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RESEARCH

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ABSTRACT

The most common approach to network development in the modern organization remains an undocumented, ad hoc method of deploying available technology rapidly to fit within a given cost structure. Current methods largely ignore the importance of integrating the networking strategy of a firm with the overall information systems architecture of the enterprise. To address this problem, a new approach to network analysis and design is presented.

The new method integrates existing principles of information systems analysis and design with the unique requirements imposed by distributed systems. The integrated approach seeks to provide the organization with a set of guidelines for allocating resources to a computer network based upon the business goals of a firm. Specifically, the method calls for

(1) defining the business problem,

(2) modeling business requirements,

(3) modeling location requirements,

(4) developing a network architecture,

(5) simulating network operation, and

(6) implementing the network.

The method is illustrated and compared to other network development methods. DEACON is found to be an advantageous approach.

Keywords: network analysis and design, wide area networks, network modeling

I. INTRODUCTION

For most organizations, the development of new networks is an ad hoc process that meets with only limited long-term success [Duchessi and Chengalur-Smith, 1998]. This lack of success is especially troubling given the reliance of modern society on information networks for electronic commerce and day-to-day business operations [Kalakota and Whinston, 1996]. Sophisticated techniques such as information engineering are being used to enhance the process of developing software. Why, then, are there not more sophisticated methods for the development of computer networks? In fact, the field does have advanced network simulation and performance modeling tools such as COMNET [http://www.compuware.com/products/ecosystems/], but the problem is that organizations lack methods for integrating the use of these tools into an overall IS architecture.

In general, when designing computer networks, an organization should consider both its business process and data distribution issues as well as technical issues [Whitten et al., 1994, Whitten et al., 1997]. However, current network development methods focus primarily on technical issues, and consequently, the network requirements are not integrated with the business requirements. For example, in software development, data flow diagrams and structure charts can be used to ensure that the modules of information system software are integrated with business processes. In network design, however, there are no similar alternatives to analyze fundamental issues such as hub placement or data distribution.

To aid organizations in developing computer networks and to aid instructors in the pedagogy of network development, this paper addresses the lack of integration of computer networks with firm level requirements and proposes a methodology for the analysis and design of computer networks. The methodology integrates network development into the context of overall information system development by deriving network architectures from traditional business models including process models or data models. The methodology can also be extended easily to facilitate the use of object-oriented analysis and design techniques, and the use of modern performance modeling tools (e.g., COMNET) is a critical component of the methodology. In addition, a network development method that is integrated with the business processes of a firm is particularly desirable for an organizational wide area network because of the widespread effect of the network on the entire organization [Shaw and Yadav, 1998]. A sample illustration of the methodology and comparisons to other approaches are presented in the following sections.

II. CURRENT PROBLEMS IN DEVELOPING COMPUTER NETWORKS

Why do organizations encounter such a large number of difficulties when developing computer networks? There are certainly a multitude of reasons that can be cited; however, some problems appear to be more prevalent than others. For example, rapid technological advances (new hardware, new software, etc.) have been shown to impact IT management significantly [Benamati et al., 1997, Lederer and Benamati, 1998]. Unfortunately, organizations have not necessarily determined how to cope with problems associated with advances in networking technology [Benamati, 1997, Benamati et al., 1997, Lederer and Benamati, 1998]. As an example, consider IPv6, the latest version of IP that is designed to allow for advances in Internet addressing and use. How will organizations manage upgrades to the new technology? Obviously this is always a valid question for any upgrade, but in an extensive wide area computer network, any problems that arise typically have a more serious impact for the organization than problems on individual machines [Shaw, 1999]. The network supports the information flow in an organization, and a network outage is almost always more troubling than the failure of a particular node [Goldman, 1998].

A second problem in the current practice of network development is the issue of inappropriate specifications. The most common cause of such a problem is the lack of research and thought that go into development. Unless the current and future needs of the organization are analyzed thoroughly, the capacity of a computer network might be much too large or much too small, thus eventually leading to an improper allocation of resources at the firm level.

It can be argued that the first two problems discussed are manifestations of a third, more important issue. In fact, one can argue that almost all computer network development problems can be traced to one particular issue: the lack of integration with the IS architecture of the firm. A logical extension to this concern, then, is the question of how best to integrate computer networks into the firm. If network design and development are completed in isolation, as is so often the case for many organizations, the true benefits of the network may not be realized, and additional problems are created as well. For example, when developing a network, many IS professionals opt to use a simulation software product to determine optimal node configurations and locations without considering other issues. This approach is largely flawed because the "optimal" node configuration for the software might not make any sense for the organization. Suppose a company has business offices in Seattle, New York, Dallas, and San Francisco with the headquarters located in Dallas. In the development of a wide-area network, a simulation software product might recommend a star topology with the central node located in San Francisco because such a design minimizes network traffic and latency; however, the software might not be aware of organizational considerations such as a central IS staff in Dallas, or a new information system under development in New York. Blindly trusting a simulation software package in this case could lead to a poor decision.

III. AN INTEGRATED APPROACH TO NETWORK ANALYSIS AND DESIGN

To address the current problems in network development, an integrated approach is needed to ensure that network development is consistent with organizational goals and objectives and overall IS goals and objectives. One of the most prominent representations of organizational IS integration is the IS architecture framework developed by Zachman [Zachman, 1987]. This framework provides an excellent starting point for a new approach to network design because:

(1) it shows the layers of abstraction necessary for network development from high level location modeling to low level network architecture, and

(2) it postulates relationships among computer networks and a firm's overall IS architecture.

Figure 1 shows an integrated approach to network design based upon the Zachman framework which has been named DEACON (Design of Enterprise Architecture-Based Computer Networks). The method shown in Figure 1 is intended to detail the sequence of steps necessary for effective analysis and design of computer networks. Client-server networks are probably best suited to the DEACON approach since the complexity associated with designing a tiered network architecture necessitates a robust design methodology, but the steps of the DEACON method are general enough to apply to a multitude of network configurations. The following paragraphs expand on Figure 1 and give specific descriptions of each step in the methodology.

- *Problem Definition* --- The first step in the methodology involves establishing goals and objectives at three levels. This step is crucial due to the need to establish properly the context and scope of the network development effort. Ideally, the firm should first establish (or hopefully already have established) goals and objectives. The goals and objectives might be in the form of a mission statement or vision statement. Then, information system goals and objectives should be established in a manner that will aid the organization in attaining the firm level goals. Finally, goals and objectives should be set for the network that will allow the information system to support the organization. The need for this particular step is reinforced by the increased emphasis on human and social issues in networking that has arisen with the rapid proliferation of networks in the Internet era.

1. Problem Definition
    a. Define organizational goals and objectives
    b. Define IS goals and objectives
    c. Define network goals and objectives

2. Requirement Specification
    a. Model business processes (process models)
    b. Model organizational data (data models)

3. Location Model
    a. Construct extended location connectivity diagram from user requirements
    b. Use data-location and process-location matrices to refine extended location connectivity diagrams, process models, and data models

4. Network Architecture
    a. Design architecture diagram from extended location connectivity diagram
    b. Assign data and processes to nodes
    c. Match available technology with specifications on architecture diagram

5. Network Performance Evaluation
    a. Simulate network operation (e.g. using software such as COMNET)
    b. Identify performance bottlenecks and optimize network
    c. Refine network architecture

6. Implementation
    a. Implement the network architecture
    b. Prepare a conversion plan
    c. Convert to the new network

Figure 1. The DEACON Method

- *Requirements Specification* --- The second step encompasses traditional business modeling activities. Organizational business processes and data must be captured and documented to develop an information system to satisfy business requirements properly. With computer networks, the same principle applies because the proper evaluation of existing and future organizational processes and data should be used to guide the network development to ensure integration and consistency with other facets of the organization. Specifically, business process modeling using data flow diagrams is prescribed by this methodology. Other process modeling tools such as IDEF0 can be easily modified to work with the DEACON approach. Similarly, a data model should be constructed using entity-relationship diagrams or object-oriented data modeling. The most important aspect of the modeling effort, in whichever structural form is used, is to focus on the identification of tasks. Of course, the tasks should be aligned with the goals and needs identified in the first step of the DEACON method. This particular step is one of the foundations of social network analysis, which is based upon the idea of applying information about human networks to the analysis and design of human networks [Krebs, 2000].

- *Location Model* --- Location modeling involves constructing increasingly more detailed models of node locations for the new network. Nodes can be decomposed, as in a data flow diagram. The information used to develop location models should come from users and managers, as do traditional business models, so that the organization can capture data distribution and location requirements that are not necessarily captured with traditional business modeling. Interviews with users could, for example, show that nodes are really needed in locations that might have been ignored previously. In addition, the location models are reconciled with process and data models through the use of matrices. The optimal location of processes will be determined largely by the identification of tasks in the previous step, as well as by the interrelationships among them.
- *Network Architecture* --- In this stage, the location models are transformed into architecture models that show specific hardware and software options. This step is necessary to transform the conceptual models developed in prior stages into physical models including technological specifications. First, the location models are transformed into architecture diagrams, and data and processes are assigned to nodes according to a set of guidelines. Finally, the specifications in the diagrams are matched with available hardware and software to determine possible network configurations.

- *Network Performance Evaluation* --- The fifth step is the proper place for the use of network simulation software. After the optimal architecture is developed, simulations can be used to uncover bottlenecks or problems that were not seen before. The performance evaluation effort provides an additional level of testing and quality assurance before actual purchase and implementation plans are made. In addition, instead of using only simulation software for network development, the use of simulation software has been integrated into the overall organizational network development process. Since organizational requirements have been used as the starting point for network simulation, the simulation process will be more consistent with other areas of the organization and its information systems.
- *Implementation* --- Finally, the network is ready for implementation. The hardware and software specified in the network architecture is purchased, assembled, and tested. A conversion plan is prepared to determine the best approach for conversion to the new network. Possible options include parallel, direct, phased, and modular installations [Hoffer et al., 1996]. In general, network conversions are very similar to other IS conversions, although the backward compatibility of most network architectures often helps to ease the data conversion difficulties associated with most implementations. After a suitable plan is developed, installation takes place.

The DEACON approach assures that the network design is consistent with organizational goals, business processes, and information systems. Operationally, the middle two steps in the methodology (location analysis and network architecture) are not as well known as the other four steps. These two steps were originally proposed by Whitten et al. [Whitten et al., 1997]. To make development more complete and consistent, their models were refined and extended. The next subsections explain these two steps in more detail and delineate the extensions that were made

LOCATION ANALYSIS

After developing traditional business models for an information system, the next task is to elicit location requirements from users that are often ignored in traditional business modeling. More specifically, information must be gathered about the geographical locations of system use together with details about where the information originates geographically. That is, where does the data come from and where is it going? Also, how do people use information at a particular location?

Location connectivity diagrams (LCDs) [Whitten et al., 1997], are used to model such information as "communication requirements." Although these diagrams are useful, they do not provide information about data distribution, response time, or volume of data transmitted. Thus, we propose the 'extended location connectivity diagram' (ELCD) as a tool for modeling communication requirements including the data distribution, response time, and volume of data to be transmitted. An example ELCD is shown in Figure 3 in Section V.

Security needs can also be captured with an ELCD. Secure channels are denoted by double lines, while insecure channels are denoted by single lines.[1] Next, process-location matrices and data-location matrices are constructed to determine any processes, data, or locations that are not needed or that must be added. Using these matrices, the process model, data model, and location model are refined in preparation for the next phase.

NETWORK ARCHITECTURE MODELING

The network architecture diagram (NAD) is used as a tool to model the relationships among network hardware, software, processes, and data. The network architecture diagram is based upon the concept of a network topology data flow diagram [Whitten et al., 1994]. First, a diagram of nodes is drawn from the ELCDs developed in the Location Analysis step. Next, the modeler should assign processes and data to nodes based upon the user requirements

[1] For other notational details, the reader is referred to existing literature on location connectivity diagrams and network architecture diagrams [Whitten et al., 1994, Whitten et al., 1997].

documented earlier. In general, the following rules can be used to assign processes and data to specific nodes.

- *Rule #1*: Processes that interact with users (e.g., presentation, editing) are assigned to client nodes.
- *Rule #2*: Processes that include application logic and business logic are assigned to server nodes. A mainframe is considered to be simply another server in the network [Whitten et al., 1997].
- *Rule #3*: Data are assigned to nodes based on user requirements and managerial decisions regarding centralization and decentralization concerns. The assignment of data to nodes is often an iterative process that may continue to the next phase.

Once the network requirements are modeled explicitly, the analyst can match the requirements with available (and feasible) technology. For example, if a network link requires a 30 Mbps transfer rate, a communication medium must be chosen that can support this transfer rate. Similarly, a network protocol must be chosen that can support the transfer rate. This process is repeated until an initial decision is made for all the hardware and software. It is not necessary to be absolutely correct on the first try. The simulation process in the next phase, Network Performance Evaluation described in Table 1, will aid in choosing the most appropriate technology.

IV. A COMPARISON OF NETWORK ANALYSIS AND DESIGN METHODS

The DEACON methodology presented here is not the only one that exists for designing computer networks. To demonstrate the usefulness of the integrated methodology further, and to show why an organization might want to use the DEACON methodology instead of others, the DEACON approach is compared in this Section with existing approaches. Since there is no clear consensus on the current best network development method, we consider the following four methods that are proposed and/or used in organizations.

- *"Ad hoc" (informal) method* --- By far the most common method of network development, this approach is an informal process in which the network design and configuration is based on hunches, intuition, and/or experience. Often only a few people are involved, usually technical personnel.
- *LCD method* [Whitten et al., 1997] --- The LCD approach involves the fundamentals of the third and fourth steps in the DEACON approach. LCDs are constructed together with data-location and process-location matrices, and then data and processes are assigned to nodes in the network architecture.
- *Simulation method* --- The simulation method is focused primarily on design via performance modeling software such as COMNET. Existing network schema or ideas for new networks can be used as the starting point for the simulation.
- *"Systems approach"* [Fitzgerald and Dennis, 1996] --- The systems approach is a ten step process which addresses the following issues: (1) feasibility study, (2) network design plan, (3) current network, (4) network requirements, (5) geographic scope, (6) circuit requirements, (7) network security and control, (8) network configuration, (9) network costs, (10) implementation.

While there are no standard criteria for comparing network development methods, the following criteria are designed to give a representative and objective view of the methods so that an organization may choose the most appropriate method for a given situation. The criteria were developed using a set of generally desirable characteristics of data communication networks [Fitzgerald and Dennis, 1996, Goldman, 1998, Hoffer et al., 1996, Shaw and Yadav, 1998, Stallings and Van Slyke, 1998, Whitten et al., 1994, Whitten et al., 1997].

- *Usability* (To what extent is the methodology usable?) --- The methodology should be easy for an organization to apply, in the sense that an organization must be able to apply the methodology without excessive problems and/or confusion.

- *Integration* (To what extent is the network integrated with IS architecture?) --- The methodology should be integrated with the information system(s) in an organization. Networks in isolation are not helpful to the firm, and thus the integration of the network with the IS architecture is crucial.
- *Documentation* (What level of documentation does the methodology provide?) --- The methodology should provide extensive documentation including user requirements and network architecture.
- *Complexity* (How easy is the methodology to learn and to apply?) --- Ideally, the methodology should be relatively easy to learn and to apply.
- *Allocation Guidelines* (To what extent does the method help allocate data and processes to nodes?) --- The methodology should provide rules and guidelines for determining which processes and/or data to assign to each node.
- *Principles* (What principles does the methodology emphasize?) --- The methodology should be based on sound fundamental principles that have been proven effective instead of relying on intuitive ideas that have a low likelihood of success.
- *Outcomes* (What are the major end products of the methodology and are the products of a high caliber?) --- The outcomes should be relevant to organizational goals, and they should be of high quality.

Table 1 summarizes the results of applying the criteria for each of the four methodologies described above and to DEACON. The table shows that, from a functionality perspective, the best approaches are the DEACON approach proposed here and the systems approach; however, these two methods also introduce complexity into the process which might not be appropriate in some organizational situations. The major advantages of the integrated DEACON method and the systems approach are similar, but the DEACON method has the additional advantages of providing firm level integration of the network and a set of guidelines for allocating business processes and data across network nodes.

Table 1. A Comparison of Network Development Methodologies

	DEACON	Ad Hoc	Simulation	Systems	LCD
Usability	High	Medium	Medium	High	Low
Integration	High	Low	Low	Medium	High
Documentation	High	Low	Medium	High	Medium
Complexity	High	Low	Low	High	Medium
Allocation Guidelines	Good	None	Some	None	Good
Principles	Integration; completeness; consistency	Hunches; Intuition; Luck	Simulation modeling	Cost structure; technical accuracy	Integration
Outcomes	Implementation	Hopefully implementation	Network model	Implementation	Network model
Quality	High	Low	Average	High	Above average

V. AN ILLUSTRATION OF THE DEACON METHOD

To illustrate the integrated network development methodology, consider a simple example that provides an opportunity to examine the methodology more closely. Although this example is relatively unrealistic, it helps to illustrate the utility of the DEACON approach. An actual case study example is beyond the scope of this article, but the concepts applied in the example can be extended to more complex problems.

SHIPIT is a fictitious firm that provides order processing services for mail order companies. The products are stored in a SHIPIT warehouse, and orders are shipped as they are received. The SHIPIT organization consists of three locations:

- the warehouse in Kansas City, Missouri,
- the office building in Dallas, Texas, and
- the call center in Albuquerque, New Mexico.

Currently, each facility has computers, but they are not integrated, and thus the only mechanism for sharing information is to print reports and physically send the reports to the other locations. Managers at SHIPIT believe that a computer network that allows them to share information would be beneficial, and they decided to develop such a network using the integrated methodology. The primary business driver for the company in its network design is a desire to reduce business operating costs.

Using the DEACON approach, their procedures would be similar to the following:

- *Business Requirements Definition* --- The overall objective of the firm is to improve speed and accuracy of order processing and to reduce costs, if possible. This goal is driven by business needs, and it should be first and foremost a business goal. In other words, to design a network properly, the firm should first set goals for the business before setting goals for the network. Next, the firm should set requirements/goals for the overall IS architecture of the firm. Again, the IS goals should be driven by the business goals. Since the business goals of the firm were to improve efficiency and thus reduce costs, the goals for the overall IS are to facilitate storage and retrieval of information that is accurate and timely. At a more operational level, the goals of the information system are to facilitate data sharing among the various departments at SHIPIT so that the number of printed reports can be reduced. Finally, the goals for the network should be established based upon the requirements of the information system.

  If the entire step is completed correctly, the result should be a set of requirements or goals for the network that, if achieved, will aid the company in achieving its overall business goals. Thus, the goal of the network is to provide error-free and reliable communication channels to support the information system and consequently the organization. More specifically, the network must provide a flow of information among the facilities at SHIPIT, and the response time must be sufficient to support online transaction processing. To this end, reports that are currently printed and transferred manually should be sent electronically over the new network.

- *Business Modeling* --- The lowest level data flow diagram and the entity relationship diagram are shown in Figure 2. The specific algorithms and

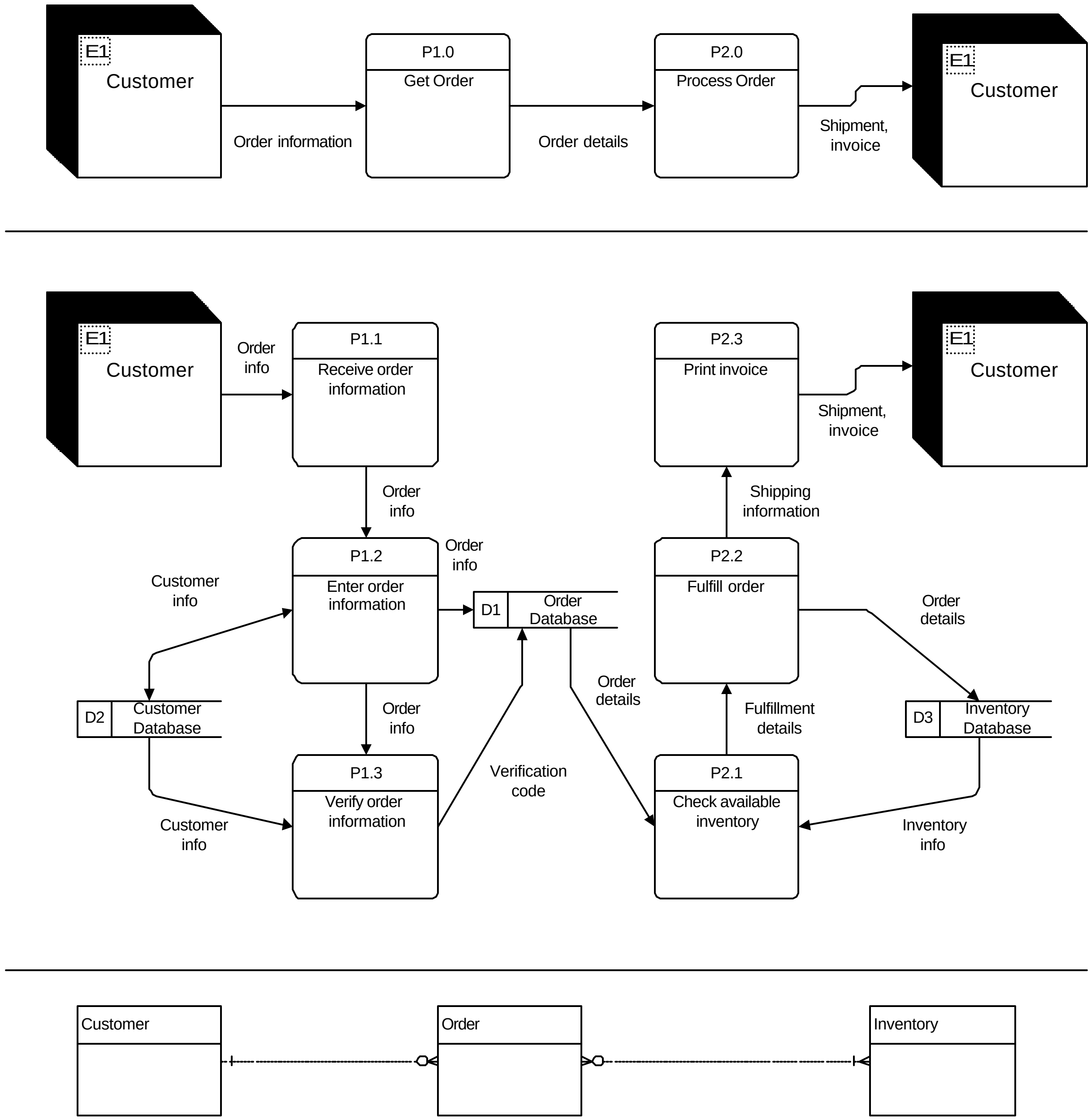

Figure 2. Business Models for SHIPIT

notational details for developing these diagrams are not presented here since data and process modeling techniques are well-known and well-documented [e.g., Hoffer et al., 1996, Whitten et al., 1997]. Although process and data models are not specific to network analysis and design, they play a critical role in the DEACON method. At SHIPIT, the goals established in the first step of the network development require that the network provide for effective information flow to improve efficiency and to reduce costs. To improve efficiency, however, a clear understanding of the organization's business processes must be gained in addition to knowledge of the organization's data requirements. That is, the most critical efficiency gains for SHIPIT will be achieved if the network is aligned properly with the company's processes and data. Thus, the company's processes and data must first be well documented. This particular step is one that is often omitted in network analysis and design.

- *Location Modeling* --- The extended location connectivity diagram for this example is shown in Figure 3. Notice that there are two levels of the extended location connectivity diagram shown in the figure. The first level shows only the three locations (warehouse, office, and call center), while the second level shows networks within each location. Further levels would show individual node locations within the localized networks. Tables 2 and 3 show the process-location matrix and the data-location matrix. The purpose of these matrices is to reconcile the location model with the process model and data model that were developed in the previous step. If any location does not use any data or processes, then the analyst must consider removing that node. Unless there is a specific reason to keep the unused location, it can probably be omitted to improve the performance of the network and lower development costs. From the process-location matrix, one can see at a glance that there are a large number of processes concentrated in the remote call center. Such a realization is one of the major reasons for using the DEACON approach.

The process-location and data-location matrices are used not only to help identify locations without any assigned processes or data, but also to aid in determining the actual transmission requirements at each location. The abundance of business processes in the call center suggests the need to increase the communication requirements for the link between the headquarters and the call center. This requirement is reflected in Figure 3.

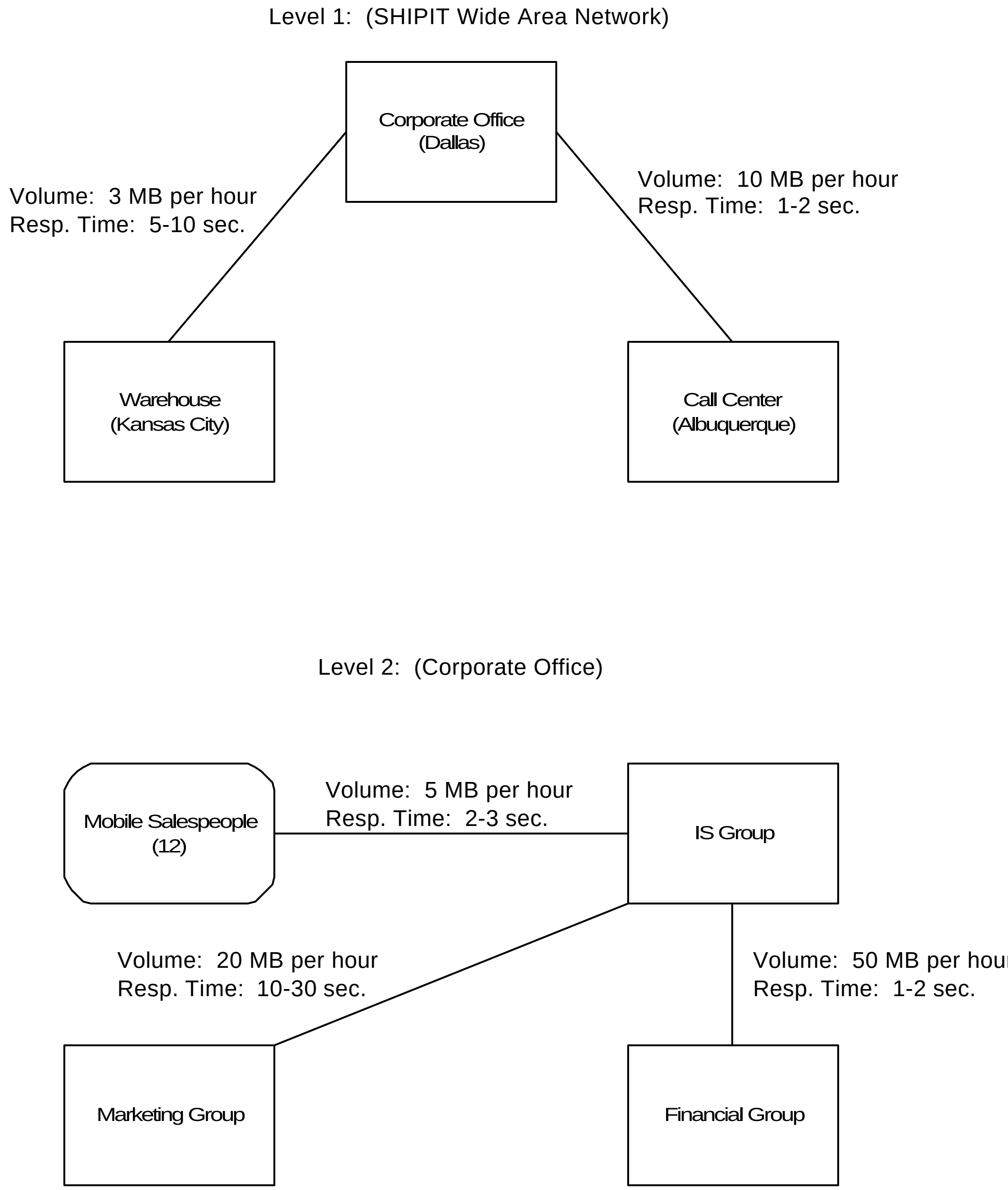

Figure 3. SHIPIT Extended Location Connectivity Diagram

Table 2. Process-Location Matrix

	Office	Warehouse	Call Center
Receive Order Info			X
Enter order info			X
Verify order info			X
Check inventory		X	X
Fulfill order		X	
Print invoice	X		

Table 3. Data-Location Matrix

	Office	Warehouse	Call Center
Customer	RUD	R	CRU
Order	R	RU	CRUD
Inventory	RU	CRUD	R

C = Create, R = Read, U = Update, D = Delete

- *Network Architecture Modeling* --- Figure 4 shows a portion of the network architecture diagram (NAD) for the SHIPIT example. The portions that are not shown are easily derived. The initial nodes in the diagram are derived from the lowest level extended location connectivity diagram. Then, the processes and data are assigned to the proper node locations to complete the architecture specification. Finally, available and feasible hardware and software are matched to the requirement specifications given on the network architecture diagram.

- *Performance Modeling* --- Once the network architecture diagram and the initial technology selection are established, this initial configuration is simulated in a network simulation software package such as COMNET. The simulations are used to identify problems and bottlenecks, and the

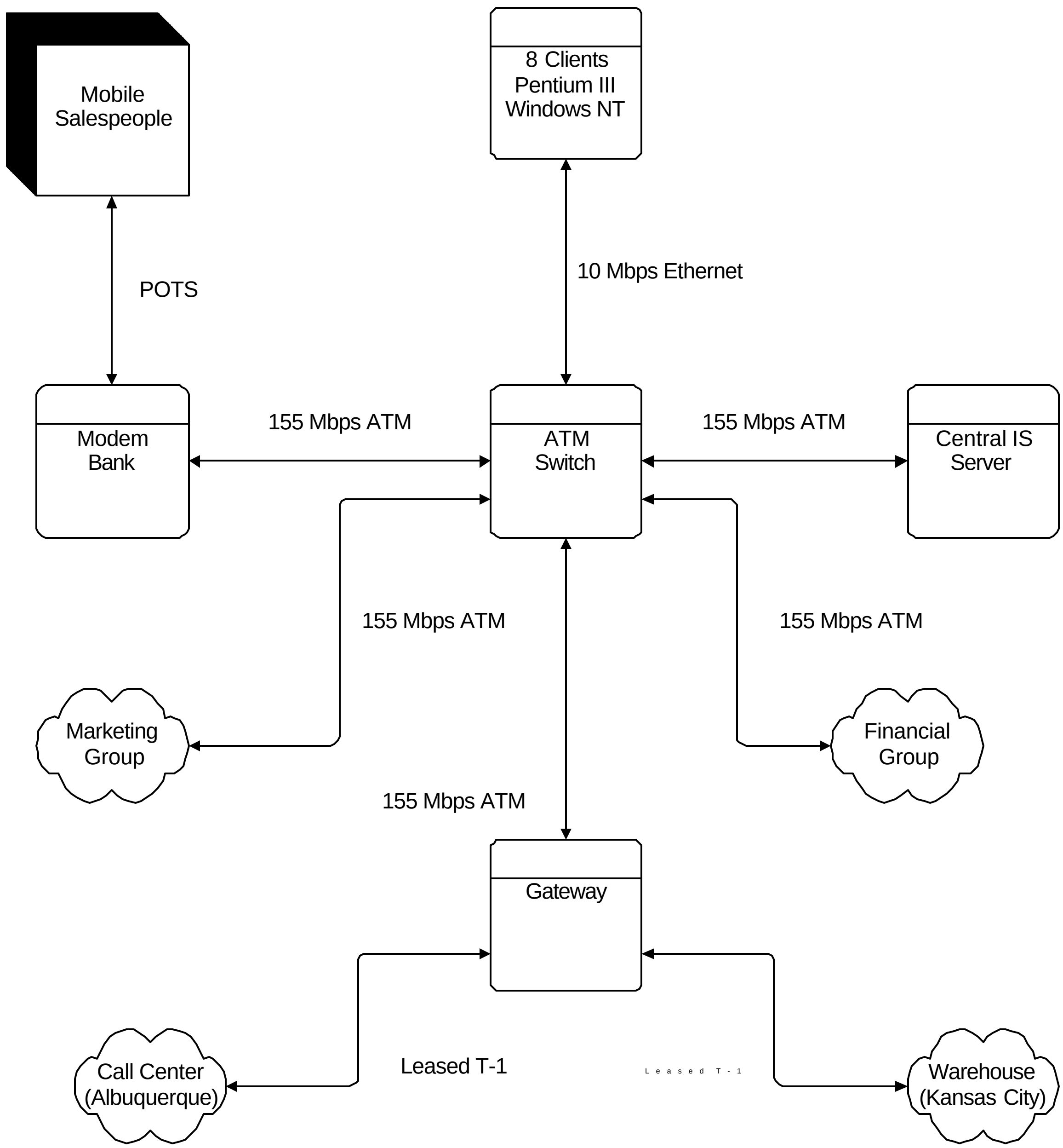

Figure 4. SHIPIT Network Architecture Diagram

network architecture diagram is modified to reflect the results of the optimal network configurations in the simulation trials.

- *Implementation* --- Finally, SHIPIT is able to implement the new network successfully via purchase of hardware and software and preparation of a conversion plan. The installation then takes place according to the conversion plan.

To summarize, the case study example of the SHIPIT company illustrates the usefulness of the DEACON method in the integration of business issues in the design of computer networks. At SHIPIT, the primary purpose of the network to be developed was to reduce costs through information sharing. The majority of business processes and tasks were concentrated in a remote call center which was to be connected to other parts of the corporate network. With other network development methods, it is possible that the concentration of tasks and processes in the remote location might have gone unnoticed. If this were the case, it likely would have caused the organization to invest in a remote communication link which would have been insufficient to handle the volume of communication needed at the call center. For example, a designer using the ad hoc development approach might have recommended a cable or DSL solution for the remote links. Unfortunately, these products do not support the upstream data transfer requirements necessary for the volume of data at the remote call center. Certainly, a thorough job of requirements gathering in any development approach can help alleviate such problems, but the advantage of the DEACON method is that the business requirements must be explicitly specified and documented, so errors in the requirement determination process are much less likely to occur.

VI. CONCLUSION

Organizations can use the methodology presented here to design and develop computer communication networks that are integrated with the business requirements of the firm. An integrated approach to network analysis and design is superior to a purely technical approach because it facilitates support for business processes and the overall IS architecture for an organization. In addition, this approach can be used to understand the proper role of popular performance modeling tools in network development. Figure 5 summarizes the advantages of DEACON.

1. *Business Requirements Definition*

The first step in the DEACON method sets it apart from the other methods discussed in the previous section. Although some of the other methods require an examination of business requirements, the advantage of the DEACON method is that the business goals are an explicit part of the methodology, and indeed the goals form the foundation for the rest of the design approach.

2. *Business Modeling*

Of the five network development methods discussed in the previous section, the DEACON method is the only one that mandates a clear definition of organizational business processes and data. In the other methods, the processes and data are embedded in other aspects of development, and thus they are addressed implicitly. The DEACON approach requires that the processes and data be explicitly stated and documented, as in the SHIPIT example.

3. *Location Modeling*

The other network development approaches presented in Section IV do not provide specifically for easy identification of process or data overloads such as the one in the SHIPIT example, thus further supporting the utility of the DEACON approach.

4. *Network Architecture Modeling*

This step is an important distinction between the DEACON method and the other network development methods, because the DEACON method provides for an explicit transition from logical models to physical models.

5. *Performance Modeling*

Performance modeling uses simulation. However, the simulation results are not accepted blindly. They are interpreted in such a way that common sense is not over-ridden.

6. Implementation

When the implementation stage is reached, DEACON ensures that the implementation takes into account both the business and the technical imperatives.

Figure 5. Summary of DEACON Advantages

The demand for computer network services increased significantly with the growth of the Internet, and demand growth far outpaced advances in computer network development. The development of networks is critical to the success of the modern organization, and the use of an integrated network development method, such as DEACON, is a first step toward efficient network analysis and design.

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