Application of principles of event related open systems to business process reengineering☆

Chandrashekhar Chiplunkar, S.G. Deshmukh, R. Chattopadhyay*

Department of Textile Technology, Indian Institute of Technology Delhi, Haul Khas, New Delhi, India

Accepted 1 August 2002

Abstract

This paper is focused on analysing the complete business environment with the help of information technology. It takes into account various interactions between different business processes while conducting BPR exercise. It also provides a framework based on event diagrams to record logical flow and other relevant details, which can be used for design of an information system. The event diagrams are useful for intelligent information system design. This methodology can also be used to develop a system for system design. Each event can be analysed for requirement of data, operations and resources. Interactions between various forces, events, modules, applications can be shown through interaction diagrams. The paper also lists out the driving forces for BPR and their contents.

Keywords: System analysis and design; Business process reengineering; Inter-organisational information systems; Enterprise resource planning

1. Introduction

It has been recognised that for successful implementation of integrated information management solution, corresponding changes in business practices should take precedence. Schneider (1999) states that consultants believe that evolutionary change in business from ERP will not occur until organisations begin to reorganise their businesses around processes, which means pitching the old organisation chart and starting anew.

Business analysis is different from systems analysis and therefore existing Information System (IS) tools cannot be effectively used for business analysis. Business process reengineering (BPR)

has been revisiting industrial environment in different forms like Total Quality Management (TQM), Supply Chain Management (SCM), Enterprise Resource Planning (ERP) and so on. All these theories need support from a comprehensive information system to tackle the related issues. Process redesign is the essence of quality improvement programs or SCM exercise. Similarly other techniques, like ERP, are also based on process changes for better management of the business.

As one will notice TQM, SCM, ERP too try to analyse all business process to retain the existing customer base and to improve the market share by offering better quality product at reduced costs. These techniques focus on improving the product quality by maintaining the quality of raw material inputs, by controlling the processes through statistical methods and by arriving at optimum process sequence. SCM takes care of quality and markets through process variability and of demand variability, respectively. TQM takes care of supplier through different quality checks on supplier which include delivery time and supplier's flexibility while customer care is taken through customer relationship management to meet customer expectation through continuous design change. ERP software needs to have added capability to support TQM or SCM or BPR.

A product cycle includes many process related business areas, ranging from marketing, administration and production to raw material procurement. A highly competitive atmosphere made it imperative to look into problems of suppliers, as well. Additionally, the communication revolution made it possible to link different organisations to each other through an electronic data transfer facility. In this context, BPR needs to take into account all the factors that can affect business performance. It is also necessary to have a common platform to judge the overall effect of different forces on the ultimate business performance. Such platform should take care of conflicting requirements of different forces, if any, to arrive at standard business practices. The scope of this paper is limited to propose a BPR methodology based on Event Related Open Systems principles and to highlight its advantages over other methodologies offered in the literature. The recommended process is based on analysis of various drivers, which are described in this paper. The paper includes various factors, which need careful analysis. Study of these data needs is expected to bring out deficiencies or additional requirements of the current processes and products so as to improve the customer satisfaction. Thus, the methodology would provide the base for bringing about breakthroughs in the current processes and products because processes and products will have to be redesigned to remove the existing deficiencies and to incorporate additional requirements.

The objective of this paper is to propose a common platform for information systems analysis and design, and BPR. The organisation of the paper is:

- Section 2—Review of literature
- Section 3—The motivation for this paper
- Section 4—General description of BPR model
- Section 5—Driving forces for BPR
- Section 6—Role of Information Technology in BPR exercise
- Section 7—Project phases for BPR and IS
- Section 8—Broad data requirement for BPR exercise
- Section 9—Concluding remarks

2. Past studies

Authors' comments, which are pertaining to the literature presented, are given in the italic typeface.

2.1. Strategic drivers for information management solution

Pertti, Kati, and Erro (1998) reported key requirements for the information management solution, which are given in Table 1.

Authors have mentioned the strategic questions and drivers for information management solution in today's context, which are given in Table 2.

It may be noted that not only quality of information but quality of product should also be included in the strategic drivers for modern information management solution. In addition, employee satisfaction needs to be given due consideration while designing information management solution.

2.2. BPR methodologies

Bond (1999) made the following observations. Although systems analysis for designing information systems shares much in common with business process mapping, there are critical differences. System analysis methodology produces a logical model, which omits all extraneous details in somewhat

Table 1
Key requirements for the information management solution

Strategic direction and focus
Integration
Information coverage and availability
Flexibility and adaptability
Information quality (Relevance, Timeliness, Continuous Flow, Validity, Accuracy, Intelligibility, Accessibility and Visibility)
Decision making support and simplicity

Table 2
Strategic drivers for Information Solution

How to improve customer satisfaction through
Product availability
Delivery accuracy
Responsiveness and flexibility
Offer of value adding services
Improvement through effective feedback and learning
How to increase profitable sales revenue
How to improve efficiency of operations through eliminating unnecessary activities, reducing inventory and improving utilisation of assets
How to improve and support understanding of logical links and causalities in the supply chain
How to manage performance in real time, process based mode instead of traditional functional performance management
How to improve relevance, quality, timeliness and visibility of information

similar spirit to BPR. The approach is based on two views: entity relationship diagrams for data modelling and data flow diagrams for representing functions. A third view using an event driven process network, which serves as a macro representation complementing other two views, is advocated.

Proposing such view in addition to dataflow diagrams makes the technique too cumbersome. The kind of notation used in proposed methodology would not result in compact diagrams. Author has not presented any diagram for any of the business process based on suggested methodology. Event diagrams proposed by this paper obviates need for dataflow diagrams and give compact representation of the business processes, in addition.

This section, here onwards, summarises commentary of Valiris and Glykas (1999) on BPR methodologies. Valiris and Glykas (1999) stated that a plethora of BPR methodologies have appeared in literature in recent years. These can be classified into two main categories depending on the perspective they take in BPR. First one is management accounting perspective and another is information system perspective (Buttler-Cox, 1991; Lewis 1993; Morris & Bradon 1993; Morrow & Hazzel, 1992; Petrozzo & Stepper, 1994; Short & Venkatraman, 1992; Smith, 1993). Lately, a few methodologies have started to apply organisational theoretic principles to BPR. In the management accounting perspective, the analyst attempts to reorganise business process and use Information Technology (IT) as an enabler in their effort. In the IS development perspective IS developers need to understand and possibly reorganise business processes so that the introduction of IT has the highest possible impact on them.

Management accounting methodologies. These methodologies view organisation from process perspective. The process perspective has following factors (Harrington, 1991):

- Flow: The methods for transforming inputs into outputs
- Effectiveness: How well customer expectations are met
- Efficiency: How well resources are used to produce the output
- Cycle time: Time taken for transformation from input to final output
- Economy: The expense of the entire process

A simple process modelling technique like process diagrams or flow charts are used for business process modelling. IS methodologies use data flow diagram to analyse processes and add another structural perspective (data perspective) to process perspective.

Structural or data perspective. This perspective defines the static business elements or data elements. Data elements are usually modelled on entity relationship diagram (Chen, 1976). IS methodologies, which support both the process and the data perspective are called structured methodologies (Avison & Fitgerald, 1988; Gane & Sarson, 1977; Jones, 1980).

Behavioural perspective. A third behavioural perspective is also included in most of the IS methodologies. This perspective tells about networking of various processes involved in the process model. Thus, these methodologies include three perspectives of data, process and network. Lately object oriented designing techniques are also used to address these three perspectives. In comparison with accounting methodologies, IS methodologies provide richer models by incorporating two additional perspectives. However, IS methodologies, which try to model all three perspectives face problem of integration. The most significant problem comes from the fact that different modelling techniques built for different point of times for different purposes are amalgamated. The stress here is on modelling with an aim to understand the organisational environment. Issues like cost, cycle time reduction, steam lining and continuous improvement are not taken into account.

Organisational perspective. Organisational based methodologies add more elements to business modelling like people, their accountabilities and their roles. They are emerging due to the identification that IS do not provide model of the organisational setting based on organisation theory and as a result fail to understand the relation between organisational actors and business processes. Many enterprises have started to apply process management principle to business processes. BPR methodologies based on the manufacturing and the software development paradigms have proven to be more and more incomplete. Sherr (1993) incorporates a focus on people and their accountabilities to resolve this problem.

Organisational theory based methodologies actually represent a model of some business situation but lack sufficient level of abstraction to represent the business of IS design and implementation issues. Employees and their roles, for example appear as data entities in entity relationship diagram. People's actions and interactions appear as processes and data flows, respectively, in data flow diagram.

The aforementioned methodologies were developed for other purposes and were later re-labelled to fall under the BPR umbrella. Most of these re-labelled methodologies appear to have many limitations and there are only a few exceptions where methodologies were developed solely for BPR (Davenport, 1993; Hammer, 1993; Harrington, 1991; Morris & Bradon, 1993; Petrozzo & Stepper, 1994; Ould, 1992). However, even these methodologies, according to Valiris and Glykas (1999), are non-systematic and their emphasis is more on hands on experience and case studies. They have summarised limitations of existing methodologies as follows

- IS methodologies, which try to model all three perspectives face problem of integration. The most significant problem comes from the fact that different modelling techniques built for different point of times for different purposes are amalgamated. *This paper proposes a model, which provides well-integrated view of all business perspectives. All other views are tightly coupled with the backbone of event diagrams.*
- The stress in IS methodologies is on modelling with an aim to understand the organisational environment. Issues like cost, cycle time reduction, streamlining and continuous improvement are not taken into account. "That is, IS methodologies focus on the smooth functioning of the various processes of the organisation with the help of computerised systems. Other issues, such as, cost of product, cycle time reduction, streamlining of different processes and continuous improvement are not taken into account". *Proposed model does focus on these issues. It would be evident from the data elements that considered for arriving at suitable analysis base.*
- IS do not provide model of the organisational setting based on organisation theory and as a result fail to understand the relation between organisational actors and business processes. *Proposed model does focus on these issues like roles and responsibilities and takes into account various management theories like SCM, TQM, etc. to propose a common analysis and design tool for all.*
- There is a lack of systematic approach that can lead a process re-designer through a series of steps for the achievement of process redesign. Most of the existing methodologies are based either on real life experience with little attention on the modelling and analysis of the business environment or vice versa. *Proposed model takes into account various industrial practices in detail. It is aided with excellent tool for modelling and analysis of business environment. The approach for analysis is extremely systematic and simple one, which involves hierarchical breaking down the business to reach to smallest unit of event, which can be easily analysed for various aspects.*

- There is a big division in the BPR literature between methodologies that concentrate either on process improvement or process innovation. The main difference is on the way organisational change is understood. In the first case change is performed in an incremental fashion whereas in the latter in a radical way. However, in many cases a combination of the two approaches has yielded the most impressive results. *Proposed model provides a platform for analysis and design of existing processes along with analysis of market changes and technological changes to decide necessary course of action. It provides a base for process and product innovation. Such innovations then can be absorbed in the existing business depending on their viability.*
- There is a need for an integrated holistic and individualistic view of the organisation. Most methodologies concentrate on organisational processes without paying any attention to the roles and responsibilities of the employees that carry out the activities that compose these processes. *Proposed methodology supports both the views. It considers individual limits as well as combined limits of the business environment. It also takes into account roles and responsibilities of actors.*
- Most methodologies are oriented towards specialists rather than being oriented to be used by organisational managers and people who want to carry out BPR in their organisation. *Event diagram, a tool used for business process analysis and design, is useful from all angles: simplicity of construction and understanding, exhaustive coverage of procedures, quantum of information display, ease of modification and user participation.*
- Most methodologies use a more black and white approach. This sort of approach is characterised by narrow thinking without considering all the aspects of the business and arriving at decision based on one or two criteria, if that criterion is satisfied, decision is yes else it is no. For example, in some methodologies cost is the central issue whereas in others generic management and the use of IT are the main objective. *Proposed methodology gives importance to all three issues.*
- Most methodologies fail to recognise the importance of a diagnostic stage at the beginning of the redesign process. During this stage the BPR scope, mode and objectives are determined. *Proposed methodology is supported with an exhaustive questionnaire to diagnose the business and to arrive at the scope for improvement in sales, improvement in customer relation, improvement in supplier base, improvement in cycle time, improvement in machine uptime, improvement in cost savings and improvement in employee satisfaction.*
- There is inadequate support for storage and access of gathered information during and after the redesign process, especially for non-participants in the redesign exercise. *Suggested development of software would solve this problem.*
- Business modelling is performed using either inadequate descriptive notation from management accounting or through poor use of graphical notations that were created for software development and do not take into account organisational issues. *Proposed model makes use of easy to understand graphical notation and is supplemented with information related to different perspectives. For example, it allows to record information related to event analysis, data analysis, operation analysis and resource analysis.*
- Most of business analysis performed is based on subjective rather than objective analytical methods. *Proposed methodology provides for recording of all information in a manner, which can be handled by an information system. It implies that subjective information is broken down into small elements, which can be associated with individual events as an object or as an attribute of an object.*
- There is a lack of integrated tool sets that allow modelling and analysis of the business environment. Most of the existing tools for modelling come from the area of software development and usually

concentrate on conceptual business modelling. At present there is a lack of business analysis tools that are integrated with the business modelling ones. *As stated earlier, a single tool is proposed for system analysis and business analysis.*

- There is no formal underpinning to ensure consistency across models. When graphical notations are used in business modelling and business redesign there is no means of verifying the logical consistency of the resulting models. This creates a feeling of insecurity to the business process re-designer that his work might be undermined by the company's cynics. *Proposed tool takes a logical approach right from the beginning and consistency in all the perspective is maintained because all other views are derived from the event diagrams.*
- BPR is a new discipline that is in need of case studies that provide justification of the benefits it can provide to the organisation. BPR should be applied in different organisational contexts in different cultures and different organisation sizes. Most of the existing methodologies are applied in western countries where the business environment is more suitable to the BPR philosophy. *A sample case study was conducted to highlight scope for business improvements in a textile organisation and to judge the applicability of suggested event diagrams to achieve the visualised improvements.*

Valiris and Glykas (1999) suggested Agent Relation Morphism Analysis (ARMA) to take holistic view of organisation. In ARMA, the modelling of business environment is achieved with the use of three perspectives: the structural, behavioural and process. Models, which are advocated to analyse the business, are based on object oriented technology.

The event driven approach, proposed by this paper, is much simpler to analyse business than the object oriented one and everyone can contribute to the process of BPR as it is easy to understand by all levels. Valiris and Glykas have not explained modelling of business using suggested tools. Nor the explanation is available for how the proposed model (ARMA) is going to bridge gaps, which are mentioned earlier.

3. Motivation for the proposed model

Literature review reported in Section 2, points out to the deficiencies of the existing methodologies. The solution proposed by Valiris and Glykas (1999), to overcome these deficiencies is again a complex one, which is based on object oriented methodology. Object orientation requires object perspective in addition to three perspectives namely, data perspective, process perspective and network perspective. In addition, roles, responsibilities and cultural and human management issues need separate treatment. Exact procedure of building model is not described at length nor sufficient light is thrown on modelling tools used for this purpose. It is also not very clear how the proposed model (ARMA) is going to overcome deficiencies of existing methodologies.

The conceptual modelling tools described so far in the literature need assistance from each other to arrive at complete business model, which is different from information system model. Not a single tool is capable of analysing all aspects of business. The methodology (System Simulation Software, Chiplunkar, 1997a-c) proposed through this paper allows for analysis of the business and, at the same time, it has capability of providing necessary abstraction, which is essential for information systems. Although data model is required to analyse entity relationship and event relationship, it is not

done in isolation as it is done with other structural views. A need was also felt to divide organisation-balancing forces further with each having singular characteristics. An attempt is made to provide a methodology, which is simple and, at the same time, comprehensive enough to take into account all the four views—data, structural, behavioural and management theoretic.

4. General description of the model for BPR

The proposed model considers nine BPR drivers so that the minute detailing of the business processes can be taken into account before doing the exercise, while doing the exercise and after the exercise is over. The model is also useful to check the implementation status and to make process of on going change possible. The drivers are Market, Product, Finance, Technology, Process, Work Force, Culture, Environment and Project. Since the objective of the paper is to propose a common platform for the analysis and the design of information systems and BPR, consideration of nine drivers is very much in accordance with the essence of the topic. Without such detailing, it would be difficult to arrive at data and information needs of the business environment required for BPR and IS.

All these business forces interact with each other directly or indirectly and they are all connected through the information system. Each factor has its own sphere of operation, which is included within the large business sphere. Business sphere decides the boundaries of business operation. Information travels to and from one sphere to another in the form of data elements and, in the process, changes the values of the basic data elements that decide the behaviour of the individual sphere and therefore, the behaviour of the business sphere (Fig. 1).

Table 3 describes Fig. 2.

The sequence of operation is according to the importance attached to the various drivers. The foremost important factor is the market because the majority of changes are market driven. Then, it

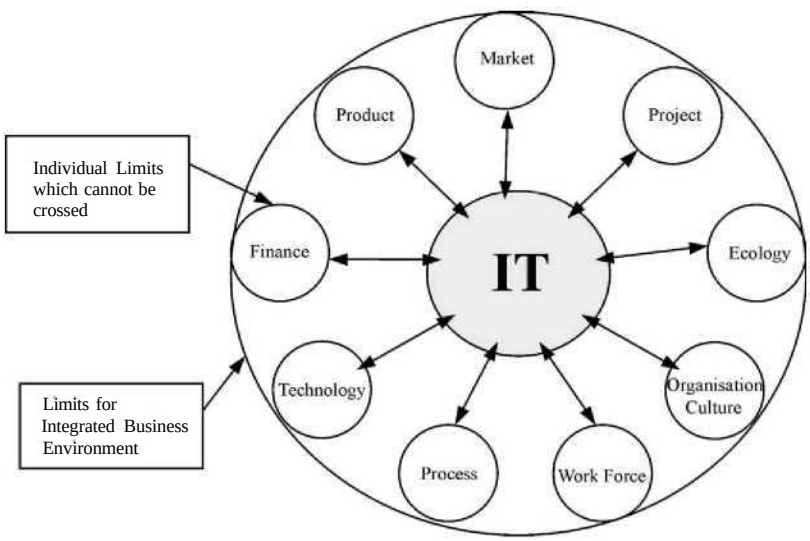

Fig. 1. Business process reengineering.

Table 3
Areas addressed through the proposed model

	Area coverage	Provides for additional requirements
1	BPR, CRM, SCM	The model takes into account capacity and material planning, supply bases and markets of suppliers and partners and customers
	Partial	The model can be supplied with interfaces with other analytical tools, which help managers making decisions about their day to day activities and strategic planning. Events can be introduced in the model, which will transfer the information from database to such tools and accept the results back
2	PDM	Provides ways and means for systematic treatment of product parameters in product development module. Parts requirement can be exploded once the bill of material is ready
	Partial	Interconnection with CAD software to capture product parameters is not provided in the current model
3	KM	Provision can be for problem analysis and data mining. System is also expected to learn of its own the decision making patterns by capturing the relative information from certain fields and then processing that information through the problem analysis or trouble shooting module. A general trouble shooting module can be provided for construction of analysis for wide variety of objectives and problems. It can keep the track of different variables that led to a particular decision, thus helping in arriving at rules of business governance
	Partial	Procedures for capturing knowledge from various information elements are not fully visualised
4	CM	It is clear from the earlier analysis that with the event diagram all the four views of an organisation can be analysed and, in addition, they are tightly coupled with each other because everything rests on a strong backbone of the event diagram. Thus conceptual modelling is thus taken care of
	Complete	
5	ERP, DW, DP, MIS	All the data and operation needs of ERP, DW can be well addressed through the current framework
	Complete	
6	PM	Model also provides for planning and management of projects, thus, covering the area of PM. Different paths from source to destination can also be visualised through suggested event diagrams. Additionally, it also facilitates time and resource analysis for each event of a project
	Complete	
7	DSS	A separate trouble management module can also be provided to help building analysis to offer solution to problems
	Partial	Interaction with analytical tools is not defined
	SAD, SDSAD	SAD can be divided into sequence of events and, therefore, SAD can be treated as any other computerised system. SD is then taken care of automatically through a set of central programs, which would run the supplied design without any development efforts. It is a step towards Code-less DBMS, which is capable of running the system from the supplied design without involving substantial development efforts. Chiplunkar (1997a-c) suggested a prototype of file based DBMS named as EASY Program
	Complete	

is essential to check the products against market demand or expected market demand to make them more competitive. Once product requirements are defined, one needs to be clear about financial ability for investment in BPR exercise. Next step is to study alternative processes and different manufacturing technologies, which offer the same end product. Work force training and other requirements are the next. What kind of organisational culture is essential? It is decided in the step seven. Step eight deals with the ecological requirements and finally project planning and project execution details are arrived at in step nine (Fig. 3).

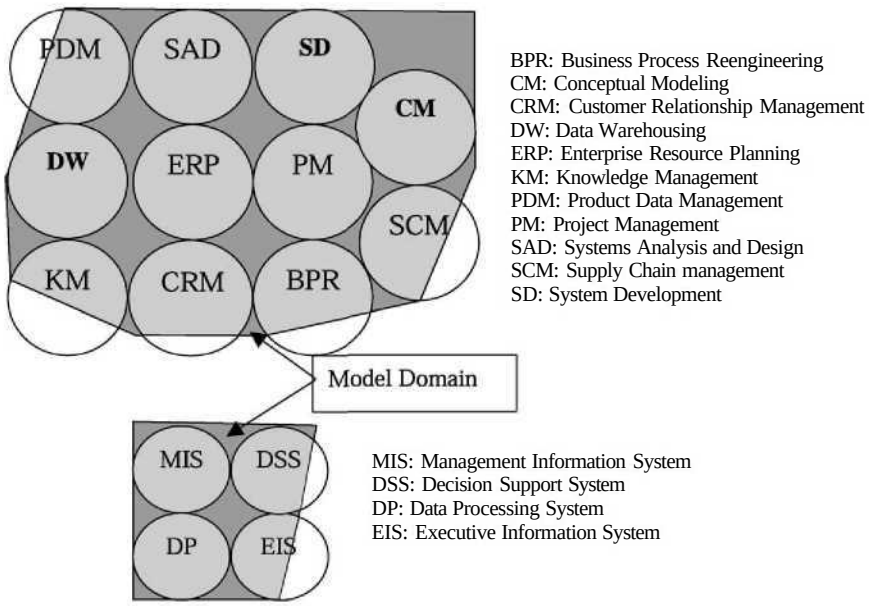

Fig. 2. Areas addressed through the proposed model.

5. Driving forces for BPR

Flynn, Schroeder, and Flynn (1999) suggested measures for improving the company performance. Table 4 lists some of the measures and tells how these measures are attempted to be resolved in the proposed system through the relevant IS module.

IT infrastructure capabilities underpin the competitive positioning of business initiatives such as cycle time reduction, implementing realigned cross-functional processes, utilising cross-selling opportunities and capturing the channel to the customer (Braodbent & Weill, 1997).

Mohanty and Deshmukh (1998) have given some strategies for waste minimisation. Some of the points are listed below. Italic typeface shows IS module to tackle these issues.

- Wastage due to excess finished goods inventory *Production Planning.*

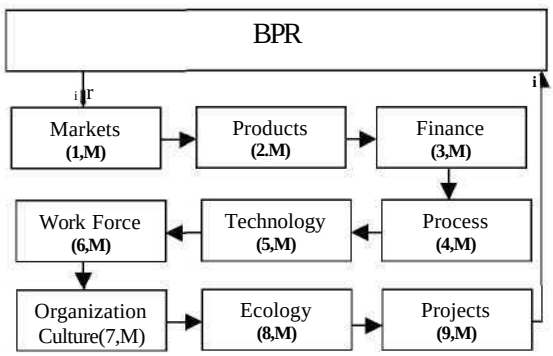

Fig. 3. Sequence of analysis.

Table 4
Measures for improving organisation performance

Parameter	Measures	Relevant IS module
Cost	Reduce inventory	*Material planning & Inventory control*
	Increase capacity utilisation	*Capacity planning*
	Reduce production costs	*Planning & Inventory control*
	Increase labour productivity	*Training personnel*
Quality	Provide high performance products	*QC*
	Offer consistent, reliable quality	*Trouble shooting*
	Improve conformance to design specifications	
Delivery	Provide fast deliveries	*Material & Capacity Planning*
	Meet delivery promises	*Material & Capacity Planning*
	Reduce production lead-time	*Capacity Planning*
Flexibility	Make rapid design changes	*Product Development*
	Adjust capacity quickly	*Planning*
	Make rapid volume changes	*Simulation*
	Offer a large number of product features	*Product Development*
	Offer a large degree of product variety	*Product Development*
	Adjust product-mix	*Market Planning*

- Waste of floor space. (Increase storeroom capacity by modern systems like drive-in system instead of conventional storage on racks with the isle space used for forklift movement.)
- Waste due to rejection. *Product Development.*
- Wastage due to non-value-adding activities (Unnecessary movement, delays and deployment of manpower) *Integration of activities, Business Events Analysis.*
- Wastage due to excess of raw material inventory and work-in-process. *Production Planning.*
- Waste in raw material *Quality Control.*
- Capital waste (From uptime, losses due to set up times, lack of proper preventive Maintenance program) *Down time analysis.*
- Waste in yield (Productivity use of latest technology) *Product Development.*
- Waste in energy (Energy conservation, proper utilisation of energy avoid losses due to poorly maintained machinery, use of latest technology) *Plant Maintenance.*
- Waste in manpower (Persons without specific job descriptions, uneven workload distribution) Labour *utilisation report.*
- Waste in information (Unnecessary record keeping) *Data pickup at source.*

System changes are closely associated with process redesign. It is impractical to focus the organisation on customers with lifetime value or most profitable segment or presume to offer seamless services with a hodgepodge of mismatched legacy systems (Day, 1999). Tracey, Mark, and Jeen (1999) reported following factors for competitive capabilities: price offered, quality of products, product line breadth, order fill rate, order cycle time, order shipment information and frequency of delivery. These areas can be taken care of through *product development, marketing and sales monitoring* in the proposed system. It is imperative that the quality implementation strategies, tactics and measurements are correctly aligned with strategies in areas of finance, operations, procurement, logistics and marketing, new product development and sales (Kannan,

Tan, Handfield, & Ghosh, 1999). *That is integrated approach is essential.* Angeles (1999) argued that IT could be used to meet seven dimensions which customers use to judge a firm's service as identified by Parasuraman, Zeithaml, and Berry (1985, 1990). These dimensions are

- Reliability: Consistency of performance and dependability
- Responsiveness: Willingness and readiness of employees to provide service and timeliness of service
- Competence: Possessions of skills and knowledge required to perform the service
- Access: Approachability and ease of contact
- Communication: Keeping customers informed in a language they can understand and listening to them
- Understanding and knowing the customers: Making the effort to understand the needs of customers
- Credibility: Trustworthiness, believability, honesty and having best interest of customers at heart

On the above background, nine driving forces for BPR, which are visualised, are discussed below.

5.1. Market

Today's world is world of competition. A company can survive only if it can satisfy its customers by meeting their expectations on cost, quality and delivery of the product. Any business that does not incorporate this vital force in business strategy will die out some day or other. Business must be market oriented. Company should produce what market demands rather than try to sell what it produces. Company should also consider marketing and advertising strategies, which are necessary to promote the product. A continuous feedback from markets is essential to know market trends and to include them in product design.

5.2. Product

Calculation of the product resource requirements and ensuring the product attributes within specified control limits is yet another force that decides product sales. In order to produce products according to conformance to the standards, efficient resource planning system and quality management systems are extremely important. Unless these requirements are taken into account while designing business processes, company would find it difficult to push its product into the market. Some companies have product in the market without quality control and production planning system, however, if such system (whether computerised or manual) is in place, it would improve competitiveness of the company. In case of service industry, product analysis would take the form of service definition and analysis of service operations.

5.3. Finance

Business improvements can be achieved only if initial investment needs and ongoing expenses of BPR are met. Financial constraints must be well known to conduct any BPR exercise. Various alternatives such as securities issue, loan facilities or long term deposits are available to raise

the required finance. According to the standing of the company and the market and public, ways and means to arrange finance should be determined.

5.4. Process

While taking into account process design appropriate to technology to achieve efficient administration, careful analysis of different processes involved in the business cycle, that starts from order receipt and ends in delivery of product to customer needs, is necessary. Cost, time, resource utilisation and associated variability to arrive at stock levels are important factors while analysing processes. Economics of all alternative process sequences can be worked out to select the best of the processes.

5.5. Technology

Changes in manufacturing technology affect production economics and product cycle time. Fashion garment sector specially requires very short lead times. Naturally, technology selection has an impact on over all business performance. Future technological trends, if not taken into account, would make it difficult to compete in future markets in terms of quality and productivity when faced with the competition from superior technology. Technological changes, affecting communications and e-commerce, are forcing reorganisation of business processes.

5.6. Workforce

Persons, who tackle production (equipment operators) and administration issues (clerks to managers including CEO), govern the outcome of business. Capable person can fully utilise the market and production potential to make the business profitable. Different training programs can be designed to bring skills to the required level. BPR needs to provide adequate emphasis on filling the gap between present and required skill level and job practices.

5.7. Organisation culture

Work culture is an important parameter that influence employee moral and, therefore, the quality and the quantity of the product. After careful study of the factors affecting the employee behaviour at work, work environment needs to be selected. If workers are totally security and money oriented, hierarchical organisational structure suits well otherwise culture of production team, in which employee is empowered to take decisions regarding production related matters, is more suitable (Jayawardhane, 1995). Clear-cut responsibilities and rewarding schemes for efficient performance are important for healthy organisational culture.

5.8. Ecology

In many countries, strict regulations, which govern the environment protection, impose restrictions on the usage of technology and raw materials. Such regulation would not allow the use of the conventional raw materials. For example, use of certain chemicals in the processes is hazardous to the health of

the employee or to the health of the end user. Such materials, although cheaper, cannot be used to produce low cost product. Some processes and materials generate pollution in the surrounding environment and some governments might insist that such materials and processes should not be the part of the manufacturing process. Yet another requirement could be the obligation to recycle the pollutant waste to make it pollutant free. Ecological demands should be taken into account while carrying out the BPR exercise.

5.9. Projects

Analysis of the investment in the BPR project can be carried out with the help of standard methods like payback period, break-even analysis and so on. Return on Investment (ROI) is yet another indicator of viability of the project. BPR project needs to be managed well to make it a success. Only careful planning and execution of BPR project or any other project like SCM, TQM can bring in rewards. The project management team should keep a close watch on the status of the implementation and seek the feedback to judge the effectiveness of different stages. It is necessary to provide for framework to plan and manage the project.

6. Role of Information Technology

IT can act as an enabler in the BPR. It provides a platform to

- Manage the BPR project.
- Provide a link between various BPR drivers discussed earlier.
- Optimise processes such as transportation, product mix decisions, etc.
- Provide a platform to record various parameters of all forces.
- Allow cost benefit analysis of various process sequences.
- Study complete supply chain economics and delivery time requirements.
- Arrive at the best possible business process within the constraints of the forces that affect the business performance.
- Judge the impact of the reengineered processes to make the BPR as an on going activity.

IT, as discussed earlier, has been playing important role in the business process restructuring. IT is useful in business modelling. It is also useful to judge the interactions of the various BPR drivers to arrive at the best business practices. Analysis and design of information systems can be coupled with BPR. This topic is discussed in depth in Section 7.

7. Phases for BPR and IS project

BPR project phases are shown in Fig. 4.

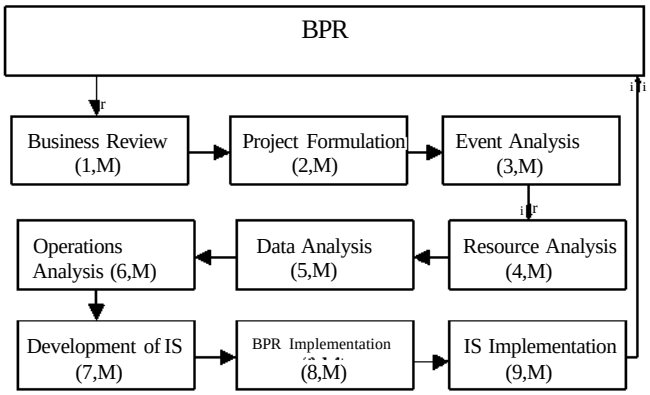

Fig. 4. BPR project phases.

7.1. Phase I: business review

Step 1: Decide project in-charge

Decide on the main person who would carry out the job of BPR. He is the person who will be with the project from the beginning to the end and designated as project in-charge. He could be from a consultancy organisation or from the company. He should have sufficient knowledge of system designing and integrated management solutions. He should be aware of industrial practices and should be able to guide BPR team on various issues related process analysis and implementation of suggested changes.

Step 2: Prepare questionnaire and event diagrams

Project in-charge would work out an exhaustive questionnaire to elicit the current state of the processing sequences of information and physical goods from various departments. He would also prepare event diagrams for the information system and the business system to minimise the communication gaps and to assist the management on various issues.

Step 3: Formulate strategy for BPR exercise

Work out a strategy for BPR exercise. Most advisable way is to take business review at different sites before deciding on changes in the business processes and information system solution. Company can aim at the radical implementation after software is tested and implemented at one site. It would also be convenient to conduct business review at one place and present its finding at other sites so that the process of business review can be completed in a shorter duration.

Step 4: The beginning

Project in-charge should conduct a presentation to a group of about 10-20 top persons, which may include President, Personnel Manager, Production Manager, Production Executives, QA Manager, QA Executives, Purchase Manager, R&D in-charge and Planning personnel. This presentation would emphasise the need for BPR exercise and the advantages that company would derive from such exercise. The presentation should focus on the need for integrated management solution and necessary business process changes for successful implementation of such system.

Step 5: User team selection

A team of persons would be selected who will take active participation in the review of current business. These persons, who are from end users, are actually involved in implementing business processes and information systems in their respective departments.

Step 6: Interview the user team members

Project in-charge would contact each one from the user team separately and explain the questionnaire to him in detail. Questionnaire could be left with team members for discussion with other departmental persons and again after two to three visits, final response should be conducted. Project in-charge should show event diagrams, which he has already prepared, to the end users and explain the steps included in the event diagrams. Event diagrams should be discussed in detail. Users should be asked to give their opinion about the event diagrams regarding its suitability from adoption point of view and regarding coverage of different functions of the respective departments. Users are encouraged to suggest the modifications in the event diagrams, if necessary, to make the diagrams better representative of their respective functions.

Step 7: Analyse the response

Project in-charge should analyse the obtained response and arrive at the scope for improvement in sales, improvement in customer relation, improvement in supplier base, improvement in cycle time, improvement in machine uptime, improvement in cost savings and improvement in employee satisfaction.

7.2. Phase II: project formulation

Step 1: Define physical organisation of the company

Make a representation of the organisation in the manner shown in Fig. 5. Such representation would be useful to link the occurrence of an event to the specific location and to depict flow of information and goods from one place to another in a compact manner, which can be used for IS the design.

Step 2: Decide team for BPR project

Decide on team structure for the management of the project. It would depend on the size of the project. All teams members will report to the project in-charge. These team members are totally dedicated to the project while the project is on. They are expected to be expert in the respective areas. These members can be from the company, if such expertise is available within the company. After completion of the project team members can be sent back to their respective day to day functions.

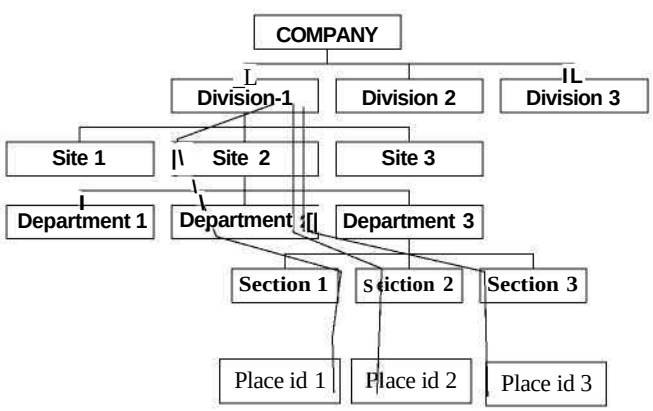

Fig. 5. Representation of an organisation.

In case of non-availability of the expertise within the company, it would become imperative to hire the persons from a consulting firm.

Step 3: Finalise the event diagrams

Finalise on event diagrams after incorporating changes suggested in phase one. Please refer to Section 7.3 for detailed discussion of event diagram.

Step 4: Make a project plan

Prepare a detailed project plan with project phases and their schedule and locations.

Step 5: Work out project requirements

Arrive at detailed requirement of resources, manpower and cost requirements at various stages to manage the project. Decide hardware and software platforms.

Step 6: Decide on project review procedure

Decide procedure for collecting feedback and review meetings.

Step 7: Prepare final estimate of the project

Make cost estimate of the whole project and present the plan, which is divided into weeks to the management.

7.3. Phase III: event analysis

Step 1: Construction of event diagram

There are many definitions of systems appear in literature. A simple definition that can cover all possible systems is offered here. *System is a set of related events* (System Simulation Software, Chiplunkar, 1997a-c, 2001). Since all systems contain some activity or the other, this definition encompasses all areas from manufacturing, information to biological and astronomical systems. Consider a business system. Business system can be divided into number of activities that are inter-linked. It can be said that a business system consists of a number of events that lead to conversion of raw materials into finished products. To generalise, a business system consists of a number of events that lead to conversion of inputs into outputs. In service industries, service operations expect certain inputs to render required service to the customer. The whole service sequence can be broken down into number of events. Thus, the approach to analysis is the decomposition of the whole business system into number of smaller events. To analyse the business, following considerations are taken into account.

- Functional grouping in any organisation essentially involves grouping of similar activities together.
- Basic activities (application area): Describe the business in the shortest possible steps.
- Activity groups (module): Describe the steps involved in basic activities.
- Main activities (sub module): Describe steps involved in the activity group.
- Activities (events): Detail out the steps involved in the main activity.

Thus, *an Activity (Event)* is associated with actual business dealing, which needs recording of the new information or manipulating the existing information or the both. Following are the essentials of an event.

- Event is an activity in the system.
- It is associated with well-defined information elements.

- It suggests flow of information, flow of goods, flow of manpower, flow of finance, flow of decision, which can be made out from the information elements associated with that event.
- It is related to one or many of other events in the system.
- It has a definite sequence of operation.
- It lasts over a finite duration.
- It can be avoidable or mandatory.

Event has following attributes:

- *Event Hierarchy:* 1: Application, 2: Module, 3: Major Event, 4: Event.
- *Event Number*: This number may or may not denote the sequence as it occurs in the system. It would be utilised to identify an event uniquely in the system.
- *Event Name:* This is a short name given to event, which would appear on event diagrams.
- *Is Event Optional?:* Whether system can work without occurrence of this event.
- *Base Event:* This gives the earliest event, which should be complete to take up the current event during the operations.
- *Event Contents:* What information does the event carry? As discussed earlier it can denote flow of physical entities.
- *Event Storage:* How often does the event repeat? What is the duration for which the event is active? What is the duration for which details of inactive event should be made readily available? A physical storage requirement is a part of information associated with the event.
- *Performance Requirements:* Desired event response time, event completion time.
- *Event life:* Time period up to which information related to the event should be made readily available on computer. Physical existences of entities, which are related to the event, appear in information elements, associated with the event.
- *Event Relation:* On which events this event is dependent? How?

Table 5 shows the various event notations that can be used in an event diagram.

Parallel events can be found out from the base event of an event. All events having the same base event are parallel events. Unless specific mention is made, output of earlier event goes as input to the next event. Fresh input to the event is always possible and input from any other event than prior event can also be shown. Fig. 6 shows a sample event diagram for the purchase function.

Step 2: Record event details

Record all the details related to an event as stated earlier.

Step 3: Construct interaction diagrams

Events, which interact with the other events, can be found out from data analysis of the events. Interaction diagrams explain the relationship between events of different applications or modules. Arrow indicates the direction of the information flow. Boxes within the application tell about the events whose data elements are transferred. Physical transfer of goods or flow of finance can also be represented through an interaction diagram. All flows are related to the event mentioned at the centre (Fig. 7).

Interaction diagrams can be constructed at any level of abstraction. They differ from the standard data flow diagrams. Arrows indicate that the information or physical resources of a specific event are required by some other event in the system. It is possible to club one or more events together in a group unlike data flow diagrams, which cannot describe two processes in the same process box. Interaction diagrams

Table 5
Event notations

X	Event number X of the current hierarchy
X.Y	Event number Y which is child of event X
X.Y.Z	Event number Z, which is child of Y and Y is child of X. It is possible to extend this notation up to any level down the line.
X:Y	Event number X which is child of Y
X:Y:Z	Event number X which is child of Y and Y is child of Z and so on. It is possible to extend this notation up to any level up the line.
$X:Y^0$	Event number Y which lies in one hierarchy up of the X
$X:Y:Z^0$	Event number Z which one up of Y and Y is one up of X and so on. It is possible to extend this notation up to any level up the line
In all above cases X is current event	
A	Absolute hierarchy of event can always be mentioned if required by giving subscript For example 1.2A means it is an event having identification 2 in second hierarchy and is child of event 1 of the first hierarchy. While 1.2 means child event 2 of the event 1 of current hierarchy
E(I1,I2,I3,…)	Shows happening of any single event from the list of events. E(1,2,3) means that for any cycle of operations, out of events 1, 2 and 3, only one event takes Place. That is events 1, 2 and 3 are mutually exclusive
M(I)	To show dependence of existence. If M(1) is written in the event box having event number 5, it means that event 5 in mandatory only when event 1 has taken place. Otherwise it does not take place. If there are two prior events, which need execution of this event at later stage then M(1), M(3) could be written to denote that the current event 5 is mandatory if event 1 occurs or event 2 occurs or both of them occur
M(I1,I2,I3,…)	M(1,3) would mean same as M(1), M(2)
S(I)	S is used as a stop signal on the current event. S(1) means next event in the System is not possible until event 1 has taken place. The notation M(1) means current event 5 is mandatory if event 1 has taken place while notation S(1) denotes that in order that event next to 5 to happen, event 1 must have happened. S(1), S(2) tells that system does not proceed to the next event unless event 1 and event 2 has taken place
S(I1,I2,I3,…)	S(1,2) would mean same as S(1) and S(2)
N(I)	To show non-existence of an event. If N(1) is written is the event box having event number 5, it means that event 5 is bypassed (or not required) if event 1 has happened. If there are two prior events, which do not need execution of this event at later stage, then N(1), N(3) could be written to denote that the current event is not required if event 1 occurs or if event 2 occurs or if both of them occur
N(I1,I2,I3,…)	N(1,2) is same as N(1), N(2)
M(NI)	To denote that Current event is mandatory if event I does not occur. N(NI) would mean that current event is not required if I does not occur. (Combination of M and N)
G(I1–I2)	G is used to give transfer signal after completion of current event. G(1-10) means After current event 5, instead of going to next event go to event 10 if 1 has taken place. G(1-10), G(2-10) would mean go to event 10 if 1 has taken place or 2 has taken place or both of them have taken place. G(1-10,2-10) would mean the same as G(1-10) and G(2-10)
G(I1,I2–I3)	G(1,2-10) means go event 10 after current event only if event 1 and 2 both have taken place
F(I1–I2)	F is used to denote flow or transfer signal depending on incoming event. It says that if control to this event is transferred from event I1 then proceed to event I2. F(1-10) means after current event 5, instead of going to next event go to event 10 if current event is taken up after event 1. F(1-10), F(2-10) would mean go to event 10 if current event has taken place after event 1 or event 2. F(1-10,2-10) would mean the same as F(1-10) and F(2-10)

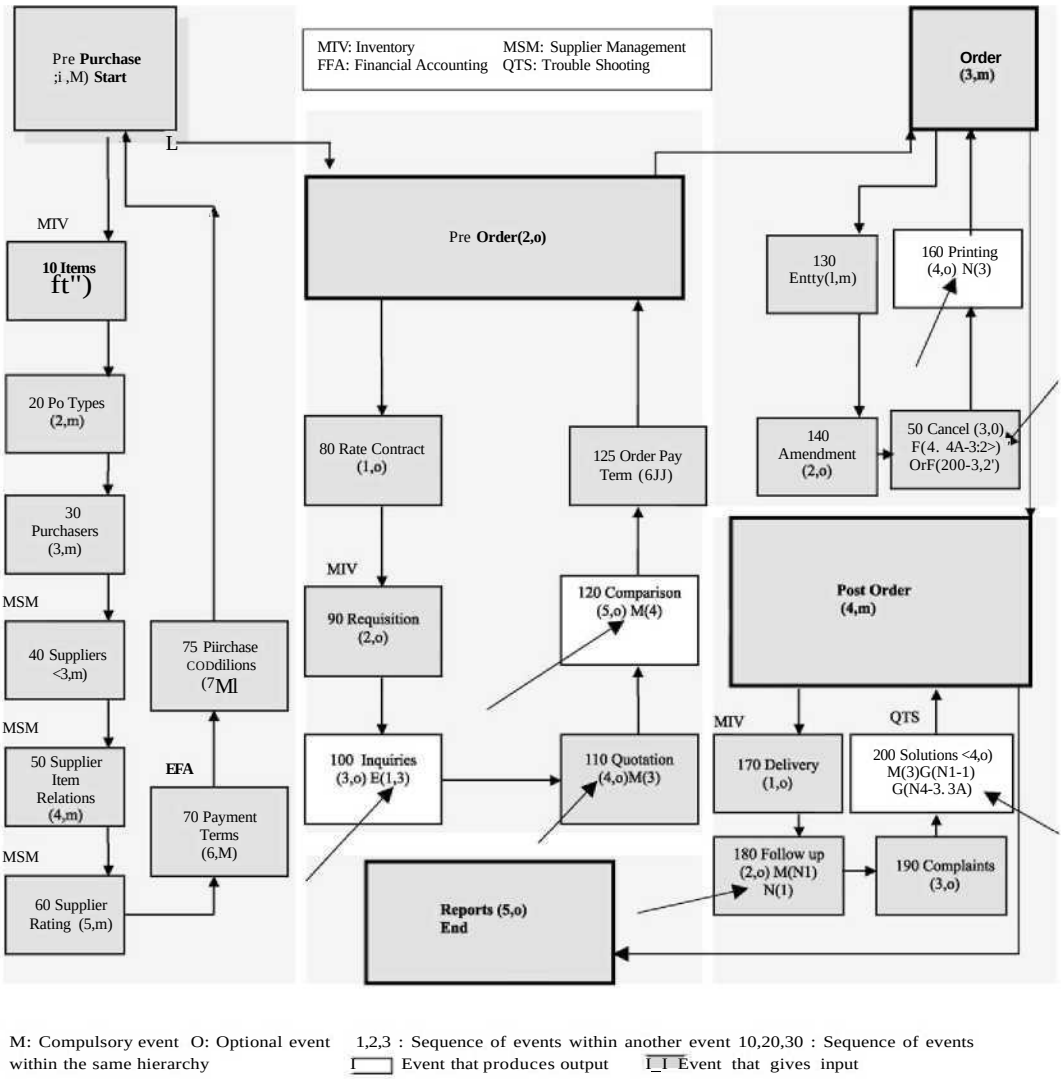

Fig. 6. Event diagram for purchase function.

also tell you the application in which the events are originated. That is, they define the primary responsibility of supplying input to the event. Details of contents of an event are available in the system. Only those events are listed which form the part of the flow. It is convenient way of representing the system as events can be listed either at arrowhead or at arrow tail. This makes representation clearer and less cluttered. Interaction diagrams are simple to construct, easy to understand and more informative. Detailed flows are worked out at later stage of the design.

Step 4: Analyse events

Events are now analysed for their physical connections, actual flow of documentation, non-value adding processes and bottleneck events. Alternative sequences can be found out to select an appropriate sequence of events in an operation.

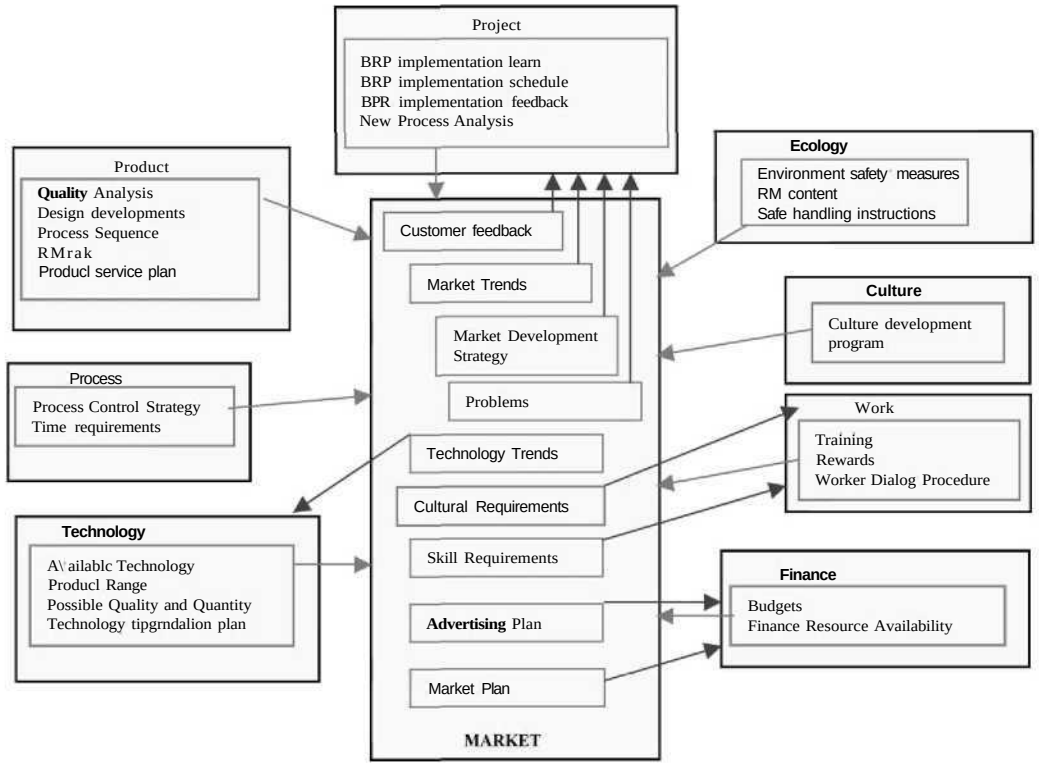

Fig. 7. Interaction diagram (Markets).

7.4. Phase IV: resource analysis

Step 1: Analyse inputs to the event

- Items
- Quantity
- Conditioning Period
- Ordering Period
- Frequency
- Quality Criteria
- Inspection Procedures
- Procurement Policy
- Supplier Management
- Alternative Arrangements for Emergency
- Industry Standards for Consumption
- Optimisation of Input Mix

Step 2: Analyse outputs from the event

- Product

- Quantity
- Product Characteristics
- Quality Checks
- Sales Policy
- Disposal Policy
- Customer Management
- Distribution Management
- Industry Standards for Production
- Product Mix Optimisation

Step 3: Analyse manpower requirements

- Qualification
- Experience
- Working Methods
- Responsibilities
- Performance Criteria
- Reward
- Cultural Requirements

Step 4: Analyse technological requirements

- Machines
- Maintenance Policy
- Safety Measures
- Spare Parts Requirement
- Operating Instructions
- Critical Factors Affecting Product Quality
- Trends in Innovations in The Current Technology

Step 5: Analyse time requirements

- Event Duration
- Machine time
- Personnel Time
- Productive time
- Unproductive time

Step 6: Analyse associated costs

- Machine Cost
- Labour Cost
- Input Cost
- Product Selling Price

- Value Addition
- Profitability

Step 7: Select event sequence

Select most viable sequence of events.

7.5. Phase V: data analysis

Step 1: Build a database

Build a database to manage the event through the computer. It includes Entity Relationship models, information groups and related information elements. Tables, fields and their attributes are defined. Heavily normalised structures are created and operations at field are notified. It includes entry condition, validation for ranges and references, pre-field and post-field triggers, database procedures to update or check other tables, sequences and so on. In ER diagram additional notation M and O is used to denote whether presence of any of related entities is mandatory or optional. This information is used for deciding not-null characteristic while creating database tables.

Step 2: Formalise the data reconciliation needs

The data reconciliation needs point to the required data transfers from and to different location. It includes the data distribution and the data consolidation requirements.

Step 3: Decide the networking requirements

Work out site map for LAN set up, severs, clients and so on.

Step 4: Arrive at input and output formats

Formats for inputs and outputs are decided after consultation with users.

7.6. Phase VI: operations analysis

Step 1: Decide on programming

Arrive at the coding requirements for the events or the group of events. Access rights are also decided at this stage. Such securities can be related to the execution of a program or to a particular operation in the program like adding a record, deleting a record and so on. Field securities can also be decided if software allows the implementation of the field securities.

Step 2: Decide exact operating procedures

Decide on sequence of operation for entry, report, query, and validation procedures.

Step 3: Decide exception-handling procedures

Decide the procedures for error handling for both information system and business processes.

Step 4: Decide the responsibilities

Decide who is responsible for data input, data validation and generating reports.

Step 5: Decide report requirements

Who is going to use reports generated from the system and with what frequency?

Step 6: Decide back up and restore procedures

Decide on required operations and time schedule for back up procedures. Also decide on restore procedures to load back up.

Step 7: Work out the disaster recovery plan

The disaster recovery plan should be worked out for unforeseen situations like fire.

7.7. Phase VII: system development

Step 1: Coding
This activity is actual writing of the programs as conceived in the earlier design stages.
Step 2: Testing
Testing tries to identify bugs in the program to make it more perfect.
Step 3: Debugging
Debugging is the activity of correcting the bugs in the program to make it more perfect.

7.8. Phase VIII: BPR implementation

Step 1: Outline the new roles and responsibilities.
Step 2: Conduct training programmes, if required.
Step 3: Initiate cultural change.
Initiating cultural change would mean dealing with the changes in the psychological attitude of the employees and managers. Most important of all is fear of losing importance or fear of losing the job. Both the issues should be addressed well at the individual level and at the group level. Benefits of 'Doing the things together' rather than 'Doing the things alone' should be highlighted. To achieve this goal, growth path of the employee and possible monetary rewards would serve a good purpose. Top management must develop a sense of trust that shared information would not hamper the future career path of an employee. It should be emphasised that in order to survive, these changes are essential; otherwise time is not long before the unit goes into red. This would generate a sense of security in favour of the change.
Step 4: Address the problems arising out of the change of environment.
Step 5: Announce the targets to be achieved in a specific time frame.
The project team decides the targets. Targets must measurable. Initial and final performances are measured to arrive at the decision about the achievement of the targets.
Step 6: Give rewards for average and excellent performance.
Step 7: Collect feedback from the users and incorporate the necessary changes.

7.9. Phase IX: Information System implementation

Step 1: Ensure that the required hardware is in place.
Step 2: Ensure that the networking facilities are working smooth.
Step 3: Ensure that persons from development team are available to address the concerns of the users of the new system.
Step 4: See that the sample outputs of the new system are in accordance with the old system with the live test data.
Step 5: Convert all the old data from the old system to the new system.
Step 6: Collect the feedback from the users and incorporate the necessary changes.
Step 7: Go live with the new system.
At all stages proper documents should be created and stored for the future reference. Start the BPR cycle again. This time presentation may not be necessary. Some changes in the questionnaire could be

made depending on the process changes that are implemented. The feedback on effectiveness of implementation and effectiveness of changes implemented should collected as an ongoing process.

8. Broad data requirements for analysis

Table 6 summarises broad data requirements for BPR driving forces discussed earlier. These data requirement need to be analysed according to the process mentioned earlier in Section 7.4, which described data analysis in detail.

Easy to understand and easy to operate universal report writer should be available to the project implementation team which can generate various reports from the selection of the required information from the database, broad contents of which are described in Table 6. Reports would include analysis of the various sequences for their cost effectiveness, expected life of machine and product, expected and actual cultural development, expected and available skill set, need for training and comparison of company' s product with those of competitors'. Selection of an event sequence can be done depending on the economic, technical and operational viability.

9. Concluding remarks

A systematic procedure, which combines the analysis and design needs of business process analysis and information system analysis, is suggested. The methodology proposes two tools in the form of the event diagram and the interaction diagram. All the four necessary views of an organisation are tightly integrated with each other. For example, in classical methods of BPR, the structural view or the data view is separate and is represented by ER diagrams. The process view is expressed by data flow diagrams and network diagrams are used for the behavioural view. As discussed earlier, it is difficult to integrate all these views. In addition, organisational theoretic of roles and responsibilities is not taken into account. The proposed methodology offers the following advantages:

- The methodology has only one backbone to support all the views namely the data view, the process view and the behavioural view. In addition, the roles and the responsibilities and cultural requirements of an event can also be defined. The interaction diagrams are actually constructed from the event diagrams and, therefore, there is no chance of discrepancy between the interaction diagrams and the event diagrams. Again, the interaction diagrams are constructed after data analysis of the required events and, therefore, these diagrams represent exactly what that event has to pass on.
- The process view is available in the form of the event diagrams and the interaction diagrams. It offers hierarchical view of the organisation. The event diagram also has behavioural attributes, through different notations provided to describe different connections on different conditions. It can also represent conditions in which iterations are required. For example, Fig. 6 shows such case of iteration between delivery and solution. It also suggests that solution should be worked out to see material is delivered to the factory and in case delivery is not possible, order should cancelled and activity of pre-order should be taken up to initiate new purchase order.
- Base event recording for every event gives the complete network of the events to give completeness to the behavioural view. Thus, the behavioural view is fully integrated with the structural and the process view.

Table 6
Broad data requirement for business process reengineering

Area	Data requirements
Market	Product Range, Product Quality, Service Quality, CRM Quality, Product Features, Market Requirements, Market Trends, Product Development, Technology Development, Product Service Requirements, Work Force Requirements, Required Organisation Culture, Partners and Alliances, Problem and Knowledge Management
Product	Quality, Cost, Finance Management, Market Trends and Feedback, Profits, Process Sequence, Resource Requirements, Supply Chain, Technology Requirements, Work Force Requirements, Required Organisation Culture, Safety Measures, Environmental Precautions, Reused material, Optimisation of Transportation, Distribution, Product Mix, Problem and Knowledge Management
Finance	Resources, Product and Process Cost, Administrative Costs, Environmental Precaution Costs, Value Addition, Bottle Neck Problems, Training Costs, Cost of Quality, Facilities Requirements, Savings and Profits, Problem Management, Knowledge Management
Technology	Product Range, Possible Quality, Technology Cost, Finance Management, Market Trends and Feedback in relation to technology change, Economics of Technology, Resource Requirements, Service Requirements, Spare Part Requirements, Work Force Requirements, Required Organisation Culture, Safety Measures, Environmental Precautions, Energy Conservation, Problem and Knowledge Management, Maintenance Requirements
Process	Time, Cost, Safe Practices, Skills Requirements, Work and Time Studies, Environmental Precautions, Value Addition, Bottleneck Problems, Morale Requirements, Quality Consciousness, Facilities Requirements, Problem and Knowledge Management
Work Force	Product Range, Quality Practices, Technology Handling Capability, Skill Set, Team Set-up for Quality in All Areas, Training Needs, Training Costs, Salary Requirements, Working Conditions, Facilities Requirements, Reward Scheme, Safety Practices, Problem and Knowledge Management
Organisation Culture	Working Conditions, Reporting Structure, Inter-Group Relations Workers-Manager Relations, Morale Requirements, Quality Consciousness Empowerment, Employee Orientation (Money, Security, Management Participation, Job Enrichment, and such issues), Facilities Requirements, Reward Scheme, Safety Practices, Problem and Knowledge Management
Ecology	Product Hazards, Process Hazards, Water Contamination, Air Contamination, Recycling Cost, Safety Measures, Energy Conservation Techniques, Waste Treatment, Green Procedures
Projects	Quality Projects, Product development projects, New project analysis, Payback Period, ROI, Service, Project Aim, Project Team, Project Plan, Mile Stones, Project Evaluation, Project Returns, Project Cost, Business Performance Indicators Ongoing Improvement Loop, Awareness Requirements, Knowledge and Problem Management

- The proposed methodology clearly demarcates the responsibilities for the various departments of an organisation and help in deciding the procedures for communications.
- BPR and IS are based on the same methodology and, therefore, BPR can get a good support from the relevant information system.

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