The rôle of information technology in enterprise reengineering.

Title	The rôle of information technology in enterprise reengineering.
Author(s)	Lyons, Gerard J.
Publication Date	1997
Publisher	Wiley

The rôle of information technology in enterprise reengineering

Dr. Gerard Lyons
Director, I.T. Centre, U.C.G., Ireland.
Tel.: 353-91-750382 (Direct)
E-mail: Gerard.Lyons@UCG.IE

ABSTRACT

Information Technology has been central to the development and implementation of redesigned business processes from the first appearance of the term "Business Process Reengineering". Yet, the contribution of IT to process redesign is not well understood. IT has also been found to be the principal impediment to the realisation of redesigned processes, in practice. This paper examines the rôle of IT, both as a BPR project support tool and as an infrastructural enabler of realigned enterprise processes. It places IT firmly within the context of holistic BPR project methodologies and presents the results of a study on the features of automated process redesign tools. It discusses the process enactment capabilities of IT and explores the difficulties of developing process support systems, as well as strategies for migration from legacy systems platforms.

1 INTRODUCTION

There can be little doubt that information technology has played a substantial part in promoting widespread industry re-structuring and deep-rooted organisational change during the past decade. Despite a lack of evidence linking real productivity gains with IT investment, organisations throughout the private and public sectors have persevered with the implementation of new IT infrastructure. For many organisations, these investments have been viewed as the price of remaining competitive, as the capabilities of advanced information and telecommunication technologies have altered business scale and scope economics, as well as facilitating radically different business delivery models. (Keen, 1991; Savage, 1990; Slywotzky, 1996).

From its first public premiere in the early 1990's, business process reengineering (BPR) has been synonymous with the application of IT to the remodelling of business organisations and extended enterprises. (Davenport & Short, 1990; Hammer, 1990, Kaplan & Murdock, 1991). But while offering a host of technical opportunities for radical re-design, IT has proved to be as much an impediment to process based change as a pivotal enabler (CSC Index, 1994).

For its part, the IT industry has responded rapidly to the challenge of BPR, which has already spawned a host of software tools to aid in redesign efforts as well as creating a lucrative market for enabling information technologies. But, despite the array of BPR tools and technologies, radically redesigned business processes remain difficult to implement and, where successfully realised, have more to do with an altered business logic or organisation structure, than with advanced IT.

This paper attempts to demystify the important, but limited, contribution of IT to the redesign and implementation of business processes. It distinguishes between two discrete functions of IT in process re-engineering:

1. as a BPR project support tool; and
2. as an infrastructural component of re-designed organisations.

Finally it examines some of the difficulties inherent in the design and implementation of process based information systems.

2 BPR PROJECT SUPPORT TOOLING

2.1 BPR METHODOLOGY

During the past five years, various attempts at defining systematic methods for BPR have appeared in the technical literature and at public business seminars. The more commonly found methods characteristically emanate from one of two sources:

1. large consulting groups who have restructured their Performance Improvement products as "cook book" guides to BPR projects; or
2. academic systems analysts, software engineers and industrial engineering researchers, exploring new applications for their cherished modelling techniques.

Regardless of parentage, both of the resulting approaches have technical merit. But in application terms, the consulting methods come closer to the spectrum of needs of BPR practitioners.

A number of reviews of BPR methods have appeared in the literature (Klein, 1994; Hess & Oesterle, 1996). The taxonomy of methods presented by Hess and Oesterle, in a recent issue of this journal (Hess & Oesterle, 1996), provides a useful ranking of the more comprehensive methods along the *breadth* and *depth* axes of BPR, originally developed by Gene Hall *et alia*, from McKinsey & Co. (Hall, Rosenthal and Wade, 1993). Much of the academic discussion on methods research has centred on developing suitable modelling techniques, frequently missing the practical realities of promoting and implementing behavioural and infrastructural change in large organisations.

It is clear from the literature, and from the author's own consulting experience, that BPR is primarily an holistic and radical performance improvement intervention. It carries responsibility for assessing and redesigning the full array of enterprise components (Waterman, R.H., Peters, T.J. and Phillips, J.R., 1980), although centred on the *work process* and *IT* dimensions of the organisational diamond (Scott Morton, 1991). The organisation development (OD) method, applied by some practitioners, supported by the modelling techniques of IT and industrial engineering, collectively provide the breadth of understanding and rigorous analytical capability needed for effective process redesign. The methods reviews, discussed above, would appear to confirm the holistic nature of BPR initiatives, as well as the subordinate rôle of particular modelling techniques and tools.

While documented BPR methods vary in emphasis and detail, they all set out to develop integrated, minimum cycle-time work processes. In common with many other "home grown" BPR approaches found in practice, the *re-design project* stage of such methods typically traverses four discrete phases:

Phase 1 Process identification, mapping and diagnosis;
Phase 2 Process baseline measurement;
Phase 3 Process benchmarking; and
Phase 4 New process design.

The extent to which each of these phases is supported by IT tools is a topic of specific interest in this paper.

2.2 Computerised Support Tools

A host of IT support tools are now available to aid the BPR project team. For the most part, these are based on established techniques, which have been applied successfully in the analysis and design of information systems in both commercial and manufacturing settings for a number of years. Table 1 presents a summary of the techniques relevant to each phase of the BPR project, following the 4-phase framework outlined.

A variety of modelling and analytical approaches are, thus, available to support process analysis and redesign. Within the past five years, computerised tools have been developed, or "repackaged", to enable the application of these techniques in BPR studies. These range from the simplest of graphics applications, which support process mapping (usually IDEF or process block diagramming), to integrated tool-sets capable of: mapping, spreadsheet based evaluation, simulation, and even code generation.

Tool Features

A number of commercial research reports of available BPR tools have been published during the past year, or so. These confirm the explosion of interest amongst IT vendors in the development of BPR project support tools. A report from CMI, for instance, makes reference to over 150 tools, expanding from just a handful over a two year period (CMI, 1996).

Table 1. IT as a process reengineering project support tool.

Project Phase	IT Support Rôle	Techniques
1. Mapping and diagnosis	Process capture and appraisal	• Data flow diagrams • SADT/IDEF models • Rôle Activity diagrams • Action diagrams • Work Study process flow diagrams • IS flowcharting • Functional entity diagrams • Soft systems methods
2. Baseline measurement	Process evaluation	• Activity based costing • Value added flow analysis • Shop floor data collection • Spreadsheet models
3. Process benchmarking	Information retrieval and process evaluation	• Benchmarking databases • Electronic library information services
4. Process design	Process description and development	• Mapping tools as in 1., above • Simulation • Workflow modelling • Code and schema generation
BPR Project management	Co-ordination and control	• GANTT, PERT, CPM • PM software

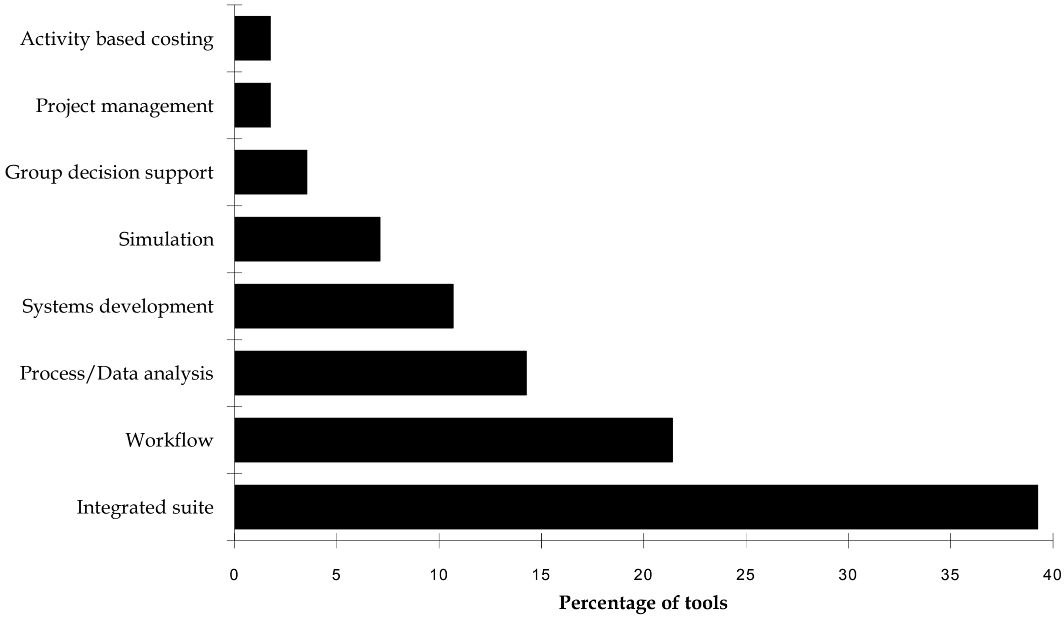
An annual survey conducted by this author, using a consistent baseline of tool definition and scope, has shown an increase from just 4-5 relevant tools in 1992 to 67 in 1996. This survey filters-out possible duplication of citations, by ensuring that individual tools receive a single reference, although some may consist of functionally discrete modules, or have implementation versions available on several different operating system platforms.

This survey suggests that many of the available tools are based on enhancements to modelling products developed earlier for other, albeit related, purposes, including: software engineering, workflow modelling, manufacturing simulation, and general graphics. Many are derived from earlier CASE, manufacturing simulation or systems dynamics products, and their orientation and functionality reflect their pedigree. While most of these tools are generic, a handful have been developed by consulting firms to support particular BPR methodologies.

It is difficult to generalise about the feature sets, technical dimensions and operational strengths and weaknesses of current BPR tools, as they represent such a wide range of functionality and cost. For instance, the price range of software products generally described as "BPR Support Tools" is of the order $100 - $100,000 or more. While most provide process mapping features, the more basic packages are limited to single level analysis and do not allow multi level "explosion" (or levelling) of the processes being analysed. Only a few are capable of dynamic simulation and statistical evaluation, and code generation is restricted to the top end of the cost/functionality spectrum. Tool integration is also a weakness, and only the more sophisticated proprietary packages offer full integration of mapping, simulation and analysis functions. However, a number of the simpler graphical packages are now supporting DDE linkages to common spreadsheet software, to enable activity based analysis and process measurement.

Various classifications of these tools are possible, based on price, functionality, methodology support, BPR project phase, purpose and orientation. The CMI report, for instance identifies eight tool categories: process/data analysis; activity based costing; project management; simulation; systems development; integrated suite; workflow; and group decision support. Applying this taxonomy to 56 of the tools identified in the author's own 1996 survey, for which detailed product information was available, yields the distribution presented in Figure 1. A further analysis of these to classify the tools by virtue of their central purpose and/or parentage,

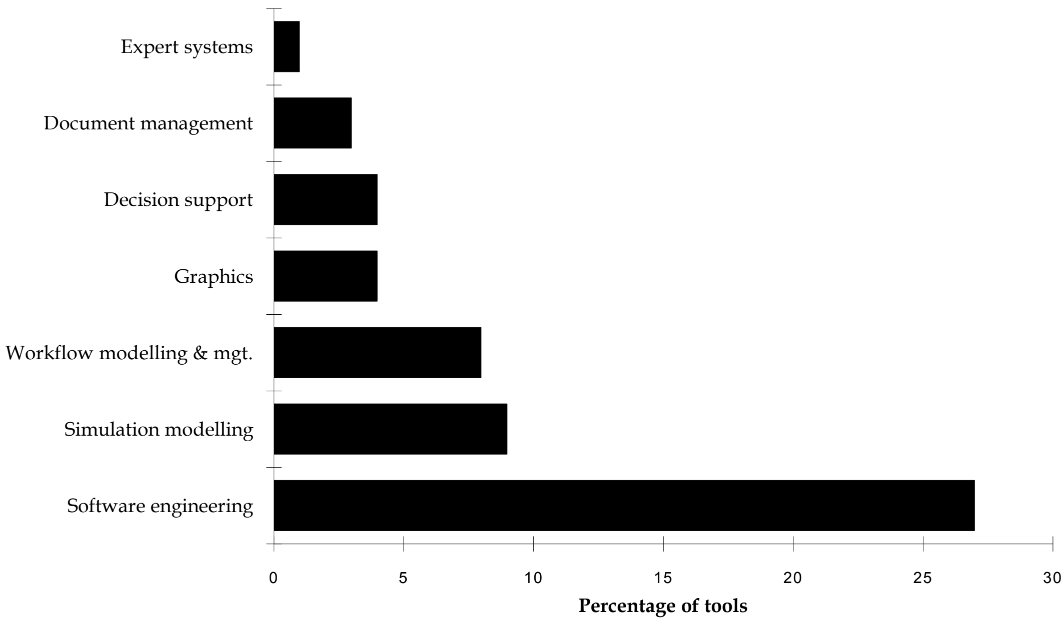
Figure 1. General classification of BPR support tools.



confirms earlier survey findings on the predominance of their classical software engineering orientation (figure 2).

Given the array of BPR project support tools available on the market, the practitioner is faced with the unenviable task of evaluating which product best meets the immediate project requirements, and the likely longer-term needs for systems development. Some years ago, IT practitioners were faced with a similar challenge in selecting from a host of sophisticated CASE tools, which all equally proposed to revolutionise software development productivity. Then, as with BPR initiatives today, the operating practices and broader issues of software development management were often seen as secondary to the computerised tools. Practical experience and much disappointment with CASE tool-sets has taught software developers to sub-ordinate automation choices to better process, management and behavioural aspects of software development. Table 2 presents a framework and high level synthesis of some of the many features encountered in BPR project tools, as an aid to the development of tool selection criteria.

Figure 2. Detailed classification of BPR tools by principal function & orientation.



While the development of fully automated BPR support environments remains technically challenging, there is a danger that, once again, IT specialists will become embraced by technical elegance rather than application value. The limited success to date in the application of advanced CASE technology, should serve as a timely reminder that process redesign is primarily a group learning activity. While fully automated solutions provide discipline and precision, and go some way to identifying optimal solutions, they rely too heavily on the individual designer's breadth of experience and business understanding. In practice, this has proven to be a poor substitute for less automated, but more "involving" approaches to process redesign.

Table 2. Summary of BPR tool features

Mapping techniques	Measurement	Bench-marking	Simulation	Analysis & design	Repository	Project Management	Technical features	User support
• DFD's; • ER diagrams; • SADT; • IDEF0 and IDEF1X; • Rôle-activity diagrams; • Decomposition & levelling; • Flowcharting; • Soft systems techniques; • GRAI method; • Object models; • Event models and STD's.	• Activity based costing; • Cycle-time measures; • Value-added flow anal.; • Quality and productivity tracking; • Process audit & control; • Auto. data collection. • Customer value measures; • CSF monitoring.	• Process benchmark setting; • Self monitoring & automatic comparison; • External reference to industry benchmark databases; • Information search and retrieval.	• Discrete event simulation; • Continuous simulation; • System dynamics; • Statistical random event modelling; • Rule-based modelling; • Interactive model execution; • Animation capability.	• What-if analysis; • Statistical analysis and represent-ation of results; • Process optimisation; • Expert system support for analysis; • Schema generation; • Code generation; • Reverse engineering of code.	• Common & shared meta-data database for all tool modules; • Consistency checking and integrity control across modules; • Repository security control; • Version control; • Data Import & Export facilities; • Network access.	• Work breakdown structure; • GANTT; • PERT; • Resource allocation & monitoring; • Drill-down capability; • Report generation.	• External data exchange; • Hardware & operating system compatibil.; • Portability to other platforms; • Compatibil. with related applications software; • Single- or multi- user; • Network support; • Graphical user interface.	• Installation, training and technical support services; • Interface design and modular structure; • Learning curve & time; • Tutorial & example facilities; • Context sensitive Help; • User document-ation.

In short, automated analysis and modelling tools perform useful point solutions in the appraisal and redesign of business processes. The tools are capable of removing much of the drudgery from process mapping and evaluation, and support more sophisticated analyses and higher standard presentation. Automated BPR tools focus the practitioner's attention upon the most tangible infrastructural aspects of processes, most notably the *workflow*, given their philosophical origin in manufacturing process design and information systems development. However, the low level of formalisation encountered in service industry processes, in particular (and in manufacturing related services), renders such sophisticated tooling of limited value, and may absorb a considerable amount of effort in tool familiarisation and unnecessary documentation.

The rôle of the BPR practitioner, consultant or internal facilitator is to:

- develop a detailed understanding of the current business process, its performance levels and organisational limitations;
- create a tangible and realisable model of the ideal, simplified business process, together with proof of its performance capabilities;
- develop the organisational framework needed to implement the redesigned processes; and
- stimulate the climate for organisational change, within which transition to the new process design is likely to succeed.

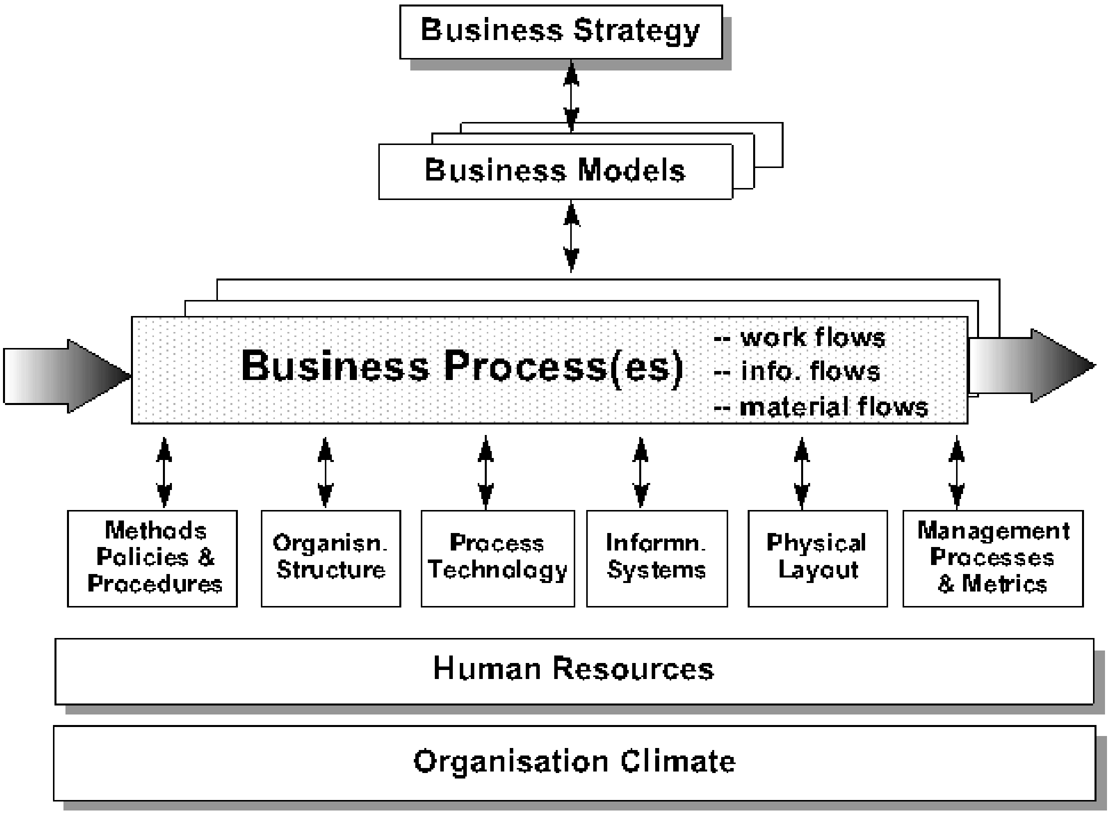
Judged against such a spectrum of needs, automated tools provide a very narrow range of functions, and are only valuable when used in support of a systematic and challenging consulting methodology, where innovation and willingness to explore new "ways of working", at high levels of abstraction, are more important than model precision.

3 IMPLEMENTATION OF RE-DESIGNED PROCESSES

Having successfully developed optimal process models, with or without automated tooling, the real challenge for the enterprise engineer now begins. As simulation models, business processes remain an abstraction of "the way things work around here", and have no physical manifestation in terms of organisation structure, IT architecture or building design. The task of implementation may be nothing short of a complete appraisal and re-modelling of the fundamental building blocks of the organisation, and not just the workflows or information systems. This is likely to entail a redesign of procedures, organisation structure, accountabilities, measurement systems, management processes, key relationships (both internal and external), staff and skill profiles, work design and workflows, geographic or facility design and IT infrastructure.

Figure 3 presents a graphical view of the key structural "footings" upon which new business processes are built. These are the individual building blocks that must be deliberately designed and implemented in order to realise the new process logic, and represent the tangible organisational

Figure 3. Organisational "footings" required for new process enactment.



components commonly found in techno-structural or holistic approaches to organisation development (Waterman, R.H., Peters, T.J. and Phillips, J.R., 1980; Scott Morton, 1991). Indeed, a comprehensive study of BPR success and failure factors by Hall *et alia* (Hall, Rosenthal and Wade, 1993) has highlighted the need to address these deep-rooted organisational elements. This view has been further elaborated in the studies of BPR methods research, discussed above.

New process implementation, then, relies on the comprehensive design of a diverse set of behavioural, technical and managerial factors. Furthermore, the careful integration of these inter-dependent components is essential to ensure congruence of the overall design with the desired business process logic and supporting IT infrastructure. Failed BPR projects frequently overlook the complexity of implementation design and address the redesign as a uni-dimensional *workflow* or *systems* project.

A CSC Index (1994) survey of over 600 US and European corporations engaged in process reengineering highlights the difficulties of new process implementation, with over 67% of projects providing zero or, at best, marginal results. The most commonly found difficulties listed were:

1. Getting the information systems and technology infrastructure in place; and
2. Dealing with fear and anxiety throughout the organisation.

Perhaps fortuitously, the business need to re-think core processes in response to competitive factors has coincided with the commercial maturity of a powerful array of advanced information and communication technologies. There is every likelihood that the BPR momentum will, thus, be maintained and organisational transformation will give rise to significant improvements in business performance through the application of enabling IT.

Table 3 presents a summary of the information technologies which are currently available as infrastructure components for the process based enterprise, and illustrates the principal business process requirements which these address.

Table 3. IT as a process enactment technology.

Process Requirement	IT Enabling Technologies
Process integration & communication	• LAN, WAN, Telecomms., EDI, EFTPOS;
Process co-ordination & control	• Workflow, process scheduling, Internet and Intranet, etc.
Front-end data capture & validation	• Imaging, ATM, Minitel, Factory data collxn., bar-coding, lap-top;
Integrated work support	• Workflow, Client-Server, Imaging;
Information storage & access	• Database and query tools, COLD technology;
Documentation & document mgmt.	• WP, DT publishing, Imaging
Process work support	• Expert systems, Client-based applications
Process systems development	• CASE, IPSE, RAD, Prototyping, Object technology.

It is evident that the BPR practitioner has a well equipped arsenal of enabling information technologies to support the implementation of radically new business processes. However, new process designs seldom fail due to lack of imagination and technology opportunities. But, the implementation of these technologies has been the single greatest impediment to process realisation in BPR practice to date (CSC Index, 1994). And, unless the implementation difficulties highlighted here can be overcome, IT based process redesign is in danger of becoming yet another "technology swallow hole."

But, as the existing systems infrastructure is a durable component of a functionally designed business, it too must be reconfigured or replaced. The reengineering of IT architectures must, then, be an essential part of BPR initiatives.

4 ENTERPRISE PROCESS SUPPORT SYSTEMS

Apart from modelling and evaluating new business processes themselves, specification and development of the software infrastructure needed to codify and implement these designs is an essential product of the BPR project. Viewed from this perspective, the automated modelling tools discussed above perform a more central function -- that of translating high level process abstractions into tangible specifications of realisable software modules. The software engineering orientation of these products, as highlighted, can be justified specifically in this systems development context.

In many situations, BPR endeavours will render the entire current systems infrastructure redundant or flawed. An enterprise's information systems, like its processes, grow organically as the immediate needs of the business change. After many years, these systems have acquired a thick covering of "barnacles" -- patches to the core systems to accommodate variations in procedures, product designs, etc., as the business evolves. While not meeting high standards of architectural design, these patched systems work, keep the business running, and embrace a wealth of knowledge developed by the business over many years. Apart from the enormous costs involved in replacing the entire systems infrastructure, there are risks associated with losing much of the "hidden intelligence" of the business, currently coded in legacy systems. In most cases, then, the enterprise will not be able to afford the luxury of an overnight conversion to new process based systems, and legacy systems will need to be maintained as new applications are developed and installed.

The emergence of highly integrated Supply Chain Management (SCM) business models is further stretching the capabilities of IT infrastructure to support enterprise wide transaction processes. Integrated Supply Chains represent the lateral extension of business process definitions to cover the full business chain of activities, from raw material suppliers to end-customer demand for products and services. These supply chain processes, not only cut across internal functional barriers, but also create a tight coupling of process activities and workflows across company and geographic boundaries. Venkatraman (1994) refers to this logical extension of BPR at “Business Network Redesign”.

From an IT perspective, SCM creates a demand for the seamless interlinking of systems involved in automating the various components of end-to-end supply chain processes -- across international boundaries and, increasingly between separate companies collaborating to fulfil customer requests. This challenge reaches far beyond the more trivial exchange of structured data *via* EDI linkages and has been nervously described in an authoritative commercial IT journal (Datamation) as "extreme integration" which is at the frontier of reengineering (Darling, C.B. and Semich, J.W. 1996).

Conventional IT planning and software development methodologies are based on the functional decomposition of high level abstractions of an enterprise's procedures and information needs, usually achieved through:

1. the refinement of high level statements of procedure, until detailed definitions of functionality can be specified as software modules; and
2. data modelling and analysis, of a high level interpretation of an enterprise's subject areas, data "entities" or "objects", until rational data structures can be specified.

However, the *processes* examined by software engineers on Data Flow Diagrams are the defined activities performed *within* the boundaries of conventional organisational functions, for which IS applications are being developed. These do not match the scope of the lateral, cross-functional chains of logically linked activities normally described as *business processes*. Consequently, these approaches are too narrowly bounded to support the development of process-wide, or enterprise-wide (as with SCM business processes) process support systems, and reflect the current organisational structure underpinning (and sponsoring) systems development initiatives.

Thus, while Software Engineering gave birth to the modelling techniques found today in BPR, application of these as part of traditional software development methodologies will not, naturally, yield business process based solutions and systems. What is called for, then, is a systems development framework which supports the realignment of the *process* dimension of Software Design and the end-to-end, lateral process models yielded by BPR. This realignment should be a prerequisite for the identification of systems' boundaries, early in the application development work, and should produce high level conceptual models of the enterprise (both process and data models) which reflect the process based enterprise orientation.

A recent survey conducted by CSC Index in both the US and Europe confirms the predominance of functionally bounded software development projects being undertaken today, despite the accumulated experience of 6 years BPR practice and advances in Supply Chain Management (CSC Index, 1996). Of the 500 or more senior IT executives surveyed, only 20% of US and 9% of European respondents described their current development projects as "enterprise wide" implementations.

In summary, the IT industry has developed a rich collection of enabling technologies to support the integration of enterprise business processes. But while much of the hardware and telecommunications infrastructure is technically advanced, the development of truly process based, enterprise wide software applications is still in its infancy. Companies are frequently confronted with technology constraints in implementing newly designed business processes. However, a number of temporary, *transition solutions*, to this dilemma are becoming established in practice. These strategies are necessary to overcome current technology bottlenecks, but are even more essential to the orderly migration from current IT infrastructure and legacy systems to process based IT architectures.

Amongst the feasible approaches to migration management now emerging, the "surround approach", proposed by Heygate in 1993 (Heygate, 1993), and the application of Intranet technology are gaining currency. The *surround* strategy is designed to preserve the integrity of legacy systems while building new process functionality and user interfaces *around* the existing infrastructure. Workflow software can be deployed, in this approach, as a middle-ware solution, which provides for the co-ordination of transactional systems and data across legacy and new platforms, creating the appearance of process integration at the user interface level. More recently, Intranet technology has begun to provide for the connection of functionally discrete systems and data, across different hardware platforms, over controlled internal WAN's using the Internet as a distribution layer (James, G. 1996). In this way, process workers can seamlessly share data and applications, without incurring the overhead involved in replacing legacy systems with fully engineered enterprise wide process support systems.

5 CONCLUSIONS

From the earliest appearance of BPR on the management radar screen, IT has been seen as the key enabler of radically redesigned business processes. This paper has discussed two discrete functions of IT in enterprise reengineering:

1. a BPR project support tool, used as an aid to mapping, modelling and evaluation of processes; and
2. an infrastructural component of redesigned organisations, providing essential computer hardware, telecommunications and software for the process based business.

As a project support tool, IT now presents a confusing array of candidate software utilities and features to aid the BPR practitioner. Selection of suitable tools, and the search for best clinical methodologies, has become a concern for practising managers and consultants, as well as academic methods researchers. However, much time and energy can be devoted to this debate in practice, and it is important to recognise the limited function of such tools in the facilitation of organisational change. The choice and use of automated BPR project support tools must be subordinated to the real and “messy” challenge of promoting a sustainable realignment of all the organisational components along business process dimensions.

A more important issue for the application of IT in BPR is the enactment of redesigned processes in new software and hardware applications. In this respect, IT has been an impediment to early realisation of BPR benefits, due to the difficulties associated with software development, inappropriate skills, business reliance on legacy systems, and platform migration. These issues must be addressed in BPR implementation planning, if the intentions and efforts of enterprise process redesign are not to be discredited before they've had a chance to deliver results.

Implementation planning must recognise, in particular, that:

- IT infrastructure is just one component of a complex organisation redesign;
- idealised process simulations may be very difficult to implement in practice;
- IT architecture planning and systems development should be based on the broad, lateral definition of business processes, rather than being incrementally developed as functionally bound systems and data;
- IT migration strategies should be developed to support the transition from legacy systems in a manner which should not impair the achievement of greatly improved performance results while new technologies and applications are being assimilated.

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7 KEYWORDS

Information Technology;
BPR tools;
organisation design;
process based systems;
systems migration strategy.

8 AUTOBIOGRAPHICAL NOTE

Dr. Gerard Lyons is Head of the Information Technology Department at University College, Galway. He is also an international management consultant to leading multi-nationals and previously worked for Digital Equipment Corporation. He is a founder member of the IBPR.