and this workflow B coordination object sends an event notification to workflow engine B, to start workflow B. When workflow systems are coordinated via e-mail, the situation is similar. The purpose of the coordination object is to consolidate the interface for coordination and to eliminate the need to modify engines in order to coordinate with other workflow engines.

(e) Integrated database: The workflow system operates based on an integrated database, and each processing object executes business processes drawing on this database. However, when passing from workflow A processing to workflow B processing, what is processed by the processing object is the integrated database of business unit B. Processing in succession to workflow A requires that the integrated database for A be accessed; this is accomplished by mapping it to part of the integrated database of B.

(f) Mail server: When in a workflow the processing for one object is completed, the mail server sends mail notifying the person to perform the subsequent processing of this fact. The mail server ensures the timing wherein a workflow engine receives the completion event for processing of an object and triggers startup of the next processing object. When the mail server receives mail for a specific address, the attached file is stored in the database, and an event notification is sent to the workflow engine stipulated by the mail address. Thus workflow coordination is achieved by means of Internet e-mail.

(g) User: When a user receives mail notification of a processing event, he or she calls up the task screen for processing and performs processing for the corresponding processing object.

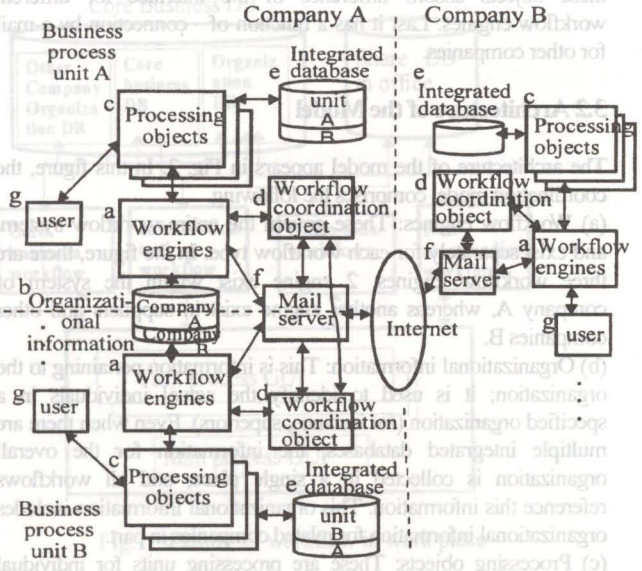

Fig.3 Architecture of business process connection model

3.3 Coordination processes

A series of coordination processes is as follows based on Fig. 4.

(1) The workflow engine A of company A is started by a user and this engine starts object A1 to process tasks. On completion of A1, control returns to the workflow engine, and then object A2 is started. Following A2 a coordination object(C0) of workflow engine A is started, and this trigger coordination object for workflow engine B ; the latter starts workflow B and also passes any necessary information. The definition of the workflow includes definitions of the order of processing of a series of processing objects and of the organization processing them; by passing the definition number and other information using a coordination object, coordination of workflow engines is achieved.

(2) Workflow engine B is started and processing for objects B1, B2 is performed. The coordination object following the processing object B2 is started, and by means of information passed from the engine it is learned that the next object to be started is across the Internet, so that e-mail is sent to the mail server of company B. At this time, the information to be passed is read from a database and sent as a mail attachment.

(3) On receipt of e-mail from a specific address, the mail server of company B starts the coordination object, and the latter starts the workflow engine C. The attached file information is stored in a database.

(4) The workflow engine C starts processing objects C1 and C2 in succession, to execute task processing. Finally the coordination object is started, and by this means mail is sent to the workflow engine B of company A; at the same time, the information to be passed is read and is included as an attached file.

(5) On receipt of mail from a specific address, the mail server of company A starts the coordination object, which in turn starts the workflow engine B and stores the passed information in a database. By this means, control is again returned to the engine B.

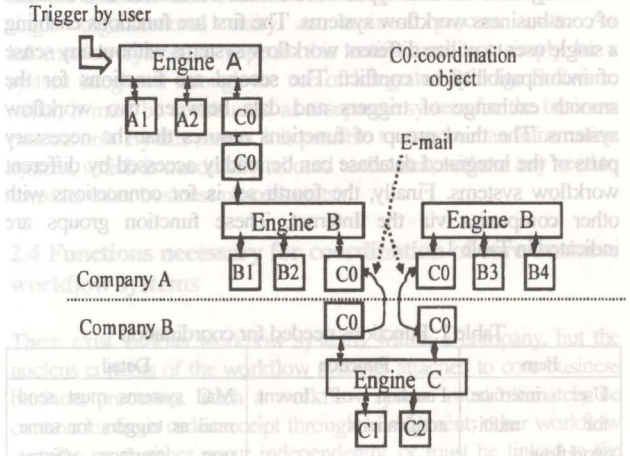

Fig.4 Flow of workflow in business process connection model

4. Construction and Verification of the Proposed Model

4.1 Business processes for applied tasks

In order to verify the efficacy of this model, we constructed an actual system. This system coordinates the processing systems of a certain business process unit and of the materials division at which the coordinating system is located. Tasks handled by the business process unit consist of estimate assessment for software procurement; after evaluating prices, the unit coordinates with normal material ordering task processing.

Software estimate assessment consists of a series of tasks--creation of an estimate request by the design division of the business process unit, issuance of an estimate request to the supplier, assessment of the estimate returned by the supplier, and determination of price. Material tasks include ordering, receipt of delivery, acceptance of delivery and calculation of totals; these tasks are common to normal material procurement tasks requested by other business process units. The order of processes is illustrated in Fig. 5.

In the figure, business process unit A is a software system integrate business unit and business process unit B is a business for order-to make based hardware products. Processes from order receipt until part procurement or determinations of software costs are greatly varied, but from the figure we see that ordering tasks in the materials division are themselves common among processes.

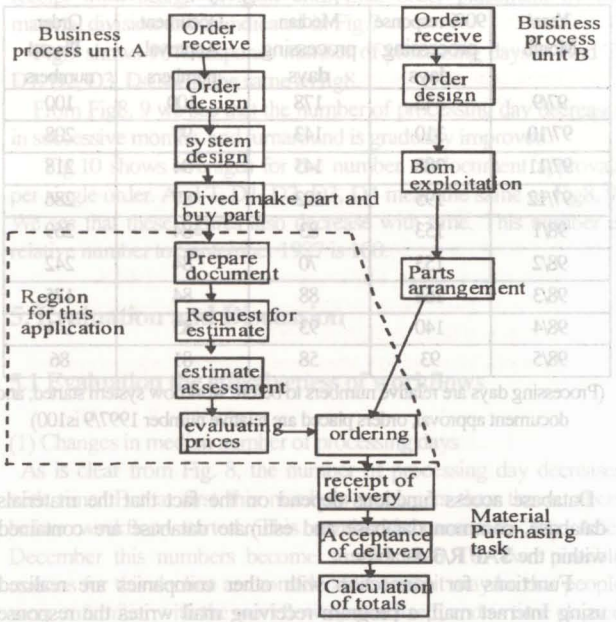

Fig.5 Business process of application

4.2 Architecture of the verification system

Figure 6 shows the architecture of the system used in verification. The roles of the components in the figure are as follows.

(a) SAP R/3 system: An Integrated package system, operating as one subsystem of the materials system.

(b) Materials system: This performs materials procurement tasks, including ordering, receipt of goods, acceptance inspections, and calculation of totals. Each processing object operates based on the workflow engine.

(c) Workflow engine: One part of the SAP R/3 functions; the engine includes workflow control and route registration functions. Each processing object is started by an event from the engine, and the engine is notified of the completion of object processing. By repeating this process, the engine controls the workflow.

(d) Estimate assessment system : This system is provided for each business process unit, and consists of processing objects for preparation of an estimate request in the design division, request approval, approval in the materials division and transfer to suppliers, receipt of responses from suppliers, approval of assessment in the design division, and determination of price in the materials division. This estimate assessment system employs the SAP R/3 workflow engine; engine event startup utilizes RFCs (remote function calls), and startup of processing objects by the engine is based on OLE (object linking and embedding).

(e) Mail system : This is used by a workflow engine to notify a user of an event to be processed. In addition, estimate requests and attached documents are sent via mail to suppliers by one processing object of the estimate assessment system. Responses from suppliers consist of startup of a processing object by receipt of mail with a specific address; by storing the attached information in a database and using an RFC to start a workflow engine, the process is again transferred to a workflow.

(f) Materials database: A database used in operation of the materials system.

(g) Estimate database: A database used in operation of the estimate assessment system.

(h) Common database: A database used in common by the materials system and by the estimate assessment system; it contains shared information such as company codes for suppliers, as well as information passed between the two systems. These three databases each constitute part of the SAP R/3 database.

(i) Supplier estimate systems : Suppliers respond to receipt of mail from workflows with this simplified workflow system based on e-mail and attached files.

4.3 User actions and system operation

Figure 7 shows the flow of actions actually performed by persons performing registration and approval. There also exist refusal processing in the estimate assessment workflow wherein a result is refused and returned to the person responsible for the immediately preceding processing, and return processing in which the materials division refuses a result and returns it to the design division. In return processing, a result is returned by the materials division to a manager in the design division, and the latter manager returns the result to the person responsible.

At the end of price determination in the materials division, the flow of processing is linked with the materials task workflow and actual ordering is performed. For each of these documented approval processes there are rules for bypassing normal processing according to the supplier and amount involved, without passing through all steps.

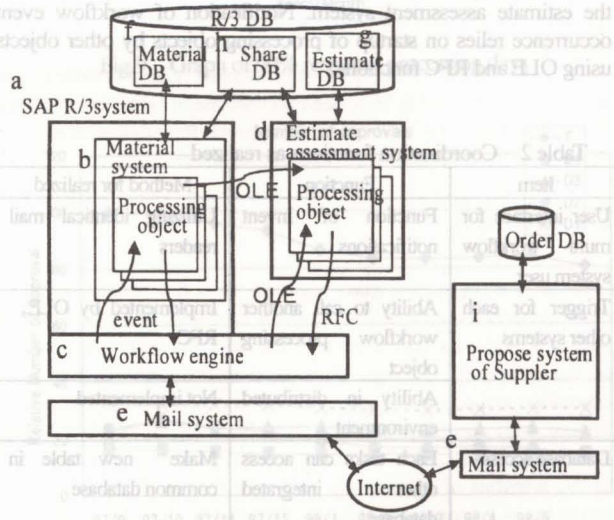

Fig.6 Architecture of verification system

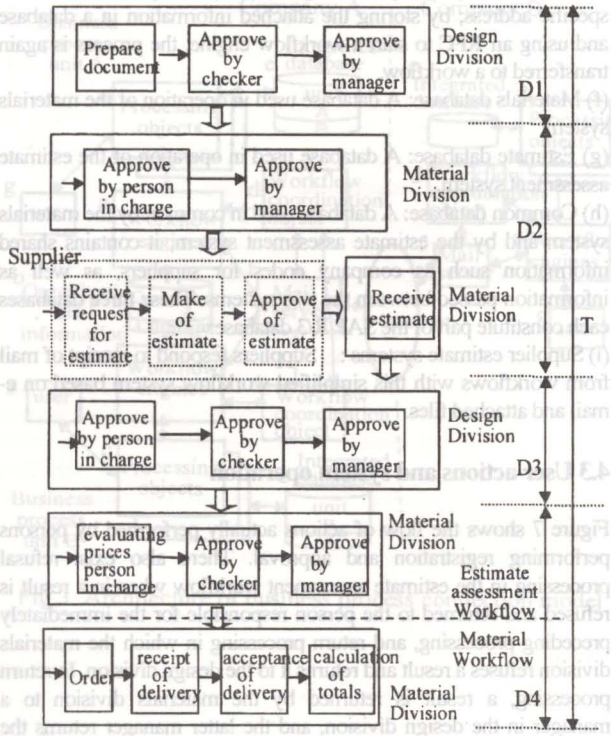

Fig.7 Flow of workflow operation

4.4 Implementation of coordination functions

Table 2 shows the details of coordination functions as realized in the verification system. Interface integration is achieved on the user's end by utilizing identical mail readers in the materials system and in the estimate assessment system. Notification of workflow event occurrence relies on startup of processing objects by other objects using OLE and RFC functions.

Table 2 Coordination functions as realized

Item	Function	Method for realized
User interface for multi- workflow system user	Function of Invent notifications	Utilizing identical mail readers
Trigger for each other systems	Ability to call another workflow processing object	Implemented by OLE, RFC
	Ability in distributed environment	Not implemented
Database access	Each tasks can access other integrated database	Make new table in common database
Connection with other companies	Coordination function by networks	Implementation by E-mail function

Table 3. Number of processing days in workflow

Year/ Month	90% response processing days	Median processing days	Document Approval numbers	Order Placed numbers
97/9	345	178	100	100
97/10	310	143	97	208
97/11	288	145	94	218
97/12	195	123	87	286
98/1	153	83	84	269
98/2	153	70	84	242
98/3	168	88	84	175
98/4	140	93	85	141
98/5	93	58	81	86

(Processing days are relative numbers to before workflow system started, and document approval, orders placed are relative number 1997/9 is100)

Database access functions depend on the fact that the materials database, common database and estimate database are contained within the SAP R/3 database.

Functions for connection with other companies are realized using Internet mail; a program receiving mail writes the response contents to a database and then creates a processing object to notify a workflow engine of the event

4.4 Processing contents

Table 3 shows the number of order placed document in this system for each month from September 1997 through May1998. Number of users of this workflow system is about 8 hundred at May1998, and number of order placed in this term is about 1700.The numbers in table3 are relative number 1997/9 is100. Since initiation of the system in August 1997, the number of order placed has increased due to expansion of the workplaces in question.

In addition, Table 3 shows the number of processing days from the first issue of a request by the design division until final order placement by the materials division. The table shows median and 90% response numbers of processing days. These numbers are relative numbers to the median days before this workflow system started. Here median numbers are used instead of averages in order to eliminate the effects of anomalous numbers due, for instance, which cannot be processed owing to some problem.

And Table3 also shows average numbers of document approval these are relative number to September 1997 is 100.

Fig.8 shows median number of processing days. In this figure there are 5 graphs. T shows total processing days from the first issue of a request by the design division until final order placement by the materials division as shown in the Fig.7. In this graph when processing days is 100 it is as same as before workflow system started. D1 shows proceeding days from the first issue of a request in design division until pass to material division as it is indicated in Fig.7. D2 shows processing days from receipt by material division until return from suppliers as it is indicated in Fig7. D3 shows processing days of receipt from material division until end of design division as it is indicated Fig7. And D4 shows processing days of

receipt from design division until final order placement by the material division as it is indicated in Fig.7

Fig.9 shows 90% response number of processing days. And T, D1, D2, D3, D4 show the same as fig8.

From Fig8, 9 we see that the number of processing day decreases in successive months, and turnaround is gradually improved.

Fig.10 shows averages for the number of document approvals per single order. And T, D1, D2, D3, D4 mean the same as Fig8, 9. We see that these figures also decrease with time. This number is relative number to September 1997 is 100.

5. Evaluation and Discussion

5.1 Evaluation the effectiveness of workflows

(1) Changes in median number of processing days

As is clear from Fig. 8, the number of processing day decreases with time. But at first this numbers are lagers than the numbers before workflow started (This number is named to T0). After December this numbers become smaller than T0. Two possible reasons for this decline are considerable. First, it may be that people were unfamiliar with the workflow system itself, and as time elapsed they became familiar with the system, with a resulting decrease in the time required for processing. Or, it may be that by transferring operations to a workflow system, processing really is streamlined compared with conventional procedures. From September 1997 through December 1997, the workplaces involved were successively expanded, with many new users; though this effect is not immediately apparent, once the bulk of the expansion had been completed, the number of days for processing began to decline under To. From Fig.8 the most effective element of this decline is D2. This D2 consist by from sending request by material division until return from supplier. In this system, the workflow of suppliers is coordinated by e-mail over Internet, and this too is expected to have had a significant effect

In March and April number of processing days increases a little, this is because by end of fiscal year's congestion. Increases of D4 in March suggest this. In these month number of order placed are not increases, but material procurement division is very busy for other procurement works other than software.

(2) Changes in 90% response number of processing days

As is clear from Fig9, the number of 90% response of processing days decreases constantly than the decreases of median number. This means decreases of deviation of processing days. There is a significant result of adoption of workflow systems. From this graphs the element of this decreases are D2 and D1. The effect of D2 is as the same (1). The effect by D1 is thought that by adoption of a workflow system, past cases could be referenced as templates in preparing estimate requests, and the consequent learning effect resulted in fewer processing returns in the design division.

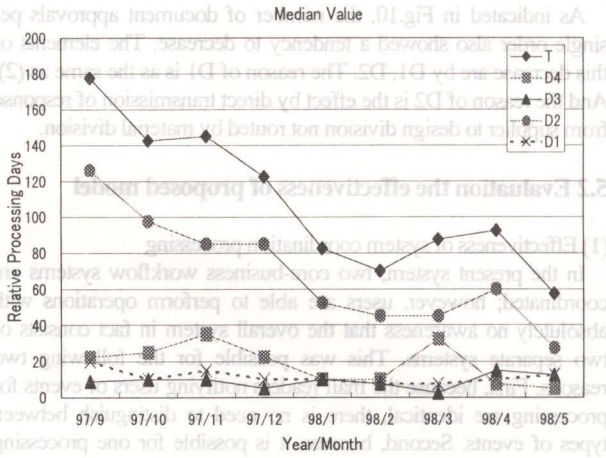

Fig.8 Graph of median processing days

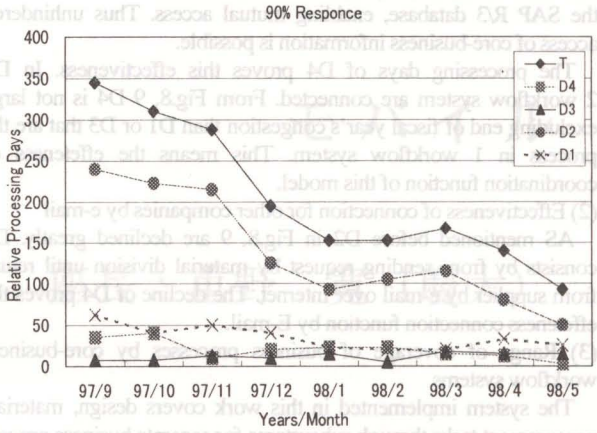

Fig.9 Graph of 90% response processing days

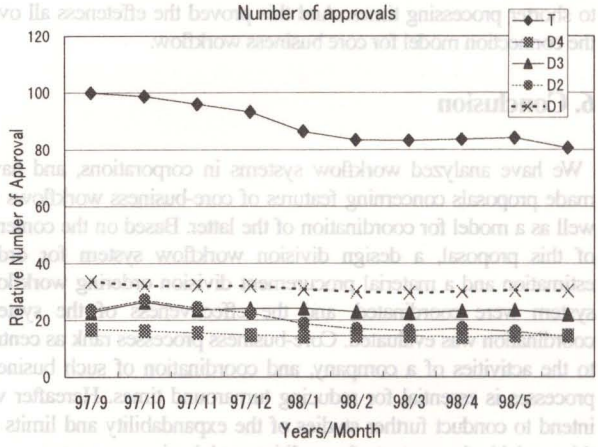

Fig.10 Graph ofnumber of approval document

(3) Changes in number of document approvals per single order

As indicated in Fig.10, the number of document approvals per single order also showed a tendency to decrease. The elements of this decrease are by D1, D2. The reason of D1 is as the same as (2). And the reason of D2 is the effect by direct transmission of response from supplier to design division not routed by material division.

5.2 Evaluation the effectiveness of proposed model

(1) Effectiveness of system coordination processing

In the present system, two core-business workflow systems are coordinated; however, users are able to perform operations with absolutely no awareness that the overall system in fact consists of two separate systems. This was possible for the following two reasons. First, because the mail readers notifying users of events for processing are identical, there is no need to distinguish between types of events. Second, because it is possible for one processing object to start another processing object, processing screens appear smoothly in succession. These results demonstrate the efficacy of the coordination model. Further, all databases are constructed within the SAP R/3 database, enabling mutual access. Thus unhindered access of core-business information is possible.

The processing days of D4 proves this effectiveness. In D4 2 workflow system are connected. From Fig.8, 9 D4 is not large excluding end of fiscal year's congestion than D1 or D3 that are the process in 1 workflow system. This means the effeteness of coordination function of this model.

(2) Effectiveness of connection for other companies by e-mail

AS mentioned before D2 in Fig.8, 9 are declined greatly. D4 consists by from sending request by material division until return from supplier by e-mail over Internet. The decline of D4 proves the effeteness connection function by E-mail.

(3) Range of coverage of business processes by core-business workflow systems

The system implemented in this work covers design, materials procurement tasks through subsystems for separate business process units, and also handle materials procurement and supplier tasks in materials divisions, including most processing related to ordering as well. This is believed to have been another major factor contributing to shorter processing times. And this proved the effeteness all over the connection model for core business workflow.

6. Conclusion

We have analyzed workflow systems in corporations, and have made proposals concerning features of core-business workflows as well as a model for coordination of the latter. Based on the contents of this proposal, a design division workflow system for order estimation and a material procurement division ordering workflow system were coordinated, and the effectiveness of the system coordination was evaluated. Core-business processes rank as central to the activities of a company, and coordination of such business processes is essential for reducing turnaround times. Hereafter we intend to conduct further studies of the expandability and limits of this model in the context of expediting such business processes.

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