A human–computer interactive approach based on activity–section analysis for BPR

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Abstract. In any business process reengineering (BPR) project, a thorough understanding of various tasks and activities of the organization is required. Very often this idea is captured using a simple flow chart or static representation diagram. The weakness here is that the process design complexity is not adequately represented by the use of flow charts, and this allows for limited human–computer interaction during the process design and analysis. In this paper, we propose an enhanced flow chart approach; the concept of activity–section flow chart to support BPR, which is a combination of the existing activity flow chart and section flow chart. Using this approach, a human–computer interactive model for BPR is developed. This model can identify the unreasonable activity loops and excessive business rounds between sections by the adjacent and reachable matrices. Via the human–computer interaction, the process can be revised by human experience. This approach provides an efficient tool for BPR of large-scale systems. It has been applied to the material supply management system of an iron and steel works, and satisfactory results have been achieved.

1. Introduction

Since Hammer and Champy (1993) first proposed the concept of business process reengineering (BPR), it has been applied to many enterprises for the improvement of their organizations and business processes. BPR is regarded as a revolution of enterprise management and can swiftly put a management system in order and increase its work efficiency. Consequently, those enterprises adopting BPR achieve the greater benefits of enhanced competitiveness (Evans et al. 1995). In the BPR project, Davenport and Short (1990) identified...
the importance of ‘the analysis and work flows and processes within and between organizations’. They observed that while process thinking has gained acceptance, the majority of organizations concerned about ineffective business processes tend to try to improve each individual process with the result that overall processes may actually be rendered slower and less effective than before. This view is also acknowledged by Morrow and Hazell (1992), and Harrington (1991) who agreed the need for a complete redesign of the total process. Katz (1990) proposed the enterprise analysis technique for BPR using meta modelling and model building. However, owing to the fact that the BPR often cuts across organization boundaries and the design is often complex as it relates to social and human factors which are difficult to model mathematically, the BPR design and analysis cannot be supported effectively by computer.

The approaches to model BPR by different kinds of flow charts have been discussed in some literatures. Kusiak et al. (1994) described the activity flow by IDEF modelling tools (Mayer et al. 1992, Colquhoun et al. 1993), and the process cycles can be found by matrix triangularization algorithm. Huang (1997) suggested an approach to describe the activity flow by the hyper graph, and the business sections were redivided by the strongly connected activities. Yang and Liu (1998) proposed a method to describe the information flow between business sections for BPR analysis. These different approaches have different advantages and disadvantages. There are also some commercial BPR software packages available, e.g. i-Think, ProcessModel and Optimal! (High Performance System 1996, Promodel Corporation 1996, Zhu and Zuo 1997). Most of these are based on activity flow chart and simulation procedures.

In this paper, we combine the activity and section flows into one chart called the activity–section flow chart, and developed a human–computer interactive approach to support BPR applications. This procedure can identify the unreasonable activity loops and excessive business rounds between sections by the adjacent and reachable matrices (Bond and Murty 1976, Sage 1977, Wang 1981). Via the human–computer interaction, the process can be revised by human experience. The approach provides an efficient tool for the BPR of large-scale systems. It has been applied to the material supply management system of an iron and steel works, and satisfactory results have been achieved.

The rest of this paper is organized as follows. Section 2 contains the description method for the business process by the activity–section flow chart. The human–computer interactive approach for BPR is discussed in section 3. The application of the recommended approach to the material management process of an iron and steel works is presented in section 4. Finally, the conclusions are given in section 5.

2. Description of business process by activity–section flow chart

2.1. Activity–section flow chart

The activity–section flow chart is a combination of the current activity flow chart and the section flow chart. It
describes each activity and its appropriate section by a box-type representation, which is the block element of the chart. The upper half of the box denotes the activity or its code, and the lower half denotes the section bearing the activity or its code. The block of activity–section flow chart is shown in figure 1.

The connected boxes consist of an activity–section flow chart to describe a business process. For example, the chart in figure 2 represents a simplified process of purchase contracting. In figure 2, the codes of activities represent:

1. purchase planning;
2. planning approval;
3. goods checking and bargaining;
4. price examination and approval;
5. reselecting supplier;
6. signing purchase contract.

The meanings of the section codes are:

(A) purchase section;
(B) office director.

2.2. Activity cycle and section round

The adjacent matrix of an activity–section flow chart, \( A \), is defined as:

\[
A = [a_{ij}]_{n \times n}, a_{ij} = \begin{cases} 
1, & \text{Activity } j \text{ just follows activity } i, \\
0, & \text{Otherwise} 
\end{cases}
\]

where \( n \) is the number of nodes (boxes) in the chart, i.e., the number of activities involved in the process.

From the activity–section flow chart, we can see that the activities corresponding to the columns which have all the zero elements in \( A \) are the input activities of the process described by the chart. Similarly, the activities corresponding to the rows containing all the zero elements are the output activities. For any business process, it is possible that more than one input or output activities exist.

The reachable matrix of activity–section flow chart, \( R \), is defined as (Sage 1977):

\[
R = (I + A)^{n-1},
\]

where \( I \) is the identity matrix.

Let matrix \( Q = R \cap R^T \). If there are any rows with more than one non-zero element in matrix \( Q \), this means that connected loops exist. The non-zero elements in a row consist of a loop. We refer to the loop as an activity cycle. If the activities in an activity cycle are borne by more than one section, we refer to the cycle as a multi-section activity cycle.

Assuming that a pair of activities \( i \) and \( j \) are the input and output activities of a process, respectively, if the element in matrix \( R \), \( r_{ij} = 1 \), there exists at least one continuous activity chain between activities \( i \) and \( j \). Let the set \( R(i) = \{k | r_{ik} = 1\} \) be the reachable node set of activity \( i \) and the set \( S(j) = \{k | r_{kj} = 1\} \) be the source node set of activity \( j \), then, the activity chains between \( i \) and \( j \) can be found by the intersection set \( P(i,j) = R(i) \cap S(j) \).

For a given activity chain, we can obtain its corresponding section chain by linking the sections to bear these activities in sequence. For any pair of sections A and B in the section chain, a business round between A and B is referred to as a section round. The time of the section round between the section pair is referred as the number of section round. We delete all other sections in the section chain except A and B, and unite the repeated A and B. Let \( k \) be the number of the remaining sections in the chain. Then, the number of the section round between A and B is

\[
m(A,B) = \lceil(k-1)/2\rceil,
\]

where \( \lceil x \rceil \) stands for the integer less than or equal to \( x \).

2.3. Example for description method

For the activity–section flow chart shown in figure 2 to represent a purchase contracting process, its adjacent matrix \( A \), reachable matrix \( R \) and matrix \( Q \) are as follows:
From $A$, we know that activities 1 and 6 are the input and output activities, respectively. From $R$ we see $r_{16} = 1$, which means that there are activity chains between activities 1 and 6. And from matrix $Q$, we find that the activities 3, 4 and 5 compose an activity cycle. This is also a multi-section activity cycle.

For this activity cycle:

$$1 \rightarrow 2 \rightarrow 3 \rightarrow 4 \rightarrow 5 \rightarrow 3 \rightarrow 4 \rightarrow 6,$$

the corresponding section chain is:

$$A \rightarrow B \rightarrow A \rightarrow B \rightarrow A \rightarrow A \rightarrow B \rightarrow A.$$

By deleting and uniting the redundant sections, we obtain the section chain:

$$A \rightarrow B \rightarrow A \rightarrow B \rightarrow A \rightarrow B \rightarrow A.$$

This has seven elements. From equation (3) we know that the number of section round between sections $A$ and $B$ is: $m(A, B) = 3$.

The description method can be easily implemented by computer program. Thus, the operators need only to input the activities and the bearing sections of the concerned business process, the activity cycles, section chains and the section rounds can all be found by the computer.

### 3. Human–computer interactive approach for BPR

#### 3.1. Problem analysis for the business process

To realize BPR, the first key work requires an analysis of the existing problems in the business process. The activity–section flow chart is able to support this work.

If an activity cycle exists in the process, this means that some business operations are possibly undertaken repeatedly. Especially for multi-section activity cycles, this may become a ‘dead cycle’ due to the fact that sections may possibly be uncooperative and shift responsibility to others. Thus, the business process could become delayed.

If there are too many section rounds involved in a business process, this means that business processes have to be transferred between two sections many times. Thus, the processes would progress very slowly.

Therefore, appropriate reengineering should aim at improving all the existing activity cycles and reducing the section rounds as far as possible. In addition, as the application of information technology to business processes it should be considered which activities can be borne by computers instead of sections in reengineering.

#### 3.2. Human–computer interactive approach for BPR

As discussed above, the problems existing in any process can be found and used by computer to determine the activity cycles and section rounds in the activity–section flow chart, but the process modification which includes activity removing and uniting depends mainly upon working experience. This cannot easily be replaced by computers. In addition, those activities that can be aided by computers depend upon the enterprise condition and the type of the activity, and these also have to be pointed out by staff. Thus, we propose the human–computer interactive approach. Its step by step procedure is described as follows.

Procedure HC

**Step 1.** Analyse the current business process and draft its activity–section flow chart.

**Step 2.** Input these activities, their bearing sections and the adjacent relations of these activities into the computer.

**Step 3.** Based on the adjacent relation of activities build the adjacent matrix $A$ using equation (1), and find the input and output activities.

**Step 4.** Calculate the reachable matrix $R$ and matrix $Q$ from equation (2), and determine all the activity cycles and activity chains.
Step 5. Find out all section chains corresponding to the activity chains, and calculate all the numbers of section rounds from equation (3).

Step 6. Display the activity–section flow chart and show all existing activity cycles and the activity chains with the number of section rounds greater than 1.

Step 7. If the operator is satisfied with the current activity–section flow chart or there is no way to modify the process, output the current chart and stop. Otherwise go to step 8.

Step 8. Remove, unite or add activities by the operator, and point out which ones can be aided by computer. Input the modification into the computer. Then, go to step 3.

3.3. Example for the BPR approach

For example, in the activity–section flow chart for the purchase contracting process shown in figure 2, the computer shows us that activities 3, 4 and 5 comprise a multi-section activity cycle and the number of section rounds between section A and B is 3, i.e. \( m(A,B) = 3 \). The computer suggests that the operator should modify the process.

After the study, the operator decides to merge the part function of activity 4 into activity 2. This means that the office director will give the price limitation when he/she reviews the purchase planning, and the data management will be performed by the computer. On the other hand, those small purchases which previously do not have to pass the approval procedure will now be required to do so. This modification prevents money leaking away from the enterprise. Another modification is to change the bearer of activity 4 (purchase approval) from the office director to the purchase section aided by computer. The computer checks the purchase contract input by the purchaser. Only those contracts with a price limitation can be printed out. Thus, the contracts beyond the limitation are not signed. Then, activity 5 is removed. After making the above modifications, we obtain the updated activity–section flow chart as shown in figure 3. We can see that there is no activity cycle in the new process and the number of section rounds is just 1.

In figure 3, the codes of activities represent:

(1) purchase planning;
(2) planning approval and price limiting;
(3) goods checking and bargaining;
(4) price examination and output;
(5) signing purchase contract.

The meanings of the section codes are:

(A) purchase section;
(B) office director;
(C) computer.

4. Application of the approach

The recommended BPR approach was developed for the material supply management system of a large iron and steel works in eastern China. The functions of the system include the purchase, distribution and selling of thousands of kinds of metals, and electrical, chemical and construction materials. The purchase budget per year is over RMB 1.6 billions. The business process includes 31 main activities and six sections. Its activity–section flow chart is shown in figure 4. In figure 4, the codes of activities represent:

(1) requirement submitting;
(2) requirement book in;
(3) store amount checking;
(4) balance of requirement and store;
(5) purchase planning;
(6) planning approval;
(7) goods checking and bargaining;
(8) price examination and approval;
(9) reselecting supplier;
(10) signing purchase contract;
(11) contract implementation;
(12) invoice checking;
(13) pay bill implementation;
(14) account booking in;
(15) financial reporting;
(16) goods examination;
(17) goods acceptance bill;
(18) quality dissent;
(19) goods checking in;
(20) store accounting;
(21) store reporting;
(22) application for material drawing;
(23) book draw billing;
(24) draw examination;
(25) material issuing;
(26) selling requirement;
(27) store amount checking;
(28) book selling bill;
(29) gathering and bill stamping;
(30) selling goods issuing;  
(31) reject selling.

The meanings of the section codes are:

(W) work shops;  
(P) purchase section;  
(M) office manager;  
(S) storekeeper section;  
(F) financial office;  
(E) other enterprises.

By inputting the above activity–section flow chart into the computer, the computer displays that there are three input activities: requirement submitting, application for material drawing and selling requirement; and four output activities: financial reporting, store reporting, quality dissent and reject selling. A multi-section activity cycle including activities 7, 8 and 9 also exists. The number of section rounds of sections P and M in the activity chain between activities 1 and 18 is \( m(P, M) = 3 \), and that of P and S is \( m(P, S) = 2 \). The computer suggests modification of the process to solve these problems.

After study, the operator first unitizes 14 with 20, and 15 with 20. This means that the separate financial and store accounts are united to one account. To remove the activity cycle, the part function of activity 8 is merged into activity 3. This means that the office manager will give the price limitation when he reviews the purchase planning, and the data management will be performed by the computer. On the other hand, the small purchases which previously were not required to pass the approval procedure must now do so. The modification prevents loss of earnings for the enterprise. Another modification is to change the bearer of activity 8 (purchase approving) from the office manager to the purchase section aided by computer. The computer will check the purchase contract input by the purchaser. Only those contracts with the price in the limitation can be printed out. Thus, the contracts beyond the limitation are not signed. Then, the activity 9 is removed.

After several interactions between operators and computer, some activities are removed and others are added. They obtain the updated activity–section flow chart as shown in figure 5. There are 26 activities in the new chart, and nine of these aided by computer. We can see that there is no activity cycle in the new process and all numbers of section rounds are no more than 1. A satisfactory result has been achieved. After implementing BPR, the material management system greatly increased its profit. In figure 5, the codes of activities represent:

(1) requirement submitting;  
(2) requirement book in;  
(3) store amount checking;  
(4) balance of requirement and store;
5. Conclusion

This study shows us that BPR is necessary for the application of information technology to enterprise management. Without BPR, any success to be derived from the application of IT is unavailable. The proposed activity–section flow chart and the new concepts including activity cycle, section chain and section round provide an efficient tool for the application of BPR. The recommended human–computer interactive approach based on the chart has potential for various large-scale BPR applications.

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