CROSS-FUNCTIONAL INTEGRATION: THE ROLE OF INFORMATION SYSTEMS

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ABSTRACT

As international competition intensifies, more and more firms are finding themselves under mounting pressure to improve productivity and marketing strategy. Information systems (IS) technology has been identified as potentially one of the most important tools for accomplishing this task. This paper discusses the importance of developing cross-functionally integrated information systems as a backbone infrastructure for improving productivity and competitive position of an organization. Such integrated information systems are essential for organizations to initiate business restructuring and reengineering through strategies such as business process reengineering (BPR) and total quality management (TQM). Efforts for implementing cycle time reduction, workflow automation, group collaboration and coordination systems, and inter-organizational systems also depend on cross-functional integration (CFI) infrastructure. The paper discusses information technologies that play an important role in developing cross-functional integration and calls for the development of a MIS plan and strategy that explicitly aims to achieve CFI.

INTRODUCTION

All over the world organizations are attempting to improve productivity and marketing strategies as a means of remaining competitive in changing world markets. In achieving these goals; information systems (IS) technology continues to provide the most powerful set of tools that management has at its disposal. Advances in computing speed and power, database and telecommunications technology, computer programming, and innovative new applications of these technologies have opened up a wide range of options for the use of IS technology. Information technology has the potential to increase the productivity of operations and improve competitiveness through factors such as better cost, quality, availability, customer service, electronic outreach, and reduced cycle times. Indeed, information technology can play a role in improving management and enhancing performance related to all four marketing strategy elements: product, price, promotion, and placement (distribution).

Historically the emphasis of information systems has been towards the design of systems that use information technology to process and deliver information for individual functions. However, in the last few years, there has been an increasing recognition of the potential of IS in improving productivity through organizational redesign and integration across functions. Different management concepts such as business process reengineering, cycle time reduction, workflow automation, supply chain management, and group coordination and collaboration have been widely recognized as critical conceptual developments on how to use IT to enhance productivity in organizations. One important issue that deserves attention is: What is the fundamental underlying information systems infrastructural characteristic that is needed for successful implementation of IT based innovations identified above?

IT based cross-functional integration (CFI) is the fundamental underlying requirement for the implementation of innovations discussed above to help streamline, improve, and automate business processes. A recognition and understanding of this fundamental infrastructural requirement can contribute to its consideration and incorporation in the design and development of information systems structures, right from the early stages of such efforts. CFI issues can be considered throughout the IS architectural design and development phases as a fundamental design requirement, independent of any current or future BPR or restructuring initiatives. In fact when CFI is already designed in systems, it will facilitate easier implementation of innovations such as BPR (Hammer, 1990), cycle time reduction (Stalk, 1988; Marucheck, 1992), group processes (Rao and Jarvenpaa, 1991), and workflow automation (Bitzer and Kamel, 1996; Joosten and Schipper, 1996). Further, identification of the importance of CFI and its implementation in successive enhancements to information systems architecture would lay the foundation for future process improvements throughout the organization, whether through a radical restructuring of selected processes or through a gradual improvement of all processes, e.g., in the mode of TQM (Earl and Khan, 1994). Researchers have reported very high failure rates for initial BPR efforts (Clemons, Thacher, and Row, 1995; Moad, 1993; Bashein, Markus, and Riley, 1994). One cause of such failures may be weak CFI in the underlying information systems. Weaknesses in the existing information systems in the area of CFI could limit the scope and success in implementing process innovations, which usually cross functional boundaries. Further, the need for large, unplanned investments to overhaul IS infrastructure, may render many BPR efforts economically infeasible.

However, in many organizations, it is BPR initiatives that have helped improve CFI and spurred the drive for CFI through investments in technology and attention to the need for common definitions and sharing of data. While an overall comprehensive planning and design approach for an organization-wide CFI is desirable, in the short term many organizations find value in making CFI improvements along key business processes as part of their BPR efforts. Such efforts with limited resources and scope can also yield valuable results for organizations. Additional benefits can be obtained through a comprehensive, organization-wide information systems strategy that focuses on developing CFI as a long term goal.

CFI is also needed across firms to help create a well coordinated supply chain of cooperating organizations. Such efforts can enhance the productivity of the entire chain and even an entire industry if all members cooperate to help develop common standards and structures for such integration.

Importance of CFI had been recognized well before the introduction of concepts such as BPR, cycle time reduction, or workflow automation. For example, based upon a comparison of British and German manufacturing firms, Child (1984) noted that the compartmentalization of activities that accompanies functional specialization is hurting the competitiveness of British firms. Cross-functional integration permits reversal of such trends through adjustments to the organizational structure in the form of consolidation of tasks and activities, merger of organizational roles, and changes in functional boundaries. Many researchers have called for CFI to improve an organization's performance in areas such as product innovation (Swink, Sandvig, and Vincent, 1996), R&D (Miller, 1995), product quality (Numerof and Abrams, 1994), development capability (Wheelwright and Clark, 1992), and TQM and quality improvement efforts (Porter, 1991).

This paper highlights the importance of CFI and examines the role of information systems in enhancing productivity and competitiveness through cross-functional integration. The next section discusses opportunities and issues for CFI within organizations and across organizations. The following section discusses the role of IS technology in facilitating cross-functional integration in organizations. The following section identifies some alternative management strategies for effecting organizational restructuring to take advantage of CFI. The following section presents the experiences of some organizations who have implemented CFI. The paper concludes with a discussion of recommendations for management.

CROSS-FUNCTIONAL INTEGRATION

Cross-functional integration is the establishment of mechanisms and links that facilitate the needed coordination of the activities of different functions to ensure that these functions work together effectively to achieve the overall objectives of the organization. Such integration is also needed across different organizations to create a well managed, integrated supply chain of cooperative organizations with high responsiveness and low transactions costs. Therefore, CFI issues have been considered important at the intra-organizational as well as the inter-organizational level.

Intra-organizational CFI

Even before the advent of information technology the need for cross-functional coordination and information flows existed and mechanisms and structures evolved in response to this need. Close cross-functional coordination is vital for the effective functioning of an organization. In manufacturing organizations, sales, production, and purchasing have to closely coordinate their activities to develop and adjust production and procurement plans to optimize inventories at all stages of production in line with customer preferences and demands. Budgeting, recruitment, manpower levels, and production capacities need to be tied to short term and long term production plans. Activities of warehouse, goods movement, various production lines, maintenance, tools engineering, and shipping also need to be coordinated. Similar coordination is also needed among various functional units in the non-manufacturing sector. For example, in insurance companies, coordination is needed between different functions that perform credit checking, quoting, rating, underwriting, and other related processes.

With the advent of information technology, many activities involving cross-functional integration are now being supported by information systems. Information systems can provide varying degrees of support for cross-functional integration. In the case of a low degree of support for cross-functional integration, IS can improve the flow of needed information across functions, for example in the form of reports. However, as more and more data is being generated, stored, and exchanged in electronic form, the role of IS technology in cross-functional integration is constantly expanding. Information technology provides means for faster, more accurate, more complete, and effectively coordinated information flows across functional boundaries. Therefore, information technology can play a key role in further advancing cross-functional integration to a high degree where the activities of different functions can be closely integrated, and even placed under one overall system.

One important characteristic of a high degree of cross-functional integration between two functions is that the electronic information flows between functions are in a form that can be directly used by the respective functional subsystems with little or no manual support. To the extent such information flow are more coordinated and complete, the role of manual efforts in interpreting and coordinating cross-functional flows can be minimized. A high degree of cross-functional integration may also permit elimination of functional boundaries and consolidation of responsibility under one head. Such cross-functional integration may result in a more responsive and leaner organization, wherein changes originating in one function can be immediately communicated to other functions for any needed action. An example of a high degree of cross-functional integration is the integration of computer-aided design (CAD), computer aided engineering (CAE), and computer aided manufacturing (CAM). Information flows from CAD to CAE to CAM can be directly used with little manual support. This high level of integration has permitted consolidation of design and manufacturing under one head (Meredith and Hill, 1987). Such integration in manufacturing also leads to significant improvements in productivity, lead time, flexibility, process control, quality, and reductions in manufacturing costs (Datamation, 1989b; Datamation, 1990; Gold, 1989; Groves, 1990; Koelsh, 1990; Maruyama, 1990). For example, in the case of Ashai Video Products, over a four year period, manufacturing costs declined by 22%, yields improved by 8 to 26%, and quality improved by 42 to 121% as a result of better integration (Koelsh, 1990).

Reports of benefits from CFI efforts in non-manufacturing sector include improved customer service, reduced lead-times, improved coordination, and optimized inventory levels (McFadden and Hoffer, 1991; Fitzgerald, 1990). Implementation of CFI also leads to elimination of duplicate efforts by different functional units. In one organization 30 to 50 percent tasks that people were performing were identified to be redundant during CFI analysis (Datamation, 1989a). CFI may also lead to a reduced role for manual coordination efforts. Presently, many white collar employees in supervisory and middle management positions are engaged in a manual coordination of activities of different functions. When information systems support cross-functional coordination, the manpower level needed to coordinate cross-functional efforts should decline. It may also free up staff from routine activities and enable them to devote more time to strategic issues.

Interestingly, the trend towards decentralization of MIS activities and end user development has hurt the goals of CFI. In many organizations, these trends have led to the development of disparate systems that are almost impossible to integrate. One retail industry executive asserted that user developed and managed systems are the biggest hurdles in achieving CFI in his organization. IS department would need to put in significant efforts to overcome the difficulties created by unplanned development and poor choice of technologies selected. For an example, it was pointed out that videos rented from one location can=t be tracked if they are returned to another location at one of their 42 stores. Similarly, prescription information submitted to one store can not be retrieved from any other store for refilling prescriptions. Poor integration of existing systems is also favoring development of additional structures such as data warehouses to help integrate historical information from different systems. However, a data warehouse solution can not help solve the problems of integration for operational systems.

Inter-Organizational Integration

In the above discussion we have demonstrated the usefulness of intra-organizational integration. However, the benefits of CFI can also be extended to inter-organizational context. Such integration may play an important strategic role in enhancing the outreach of an organization to its customers and vendors.

Many organizations view such integration as a strategic advantage that can reduce cost of processing transactions, lower costs of inventories, reduce stockouts, minimize coordination costs, reduce cycle time, and create a more responsive and adaptable system that provides for efficient procurement, manufacturing, and distribution planning and operations.

The commonly employed technology for inter-organizational integration is electronic data interchange (EDI) for which X.12 standards have evolved. However, new forms of Internet based inter-organizational communication patterns are emerging. Organizations are recognizing the advantages of integrating internet based systems having standard, intuitive, easy to use graphical user interfaces (GUI) with enterprise business application software. This will help create an extended supply chain where millions of users, both individual and business, will be able to participate in electronic commerce. Most major vendors have begun to pay attention to developing Web based business solutions. For example, IBM (Sivakumar, 1996) plans to take a leadership role in Web-based enterprise computing solutions, with Notes as the vehicle to play an integrating role in the server, client, and the middleware tiers of the overall Web architecture.

IT INFRASTRUCTURE FOR CFI

One of the important questions to ask with respect to CFI is: what is the underlying fundamental information systems infrastructural requirement for achieving CFI, and what new developments are taking place to facilitate CFI. We will first review the currently standardized information systems technologies and then review emerging object-oriented technologies.

Effective integration requires the development of an overall architecture that defines a plan for the infrastructure of available information and technologies to be used. A framework that helps understand the components of IT enabled CFI is presented in Figure 1. It breaks down the overall infrastructure into three different, somewhat independent components. The first part is the enterprise architecture. This is a high level conceptual representation of the organization. It identifies the organizational hierarchy and its components in the form of different functions and business processes in the organization. It also includes an identification of objects and events that occur in the business environment and an understanding of cross-functional interactions and workflows.

Figure 1: A Framework for IT Enabled Cross-Functional Integration

Level	Architectural Component
Conceptual Level	**Enterprise Architecture**
	Organizational hierarchy Business functions and processes Business objects and events Cross-functional workflow models
Logical Level	**Information Architecture**
	Enterprise-wide data models Meta-data repository, Enforcement of common data definitions Server and client level business process logic
Physical Level	**Computing and Network Architecture**
	Computing nodes (servers and clients), Data storage devices, Physical database segments, Network connections Network protocols, Operating systems Middleware: API, ODBC, CORBA, COM/DCOM Server level stored procedures and client level user interface programs.

The second part of the framework is an information architecture at the logical level, which considers the objects and events of interest throughout the organization and develops an enterprise-wide data model depicting the relationships between such objects and events. The model also identifies business rules and constraints, and data integrity requirements. Information architecture also includes a data dictionary or a meta data repository that helps organize and enforce uniform data definitions across the organization. The model is then implemented on a set of interrelated relational databases, that may be a central resource or more typically a set of databases distributed over a number of nodes in the organization. Establishment of common databases permits users to share the same data through common data definitions and formats - which is a critical requirement for logical integration. The logical level also includes business application logic that is derived based on functional and cross-functional processing needs.

The third part is the computing and networking architecture at the physical level. It defines the layout and specification of computing nodes and associated operating systems, storage devices, and physical database segments in the organization. This architecture also includes the specification of arrangements for providing telecommunication interconnections among different nodes (clients and servers) internally and with external entities There are well developed standards for accomplishing this task by using products from different competing vendors. Development of standards and common network protocols in this area has been supported by the efforts of International Standards Organization (ISO) through its specification of a seven layer architecture for data communication. New technologies such as high bandwidth fiber optic cables, asynchronous transfer mode (ATM) switches and frame relay protocols have made it technically and economically feasible to offer high bandwidth multimedia interconnections across the organization that can carry text, graphics, sound, and video. These advances permit support for higher levels of integration through richer information flows in the networks.

A critical part of the computing and networking architecture is the set of development software, tools, and middleware programs that are used to provide a complete software project environment to integrate the information and deliver the necessary reports and interactive screens to users across the organization. This includes various application program interfaces (API), middleware software, and server and client end application software that implements the business logic. The middleware enables simplified, transparent interconnections from different client stations to target database servers without being aware of the complexities of different hardware platforms, operating systems, application languages, database software, network topology, and communication protocols. Thus user interface applications can transparently provide access to different databases on different platforms and present a cross-functionally integrated view of the organizational model to users, which is unconstrained by organizational boundaries in the form of departments, functions, and physical locations.

Clearly a central issue in integration is the use of common standards and data definitions. Some enterprise resource planning (ERP) vendors, who provide integrated packages for different functions in a wide range of industries, have demonstrated success in integrating different functions in organizations through the use of in-house developed common standards, data definitions, and middleware for such integration. The common standards provided by such products (e.g., SAP) are also being used by a number of competing organizations to develop integrated supply chain management systems on a cooperative basis for the entire industry (Moad, 1995).

As an illustration of the application of the framework, let us consider the case of a customized products manufacturer. The enterprise architecture helps formally define the different functions and processes that occur within a functional area as well as across the functions. This architecture will include functions such as sales, accounting, finance, purchasing, manufacturing, and human resources. It will also identify objects and events in the business environment such as customers, vendors, products, employees, and receipt of materials, sales transaction, and raising of a purchase order. Interrelationships between these objects and events are further elaborated by cross-functional processes and workflow models such as order entry to shipping and invoicing cycle, or purchase order to material receipt and vendor payment cycle. Thus business level cross-functional relationships and interfaces are identified by the enterprise architecture at the conceptual level.

The details gathered in developing the enterprise architecture are useful in developing an information architecture at the logical level. It defines an overall common data model that includes the data pertaining to objects and events such as customers, vendors, products, employees, sales transaction, and materials receipt. The functional integration is also supported by the development of process logic that integrates the data from different entities and presents a unified view to users. An example of this may be an integrated inventory management business process that may need to integrate purchasing, warehouse, manufacturing, and sales data right from raw material stage through manufacturing cycles to the finished goods stage to help optimize inventory levels.

The actual integration will be implemented at the physical level by designing the computing and networking architecture. The first part will be a network of server and client computers that will be connected together through physical links and network protocols. A middleware layer will arrange for communication and interaction among different databases and application processes through out the network. The second part will consist of a set of programs that provide user interface through application programs that run at the client end and implement the business logic directly or in cooperation with other programs stored at the server level. The physical layer will store all database segments, either in one central location or in a distributed mode on several servers. While the entire system presents an integrated view to users, the architecture provides flexibility to store data and processes at any location with the object of optimizing the overall performance of the system. An integrated application such as order status review, can seek data from sales, design, purchasing, warehouse, manufacturing, and shipping activities through the central data base model and present an integrated view of the status of an order to the user. Thus the three levels of the framework help develop architectures that enable easy, transparent integration of activities and processes across functions in an organization.

Object-Oriented Approaches

Of all developments in the information architecture, object oriented technologies hold the most promise for providing a seamless, transparent, and universal integration between various functions within a business and among cooperating business organizations. Object-oriented approaches aim to provide integration through the universal sharing of common objects, which are designed to be completely independent of existing networks, architecture, systems, applications, and processes.

Distributed object computing (DOC) technologies have been proposed for business applications that spread across multiple platforms and networks. One important objective of DOC is to provide CFI across the organization and with other organizations in a seamless manner which is transparent and adaptive to needed future changes. DOC permits application of object-oriented technologies to client-server and distributed computer environments. As such DOC represents a convergence of client-server and object-oriented technologies.

DOC permits objects, containing data and services, to be distributed across a heterogenous network, yet permit each of the components to interoperate as a unified whole. In this environment object request brokers (ORB) act as middleware that permit interoperability in heterogeneous networks. ORBs provide the glue that permits objects to locate and activate other objects, regardless of the operating system or programming language used. ORBs hide networking complexity from the systems developers and permit the same object to act as client or server at different times, depending on the need. In essence this helps create a highly integrated system where the network, consisting of multiple processing nodes running different operating systems, itself becomes a unified computer.

Objects may be programs written in COBOL on mainframe, Java, C++, or SMALLTALK on a workstation, or an EXCEL spreadsheet on a microcomputer. The application developer is not concerned with these platforms and programming environments. The developer simply sees objects interacting with one another as a unified whole. These objects provide a built in business functionality that can be used to integrate applications easily.

As discussed earlier any integration effort would need to address issues of common standards at the information architecture level and the computing and network architecture level. DOC addresses the issue of integration at both of these levels. IS vendors have taken a number of initiatives to address the issue of common standards. One such initiative involves the development of standards for DOC in heterogeneous environments by object management group (OMG), an organization floated by a group of IS vendors. OMG aims to define object management architecture (OMA) that includes specification of four sets of standards: common object requester broker architecture (CORBA) which is needed for communication and integration between objects, common object services specification (COSS), common facilities, and standards for application objects. Concurrently, other vendors under the leadership of Microsoft are working on the development of similar standards under the title of object linking and embedding (OLE) and common object model (COM) and distributed COM (DCOM) using the Active-X framework. Hopefully, in the near future, as the standards stabilize and mature, these vendors will eventually agree to common standards or provide well developed interfaces in their products incorporating object-oriented technologies to permit full interoperability and transparent integration of information contained in the object structures. These technologies would help create highly cross-functionally integrated information systems that would support creation of revolutionary new organizational and inter-organizational structures that are highly flexible. Such flexibility will greatly contribute to experimentation and innovation in the development of new organizational forms and structures that would successfully compete in the next century. Advantages of distributed objects in facilitating BPR efforts have been recognized in the literature (Rymer, 1994).

DISCUSSION AND CONCLUSION

Organizations are on the lookout for ways to improve their productivity and competitive position through the use of suitable information systems technology. This paper addresses the need for developing an information systems infrastructure that is built to provide cross-functional integration (CFI) within an organization and with other business partners outside the organization. Organizations should pay attention to building such cross-functional integrated systems in their MIS plans and strategy independent of any current organizational restructuring or reengineering projects. Adoption and acquisition of new IS technology should be made keeping in view the overall IS architecture that is designed for CFI.

CFI provides the backbone upon which organizations can build better organizational structures to improve productivity and cycle time. Such efforts can provide benefits such as elimination of redundant activities, facilitate coordination and control, merging of different functional units, streamlining of processes, improvements in quality, and significant reductions in cycle times. CFI also permits streamlining and automation of workflows, implementation of group cooperation and collaboration systems and inter-organizational systems that help streamline an entire supply chain. However, taking advantage of CFI structures may require explicit top management attention and initiative. CFI could provide the basis for undertaking process improvements through approaches such as BPR and TQM. In fact well developed CFI structures could facilitate innovation and experimentation on a wider scale than BPR efforts that are focused on few processes.

In the absence of established CFI structures, many organizations have used BPR initiatives to lead the CFI effort along the processes being improved. This can be a possible approach in the short term that may yield quick results and require fewer resources to show demonstratable results for key processes. Such success and benefits should spur the organization to consider investment in initiating wider CFI efforts.

The issue of CFI needs to be addressed at the MIS planning and strategy level. Management should pay attention to the need for CFI in developing its overall IS strategy. Design of IS architecture at the information architecture level and network architecture level should include explicit consideration of CFI. Selection of IS hardware and software technologies should be made only after considering their suitability and compatibility with the overall plan for CFI. As there are a number of alternative standards and technologies available for IT based cross-functional integration, organizations need to be very proactive in assessing these technologies and choosing the right recipe for their specific needs. This issue should be given appropriate strategic importance in view of the risks involved in making a wrong decision.

Given the strategic importance of CFI structures, top management may need to get involved and direct the development of CFI structures. Top management attention is also needed for the subsequent organizational change and reengineering efforts in view of the significant investments that may be needed for such endeavors and the cross-functional nature of the associated restructuring efforts. Many organizations are also choosing to adopt enterprise resource planning packages (e.g., SAP, Peoplesoft, Baan) to achieve CFI. Again the role of top management in critical in such strategic decisions. Given the important implications of CFI for organizations, future research should focus on empirical investigation of various aspects of CFI implementation, including the role of MIS planning and strategy formulation, selection and adoption of CFI architecture, barriers and inhibiting factors, productivity impacts, process and workflow improvements, and other organizational impacts.

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