Integrating Information Technologies Into Business Functions: A Taxonomy of Integration Strategies

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ABSTRACT. The objective of this paper is to establish a taxonomy of integration strategies that will assist information technology managers in integrating information technologies into business functions and strategies. Such integration is becoming even more of a reality now because of several factors: increased capabilities of inter-networking, availability of development tools that permit multi-platform interfaces, and the evolution of distributed databases. The paper provides a scheme for defining integration that identifies three dimensions: scope, object, and organization. Objectives of integration are classified into gaining competitive advantage, achieving more effective and efficient operations, and improving customer relations. The taxonomy of integration strategies is presented based on the following layers of platforms: information technologies, network, data base, application development, and organization strategies. An integration project may include one or more dimension, achieve one or more objectives, and span over one or more platforms. Without proper planning and implementation, integration projects may fail causing the loss of technology and financial resources.

1. INTRODUCTION

The objective of this paper is to establish a taxonomy of integration strategies that will assist Information Technologists (IT) and business managers in identifying an organization's needs and specifying requirements for integrating information technologies into business functions and strategies. This approach to integration is more of a reality now because of several factors: a) increased capabilities of inter-networking, particularly the *internet*, b) availability of development tools that permit multi-platform interfaces such as Java language, c) the evolution of distributed data bases, such as client/sever technology, and d) the development of new IT concepts such as data warehousing. The paper starts by providing a scheme for defining integration. The definition delineates three dimensions: scope, object, and organization. The paper then discusses the following objectives of integration: gaining competitive advantage, achieving more effective and efficient operations, and improving customer relations. Finally, the taxonomy of integration strategies is presented based on layers of platforms. The following platforms are discussed: information technologies, network, data base, application development, and organization strategies.

2. A SCHEME FOR DEFINING INTEGRATION

The verb "integrate" is defined in **Webster's** dictionary as "to make whole or complete by adding or bringing together parts." In the information systems arena, a unique definition of integration does not exist. Businesses conduct integration projects in different contexts depending on the parts, objectives, and platforms that integration brings together. This paper develops a scheme for defining integration by identifying three dimensions and sub-dimensions, as summarized in Table 1.

Table 1: Dimensions and Sub-dimensions of Integration

Dimensions	Sub-dimensions
Scope	Horizontal, Vertical
Object	Physical, Logical
Organization	Internal, External

The following sections discuss these dimensions and give supporting material from the literature.

2.1 Scope

Scope defines the boundaries of integration projects. The scope has two sub-dimensions: horizontal and vertical. The horizontal scope of an integration project may have a range that may cover the whole organization, activities of a single department, or processes of a single type of functional information system. The vertical scope of an integration project may span over more than one of the levels of the organizational structure, which is generally classified as top, middle, and lower.

2.2 Object

Object defines the parts or components that integration brings together. Objects may be classified into two sub-dimensions: physical and logical. The physical sub-dimension may include objects, such as networks, data bases, and humans. On the other hand, the logical sub-dimension may have objects such as concepts, for example Decision Support Systems (DSS) and Expert Systems (ES), and functions such as customer relations, inventory control and manufacturing. Objects are linked together by some means of either automated communication media, such as Electronic Data Interchange (EDI) or conceptual communication links, such as modeling techniques, group dynamics, walkthroughs and interviews.

2.3 Organization

The organizational dimension has two sub-dimensions: internal and external. Internal integration links objects within the organization, such as data and humans, while external integration links objects outside the organization, such as customers and vendors. Figure 1 shows the relationship between the dimensions of integration and levels of management.

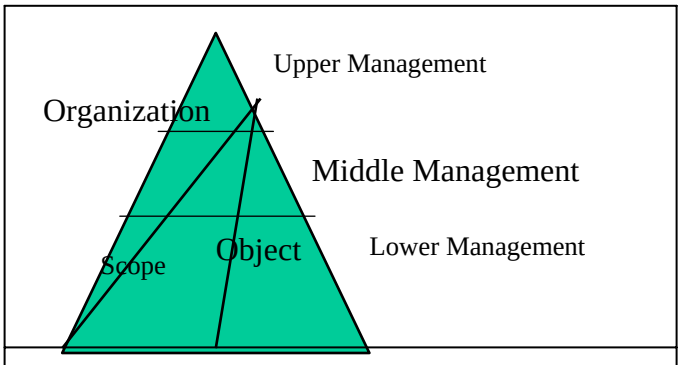


Figure 1: Dimensions of Integration and Levels of Management

The scope triangle is narrow at the top and wide at the bottom, indicating the downward increase in scope. The object dimension, on the other hand, is logical at the top and becomes more physical towards the bottom. Finally, the organizational dimension is wide at the top and narrow at the bottom. This shape implies that higher level integration encompasses strategic management and external objects, while lower level integration involves internal objects.

Integration dimensions, similar to the one used in this study, are mentioned in the literature. [01] The author states that network integration can occur in three dimensions: a) functional purpose, b) organizational setting, and c) physical composition.

The types of integration were revealed in the results of a survey of 129 members of the **Computerworld** editorial board of information managers and published in the 19 February 1990 issue:

1. 72% were involved in business networking projects, such as EDI, Local Area Networks (LAN) or Wide Area Networks (WAN).
2. 70% were engaged in multi-vendor connectivity (hardware and software integration).
3. 54% were involved in organizational integration.

Therefore, the majority of businesses are engaged in integration projects that are external (EDI), internal/vertical (LAN and WAN), and internal/horizontal (multi-vendor connectivity and organizational). The third group is the logical integration of the two sides of organization: business and Information Systems (IS). The scope is determined by the actual detailed implementation of each integration project.

3. OBJECTIVES OF INTEGRATION

Several objectives for conducting integration projects are identified, as listed in Table 2. Figure 2 incorporates the objectives of integration into Figure 1.

Table 2: Objectives of Integration

Gaining Competitive Advantage
Achieving More Effective and Efficient Operations
Improving Customer Relations

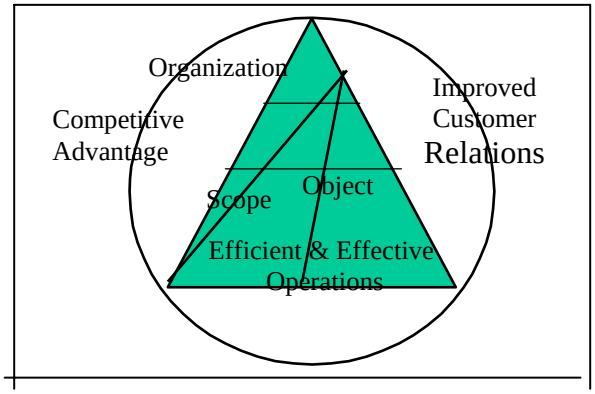


Figure 2: Dimensions of Integration,
Objectives of Integration, and Levels of Management

At the bottom of the organization, the objective is to achieve more effective and efficient operations by improving Transaction Processing Systems (TPS). Achieving competitive advantage requires more of the organizational dimension, especially at the top. Finally, improving customer satisfaction requires linking physical as well as logical objects. The following section discusses these objectives and cites examples from the literature that represent real world integration cases.

3.1 Gaining Competitive Advantage

This objective is accomplished through strategic use of technology through integration. It may involve the integration of multiple classes of transaction data, group communications, and multiple forms of data

representation. [02] Interviews with top consultants highlighted the effect of system integration on improving the competitive position and strategic advantage of an organization. [03]

Travelers Insurance Co. achieved competitive capacity by establishing an integrated IS infrastructure to meet long-term business needs while providing the possibilities of exploiting specific medium- and short-term market opportunities. Those opportunities were exploited with the same flexibility, economies of scale, and ability to innovate as in computer-integrated factories. [04] General Motors Corporation used Manufacturing Automation Protocol (MAP) to gain a competitive edge. MAP controls information exchange among a number of vendors' products and operating systems by linking data processing, networking, office automation, engineering and manufacturing. [05]

To stay competitive, Chase Manhattan Bank developed a global network infrastructure to connect over 100 multi-vendor nodes worldwide into an electronic mail system using vertical/internal and horizontal/external integration dimensions for management and customers, respectively. [06] After three months, more than 7,000 users on the system and 20,000 managers and others were added to the system. By using Softswitch's X.400 gateway interconnecting with MCI's MCI/Mail, real-time financial account information was made available. The project used a token-ring network based on IBM's OS/2 LAN server.

3.2 Achieving More Effective and Efficient Operations

This objective is particularly important in manufacturing. [03] The literature reported several integration projects using Computer Aided Design/Computer Aided Manufacturing (CAD/CAM), Just-in-Time (JIT), and Computer Integrated Manufacturing (CIM).

Integration of the manufacturing process by using the JIT concept involves: a) timely arrival of material at a production line, b) production in small lots, c) on-time delivery, and d) quality improvements. Available off-the-shelf software packages may not be totally JIT-compatible. However, some packages, such as those available from Creative Output Inc., Xerox Computer Services, and Hewlett-Packard Co. provide JIT-like software. [07] Consultants discussed the positive effects of decentralized integration of logistics and JIT concepts on the effectiveness and efficiency of organizations. [08] Furthermore, consultants stressed the importance of integration between information systems and manufacturing. Such integration reduced conflict and improved communication between the DP professionals and the manufacturing people. [09]

Ingersoll Milling Machine Co. used CIM to turn out machining lines and milling products with flexibility, minimizing waste. The system used and linked a common data base on IDMS, 217
CAD/CAM terminals and an expert system for parts purchasing. [10] Another example of integrating design and manufacturing was completed at General Dynamics. PC-base software reduced prototyping problems, saved several million dollars and decreased assembly time by 30% to 40%. This CAD/CAM integration was based on concurrent engineering, cross-design teams, product data base, standard bills of material with single data base dictionaries, and the use of 3-D solid terminals. [11]

A second area is hospital administration, where integration among three different information systems is needed: patient, clinical, and financial data. In late 1970, MacNeal Hospital and the University of Iowa Hospitals and Clinics purchased IBM's Patient Care System/Application Development Systems (PCS/ADS) to integrate clinical and financial data. Both were able to reduce clerical staff as a result of using this system. [12] A Wisconsin hospital saved $1.2 million and cut order processing time from 20 minutes to 5 minutes by installing an administrative/clinical IS. [13]

A third area of increasing effectiveness and efficiency of operations is mass merchandising. In this area, integration may involve the following areas: category management, electronic marketing, electronic benefit transfer, communication switch ownership, scan data quality, and short shelf-life products. Vons Company was a leading experimenter of this technology. Vons used innovative products, such as video-carts, customer check-out cards, on-line tracking of inventory on an IBM 3090, a single dedicated cable (with EDI capacity) for order entry, and POS terminals. [14]

3.3 Improving Customer Relations

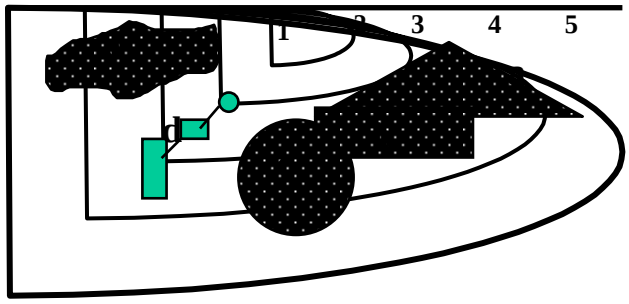
Companies establish electronic links with customers to facilitate information flow in both directions. This link would increase the customer base and loyalty, reduce chances of delivery delays, eliminate the possibility of running out of stock, make ordering systems more convenient, minimize inventory costs, and enhance the competitive edge. Tramsco Energy Co. used an EDI network to allow customers to quickly check rates, arrange routes, and transmit/receive messages. Using standard dial-up lines connected to an IBM 3090, the system cut contact turnaround from 6 weeks to less than 5 days. By 1990, half of the contracts were made through the system. [15]

Two health care companies used customer integration systems. [16] Mckesson Corp. had an automated delivery system for health-care supplies, which made next-day delivery possible by electronic order processing. Bergen Brunswig integrated its various customer order systems to permit cheaper and faster handling of larger quantities of customer orders and to allow itself to accomplish long-term strategic value in sales forecasting and promotion management. Other features of the Brunswig integration included: a) Just-In-Time delivery, b) automated partial case picking that saved money and cut handling time, c) usage of EDI to handle 88% of the supply-purchasing money, and d) inventory management with consequent savings.

Dow Chemical Co. developed a system that mixed data center consolidation and global systems integration with the goal of restructuring customer service. [17] The system aimed at allowing salespersons to access relevant business information in any Dow database around the globe. The new systems simplify order entry, order management, and inventory control applications running on an IBM mainframe and accessible from desktop computers. These activities permitted greater control over its global operations and produced immediate cost savings. After introducing objectives of integration, the next section presents the taxonomy of integration strategies.

4. A TAXONOMY OF INTEGRATION STRATEGIES

Figure 3 shows the taxonomy of integration strategies in half circle layers. Each layer represents a platform for that strategy. In addition, the figure illustrates possible scenarios of integration projects.



Layers of Integration Strategies
1. Organization
2. Application Development
3. Data Base
4. Network
5. Information Technologies

Shapes “a” “b” “c” “d” & “e”: scenarios of integration projects from best to worst

Figure 3: Layers of the Taxonomy of Integration Platforms and Possible Scenarios for Integration Projects

The platforms are presented in layers, moving from the most logical at the top to the most physical at the bottom of the chart. The figure also shows shapes of possible scenarios of integration projects arranged from the best (“a”) to the worst (“e”). Shape “a” shows the best acceptable scenario for an integration project: to span through all layers in a top-down method. Shape “e” shows the worst scenario: a haphazard implementation of

an integration project. In between these two extreme scenarios, shape "b" barely reaches organization strategies and implements the integration project squarely, perhaps combining unnecessary components. Shape "c" illustrated a well-rounded integration project that encompasses one or a couple of platforms but lacks the comprehensive view of organization strategies. Shape "d" integration projects are conducted in a piece meal approach and management tries to link the pieces together. The following sections discuss these platforms and present real-world examples.

4.1 Organization Strategies Platform

Each integration project should start by having a clear view on how IT and business strategies mix together. Two areas of integration are suggested.

4.1.1 Integrating business strategies and information systems

This integration is accomplished at the macro organizational level. Blending business strategies and IT is becoming very critical to the success of organizations. MIS professionals are requested to demonstrate how IT will increase competitive advantage. [18] To accomplish this type of integration, each organization must insure that its strategic plan must state how IT will assist in achieving the strategic objectives of the organization. One author suggested that the use of techniques of business strategy formulation in the IS field will be more effective than extending IS techniques of strategy formulation into business analysis. [19] Further research is needed to device a method/model of integration between the two.

4.1.2 Integrating activities of end-user and IS professional

On the opposite side of the above integration is the micro-organization level. Organizations may decentralize analysis and design activities into end-user departments while keeping programming centralized, as CBS [20] and Riggs Bank did. Mellon Bank moved programmers with experience in 4GLs to end-user departments.

4.2 Application Development Platform

In this platform, two areas of integration are identified.

4.2.1 Computer-Aided Software Engineering (CASE)

CASE tools automate software development and maintenance. Two integration schemes are possible: integration of CASE tools into existing organizational and DP department environments and integration among different components of CASE tools. [21]

In the first scheme, organizational integration requires CASE to be used for modeling business functions at all three levels of management: upper, middle and lower. Upper CASE, Middle CASE and Lower CASE integration permits modeling of organization and department objectives and activities, developing requirement specifications and implementing (programming) IS.

In the second scheme, CASE tools must support portability among different hardware and software platforms. Hardware platforms include computers from different vendors and of different sizes. One critical aspect of this integration is a PC-mainframe link that allows distribution of CASE development on the PC and later transforms the results to a mainframe computer. Software platforms include operating systems and DBMS running under a teleprocessing (TP) monitor that controls interactive communications with terminals. CASE tools may be compatible with different versions and types of operating systems running on the same or different types of computers. For example, CICS is the IBM TP monitor. ADABAS and IDMS provide their own TP monitor. CASE tools may run under one or more DBMSs and TPs.

Another aspect of the second scheme involves integration of different components of CASE tools: front-end (analysis and design) and back-end (programming). Phase CASE tools from different vendors are not currently integrated. Some vendors provide life-cycle CASE tools that integrate all activities of the software development life cycle.

4.2.2 Internet application development

The most recent challenge is the development of applications on the *internet.* Marketing applications are the major target for such applications. [22,23] Java language allows the development of application software that will run using multi-platform graphic user interfaces, i.e. Windows 95, Windows NT, and X Windows. [24] Sun Microelectronics is supporting the Java language by introducing distributed capabilities for the language [25] and Java processors. [26]

4.3 Data Base Platform

Requirements of data base integration may take one or more of the following types.

4.3.1 Integration within a single data base

Data integrity within a single data base is determined by good design and implementation of the database. Data linkages may not be complete and data redundancy may still prevail. Consequently, data retrieval may not satisfy management needs.

Data Base Management System (DBMS) is possibly the earliest method of integrating data. By moving from COBOL, Pascal, and other procedural languages to C and Relational DBMS, Batterymarch Financial Management in Boston was able to integrate three areas of information systems: strategy development, portfolio management, and accounting. [27] Every analyst of the firm had two desktop computers for decision support and "what if" stock analysis. The company needed only 50 employees while other similar firms need 200 to 300 people. The system flags unusual stock price fluctuations so that the analyst can investigate and explore a possible business opportunity.

4.3.2 Integration of two external and different data bases, or data bases and other specialized applications

In the airline industry, TWA Getaway, Inc. saw business jump 40% in a year after installing a DEC-VAX tour automation system, which links the data from an airline Computer Reservation System (CRS) to a complex database of hotels and entertainment options. The toy maker, Mattel, tied PSDI's Project/2 project management system to a toy database under DB/2. [28] Management was able to look at schedule adherence and then develop yearly planning and revenue projections. With 3,400 employee and revenues at $250 million, Jones Truck Lines, Inc. implemented a $9 million integrated database and freight hauling application in 1988. [29] The system uses Software AG ADABAS DBMS and Natural2 4GL on an IBM 3090 under MVS/XA. The results were faster response time, management access to necessary internal information, labor savings, EDI service for customers, and improved revenues.

4.3.3 Integration of file processing applications and DBMS

This interface is possible through a program interface that passes data between file processing applications and a DBMS. Mead Johnson, for example, uses this approach to transfer data between systems using COBOL and IMS DBMS. [30]

4.3.4 Integration of data requirements for management support systems

Such management support systems include Decision Support Systems (DSS), Expert Systems (ES), Executive Support Systems (EIS), and Natural Language Processing (NLP). The integration of management support systems is required to achieve a higher level of data use and access. Research on such integration is still lacking and must be encouraged. [31] Since DBMS existed before the development of such systems, their integration into current data bases is critical.

DBMS, such as ADABAS and IDMS, has built-in decision support languages for use by management and other end-users to facilitate the access and analysis of data to improve their decision processes. Advances in NLP have the potential for being used as a link between DBMS and EIS. [32] Data representations in ES and DBMS are different. ES processes data in symbolic form, while DBMS processes data in alphanumeric form. This poses integration difficulties. However, data in DBMS may be used as input to a process that transforms such data into a symbolic data representation which is suitable for ES. Current applications involve use of data

stored in a DBMS, such as PC-based dBase, as input for rule induction mechanism. In August 1990, IBM introduced a new ES shell called TIRS (The Integrated Reasoning Shell) that runs on OS/2, AIX, MVS, and VM. Eventually, all System Application Architecture environments will be included. The ES shell is linked to IBM's IMS DBMS, CICS, and DB2. Current research on linking DBMS and ES focuses on the use of object-oriented data representation, natural language interface for query processing, and cooperative processing. [33]

An evaluation of two EIS, in the 16 July 1990 issue of **Computerworld** highlighted the importance of integration in EIS use. The issue listed the following integration and interface issues: integrating data from different sources, efficient data extraction from existing databases, efficient access to external databases, well-integrated decision support systems, and effective interface to software such as Profs and Lotus 1-2-3. An author developed a comprehensive model that integrated DSS, ES, and NLP. The model enhances data access by managers for decision-making purposes. [34]

4.3.5 Data and business function integration

The newest technology that integrates data bases with distributed organizational functions is client/server technology. [35, 36, 37] Under this technology, data is stored at different locations within the organization on LANs and/or WANs environment. Structured Query Language (SQL) command-based applications move only requested data, not whole files, between two locations: a data requesting *client* and a data providing *server*. To achieve this type of integration, many organizations were engaged in downsizing operations from mainframes to LAN. Issues concerning downsizing data using LANs are [38]:

a) Should data be distributed?
b) What data is appropriate for distribution?
c) Who needs access to data? How often must it be updated and redistributed?
d) Safeguard for data base security and integrity.
e) Consistent security protocols.
f) Retraining of IS staff to handle data integration issues.

On the other hand, data warehousing allows the integration of distributed historical data in a central location to be retrieved for decision-making purposes. [39,40,41] Both of these two technologies are new and need more time to mature and more companies to implement them.

4.4 Network Platform

Multi-vendor integration and connectivity in a network, covering both intra- and inter- networks, is a major concern for businesses. These networks normally operate within single organizational boundaries. However, a new trend is emerging that encourages inter-organizational networking among organizations that share some common characteristics, such as educational institutions. In any organization, inter-connectivity may be required among one or more of the following types in an inter- and / or intra- network configuration:

a. Mainframe to mainframe
b. Mainframe to minicomputer
c. PC to PC (or LAN)
d. PC to mainframe/minicomputer/LAN
e. LAN to mainframe/minicomputer
f. LAN to LAN
g. Wide Area Networks (WAN) linking multi-platform hardware and networks.

Several examples of network integration are cited in the literature. Telecom Canada devised a plan to standardize and integrate EDP and administrative functions that include integrated requirements of office automation, databases, communications, and decision support tools. The plan recommended a three-layer hardware strategy: a) corporate systems with IBM mainframe computers serving each of the 10 major Canadian telecommunication companies, b) departmental systems with Digital Equipment Corporation mini-computers, and c) individual systems with IBM PCs and DEC's VT200 and VT300 terminals. [42]

PC-mainframe connectivity is accomplished through communication software, such as Kermit and Procomm. However, IBM's OS/2 Extended Edition and SQL will have a build-in micro-to-mainframe connectivity feature for both IBM PCs and Macs System 7.0. [43] Mac connectivity to mainframes has three features that can help MIS balance the demand for fast, easy connectivity with limits imposed by budgetary constraints: a) consistent user interface, b) standardized file transfer, and c) powerful script language. [44]

Linking LANs to corporate systems is giving IS departments more control over LAN management. However, this linking may create two difficult issues: a) different IS and user LAN implementation and b) IS support for LANs through decentralized groups may produce IS department-corporate staff disputes. Regardless of how LAN is supported, the central issue is the required connectivity between LAN and corporate IS. [45]

Current technology allows LAN to LAN link by using the "virtual LAN" concept. This link is accomplished by using switched-based networking paradigm rather than router-based. [46] Such technology can also be used to link LAN to WAN, creating an enterprise-wide network based on virtual infrastructure rather than purely a physical one.

4.5 Information Technologies Platform

Three technologies are identified: data, voice, and video. Voice and data processing integration is one area. Many businesses moved into a computerized voice response system which allows callers to make financial transactions, place orders, register for classes, retrieve information, and track use of services in marketing research, and product planning. [47]

Integrating information from mainframe applications with imaging systems was a mini-theme at the Imaging '90 show. For example, Bull HN Information Systems, Inc. offered Imageworks --a client/server-based suite of document management tools that runs on Unix systems and could be developed for IBM. Imageworks incorporates several industry standard technologies, including DOS, MS Windows, Oracle, and Transmission Control Protocol/ Internet Protocol (TCP/IP). Imagework, thus, will be appropriate for the large mainframe world of government agencies, corporations, banks and insurance companies. [48]

As one of the newest communication technologies, Integrated Services Digital Networks (ISDN) allows the transmission of voice, data, and video on the same line. [49] Another supporting technology that made ISDN more feasible is Asynchronous Transmission Mode (ATM). Boeing Information services' Richland Operations plans to use ATM to consolidate communication services for the Department of Energy Richland Labs' Hanford Nuclear Reservation. [50] The goal of the system is to evolve the voice, data, and video systems into a single 'PC-centric' communications system that uses a multimedia PC as the primary method of accessing all three services.

Finally, Figure 4 combines platforms of integration taxonomy, dimensions of integration, and objectives of integration.

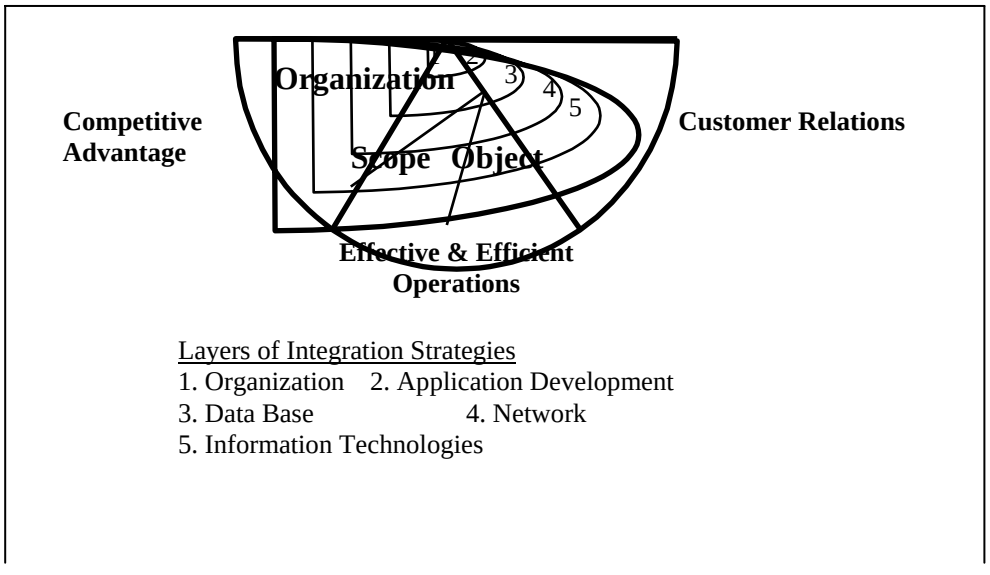


Figure 4: Relationship Among Dimensions / Objectives
of Integration and Taxonomy Platforms

An organization strategy platform prevails at the top. As the layers of integration platforms move downwards, organization strategy integration decreases, objects move from logical to physical, and the scope widens. At the lowest edge, the objectives are accomplished as described earlier in the discussions associated with Figure 2.

5. SUMMARY

This paper developed a scheme for defining integration based on three dimensions: scope, object, and organization. A combination of one or more of the three dimensions will constitute the domain of the integration project. An integration project may have one or more of the following objectives: gaining competitive advantage, cost-cutting and time-saving, and improving customer relations. The research taxonomy is based on several layers of integration platforms: information technologies, network, data base, application development, and organization strategies. This paper did not develop a precise definition of integration. Discussions and examples on integration dimensions, integration objectives, and integration platforms demonstrated the difficulties involved in accomplishing such a task. Any integration project may involve include one or more dimensions, achieve one or more objectives, and span over one or more platforms. Currently, most integration projects involved networking and organizational integration.

The framework presented by this paper should assist IS managers in devising a comprehensive strategy and an implementation plan to raise the level of integration in their respective organizations. Any integration project that attempts using information technologies at the operational level of the organization without the proper link to the organization's strategic objectives may result in wasted technology and financial resources. Therefore, an integration project must encompass all layers with varying degrees in order to insure its success. This is becoming more critical with the recent increased emphasis on intra- and inter- network integration.

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